FINAL PROGRAM and BOOK OF ABSTRACTS

2026 IEEE 15th Data Driven Control and Learning Systems Conference (DDCLS'26)

Jishou, Hunan, China

May 8–11, 2026

Organized by

Qingdao University

Technical Committee on Data Driven Control Systems, Asian Control Association

Locally Organized by

Jishou University

Hunan University of Science and Technology

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Welcome Message from General Chairs

Zhongsheng Hou
General Chair of DDCLS'26

Donghui Fang
General Chair of DDCLS'26

Dear Friends and Colleagues,

On behalf of the Organizing Committee, it is our greatest pleasure to welcome you to the 2026 IEEE 15th Data Driven Control and Learning Systems Conference (DDCLS'26), which is organized by Qingdao University and Technical Committee on Data Driven Control Systems, Asian Control Association, locally organized by Jishou University and Hunan University of Science and Technology, and sponsored by IEEE China Council and IEEE Beijing Section. The conference is held at Jishou Xiangquan Sunshine Hotel, Jishou, Hunan Province, China, May 8–11, 2026.

Data driven control and learning systems, together with model-based control methods for the target of forming the complete control theory, is an emerging hot research area in the field of automation engineering and in systems & control. It focuses on all the issues of control, learning and optimization for the plants whose models are unavailable. Although the study on data driven control and learning is still in the embryonic stage, it has attracted a great amount of attention within the systems and control community, such as the special issues published in the top journals: *ACTA AUTOMATICA SINICA* (2009), *IEEE Transactions on Neural Networks* (2011), *Information Sciences* (2013), *IEEE Transactions on Industrial Informatics* (2013), *IEEE Transactions on Industrial Electronics* (2015, 2017), and *IET Control Theory & Applications* (2015, 2016), Energies (2019), IEEE Control Systems Magazine (2023). Further, the problems in the data driven control and learning systems would be fundamental challenges in the coming age of the *Internet of Things*, *Cyber-Physical Systems*, *Industry 4.0*, *China Manufacturing 2025*, and *Artificial Intelligence 2.0* under the big data environment, which is already on our road ahead but beyond the traditional systems & control methods.

As an inheritance of previous ten conferences, DDCLS'26 continues to attract broad interest throughout the world, with a total of 352 submissions. This reflects the increasing interest in our field, and meanwhile creates a difficult workload in evaluating the papers and organizing a cohesive program. We are fortunate to have an exceptional Technical Program Committee (TPC) that sorted through the evaluations and

integrated the individual submissions into the final technical program described in the proceedings. We want to thank our Organizing Committee for their invaluable assistance in arranging the diverse offerings at the conference, from registration and local arrangements to technical programs. Last but not least, we would like to express our deep appreciation to Jishou University and Hunan University of Science and Technology for their great support.

The Technical Program Committee has assembled a comprehensive technical program that covers a broad spectrum of topics in data driven control and learning systems. The DDCLS'26 technical program comprises 19 regular sessions, 17 invited sessions, 1 best paper award session and 2 poster sessions. Besides the technical sessions, the highlights of the DDCLS'26 are the keynote addresses given by world-class level scholars, Prof. Lihua Xie from Singapore, Prof. Jian Chu from China, and the distinguished lectures given by active young scholars. They are Prof. Zhongkui Li, Prof. Long Jin, Prof. Chao Shang, Prof. Anyang Lu, and Prof. Hao Yu, all from China. In addition, DDCLS'26 has newly added excellent doctoral forum. These activities provide high quality research and professional interactions with subject of data driven control such as mode-free adaptive control and iterative learning control, artificial intelligence, automation and industrial applications. We sincerely appreciate all the contributors, especially the keynote address speakers, distinguished lecture speakers, excellent doctoral forum speakers, invited session organizers, and session chairs for their tremendous efforts towards a top-quality conference.

We also want to thank the young lovely volunteers who have made this conference possible. Without you, the monumental task ahead of us for organizing this conference would be significantly beyond our capabilities.

May you have a wonderful and fascinating stay in Jishou, Hunan Province, China, and enjoy the colorful scenery and magic foods.

Best wishes

Zhongsheng Hou
General Chair of DDCLS'26

Donghui Fang
General Chair of DDCLS'26

Message from Technical Program Chairs

Mingxuan Sun
Technical Program Chair

Ronghu Chi
Technical Program Chair

Dear Friends and Colleagues,

On behalf of the Technical Program Committee, it is our great honor to welcome you to the 2026 IEEE 15th Data Driven Control and Learning Systems Conference (DDCLS'26) in Jishou, China.

The annual event of DDCLS has proven to be one of the excellent forums for scientists, researchers, engineers, and industrial practitioners to present and discuss the latest technological advancements as well as future directions and trends in Data Driven Control, Learning and Optimization, and to set up useful links for their works. DDCLS'26 has received enthusiastic responses with a total of 352 submissions. All the submissions had been processed by the Technical Program Committee. All committee members worked professionally, responsibly, and diligently. Besides evaluations from reviewers, each member also provided his/her own assessments on the assigned papers, so as to ensure that only high-quality papers would be accepted. Their commitment and hard work have enabled us to put together a very solid proceeding for our conference. The proceeding includes 307 accepted papers which are divided into 37 oral sessions and 2 poster sessions for presentation. Moreover, 9 extended abstract papers are invited for presentation to show the latest academic development in data driven control and learning systems.

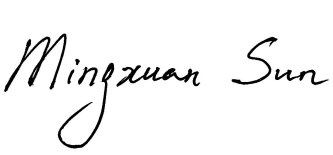
Ahead of the parallel technical sessions, two keynote talks will be delivered by eminent scientists. These lectures will address the state-of-the-art developments and leading-edge research topics in both theory and applications in Data Driven Control, Learning and Optimization. We are most honored to have Prof. Lihua Xie (Nanyang Technological University) and Prof. Jian Chu (Shanghai Jiao Tong University) as the keynote address speakers. Besides, we are very fortunate to have the distinguished lectures given by the five outstanding young scholars, Prof. Zhongkui Li (Peking University), Prof. Long Jin (Lanzhou University), Prof. Chao Shang (Tsinghua University), Prof. Anyang Lu (Northeastern University), and Prof. Hao Yu (Beijing Institute of Technology). We are confident that their presence would undoubtedly act prestige to the conference. We would like to express our sincere appreciations to all of them for their enthusiastic contributions and strong supports to DDCLS'26.

To promote the development of the society of Data Driven Control, Learning and Optimization, the highest quality papers will be rewarded with the Best Paper Award at DDCLS'26. Based on reviewers' comments and nominations as well as the evaluations of Technical Program Committee members, 21 papers were selected for consideration for the award by the Best Paper Award Committee. These papers were sent to some distinguished experts in the relevant areas for additional evaluations in a double-blind manner. Based on their comments and recommendations, 8 papers were shortlisted as the finalists for the award. During the conference, the oral presentations of the 8 finalists will be further assessed by the DDCLS'26 Best Paper Award Committee. The winner of the "DDCLS Best Paper Award" and "DDCLS Best Student Paper Award" will be selected by the committee after assessing the oral presentations. Furthermore, the interactive presentations of 92 papers in 2 poster sessions will be assessed by the DDCLS'26 Best Poster Award Committee during the conference, and one or two papers will be conferred to the "DDCLS Best Poster Award" by the committee after assessing the interactive presentations. Meanwhile, DDCLS'26 is also organized an excellent doctoral forum. Five distinguished scholars will present their new research findings in the field of artificial intelligence, data-driven control and industrial applications. We would like to express our sincere appreciations to all of them for their enthusiastic contributions and strong supports to DDCLS'26.

The conference materials containing the PDF files of all papers scheduled in the program and an Abstract Book will be downloaded from the cloud storage by each registered participant. The official conference proceedings will be published by the IEEE and included in the IEEE Xplore Database.

On behalf of the Technical Program Committee, we would like to thank all reviewers for giving time and expertise to provide comments, which are contributive to the Committee in making a fair decision on the acceptance/rejection of each paper. Thanks also go to the dedication, diligence, and commitments of the Invited Session Chairs, Subject Session Chairs, Excellent Doctoral Form Chairs and all the members of the Technical Program Committee. We would like to gladly acknowledge the technical sponsorship provided by the Organizing Committee of DDCLS'26 and Technical Committee on Data Driven Control Systems, Asian Control Association. We also convey our heartfelt thanks to friends, colleagues, and families who have helped us in completing the technical program directly or indirectly. Last but not least, we are grateful for the strong and enthusiastic support of all delegates, especially those old faces around the world.

We do hope that you will find your participation in DDCLS'26 in Jishou is really stimulating, rewarding, enjoyable, and memorable.



Mingxuan Sun
Technical Program Chair

Ronghu Chi
Technical Program Chair

Keynote Address

Keynote Address 1

Data-Driven and Learning-based Control

Prof. Lihua Xie
Nanyang Technological University, Singapore

Saturday, May 9, 2026
08:20-09:10
Grand Hall / 大宴会厅

Abstract

The traditional control theory relies on mathematical models of physical systems for estimation and control. In many applications such as power systems and robotics, it is difficult to obtain accurate system models due to the complexity of the system under study and the environment it interacts with. In recent years, data-driven and learning-based control have attracted a lot of interest in various fields of engineering including manufacturing, robotics, and transportation systems. In this talk, we shall introduce some recent developments in data-driven control and Gaussian Process based learning control, and demonstrate their application in sensor fusion for robotic systems.

Biography

Lihua Xie is Professor and President's Chair in Control Engineering and Director, Center for Advanced Robotics Technology Innovation, Nanyang Technological University. He has served as the Head of Division of Control and Instrumentation and Co-Director, Delta-NTU Corporate Lab for Cyber-Physical Systems. He has directed several major research programs with a total funding of over S$100M. His research interests include system theory and control, networked systems, multi-agent networks, learning-based control, and unmanned systems. He is an Editor-in-Chief for Unmanned Systems and Associate Editor for IEEE Control System Magazine. He has served as Editor for IET Book Series in Control and Associate Editor for a number of journals including IEEE Transactions on Automatic Control, Automatica, IEEE Transactions on Control Systems Technology, etc. He was an IEEE Distinguished Lecturer (2011-2014), the General Chair of the 62nd IEEE Conference on Decision and Control (CDC 2023), and currently Vice-President of IEEE Control System Society. Dr Xie is Fellow of Academy of Engineering Singapore, IEEE, IFAC, and CAA.

Keynote Address 2

A Pathway to Industrial AI for Process Industry

Prof. Jian Chu
Shanghai Jiao Tong University, China

Saturday, May 9, 2026
09:10-10:00
Grand Hall / 大宴会厅

Abstract

Time series production data are the richest and high quality in process industry, like petroleum chemical industry. A time series data based pre-trained Transformer (TPT), an AI model, was developed. Many practical applications by TPT have shown a possibility that the traditional software like APC and RTO could be replaced by AI technologies.

Biography

Jian Chu is a professor in process control area for many years. He is the founder of SUPCON, a Hangzhou based company focusing on autonomous operating plant (AOP) for process industries, since 1993.

Distinguished Lecture

Distinguished Lecture 1

逻辑引导与数据驱动的规划控制方法

Prof. Zhongkui Li
Peking University, China

Sunday, May 10, 2026
8:00-8:40
Ruyi Hall / 如意厅

Abstract

任务规划和行为控制是无人集群系统的核心关键技术，在大数据和大模型时代面临新的机遇与挑战。基于大模型的端到端任务规划方法，面临可靠性不足、难解释、难验证等问题，为此，我们提出了形式逻辑与大模型融合的集群任务规划新架构，大幅提高了任务成功率、规划可靠性和资源利用效率。针对无模型自适应和威廉姆斯基本引理等数据驱动控制框架，我们提出了基于局部数据采样的分布式数据驱动控制方法，有效避免了现有方法对于全局信息的依赖，进一步提出嵌入部分已知模型信息的混合自适应控制方法，有效提升了控制性能。

Biography

李忠奎，北京大学先进制造与机器人学院博雅特聘教授，2005 年于国防科技大学获学士学位，2010 年于北京大学获博士学位。从事无人集群协同控制与决策研究。撰写英文专著 2 部，发表期刊论文 100 余篇。入选国家杰青，教育部青年长江，北京市杰青，全国百篇优博。获国家自然科学二等奖 1 项，教育部自然科学一等奖、二等奖各 1 项，中国指控学会科技进步一等奖 1 项，SCI 期刊最佳论文奖 2 个。目前担任 IEEE Transactions on Automatic Control 等期刊编委。

Distinguished Lecture 2

控制论思想引导的动态系统数据驱动预测控制方法

Prof. Chao Shang
Tsinghua University, China

Sunday, May 10, 2026
8:40-9:20
Ruyi Hall / 如意厅

Abstract

近年来，数据驱动的智能建模与控制技术迅猛发展，为复杂动态系统控制开辟了新路径，但存在对数据质量要求高、对不确定性敏感等局限性。本报告将介绍一种新息反馈的数据驱动预报器，在理论上给出了该预测器与Kalman滤波器的严格等价条件，从而揭示了在数据驱动建模方法中引入误差反馈的意义；介绍一种保证因果性的数据驱动预测控制方法，在不额外增加计算量的前提下有效减少非因果建模误差、改善控制性能。通过回顾研究进展，剖析经典控制论思想、概念在现代数据驱动方法研究中的价值与意义，并初步探讨未来研究方向。

Biography

尚超，清华大学自动化系长聘副教授、党委副书记，研究方向为工业大数据驱动的过程建模、控制与优化，成果在光伏、炼化等国民经济重点行业中得到规模化推广应用并取得成效。目前担任中国自动化学会技术过程的故障诊断与安全性专委会副秘书长、过程控制专委会委员，SCI 期刊《Expert Systems with Applications》、《Control Engineering Practice》编委等职。独立出版英文专著 1 部，发表论文 100 余篇，其中在 IEEE Transactions on Automatic Control、Automatica 等控制与决策权威期刊发表 SCI 论文 50 余篇，引用 4000 余次。入选国家“万人计划”青年拔尖人才，被 IFAC 期刊 Control Engineering Practice 评选为“新兴领导者”（Emerging Leaders）。此外，获 Springer 全球杰出博士论文奖、多个学术会议最佳论文奖、清华大学年度教学优秀奖等奖项。

Distinguished Lecture 3

网络攻击下信息物理系统的安全性分析与安全防护

Prof. Anyang Lu
Northeastern University, China

Sunday, May 10, 2026
9:20-10:00
Ruyi Hall / 如意厅

Abstract

信息物理系统是一类深度集成信息技术和自动化技术的智能系统。近几十年来，随着信息物理系统逐渐成为能源、医疗、交通等关键基础设施的核心，其面临的安全威胁也日益严重。由于对通讯网络依赖的不断增强，信息物理系统面临的网络信息攻击威胁尤为突出。而网络攻击下的信息物理系统安全技术正是保障关键基础设施安全和产业安全的重要手段之一。本次报告主要介绍团队近年来在隐蔽性攻击设计、隐性攻击检测以及安全状态估计三个方面开展的研究。首先，针对隐蔽性攻击设计问题，构建了基于虚拟系统的攻击模型，将攻击的恶意性描述为设计攻击诱导监测中心估计一个与正常系统相似的虚拟系统，进而实现恶化估计性能的目标。基于构建的攻击模型，提出了不依赖观测器信息的攻击设计策略，并给出隐蔽性攻击存在的充要条件。其次，针对隐蔽性攻击下的信息物理系统，考虑到传统的残差检测器无法检测精心设计的隐蔽性攻击，提出了一类基于辅助信息的攻击检测方法。通过分析系统脆弱点以及关键辅助信息，有效实现了对隐蔽性攻击的检测。最后，在检测攻击的基础上，进一步考虑在攻击干扰下获取正确系统状态信息（安全状态估计），重点解决了现有安全状态估计方法面临的计算复杂度高以及适用范围受限的问题。

Biography

芦安洋，东北大学教授、博士生导师。主要研究方向包括：信息物理系统安全性分析与防护、故障/攻击诊断、容错/容侵控制。发表学术论文 40 余篇，以第一/通信作者身份发表 SCI 检索论文 28 篇。一作论文包括控制领域国际顶级期刊 IEEE Transactions on Automatic Control 及 Automatica 论文共 14 篇，其中长文 7 篇。主持国自然青年基金项目（B）[原优秀青年基金项目]、面上项目、辽宁省优青、博新计划广东省联合基金等 9 项。应用方面，主持多项面向天然气管道、钢铁等行业的工程攻关项目，项目额 228 万元。获 2023 年中国自动化学会自然科学奖一等奖、2021 年中国自动化学会优秀博士学位论文奖、2020 年博士后创新人才支持计划优秀创新成果奖等。入选 2024 年沈阳市领军人才、连续三年入选“全球前 2%顶尖科学家”名单。任国际期刊 Journal of Control and Decision、Applied Sciences、International Journal of Intelligent Autonomous Systems 及 Actuators 编委，任中国自动化学会青年工作委员会委员、中国人工智能学会动态规划与智能自适应学习专委会委员、中国指挥与控制学会青年工作委员会委员。

Distinguished Lecture 4

Sampled-data/continuous-time model free adaptive control: modeling, design, and robustness

Prof. Hao Yu
Beijing Institute of Technology, China

Sunday, May 10, 2026
10:10-10:50
Ruyi Hall / 如意厅

Abstract

In practical implementations, physical plants are typically controlled using either continuous-time or sampled-data control laws. Traditional model-free adaptive control (MFAC) methods are inherently designed for discrete-time systems, which often leads to a structural mismatch between the plant dynamics and the controller formulation. This lecture presents two novel MFAC design frameworks—one based on continuous-time control and the other on sampled-data control—both of which aim to better align the controller structure with the actual plant characteristics. Central to these frameworks are new dynamic linearization techniques that facilitate the systematic development of control and adaptation laws. By casting the resulting closed-loop dynamics as (weakly) interconnected nonlinear systems, we introduce novel Lyapunov-based robustness analysis approaches that explicitly account for external disturbances—and, in the sampled-data case, also for discretization errors. Furthermore, the theoretical analysis for the sampled-data MFAC rigorously quantifies the interplay among tracking error convergence, allowable ranges of adaptive parameters, and sufficiently small sampling periods. Finally, experimental validations of the proposed sampled-data MFAC are demonstrated through vehicle speed tracking tests and spacecraft attitude angle tracking applications.

Biography

Hao Yu is a Professor and Ph.D. Supervisor at Beijing Institute of Technology and was awarded the National Excellent Young Scientists Fund (Overseas) in 2022. He received his B.E. degree in 2013 and Ph.D. degree in 2018 from the School of Automation Science and Electrical Engineering, Beihang University. From 2019 to 2022, he conducted postdoctoral research in the Department of Electrical and Computer Engineering at the University of Alberta, Canada. His main research interests include networked control systems, event-triggered control, multi-agent systems, data-driven PID control, neural network adaptive control, and cyber-physical systems. He has published more than 40 academic papers as first or corresponding author, including over 10 papers in leading control journals such as IEEE Transactions on Automatic Control and Automatica.

Distinguished Lecture 5

Designs of Network Architectures and Optimization Algorithms Based on Neural Differential Equations

Prof. Long Jin
Lanzhou University, China

Sunday, May 10, 2026
10:50-11:30
Ruyi Hall / 如意厅

Abstract

This presentation investigates the theoretical and practical integration of deep neural networks and neural differential equations to address fundamental challenges in model robustness, trainability, and generalization. By interpreting network depth as time in dynamic systems, the research leverages numerical analysis concepts, specifically zero stability, consistency, and Shannon's sampling theorem, to guide the design of stable and efficient network architectures. Furthermore, it introduces novel optimization algorithms, such as gradient activation, loss landscape reshaping, and integral-based smoothing, which utilize dynamic system principles to handle ill-conditioned problems, escape saddle points, and converge to flat minima. Collectively, we provide a low-cost, high-efficiency framework for enhancing deep learning performance by bridging discrete network structures with continuous differential equation theory.

Biography

Long Jin is a Professor and Ph.D. Supervisor at Lanzhou University and a recipient of the National Young Talent Program. In 2023, he served as a Visiting Professor in the Department of Computer Science at City University of Hong Kong. He has led four projects funded by the National Natural Science Foundation of China, one project under the National Key R&D Program of China, and multiple provincial and ministerial-level projects, including Key and Distinguished Young Scholar grants from the Natural Science Foundation of Gansu Province. He has been consecutively recognized as a Highly Cited Chinese Researcher by Elsevier and ranked among the top 0.05% of scientists worldwide. He has received several prestigious awards, including the Excellent Doctoral Dissertation Award from the Chinese Association for Artificial Intelligence, the Wu Wenjun Artificial Intelligence Award for Outstanding Young Scientist, and the Second Prize of the Natural Science Award of Gansu Province. His students have received numerous honors, including Excellent Doctoral and Master's Thesis Awards from national academic societies and provincial authorities as well as the Excellent Doctoral Student Program funded by the National Natural Science Foundation of China. He currently serves as Associate Editor for several SCI journals, including IEEE Transactions on Industrial Electronics, IEEE Transactions on Intelligent Vehicles, IEEE Transactions on Automation Science and Engineering, IEEE Transactions on Fuzzy Systems, IEEE/CAA Journal of Automatica Sinica, Neural Networks, and CAAI Transactions on Intelligence Technology, and has received multiple Outstanding Editor Awards from IEEE/CAA JAS, CAAI TRIT, and IJCAS. His research interests include computational intelligence and its applications.

Excellent Doctoral Forum

Saturday, May 9, 2026
13:30-17:00
Ruyi Hall / 如意厅

Chair：刘磊（辽宁工业大学）

Biography：刘磊，博士，教授，国家高层次青年人才计划入选者，辽宁工业大学交叉科学学院副院长。主持国家自然科学基金联合重点项目、面上项目等 3 项，分别主持辽宁省教育厅重点项目、辽宁省教育厅重点攻关项目等。研究方向为智能博弈和群体优化。以第一作者/通讯作者在《Automatica》或 IEEE 汇刊上发表论文 28 篇，出版学术专著 2 部，出版教材 2 本；获辽宁省自然科学二等奖、中国自动化学会自然科学二等奖、中国自动化学会优秀博士学位论文奖、辽宁省青年科技奖；入选辽宁省“兴辽英才计划”青年拔尖人才、辽宁省“百千万人才工程”；获《IEEETransactions on Cybernetics》最佳论文奖、中国百篇最具影响国际学术论文及《IEEE/CAA Journal ofAutomatica Sinica》钱学森论文奖；担任 IEEE TSMCS 等 5 个国际期刊的编委；现为中国自动化学会、中国人工智能学会会员；指导大学生参加创新竞赛获国家级一等奖 5 项。

Chair：陈宏田（上海交通大学）

Biography：陈宏田，现为上海交通大学副教授、博士生导师，国家级高层次青年人才、玛丽居里学者、上海市高等教育优才揽蓄人才、上海市高层次人才、浦江学者。本硕毕业于南师大，博士毕业于南京航空航天大学。2019 年至 2023 年为加拿大 Alberta 大学博士后。主要研究方向为数据驱动技术、可解释人工智能等及其在高速列车、机器人、海陆空系统应用。目前为止，发表英文专著 2 部，Automatica 与 IEEE 汇刊 60 余篇、授权与受理国家专利 20 余项。主持国际项目、国家级项目等 10 项，进 5 年累计经费超 1000W。获得中国自动化学会优秀博士论文奖、工信部创新特等奖， IEEE RCAE 青年科学家奖等多项个人奖与团体奖。目前为 IEEE TFS、IEEE TII、IEEE TIM、CEP 等多个国际期刊编委，可靠性系统科学与工程专委会副主任委员。受邀作为组织主席，举办 RCAE 2022-2024 国际会议；并承担多个大会程序主席、联合主席等。

Forum Speakers

Speaker 1：王钢（北京理工大学）

Title：高效世界模型及自主导航

Abstract：世界模型通过“想象”生成数据，显著提升了样本效率并降低了训练成本，是实现智能体高效自主决策的关键途径。本报告介绍了我们在世界模型方面的四个初步成果。提出基于 Transformer 架构的世界模型 STORM，在 Atari 100k 基准上取得 SOTA 性能，训练时间和资源消耗显著低于经典 DreamerV3 算法。DyMoDreamer 通过引入动态调制机制，提升模型对环境变化的敏感性，在 Atari 100k 与 DMControl 等多个基准中均取得 SOTA 性能。这些成果展示了世界模型强化学习的核心优势与应用潜力，并为智能体在复杂环境中的高效决策提供了新的思路。MAD 将世界模型从纯“想象”扩展为显式空间建模，能够同时学习占据/可见性地图与时序表征，从而在视觉导航中获得更强的空间推理与泛化能力，并在复杂场景中相较于传统模块化与视觉端到端导航方法，显著提升成功率、飞行速度和任务迁移性能。

Biography：王钢，北京理工大学自动化学院教授，国家级领军人才。主要研究无人系统数据驱动控制和世界模型学习。主持（完成）国家重点研发计划、国家自然科学基金联合重点木、面上等项目，在 IEEE TIT/TAC/TSP 等汇刊发表期刊论文 70 篇，NeurIPS/ICLR/ICRA/IROS 等国际会议发表论文 70 篇。获中国自动化学会自然科学一等奖(排 1)、IEEE/CAA Journal of Automatica Sinica 钱学森论文奖、ICCA 最佳论文奖、

IEEE 信号处理学会“优秀编委奖”、中国工程院院刊《信息与电子工程前沿（英文版）》“最佳论文奖”、欧洲信号处理会议“最佳学生论文奖”等。现任 IEEE Control Systems Magazine、IEEE Trans. Signal and Information Processing over Networks、IEEE Open Journal of Control Systems 等期刊编委，以及中国自动化学会控制理论专业委员会委员、中国自动化学会具身智能专委会副主任委员等。

Speaker 2：陈宏田（上海交通大学）

Title：基于 Mamba 的时变系统故障诊断及其在鲲龙 AG600 上的应用

Abstract：本报告围绕“基于 Mamba 的时变系统故障诊断及其在鲲龙 AG600 上的应用”展开，探讨了结构化状态空间模型（SSM）及其代表模型 Mamba 在复杂动态系统智能诊断中的发展与应用。在应用部分，报告面向鲲龙 AG600，分析了其在任务载荷变化、飞行包线变化等因素下产生的强时变、强耦合动力学特性及其带来的故障诊断难点。并根据改进的 Mamba 模型，构建了适应 AG600 动态特性的故障检测方法。

Biography：陈宏田，现为上海交通大学副教授、博士生导师，国家级高层次青年人才、玛丽居里学者、上海市高等教育优才揽蓄人才、上海市高层次人才、浦江学者。本硕毕业于南师大，博士毕业于南京航空航天大学。2019 年至 2023 年为加拿大 Alberta 大学博士后。主要研究方向为数据驱动技术、可解释人工智能等及其在高速列车、机器人、海陆空系统应用。目前为止，发表英文专著 2 部，Automatica 与 IEEE 汇刊 60 余篇、授权与受理国家专利 20 余项。主持国际项目、国家级项目等 10 项，进 5 年累计经费超 1000W。获得中国自动化学会优秀博士论文奖、工信部创新特等奖，IEEE RCAE 青年科学家奖等多项个人奖与团体奖。目前为 IEEE TFS、IEEE TII、IEEE TIM、CEP 等多个国际期刊编委，可靠性系统科学与工程专委会副主任委员。受邀作为组织主席，举办 RCAE 2022-2024 国际会议；并承担多个大会程序主席、联合主席等。

Speaker 3：周敏（同济大学）

Title：数据与知识融合驱动的高铁列车运行自主调度

Abstract：近年来，我国高铁发展取得了举世瞩目的成就。截至 2025 年底，高铁运营里程达到 5 万公里，成为了世界上唯一成网运营的国家。然而，大客流、大风、大雪等突发事件时有发生，影响列车正常运行，导致乘客滞留，严重时甚至造成恶劣的社会影响。本报告主要围绕突发事件下高铁列车自主运行优化与调度问题，针对区间临时限速、线路临时中断等典型场景，介绍数据与知识融合驱动的列车自主运行下速度曲线在线优化、运行图智能调整和调度控制一体化方法，以解决突发情况下由于过度依赖人工操作、列控调度分层导致的恢复能力受限等问题，为提高高铁智能化和自主化水平提供有效支撑。

Biography：周敏，同济大学电子与信息工程学院长聘副教授，青年百人 A 岗，长期从事轨道交通列车运行优化与调度、控制调度一体化、人工智能等研究，主持国家自然科学基金面上、青年、重点研发子课题等项目近 10 项，骨干参与了国家自然科学基金重大、重点等项目，以第一/通讯作者在领域重要期刊和会议发表论文 70 余篇，申请国家发明专利 40 余项，获教育部科学研究优秀成果奖工程技术一等奖、中国自动化学会技术发明一等奖、自然科学二等奖、优秀博士学位论文奖，获优秀会议论文奖 7 篇等。入选博士后创新人才支持计划、北京市科协青年人才托举工程。担任国际期刊 IEEE Transactions on Intelligent Vehicles 和 IEEE Transactions on Computational Social Systems 的 AE、以及中国自动化学会人工智能与机器人教育专委会和综合智能交通专委会副秘书长等。

Speaker 4：刘剑（东南大学）

Title：Intermittent Event-Triggered Fixed/Predefined-Time Cooperative Control

Abstract：For the cooperative control problem, the convergence rate is a very meaningful and important research topic. Compared with the finite-time control, the fixed/predefined-time control can obtain the estimate of the convergence time regardless of the initial conditions, which can better meet the high requirements of the convergence time. Moreover, to reduce energy consumption, we investigate the fixed/predefined-time cooperative problem of multi-agent systems via intermittent event-triggered control, and the self-triggered control is also considered. Combining different control methods with different control objectives not only ensures fast convergence but also reduces the energy consumption of communication.

Biography：刘剑，东南大学自动化学院副教授，博士生导师，主要研究方向为自主无人系统协同控制和多智能体系统博弈优化。共发表或接收 SCI 期刊论文 70 余篇，其中第一/通信作者 SCI 论文 30 余篇。授权与受理国家发明专利 20 余项。获 2023 年中国自动化学会自然科学一等奖，2021 年中国自动化学会优秀博士学位论文奖，2021 年吴文俊人工智能优秀博士学位论文奖等荣誉。主持多项国家级、省部级和其他各类基金项目，包括国家自然科学基金（青年基金、面上项目），江苏省基础研究计划青年基金，中国博士后创新人才支持计划等。担任 IEEE/CAA Journal of Automatica Sinica 和工程科学学报青年编委、智能科学与技术学报专题编委。

Speaker 5：杨超（中南大学）

Title：列车牵引传动系统关键部件故障诊断与延寿控制方法研究

Abstract：轨道交通装备是我国高端装备制造业的亮丽名片，牵引变流器、牵引电机等作为轨道列车牵引传动系统的关键部件，其可靠性直接影响列车的安全运行。为此，本报告将聚焦牵引传动系统中关键部件可靠性提升和服役能力增强的迫切需求，对故障诊断和延寿控制技术研究中的若干关键问题和研究进展进行简要介绍和分享。

Biography：杨超，中南大学自动化学院副教授、硕士生导师，“轨道交通节能控制与安全监测”湖南省重点实验室固定成员，入选第八届中国科协青年人才托举工程项目，曾获湖南省和中国自动化学会优秀博士学位论文奖、全国"工程硕士实习实践优秀成果获得者"等荣誉。主要的研究方向包括：轨道交通装备/系统性能监测与智能运维，故障注入与测试验证等。

2026 IEEE 15th Data Driven Control and Learning Systems Conference (DDCLS'26)

Technical Program
and
Book of Abstracts

Technical Program

Saturday, May 9, 2026

SatA00 13:30–17:40 Jinxiu Hall
Award Session: Best Paper

Chair: SUN, Mingxuan Zhejiang Univ. of Tech.
Co-Chair: Chi, Ronghu Foshan Univ.

▶ SatA00-1 13:30–13:55
Sampled-data MFAC for High-order Nonlinear Systems
Zhao, Zhenbang Beijing Inst. of Tech.
Yu, Hao Beijing Inst. of Tech.

▶ SatA00-2 13:55–14:20
HIL-VFD: Learning High-Precision Insertion under Grasp Uncertainty via Vision–Force Imitation Learning with Human-in-the-Loop DAgger
Chen, Yuxi Zhejiang Univ.
Zhang, Xuanyu Zhejiang Univ.
Bai, Hongyu Shanghai Jiaotong Univ.
Zhou, Zhongxiang Zhejiang Humanoid Innovation Center
Xiong, Rong Zhejiang Univ.
Zhang, Jianming Institution of Cyber-Sys. & Control
Yu, Hongxiang Zhejiang Univ.

▶ SatA00-3 14:20–14:45
Large Language Model-driven Two-Stage Spatiotemporal Dual-Stream Collaborative Framework for Industrial Quality Prediction
Fu, Zehao Xi'an Univ. of Tech.
Liu, Han Xi'an Univ. of Tech.
Tong, Shuo Xi'an Univ. of Tech.
Guo, Runyuan Xi'an Univ. of Tech.

▶ SatA00-4 14:45–15:10
Trackability-Based Cooperative Learning Control for Heterogeneous Networks
Wu, Yuxin Beijing Inst. of Tech.
Sun, Jian Beijing Inst. of Tech.

▶ SatA00-5 15:10–15:35
Data-Driven Prescribed-Iteration Convergence Control for Discrete-Time Nonlinear Systems via Iteration-Varying Gain
Xu, Meilu Shenyang Aerospace Univ.
Liu, Dong Shenyang Aerospace Univ.
Li, Guohao Shenyang
Wang, Xin Heilongjiang Univ.

▶ SatA00-6 15:35–16:00
Data-driven Fault Detection with Orthogonal Projection
Cui, Kaixin Beijing Inst. of Tech.
Li, Linlin Univ. of Sci. & Technoloty Beijing
Shi, Dawei Beijing Inst. of Tech., Beijing
Ding, Steven Univ. of Duisburg-Essen

▶ SatA00-7 16:00–16:25
FFDL-Enhanced Distributed Cooperative Localization for Vehicle Swarms in GNSS-Denied Environments
Shi, Lei Univ. of Electronic Sci. & Tech. of China
Yan, Shuaiming Henan Univ.
Zhu, Panpan Henan Univ.
Zhou, Yi Henan Univ.
Lv, Lingling North China Univ. of Water Conservancy & Electric Power

▶ SatA00-8 16:25–16:50
Memory-Augmented A ine Formation Control for UAV Swarms Using Available Networked Information
Dai, Ziyi City Univ. of Macau
Yu, Wei City Univ. of Macau
Yu, Jinzhi City Univ. of Macau
Li, Zuopeng City Univ. of Macau

SatA01 13:30–15:30 Yangguang Hall
Invited Session: Data-Driven Self-Learning Control and Optimization for Nonlinear Systems

Chair: Wei, Qinglai Inst. of Automation
Co-Chair: Wang, Ding Beijing Univ. of Tech.

▶ SatA01-1 13:30–13:50
Self-Triggered Robust Optimal Consensus Control for Nonlinear Multi-Agent Systems with Control Constraints
Hao, Jiang Macau Univ. of Sci. & Tech.
Wei, Qinglai Inst. of Automation
Song, Ruizhuo Univ. of Sci. & Tech. Beijing

▶ SatA01-2 13:50–14:10
Risk Estimation of Power Construction Operations via Domain-Adaptive BERT and Multimodal Transformer
Wang, Yulin Tianjin Univ.
Zhu, Xinshan Tianjin Univ.
Yang, Xiong Tianjin Univ.
Zhang, Shumei Tianjin Univ.

▶ SatA01-3 14:10–14:30
Event-Triggered Safe Critic Learning Control via Swarm Intelligence Optimization
Li, Xin Beijing Univ. of Tech.
Wang, Jiangyu Beijing Univ. of Tech.
Ye, Kai School of Information Sci. & Tech.
Wang, Ding Beijing Univ. of Tech.

▶ SatA01-4 14:30–14:50
Dynamic Event-Triggered Prescribed-Time Optimal Attitude Control for Helicopters
Zhang, Shunchao Guangdong Univ. of Finance
Liu, Dacai Guangdong Univ. of Finance
Zhang, Yongwei South China Agricultural Univ.
Lin, Mingduo Southern Univ. of Sci. & Tech.
Zhao, Bo Beijing Normal Univ.

▶ SatA01-5 14:50–15:10
Nighttime Vehicle Detection and Depth Estimation Based on Infrared Thermal Cameras
Wang, Zhangu Shandong Univ. of Sci. & Tech.
Cheng, Lingping Shandong Univ. of Sci. & Tech.
Li, Zhenye Qingdao Lulu Agricultural Equipment Co, Ltd
Bu, Zhao Shandong Univ. of Sci. & Tech.
Li, Zhaoyu Qingdao Univ. of Tech., Linyi
Wang, Wenkai Ysneuro (Qingdao) Tech. Co, Ltd
Liu, Xuechen Shandong Univ. of Sci. & Tech.

▶ SatA01-6 15:10–15:30
Vehicle-Pose-Aware Effective Target Recognition for Automotive Radar
Wang, Zhangu Shandong Univ. of Sci. & Tech.
Bu, Zhao Shandong Univ. of Sci. & Tech.
Li, Zhenye Qingdao Lulu Agricultural Equipment Co, Ltd
Cheng, Lingping Shandong Univ. of Sci. & Tech.
Li, Zhaoyu Qingdao Univ. of Tech., Linyi
Wang, Wenkai Ysneuro (Qingdao) Tech. Co, Ltd
Li, Zhengzhao Shandong Univ. of Sci. & Tech.

SatA02 13:30–15:30 Changle Hall
Invited Session: Estimation and Compensation of System Uncertainties: Methods and Applications (I)

Chair: Chen, Zhixiang Qingzhou Hi-tech
Co-Chair: Wang, Yongshuai Tiangong Univ.

▶ SatA02-1 13:30–13:50
Weak-Model-Dependent Disturbance Rejection Decoupling Control for Wide-Envelope Flight Vehicles
Wang, Yongshuai Tiangong Univ.
Zhang, Di Tiangong Univ.
Xia, Chengyi Tiangong Univ.
Sun, Mingwei Nankai Univ.

▶ SatA02-2 13:50–14:10
Improved Extended State Observer for Quadrotor UAV Tracking Control
Zheng, Ning China Three Gorges Univ.
Wang, Yaqi China Three Gorges Univ.
Mei, Qicheng China Three Gorges Univ.
Zhu, Chi China Three Gorges Univ.
Chen, Zijian CHINA THREE GORGES Univ.

▶ SatA02-3 14:10–14:30
A Parallel State Observer Integrated LSTM Framework for Target Acceleration Estimation and Prediction
Zhang, Xilian — Beijing Aerospace Automatic Control Inst.
Wang, Huixia — Beijing Aerospace Automatic Control Inst.
Wang, Zhaolei — Beijing Aerospace Automatic Control Inst.
Yang, Tuo — Peking Univ.

▶ SatA02-4 14:30–14:50
GNSS-IMU Integrated Navigation Based on Extended Kalman Filter: Design and Verification
Zhang, Lianpeng — Qingzhou High-tech Inst.
Liu, Fanghong — Qingzhou High-tech Lnstitute

▶ SatA02-5 14:50–15:10
Cooperative Formation Control Design for Multiple Ground Unmanned Vehicles
Chen, Qi — Qingzhou High-tech Inst.
Wang, Jingyu — Qingzhou High-tech Inst
Chen, Zhixiang — Qingzhou Hi-tech

▶ SatA02-6 15:10–15:30
Adaptive Safety Time Interval and Improved PID Design Based on Most Dangerous ACC Condition
Shang, Jianhao — Qingzhou High-tech Lnstitute
Wang, Xinyu — Qingzhou High-tech Lnstitute
Chen, Zhixiang — Qingzhou Hi-tech

SatA03 13:30–15:30 Langyue Hall
Invited Session: Distributed Security Cooperative Control in Complex Environments
Chair: Che, Wei-Wei — Northeastern Univ.
Co-Chair: Zhang, Peng — Northeastern Univ.

▶ SatA03-1 13:30–13:50
Iterative Learning Control of Position-constrained Permanent Magnet Synchronous Motor Servo Systems under Varying Iteration Lengths
Wang, Zihao — Nanjing Tech Univ.
Shen, Mouquan — Nanjing Tech Univ.
Park, Ju Hyun — Yeungnam Univ

▶ SatA03-2 13:50–14:10
Compensation-based Model-Free Adaptive Control for High-Order Nonlinear Systems under DoS Attacks
Feng, Siwei — Shenyang Aerospace Univ.
Liu, Dong — Shenyang Aerospace Univ.
Wang, Yuxuan — Shenyang Aerospace Univ.
Wang, Xin — Heilongjiang Univ.

▶ SatA03-3 14:10–14:30
Hierarchical Distributed Data-Driven Platooning Containment Control with Obstacle Avoidance
Che, Wei-Wei — Northeastern Univ.
Zhang, Peng — Northeastern Univ.

▶ SatA03-4 14:30–14:50
Neural Network-Based Data-Driven Security Control for UMVs under FDI Attacks with TGAI Operator
Liu, Huiying — Shanghai Jiao Tong Univ.
Hao, Li-Ying — Dalian Maritime Univ.

▶ SatA03-5 14:50–15:10
Observer-Based Model-Free Adaptive Heading Control for An Unmanned Surface Vehicle with False Data Injection Attacks
Zhao, Yihang — Qingdao Univ.
Liu, Yongchao — Qingdao Univ.
Li, Shuaixi — Qingdao Univ.

▶ SatA03-6 15:10–15:30
Model-Free Adaptive Predictive Control for Subway Trains under Channel Fading
Liu, Genfeng — Henan Univ. of Tech.
Zhang, Wenhui — Henan Univ. of Tech.
Wang, Yangyang — PLA Strategic Support Force Information Engineering Univ.

SatA04 13:30–15:30 Xinghui Hall
Regular Session: Data-Driven Control and Its Applications (I)
Chair: Liang, Jiaqi — Henan Polytechnic Univ.
Co-Chair: Liu, Zhiqing — Qingdao Univ. of Sci. & Tech.

▶ SatA04-1 13:30–13:50
Distributed Data-Driven Learning Consensus Tracking Control for Nonlinear Continuous-Time Multi-Agent Systems
Meng, Bo — Shandong Univ. of Sci. & Tech.
Xu, Kechao — Harbin Inst. of Tech.
Wan, Zhenyang — National Univ. of Singapore
Zhen, Wang — Shandong Univ. of Sci. & Tech.

▶ SatA04-2 13:50–14:10
PI Iterative Feedback Tuning for Load Frequency Control in Wind-Integrated Power Systems
Zeng, Yiming — Jiangnan Univ.
Xu, Dezhi — Southeast Univ.
Ji, Xunsheng — Jiangnan Univ.
Pei, Jinlei — Jiangnan Univ.
Hu, Guanyang — Jiangnan Univ.
Hua, Fei — Jiangnan Univ.
Zhang, Weiming — Taizhou Univ.

▶ SatA04-3 14:10–14:30
Accurate Data-Component-Adjustment Anti-Stagnation-based Model-Free Predictive Control on PMSM Drives
Wei, Yao — Chinese Acad. of Sci.
Lan, Mingyan — Fujian Normal Univ.
Chen, Yuanhang — Fuzhou Univ.
Ma, Weiyuan — Fujian Agriculture & Forestry Univ.
Xie, Haotian — Haixi Inst.s, Chinese Acad. of Sci.
Wang, Fengxiang — Chinese Acad. of Sci.

▶ SatA04-4 14:30–14:50
Model-Free Finite-Time Control for Multi-Agent Systems
Lin, Qingtian — Qingdao Univ. of & Sci. & Tech.
Liu, Zhiqing — Qingdao Univ. of Sci. & Tech.
An, Zhiying — Qingdao Univ. of Sci. & Tech.
Chi, Ronghu — Foshan Univ.

▶ SatA04-5 14:50–15:10
Pitch Control of Wind Power Systems Using Nonlinear Hammerstein Model
Li, Jinqiang — Jiangsu Univ. of Tech.
Li, Feng — Jiangsu Univ. of Tech.

▶ SatA04-6 15:10–15:30
Transformer-Based Model Predictive Control for Concentrate Fe Grade Tracking in Flotation Processes
Yi, Junxuan — Beijing Univ. of Tech.
Wang, Kang — Beijing Univ. of Tech.
Li, Xiaoli — Beijing Univ. of Tech.

SatA05 13:30–15:30 Meixue Hall
Regular Session: Model-Free Adaptive Control
Chair: Zhao, Huarong — Jiangnan Univ.
Co-Chair: Xu, Dezhi — Southeast Univ.

▶ SatA05-1 13:30–13:50
Delta Operator Based Model-Free Sliding Mode Control for Second-Order Systems
Hua, Fei — Jiangnan Univ.
Xu, Dezhi — Southeast Univ.
Zhang, Weiming — Taizhou Univ.
Pan, Tinglong — Jiangnan Univ.
Yang, Weilin — Jiangnan Univ.
Huang, Wentao — Jiangnan Univ.
Hu, Guanyang — Jiangnan Univ.
Pei, Jinlei — Jiangnan Univ.

▶ SatA05-2 13:50–14:10
Model-Free Predictive Control for Nonlinear MASs with Unknown Actuator Faults and Stochastic Data Dropouts
Chuai, Ce — Nankai Univ.
Cao, Ao — Nankai Univ.
Chen, Tongtong — Tianjin Sino-German Univ. of Applied Sci.
Wang, Fuyong — Nankai Univ.

▶ SatA05-3 14:10–14:30
Improved Data-driven Control Based on Incremental PD for Piezoelectric Micro-Scanning Stage
Chu, Wei — Changchun Inst. of Optics, Mechanics & Physics, Chinese Acad. of Sci.
Xu, Rui — Changchun Inst. of Optics, Mechanics & Physics, Chinese Acad. of Sci.
Tian, Dapeng — Chinese Acad. of Sci.

▶ SatA05-4 14:30–14:50
MFAPC Control for Variable Speed Adjustment of Boil-off Gas Compressor in LNG Fuel Supply System

Cheng, Pengfei — Qingdao Univ. of Sci. & Tech.
Yue, Yaobin — Qingdao Univ. of Sci. & Tech.
Dong, Songli — Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Chi, Ronghu — Foshan Univ.
Yao, Wen-Long — Qingdao Univ. of Sci. & Tech.

► SatA05-5 14:50–15:10
Smooth Saturation Control for Redundant Manipulator Trajectory Tracking Based on Dynamic Neural Networks
Yu, Chenling — Lanzhou Univ.

► SatA05-6 15:10–15:30
Model-free Adaptive Control for An Inverted Pendulum System with Real-time Experiments
Wang, Xin — Jiangnan Univ.
Zhao, Huarong — Jiangnan Univ.
Ye, Yiyang — Taizhou Product Quality & Safety Testing Inst.
Peng, Li — Jiangnan Univ.

SatA06 13:30–15:30 Guibin Hall
Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (I)
Chair: Li, Dazi — Beijing Univ. of Chemical Tech.
Co-Chair: Gao, Huihui — Beijing Univ. of Tech.

► SatA06-1 13:30–13:50
A Two-Stage Remaining Useful Life Prediction Method for Rolling Bearings Based on Attention Enhanced Time-Frequency Transformer
Gao, Huihui — Beijing Univ. of Tech.
Feng, Tianyang — Beijing Univ. of Tech.
Gao, Xue-Jin — Beijing Univ. of Tech.

► SatA06-2 13:50–14:10
A Cooperative Structural Defect Detection Method Based on Homogeneous MFL-EMAT
Feng, Yunning — Northeastern Univ.
Feng, Jian — Northeastern Univ.
Li, Qiangxin — Northeastern Univ.
Li, Yajing — Northeastern Univ.
Yao, Yu — Northeastern Univ.

► SatA06-3 14:10–14:30
Nonstationary Process Monitoring with Joint-Optimized Design
Lu, Zhang — Shandong Univ. of Sci. & Tech.
Shi, Ze — Shandong Univ. of Sci. & Tech.
Zhong, Maiying — Shandong Univ. of Sci. & Tech.

► SatA06-4 14:30–14:50
State of Health Estimation and Remaining Useful Life Prediction of Lithium-Ion Batteries Based on Physics-Constrained Federated Meta-Learning
Deng, Jie — Hubei Minzu Univ.
Hu, Yuhang — Hubei Minzu Univ.
Wang, Ximeng — Hubei Minzu Univ.
Liao, Yu — Hubei MinZu Univ.
Guo, Li — Anhui Polytechnic Univ.

► SatA06-5 14:50–15:10
A Novel Orthonormal Neuron Subspace Analysis Network for Process Monitoring
Zhang, Handa — Beijing Univ. of Chemical Tech.
Li, Xiang — Beijing Univ. of Chemical Tech.
Hao, Weichen — Beijing Univ. of Chemical Tech.
Li, Dazi — Beijing Univ. of Chemical Tech.

► SatA06-6 15:10–15:30
Improved Voiceprint Signal-based Power Equipment Fault Diagnosis Using Large Language Models
Chen, Jinning — Univ. of Sci. & Tech. Beijing
Zhang, Kai — Univ. of Sci. & Tech. Beijing
Han, Shuai — China Electric Power Research Inst.
Lu, Hongming — Univ. of Sci. & Tech. Beijing

SatB01 15:40–17:40 Yangguang Hall
Invited Session: Intelligent Model-free Adaptive Control as New Engine for UAVs and Transportation
Chair: Yu, Xian — Shenzhen Univ.
Co-Chair: Zhu, Juanping — Yunnan Univ.

► SatB01-1 15:40–16:00
A Data-Driven Kalman Filtering for Unknown Nonlinear Systems
Shao, Sichao — Yunnan Univ.
Zhu, Juanping — Yunnan Univ.

► SatB01-2 16:00–16:20
Model-Free Adaptive Finite-Time Bipartite Containment Control for Nonlinear MultiAgent Systems
Ge, Zhaojie — Inner Mongolia Univ.
Wang, Qian — Inner Mongolia Univ.
Xue, Yixuan — Inner Mongolia Univ.

► SatB01-3 16:20–16:40
Model-free Adaptive Iterative Learning Control with Applications to Quadrotors
Huang, Zhaoran — Shenzhen Univ.
Yang, Zunyao — Beijing Jiaotong Univ.
Yu, Xian — Shenzhen Univ.
Zhong, Xiaopin — Shenzhen Univ.

► SatB01-4 16:40–17:00
Hierarchical Quadrotor Path Planning: Integrating Adaptive Goal-Biased RRT with Control Barrier Function*
Huang, Jing — Shenzhen Univ.
Lai, Jialun — Guangzhou Maritime Univ.
Zhong, Xiaopin — Shenzhen Univ.
Yu, Xian — Shenzhen Univ.

► SatB01-5 17:00–17:20
CA-RCNN : Cascaded-Attention Networks for 3D Object Detection from LiDAR Point Clouds
Ji, Honghai — North China Univ. of Tech.
Liu, Xinjing — North China Univ. of Tech.
Liu, Shida — North China Univ. of Tech.
Ren, Ye — North China Univ. of Tech.
Fan, Lingling — Beijing Information Sci. & Tech. Univ.

► SatB01-6 17:20–17:40
Extended State Observer Based Model Free Adaptive Compensatory Control for Subway Trains under Mixed Network Attacks
Liu, Genfeng — Henan Univ. of Tech.
Zhu, Jinbao — Henan Univ. of Tech.
Wang, Yangyang — PLA Strategic Support Force Information Engineering Univ.
Zhang, Wenhui — Henan Univ. of Tech.

SatB02 15:40–17:40 Changle Hall
Invited Session: Estimation and Compensation of System Uncertainties: Methods and Applications (II)
Chair: Wang, Yongshuai — Tiangong Univ.
Co-Chair: Chen, Zhixiang — Qingzhou Hi-tech

► SatB02-1 15:40–16:00
State Cooperative Control of Supercavitating Vehicles Based on Robust Model Predictive Control
Liu, Yong — Qingzhou High-tech Inst.
Chen, Zhixiang — Qingzhou Hi-tech

► SatB02-2 16:00–16:20
Zero-Pole Configuration Criteria for Stable Step Responses with Single Overshoot
An, Jiale — Nankai Univ.
Sun, Mingwei — Nankai Univ.

► SatB02-3 16:20–16:40
Performance Index Function without Control Input-based Modular Manipulator Optimal Tracking Control via Nonzero-sum Game
Ji, Zebin — Changchun Univ. of Tech.
Qin, Yi — Aviation Univ. of Air Force
Ma, Bing — Changchun Univ. of Tech.
Zhu, Xinye — Changchun Univ. of Tech.
An, Tianjiao — Changchun Univ. of Tech.

► SatB02-4 16:40–17:00
Identifiability Analysis and Identification Design for A Class of Uncertain Rigid-Elastic Coupled System
Yin, Qianbao — Chinese Acad. of Sci.
Xue, Wenchao — Chinese Acad. of Sci.

► SatB02-5 17:00–17:20
Nonsingular Prescribed-Time Attitude Tracking for Rigid Spacecraft with Enhanced Extended State Observer
Zhang, Chuanzhi — Anhui Polytechnic Univ.
Tao, Meiling — Anhui Polytechnic Univ.
Ding, Siao — Anhui Polytechnic Univ.

► SatB02-6 17:20–17:40
Time-Varying Bandwidth ADRC for Strict-Feedback Nonlinear Systems

with Prescribed Performance Function
Jiang, Yan — Guangxi Univ.
Zhu, Jintao — Guangxi Univ.
Luo, Shixian — Guangxi Univ.

SatB03 15:40–17:40 Langyue Hall
Invited Session: Adaptive Control Methods for Nonlinear Mechatronics Systems
Chair: Wang, Shubo — Kunming Univ. of Sci. & Tech.
Co-Chair: Zhao, Jun — Shandong Univ. of Sci. & Tech.

▶ SatB03-1 15:40–16:00
A Fractional-Order Sliding Mode Control Strategy for Thermal Management of Proton Exchange Membrane Fuel Cells
Zhao, Ziliang — Shandong Univ. of Sci. & Tech.
Jia, Jingyu — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Guo, Bin — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.
Fu, Yifan — Shandong Univ. of Sci. & Tech.
Ma, Duo — Shandong Univ. of Sci. & Tech.

▶ SatB03-2 16:00–16:20
Model-Free Optimal Control of Mixed Traffic Systems via Q-Learning with Driver Reaction Time
Song, Shurun — Shangdong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.

▶ SatB03-3 16:20–16:40
A Hybrid MC-BiTCN-N-BEATS Model for Predicting the Remaining Useful Life of Lithium-Ion Batteries
Zhang, Pei Yu — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.

▶ SatB03-4 16:40–17:00
Fixed-Time Prescribed Performance Control for Manipulator System with An Improved Extended State Observer
Chi, Teng — Qingdao Univ.
Zhou, Zhongkai — Qingdao Univ.
Wang, Shubo — Kunming Univ. of Sci. & Tech.

▶ SatB03-5 17:00–17:20
Predefined-Time Robust Repetitive Learning Control for Rehabilitation Exoskeleton Robots
Xiao, Chunjie — Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.
Cheng, Yun — Zhejiang Univ. of Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ SatB03-6 17:20–17:40
Monitoring Abnormal Tire Temperatures at Tunnel Entrances Using Infrared Thermography and YOLOv8
Zheng, Tong — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Li, Zhimin — Qingdao Lulu Agricultural Equipment Co, Ltd
Zhang, Jian — Shandong Univ. of Sci. & Tech.

SatB04 15:40–17:40 Xinghui Hall
Regular Session: Data-Driven Control and Its Applications (II)
Chair: Yang, Xu — Univ. of Sci. & Tech. Beijing
Co-Chair: Quan, Quan — Beihang Univ.

▶ SatB04-1 15:40–16:00
Data-Driven Sliding Mode Security Control under Multi-Channel Deception Attacks
Tan, Menghan — Donghua Univ.
Yang, Yekai — Donghua Univ.
Zhao, Haijuan — Qingdao Univ. of Tech.

▶ SatB04-2 16:00–16:20
Multidimensional Frequency Interpolation for Missing Value Imputation of Device Clusters Time Series Data
Yan, Kai — Guoneng Wuhai Energy Wuda Coal Processing Co., Ltd
Liu, Hanwen — Guoneng Wuhai Energy Wuda Coal Processing Co., Ltd
Liu, Binyu — Dalian Univ. of Tech.

▶ SatB04-3 16:20–16:40
A Dual-Observer Method for Distributed Fault-Tolerant Leader–Follower Formation Control of Nonlinear Multi-Agent Systems
Xu, Shuwei — North China Univ. of Tech.

▶ SatB04-4 16:40–17:00
Stable Tracking of Flapping-Wing Micro Aerial Vehicles Based on L-Learning
Abbasi, Saddam Hussain — Beihang Univ.
Li, Hao — Beihang Univ.
Wang, Chenyu — Beihang Univ.
Quan, Quan — Beihang Univ.

▶ SatB04-5 17:00–17:20
Design and Implementation of A Multi-Source Information Acquisition System for Aluminum Reduction Cells
Cui, Jiarui — Univ. of Sci. & Tech. Beijing
Shi, Wenqi — Univ. of Sci. & Tech. Beijing
Zhang, Baowei — Zhengzhou Non-ferrous Metals Research Inst. Co. Ltd of CHINALCO
Yan, Qun — Univ. of Sci. & Tech. Beijing
Wang, Minggang — ALUMINUM CORPORATION OF ZUNYI LIMITED
Yang, Xu — Univ. of Sci. & Tech. Beijing
Li, Qing — Univ. of Sci. & Tech. Beijing

▶ SatB04-6 17:20–17:40
Direct Data-Driven Bipartite Cooperative Output Consensus for Heterogeneous Multi-Agent Systems with External Disturbances
Gu, Mingxia — Xinjiang Univ.
Abdurahman, Abdujelil — Xinjiang Univ.
Sader, Malika — Beijing Information Sci. & Tech. Univ.
Jiang, Haijun — Xinjiang Univ.

SatB05 15:40–17:40 Meixue Hall
Regular Session: Iterative Learning Control and Its Applications
Chair: Dai, Xisheng — Guangxi Univ. of Sci. & Tech.
Co-Chair: Meng, Deyuan — Beihang Univ. (BUAA)

▶ SatB05-1 15:40–16:00
Event-Triggered Quantized Iterative Learning Control under Finite Quantization Levels
Liu, Taojun — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China

▶ SatB05-2 16:00–16:20
Iterative Learning Control for A Class of Multi-Agent Systems with Random Varying Lengths
Liu, Yating — Qingdao Univ. of Sci. & Tech.
Wang, Qian — Qingdao Univ. of Sci. & Tech.
Zhang, Ruikun — Qingdao Univ. of Sci. & Tech.
Lin, Xue — Qingdao Univ. of Sci. & Tech.

▶ SatB05-3 16:20–16:40
Fuzzy Iterative Learning Control for Nonlinear Hyperbolic Distributed Parameter Systems
Zhao, Feng-Liang — Sun Yat-Sen Univ.
Li, Xiao-Dong — Sun Yat-sen Univ.

▶ SatB05-4 16:40–17:00
Quantized Iterative Learning Identification for Discrete Nonlinear Time-Delay Multi-Agent Systems with Data Dropout
Sun, Jiajun — Nantong Univ.
Yang, Yuhan — Nantong Univ. - Robotics Engineering
Xu, Xiaoxiao — Nantong Univ.
Han, Tianxiang — Nantong Univ.
Shang, Liangliang — Nantong Univ.
Zhou, Xingyu — Nantong Univ.

▶ SatB05-5 17:00–17:20
Finite-iteration Learning Identification of First-order Hyperbolic Distributed Parameter Systems
Yang, Tongxing — Guangxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.
Wang, Rifeng — Guangxi Sci. & Tech. Normal Univ.

▶ SatB05-6 17:20–17:40
High-Precision Docking for Airport Boarding Bridge: A Learning Control Method
Lu, Changxin — Beihang Univ.
Meng, Deyuan — Beihang Univ. (BUAA)
Zhang, Jingyao — Beihang Univ.
Cai, Kaiquan — Beihang Univ. (BUAA)

SatB06 15:40–17:40 Guibin Hall

Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (II)

Chair: Tao, Hong-Feng Jiangnan Univ.

Co-Chair: Chen, Yiyang Soochow Univ.

► SatB06-1 15:40–16:00

Preliminary Study on MFA-NN : A Neural Network Realization for Model-Free Adaptive Control

Ji, Honghai North China Univ. of Tech.

Yun, Jing Yao North China Univ. of Tech.

Fan, Lingling Beijing Information Sci. & Tech. Univ.

Liu, Shida North China Univ. of Tech.

Wang, Li North China Univ. of Tech.

► SatB06-2 16:00–16:20

Industrial Process Fault Detection Based on Self-supervised Multi-scale Principal Component Spectrum Analysis

Zhang, Yuchao Nantong Univ.

Shang, Liangliang Nantong Univ.

Ma, Xinghao NantongUniv.

Chen, Junyu Nantong Univ.

Tian, Saibo Nantong Univ.

► SatB06-3 16:20–16:40

A Multi-Scale Feature-Domain Adversarial Transfer Network for Open-Circuit Fault Diagnosis of Three-Phase Inverters

Chen, Peng Hubei Minzu Univ.

Li, Jingcong Hubei Minzu Univ.

Lai, Guohong Hubei Minzu Univ.

► SatB06-4 16:40–17:00

Data-Driven Lithium-Ion Battery Fault Diagnosis: LSTM Enhanced by Segmented Asymmetric Denoising Preprocessing

Ji, Yushuo Soochow Univ.

Wu, Penghao School of Mechanical & Electrical Engineering, Soochow Univ.

Tian, Engang Nanjing Normal Univ.

Tao, Hong-Feng Jiangnan Univ.

Chen, Yiyang Soochow Univ.

► SatB06-5 17:00–17:20

Simulated Data-based Adversarial Learning for Zero-shot Anomaly Monitoring of Pipeline Leakages

Jiang, Yu Harbin Inst. of Tech.

Gao, Hewei Harbin Inst. of Tech.

Huo, Xin Harbin Inst. of Tech.

Zheng, Kai Dalian Maritime Univ.

► SatB06-6 17:20–17:40

Knowledge-Constrained Multiscale Spatiotemporal Learning for Multivariate Anomaly Detection

Li, Yahui Huazhong Univ. of Sci. & Tech.

Liu, Qingyun Huazhong Univ. of Sci. & Tech.

Fang, Shiyu Huazhong Univ. of Sci. & Tech.

Tian, Yuchu Queensland Univ. of Tech.

Chen, Feng Huazhong Univ. of Sci. & Tech.

Zhou, Chunjie Huazhong Univ. of Sci. & Tech.

Sunday, May 10, 2026

SunA01 08:00–10:00 Yangguang Hall
Invited Session: Learning-Based Intelligent Control for Complex Dynamic Systems

Chair: Pan, Yingnan — Bohai Univ.
Co-Chair: Cao, Liang — Bohai Univ.

▶ SunA01-1 08:00–08:20
An Improved NNSO-Based Optimized Control for Robotic Manipulators under the Deception Attacks
Wang, Shuang — Bohai Univ.
Zhao, Meng — Bohai Univ.
Wang, Wei — Bohai Univ.
Cao, Liang — Bohai Univ.

▶ SunA01-2 08:20–08:40
Asynchronous Control for T-S Fuzzy Semi-Markov Jump Neural Networks with Partially Unknown Membership Functions: A Dynamic Event-Triggered Scheme
Li, Yiru — Bohai Univ.
Zhang, Linchuang — Bohai Univ.
Xing, Xing — Bohai Univ.
Jia, Zhichun — Bohai Univ.
Zhao, Qingyi — Bohai Univ.

▶ SunA01-3 08:40–09:00
Formation Collision Avoidance Control of Unmanned Surface Vehicle under Position Constraints
Wang, Wei — Bohai Univ.
Zhao, Meng — Bohai Univ.
Pan, Ziyao — Bohai Univ.

▶ SunA01-4 09:00–09:20
Tracking Control and Obstacle Avoidance for Multi-USV Systems Based on Artificial Potential Field Method
Gao, Lu — Bohai Univ.
Pan, Yingnan — Bohai Univ.

▶ SunA01-5 09:20–09:40
Impact of Wavelet Kernel Selection on Adaptive Constructive Wavelet Neural Networks for Nonlinear Systems
Huang, Dunsheng — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China

▶ SunA01-6 09:40–10:00
Dynamic Event-triggered-based Fixed-time Composite Learning Control for Nonlinear Multiagent Systems
Du, Haoran — Guangdong Polytechnic Normal Univ.
Zheng, Xiaohong — Guangdong Univ. of Tech.
Lin, Wenshuai — Guangdong Polytechnic Normal Univ.
Guo, Zijie — Guangdong Polytechnic Normal Univ.

SunA02 08:00–10:00 Changle Hall
Invited Session: Adaptive Learning Control and Application of Complex Dynamic Systems

Chair: Liu, Yang — Qingdao Univ. of Sci. & Tech.
Co-Chair: Ma, Hui — Guangdong Univ. of Tech.

▶ SunA02-1 08:00–08:20
Prescribed-Time Optimal Tracking Control for Nonlinear Systems with Actuator Faults
Liu, Xiangyu — Qingdao Univ.
Wang, Lijie — Qingdao Univ.
Liu, Yang — Qingdao Univ. of Sci. & Tech.
Zhang, Miaoxin — Qingdao Univ. of Sci. & Tech.

▶ SunA02-2 08:20–08:40
Adaptive Practical Prescribed-Time Funnel Control for Nonstrict-Feedback Multiagent Systems via Composite Predictor
Li, Zhiqiang — Guangdong Univ. of Tech.
Du, Haoran — Guangdong Polytechnic Normal Univ.
Zheng, Xiaohong — Guangdong Univ. of Tech.
Luo, Ao — Guangdong Polytechnic Normal Univ.

▶ SunA02-3 08:40–09:00
Accuracy Analysis on Data-Driven Adaptive T-S Fuzzy Approximator for A Class of Unknown-structure Control System
Zhang, Miaoxin — Qingdao Univ. of Sci. & Tech.
Yan, Wen — Shanghai Jiao Tong Univ.

▶ SunA02-4 09:00–09:20
End-edge-cloud Collaborative Architecture for Intelligent Industrial Robots in the Industrial Internet of Things
Chen, Wenyu — Guangdong Univ. of Tech.
Duan, Junzhe — Guangdong Univ. of Tech.
Cheng, Zhijian — Guangdong Univ. of Tech.
Ren, Hongru — Guangdong Univ. of Tech.
Lu, Renquan — Hangzhou Dianzi Univ.

▶ SunA02-5 09:20–09:40
Research on the Performance Degradation of Lithium-ion Batteries in Multi-Temperature Domain Based on Empirical Model Parameter Identification
Qin, Xinrui — Liaoning Univ.
Feng, Weiwei — Liaoning Univ.
Gao, Xiaoting — Liaoning Univ.
Wu, Chaoyang — Liaoning Univ.
Cui, Enchang — Liaoning Univ.

▶ SunA02-6 09:40–10:00
Real-time Vehicle Tracking for Complex Dynamic Environments Based on YOLO-ReID Fusion for Intelligent Transportation Systems
Liu, Yuanhao — WuHan Univ.
Lei, Zhongcheng — Wuhan Univ.

SunA03 08:00–10:00 Langyue Hall
Invited Session: Cooperative Learning Control of Network Systems: Theories and Applications

Chair: Zhang, Fan — Northwestern Polytechnical Univ.
Co-Chair: Du, Mingjun — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

▶ SunA03-1 08:00–08:20
A Parameter-Varying Dynamic Method for Lyapunov Equation Solving and Its Kinematic Application to Redundant Manipulators
Zhao, Shige — Zhejiang Univ. of Sci. & Tech.
Hao, Junjie — Zhejiang Univ. of Sci. & Tech.
Kong, Ying — Zhejiang Univ. of Tech.

▶ SunA03-2 08:20–08:40
DAF-DETR: Dual Adaptive Fusion DETR for Fresnel Lens Defect Inspection
Zhu, Xiaohua — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Xu, Yan — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Yu, Jie — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhao, Yongguo — Shandong Acad. of Sci.
Li, Guangliang — Shandong Yuying Optical Instrument Co., Ltd
Gong, Qingxia — Shandong Yuying Optical Instrument Co., Ltd
Ren, Xiangming — Shandong Yuying Optical Instrument Co., Ltd
Li, Guangnan — Shandong Yuying Optical Instrument Co., Ltd
Pang, Shaopeng — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

▶ SunA03-3 08:40–09:00
Universal Edge Core Percolation in Complex Networks
Liu, Cheng — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhu, Xiaohua — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Yu, Jie — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Xu, Yan — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhao, Yongguo — Shandong Acad. of Sci.
Li, Guangliang — Shandong Yuying Optical Instrument Co., Ltd
Gong, Qingxia — Shandong Yuying Optical Instrument Co., Ltd
Ren, Xiangming — Shandong Yuying Optical Instrument Co., Ltd
Li, Guangnan — Shandong Yuying Optical Instrument Co., Ltd
Duan, Gaopeng — Peking Univ.
Pang, Shaopeng — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

▶ SunA03-4 09:00–09:20
Multi-Drones Active Exploration and Coverage of Uncertain Spatial Field with Limited Sensing Range
Xu, Jingwen — Northwestern Polytechnical Univ.
Zhang, Fan — Northwestern Polytechnical Univ.
Guo, Yaohua — Northwestern Polytechnical Univ.

▶ SunA03-5 09:20–09:40
Mean-Square Regional Stability for One-Dimensional Switched Stochastic Linear Systems with Multiple Equilibrium Points
Yan, Zijun — Qilu Univ. of Tech.(Shandong Acad. of Sci.)
Zhu, Liying — Qilu Univ. of Tech.(Shandong Acad. of Sci.)
Hu, Guolin — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

▶ SunA03-6 09:40–10:00
Predefined-Time Disturbance Observer-Based Spacecraft Attitude Fault-Tolerant Control
Zhang, Jiayuan — Qilu Univ. of Tech.
Wang, Mengyi — Qilu Univ. of Tech.
Zhang, Yang — Qilu Univ. of Tech.
Huo, Baoyu — Beijing Institude of Teachnology
Du, Mingjun — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

SunA04 08:00–10:00 Xinghui Hall
Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (III)
Chair: Li, Jinghao — Northeastern Univ.
Co-Chair: Gao, Rui — Northeastern Univ.

▶ SunA04-1 08:00–08:20
Unified Time–Frequency Representation with Selective State Space for Multivariate Time Series Anomaly Detection
Xu, Yuan — Beijing Univ. of Chemical Tech.
Xie, Zeng — Beijing Univ. of Chemical Tech.
He, Yan-Lin — Beijing Univ. of Chemical Tech.
Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
Zhang, Yang — Beijing Univ. of Chemical Tech.
Zhang, Ming-Qing — Beijing Univ. of Chemical Tech.

▶ SunA04-2 08:20–08:40
Semantic-Aware Smooth Path Planning with Dynamic Prediction for Mobile Robots in Complex Service Environments
Liu, Dewang — Beijing Jiaotong Univ.
Jin, Shangtai — Beijing Jiaotong Univ.

▶ SunA04-3 08:40–09:00
Multi-Agent Proximal Policy Optimization Based Connected Vehicle Platoon Planning
Wang, Han — Beijing Jiaotong Univ.
Jin, Shangtai — Beijing Jiaotong Univ.

▶ SunA04-4 09:00–09:20
Hierarchical Spatial-Temporal Graph Convolutional Network for Fault Detection and Diagnosis in Complex Industrial Processes
Wang, Yuanqing — Central South Univ.
Wang, Sijia — Central South Univ.
Wang, Kai — Central South Univ.
Yuan, Xiaofeng — Central South Univ.
Wang, Yalin — Central South Univ.

▶ SunA04-5 09:20–09:40
Surveillance of Rod Pumping Systems Based on Load Series
Jiang, Changhao — Northeastern Univ.
Li, Jinghao — Northeastern Univ.
Gao, Rui — Northeastern Univ.

▶ SunA04-6 09:40–10:00
Temporal Causal Discovery with Counterfactual Data Augmentation for Automotive Fault Diagnosis
Chen, Xiaolu — Anhui Polytechnic Univ.
Chen, Can — Anhui Polytechnic Univ.
Wu, Wen Tai — Anhui Polytechnic Univ.
Guo, Li — Anhui Polytechnic Univ.
Yang, Zeyu — Huzhou Univ.

SunA05 08:00–10:00 Meixue Hall
Regular Session: Data-Driven Modeling, Optimization, Scheduling (I)
Chair: Shen, Dong — Renmin Univ. of China
Co-Chair: Kang, Qi — Tongji Univ.

▶ SunA05-1 08:00–08:20
Iterative Learning Control for Overhead Cranes via Optimal Path Planning
Chen, Kunhong — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ SunA05-2 08:20–08:40
Adaptive Hierarchical Multi-Robot Path Planning and Execution with Task Allocation Schedule
Wu, Siqi — Tongji Univ.
Huang, Wangya — Tongji Univ.
Kang, Qi — Tongji Univ.

▶ SunA05-3 08:40–09:00
Day-Ahead Two-Stage Coordinated Scheduling Optimization for PSCS Considering Price-Based Demand Response
Yang, Guangshi — State Grid Bengbu Electric Power Supply Company
Dai, Wei — State Grid Bengbu Electric Power Supply Company
Wei, Jiandong — State Grid Anhui Integrated Energy Services Co., Ltd. Bengbu Branch
Kang, Yu — State Grid Bengbu Electric Power Supply Com
Li, Wei — State Grid Bengbu Electric Power Supply Company
Teng, Nan — State Grid Bengbu Electric Power Supply Company
Cheng, Xi — STATE GRID ANHUI INTERGRATED ENERGY SEVICE CO.LTD
Zhang, Xiulu — State Grid Corporation of China
Fei, Cao — State Grid Bengbu Electric Power Supply Company
Shen, Weibing — Southeast Univ.
Bai, Yunlong — State Grid Tongling Power Supply Company

▶ SunA05-4 09:00–09:20
Research on Ballistic Impact Point Prediction Method Based on Group Target Resource Scheduling
Yu, Chao — College of Sci.，National Univ. of Defense Tech.
He, Zhangming — National Univ. of Defense Tech.
He, Yujie — 95859 Unit of the Chinese People's Liberation Army
Xu, Tao — Unit 95765 of the PLA
Ma, Tao — Unit 95765 of PLA
Zhou, Mo — National Univ. of Defense Tech.

▶ SunA05-5 09:20–09:40
Optimization Method for Catalytic Reforming Process Operating Path Based on Virtual Guide Points and Smoothing Strategy
Xu, Zikang — China Univ. of Petroleum, Beijing
Fang, Yaning — China Univ. of Petroleum (Beijing)
He, Renchu — China Univ. of Petroleum

▶ SunA05-6 09:40–10:00
Wind Power Prediction Integrating Transformer Deep Learning Model with Random Forest
Fang, Lei — Jiangsu Univ. of Tech.
Li, Feng — Jiangsu Univ. of Tech.

SunA06 08:00–10:00 Guibin Hall
Regular Session: ADP and RL Based Learning Control (I)
Chair: Ren, Qinyuan — Zhejiang Univ.
Co-Chair: Zhao, Feng-Liang — Sun Yat-Sen Univ.

▶ SunA06-1 08:00–08:20
Motion Simulation-enhanced Data Scaling for Integrated Prediction and Planning of Autonomous Driving
Gao, Bitao — Beihang Univ.
Li, Ding — Beihang Univ.
Wang, Ziyan — Beihang Univ.
Xia, Qi — Beihang Univ.
Zhang, Qichao — Chinese Acad. of Sci.
Xia, Zhongpu — Chinese Acad. of Sci.
Yu, Guizhen — Beihang Univ.

▶ SunA06-2 08:20–08:40
Comparative Evaluation of PPO and SAC for Robust Autonomous Low-Thrust Transfers in Cislunar Space
Ul Haq, Izhar — Northwestern Polytechnical Univ.
Dai, Honghua — Northwestern Polytechnical Univ.
Shahid, Faizan — HIT

▶ SunA06-3 08:40–09:00
Reference-Guided Soft Actor-Critic for Unmanned Surface Vehicle Navigation in Constrained Waterways
Ma, Hanyang — Beijing Univ. of Chemical Tech.
Li, Dazi — Beijing Univ. of Chemical Tech.

▶ SunA06-4 09:00–09:20
Learning-Enhanced Distributed Self-Triggered Consensus of Heterogeneous Nonlinear Multi-Agent Systems
Ke, Jiachen — Tongji Univ.
Zhou, Yanmin — Tongji Univ.
Wang, Zhipeng — Tongji Univ.
Wang, Zhongjie — Tongji Univ.
Cheng, Bin — College of Electronics & Information Engineering, Tongji Univ.

▶ SunA06-5 09:20–09:40
Safe and Informative Battery Excitation via Constrained Reinforcement Learning: A Budget-Aware Approach
Li, Junyi — Shandong Univ.

Li, Yan Shandong Univ.
Wang, Qiaoling Shandong Univ.

▶ SunA06-6 09:40–10:00
Learning-Based Active Compliance Control for Peg-in-Hole Assembly via a Policy Distillation
Li, Shenyuan Zhejiang Univ.
Lang, Yilin Zhejiang Univ.
Zhu, Wenxin Zhejiang Univ.
Zhao, Yuhong Inst. of Industrial Intelligence & Sys. Engineering
Ren, Qinyuan Zhejiang Univ.

Poster Session SunA07
May.10, 8:00–10:00
Front Hall

▷ SunA07-01
Robust Model Predictive Control Based on Equivalent Input Disturbance for Speed Control with Unknown Disturbances
Feng, Yingchao China Nuclear Lndustry 23 ConstructionCO.,LTD
Sun, Qiuyang China Nuclear Industry 23 ConstructionCO.,LTD
Sun, Liuqing Nuclear Industry Engineering Research & Design Co., Ltd
Fang, Jiang Nuclear Industry Engineering Research & Design Co., Ltd
Liu, Jinping Nuclear Industry Engineering Research & Design Co., Ltd
Li, Zhuyuan Nuclear Industry Engineering Research & Design Co., Ltd
Liu, Kangtai Nuclear Industry Engineering Research & Design Co., Ltd
Han, Changren Nuclear Industry Engineering Research & Design Co., Ltd

▷ SunA07-02
Algorithm Unrolling for Discrete-time Periodic Sylvester Matrix Equations with Unknown Parameters
Sun, Yuge North China Univ. of Water Resources & Electric Power
Lv, Lingling North China Univ. of Water Conservancy & Electric Power

▷ SunA07-03
Model-Free Adaptive Formation Control for Multi-UAV Systems with Unknown Dynamics
Chen, Hao Dalian Maritime Univ.
Weng, Yongpeng Dalian Maritime Univ.
Zhu, Jiaxing Shenyang Aircraft Design & Research Inst.
Wang, Huanyu State Grid Liaoning Electric Power Co.,Ltd.Dalian Jinzhou New District Power Supply Branch

▷ SunA07-04
A Data-driven Model-free Adaptive Control Method under Non-periodic DOS Attack
Ren, Bing Lanzhou Jiaotong Univ.

▷ SunA07-05
Risk-Decision-Based Sliding Mode and Model-Free Hierarchical Control for Combined Aircraft
Wen, Qifeng Huazhong Univ. of Sci. & Tech.
Liu, Lixin Huazhong Univ. of Sci. & Tech.
Fan, Huijin Huazhong Univ. of Sci. & Tech.
Liu, Lei Huazhong Univ. of Sci. & Tech.
Wang, Bo Huazhong Univ. of Sci. & Tech.

▷ SunA07-06
Model-free Adaptive Quadrotor Control with Full-form Dynamic Linearization
Zhang, Lei Shenzhen Univ.
Yang, Zunyao Beijing Jiaotong Univ.
Yu, Xian Shenzhen Univ.
Zhong, Xiaopin Shenzhen Univ.

▷ SunA07-07
Adaptive Sliding Mode Control for Position and Velocity Tracking in MEMS Gyroscope
Li, Xinsuo Guangxi Univ. of Sci. & Tech.
Hao, Yiran Guangxi Univ. of Sci. & Tech.
Li, Fapeng Guangxi Univ. of Sci. & Tech.
Xu, Dengguo Guangxi Univ. of Sci. & Tech.

▷ SunA07-08
DS-STAE: Dual-Stream Spatio-Temporal Transformer for Context-Aware Anomaly Reconstruction in UAVs
Chen, Yinchao AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)
Cui, Xiaojing AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)
Liang, Zhaoxin AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)
Tan, Zheng AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)

▷ SunA07-09
Dynamic Event-Triggered Model-Free Adaptive Control for Longitudinal Cooperative Control of Connected and Automated Vehicle Platoons
Ji, Honghai North China Univ. of Tech.
Zhai, Limin North China Univ. of Tech.
Liu, Shida North China Univ. of Tech.
Ren, Ye North China Univ. of Tech.
Wang, Li North China Univ. of Tech.

▷ SunA07-10
A CMPC-PI Controller for Series Battery Packs Based on Dual-layer Equalization Topology
Xing, Xiangzhao Shandong Univ.
Wang, Shun Shandong Univ.
Li, Yan Shandong Univ.

▷ SunA07-11
ADRC-PID Based Cascade Control for Multi-Temperature-Zone Systems with Large Inertia
Li, Xiangyang South China Uni. of Tech
Xu, Zhitian South China Univ. of Tech.
Wang, Bingbing Changji Univ.
Ai, Wei South China Univ. of Tech.

▷ SunA07-12
Graph Attention Network-Based Fault Diagnosis for Multiple Unmanned Helicopters
Ning, Hanlin Anhui Polytechnic Univ.
Qi, Darui Anhui Polytechnic Univ.
Li, Runze Anhui Polytechnic Univ.
Su, Zhengyang Anhui Polytechnic Univ.
Guo, Li Anhui Polytechnic Univ.

▷ SunA07-13
Aeroacoustic Damage Detection for Wind Turbine Blades Based on Masked 1D U-Net and AS-YOLO
Chen, Junming Changsha Univ. of Sci. & Tech.
Yang, Ke Changsha Univ. of Sci. & Tech.
Wang, Chengyu Changsha Univ. of Sci. & Tech.
Xiong, Yong College of Computer Sci., Hunan Univ. / Hunan Lianzhi Tech. Co., Ltd
Tang, Mingzhu Central South Univ.
Luo, Jiawei Changsha Univ. of Sci. & Tech.
Li, Zhimin Changsha Univ. of Sci. & Tech.

▷ SunA07-14
Multi-Modal Feature Driven Adversarial Domain Adaptation Method for Bearing Fault Diagnosis
Qin, Xinghua National Univ. of Defense Tech.
Yang, Chenxi National Univ. of Defense Tech.
Zhang, Yiyin National Univ. of Defense Tech.
Wu, Jialong National Univ. of Defense Tech.
Ruan, Yirun National Natural Sci. Foundation of China

▷ SunA07-15
Accurate Capacity Estimation of Retired Lithium-ion Batteries Based on Electrochemical Impedance Spectroscopy
Sun, Huayi Shandong Univ.
Liu, Xuefeng Shandong Univ.
Kang, Yongzhe Shandong Univ.
Li, Changlong Shandong Univ.
Duan, Bin Shandong Univ.

▷ SunA07-16
Research on Trend Anomaly Diagnosis Based on Variational Autoencoder
Xu, Peng China Univ. of Petroleum, Beijing
Wang, Zhu China Univ. of Petroleum (Beijing)

▷ SunA07-17
An ITransformer-based Approach for UAV Anomaly Detection via Sensor

Correlation Learning
Yuan, Haoxuan — Dalian Maritime Univ.
Liu, Jingxiang — Dalian Maritime Univ.
Wang, Jianyu — Sichuan Univ.

▷ SunA07-18
Structure-aware Graph Contrastive Low-Rank Adaptation for Cross-Domain Few-Shot Fault Diagnosis
Qi, Hongfei — Huzhou Univ.
Yang, Zeyu — Huzhou Univ.
Yu, Jiaxin — City Univ. of Hong Kong
Ye, Lingjian — Huzhou Univ.

▷ SunA07-19
Iterative Learning Consensus Control for Nonlinear Multi-Agent Systems with Random Initial States
Wang, Yinong — Xi'an Univ. of Tech.
Yan, Fei — Xi'an Univ. of Tech.

▷ SunA07-20
Spatial-Repetitive-Learning-Based Disturbance Rejection Model Predictive Control for Rotational Systems
Hu, Genshuo — Hunan Univ. of Sci. & Tech.
Zhou, Lan — Hunan Univ. of Sci. & Tech.
Xia, Jingkang — Hunan Univ. of Sci. & Tech.
Li, Meiliu — Hunan Univ. of Sci. & Tech.
Xiao, Wenbin — Hunan Univ. of Sci. & Tech.

▷ SunA07-21
Iterative Learning Control for Linear Singular Fractional-order Systems under State Disturbances
Liu, Qian — Yantai Univ.
Tian, Senping — South China Univ. of Tech.
Xin, Jiaqi — South China Univ. of Tech.

▷ SunA07-22
Optimizing Weight Matrix Estimation via Biased Methods for Data Driven Modeling
Li, Jiang — National Univ. of Defense Tech.
He, Zhangming — National Univ. of Defense Tech.
Zhou, Mo — National Univ. of Defense Tech.
Wang, Jiongqi — National Univ. of Defense Tech.

▷ SunA07-23
Bias-Compensated Recursive Least Squares for LPV Models with Scheduling-Dependent Input Coefficients
Hou, Jie — Chongqing Univ. of Posts & Telecommunications
Tian, Cheng — Chongqing Univ. of Posts & Telecommunications

▷ SunA07-24
Robust Estimate Based on Lp Norm for Doppler Velocimetry
Zhou, Mo — National Univ. of Defense Tech.
He, Zhangming — National Univ. of Defense Tech.

▷ SunA07-25
K-STGCT: A Causal-Enhanced Spatio-Temporal Gated Convolutional Transformer with KAN-based Positional Encoding for Industrial Soft Sensor Forecasting
Hu, Xuan — Beijing Univ. of Chemical Tech.
Jia, Huichi — Beijing Univ. of Chemical Tech.
Cheng, Xu — Smart Innovation Norway
Jiang, Guoqian — Yanshan Univ.
Han, Yongming — Beijing Univ. of Chemical Tech.
Geng, Zhiqiang — Beijing Univ. of Chemical Tech.

▷ SunA07-26
Large Language Model-assisted Optimal Scheduling Method for Electric Vehicle Charging and Discharging Based on PER-DDPG Algorithm
Zhao, Chunyang — Shenyang Inst. of Engineering
Liu, Siyuan — Tieling Power Supply Company, State Grid Liaoning Electric Power Company
Pang, Xinfu — Shenyang Insitute of Engineering
Zhu, Yue — Shenyang Inst. of Engineering
Jiang, Yingchun — Shenyang Agricultural Univ.

▷ SunA07-27
MTAMformer: Multi-scale Threshold Filtering Attention Mixture of Experts Transformer for Multi-Step Time Series Forecasting
Fu, Xuefeng — Jiangnan Univ.
Ma, Hao — Jiangnan Univ.
Liu, Xiang — Jiangnan Univ.

▷ SunA07-28
Large Language Model-Assisted State Transition Algorithm for Solving Sensor Network Localization Problem
Zhang, Quan — Central South Univ.
Zhou, Xiaojun — School of Automation, Central South Univ.

▷ SunA07-29
From Multi-Source Indicators to Reaction–Diffusion PDEs: Interpretable Cybercrime Risk Forecasting
Liu, Haochen — Qingdao Univ. of Sci. & Tech.
Chen, Wenkun — Qingdao Univ. of Sci. & Tech.
Ye, Fengming — Qingdao Univ. of Sci. & Tech.
Zhang, Ruikun — Qingdao Univ. of Sci. & Tech.

▷ SunA07-30
Centroid-Prediction-Assisted Dynamic Multi-Objective Optimization with Transformer Surrogates for Flotation
Gong, Shiwei — Beijing Univ. of Tech.
Wang, Kang — Beijing Univ. of Tech.
Li, Xiaoli — Beijing Univ. of Tech.

▷ SunA07-31
FTPS²: Future Timestamp-Aware Patchified Diagonal State Space Model for Time Series Forecasting
Xu, Yuan — Beijing Univ. of Chemical Tech.
Chen, Wenhui — Beijing Univ. of Chemical Tech.
He, Yan-Lin — Beijing Univ. of Chemical Tech.
Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
Zhang, Yang — Beijing Univ. of Chemical Tech.
Zhang, Ming-Qing — Beijing Univ. of Chemical Tech.

▷ SunA07-32
Establishment and Application of A Calculation Model for Silicon Carbide Epitaxial Layer Thickness Based on Infrared Interference Method
Wang, Junjie — Qingdao Univ. of Sci. & Tech.
Wang, Changxue — Qingdao Univ. of Sci. & Tech.
Feng, Jiahui — School of Mathematics & Physics
Zhang, Ruikun — Qingdao Univ. of Sci. & Tech.

▷ SunA07-33
Hierarchical Context-Based Meta-Learning for Stochastic LPV System Identification
Su, Tianjun — Sun Yat-sen Univ.
Mao, Yawen — Jiangnan Univ.
Huang, Hanyan — Sun Yat-Sen Univ.
Xu, Chen — Jiangnan Univ.

▷ SunA07-34
Variable Population Differential Evolution Algorithm Driven by Multiple Indicators
Li, Zhichao — Shaoxing Univ.
Cai, Changyu — Shaoxing Univ.
Tian, Li — Shaoxing Univ.

▷ SunA07-35
Adaptive Clustering-Based Federated Learning for Non-Intrusive Load Monitoring Across Multiple Users
Li, Ding — Wuhan Inst. of Tech.
Xu, Jinghao — China Univ. of GeoSci.
Wu, Zhe — China Univ. of GeoSci. (Wuhan)
Hu, Wenkai — China Univ. of GeoSci.

▷ SunA07-36
Study on An Improved Spectral Clustering Based Semi-supervised Anomaly Pattern Detection Method
Liu, Runhan — Beijing Univ. of Chemical Tech. College of Information Sci. & Tech.
Zhou, Jinglin — College of Information Sci. & Tech.,Beijing Univ. of Chemical Tech.

▷ SunA07-37
A Magnetic Source Imaging Registration Method Based on Keypoint Self-Supervised Constraints and Multi-View Differentiable Rendering
Xu, Yu — Beihang Univ.
Fu, Xingwen — BUAA
Han, Qiuyu — Beihang Univ.
Ma, Weikai — Beihang Univ.
Liu, Kunye — Beihang Univ.
Wang, Zhuo — Beijing Univ. of Aeronautics & Astronautics
Ning, Xiaolin — Beihang Univ.

▷ SunA07-38
Semi-Supervised Incremental Learning Method with Partitioned Genetic Exemplar Selection for Smart Grid Device Identification

Zhao, Gang — State Grid Xinjiang Electric Power Company
Yao, Yongbo — State Grid Xinjiang Electric Power Company
Wang, Xiaobo — State Grid Xinjiang Electric Power Company
Zhang, Wei — State Grid Xinjiang Electric Power Company
Ma, Guoqiang — State Grid Xinjiang Electric Power Company

▷ SunA07-39
Physically Information-driven Graph Convolutional Networks for Multi-vessel Trajectory Prediction

Yuan, Li — Huazhong Univ. of Sci. & Tech.
Lv, Jiahao — Huazhong Univ. of Sci. & Tech.
Zhao, Yuchen — Huazhong Univ. of Sci. & Tech.
Zhang, Yang — Chinese People's Liberation Army
Liu, Kai — Jiangsu Inst. of Automation
Zhou, Kaibo — Huazhong Univ. of Sci. & Tech.

▷ SunA07-40
A Social Feedback Framework for Distributed Machine Learning

Liu, Jianlong — Southwest Jiaotong Univ.
Zhang, Sheng — Southwest Jiaotong Univ.

▷ SunA07-41
Towards Intelligent Construction: A Hybrid ANN-NSGA-II Framework for Compressive Strength Prediction Toward 3D Concrete Printing

Zhang, Caixia — Xi'an Univ. of Architecture & Tech.
He, Jing — Xi 'an Univ. of Architecture & Tech.
Ma, Zongfang — Xi'an Univ. of Architecture & Tech.
Liu, Chao — Xi 'an Univ. of Architecture & Tech.

▷ SunA07-42
Neural Network-Based Improved Fuzzy Adaptive Controller for Multi-Objective Control of Gas Turbines

Lin, Qiaoyi — Dalian Univ. of Tech.
Chen, Long — Dalian Univ. of Tech., Dalian
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.

▷ SunA07-43
Gradient-Based Neural Dynamics for Kinematic Control of Soft Robots

Wu, Yifeng — Lanzhou Univ.

▷ SunA07-44
Adaptive Tracking Control for Railway Inspection by Quadrotors Based on Neural Networks

Zhang, Qiyue — Beijing Jiaotong Univ.
Zhang, Tianbo — Beijing Jiaotong Univ.
Jiang, Wei — Beijing Jiaotong Univ.
Shen, Dong — Renmin Univ. of China
Yu, Yang — Guilin Univ. of Electronic Tech.
Wang, Jian — Beijing Jiaotong Univ.
Cai, Bai-Gen — Beijing Jiaotong Univ.

▷ SunA07-45
Osteoporosis Risk Prediction Method Based on TCN-Transformer

Xiao, Le — Wuhan Univ. of Sci. & Tech.
Liu, Yimin — Wuhan Univ. of Sci. & Tech.

▷ SunA07-46
HCAT-SAC: A Hybrid Cross-Attention Transformer Framework for Efficient Mapless Navigation

Zhang, Xu — Zhejiang Univ.
Zhou, Kehan — Zhejiang Univ.
Chen, Yibo — PipeChina
Zhu, Qian — Zhejiang Univ. Robotics Inst.
Zhu, Ce — Yuyao Robot Research Center
Zhang, Jianming — Institution of Cyber-Sys. & Control

SunB01 10:10–12:10 Yangguang Hall
Invited Session: Learning-Based Optimal Control and Applications

Chair: Lv, Yongfeng — Taiyuan Univ. of Tech.
Co-Chair: Huang, Yingbo — Kunming Univ. of Sci. & Tech.

▶ SunB01-1 10:10–10:30
Inverse Optimal Control of Unknown Linear Systems

Zhang, Xuhai — Taiyuan Univ. of Tech.
Xue, Kaiwen — Taiyuan Univ. of Tech.
Lv, Chenle — Taiyuan Univ. of Tech.
Li, Linwei — Zhengzhou Univ. of Light Industry
Lv, Yongfeng — Taiyuan Univ. of Tech.

▶ SunB01-2 10:30–10:50
An Improved Gradient-based Estimation Algorithm for Hammerstein Neural Network Systems

Li, Linwei — Zhengzhou Univ. of Light Industry
Zhou, Mo — State Grid Henan Marketing Service Center (metrology Center)
Li, Bingyang — State Grid Henan Electric Power Company
Lv, Yongfeng — Taiyuan Univ. of Tech.
Shi, Kunfeng — Zhengzhou Univ. of Light Industry

▶ SunB01-3 10:50–11:10
Heterogeneous Knowledge Fusion via Series–Parallel Integrated Neural Networks

Shen, Jianzhao — Xiadian Coal Mine of Lu' an Chemical Group Cilinshan Coal Industry Co., Ltd
He, Guodong — Taiyuan Univ. of Tech.
Guo, Jianhua — Taiyuan Univ. of Tech.
Lv, Qing — Taiyuan Univ. of Tech.

▶ SunB01-4 11:10–11:30
Plant-Oriented Rolling Day-Ahead Scheduling under Rigid Monthly Targets for Hydrometallurgical Zinc Production

Li, Mou — Kunming Univ. of Sci. & Tech.
Zhang, Yangjie — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Zhang, Faxiang — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.

▶ SunB01-5 11:30–11:50
Interactive Attention-Based Hybrid Temporal Modeling for Online Ion Prediction in Hydrometallurgical Zinc Purification

Xiao, Yiming — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Wang, Xian — Kunming Univ. of Sci. & Tech.
Zhang, Faxiang — Kunming Univ. of Sci. & Tech.
Wu, Long — Kunming Univ. of Sci. & Tech.

▶ SunB01-6 11:50–12:10
Adaptive High-Gain Observer with Time-Scale Separation for Nonlinear Parametric Systems

Chen, Lun — Kunming Univ. of Sci. & Tech.
He, Haoran — Kunming Univ. of Sci. & Tech.
Huang, Yingbo — Kunming Univ. of Sci. & Tech.

SunB02 10:10–12:10 Changle Hall
Invited Session: Data-Driven Modelling and Adaptive Learning Control

Chair: Chen, Qiang — Zhejiang Univ. of Tech.
Co-Chair: Kong, Ying — Zhejiang Univ. of Tech.

▶ SunB02-1 10:10–10:30
A Novel Complete Electromechanical Coupling Modular Modeling Framework for PMSM-Driven Circuit Breaker Systems

Zhi, Yiming — Shandong Univ. of Sci. & Tech.
Gao, Xuehui — Shandong Univ. of Sci. & Tech.

▶ SunB02-2 10:30–10:50
Adaptive Parameter Estimation of Fuel Cell Humidity

Fu, Yifan — Shandong Univ. of Sci. & Tech.
Zhao, Ziliang — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.
Ma, Duo — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Jia, Jingyu — Shandong Univ. of Sci. & Tech.

▶ SunB02-3 10:50–11:10
Humidity State Observer for Proton Exchange Membrane Fuel Cells Based on Dual Kalman Filter

Zhao, Ziliang — Shandong Univ. of Sci. & Tech.
Ma, Duo — Shandong Univ. of Sci. & Tech.
Guo, Bin — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.
Fu, Yifan — Shandong Univ. of Sci. & Tech.
Jia, Jingyu — Shandong Univ. of Sci. & Tech.

▶ SunB02-4 11:10–11:30
GraspNet-Baseline-Based 6D Robotic Grasp in Multi-Object Scenes

He, Xuanmian — Zhejiang Univ. of Tech.
Chen, Peng — Zhejiang Univ. of Tech.
Jin, Luyang — College of Information Engineering
Huo, Dongrui — Zhejiang Univ. of Tech.
Lu, Zhuoyi — Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.

▶ SunB02-5 11:30–11:50
Prescribed-Time Adaptive Position and Attitude Tracking Control for Patrol Quadrotor UAV

Chen, Junyu — Zhejiang Univ. of Sci. & Tech.
Xie, Shuzong — Zhejiang Univ. of Sci. & Tech.
Hou, Beiping — Zhejiang Univ. of Sci. & Tech.
Xiao, Liyang — Zhejiang Univ. of Sci. & Tech.
Dong, Jianwei — Zhejiang Univ. of Sci. & Tech.
Yang, Jun — Zhejiang Univ.

▶ SunB02-6 11:50–12:10
Adaptive Iterative Learning Control for Robotic Manipulator Systems with Non-Uniform Trajectories
Guan, Haiwa — Wenzhou Univ.
Chen, Kaijie — Wenzhou Vocational College of Sci. & Tech.
Xie, Shuzong — Zhejiang Univ. of Sci. & Tech.

SunB03 10:10–12:10 Langyue Hall
Invited Session: Intelligent Fault Detection, Diagnosis, and its Applications
Chair: Cai, Li — Southwest Jiaotong Univ.
Co-Chair: Qian, Quan — Univ. of Electronic Sci. & Tech. of China

▶ SunB03-1 10:10–10:30
Intracranial Pressure Prediction Using Phase-Aligned Multimodal Physiological Signals and Multi-Scale Temporal Modeling
Wang, Rui — Chongqing Univ.
Cai, Li — Southwest Jiaotong Univ.

▶ SunB03-2 10:30–10:50
State of Charge Estimation for Lithium-ion Batteries Based on Singular Spectrum Analysis and BiLSTM
Guo, Jiayuan — Southwest Jiaotong Univ., School of Electrical Engineering
Hu, Yuanjiang — Southwest Jiaotong Univ.
Cai, Li — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.

▶ SunB03-3 10:50–11:10
Online Fault Diagnosis under Missing Data via Multi-Kernel Learning
Cai, Li — Southwest Jiaotong Univ.
Zhang, Peng — Chongqing Univ.
Jiang, Weijie — Chongqing Univ.
Gui, Yuyang — Chongqing Univ.
Mo, Renpeng — Chongqing Univ.

▶ SunB03-4 11:10–11:30
Fuzzy State Observer-Based Cooperative Trajectory Tracking Control for Marine Surface Vehicles with Prescribed Performance
Wang, Hao — Anhui Univ.
Huang, Darong — Anhui Univ.
Wang, Xuerao — Anhui Univ.
Ouyang, Yuncheng — Southeast Univ.
Sun, Changyin — Southeast Univ.

▶ SunB03-5 11:30–11:50
Neuro-Fuzzy Wiener System Identification for Photovoltaic Power Prediction
Ma, Yao — Jiangsu Inst. of Tech.
Li, Feng — Jiangsu Univ. of Tech.
Li, Jinqiang — Jiangsu Univ. of Tech.

▶ SunB03-6 11:50–12:10
Hopf Bifurcation Analysis of A Bistable Duffing System with Washout Filter Delayed Feedback
Zhai, Lihong — Qingdao Univ. of Sci. & Tech.
Cheng, Zunshui — Qingdao Univ. of Sci. & Tech.
Xin, Youming — Qingdao Univ. of Sceince & Tech.
Shang, Yun — Qingdao Univ. of Sci. & Tech.
Lin, Xue — Qingdao Univ. of Sci. & Tech.
Xiao, Min — Zhejiang Normal Univ.

SunB04 10:10–12:10 Xinghui Hall
Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (IV)
Chair: Zhang, Xinmin — Zhejiang Univ.
Co-Chair: Huang, Darong — Anhui Univ.

▶ SunB04-1 10:10–10:30
Distributed Fault-Tolerant Optimal Consensus for Nonlinear Multi-Agent Systems via Stackelberg Min–Max Control
Liu, Fuyang — Anhui Univ.
Zhao, Dong — Anhui Univ.
Huang, Darong — Anhui Univ.
Ren, Wenjing — Hefei Univ. of Tech.

▶ SunB04-2 10:30–10:50
Fast Adaptive Count Data Regression and Its Application to Defects Prediction in Industrial Process
Zhao, Lili — Zhejiang Univ.
He, Bocun — Zhejiang Univ.
Zhang, Xinmin — Zhejiang Univ.

▶ SunB04-3 10:50–11:10
Enhanced Semantic Segmentation of Road Cracks and Potholes Based on Improved SegNeXt
Liu, Yuanhao — Harbin Inst. of Tech.
Yin, Yunfei — Harbin Inst. of Tech.
Chen, Jiangchuan — Harbin Inst. of Tech.
Li, Mingwu — School of Transportation Sci. & Engineering
Abaho, Gershome — Univ. of Rwanda
Dong, Zejiao — Harbin Inst. of Tech.

▶ SunB04-4 11:10–11:30
Neural Network with Weighted Jensen-Shannon Divergence on Key-Performance-Indicator-Related Process Monitoring
Gao, Sheng — Beijing Univ. of Chemical Tech.
Wang, Haoqian — Beijing Univ. of Chemical Tech.
Haotian, Zhang — Beijing Univ. of Chemical Tech.
Ge, Jinhao — Beijing Univ. of Chemical Tech.
Wang, Youqing — Beijing Univ. of Chemical Tech.
Ma, Xin — Beijing Univ. of Chemical Tech.

▶ SunB04-5 11:30–11:50
A Multi-source Data Weighted Fusion Root Cause Analysis Method for Microservices
Zhang, Shaokai — Inst. of Computer Application China Acad. of Engineering Physics
Zhang, Chuming — Inst. of Computer Application China Acad. of Engineering Physics
Cheng, Jianfeng — China Acad. of Engineering Physics
Zhang, Yangjing — China Acad. of Engineering Physics
Chen, Siyu — China Acad. of Engineering Physics
Ren, Qiang — China Acad. of Engineering Physis

▶ SunB04-6 11:50–12:10
Self-Adaptive Health-State Assessment and Suboptimal-Factor Tracing for Complex Industrial Process Control Systems
Cao, Huichao — Lanzhou Univ. of Tech.
Li, Kangyi — Lanzhou Univ. of Tech.
Jiang, Dongnian — Lanzhou Univ. of Tech.
Dai, Hang — Lanzhou Univ. of Tech.
Du, Honghe — Lanzhou Univ. of Tech.

SunB05 10:10–12:10 Meixue Hall
Regular Session: Data-Driven Modeling, Optimization, Scheduling (II)
Chair: Li, Yan — Shandong Univ.
Co-Chair: Yuan, Xiaofeng — Central South Univ.

▶ SunB05-1 10:10–10:30
A Dynamic Graph Convolutional Transformer Network for Product Quality Prediction in Industrial Processes
Huang, Zichen — Central South Univ.
Wang, Kai — Central South Univ.
Yuan, Xiaofeng — Central South Univ.
Wang, Yalin — Central South Univ.
Yang, Chunhua — Central South Univ., China

▶ SunB05-2 10:30–10:50
A Logging Data Classification Method Based on Implicit Spectral Embedding and Tree-Deep Learning Heterogeneous Ensemble
Li, Junhang — Huazhong Univ. of Sci. & Tech.
Zhang, Bocheng — Huazhong Univ. of Sci. & Tech.
Yuan, Li — Huazhong Univ. of Sci. & Tech.
Zhou, Kaibo — Huazhong Univ. of Sci. & Tech.

▶ SunB05-3 10:50–11:10
Multiscale Feature Fusion Extraction Framework for Multivariate Time Series Forecasting
Meng, Jing — Beijing Univ. of Tech.
Chai, Wei — Beijing Univ. of Tech.

▶ SunB05-4 11:10–11:30
Collaborative Construction of A Lunar Surface Energy Station by Heterogeneous Robots Based on Virtual Simulation

Gao, Zimeng — Automation Major,School of Mechanical & Electrical Engineering & Automation,Shanghai Univ.
Wang, Xiaoyu — Shanghai Univ.
Meng, Chen — Inst. of Aerospace Sys. Engineering Shanghai (ASES)
He, Yuena — Shanghai Univ.
Qiu, Wenwei — Shanghai Univ.
Shi, Hang — Shanghai Univ.

▶ SunB05-5 11:30–11:50
Sensitivity-Assisted Dual-Objective Parameter Identification for An Electrochemical-Thermal-Aging Coupled Battery Model
Wang, Qiaoling — Shandong Univ.
Li, Yan — Shandong Univ.
Zeng, Yi — Shandong Univ.
Li, Junyi — Shandong Univ.

▶ SunB05-6 11:50–12:10
Sliding-Mode Control Based on LQR for Markov Jump Systems with Partially Unknown Dynamics
Cheng, Shengrui — Shanghai Univ. of Engineering Sci. (SUES)
Chen, Bei — Shanghai Univ. of Engineering Sci.
Zhang, Ning — East China Univ. of Sci. & Tech.

SunB06 10:10–12:10 Guibin Hall
Regular Session: ADP and RL Based Learning Control (II)
Chair: Shi, Jia — Xiamen Univ.
Co-Chair: Wang, Xin — Southwest Univ.

▶ SunB06-1 10:10–10:30
A Meta-Learning and Physics-Informed Reinforcement Learning Framework for Multi-UGV Cooperative Defense
Chen, Dingxuan — Dalian Univ. of Tech.
Liu, Jinze — Dalian Univ. of Tech.
Jin, Feng — Dalian Univ. of Tech.
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.
Sun, Kaibiao — Dalian Univ. of Tech.

▶ SunB06-2 10:30–10:50
A Path Planning Algorithm Based on Deep Reinforcement Learning and Ant Colony Optimization
Huang, Haolei — Xi'an Polytechnic Univ.
Xu, Da — Xi'an Polytechnic Univ.
Wu, Lvyuan — Beihang Univ.
Li, Pengfei — Xi'an Polytechnic Univ.
Zhang, Hongwei — Zhejiang Univ.

▶ SunB06-3 10:50–11:10
Adaptive Optimal Control with Online Learning for Variable-Rope-Length 2D Bridge Crane
Liu, Ben — Zhejiang Univ. of Tech.
Chen, Zhongtian — Zhejiang Univ. of Tech.
Li, Yuanhao — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ SunB06-4 11:10–11:30
On Switched Event-triggered Full State-constrained Formation Control for Multi-vehicle Systems
Li, Zihan — Southwest Univ.
Wang, Ziming — The Hong Kong Univ. of Sci. & Tech., Guangzhou
Wang, Xin — Southwest Univ.

▶ SunB06-5 11:30–11:50
Reinforcement Learning-Enhanced Tube-based MPC Control Scheme for Uncertain Systems
Jiang, Shan — Xiamen Univ.
Wei, Zixuan — Xiamen Univ.
Shi, Jia — Xiamen Univ.

▶ SunB06-6 11:50–12:10
Ratio-Constrained Gradient Projection Torque-Cost Optimization for Dual-Policy Decomposed Humanoid Control
Zhi, Yuhao — Jiangnan Univ.
Xu, Zhong — JiangNan Unversity
Xu, Chen — Jiangnan Univ.
Yang, Huizhong — Jiangnan Univ.

Poster Session SunB07
May.10, 10:10–12:10
Front Hall

▷ SunB07-01
Prediction of Melt Index of Batch Polypropylene Based on Data Characteristics and Regression Modeling
Zhang, Yiyu — China Univ. of Petroleum
Wang, Jinmiao — China Univ. of Petroleum (Beijing)
Wang, Zhu — China Univ. of Petroleum (Beijing)

▷ SunB07-02
Research on Dynamic Position Management for Commodity Futures Trend Strategies Based on Deep Reinforcement Learning
Li, Chengjin — Qingdao Univ. of Sci. & Tech.
Liu, Xiangpeng — Qingdao Univ. of Sci. & Tech.

▷ SunB07-03
A Safe Reinforcement Learning Algorithm with Adaptive Lagrangian Multipliers
Jin, Jiangnan — Huzhou Univ.
Ye, Lingjian — Huzhou Univ.
Qin, Jingsheng — Huzhou Univ.
Zheng, Jiaqing — Huzhou Univ.
Xu, Xiaoyu — Huzhou Univ.
Wang, Longyan — Huzhou Univ.
Lin, Senyang — Huzhou Univ.
Xia, Yuhang — Huzhou Univ.
Miao, Jiawei — Huzhou Normal Univ.
Huang, Jiawei — Huzhou Universdity

▷ SunB07-04
Energy-Efficient Speed Profile Optimization for Maglev Trains Based on Proximal Policy Optimization
Zheng, Yuhang — Beijing Jiaotong Univ.
Zhang, Xiaoji — Beijing Jiaotong Univ.
Wu, Donghua — CRRC Qingdao Sifang Co., Ltd
Tian, Yi — CRRC Qingdao Sifang Co., Ltd
Zhong, Weifeng — Beijing Jiaotong Univ.

▷ SunB07-05
Two-Stage Decoupled Robust Framework for Wind Power Forecasting under Gross Errors via Dynamic Data Reconciliation
Lv, Yankang — Wenzhou Univ.
Hong, Zhihui — Wenzhou Univ.
Zhang, Zhengjiang — Wenzhou Univ.
Li, Li — Zhejiang Chint Electric Co., Ltd
Zhu, Zhiliang — Wenzhou Univ.

▷ SunB07-06
A Structural Optimization Algorithm with Borges Summation in TCN-NBEATS Model for SOC Estimation of Lithium-Ion Batteries
Wang, Yuhang — Liaoning Univ.
Gao, Zhe — Liaoning Univ.
An, Xianghua — Liaoning Univ.
Li, Hao — LIAONING Univ.
Zeng, Xiaowei — Liaoning Univ.
Zheng, Dongyue — Liaoning Univ.
Di, Mingzhe — Liaoning Univ.

▷ SunB07-07
Dual-Domain Transformer with Time-Domain Multi-Scale Patching and Frequency-Domain Sparse Representation for Water Wall Tube Temperature Prediction
Mao, Dongming — Hangzhou Normal Univ.
Liu, Jiabei — Hangzhou Normal Univ.
Zeng, Jiusun — Hangzhou Normal Univ.
Yao, Le — Hangzhou Normal Univ.
Zhu, Zheren — Zhejiang Univ.

▷ SunB07-08
Collaborative Prediction of Operation Rhythm and Gas Consumption for Hot Blast Stoves Group Based on A PC-STGNN Model
Chen, Long — Dalian Univ. of Tech., Dalian
Zhang, Yi — Dalian Univ. of Tech.
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.

▷ SunB07-09
Research on the Application Path Value-added of Data-driven Method in Engineering Materials
Ma, Yane — Nil
Zhao, Yanze — Beijing Univ. of Chemical Tech.
Liu, Wenbin — Beijing Univ. of Chemical Tech.
Wan, Jing — Beijing Univ. of Chemical Tech.

▷ SunB07-10

Research on Arc Voltage Control Based on RBF Neural Network Self-Tuning PID in Automatic Welding System

Sun, Qiuyang	China Nuclear Industry 23 ConstructionCO.,LTD
Feng, Yingchao	China Nuclear Lndustry 23 ConstructionCO.,LTD
Lu, Kun	China Nuclear Lndustry 23 ConstructionCO.,LTD
Zhao, Yongming	China Nuclear Lndustry 23 ConstructionCO.,LTD
Wang, Shipei	China Nuclear Lndustry 23 ConstructionCO.,LTD
Ren, Jingxin	China Nuclear Lndustry 23 ConstructionCO.,LTD
Li, Hong	China Nuclear Lndustry 23 ConstructionCO.,LTD
Yao, Shuyang	China Nuclear Lndustry 23 ConstructionCO.,LTD

▷ SunB07-11

Data-driven Model Predictive Fault-tolerant Control for Nonlinear Batch Processes with Partial Actuator Faults

Zhou, Chengyu	Chongqing Univ. of Tech.
Li, Jianfang	Chongqing Univ. of Tech.
Jia, Li	Shanghai Univ.

▷ SunB07-12

Multi-Granularity Graph Feature Fusion for Industrial Soft Sensing

Ni, Xinru	Huzhou Univ.
Mao, Longying	Huzhou Univ.
Yang, Zeyu	Huzhou Univ.
Chen, Xiaolu	Anhui Polytechnic Univ.
Yao, Le	Hangzhou Normal Univ.

▷ SunB07-13

MIF-PV: A Multi-source Heterogeneous Information Fusion Framework for Robust Short-Term Photovoltaic Power Forecasting

Hu, Runqi	Zhejiang Univ.
Yu, Wei	Huadian Electric Power Research Inst. Co.Ltd
Zhong, Zhen	CHN Energy Zhishen Control Tech. Co.,Ltd
Niu, Haiming	CHN Energy Zhishen Control Tech. Co.,Ltd
Zhang, Zhigang	CHN Energy Zhishen Control Tech. Co.,Ltd
Zhang, Xinmin	Zhejiang Univ.
Song, Zhihuan	Zhejiang Univ.

▷ SunB07-14

Transformer-CatBoost Serial Hybrid Prediction Modeling for Reheat Steam Temperature Process of Coal-Fired Power Units

Ai, Wei	South China Univ. of Tech.
Zhai, Shulei	South China Univ. of Tech.
Wu, Weining	South China Univ. of Tech.
Tang, Zikang	South China Univ. of Tech.
Li, Xiangyang	South China Uni. of Tech
Pan, Fengping	Electric Power Research Inst. of Guangdong Power Grid Corporation

▷ SunB07-15

Asymmetric Robustness in Ship AIS Spoofing Detection: A Study of Random Perturbation Stability and Adaptive Evasion Attacks

Fan, Jingv	China Machinery HuanYu (Shandong) Vehicle Certification & Inspection Co., Ltd
Ma, Xiaohui	Ministry of Industry & Information Techology Equipment Industry Developmengt Center
Xu, Shuanglong	China Machinery Huanyu(Shandong)Vehicle Certification & Testing Co.,Ltd
Zhang, Weidong	China Machinery Huanyu(Shandong)Vehicle Certification & Testing Co.,Ltd. Dezhou 251100, China
Zhou, Feng	China Machinery HuanYu (Shandong) Vehicle Certification & Inspection Co., Ltd
Yan, Shicheng	China Machinery HuanYu (Shandong) Vehicle Certification & Inspection Co., Ltd
Yang, Zhibo	China Machinery Huanyu Certification & Inspection Co., Ltd

▷ SunB07-16

Predefined-Time Control with Prescribed Performance for Multi-Motor Servo System Based on Generalized Coupling Error

Yang, Congwei	Beijing Inst. of Tech.
Ren, Xuemei	Beijing Inst. of Tech.
Song, Jiangchao	Beijing Inst. of Tech.
Zheng, Dongdong	Beijing Inst. of Tech.

▷ SunB07-17

AdaCTRec: An Adaptive Collaborative Temporal Recommendation Method

Feng, Yihui	Bohai Univ.
Xing, Xing	Bohai Univ.
Jia, Zhichun	Bohai Univ.
Xin, Mindong	Bohai Univ.
Gao, Lina	Bohai Univ.

▷ SunB07-18

Energy Consumption Prediction Model for Fresh Air and Air Conditioning System Based on STGNN-TA

Xu, Chao	Beijing Univ. of Tech.
Li, Xiaoli	Beijing Univ. of Tech.
Wang, Kang	Beijing Univ. of Tech.

▷ SunB07-19

Air Conditioning Load Forecasting Based on Optimized LSTM-Multi-Head Attention Hyperparameters

Cao, Zhenbo	Beijing Univ. of Tech.
Li, Xiaoli	Beijing Univ. of Tech.
Wang, Kang	Beijing Univ. of Tech.

▷ SunB07-20

A Hybrid Path Planning Method for Mobile Robots Based on Improved Theta and Improved APF*

Li, Xiang	Soochow Univ.
Guo, Bingbing	Soochow Univ.
Chen, Yiyang	Soochow Univ.

▷ SunB07-21

Inland River Ship Crew Fatigue Detection Method Based on Multi-Feature Fusion with Improved RT-DETR

Cui, Huiying	Qingdao Univ. of Sci. & Tech.
Wang, Qingliang	Jining Port & Shipping Development Group Co., Ltd
Feng, Hexun	Jining Port & Navigation Construction Co., Ltd
Liu, Yuchuan	Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Yao, Wen-Long	Qingdao Univ. of Sci. & Tech.

▷ SunB07-22

Towards A Secure Federated Learning Based Approach for Automatic Atrial Fibrillation Detection Using ECG Benchmark Datasets

Sehar, Uroosa	Shaoyang Univ.
Ahmad, Nouman	Northeastern Univ., Shenyang, China
Peng, Yifei	Shaoyang Univ.
Zhou, Jianhua	Shaoyang Univ.

▷ SunB07-23

SPFEMAN: Structural and Propagation Feature Enhanced Multimodal Attention Network for Multimodal Fake News Detection

Huang, Junlin	Southeast Univ.
Cao, Yang	Southeast Univ.
Tan, Xuegang	Southeast Univ.
Yu, Jiafeng	Harbin Inst. of Tech.
Wang, Zengyun	Hunan First Normal Univ.
Liao, Hao	Shenzhen Univ.

▷ SunB07-24

Robot Path Planning in Crowded Environments Based on Geometric Navigation and Spatial-Temporal Transformer

Ma, Tianshuo	Beijing Jiaotong Univ.
Xu, Hongze	Beijing Jiaotong Univ.
Zhong, Weifeng	Beijing Jiaotong Univ.
Jin, Shangtai	Beijing Jiaotong Univ.

▷ SunB07-25

Adaptive Trajectory Tracking Control of Robotic Manipulators Based on RBF Neural Networks

Li, Fapeng	Guangxi Univ. of Sci. & Tech.
Meng, Chuntao	Guangxi Univ. of Sci. & Tech.
Li, Xinsuo	Guangxi Univ. of Sci. & Tech.
Xu, Dengguo	Guangxi Univ. of Sci. & Tech.

▷ SunB07-26

A Model-Free Adaptive Predictive Control Strategy for VSG-Based Secondary Frequency Control in Inland Port Microgrids

Yang, Lei	Qingdao Univ. of Sci. & Tech.
Yue, Yaobin	Qingdao Univ. of Sci. & Tech.
Gu, Qiang	Jining Port & Navigation Longgong Port Co., Ltd
Liu, Yuchuan	Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Yao, Wen-Long	Qingdao Univ. of Sci. & Tech.

▷ SunB07-27

Wind Speed Assistance and Bayesian Optimization Based Wind Power Prediction

Deng, Dai-Shihao	Shanghai Univ.

Jia, Li — Shanghai Univ.

▷ SunB07-28

Probabilistic Random Forest-Driven Fault Diagnosis for Wastewater Treatment Process

Lu, Zhang — Shandong Univ. of Sci. & Tech.
Sun, Qinling — Shandong Univ. of Sci. & Tech.
Zhong, Maiying — Shandong Univ. of Sci. & Tech.

▷ SunB07-29

Reinforcement Learning for Robust Parameterized Gait Control of Two-Wheeled Bipedal Robots

Sun, Siwei — Xi’ an Polytechnic Univ.
Wang, Ziqian — Xi’an Polytechnic Univ.
Wang, Zeyu — Xi’an Polytechnic Univ.
Kou, Zhitao — Spesbot
Yingsheng, Mahe — Spesbot
Zhang, Hongwei — Zhejiang Univ.

▷ SunB07-30

Masked Structural Decomposition with Time Frequency Consistency for Unsupervised Multivariate Time Series Anomaly Detection

Xu, Yuan — Beijing Univ. of Chemical Tech.
Zhou, Meng Yu — Beijing Univ. of Chemical Tech.
Luo, Yi — Chinese Inst. of Coal Sci.
He, Yan-Lin — Beijing Univ. of Chemical Tech.
Zhu, Qunxiong — Beijing Univ. of Chemical Tech.
Zhang, Yang — Beijing Univ. of Chemical Tech.
Zhang, Mingqing — Beijing Univ. of Chemical Tech.

▷ SunB07-31

Robust Invariant Sets for Switched Linear Systems with Persistent Dwell-Time Constraints and Bounded Disturbances

Lu, Siyi — Shanghai Univ.
Li, Zixu — Shanghai Univ.
Lu, Yanxi — Shanghai Univ.
Song, Yang — Shanghai Univ.

▷ SunB07-32

Adaptive Iterative Learning Control for A Class of Constrained Nonlinear Systems with Unknown Control Directions and Input Saturation

Wang, Qian — Qingdao Univ. of Sci. & Tech.
Liu, Yating — Qingdao Univ. of Sci. & Tech.
Lin, Xue — Qingdao Univ. of Sci. & Tech.
Zhang, Ruikun — Qingdao Univ. of Sci. & Tech.

▷ SunB07-33

Multi-Target Allocation Based Reinforcement Learning for Cooperative Defense of USVs

Xue, Shan — Hainan Univ.
Zhao, Ning — Hainan Univ.
Zhu, Fengxian — Huaneng Hainan Changjiang Nuclear Power Co., Ltd
Zhang, Weidong — Shanghai Jiao Tong Univ.

▷ SunB07-34

Optimal Control of Mean-field Stochastic Systems with Wiener and Poisson Noises: A Data-driven Policy Iteration Approach

Yan, Zhiguo — Qilu Univ. of Tech.
Han, Anni — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Hu, Guolin — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

▷ SunB07-35

Observer-Based Prescribed-Time Consensus Tracking for Nonlinear Multi-Agent Systems

Liu, Xue — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Lv, Hui — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhu, Baolong — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Liu, Di — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Guo, Yaohua — Northwestern Polytechnical Univ.

▷ SunB07-36

Heterogeneous Ensemble Learning with Stacking Framework for Accurate Prediction of Tobacco Sheet Proportion Using Chemical Component Data

Zheng, Bowen — Yunnan China Tobacco Industry Co., Ltd
Huangfu, Dongyou — Hongyun Honghe Group Kunming Cigarette Factory
Qian, Qifu — Yunnan China Tobacco Industry Co., Ltd
Zhao, Xue — Kunming Cigarette Factory,HongyunHonghe Tobacco(Group) Co., Ltd., Kunming 650231, China
Wang, Luoping — Raw Materials Center of China Tobacco Yunnan Industrial Co., Ltd.,
Tang, Yuyang — Process Quality Section
Yang, Shuhan — Kunming Cigarette Factory,HongyunHonghe Tobacco(Group) Co., Ltd., Kunming 650231, China

▷ SunB07-37

Detection of Replay Attacks in Networked Control Systems Based on Segmented Weighted Smoothing Watermark

Wang, Yuxing — North China Univ. of Tech.

▷ SunB07-38

Jointly Optimizing Reconstruction and Prediction for Unsupervised UAV Anomaly Detection

Hu, Yiwen — Chengdu Aircraft Design & Research Inst. of AVIC
Ma, Bo — Aviation Industry Chengdu Aircraft Design Inst.
Ni, Jing — Aviation Industry Chengdu Aircraft Design Inst.
Wang, Wenzong — College of Electrical Engineering, Sichuan Univ.
Wang, Jianyu — Sichuan Univ.

▷ SunB07-39

FPGA-Based Radar PDW Data Compression Algorithm Design

Zhang, Hanliang — Univ. of Electronic Sci. & Tech. of China
Wang, Haifeng — Aviation Industry Corporation of China, LTD
Wang, Yang — Aviation Industry Corporation of China, LTD
Xie, Feng — Aviation Industry Corporation of China, LTD

▷ SunB07-40

Multi-Scale Pooling Enhanced Vision Transformer for Object Recognition on Small-Scale Datasets

Wang, Tete — Northeastern Univ.
Jiang, Lin — Univ. of Northeastern
Wen, Zhitao — Northeastern Univ.
Xu, Hang — Northeastern Univ.

▷ SunB07-41

Time Synchronization and Mapping of Multimodal Data in Weak GPS Environments

Wang, Ziming — Beijing Univ. of Chemical Tech.
Zhu, Haijiang — Beijing Univ. of Chemical Tech.
Zhao, Lina — Beijing Univ. of Chemical Tech.

▷ SunB07-42

A Fast Root Cause Diagnosis Method for Industry Process Based on Kernel Ridge Regression Granger

Chen, Xu — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Li, Yong — Shanghai Univ.
Teng, Jia Liang — Shang Hai Univ.
Chen, Rui — Shang Hai Univ.
Yao, Yuan — National Tsing Hua Univ.
Li, Chunbiao — Baoshan Iron & Steel Co., Ltd

▷ SunB07-43

Nonlinear Fault Root Cause Diagnosis Method Based on LSTM-AVAR Granger Causality Analysis

Li, Yong — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Chen, Xu — Shanghai Univ.
Lv, Yuxuan — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Kang, Jia-Lin — National Chung Cheng Univ.
Liao, Yan — Baoshan Iron & Steel Co. Ltd

▷ SunB07-44

Fault Root Cause Diagnosis Based on the Symbolic Characteristics of SENN Granger

Yang, Shixing — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Yao, Zan — Shanghai Univ.
Yao, Wanli — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Kang, Jia-Lin — National Chung Cheng Univ.
Li, Chunbiao — Baoshan Iron & Steel Co., Ltd

▷ SunB07-45

Fault Root Cause Diagnosis for Industrial Process Using Echo State Network-Based Granger Causality

Yao, Zan — Shanghai Univ.

Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Zhu, Jianguo — Shanghai Univ.
Chen, Zhuang — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Yao, Yuan — National Tsing Hua Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

▹ SunB07-46
A Nonlinear Root Cause Diagnosis Method Based on Deep Autoregressive Granger Analysis

Zhu, Jianguo — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Yang, Shixing — Shanghai Univ.
Xue, Yuzhou — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Yao, Yuan — National Tsing Hua Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

SunC01 13:30–15:30 Yangguang Hall
Invited Session: Data-Driven Adaptive and Learning Control and Applications for Unmanned Systems (I)

Chair: Yu, Wei — Peking Univ.
Co-Chair: Zhu, Panpan — Henan Univ.

▶ SunC01-1 13:30–13:50
A Multiclass Prediction Model for Estrogen Receptor Status in Breast Cancer Based on CT Radiomics and Clinical Features

Zeng, Jianfei — Southwest Jiaotong Univ.
Xu, Lulu — The Affiliated Hospital, Southwest Medical Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.

▶ SunC01-2 13:50–14:10
An Improved Neural Field-Based Coverage Path Planning Algorithm for Quadruped Robots

Fan, Yinbing — Southwest Jiaotong Univ.
Cheng, Junqiang — Europe-Aisa Hi-tech & Digital Tech. Company Limited
Wei, Shuang — Southwest Jiaotong Univ.
Zhang, Muhua — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.

▶ SunC01-3 14:10–14:30
Adaptive Iterative Learning Control for Non-Strictly Repeatable Second-Order Nonlinear Systems Subject to Deception Attacks

Chen, Qingfeng — Sun Yat-Sen Univ.,
Li, Xiao-Dong — Sun Yat-sen Univ.
Li, Xuefang — Sun Yat-sen Univ.

▶ SunC01-4 14:30–14:50
Kalman Filter-Based Event-Triggered Iterative Learning Control for Nonlinear Multi-Agent Systems

Peng, Liu — Huaqiao Univ.
Fu, Wen-Yuan — Huaqiao Univesity

▶ SunC01-5 14:50–15:10
PID-MFAILC Hybrid Speed Regulation for the Rotary Mechanism of Hydraulic Bolt Drills

Zong, Lubin — Henan Polytechnic Univ.
Liang, Jiaqi — Henan Polytechnic Univ.
Bu, Xuhui — Henan Polytechnic Univ.
Zhang, Yan — Henan Polytechnic Univ.

▶ SunC01-6 15:10–15:30
Output-Aware Latent Distribution Learning Using Variational Autoencoder for Industrial Soft Sensor

Song, Xiaolu — China Nuclear Power Engineering Co. Ltd
Zhang, Chuanwang — China Nuclear Power Engineering Co., Ltd
Zhang, Chuntao — Nettrix Information Industry (Beijing) Co., Ltd
Yu, Tao — China Nuclear Power Engineering Co., Ltd
Zhu, Panpan — Henan Univ.

SunC02 13:30–15:30 Changle Hall
Invited Session: Intelligent Control and Cooperative Strategies for Complex Systems

Chair: Zhang, Faxiang — Kunming Univ. of Sci. & Tech.
Co-Chair: Zhang, Xiufeng — Kunming Univ. of Sci. & Tech.

▶ SunC02-1 13:30–13:50
Kinematic Error Analysis and Compensation for Improving Surgical Robot Registration Performance

Yang, Senyuan — Kunming Univ. of Sci. & Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
Li, Yuan — Kunming Univ. of Sci. & Tech.
Li, Yingjie — Kunming Univ. of Sci. & Tech.
Hou, Cheng — Kunming Univ. of Sci. & Tech.

▶ SunC02-2 13:50–14:10
Fault-Tolerant Control of Reconfigurable Flight Arrays with Suspended Payloads

Li, Tianyun — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Zhang, Xiufeng — Kunming Univ. of Sci. & Tech.
Sun, Hongwei — Kunming Univ. of Sci. & Tech.
Zhang, Zexiang — Kunming Univ. of Sci. & Tech.

▶ SunC02-3 14:10–14:30
RUL Prediction of Spent Electrolyte Pumps Using A Preference-Guided Composite Loss

Wang, Chunlai — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Zhang, Xiufeng — Kunming Univ. of Sci. & Tech.
Zhang, Yangjie — Kunming Univ. of Sci. & Tech.
Zhang, Faxiang — Kunming Univ. of Sci. & Tech.

▶ SunC02-4 14:30–14:50
Kinematic Calibration of Industrial Robots Based on A Q-Learning Enhanced Coati Optimization Algorithm

Shi, Junjie — Kunming Univ. of Sci. & Tech.
Liu, Fei — Kunming Univ. of Sci. & Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
Zhang, Qinglong — Kunming Univ. of Sci. & Tech.

▶ SunC02-5 14:50–15:10
Optimal Observer Design for Anion Exchange Membrane Electrolyzers Using Approximate Dynamic Programming

Yang, Lijing — Kunming Univ. of Sci. & Tech.
Li, Siyan — Kunming Univ. of Sci. & Tech.
Xing, Yashan — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.

▶ SunC02-6 15:10–15:30
An Industrial Edge-Intelligence AI Agent Based on Agentic RAG Deep Research Framework: Construction and Application

Wang, Yanhong — China Unicom Digital Tech. Co
Yu, Rui — China Unicom Digital Tech. Co
Lu, Yun — China Unicom Digital Tech. Co
Liu, Yangyu — China Unicom Digital Tech. Co
Nie, Jianlong — China Unicom Digital Tech. Co
Yu, Qianqian — China Unicom Digital Tech. Co

SunC03 13:30–15:30 Langyue Hall
Invited Session: Data-Driven Fault Diagnosis, Monitoring, and Control for Industrial Systems

Chair: Li, Jitao — Harbin Engineering Univ.
Co-Chair: Qi, Qingyuan — Harbin Engineering Univ.

▶ SunC03-1 13:30–13:50
Cluster-Safe Oversampling Algorithm for Inter-Class and Intra-Class Imbalance

Ma, Yu — Beijing Univ. of Chemical Tech.
Wu, Haiyan — Beijing Univ. of Chemical Tech.
Wang, Jing — North China Univ. of Tech., China

▶ SunC03-2 13:50–14:10
An LOF-Based Weighted ADASYN Algorithm for Minority Intra-Class Imbalance

Zhang, Xiaoyang — Beijing Univ. of Chemical Tech.
Wu, Haiyan — Beijing Univ. of Chemical Tech.
Wang, Jing — North China Univ. of Tech., China

▶ SunC03-3 14:10–14:30
System Identification of A Micro-UUV Using UAV-Based Vision and Kernel Methods

Pang, Ran — Harbin Engineering Univ.
Luo, Yiting — Harbin Engineering Univ.
Li, Rongtao — Harbin Engineering Univ.
Li, Renjie — Harbin Engineering Univ.
Lu, Mingyu — Harbin Engineering Univ.
Li, Jitao — Harbin Engineering Univ.
Qi, Qingyuan — Harbin Engineering Univ.

▶ SunC03-4 14:30–14:50
Data-Enabled Policy Optimization for Optimal Trajectory Tracking of Unmanned Underwater Vehicles
Jiang, Yijing — Harbin Engineering Univ.
Qi, Qingyuan — Harbin Engineering Univ.

▶ SunC03-5 14:50–15:10
Multimodal Driven Fine-tuned Large Language Model for Intelligent Inspection of Power Supplies with Multi-Scale Feature Embedding
Zhao, Changwei — Anhui Xinli Power Tech. Co. Ltd
Chen, Huan — Anhui Xinli Power Tech. Co. Ltd
Fang, Zhenbang — Anhui Xinli Power Tech. Co. Ltd
Yang, Yang — Anhui Xinli Power Tech. Co. Ltd
Li, Senlin — Anhui Xinli Power Tech. Co. Ltd
Zhang, Jian — Anhui Xinli Power Tech. Co. Ltd
Wang, Ruomin — Anhui Xinli Power Tech. Co. Ltd.,

▶ SunC03-6 15:10–15:30
Prediction Model for the Quality of Weight Coating Application in Submarine Pipelines Based on BO-LightGBM
Xie, Yunhao — China Univ. of Petroleum, Beijing
Zou, Zilong — CNOOC Energy Tech. & Service
He, Renchu — China Univ. of Petroleum

SunC04 13:30–15:30 Xinghui Hall
Regular Session: Statistical Learning and Machine Learning in Automation Field
Chair: Zhang, Jianming — Institution of Cyber-Sys. & Control
Co-Chair: Liu, Shan — Zhejiang Univ.

▶ SunC04-1 13:30–13:50
Self-Training Knowledge Distillation-Based Multimodal Trajectory Prediction for Pedestrians
Zhou, Kehan — Zhejiang Univ.
Mao, Yuefeng — Acad. of Engineering
Zhang, Xu — Zhejiang Univ.
Zhu, Qian — Zhejiang Univ. Robotics Inst.
Zhu, Ce — Yuyao Robot Research Center
Zhang, Jianming — Institution of Cyber-Sys. & Control

▶ SunC04-2 13:50–14:10
TriFusion-DETR: A Light-weight Real-time Detector for Smartphone Screen Glass Defects
Fan, Xin — Zhejiang Sci-Tech Univ.
Wu, Ping — Zhejiang Sci-Tech Univ.
Yu, Yicheng — Zhejiang Sci-tech Unversity
Kandel, Nabin — Zhejiang Sci-Tech Univ.
Yang, Zheming — China National Pipeline Network Group Zhejiang Natural Gas Pipeline Network Co., Ltd
He, Guojun — Zhejiang Natural Gas Pipeline Network Co., Ltd. (PipeChina)

▶ SunC04-3 14:10–14:30
A Differentiable Oblique Decision Tree for Interpretable Interval Prediction of Photovoltaic Power
Sun, Huayan — Shanghai Univ.
Jia, Li — Shanghai Univ.

▶ SunC04-4 14:30–14:50
Edge Feature Information Enhancement Algorithm for Small Objects Detection of Remote Sensing Images
Li, Haochen — Jiangnan Univ.
Tao, Hong-Feng — Jiangnan Univ.
Zhuang, Zhihe — Jiangnan Univ.

▶ SunC04-5 14:50–15:10
A Cosine Leaky Integral Echo State Network for Time Series Prediction
Xu, Wenfu — Shenyang Univ. of Tech.
Gong, Yuanpeng — Changchun Univ. of Tech.

▶ SunC04-6 15:10–15:30
Learning A Robust Vision-Force Policy for Peg-in-hole Tasks
Fan, Xiaotian — Zhejiang Universtity
Liu, Shan — Zhejiang Univ.

SunC05 13:30–15:30 Meixue Hall
Regular Session: Applications of Data-Driven Methods to Industrial Processes (I)
Chair: Li, Xiangyang — South China Uni. of Tech
Co-Chair: Ai, Wei — South China Univ. of Tech.

▶ SunC05-1 13:30–13:50
Recognition of Flotation Abnormal Conditions Based on Multimodal Temporal-Visual Fusion
Xu, Degang — Central South Univ.
Jiang, Shan — Central South Univ.
Chen, Yiwei — Central South Univ.

▶ SunC05-2 13:50–14:10
Cooling Load Probability Density Prediction of Air Conditioning System Based on Temporal Gaussian Integrated Network
Liu, Nian — Xi'an Univ. of Architecture & Tech.
He, Ning — Xi'an Univ. of Architecture & Tech.

▶ SunC05-3 14:10–14:30
A Hybrid Genetic-ODE Framework with Multidimensional Constraints for Time Delay Estimation and Alignment in Industrial Dynamical Systems
Liu, Ke — Hangzhou Normal Univ.
Yao, Le — Hangzhou Normal Univ.
Zhu, Zheren — Zhejiang Univ.
Zeng, Jiusun — Hangzhou Normal Univ.
Song, Zhihuan — Zhejiang Univ.

▶ SunC05-4 14:30–14:50
An Evidential Deep Learning-Based Method for Boiler Combustion Optimization Objective Prediction
Wu, Yixi — Zhejiang Univ.
Zhan, Yuling — Zhejiang Univ.
Jin, Xiaohang — Zhejiang Univ. of Tech.
Xu, Zhengguo — Zhejiang Univ.

▶ SunC05-5 14:50–15:10
Coal Mine Multi-Scale Object Detection Based on Multi-Layer Vision Transformer
Yang, Xiaoyu — Middling Coal Tech. & Industry Group Chongqing Research Inst.
Luo, Chuan — China Coal Tech. & Engineering Group Chongqing Research Inst. Co., Ltd
Liu, Yanchi — China Coal Tech. Engineering Group
You, Lei — CCTEG Chongqing Research Inst. Co., Ltd

▶ SunC05-6 15:10–15:30
Intelligent MPC Strategy for SCR Denitration Process Based on VMD-AWSLSTM Model
Ai, Wei — South China Univ. of Tech.
Wu, Weining — South China Univ. of Tech.
Zhang, Tong — South China Univ. of Tech.
Zhai, Shulei — South China Univ. of Tech.
Tang, Zikang — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech

SunC06 13:30–15:30 Guibin Hall
Regular Session: Complex Systems and Artificial Intelligence (I)
Chair: Tang, Xinxin — Chongqing Jiaotong Univ.
Co-Chair: Yao, Wen-Long — Qingdao Univ. of Sci. & Tech.

▶ SunC06-1 13:30–13:50
SAR Moving Object Detection Method Based on Improved YOLOv8 in Noisy Environment
Li, Shuang — Chongqing Jiaotong Univ.
Tang, Xinxin — Chongqing Jiaotong Univ.
Huang, Darong — Anhui Univ.

▶ SunC06-2 13:50–14:10
Pathological Analysis of Asymptomatic Meningioma Based on CBAM-MED
Guo, Shengbo — Bjut
Li, Xiaoli — Beijing Univ. of Tech.
Wang, Kang — Beijing Univ. of Tech.
Du, Chao — Capital Medical Univ., Beijing, China
Hao, Shuyu — Capital Medical Univ., Beijing, China

▶ SunC06-3 14:10–14:30
DDANO: Dual-ended Dynamic Prompts Learning for Zero-Shot Anomaly Detection
Li, Qinghao — Anhui Univ.
Lu, Yixiang — Anhui Univ.
Zhu, De — Anhui Univ.

▶ SunC06-4 14:30–14:50
Observer-Based Adaptive Predefined-time Control for Uncertain Nonlinear Systems with Sensor Fault
Zhao, Weiyu — Bohai Univ.
Liu, Siwen — Bohai Univ.
Feng, Yaqi — Bohai Univ.
Wang, Huanqing — Bohai Univ.

▶ SunC06-5 14:50–15:10
Detail-Awared Virtual Try-On via A Data-Driven Cross-Domain Transformer
Liu, Jingyun — Xi'an Univ. of Tech.
Liu, Han — Xi'an Univ. of Tech.
Tong, Shuo — Xi'an Univ. of Tech.

▶ SunC06-6 15:10–15:30
Grouping-based Dual-Population Co-evolutionary Algorithm for Constrained Ship Electrical Layout Optimization
Liu, Xinyuan — Qingdao Univ. of Sci. & Tech.
Zhao, Chunliang — Qingdao Univ. of Sci. & Tech.
Liu, Yuchuan — Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Wang, Qingliang — Jining Port & Shipping Development Group Co., Ltd
Yao, Wen-Long — Qingdao Univ. of Sci. & Tech.

SunD01 15:40–17:40 Yangguang Hall
Invited Session: Data-Driven Adaptive and Learning Control and Applications for Unmanned Systems (II)
Chair: Zhou, Lan — Hunan Univ. of Sci. & Tech.
Co-Chair: Zhang, Xibeng — Henan Univ.

▶ SunD01-1 15:40–16:00
Data-Driven Adaptive Tracking Control for Nonlinear Dual-Active-Bridge Systems
Wang, Yilin — Henan Univ.
Song, Haochen — Fifth Inst. of Electronics, Ministry of Industry & Information Tech.
Yang, Zhengshuo — Henan Univ.
Zhang, Xibeng — Henan Univ.

▶ SunD01-2 16:00–16:20
Data-Driven Iterative Learning Control for Nuclear Waste Incineration Temperature Regulation
Zhang, Chuanwang — China Nuclear Power Engineering Co., Ltd
Song, Xiaolu — China Nuclear Power Engineering Co. Ltd
Ma, Jing — China Nuclear Power Engineering Co., Ltd
Zhang, Bo — China Nuclear Power Engineering Co., Ltd
Zhu, Panpan — Henan Univ.

▶ SunD01-3 16:20–16:40
Model-Free Adaptive Iterative Learning Control for Nonlinear Systems Using Partial Model Knowledge
Yu, Wei — Peking Univ.
Li, Zhongkui — Peking Univ.

▶ SunD01-4 16:40–17:00
Robust Model Predictive Control for Trajectory Tracking of Flexible-Joint Robotic Arms Based on Koopman Models
Xiang, Junchi — Hunan Univ. of Sci. & Tech.
Zhou, Lan — Hunan Univ. of Sci. & Tech.
Xia, Jingkang — Hunan Univ. of Sci. & Tech.
Xiao, Wenbin — Hunan Univ. of Sci. & Tech.
Li, Meiliu — Hunan Univ. of Sci. & Tech.

▶ SunD01-5 17:00–17:20
Altitude Control of A UAV Swarm Based on Historical Acceleration Commands
Gu, Zhuoheng — City Univ. of Macau
Yu, Wei — City Univ. of Macau
Gong, Yunbo — City Univ. of Macau
Wang, Meiyu — City Univ. of Macau

▶ SunD01-6 17:20–17:40
Adaptive Event-triggered Control for Nonlinear Multiagent Systems with Communication Link Faults
Liu, Guangliang — Northeastern Univ.
Liu, Jinhui — Bohai Univ.
Pan, Yingnan — Bohai Univ.

SunD02 15:40–17:40 Changle Hall
Invited Session: Data-Driven Control and Learning of Multi-Agent Systems
Chair: Liang, Dong — Univ. of Shanghai for Sci. & Tech.
Co-Chair: Wang, Shanshan — Univ. of Shanghai for Sci. & Tech.

▶ SunD02-1 15:40–16:00
Fully Distributed Data-Driven Cooperative Output Regulation of Linear Multi-Agent Systems by Output Feedback Control
Chen, Hong — Usst
Liang, Dong — Univ. of Shanghai for Sci. & Tech.
Dong, Yi — Tongji Univ.
Tian, Engang — Nanjing Normal Univ.
Wang, Chaoli — Univ. of Shanghai for Sci. & Tech.

▶ SunD02-2 16:00–16:20
Backstepping Neural Operators for $2times2$ Hyperbolic PDEs
Wang, Shanshan — Univ. of Shanghai for Sci. & Tech.

▶ SunD02-3 16:20–16:40
Efficient Solution of the 3D Fractional Poisson Equation Using Fourier Neural Operators
Xiao, Wei — Univ. of Shanghai for Sci. & Tech.
Wang, Shanshan — Univ. of Shanghai for Sci. & Tech.

▶ SunD02-4 16:40–17:00
Performance-Supervised Fault Detection for Model-Free Nonlinear Systems Based on Fuzzy Approximation
Gu, Yujie — Univ. of Shanghai for Sci. & Tech.
Liu, Ruijie — Univ. of Shanghai for Sci. & Tech.
Nie, Kunhao — Univ. of Shanghai for Sci. & Tech.

▶ SunD02-5 17:00–17:20
Data-Driven SIR-Based Active Defensive Control for Cyber-Physical Systems with Malicious Sensor Attacks
Nie, Kunhao — Univ. of Shanghai for Sci. & Tech.
Liu, Ruijie — Univ. of Shanghai for Sci. & Tech.

▶ SunD02-6 17:20–17:40
Edge Convergence of Second-Order Nonlinear Systems
Wang, Mengyi — Qilu Univ. of Tech.
Zhang, Jiayuan — Qilu Univ. of Tech.
Wang, Xiaofan — Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Du, Mingjun — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

SunD03 15:40–17:40 Langyue Hall
Regular Session: Advanced Data Driven Algorithms for Complex Process
Chair: Liu, Shan — Zhejiang Univ.
Co-Chair: Zhang, Jianming — Institution of Cyber-Sys. & Control

▶ SunD03-1 15:40–16:00
Model-Free Adaptive Variable Gain Predictive Vector Control for Chemical Tanker Propulsion Systems
Feng, Jianliang — Qingdao Univ. of Sci. & Tech.
Liu, Yuchuan — Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Wang, Qingliang — Jining Port & Shipping Development Group Co., Ltd
Chi, Ronghu — Foshan Univ.
Yao, Wen-Long — Qingdao Univ. of Sci. & Tech.

▶ SunD03-2 16:00–16:20
Dense Medium Separation Method Based on Improved Proportional-Integral Generalized Predictive Control with Active Disturbance Rejection Control
Zhang, Jingpei — Dalian Univ. of Tech.
Jin, Feng — Dalian Univ. of Tech.
Liu, Jinze — Dalian Univ. of Tech.
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.

▶ SunD03-3 16:20–16:40
Predefined-Time Tracking Control for Robotic Manipulators with Input Saturation Based on Disturbance Observer
Lei, Shu — Beijing Inst. of Tech.
Ren, Xuemei — Beijing Inst. of Tech.
Song, Jiangchao — Beijing Inst. of Tech.
Zheng, Dongdong — Beijing Inst. of Tech.

▶ SunD03-4 16:40–17:00
A Unified Lightweight Attention Module for Road Classification and Crack Segmentation
Li, Mingwu — School of Transportation Sci. & Engineering
Yin, Yunfei — Harbin Inst. of Tech.
Li, Wantong — Harbin Inst. of Tech.
Liu, Yuanhao — Harbin Inst. of Tech.
Abaho, Gershome — Univ. of Rwanda
Dong, Zejiao — Harbin Inst. of Tech.

▶ SunD03-5 17:00–17:20
Deep Belief Network-Based MIMO Wiener System Identification for Permanent Magnet Synchronous Motor Modeling
Zhang, Yanan — Shanghai Univ.
Jia, Li — Shanghai Univ.

Li, Feng — Jiangsu Univ. of Tech.

▶ SunD03-6 17:20–17:40
A Robust Coarse-to-Fine Peg-in-Hole Assembly Strategy via Visual Servoing and Compliance Control
Ni, Hao — Zhejiang Univ.
Liu, Shan — Zhejiang Univ.

SunD04 15:40–17:40 Xinghui Hall
Regular Session: Applications of Data-Driven Methods to Industrial Processes (III)

Chair: Yan, Fei — Xi'an Univ. of Tech.
Co-Chair: Mi, Bo — Chongqing Jiaotong Univ.

▶ SunD04-1 15:40–16:00
An IoV Access Control Model Based on Trust-Epoch-Bound CP-ABE
Wang, Xin — Chongqing Jiaotong Univ.
Mi, Bo — Chongqing Jiaotong Univ.
Huang, Darong — Anhui Univ.

▶ SunD04-2 16:00–16:20
Causal Disentanglement-Driven Robust Adaptive Physics-Informed Neural Network for Trajectory Prediction
He, Zhonghe — North China Univ. of Tech.
Xu, Ruosi — North China Univ. of Tech.
Ding, Baiwen — North China Univ. of Tech.
Li, Kailong — North China Univ. of Tech.
Li, Min — North China Univ. of Tech.
Zhai, Kaixuan — North China Univ. of Tech.
Su, Xiyao — North China Univ. of Tech.

▶ SunD04-3 16:20–16:40
A Cross-City Delay Prediction Framework for Signal Timing Optimization Integrating Floating Car Trajectories and Signal State Data
Li, Xinru — NORTH CHINA Univ. OF Tech.
Tan, Jiyuan — North China Univ. of Tech.
Li, Yi — Alibaba Group
Xie, Songming — School of Electrical & Control Engineering
Dong, Zhenning — Alibaba Group
Guo, Weiwei — North China Univ. of Tech. Beijing
Su, Yuelong — Tsinghua Univ.

▶ SunD04-4 16:40–17:00
A PD-Type Iterative Learning Control with Whale-Optimized Learning Gains for Urban Traffic Signals
Wang, Hao — Xi'an Univ. of Tech.
Yan, Fei — Xi'an Univ. of Tech.

▶ SunD04-5 17:00–17:20
Decentralized Spatiotemporal A2C with Graph Attention Communication Bottleneck for Multi-Agent Traffic Signal Control
Liu, Qian — Xiamen Univ.
Liu, Junlong — School of Electronic & Information Engineering
Shi, Jia — Xiamen Univ.

▶ SunD04-6 17:20–17:40
OSLC-based Event Synchronization Method for XBOM Model Tree
Cheng, Jianfeng — China Acad. of Engineering Physics
Zhang, Yangjing — China Acad. of Engineering Physics
Chen, Siyu — China Acad. of Engineering Physics
Zhang, Chuming — Inst. of Computer Application China Acad. of Engineering Physics
Zhang, Shaokai — Inst. of Computer Application China Acad. of Engineering Physics
Ren, Qiang — China Acad. of Engineering Physis

SunD05 15:40–17:40 Meixue Hall
Regular Session: Applications of Data-Driven Methods to Industrial Processes (II)

Chair: Hou, Yandong — Henan Univ.
Co-Chair: Lv, Feiya — Zhejiang Univ.

▶ SunD05-1 15:40–16:00
MWS-DETR: A Lightweight Model for Metal Weldment Surface Small-Scale Defect Detection
Li, Yijian — Central South Univ.
Xu, Degang — Central South Univ.

▶ SunD05-2 16:00–16:20
Knowledge-Enhanced Graph Patching Network for Fault Prediction in Chemical Processes
Zou, Chen — Henu Univ.
Hou, Yandong — Henan Univ.
Lv, Feiya — Zhejiang Univ.

▶ SunD05-3 16:20–16:40
Mechanism-Informed Nonlinear Model Predictive Control with Batch-wise Parameter Re-identification: Application to the Finishing Rolling Process
Dong, Yuanye — Peking Univ.
Li, Wenlong — Peking Univ.
Yang, Ying — Peking Univ.

▶ SunD05-4 16:40–17:00
Human-like Trajectory Evaluation Function for Autonomous Driving: Perception-aligned Structure Design and Expert Data-driven Parameter Identification
Zheng, Niannian — Geely Automobile Research Inst.
Bo, Li — Geely Automobile Research Inst.
Huo, Ke — Geely Automobile Research Inst.
Bo, Li — School of Automotive & Transportion Engineering
Chen, Chen — Xidian Univ.
Can, Xu — Hefei Univ. of Tech.
Li, Yue — Geely Automobile Research Inst.

▶ SunD05-5 17:00–17:20
Virtual Damping NOILC: A Robust Two-Stage Control Framework for Underactuated Overhead Cranes
Cai, Yujin — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China
He, Xiongxiong — Zhejiang Univ. of Tech.

▶ SunD05-6 17:20–17:40
Data-based Probability-dependent Event-triggered Control for Unknown Markovian Jump Systems
Zhang, Ning — East China Univ. of Sci. & Tech.
Niu, Yugang — East China Univ. of Sci. & Tech.
Zhao, Jiancong — East China Univ. of Sci. & Tech.
Lv, Xinyu — Qufu Normal Univ.

SunD06 15:40–17:40 Guibin Hall
Regular Session: Complex Systems and Artificial Intelligence (II)

Chair: Ning, Nianwen — Henan Univ.
Co-Chair: Cheng, Zunshui — Qingdao Univ. of Sci. & Tech.

▶ SunD06-1 15:40–16:00
Multi-task-based Finite-time Control for Second-order Multi-agent Systems
Chen, Jiajing — Tianjin Univ. of Tech. & Education
Li, Weixun — Tianjin Univ. of Tech. & Education
Du, Chengcheng — Tianjin Univ. of Tech. & Education
Li, Zhang — Tianjin Univ. of Commerce

▶ SunD06-2 16:00–16:20
Real-Time AI-Based Polyp Detection and Segmentation in Gastrointestinal Endoscopy Using Deep Learning
Aaron, Sayor — Canadian Univ. of Bangladesh
Newaz, Ashif — Canadian Univ. of Bangladesh
Abir, Sajjat Hossain — Canadian Univ. of Bangladesh
Rahman, Md. Mushfiqur — Canadian Univ. of Bangladesh
Ahosan, Nazmul — Canadian Univ. of Bangladesh
Hossain, Md Monir — Canadian Univ. of Bangladesh

▶ SunD06-3 16:20–16:40
Role-Oriented History-Aware Transformer for Spatio-Temporal Traffic Flow Forecasting
Guo, Chenyang — Henan Univ.
Ning, Nianwen — Henan Univ.
Feng, Yiting — Henan Univ.
Lv, Beilei — Henan Univ.
Zhu, Panpan — Henan Univ.
Li, Hengji — Henan Univ.
Li, Wei — Henan Univ.
Zhou, Yi — Henan Univ.

▶ SunD06-4 16:40–17:00
Consensus of Multi-agent Systems Based on Sigma-Delta Quantizer under DoS Attacks
Zhang, Ting — Henan Univ. of Economics & Law
Zhao, Kai Da — HENAN Univ. OF ECONOMICS & LAW
Liu, Zisheng — Henan Univ. of Economics & Law

▶ SunD06-5 17:00–17:20
Stability and Hopf Bifurcation Analysis of A Complex Network Model with Heterogeneous Gamma-Distributed Delays
Gao, Wenjie — Qingdao Univ. of Sci. & Tech.

Cheng, Zunshui Qingdao Univ. of Sci. & Tech.
Xin, Youming Qingdao Univ. of Sceince & Tech.
Shang, Yun Qingdao Univ. of Sci. & Tech.

► SunD06-6 17:20–17:40

A Hybrid Genetic and Dynamic Penalty-Based PSO Algorithm for Constrained Maintenance Scheduling in Distribution Networks

Liang, Yanyan State Grid Bozhou Electric Power Supply Company
Liu, Yan State Grid Bozhou Electric Power Supply Company
Wang, Jiaxiao State Grid Bozhou Electric Power Supply Company
Wu, Chengcheng State Grid Bozhou Electric Power Supply Company
Pan, Min State Grid Bozhou Electric Power Supply Company
Zhen, Chao State Grid Bozhou Electric Power Supply Company

Book of Abstracts

Saturday, May 9, 2026

SatA00 13:30–17:40 Jinxiu Hall
Award Session: Best Paper

Chair: SUN, Mingxuan Zhejiang Univ. of Tech.
Co-Chair: Chi, Ronghu Foshan Univ.

▶ SatA00-1 13:30–13:55
Sampled-data MFAC for High-order Nonlinear Systems
Zhao, Zhenbang Beijing Inst. of Tech.
Yu, Hao Beijing Inst. of Tech.

This paper presents a sampled-data control algorithm for high-order nonlinear systems. It develops a discrete-time transformation method that converts the N-order nonlinear system into an equivalent error system, where the errors take a backstepping-like form. This method is then used to design a model-free adaptive controller with uniformly bounded parameters under a sufficiently small sampling period. The stability of the closed-loop system is analyzed by constructing a novel Lyapunov function. Finally, several numerical examples are provided to illustrate the effectiveness and efficiency of the proposed methods.

▶ SatA00-2 13:55–14:20
HIL-VFD: Learning High-Precision Insertion under Grasp Uncertainty via Vision–Force Imitation Learning with Human-in-the-Loop DAgger
Chen, Yuxi Zhejiang Univ.
Zhang, Xuanyu Zhejiang Univ.
Bai, Hongyu Shanghai Jiaotong Univ.
Zhou, Zhongxiang Zhejiang Humanoid Innovation Center
Xiong, Rong Zhejiang Univ.
Zhang, Jianming Institution of Cyber-Sys. & Control
Yu, Hongxiang Zhejiang Univ.

Robotic peg-in-hole insertion is a fundamental contact-rich manipulation skill critical for industrial assembly and daily activities. Traditional solutions typically rely on rigid tool mounting and pre-taught trajectories, an assumption that breaks down in unstructured environments where tools are grasped by general-purpose end-effectors. This introduces grasp uncertainty, where grasp errors and slippage lead to misalignment even after visual servoing. To address this, we propose HIL-VFD (Human-in-the-Loop Vision-Force DAgger Imitation Learning), a multimodal imitation learning framework designed for high-precision insertion under grasp uncertainty. Our system introduces an automated grasp pose randomization procedure to efficiently collect diverse contact-rich trajectories without expensive manual resets. We learn a closed-loop policy that fuses eye-in-hand vision and wrist force feedback, employing a Human-in-the-Loop (HIL) DAgger refinement scheme to mitigate distribution shift and recover from near-failure states. Extensive real-world experiments on a UR5 platform demonstrate that HIL-VFD achieves a 95% success rate, outperforming baselines under grasp variability.

▶ SatA00-3 14:20–14:45
Large Language Model-driven Two-Stage Spatiotemporal Dual-Stream Collaborative Framework for Industrial Quality Prediction
Fu, Zehao Xi'an Univ. of Tech.
Liu, Han Xi'an Univ. of Tech.
Tong, Shuo Xi'an Univ. of Tech.
Guo, Runyuan Xi'an Univ. of Tech.

Addressing the challenge of indirectly and accurately measuring hard-to-predict key process variables in complex industrial processes, data-driven prediction methods have emerged as a key solution. However, existing approaches face limitations in complex operating conditions, including insufficient few-shot modeling capabilities, and weak representational understanding. In recent years, Large Language Models (LLMs) have demonstrated significant potential due to their strengths in cross-modal knowledge transfer and few-shot learning. Inspired by theses, this paper proposes a LLM-based two-stage spatiotemporal dual-stream collaborative key process variable prediction framework (LLM-TS2C). Specifically, LLM-TS2C comprises a Temporal Patch Dynamic-Aware Branch (TPDB) and a Spatial Graph Dependency-Aware Branch (SGDB), which jointly model long-range temporal dependencies and multivariate cross-channel couplings via a two-stage training framework, including a representation learning pre-training stage and a KPV prediction stage. To mitigate representational discrepancies across modalities and enhance spatiotemporal interactions, LLM-TS2C introduces channel-wise and patch-wise differentiated tokenization strategy. Moreover, a cross-branch feature interaction strategy is proposed to enable spatiotemporal collaborative modeling. Finally, experiments conducted on the air preheater dataset further validate the superiority of the proposed method, with significant improvements observed in the model' s representation and prediction capabilities under both full-data and few-shot scenarios.

▶ SatA00-4 14:45–15:10
Trackability-Based Cooperative Learning Control for Heterogeneous Networks
Wu, Yuxin Beijing Inst. of Tech.
Sun, Jian Beijing Inst. of Tech.

This paper investigates the cooperative learning control problem for heterogeneous networks, where the cooperative perfect tracking objective is of specific interest. The cooperative trackability is first proposed for heterogeneous networks to reveal the cooperative tracking ability of agents subject to the given desired reference, for which a distributed cooperative trackability criterion is established through the interactions among agents regardless of the heterogeneous dynamics of agents. Given the cooperatively trackable desired reference, a cooperative learning control law is developed with the insertion of the complete experiences of agents at the previous iteration. In the presence of the quasi-strong connectivity, the cooperative perfect tracking objective can be realized for heterogeneous networks with agents having irregular dynamics.

▶ SatA00-5 15:10–15:35
Data-Driven Prescribed-Iteration Convergence Control for Discrete-Time Nonlinear Systems via Iteration-Varying Gain
Xu, Meilu Shenyang Aerospace Univ.
Liu, Dong Shenyang Aerospace Univ.
Li, Guohao Shenyang
Wang, Xin Heilongjiang Univ.

This paper presents the data-driven control scheme for discrete-time nonlinear systems that achieves prescribed-iteration convergence. The design ensures the tracking error converges to a preassigned steady-state band at the prescribed iteration. Prior to the target iteration, a novel iteration-varying gain function enables energy accumulation process that geometrically compresses the error, which is constructed via a contraction mapping. Once the prescribed iteration is reached, the steady-state mechanism activates and maintains the output within the steady-state band thereafter. Simulation results demonstrate the validity and effectiveness of the proposed method.

▶ SatA00-6 15:35–16:00
Data-driven Fault Detection with Orthogonal Projection
Cui, Kaixin Beijing Inst. of Tech.
Li, Linlin Univ. of Sci. & Technoloty Beijing
Shi, Dawei Beijing Inst. of Tech., Beijing
Ding, Steven Univ. of Duisburg-Essen

This work proposes a data-driven fault detection approach for unknown linear systems with an orthogonal projection. The behavioral trajectory subspace is defined as the column space of a Hankel matrix constructed from nominal system data. Any nominal input-output trajectory lies within this subspace, and the rank of the Hankel matrix determines the dimension of the nominal system behavior. By performing a singular value decomposition (SVD) on the Hankel matrix, the orthonormal bases for the trajectory subspace and its orthogonal residual subspace are extracted, enabling complete decoupling of normal and abnormal behavior. Based on this SVD, a self-adjoint and idempotent projection operator is designed to generate a performance-based residual signal. Then, a residual evaluation function is developed to quantify the performance degradation by measuring the distance between the sampling input-output data and the nominal trajectory subspace. A system multiplicative fault is detected online when this residual evaluation signal

exceeds a tolerable threshold defined by the gap metric between the nominal and uncertainty subspaces. The effectiveness of the projection-based detection results is validated through experimental applications on a three-tank platform.

▶ SatA00-7 16:00–16:25

FFDL-Enhanced Distributed Cooperative Localization for Vehicle Swarms in GNSS-Denied Environments

Shi, Lei	Univ. of Electronic Sci. & Tech. of China
Yan, Shuaiming	Henan Univ.
Zhu, Panpan	Henan Univ.
Zhou, Yi	Henan Univ.
Lv, Lingling	North China Univ. of Water Conservancy & Electric Power

Accurate vehicle localization in GNSS-denied environments such as tunnels remains a critical challenge for connected autonomous vehicle swarms. This paper proposes a novel data-driven cooperative localization framework that integrates barycentric coordinate-based positioning with Full-Form Dynamic Linearization (FFDL) error correction. The proposed method leverages sparsely deployed roadside units (RSUs) as anchor nodes and employs vehicle-to-vehicle (V2V) communication for cooperative positioning. Unlike traditional model-based approaches, the FFDL-enhanced framework learns localization error dynamics directly from input/output data without requiring precise mathematical models of ranging errors or multipath effects. A pseudo-gradient matrix is adaptively updated online to predict and correct position estimates. Simulation results demonstrate that the proposed method achieves significant improvement in localization accuracy compared to conventional barycentric coordinate localization and Extended Kalman Filter, with enhanced robustness to measurement noise and environmental variations. The approach is computationally efficient and scalable to large vehicle swarms.

▶ SatA00-8 16:25–16:50

Memory-Augmented A ine Formation Control for UAV Swarms Using Available Networked Information

Dai, Ziyi	City Univ. of Macau
Yu, Wei	City Univ. of Macau
Yu, Jinzhi	City Univ. of Macau
Li, Zuopeng	City Univ. of Macau

Existing studies have demonstrated that active utilization of network information can effectively enhance the control performance of unmanned aerial vehicle (UAV) swarm systems. However, the specific impacts of diverse available networked information on system performance remain an open question. To address this, this paper conducts a comparative analysis of three types of high-order information in UAV control: actual velocity, velocity approximated by state differentiation, and historical velocity commands. Furthermore, a cohesion metric is introduced to evaluate and distinguish the performance variations of these information sources in UAV formation control. Finally, the swarm control strategy is validated through theoretical simulations and experiments on the RflySim platform. The results indicate that the proposed method achieves effective performance in numerical simulations. On the RflySim platform, our approach also exhibits favorable performance under the tested conditions.

SatA01 13:30–15:30 Yangguang Hall

Invited Session: Data-Driven Self-Learning Control and Optimization for Nonlinear Systems

Chair: Wei, Qinglai — Inst. of Automation
Co-Chair: Wang, Ding — Beijing Univ. of Tech.

▶ SatA01-1 13:30–13:50

Self-Triggered Robust Optimal Consensus Control for Nonlinear Multi-Agent Systems with Control Constraints

Hao, Jiang	Macau Univ. of Sci. & Tech.
Wei, Qinglai	Inst. of Automation
Song, Ruizhuo	Univ. of Sci. & Tech. Beijing

This study proposes an event-/self-triggered adaptive dynamic programming (ADP) approach to solve the robust optimal consensus control problem for nonlinear multi-agent systems (MASs) subject to control constraints. By leveraging augmented control techniques, the robust control problem with unmatched uncertainties is transformed into an optimal control problem. A nonquadratic cost function is introduced to account for input constraints, and the associated Hamilton-Jacobi-Bellman (HJB) equation is derived. To mitigate communication and computational costs, an integrated self-triggered strategy is presented. A critic-only ADP architecture is constructed to approximate the optimal control solution. Rigorous Lyapunov analysis establishes the robust stability of the closed-loop system and the uniform ultimate boundedness (UUB) of the neural network weight estimation errors. The performance of the proposed method is validated through numerical simulations.

▶ SatA01-2 13:50–14:10

Risk Estimation of Power Construction Operations via Domain-Adaptive BERT and Multimodal Transformer

Wang, Yulin	Tianjin Univ.
Zhu, Xinshan	Tianjin Univ.
Yang, Xiong	Tianjin Univ.
Zhang, Shumei	Tianjin Univ.

It is essential to properly evaluate the operational risks of power construction in order to avoid accidents on the power grid. The current approaches are predominantly based on hard-label classification of structured data and do not make full use of deep semantics inherent in unstructured texts and disregard the continuous aspect of operational risks. To resolve this problem, this paper suggests a multimodal risk assessment model that is driven by data. A domain-fine-tuned BERT model is first used to get high-dimensional semantics out of construction texts, which is then reduced using Principal Component Analysis (PCA). At the same time, a K-Nearest Neighbors (KNN) algorithm is also presented to build continuous soft labels of risk probabilities in the historical feature space, which can effectively eliminate the noise of the data due to subjective misreporting. Moreover, a multimodal Transformer regression network relying on self-attention mechanisms is developed to address the difficulty of fusing heterogeneous features created by concatenating structured tabular data and unstructured text. This architecture overcomes the limitations of spatial translation invariance imposed by conventional Convolutional Neural Networks (CNNs) and ensemble tree models through the introduction of a global [CLS] token and cross-modal interactions, resulting in a dynamically optimal distribution of heterogeneous feature weights. Experimental results on a real-world dataset of power construction show that the proposed approach obtains state-of-the-art predictive performance, with a coefficient of determination (R2) of 0.9296 and Mean Absolute Error (MAE) of only 0.0361. In comparison with the baseline models including Multilayer Perceptron (MLP), 1D-CNN, and XGBoost, the prediction accuracy and generalization ability of this architecture are significantly enhanced, and it offers a consistent data-driven solution to the fine-grained and intelligent hierarchical management of power safety supervision.

▶ SatA01-3 14:10–14:30

Event-Triggered Safe Critic Learning Control via Swarm Intelligence Optimization

Li, Xin	Beijing Univ. of Tech.
Wang, Jiangyu	Beijing Univ. of Tech.
Ye, Kai	School of Information Sci. & Tech.
Wang, Ding	Beijing Univ. of Tech.

This paper develops an event-triggered safe critic learning control algorithm for discrete-time nonlinear systems with asymmetric state constraints. A control barrier function is designed to construct a safe utility function, which transforms the constrained optimal control problem into an unconstrained one. A particle swarm optimization-based policy improvement method is developed to extend applicability of the algorithm to non-affine nonlinear systems, and an event-triggering condition is integrated to cut down computational and communication overhead. The asymptotic stability of the closed-loop system and the upper bound of the actual value function are proven to guarantee bounded performance degradation. Simulation results on a torsion pendulum system verify that the algorithm satisfies state constraints, achieves optimal control performance, and effectively balances system safety, control optimality and resource efficiency.

▶ SatA01-4 14:30–14:50

Dynamic Event-Triggered Prescribed-Time Optimal Attitude Control for Helicopters

Zhang, Shunchao	Guangdong Univ. of Finance
Liu, Dacai	Guangdong Univ. of Finance
Zhang, Yongwei	South China Agricultural Univ.
Lin, Mingduo	Southern Univ. of Sci. & Tech.
Zhao, Bo	Beijing Normal Univ.

This paper proposes a dynamic event-triggered prescribed-time optimal attitude control method for two-degree-of-freedom helicopters by using adaptive dynamic programming (ADP). A transformed tracking error is introduced by combining the attitude tracking error with a time-varying

scaling function that explicitly embeds the desired convergence time and accuracy. This transformation enables the prescribed-time control objective to be regraded as an optimal control problem for the transformed tracking error dynamics. Then, the optimal control law is obtained through the ADP framework. To mitigate communication and computational burdens, a dynamic event-triggered mechanism is designed to determine the updating instants of optimal control law. Theoretical analysis confirms that the closed-loop system achieves the prescribed-time stability while excluding Zeno behavior. Simulation studies illustrate the effectiveness of the proposed method.

▶ SatA01-5 14:50–15:10

Nighttime Vehicle Detection and Depth Estimation Based on Infrared Thermal Cameras

Wang, Zhangu	Shandong Univ. of Sci. & Tech.
Cheng, Lingping	Shandong Univ. of Sci. & Tech.
Li, Zhenye	Qingdao Lulu Agricultural Equipment Co, Ltd
Bu, Zhao	Shandong Univ. of Sci. & Tech.
Li, Zhaoyu	Qingdao Univ. of Tech., Linyi
Wang, Wenkai	Ysneuro (Qingdao) Tech. Co, Ltd
Liu, Xuechen	Shandong Univ. of Sci. & Tech.

Reliable environmental perception under low-illumination and nighttime conditions remains a critical challenge for the safety of autonomous driving systems. Conventional visible-light cameras suffer from severe performance degradation due to insufficient lighting and glare. This paper proposes a robust, low-overhead perception framework for nighttime vehicle detection and depth estimation using monocular infrared thermal imaging. First, an adaptive image enhancement algorithm based on histogram distribution is employed to improve the contrast of infrared targets and mitigate the inherent noise of thermal sensors. Second, we introduce YOLO26, a state-of-the-art native end-to-end detection architecture, and adapt it via transfer learning. By integrating Small-Target Aware Labeling (STAL) and a hybrid MuSGD optimizer, the model achieves high-precision vehicle identification with stable convergence. Furthermore, to address the computational bottlenecks of 3D spatial localization, a depth estimation model based on vehicle bottom-boundary regression is established. Statistical analysis reveals that a dual exponential fitting function optimizes the mapping between vertical image coordinates and longitudinal distance, ensuring high accuracy with minimal computational cost. Experimental results across diverse nighttime scenarios demonstrate that the proposed detection model achieves a precision of 95.4% and an F1-Score of 94.3%, while the depth estimation module restricts the mean error to 4.2%. By leveraging the unique thermal signatures of infrared imaging, this framework provides an optimal balance between detection robustness and computational efficiency. It offers a cost-effective and scalable solution for all-weather autonomous driving perception, particularly in environments where ambient illumination is absent.

▶ SatA01-6 15:10–15:30

Vehicle-Pose-Aware Effective Target Recognition for Automotive Radar

Wang, Zhangu	Shandong Univ. of Sci. & Tech.
Bu, Zhao	Shandong Univ. of Sci. & Tech.
Li, Zhenye	Qingdao Lulu Agricultural Equipment Co, Ltd
Cheng, Lingping	Shandong Univ. of Sci. & Tech.
Li, Zhaoyu	Qingdao Univ. of Tech., Linyi
Wang, Wenkai	Ysneuro (Qingdao) Tech. Co, Ltd
Li, Zhengzhao	Shandong Univ. of Sci. & Tech.

While mmWave radar is essential for autonomous driving environmental perception due to its robust performance in adverse weather, traditional 2D radars struggle with target classification and performance degradation caused by vehicle pose variations during dynamic driving. To address this issue, this paper introduces a pose-aware object recognition method. Initially, this paper constructed a 77 GHz radar experimental testbed. Radar echo features (radial velocity, longitudinal range, and RCS) were fused with synchronized real-time motion data to train and evaluate various machine learning models. Experimental results identify XGBoost as the optimal classifier, effectively capturing the non-linear dynamics between vehicle pose and radar signals. Experimental results demonstrate that the proposed method achieves an overall recognition accuracy of 97.5%, a 97.8% true recognition rate, and a false discovery rate of 2.7%. Experimental verification demonstrates that compared with traditional threshold segmentation methods and models using only radar data, integrating vehicle pose information can significantly improve detection stability and reduce false alarms. This method fully exploits the performance of standard 2D radar hardware and provides a highly reliable and cost-effective solution for improving accuracy.

SatA02 13:30–15:30 Changle Hall

Invited Session: Estimation and Compensation of System Uncertainties: Methods and Applications (I)

Chair: Chen, Zhixiang Qingzhou Hi-tech

Co-Chair: Wang, Yongshuai Tiangong Univ.

▶ SatA02-1 13:30–13:50

Weak-Model-Dependent Disturbance Rejection Decoupling Control for Wide-Envelope Flight Vehicles

Wang, Yongshuai	Tiangong Univ.
Zhang, Di	Tiangong Univ.
Xia, Chengyi	Tiangong Univ.
Sun, Mingwei	Nankai Univ.

This paper proposes a weak-model-dependent disturbance rejection decoupling control strategy for symmetric wide-envelope flight vehicles, which only relies on the relative order of the flight dynamic system. First, a high-gain extended state observer is employed to estimate the total disturbances (including input gain) and flight states. Then, a multi-time-scale separation approach is adopted to approximatively solve for the yaw and roll control deflections, thereby achieving online decoupling of the input gain matrix and attitude tracking control. Finally, numerical simulations are conducted to verify the effectiveness and robustness of the proposed design.

▶ SatA02-2 13:50–14:10

Improved Extended State Observer for Quadrotor UAV Tracking Control

Zheng, Ning	China Three Gorges Univ.
Wang, Yaqi	China Three Gorges Univ.
Mei, Qicheng	China Three Gorges Univ.
Zhu, Chi	China Three Gorges Univ.
Chen, Zijian	CHINA THREE GORGES Univ.

Active Disturbance Rejection Control (ADRC) has been widely applied in industrial electronics due to its powerful disturbance rejection capabilities. However, the performance of its core component, the Extended State Observer (ESO), is fundamentally limited by an inherent trade-off: high observer bandwidth is essential for high-precision disturbance tracking, but it inevitably leads to excessive amplification of measurement noise, resulting in control chattering and degraded steady-state accuracy. This paper proposes a Filter-based Dual-channel Extended State Observer (Filter-DESO) to effectively suppress noise and improve disturbance compensation accuracy. Experimental results on a quadrotor UAV demonstrate that the Filter-DESO achieves superior disturbance compensation performance compared to the traditional ESO.

▶ SatA02-3 14:10–14:30

A Parallel State Observer Integrated LSTM Framework for Target Acceleration Estimation and Prediction

Zhang, Xilian	Beijing Aerospace Automatic Control Inst.
Wang, Huixia	Beijing Aerospace Automatic Control Inst.
Wang, Zhaolei	Beijing Aerospace Automatic Control Inst.
Yang, Tuo	Peking Univ.

This paper proposes a novel framework for target acceleration estimation and prediction by integrating a parallel state observer (PSO) with a long short-term memory (LSTM) network. The PSO, specifically developed for multi-input multi-output (MIMO) systems, provides robust estimates of the target acceleration, which are subsequently used to train the LSTM network for predicting future accelerations. Through this process, information regarding target uncertainties is obtained in advance. As a result, the proposed framework achieves accurate estimation and prediction of target acceleration, thereby enhancing the system's capability to perceive previously unknown information. Simulation results demonstrate the effectiveness of the proposed method.

▶ SatA02-4 14:30–14:50

GNSS-IMU Integrated Navigation Based on Extended Kalman Filter: Design and Verification

Zhang, Lianpeng	Qingzhou High-tech Inst.
Liu, Fanghong	Qingzhou High-tech Lnstitute

This study focuses on the demand for high-precision six-degree-of-freedom pose information in cutting-edge technologies such as autonomous driving, and delves deeply into the integrated navigation technology of Global Navigation Satellite System (GNSS) and Inertial Navigation System (INS). To this end, a GNSS/INS loosely integrated navigation system based on the Extended Kalman Filter (EKF) is proposed, with multi-sensor data fusion achieved through an error state model and measurement equation. At the research method level, the

GNSS/INS loosely integrated navigation model is elaborated in detail. The "east-north-up" (ENU) geographic coordinate system is adopted to construct a 15-dimensional state vector. The system employs the EKF algorithm to address nonlinear problems, and linearizes the Jacobian matrix function to realize recursive optimal estimation. To verify the system performance, a GNSS-Inertial Measurement Unit (IMU) hardware platform was established, and a dynamic vehicle experiment was designed. High-precision micro-electro-mechanical systems (MEMS)-IMU and GNSS receiver were used to collect data on urban roads, with time synchronization ensured to guarantee data consistency. In terms of position error, the errors in the east and north directions are mostly within ±2 meters, and the peak error can reach 2 to 3 meters, indicating the limitations of this model in dynamic scenarios. In terms of attitude estimation, the EKF algorithm effectively enhances the stability and accuracy of the heading angle, suppresses IMU drift, and maintains the fluctuations of the roll angle and pitch angle within ±5°.

▶ SatA02-5 14:50–15:10

Cooperative Formation Control Design for Multiple Ground Unmanned Vehicles

Chen, Qi — Qingzhou High-tech Inst.
Wang, Jingyu — Qingzhou High-tech Inst
Chen, Zhixiang — Qingzhou Hi-tech

This paper is concerned with the problem of formation control for multi-agent unmanned vehicle systems. This paper proposes an improved distributed formation control strategy based on kinematic modeling. Based on the traditional leader-follower control architecture, the strategy introduces virtual reference robots as an intermediate coordination mechanism. The complex multi-robot formation control problem is transformed into a trajectory tracking control problem between each follower robot and its corresponding virtual robot. Based on the kinematic model of a three-wheeled mobile robot, a proportional control method based on error feedback is designed. The controller adopts a proportional control law to compute linear velocity and angular control inputs. Simultaneously a proportional control law with a feedforward compensation term is employed to achieve precise adjustment of the control angle. Simulation results demonstrate that the proposed control method can effectively guide the multi-robot system to quickly and stably form the desired formation, while realizing the asymptotic convergence of position errors to small values.

▶ SatA02-6 15:10–15:30

Adaptive Safety Time Interval and Improved PID Design Based on Most Dangerous ACC Condition

Shang, Jianhao — Qingzhou High-tech Lnstitute
Wang, Xinyu — Qingzhou High-tech Lnstitute
Chen, Zhixiang — Qingzhou Hi-tech

自适应巡航控制（ACC）系统是先进驾驶辅助系统的核心功能。传统的固定安全距离策略未能平衡安全与交通效率，且从期望距离到电机扭矩指令的完整控制链研究不足。为解决这些问题，本文设计并实现了一种从实时感知到扭矩执行的闭环控制算法。首先，建立车辆纵向动力学模型作为控制器设计的基础。提出了一种分层控制架构。上层决策层动态计算最优跟随距离。它通过基于最危险制动条件的自适应安全距离算法，平衡安全性与效率。下层控制采用改进的PID控制器，将距离误差直接映射到扭矩指令中。通过误差动力学建模和稳定性分析，控制器参数通过Routh准则确定。系统的动态性能（相位裕度48.69°）和鲁棒性通过博德图得到验证。最后，利用MATLAB和CarSim进行联合仿真，证明所提算法实现了安全且平稳的车辆跟踪控制。

SatA03 13:30–15:30 Langyue Hall

Invited Session: Distributed Security Cooperative Control in Complex Environments

Chair: Che, Wei-Wei — Northeastern Univ.
Co-Chair: Zhang, Peng — Northeastern Univ.

▶ SatA03-1 13:30–13:50

Iterative Learning Control of Position-constrained Permanent Magnet Synchronous Motor Servo Systems under Varying Iteration Lengths

Wang, Zihao — Nanjing Tech Univ.
Shen, Mouquan — Nanjing Tech Univ.
Park, Ju Hyun — Yeungnam Univ

This paper focuses on iterative learning control of permanent magnet synchronous motor servo systems with output constraints under varying iteration lengths. A Barrier Lyapunov Function is adopted to deal with output constraints. An actual controller is constructed via backstepping approach. Segmented parameter updating laws are proposed to estimate parameter uncertainties and disturbances. A virtual error based Barrier Composite Energy Function is provided to demonstrate error convergence along the iteration axis under varying iteration lengths. Finally, the effectiveness of the proposed approach is verified by a second-order permanent magnet synchronous motor servo system.

▶ SatA03-2 13:50–14:10

Compensation-based Model-Free Adaptive Control for High-Order Nonlinear Systems under DoS Attacks

Feng, Siwei — Shenyang Aerospace Univ.
Liu, Dong — Shenyang Aerospace Univ.
Wang, Yuxuan — Shenyang Aerospace Univ.
Wang, Xin — Heilongjiang Univ.

This paper investigates the data-driven tracking control problem for a class of discrete-time high-order nonlinear systems subjected to denial-of-service (DoS) attacks. Firstly, backstepping method reduces the control of high-order nonlinear systems to the recursive stabilization of a first-order cascade. Secondly, based on the dynamic linearization techniques, each first-order system can be represented equivalent linear data models. Then, a new data-driven control method including a predictive compensation scheme proposed to minimize the impact of DoS attacks is designed only by using I/O signals. Finally, mathematical simulation is given to validate the effectiveness of the framework.

▶ SatA03-3 14:10–14:30

Hierarchical Distributed Data-Driven Platooning Containment Control with Obstacle Avoidance

Che, Wei-Wei — Northeastern Univ.
Zhang, Peng — Northeastern Univ.

This article proposes a novel hierarchical distributed data-driven platooning containment control scheme with obstacle avoidance for nonlinear two-dimensional (2-D) vehicular platoon ing systems (VPSs). Firstly, an equivalent linear data model of heterogeneous VPSs with the incremental form is acquired. Then, for the purpose of solving the platooning containment tracking control problem, a hierarchical control framework is constructed, which includes an adaptive distributed observer and a data-driven adaptive tracking controller. Due to the part of following vehicles are unable to get direct access to the leading vehicles' information, the convex hulls of leading vehicles are estimated and generated by the distributed observer and used to guide the following vehicles. In addition, an artificial potential function method is developed to avoid collisions between the VPSs and environmental static obstacles. Furthermore, a decentralized data-driven adaptive controller with obstacle avoidance is proposed to make all the following vehicles to reach the convex hulls spanned by the leading vehicles in complex obstacle-laden environment, where the stability of VPSs is guaranteed through the linear matrix inequality technique and the energy function. Eventually, the validity of the developed control approach is explained by comparisons.

▶ SatA03-4 14:30–14:50

Neural Network-Based Data-Driven Security Control for UMVs under FDI Attacks with TGAI Operator

Liu, Huiying — Shanghai Jiao Tong Univ.
Hao, Li-Ying — Dalian Maritime Univ.

Unmanned marine vehicles (UMVs) increasingly operate over open, heterogeneous networks, where false data injection (FDI) attacks can covertly corrupt sensory feedback and degrade tracking performance or even destabilize the closed loop. Meanwhile, accurate hydrodynamic modeling remains difficult due to strong coupling, nonlinearity, and time-varying uncertainties, which limits model-based security control. To address these challenges, we develop a neural-network-based, data-driven security control framework for UMVs under FDI attacks and external disturbances. First, an equivalent incremental data-driven model is adopted to avoid explicit dependence on precise dynamics. On this basis, we design a multi-task hybrid neural predictor that integrates a causal temporal convolutional network, deep bidirectional gated recurrent unit networks, and a temporal multiplicative attention module, with task-specific heads to jointly learn the coupled nonlinear dynamics term, estimate FDI attack signals, and reconstruct clean outputs for control. To improve numerical stability and reduce computational burden in long-horizon sequence learning, we further introduce a differentiable Tanh-gated Additive Interaction operator to replace dense multiplications in the backbone modules while maintaining expressive modeling capability. Finally, combining the reconstructed clean output with the learned uncertainty/attack information, a data-driven integral sliding-mode security controller is constructed to enhance robustness against disturbances and deception. Simulations on a Cybership II platform validate the proposed method, demonstrating

improved attack-resilient tracking accuracy and robustness compared with baseline schemes.

▶ SatA03-5 14:50–15:10

Observer-Based Model-Free Adaptive Heading Control for An Unmanned Surface Vehicle with False Data Injection Attacks

Zhao, Yihang Qingdao Univ.
Liu, Yongchao Qingdao Univ.
Li, Shuaixi Qingdao Univ.

In this paper, an observer-based model-free adaptive control (MFAC) strategy is proposed for the unmanned surface vehicle (USV) heading system with false data injection attacks. First, the heading control strategy proposed in this paper only utilizes the input and output data of the heading system and does not rely on the model information. Second, an observer for the heading system is constructed and controller design with the heading observer can reduce the assumption of standard MFAC and avoid the quasi-linear problem that exists in the application of standard MFAC in the heading system. In addition, the estimated value of the heading angle is used in controller design instead of directly using the heading value with false data injection attacks can reduce the negative impact of attacks.Finally, the simulation experiment validates the effectiveness of the heading control strategy.

▶ SatA03-6 15:10–15:30

Model-Free Adaptive Predictive Control for Subway Trains under Channel Fading

Liu, Genfeng Henan Univ. of Tech.
Zhang, Wenhui Henan Univ. of Tech.
Wang, Yangyang PLA Strategic Support Force Information Engineering Univ.

In this paper, a model-free adaptive predictive control (MFAPC) scheme based on fading compensation is proposed for subway trains under channel fading. Firstly, by using the compact format dynamic linearization method, the complex nonlinear train system is transformed into an equivalent input-output data model. Secondly, considering the characteristic that channel fading is a multiplicative random disturbance, an output signal compensation mechanism is designed, and the compensated signal is introduced into the MFAPC framework. Theoretical analysis proves the convergence of the proposed algorithm in the mean sense and the bounded stability of the closed-loop system's input and output. Simulation results show that the proposed algorithm has better control performance in speed tracking and position tracking.

SatA04 13:30–15:30 Xinghui Hall

Regular Session: Data-Driven Control and Its Applications (I)

Chair: Liang, Jiaqi Henan Polytechnic Univ.
Co-Chair: Liu, Zhiqing Qingdao Univ. of Sci. & Tech.

▶ SatA04-1 13:30–13:50

Distributed Data-Driven Learning Consensus Tracking Control for Nonlinear Continuous-Time Multi-Agent Systems

Meng, Bo Shandong Univ. of Sci. & Tech.
Xu, Kechao Harbin Inst. of Tech.
Wan, Zhenyang National Univ. of Singapore
Zhen, Wang Shandong Univ. of Sci. & Tech.

This article presents a distributed data-driven iterative learning control protocol for nonlinear continuous-time multiagent systems communicating in random topology. The proposed P-type iterative learning controller in this article is essentially a model-free data-driven controller, which is designed using a novel dual-learning approach and only utilizes the input and output information of agent. By employing the rigorous Gronwall inequality, convergence of the system output error in multi-agent systems can be achieved within the transformed communication structure. The effectiveness of this method is validated through a simulation example.

▶ SatA04-2 13:50–14:10

PI Iterative Feedback Tuning for Load Frequency Control in Wind-Integrated Power Systems

Zeng, Yiming Jiangnan Univ.
Xu, Dezhi Southeast Univ.
Ji, Xunsheng Jiangnan Univ.
Pei, Jinlei Jiangnan Univ.
Hu, Guanyang Jiangnan Univ.
Hua, Fei Jiangnan Univ.
Zhang, Weiming Taizhou Univ.

In modern power systems, high renewable energy penetration and multi-area interconnection structures increasingly drive growing complexity. Load frequency control (LFC) faces multiple challenges including modeling difficulties, parameters time-varying, and load disturbances. Traditional fixed-gain PI controllers struggle to maintain robust dynamic performance in varying operating conditions. To address this, this paper proposes a data-driven PI tuning method independent of precise mathematical models. This method constructs a comprehensive performance criterion that accounts for frequency deviation and power generation control, based on the measured input/output (I/O) data during power system operation. By adjusting PI parameters online through an iterative feedback tuning (IFT) mechanism, it achieves adaptive response to complex disturbances in power systems. A three-area interconnected power system incorporating wind power is employed as the simulation model. Simulation results demonstrate the proposed method effectively maintains frequency control accuracy under both random wind power and load disturbances. This work provides a practical control method for LFC under conditions where power system models are unknown or difficult to identify.

▶ SatA04-3 14:10–14:30

Accurate Data-Component-Adjustment Anti-Stagnation-based Model-Free Predictive Control on PMSM Drives

Wei, Yao Chinese Acad. of Sci.
Lan, Mingyan Fujian Normal Univ.
Chen, Yuanhang Fuzhou Univ.
Ma, Weiyuan Fujian Agriculture & Forestry Univ.
Xie, Haotian Haixi Inst.s, Chinese Acad. of Sci.
Wang, Fengxiang Chinese Acad. of Sci.

Model-free predictive control (MFPC) has great potential for application in permanent magnet synchronous motor (PMSM) drives due to its essential robustness. However, for some data-driven models based on data gradients in MFPC, stagnation is a major challenge, as it indirectly increases the update frequency and has negative impacts on control performance. To address the stagnation and its impacts, an accurate data-component-adjustment anti-stagnation-based MFPC is proposed in this paper, implemented as a current controller in PMSM drives. By analyzing the fundamental frequency-band harmonic contents generated by modulation through the double-Fourier principle, a multi-second-order generalized integrator (MSOGI) is designed, aiming to accurately extract these harmonics and resubmit them into the sampled data with reversed phases and different amplitudes. This process is used to clean modeling data and generate mandatory gradients to prevent stagnation, while not compromising system stability by excessively extracting data components. The stability of the proposed method is verified through theoretical analysis, and its effectiveness is confirmed by experimental results, as well as advantages on current quality and model adaptability.

▶ SatA04-4 14:30–14:50

Model-Free Finite-Time Control for Multi-Agent Systems

Lin, Qingtian Qingdao Univ. of & Sci. & Tech.
Liu, Zhiqing Qingdao Univ. of Sci. & Tech.
An, Zhiying Qingdao Univ. of Sci. & Tech.
Chi, Ronghu Foshan Univ.

This paper proposes a model-free finite-time control (MFFTC) scheme for consensus tracking in nonlinear multi-agent systems with unknown dynamics. A linear data model (LDM) is constructed by using only local input-output measurements. Based on this LDM, a fractional-order control law is designed with an adaptive estimation mechanism for pseudo partial derivatives. The proposed MFFTC guarantees the finite-time convergence of tracking errors to a prespecified bound without relying on any prior model knowledge. Simulation studies validate the effectiveness of the MFFTC method in achieving bounded consensus tracking within finite time instants. Simulation illustrates the theoretical results.

▶ SatA04-5 14:50–15:10

Pitch Control of Wind Power Systems Using Nonlinear Hammerstein Model

Li, Jinqiang Jiangsu Univ. of Tech.
Li, Feng Jiangsu Univ. of Tech.

This paper addresses the variable pitch control problem of wind power generation system, and constructs wind power systems model through a Hammerstein model consisting of a static nonlinear module and a dynamic linear module. In the Hammerstein model construction, we utilize a neuro-fuzzy network (NFN) and an auto-regressive moving average (ARMA) model. To identify the Hammerstein model parameters, we introduce Gaussian signals to separately estimate the NFN and ARMA model parameters. Firstly, based on Gaussian signals, the ARMA mod-

el parameters are identified using correlation analysis. Then, based on wind speed and power of wind power systems, the NFN parameters are identified using a recursive least squares method. Furthermore, based on the identified Hammerstein model, a variable pitch control strategy is developed to regulate wind turbine output power under stochastic wind speed variations. The conducted simulation results verified that the developed methodology could predict accurately wind power and improve pitch control performance, ensuring stable power regulation near the rated operating condition.

▶ SatA04-6 15:10–15:30

Transformer-Based Model Predictive Control for Concentrate Fe Grade Tracking in Flotation Processes

Yi, Junxuan Beijing Univ. of Tech.
Wang, Kang Beijing Univ. of Tech.
Li, Xiaoli Beijing Univ. of Tech.

The flotation process exhibits strong nonlinearity, multivariable coupling, and time-varying characteristics, making concentrate Fe grade regulation challenging. In data-driven model predictive control (MPC), closed-loop performance is sensitive to multi-step prediction errors over the receding horizon. This paper proposes a Transformer-based nonlinear MPC scheme (Trans-MPC), where a full-state multivariable time-series predictor is embedded into constrained rolling optimization with online bias compensation. The proposed design improves prediction consistency and mitigates error accumulation in receding-horizon control. Industrial data–based simulations show that Trans-MPC achieves smoother tracking and significantly reduced overshoot compared with a CNN-based MPC baseline, indicating its effectiveness and engineering feasibility.

SatA05 13:30–15:30 Meixue Hall
Regular Session: Model-Free Adaptive Control

Chair: Zhao, Huarong Jiangnan Univ.
Co-Chair: Xu, Dezhi Southeast Univ.

▶ SatA05-1 13:30–13:50

Delta Operator Based Model-Free Sliding Mode Control for Second-Order Systems

Hua, Fei Jiangnan Univ.
Xu, Dezhi Southeast Univ.
Zhang, Weiming Taizhou Univ.
Pan, Tinglong Jiangnan Univ.
Yang, Weilin Jiangnan Univ.
Huang, Wentao Jiangnan Univ.
Hu, Guanyang Jiangnan Univ.
Pei, Jinlei Jiangnan Univ.

This study investigates the trajectory tracking control problem for a class of uncertain second-order systems under high-frequency sampling conditions. Traditional discrete-time designs often suffer from numerical instability, therefore, the delta operator is adopted to construct a unified model framework that approximates continuous-time behavior. To bypass the requirement for accurate system identification, a model-free control architecture is established using a data-driven ultra-local model (ULM). Subsequently, a disturbance observer is synthesized to reconstruct total system disturbances, including parameter variations and external noise. Based on the compensated dynamics, an integral sliding mode control (ISMC) law is derived to ensure system stability and tracking convergence. Numerical simulation results confirm the effectiveness of the proposed strategy in maintaining robust performance.

▶ SatA05-2 13:50–14:10

Model-Free Predictive Control for Nonlinear MASs with Unknown Actuator Faults and Stochastic Data Dropouts

Chuai, Ce Nankai Univ.
Cao, Ao Nankai Univ.
Chen, Tongtong Tianjin Sino-German Univ. of Applied Sci.
Wang, Fuyong Nankai Univ.

The resilient fault-tolerant predictive consensus control problem for nonlinear multi-agent systems with unknown actuator faults and stochastic data dropouts is explored in this paper. To avoid unknown dynamics, the data mapping of agents is built by the locally dynamic linearization technique. In the cyber layer, the stochastic data dropout process is supposed to follow the Bernoulli distribution with duration and frequency constraints, and a backward data compensation strategy is established. In the physical layer, an adaptive fault compensation mechanism derived from the improved projection algorithm is developed. Within this design, a model-free adaptive predictive consensus control method is developed to ensure the dual guarantee. The stability analysis of the method is given by the contraction mapping principle. Finally, experiments affirm the formulated method.

▶ SatA05-3 14:10–14:30

Improved Data-driven Control Based on Incremental PD for Piezoelectric Micro-Scanning Stage

Chu, Wei Changchun Inst. of Optics, Mechanics & Physics, Chinese Acad. of Sci.
Xu, Rui Changchun Inst. of Optics, Mechanics & Physics, Chinese Acad. of Sci.
Tian, Dapeng Chinese Acad. of Sci.

Piezoelectric micro-scanning stages (PMSSs) are known for their nanometer-level resolution, high bandwidth, and ease of integration. However, under complex airborne operating conditions, multi-source disturbances, such as variations in aircraft attitude and temperature fluctuations, can severely compromise control performance. To address this challenge, we propose an improved data-driven adaptive control (IDDAC) method. The approach introduces a second-order compact-form dynamic linearization model, which captures a wider range of system dynamics and incorporates input increments from the two previous control steps, especially under strong time-varying disturbances, improving dynamic tracking accuracy. Furthermore, a proportional-derivative (PD) control law is integrated with an online pseudo-partial-derivative (PPD) estimation algorithm. The PD term not only accelerates convergence but also enhances system robustness and steady-state accuracy, which are crucial for disturbance rejection. Theoretical analysis proves the uniformly ultimately bounded stability of the closed-loop system. Simulation results demonstrate that, compared to conventional model-free adaptive control (MFAC) method, the proposed method achieves faster transient response and reduced tracking error, showcasing superior tracking performance.

▶ SatA05-4 14:30–14:50

MFAPC Control for Variable Speed Adjustment of Boil-off Gas Compressor in LNG Fuel Supply System

Cheng, Pengfei Qingdao Univ. of Sci. & Tech.
Yue, Yaobin Qingdao Univ. of Sci. & Tech.
Dong, Songli Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Chi, Ronghu Foshan Univ.
Yao, Wen-Long Qingdao Univ. of Sci. & Tech.

To address the issues of frequent changes in working conditions, difficulty in establishing precise models, and insufficient dynamic response of traditional control methods in LNG supply systems, this paper proposes a variable frequency speed regulation strategy based on model-free adaptive predictive control. Firstly, considering the nonlinear characteristics of the BOG compressor system, a data-driven prediction model is established, and a multi-step forward prediction equation is constructed. Secondly, a rolling optimization strategy aiming at minimizing the speed tracking error is designed, with the control law updated online to achieve accurate speed tracking. Additionally, a dynamic compensation mechanism is introduced to enhance the system's disturbance rejection capability and steady-state accuracy, and a model-free adaptive predictive controller is designed. Finally, MATLAB/Simulink simulations are conducted for comparative analysis with traditional PID control. The results demonstrate that the proposed method significantly improves the dynamic response speed and control accuracy of the BOG compressor, providing a feasible technical approach for the adaptive operation of BOG compressors in LNG receiving stations.

▶ SatA05-5 14:50–15:10

Smooth Saturation Control for Redundant Manipulator Trajectory Tracking Based on Dynamic Neural Networks

Yu, Chenling Lanzhou Univ.

This paper addresses the high-precision trajectory tracking control of redundant manipulators while maintaining smooth joint velocities. Based on the framework of dynamic neural networks for redundancy resolution, a novel control scheme combining hyperbolic tangent (tanh) smooth saturation with velocity compensation is proposed. The tanh function provides a smooth, nonlinear saturation mechanism that effectively eliminates chattering under high feedback gains while guaranteeing strict joint velocity bounds. By integrating a first-order dynamic compensator, the proposed method enhances tracking accuracy through Jacobian transpose mapping without requiring complex matrix inversion. Simulation studies on a 6-DOF PUMA560 manipulator demonstrate that the proposed method achieves an RMS tracking error of $9.01times10^{-4}$ m.

Compared to unsaturated controllers, the approach yields a 57% reduction in velocity variance and energy consumption, validating the effectiveness of smooth saturation for precision robotic applications.

▶ SatA05-6 15:10–15:30

Model-free Adaptive Control for An Inverted Pendulum System with Real-time Experiments

Wang, Xin — Jiangnan Univ.
Zhao, Huarong — Jiangnan Univ.
Ye, Yiyang — Taizhou Product Quality & Safety Testing Inst.
Peng, Li — Jiangnan Univ.

This paper presents a dual-loop control scheme for a rotating inverted pendulum system. Firstly, the inner loop employs a proportional-integral-derivative control method to stabilize the swing angle, while the outer loop uses a model-free adaptive control method to adjust the position of the rotating arm. Subsequently, based on the stability of the inner loop and system data, a compact form dynamic linearization model is constructed, and an adaptive control law with online parameter estimation is designed. Then, based on the proposed theoretical framework, the convergence of the control error is proved. Finally, simulation and hardware experiments demonstrate the effectiveness of the proposed method.

SatA06 13:30–15:30 Guibin Hall

Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (I)

Chair: Li, Dazi — Beijing Univ. of Chemical Tech.
Co-Chair: Gao, Huihui — Beijing Univ. of Tech.

▶ SatA06-1 13:30–13:50

A Two-Stage Remaining Useful Life Prediction Method for Rolling Bearings Based on Attention Enhanced Time-Frequency Transformer

Gao, Huihui — Beijing Univ. of Tech.
Feng, Tianyang — Beijing Univ. of Tech.
Gao, Xue-Jin — Beijing Univ. of Tech.

Reliable prediction of bearings' remaining useful life (RUL) holds great significance for predictive maintenance practices in industrial systems, but traditional methods face two key issues: 1) external disturbances hinder accurate first prediction time (FPT) identification; 2) high-dimensional run-to-failure signals make effective degradation information capture difficult, compromising prediction performance. To solve these, a two-stage RUL prediction method based on an attention-enhanced time-frequency Transformer is proposed. Stage 1 designs a dual-index alert mechanism (DIAM) robust to interference for FPT identification, which uses root mean square (RMS) and kurtosis to update alarm thresholds, integrating degradation identification and noise resistance. Stage 2 develops an attention-enhanced time-frequency Transformer (AE-TFT) to improve RUL prediction by learning degradation information from time-domain and frequency-domain (TDFD) features. AE-TFT includes an attention-enhanced feature fusion (AEFF) module to strengthen TDFD features and introduces convolution in multi-head attention (MHA) to capture local degradation information. Validated on IEEE PHM Challenge 2012 bearing dataset, results show the method outperforms state-of-the-art (SOTA) methods in FPT identification robustness and RUL prediction accuracy.

▶ SatA06-2 13:50–14:10

A Cooperative Structural Defect Detection Method Based on Homogeneous MFL-EMAT

Feng, Yunning — Northeastern Univ.
Feng, Jian — Northeastern Univ.
Li, Qiangxin — Northeastern Univ.
Li, Yajing — Northeastern Univ.
Yao, Yu — Northeastern Univ.

To address the inherent limitations of single-modality non-destructive testing techniques in operational structural component inspection—such as depth coverage and spatial blind spots—this paper proposes a full-depth defect detection method based on uniform magnetic flux leakage (MFL) and electromagnetic acoustic transducers (EMAT). By designing an obliquely incident EMAT with variable angles in the target detection zone to control ultrasonic propagation direction, this method effectively suppresses reverse interference and false sidelobe peaks often caused by traditional bidirectional propagation, thereby reducing detection blind spots. To address highly coupled and aliasing multi-physics signals in the collaborative detection system, this paper further proposes a decoupling strategy combining frequency-modulated coded time-division multiplexing (TDM) with matched filtering to achieve effective separation of composite detection signals. Experimental results demonstrate that this method enables blind-spot-free detection of both surface and back-wall defects without probe replacement. The main echo pulse width is reduced by 30.27%, and the signal-to-noise ratio is improved by 20.48 dB. The proposed framework provides a scalable engineering pathway for multi-technology integration and precision composite defect diagnosis based on a data-driven paradigm.

▶ SatA06-3 14:10–14:30

Nonstationary Process Monitoring with Joint-Optimized Design

Lu, Zhang — Shandong Univ. of Sci. & Tech.
Shi, Ze — Shandong Univ. of Sci. & Tech.
Zhong, Maiying — Shandong Univ. of Sci. & Tech.

In nonstationary industrial processes, the time-varying statistical characteristics are easily identified as anomaly, leading to decreased monitoring success rate and increased false alarm rate. Aimed at this problem, a nonstationary process monitoring strategy with joint-optimized design is proposed in this paper. Firstly, a multi-view feature fusion strategy is constructed to characterize the nonstationary states. Secondly, an abnormal monitoring model based on Gaussian mixture model is constructed, whose parameters can be derived by estimation network to reduce the computational complexity. Meanwhile, a joint-optimized design is applied to update the feature extraction and monitoring model simultaneously, where the indices about reconstruction error and log-likelihood function are considered. Thirdly, an abnormal monitoring strategy based on the negative log-likelihood function is designed to identify whether the faults occur. Finally, the date from wastewater treatment process are applied to validate the effectiveness of the proposed method. The results demonstrate that the proposed method can accurately monitor the anomaly while with reduced false alarm rate.

▶ SatA06-4 14:30–14:50

State of Health Estimation and Remaining Useful Life Prediction of Lithium-Ion Batteries Based on Physics-Constrained Federated Meta-Learning

Deng, Jie — Hubei Minzu Univ.
Hu, Yuhang — Hubei Minzu Univ.
Wang, Ximeng — Hubei Minzu Univ.
Liao, Yu — Hubei MinZu Univ.
Guo, Li — Anhui Polytechnic Univ.

Accurate state of health (SOH) estimation and remaining useful life (RUL) prediction for lithium-ion batteries are challenging under heterogeneous operating conditions and decentralized data storage. These challenges lead to issues such as data silos, reduced generalization ability of federated models, and insufficient physical consistency in the predictions. To address these challenges, this paper proposes FedReptile-DeepHPM, a physics-constrained federated meta-learning framework. By integrating the Reptile algorithm into federated training, the framework establishes an optimized global model initialization that enables clients to perform rapid and efficient personalized fine-tuning. Experiments were conducted on a three-client setup using the MIT–Stanford–Toyota joint dataset. The results demonstrate that the proposed method outperforms LSTM, PINN, and federated baseline models in both SOH and RUL predictions. The best performance for SOH was achieved with RMSPE/MAPE = 0.3264/0.1616, while the best RUL performance was obtained with RMSE/MAE = 19.92/16.87.

▶ SatA06-5 14:50–15:10

A Novel Orthonormal Neuron Subspace Analysis Network for Process Monitoring

Zhang, Handa — Beijing Univ. of Chemical Tech.
Li, Xiang — Beijing Univ. of Chemical Tech.
Hao, Weichen — Beijing Univ. of Chemical Tech.
Li, Dazi — Beijing Univ. of Chemical Tech.

Key performance indicator (KPI) related process monitoring is crucial for ensuring industrial production safety and product consistency, yet traditional multivariate statistical methods face limitations in handling nonlinear processes and balancing detection accuracy with computational efficiency. To address these challenges, this study proposes a novel orthonormal neuron subspace analysis (ONSA) framework for quality-related nonlinear process monitoring. The ONSA method first leverages neural component analysis (NCA) to extract low-dimensional, uncorrelated nonlinear latent variables from process and KPI data, overcoming the linearity constraint of conventional methods. These latent variables are then fed into orthonormal subspace analysis (OSA) for orthogonal decomposition, separating the data into KPI-related common subspaces and KPI-unrelated individual subspaces. Sliding window-based T2 and

SPE statistics are constructed to monitor anomalies in respective subspaces, enabling accurate identification of fault types. Numerical simulation experiments demonstrate that ONSA achieves higher fault detection rates for four typical industrial faults and maintains an ultra-low false alarm rate (FAR), outperforming traditional OSA-derived indices in detection sensitivity, fault adaptability, and reliability. This framework effectively integrates NCA's nonlinear feature extraction capability with OSA's precise subspace separation, providing a practical solution for quality-related monitoring in complex nonlinear industrial processes.

▶ SatA06-6 15:10–15:30

Improved Voiceprint Signal-based Power Equipment Fault Diagnosis Using Large Language Models

Chen, Jinning — Univ. of Sci. & Tech. Beijing
Zhang, Kai — Univ. of Sci. & Tech. Beijing
Han, Shuai — China Electric Power Research Inst.
Lu, Hongming — Univ. of Sci. & Tech. Beijing

Power equipment fault diagnosis directly impacts the reliability of power grid supply. Traditional methods suffer from bottlenecks including difficulties in multi-source data fusion, fragmented domain knowledge, and poor interpretability of diagnosis results. Large Language Models (LLMs) excel at processing unstructured data but are incapable of handling structured data collected by sensors, while traditional Small Models (SMs) are precisely adept at processing such structured data-rendering the two model types complementary. This paper proposes a fault diagnosis method integrating large and small models：on the one hand, a domain knowledge vector database is constructed using Retrieval-Augmented Generation (RAG) technology and Embedding models to optimize LLMs performance：on the other hand, Convolutional Neural Networks (CNNs) are employed to train domain-specific small models, and their diagnostic results are converted into natural language queries via a "template library+parameter filling" mechanism. These queries are then fused with retrieved knowledge and input into the Qwen model to generate diagnostic reports. Case studies on converter station equipment verify the reliability and advancement of the proposed method, which balances diagnostic accuracy, efficiency, and interpretability.

SatB01 15:40–17:40 Yangguang Hall

Invited Session: Intelligent Model-free Adaptive Control as New Engine for UAVs and Transportation

Chair: Yu, Xian — Shenzhen Univ.
Co-Chair: Zhu, Juanping — Yunnan Univ.

▶ SatB01-1 15:40–16:00

A Data-Driven Kalman Filtering for Unknown Nonlinear Systems

Shao, Sichao — Yunnan Univ.
Zhu, Juanping — Yunnan Univ.

This paper proposes a data-driven Kalman filtering (DD-KF) algorithm that operates solely on state measurements without requiring any prior system model information. By employing dynamic linearization (DL), the unknown nonlinear system is transformed into an equivalent linear representation. Then, the pseudo-gradient in the DL-based data model is first reformulated as a least-squares estimation problem, and the Kalman gain is subsequently optimized by minimizing the covariance of the posterior estimation error. Simulation results on a pendulum model demonstrate the effectiveness and reliability of the proposed method.

▶ SatB01-2 16:00–16:20

Model-Free Adaptive Finite-Time Bipartite Containment Control for Nonlinear MultiAgent Systems

Ge, Zhaojie — Inner Mongolia Univ.
Wang, Qian — Inner Mongolia Univ.
Xue, Yixuan — Inner Mongolia Univ.

This paper investigates the bipartite containment control problem for a class of unknown nonlinear multiagent systems. Addressing the issues of slow convergence rates and large transient overshoots existing in traditional data-driven methods, a model-free adaptive finite-time bipartite containment control scheme is proposed. The unknown nonlinear dynamics of agent is first transformed into an equivalent data model via the compact form dynamic linearization method. On this basis, a control scheme incorporating a bipartite containment error-dependent variable gain mechanism and a finite-time control law is designed. The variable gain mechanism adjusts the control intensity according to the bipartite containment error magnitude to balance the transient response and steady-state precision, while the finite-time term is introduced to improve the convergence rate. Numerical simulations and comparisons with the model-free adaptive bipartite containment indicate that the proposed scheme can effectively drive the followers into the convex hull formed by the leaders with improved transient performance.

▶ SatB01-3 16:20–16:40

Model-free Adaptive Iterative Learning Control with Applications to Quadrotors

Huang, Zhaoran — Shenzhen Univ.
Yang, Zunyao — Beijing Jiaotong Univ.
Yu, Xian — Shenzhen Univ.
Zhong, Xiaopin — Shenzhen Univ.

In practical applications, quadrotors are often required to execute repetitive trajectory tasks. However, this process is challenged by model uncertainties, time-varying characteristics, and external disturbances. To address these issues, this paper adopts the feedforward-feedback model-free adaptive iterative learning control (FFMFAILC) method based on full-form dynamic linearization. A PI controller is employed in the feedback loop to suppress non-repetitive disturbances, while the model-free adaptive iterative learning control (MFAILC) is utilized in the feedforward loop to learn tracking errors in the iteration domain, thereby enhancing tracking precision at each time instant. Simulation results demonstrate that FFMFAILC is significantly more effective than MFAILC at suppressing non-repetitive disturbances.

▶ SatB01-4 16:40–17:00

Hierarchical Quadrotor Path Planning: Integrating Adaptive Goal-Biased RRT with Control Barrier Function*

Huang, Jing — Shenzhen Univ.
Lai, Jialun — Guangzhou Maritime Univ.
Zhong, Xiaopin — Shenzhen Univ.
Yu, Xian — Shenzhen Univ.

Quadrotors are widely used in civil, industrial production, national defense and other fields due to their high maneuverability, low cost and multiple types of load. How to make the quadrotor stably and smoothly fly from point to point under the conditions of ensuring safety and taking into account dynamic constraints is still an urgent problem to be solved. The existing schemes have limitations: Relying only on global planning and local optimization to obtain a safe path cannot meet the needs of dynamic obstacle avoidance; only using reactive obstacle avoidance is difficult to meet the optimality and stability of the global path. In view of the above problems, the purpose of this paper is to construct a quadrotor path planning framework that can achieve the feasibility of global planning, local smoothness and real-time obstacle avoidance safety, so as to improve the autonomous flight ability and safety of quadrotor in dynamic obstacle environment.

▶ SatB01-5 17:00–17:20

CA-RCNN : Cascaded-Attention Networks for 3D Object Detection from LiDAR Point Clouds

Ji, Honghai — North China Univ. of Tech.
Liu, Xinjing — North China Univ. of Tech.
Liu, Shida — North China Univ. of Tech.
Ren, Ye — North China Univ. of Tech.
Fan, Lingling — Beijing Information Sci. & Tech. Univ.

3D object detection from LiDAR point clouds is a fundamental task in intelligent driving and urban scene perception. However, due to the inherent sparsity, uneven distribution, and severe long-range degradation of point clouds, accurately detecting distant vehicles remains challenging. To address these issues, we proposes CA-RCNN, a cascade attention-based 3D object detection network for LiDAR point clouds. Building upon a point–voxel fusion framework, CA-RCNN introduces three key components: a Cascade Attention-based Proposal Refinement (CAPR) module, a Semantic-Guided Farthest Point Sampling (SG-FPS) strategy, and a Multi-source Feature Fusion (MSFF) module. The CAPR module performs multi-stage proposal refinement with cascade attention, enabling progressive feature interaction across stages and iteratively improving the quality of bounding box regression and classification. The SG-FPS strategy assigns semantic-aware weights during keypoint sampling to enhance foreground representation while suppressing background interference, especially for distant and sparse objects. The MSFF module integrates point, voxel, and BEV features in a unified manner, enabling fine-grained interaction across multiple representations, multiple scales, and multiple points, thereby strengthening feature discriminability. Experiments on the KITTI datasets demonstrate that CA-RCNN consistently improves overall detection performance and achieves significant gains in distant vehicle detection tasks.

▶ SatB01-6 17:20–17:40

Extended State Observer Based Model Free Adaptive Compensatory Control for Subway Trains under Mixed Network Attacks

Liu, Genfeng — Henan Univ. of Tech.
Zhu, Jinbao — Henan Univ. of Tech.
Wang, Yangyang — PLA Strategic Support Force Information Engineering Univ.
Zhang, Wenhui — Henan Univ. of Tech.

This paper presents an extended state observer (ESO) based model free adaptive compensatory control, which is used for the control system of subway trains when the communication channel between sensors and the controller is subjected to mixed denial of service (DoS) and false data injection (FDI) attacks. For FDI attacks, the ESO is used to estimate the speed state and the lumped disturbance, thereby enhancing the system's robustness against uncertainties. To counter DoS attacks, an attack compensation mechanism predicts the current speed at the onset of the attack and recursively spreads it during the prolonged attack period; meanwhile, the pseudo partial derivative update is carried out in a conservative manner to prevent unsafe control situations that might compromise the controller data. Simulations show superior tracking accuracy over model free adaptive control, kalman filtering based model free adaptive predictive control, and PID.

SatB02 15:40–17:40 Changle Hall
Invited Session: Estimation and Compensation of System Uncertainties: Methods and Applications (II)

Chair: Wang, Yongshuai — Tiangong Univ.
Co-Chair: Chen, Zhixiang — Qingzhou Hi-tech

► SatB02-1 15:40–16:00
State Cooperative Control of Supercavitating Vehicles Based on Robust Model Predictive Control

Liu, Yong — Qingzhou High-tech Inst.
Chen, Zhixiang — Qingzhou Hi-tech

Aiming at the problem of high-amplitude, high-frequency planing forces during the state cooperative control of supercavitating vehicles, a robust model predictive control method is proposed. First, the planing forces are modeled as bounded disturbances. A robust model predictive control structure combining nominal predictive control with error feedback correction is designed to achieve cooperative control and tracking of four states: depth, pitch angle, lateral velocity, and pitch rate. Then, by constructing a terminal constraint set and an optimal value function, the recursive feasibility and asymptotic stability of the closed-loop system are proven. Finally, simulation experiments under depth-varying conditions verify the effectiveness of the proposed method.

► SatB02-2 16:00–16:20
Zero-Pole Configuration Criteria for Stable Step Responses with Single Overshoot

An, Jiale — Nankai Univ.
Sun, Mingwei — Nankai Univ.

This paper proposes a criterion for determining whether the step response of a plant with stable real poles and zeros exhibits a single overshoot or not. Such a specific response is highly desirable for many motion control scenarios, a point clearly demonstrated in this paper. The proposed criterion simply checks a particular " alternating distribution" pattern among the zeros and poles, which is straightforward, intuitive, and easy to interpret. Finally, we discuss how to utilize this criterion for zero-pole configuration design to achieve a single-overshoot step response, with two illustrative examples provided.

► SatB02-3 16:20–16:40
Performance Index Function without Control Input-based Modular Manipulator Optimal Tracking Control via Nonzero-sum Game

Ji, Zebin — Changchun Univ. of Tech.
Qin, Yi — Aviation Univ. of Air Force
Ma, Bing — Changchun Univ. of Tech.
Zhu, Xinye — Changchun Univ. of Tech.
An, Tianjiao — Changchun Univ. of Tech.

To address the challenge posed by optimizing an infinite-horizon performance index that inherently couples dynamic evolution with control actions within conventional adaptive dynamic programming frameworks, this study introduces an innovative optimal tracking control for modular manipulators via nonzero-sum game. Dynamic description of manipulator is formulated via Newton-Euler iterative algorithm. According to the proposed framework, each modular joint is deemed as an autonomous participant in nonzero-sum differential game. According to adaptive dynamic programming, tracking control objective is reformulated as an equivalent optimal regulation issue. Critic neural network is employed to approximate performance index without the control input, thereby enabling derivation of optimal tracking law. The closed-loop asymptotic stability of overall system is rigorously established via a dedicated theorem, and the practical effectiveness together with the optimal nature of approach are corroborated via experimental trials conducted on physical prototype platform.

► SatB02-4 16:40–17:00
Identifiability Analysis and Identification Design for A Class of Uncertain Rigid-Elastic Coupled System

Yin, Qianbao — Chinese Acad. of Sci.
Xue, Wenchao — Chinese Acad. of Sci.

This paper investigates the identifiability and identification of elastic frequency in uncertain rigid-elastic coupled systems. The necessary and sufficient condition for elastic modal frequency identifiability is established, and an upper bound on the relative identification error is derived. An extended state observer-based frequency identification method (ESOFI) is proposed achieve rigid–elastic separation. An ESO estimates the rigid-body modes timely and compensates for them in the measured output, after which the compensated signals are analyzed using a novel FFT-based procedure to extract the elastic modal frequency. Finally, simulation results validate the theoretical findings and demonstrate that the proposed algorithm achieves faster convergence and higher accuracy compared with conventional approaches.

► SatB02-5 17:00–17:20
Nonsingular Prescribed-Time Attitude Tracking for Rigid Spacecraft with Enhanced Extended State Observer

Zhang, Chuanzhi — Anhui Polytechnic Univ.
Tao, Meiling — Anhui Polytechnic Univ.
Ding, Siao — Anhui Polytechnic Univ.

This paper investigates high-precision attitude tracking control for rigid spacecraft subject to external disturbances and internal unknown dynamics. Based on unit quaternion kinematics, an enhanced prescribed-time extended state observer (EPTESO) is constructed to compensate for the lumped disturbances and avoid singularity problems within a prescribed time. The convergence time can be pre-assigned independently of initial conditions. To resolve the singularity inherent in conventional approaches, a C^1-continuous, practical prescribed-time adjustment (PPTA) mechanism is developed. A nonsingular prescribed-time controller based on the EPTESO compensation (EPTESO-NPTC) is proposed to ensure the practical prescribed-time stability (PPTS) of the closed-loop system. Simulation results verify the effectiveness of the proposed control strategy.

► SatB02-6 17:20–17:40
Time-Varying Bandwidth ADRC for Strict-Feedback Nonlinear Systems with Prescribed Performance Function

Jiang, Yan — Guangxi Univ.
Zhu, Jintao — Guangxi Univ.
Luo, Shixian — Guangxi Univ.

This paper investigates the trajectory tracking control problem for strict-feedback nonlinear systems subjected to unknown external disturbances. First, a recursive coordinate transformation is employed to map the original system into a canonical form characterized by generalized lumped disturbances. To accurately estimate these dynamics, a time-varying bandwidth extended state observer is proposed. By introducing a novel scaling function to dynamically adjust the observer bandwidth, this design effectively mitigates the peaking phenomenon inherent in traditional fixed-gain observers while maintaining high estimation precision. Building upon these estimates, an adaptive active disturbance rejection controller is synthesized. The proposed control scheme ensures that the tracking error strictly satisfies both transient and steady-state prescribed performance specifications. Rigorous Lyapunov-based analysis proves that the tracking error is tightly confined within the predefined performance bounds. Finally, simulation results validate the effectiveness and superiority of the proposed methodology.

SatB03 15:40–17:40 Langyue Hall
Invited Session: Adaptive Control Methods for Nonlinear Mechatronics Systems

Chair: Wang, Shubo — Kunming Univ. of Sci. & Tech.
Co-Chair: Zhao, Jun — Shandong Univ. of Sci. & Tech.

► SatB03-1 15:40–16:00
A Fractional-Order Sliding Mode Control Strategy for Thermal Management of Proton Exchange Membrane Fuel Cells

Zhao, Ziliang — Shandong Univ. of Sci. & Tech.
Jia, Jingyu — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Guo, Bin — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.
Fu, Yifan — Shandong Univ. of Sci. & Tech.
Ma, Duo — Shandong Univ. of Sci. & Tech.

The thermal management system of proton exchange membrane fuel cells (PEMFCs) exhibits strong nonlinearity, significant hysteresis, and time-varying parameters, making it challenging to establish an accurate mechanistic model. To address this issue, this paper proposes a fractional-order sliding mode-based temperature control strategy for PEMFCs. First, a lumped-parameter thermal dynamic model structure for the PEMFC is constructed based on the first law of thermodynamics. Utilising experimental input-output data, the Nonlinear Least Squares (NLS) algorithm is employed for offline identification of key physical parameters including heat generation coefficient, heat dissipation coefficient, and equivalent heat capacity, yielding a high-precision control-oriented model. Building upon this foundation, a fractional-order sliding mode controller is designed. Fractional calculus operators are introduced to augment control degrees of freedom, coordinating pump speed with the heating power of positive temperature coefficient (PTC) heating elements. Simulation results demonstrate superior control performance for the FOSMC strategy, reducing overshoot by 51.45%. Under step current disturbances, this strategy maintains stack temperature at 70℃with steady-state error confined within ±2℃, reducing settling time by 8.33%. Compared to conventional integer-order sliding mode control and PID algorithms, the proposed method significantly suppresses control chatter, demonstrating superior robustness and dynamic tracking performance.

▶ SatB03-2 16:00–16:20

Model-Free Optimal Control of Mixed Traffic Systems via Q-Learning with Driver Reaction Time

Song, Shurun — Shangdong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.

This paper focuses on the mixed traffic system on a single-lane ring road, where Connected and Autonomous Vehicle(CAV) are regarded as moblile control units. A model-free optimal controller that considers the reaction time of Human-Driven Vehicle (HDV) drivers is designed for the CAV based on an adaptive Q-learning approach, ensuring smooth traffic flow regulation. Specifically, the reaction time of human drivers is first modeled as a system state delay. The challenges of inherent nonlinearity and completely unknown system dynamics in the mixed traffic system are addressed using an adaptive dynamic programming (ADP) algorithm. By synchronously updating the adaptive Critic Neural Network (CNN) and Actor Neural Network (ANN) online, dependence on initial stable control strategies and hybrid structures is avoided. Additionally, a sliding mode control scheme is used to ensure the fast convergence of the CNN weights. Simulation results demonstrate the effectiveness of the proposed control method in smoothing traffic flow.

▶ SatB03-3 16:20–16:40

A Hybrid MC-BiTCN-N-BEATS Model for Predicting the Remaining Useful Life of Lithium-Ion Batteries

Zhang, Pei Yu — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.

The prediction of the remaining useful life (RUL) of lithium-ion batteries is crucial for ensuring the safety and reliability of battery systems. This paper proposes a novel hybrid deep learning model, MC-BiTCN-N-BEATS, to improve the accuracy of battery RUL prediction. The proposed model incorporates a Multi-channel Bidirectional Temporal Convolutional Network (MC-BiTCN) module to extract deeper spatial features from multidimensional battery charge-discharge data via bidirectional convolutions, coupled with the Neural Basis Expansion Analysis for time-series forecasting(N-BEATS) residual decomposition mechanism to capture complex dynamics in battery degradation. In this study, we comprehensively integrate charge and discharge behavioral features of batteries and employ Pearson correlation coefficient (PCC) analysis to screen variables highly correlated with RUL as multi-channel inputs, thereby enhancing the prediction accuracy and robustness of the model. Experimental results show that compared to single-model and single-channel methods, the proposed approach achieves superior performance in battery RUL prediction, with an MSE of 0.0005 and an R^2 of 98.60%.

▶ SatB03-4 16:40–17:00

Fixed-Time Prescribed Performance Control for Manipulator System with An Improved Extended State Observer

Chi, Teng — Qingdao Univ.
Zhou, Zhongkai — Qingdao Univ.
Wang, Shubo — Kunming Univ. of Sci. & Tech.

This paper focuses on the trajectory tracking control problem of nonlinear manipulator systems with unknown dynamics and unknown disturbances, and proposes a fixed-time sliding mode control strategy based on an enhanced nonlinear extended state observer (ESO). First, the non-smoothness issue inherent in the traditional ESO with the fal function is effectively addressed by refining its structure, thereby improving the observer's stability, adaptability and ability to estimate unknown disturbances. Second, a modified prescribed performance function is introduced to establish a state constraint mechanism, which strictly confines the system tracking error within predefined bounds and thus significantly improves the transient response and robustness of the system against unknown disturbances. Finally, a novel sliding surface is designed. By strategically integrating the improved ESO with this sliding surface, a composite sliding mode control framework is developed to optimize the system's dynamic performance and suppress the impact of unknown disturbances. The proposed method achieves high-precision trajectory tracking control for robotic manipulator systems through straightforward parameter tuning. To verify the effectiveness of the proposed scheme, comparative simulations are conducted on a two-link robotic manipulator. The results demonstrate that the proposed control strategy significantly improves tracking accuracy and error convergence speed, and has strong robustness against unknown disturbances, achieving superior overall performance.

▶ SatB03-5 17:00–17:20

Predefined-Time Robust Repetitive Learning Control for Rehabilitation Exoskeleton Robots

Xiao, Chunjie — Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.
Cheng, Yun — Zhejiang Univ. of Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.

This article proposes a predefined-time robust repetitive learning control (RLC) scheme for uncertain rehabilitation exoskeleton robots. In control design, the lumped uncertainty of the exoskeleton is divided into periodic and non-periodic parts by considering the periodic characteristics of reference trajectories, and a fully saturated repetitive learning law is constructed to estimate the periodic uncertainty. Meanwhile, a novel predefined-time disturbance observer (PTDO) is proposed to estimate and compensate for composite disturbances comprising the non-periodic uncertainty, external disturbance, and periodic uncertainty estimation error, such that the disturbance estimation error can converge rapidly and accurately. Compared to traditional RLCs, a non-singular predefined-time controller is developed to ensure the trajectory tracking error can converge into a small region around the origin within a predefined time, without requiring several periods of iterative learning. Besides, the "explosion of complexity" issue of the differentiating virtual control signals is effectively overcome by constructing a predefined-time filter in the backstepping control framework. Finally, simulation results validate the effectiveness of the proposed control scheme.

▶ SatB03-6 17:20–17:40

Monitoring Abnormal Tire Temperatures at Tunnel Entrances Using Infrared Thermography and YOLOv8

Zheng, Tong — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Li, Zhimin — Qingdao Lulu Agricultural Equipment Co, Ltd
Zhang, Jian — Shandong Univ. of Sci. & Tech.

To address the challenges of low accuracy in non-contact tire temperature monitoring within complex tunnel entrance environments, this paper proposes a real-time anomaly detection method integrating infrared thermography with the YOLOv8 deep learning algorithm. Leveraging the lightweight YOLOv8s architecture, the approach utilizes its integrated C2f modules and decoupled head design to effectively mitigate edge blurring in infrared imagery and suppress thermal noise interference from road surfaces, enabling precise localization of tire regions on high-speed vehicles. Building upon this, statistical analysis is employed to quantitatively assess tire temperatures and construct a multi-level dynamic warning mechanism for graded alerts. Experimental results demonstrate that the enhanced YOLOv8 algorithm achieves a precision of 92.4% and

an mAP@0.5 of 91.9%, significantly outperforming the YOLOv5 baseline. Simulation experiments further confirm the system's robustness against motion blur and its high accuracy in identifying overheating states, effectively eliminating false alarms caused by pavement thermal radiation. By integrating computer vision with thermodynamic principles, this research provides a robust technical framework for proactive tunnel safety prevention.

SatB04 15:40–17:40 Xinghui Hall
Regular Session: Data-Driven Control and Its Applications (II)
Chair: Yang, Xu Univ. of Sci. & Tech. Beijing
Co-Chair: Quan, Quan Beihang Univ.

► SatB04-1 15:40–16:00
Data-Driven Sliding Mode Security Control under Multi-Channel Deception Attacks
Tan, Menghan Donghua Univ.
Yang, Yekai Donghua Univ.
Zhao, Haijuan Qingdao Univ. of Tech.

This paper studies the sliding mode security control problem for a class of discrete-time systems subject to unknown model parameters and random cyber attacks. The stochastic characteristics of deception attacks is described using a finite-state Markov chain, where each mode corresponds to a distinct attack scenario occurring in a multi-channel communication network. To mitigate the effects of deception attacks, a sliding mode security controller is designed to ensure exponential ultimate boundedness of the closed-loop system and reachability of the sliding domain. By using the data-based representation of the dynamic system and pre-collected input/state data, sufficient conditions in data-based form are derived to eliminate the requirement for exact system parameters. Finally, simulation results validate the effectiveness of the proposed data-driven control scheme.

► SatB04-2 16:00–16:20
Multidimensional Frequency Interpolation for Missing Value Imputation of Device Clusters Time Series Data
Yan, Kai Guoneng Wuhai Energy Wuda Coal Processing Co., Ltd
Liu, Hanwen Guoneng Wuhai Energy Wuda Coal Processing Co., Ltd
Liu, Binyu Dalian Univ. of Tech.

In the intelligent monitoring and management of device clusters, the presence of missing values can significantly hinder real-time surveillance and introduce substantial bias into model-based analyses. Exploiting the inherent inter-dependencies within cluster data, we propose a multidimensional frequency-domain interpolation technique that leverages the coupling among multi-channel measurements to improve imputation accuracy even when only limited observations are available. Unlike approaches that operate directly on raw time-domain signals, the method performs interpolation in the rich complex-frequency domain, achieving superior reconstruction performance with a markedly lighter model footprint.

► SatB04-3 16:20–16:40
A Dual-Observer Method for Distributed Fault-Tolerant Leader–Follower Formation Control of Nonlinear Multi-Agent Systems
Xu, Shuwei North China Univ. of Tech.

This paper addresses the distributed fault-tolerant formation control problem for nonlinear second-order multi-agent systems with leader–following structure. A dual-observer based sliding mode control framework is proposed, comprising a distributed sliding-mode leader observer for state reconstruction, a double-power fixed-time nonlinear extended state observer for lumped disturbance estimation and a sliding-mode fault-tolerant controller. The closed-loop system achieves fixed-time stability with convergence time independent of initial conditions. Simulation results demonstrate the effectiveness of the proposed method against actuator faults and external disturbances.

► SatB04-4 16:40–17:00
Stable Tracking of Flapping-Wing Micro Aerial Vehicles Based on L-Learning
Abbasi, Saddam Hussain Beihang Univ.
Li, Hao Beihang Univ.
Wang, Chenyu Beihang Univ.
Quan, Quan Beihang Univ.

Flapping-Wing Micro Aerial Vehicles (FMAVs) have a highly nonlinear, underactuated, and strongly coupled dynamics, which makes their stability and control a laborious task. This paper presents a Lyapunov-based data-driven control framework for FMAVs utilizing L-Learning, merging Lagrangian mechanics with Lyapunov stability theory. The Lagrangian Network is trained from interaction data to capture the FMAV's physical dynamics, achieving a final torque prediction mean squared error (MSE) of 4.05×10^{2}after 100 epochs of training. The learned dynamics data is then used to create a nonlinear control law that guarantees asymptotic closed loop stability and tracking. The method is finally tested on a hummingbird-based nonlinear FMAV model for six-state simultaneous step reference tracking. Simulation results enunciate that all states reach the desired references within 1.2 seconds with almost zero steady-state error and no oscillations. These results validate the stability, data efficiency, and multivariable robustness of the L-Learning framework for nonlinear FMAV control.

► SatB04-5 17:00–17:20
Design and Implementation of A Multi-Source Information Acquisition System for Aluminum Reduction Cells
Cui, Jiarui Univ. of Sci. & Tech. Beijing
Shi, Wenqi Univ. of Sci. & Tech. Beijing
Zhang, Baowei Zhengzhou Non-ferrous Metals Research Inst. Co. Ltd of CHINALCO
Yan, Qun Univ. of Sci. & Tech. Beijing
Wang, Minggang ALUMINUM CORPORATION OF ZUNYI LIMITED
Yang, Xu Univ. of Sci. & Tech. Beijing
Li, Qing Univ. of Sci. & Tech. Beijing

In the aluminum electrolysis process, various process parameters exhibit significant differences in signal forms, electrical characteristics, and acquisition methods. Consequently, conventional systems based on general-purpose interfaces are rendered inadequate for reliable multi-type signal access and long-term stable operation. To address these challenges, a multi-source information acquisition system for aluminum electrolytic cells is designed and implemented.The system is composed of a power supply module, a signal acquisition module, a microcontroller module, and a host computer communication module. A regulated 3.3 V output is generated by the power supply module through conditioning circuits. The signal acquisition module is equipped with an analog signal acquisition circuit, a frequency signal capture circuit, a CAN communication circuit, and an RS485 communication circuit, through which different types of operational information are acquired. Multi-source data are received and processed by the microcontroller module, where data analysis, storage, and uploading are performed. Furthermore, information exchange between the microcontroller and the upper computer is enabled by the host computer communication module.Experimental results demonstrate that the relative error for high-frequency signal acquisition is kept below 2 ms, while the error for lower-frequency signals is maintained under 200 ms. Ultimately, stable and reliable acquisition of multi-source operational information from aluminum electrolytic cells is achieved by the proposed system, whereby refined process control and the intelligent upgrading of the aluminum electrolysis industry are supported.

► SatB04-6 17:20–17:40
Direct Data-Driven Bipartite Cooperative Output Consensus for Heterogeneous Multi-Agent Systems with External Disturbances
Gu, Mingxia Xinjiang Univ.
Abdurahman, Abdujelil Xinjiang Univ.
Sader, Malika Beijing Information Sci. & Tech. Univ.
Jiang, Haijun Xinjiang Univ.

This paper investigates the bipartite cooperative output consensus (BCOC) problem of heterogeneous multi-agent systems with external disturbances using direct data-driven control. Unlike most existing bipartite consensus, the controller is directly designed using data collected within a finite time, which eliminates the requirement for an accurate system model. The leader's system matrix is estimated using sampling data generated by an auxiliary system. In addition, a distributed observer is constructed to handle the situation where some followers lack direct interaction with the leader. Moreover, the specific expression of the regulation equations for BCOC is derived. For the follower dynamics influenced by external disturbances and the leader, the criteria for the data to be informative for the stabilization of the error system and the data-driven solution of the regulation equation are established by employing the data informativity conditions and the relevant data. These results are further extended to the special case of bipartite consensus. Ultimately, a numerical simulation example is showcased to validate the effectiveness of the theoretical results.

SatB05 15:40–17:40 Meixue Hall

Regular Session: Iterative Learning Control and Its Applications

Chair: Dai, Xisheng — Guangxi Univ. of Sci. & Tech.
Co-Chair: Meng, Deyuan — Beihang Univ. (BUAA)

▶ SatB05-1 15:40–16:00

Event-Triggered Quantized Iterative Learning Control under Finite Quantization Levels

Liu, Taojun — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China

This paper investigates an event-triggered quantized iterative learning control scheme for discrete-time linear systems with finite quantization levels. In order to alleviate the performance degradation resulting from quantizer saturation, an event-triggered encoding–decoding mechanism is devised. The proposed approach precludes the transmission of saturated or corrupted measurements and adaptively adjusts the quantization range in a data-driven manner based on the information accessible during the learning process. A P-type learning law is employed, and the convergence of the system error is meticulously analyzed during both the adjustment and convergence phases. Simulation results of a robotic servo system illustrate that the proposed algorithm attains accurate trajectory tracking while sustaining unsaturated quantization and minimizing unnecessary data transmission.

▶ SatB05-2 16:00–16:20

Iterative Learning Control for A Class of Multi-Agent Systems with Random Varying Lengths

Liu, Yating — Qingdao Univ. of Sci. & Tech.
Wang, Qian — Qingdao Univ. of Sci. & Tech.
Zhang, Ruikun — Qingdao Univ. of Sci. & Tech.
Lin, Xue — Qingdao Univ. of Sci. & Tech.

This paper proposes an iterative learning control (ILC) strategy for a class of linear time-varying multi-agent systems(MASs) with randomly varying lengths. By considering the problem of random variation in experimental length, an ILC scheme with an iterative average operator and an extended tracking error term is designed, which relaxes the traditional requirement of ILC that trial length must be equal in each iteration. Then, the convergence property of the proposed ILC strategy for multi-agent systems under mathematical expectations is proved.

▶ SatB05-3 16:20–16:40

Fuzzy Iterative Learning Control for Nonlinear Hyperbolic Distributed Parameter Systems

Zhao, Feng-Liang — Sun Yat-Sen Univ.
Li, Xiao-Dong — Sun Yat-sen Univ.

This study investigates fuzzy iterative learning control (ILC) for a class of nonlinear hyperbolic distributed parameter system (DPS). A Takagi-Sugeno fuzzy DPS model with parameter uncertainties is first introduced to approximate the nonlinear hyperbolic DPS. Based on this model, a fuzzy P-type ILC algorithm is designed, which dynamically adjusts the learning gain according to the system output error. By constructing an appropriate Lyapunov functional, it is theoretically proved that the tracking error converges to zero, while the input error also exhibits monotonic convergence. Finally, a numerical simulation verifies the effectiveness of the proposed algorithm.

▶ SatB05-4 16:40–17:00

Quantized Iterative Learning Identification for Discrete Nonlinear Time-Delay Multi-Agent Systems with Data Dropout

Sun, Jiajun — Nantong Univ.
Yang, Yuhan — Nantong Univ. - Robotics Engineering
Xu, Xiaoxiao — Nantong Univ.
Han, Tianxiang — Nantong Univ.
Shang, Liangliang — Nantong Univ.
Zhou, Xingyu — Nantong Univ.

This study investigates an iterative learning-based identification scheme for discrete-time nonlinear multi-agent systems incorporating time delays, with particular emphasis on resolving challenges associated with initial value learning and random data dropouts. The innovations of this research are mainly reflected in the following aspects: An iterative learning identification method suitable for multi agent-discrete time-nonlinear systems with time delay is proposed and analyzed. In the context of time-delay existing in actual data exchange, the time delay factor is incorporated into the system modeling, and its influence is analyzed. The adoption of logarithmic quantizers greatly facilitates data acquisition and subsequent processing. The system under study is essentially a discrete-time nonlinear system with time delay, rather than a traditional time-invariant system.

▶ SatB05-5 17:00–17:20

Finite-iteration Learning Identification of First-order Hyperbolic Distributed Parameter Systems

Yang, Tongxing — Guangxi Univ. of Sci. & Tech.
Dai, Xisheng — Guangxi Univ. of Sci. & Tech.
Wang, Rifeng — Guangxi Sci. & Tech. Normal Univ.

This paper proposes a finite-iteration identification algorithm for the first order hyperbolic distributed parameter systems with unknown parameters. The algorithm designs a P-type learning identification controller to achieve estimation of the unknown spatiotemporally varying parameters. Through detailed theoretical analysis, sufficient conditions are derived to ensure that the identification error converges to any prespecified accuracy after a finite number of iteration in the sense of the L^2-norm. Finally, the effectiveness of the proposed learning identification algorithm is demonstrated by numerical simulation results.

▶ SatB05-6 17:20–17:40

High-Precision Docking for Airport Boarding Bridge: A Learning Control Method

Lu, Changxin — Beihang Univ.
Meng, Deyuan — Beihang Univ. (BUAA)
Zhang, Jingyao — Beihang Univ.
Cai, Kaiquan — Beihang Univ. (BUAA)

Automated docking of Passenger Boarding Bridges (APBBs) represents a critical challenge in airport surface operations, characterized by inertial variations, nonlinear coupling, and aerodynamic disturbances. Feedback controllers struggle to reconcile the requisite tracking precision with the system's massive, variable-structure dynamics, while optimization-based methods risk inducing actuator saturation due to aggressive gain scaling near boundaries. This paper proposes a Data-Induced Learning Control (DiLC) method. To address the complexity of the structural mass, we employ an equivalent lumped-parameter model with augmented equivalent stiffness and damping terms for the telescopic joint, treating the discrepancy between the design model and the dynamics as structured uncertainties. We guarantee convergence of compensated tracking errors, while actual tracking errors converge to a tunable residual set. Theoretical analysis and simulations demonstrate that the proposed method achieves high precision in simulations under bounded disturbances approximating stochastic wind loads, offering a viable pathway for fully automated apron operations.

SatB06 15:40–17:40 Guibin Hall

Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (II)

Chair: Tao, Hong-Feng — Jiangnan Univ.
Co-Chair: Chen, Yiyang — Soochow Univ.

▶ SatB06-1 15:40–16:00

Preliminary Study on MFA-NN : A Neural Network Realization for Model-Free Adaptive Control

Ji, Honghai — North China Univ. of Tech.
Yun, Jing Yao — North China Univ. of Tech.
Fan, Lingling — Beijing Information Sci. & Tech. Univ.
Liu, Shida — North China Univ. of Tech.
Wang, Li — North China Univ. of Tech.

Deep learning methods face several limitations in the real-time data-driven control of complex nonlinear systems. These limitations include low computational efficiency, weak theoretical reliability, and a lack of interpretability. The root causes are the network's reliance on static nonlinear activation functions and the inadequacy of conventional single-step parameter update mechanisms. To address these limitations, this paper proposes a novel Model-Free Adaptive Neural Network (MFA-NN) control algorithm. First, the proposed method eliminates nonlinear activation functions. Instead, it constructs an underlying architecture composed of cascaded multi-layer purely linear weight matrices. This structural design effectively mitigates both the vanishing gradient and dead neuron problems. Second, this paper introduces an online dual-axis optimization mechanism. This mechanism performs multiple error-driven iterations within a single sampling period. Consequently, it effectively improves the utilization of single-step data and enhances the controller's robust adaptability to abrupt system changes. Theoretically, the proposed framework directly maps the cascaded network matrices into a high-dimensional Pseudo Partial Derivative (PPD) with clear physical significance. This mapping effectively overcomes the black-box limitations of traditional

neural networks. Furthermore, based on the differential mean value theorem, this paper proves the existence and boundedness of the equivalent mapping parameters. This proof provides a theoretical basis for the stability of the closed-loop system. Comparative simulation results on discrete-time nonlinear systems are presented. The results demonstrate that the proposed method maintains high-precision steady-state tracking and strong robustness, even under severe abrupt structural changes.

► SatB06-2 16:00–16:20

Industrial Process Fault Detection Based on Self-supervised Multi-scale Principal Component Spectrum Analysis

Zhang, Yuchao	Nantong Univ.
Shang, Liangliang	Nantong Univ.
Ma, Xinghao	NantongUniv.
Chen, Junyu	Nantong Univ.
Tian, Saibo	Nantong Univ.

Traditional data-driven fault detection methods, such as principal component analysis (PCA), may become unreliable under strong noise contamination or when redundant variables dominate the statistics, leading to distorted decision indices and unreliable alarms. Thus, a self-supervised, spectrum-enhanced PCA framework is proposed to mitigate the noise sensitivity of conventional methods and alleviate feature redundancy in the data. We first learn compact, redundancy-suppressed embeddings via Barlow Twins, then construct PCA in the embedding space, and finally apply continuous wavelet transform (CWT) to denoise the principal scores while retaining low-frequency fault trends. Performance is assessed against PCA using FDR and FAR. Simulation results show that this method can solve the performance degradation problem of PCA in high-noise and feature-redundant scenarios.

► SatB06-3 16:20–16:40

A Multi-Scale Feature-Domain Adversarial Transfer Network for Open-Circuit Fault Diagnosis of Three-Phase Inverters

Chen, Peng	Hubei Minzu Univ.
Li, Jingcong	Hubei Minzu Univ.
Lai, Guohong	Hubei Minzu Univ.

To address the limited cross-domain generalization of open-circuit IGBT fault diagnosis in three-phase inverters under parameter variations and noise, this paper proposes a Multi-Scale Feature-Domain Adversarial Transfer Network (MSFDAN). Using three-phase currents as inputs, the signals are first transformed into the Clarke domain, and an $\alpha\ \beta$-energy-based normalization scheme is introduced to reduce amplitude-scale discrepancies across domains. A lightweight multi-scale one-dimensional convolutional network is then used to capture both local waveform distortion and broader phase-imbalance characteristics. On this basis, adversarial training with a gradient reversal layer and a domain discriminator is employed to learn domain-invariant yet fault-discriminative representations without using target-domain labels. Cross-domain experiments on MATLAB/Simulink datasets show that the proposed method achieves 98.91% accuracy in the target domain and maintains stable performance under additive noise with SNRs ranging from 3 dB to 10 dB.

► SatB06-4 16:40–17:00

Data-Driven Lithium-Ion Battery Fault Diagnosis: LSTM Enhanced by Segmented Asymmetric Denoising Preprocessing

Ji, Yushuo	Soochow Univ.
Wu, Penghao	School of Mechanical & Electrical Engineering, Soochow Univ.
Tian, Engang	Nanjing Normal Univ.
Tao, Hong-Feng	Jiangnan Univ.
Chen, Yiyang	Soochow Univ.

Under complex dynamic conditions, noise often masks minor faults in electric vehicle lithium-ion batteries. Motivated by this challenge, a fault diagnosis framework based on Long Short-Term Memory networks and Piecewise Asymmetric Denoising is proposed. This framework is distinctively denoted as LSTM-SAD. The method utilizes LSTM to capture the nonlinear dynamics of voltage. It decouples the influence of SOC and load current on terminal voltage. This process produces detrended residuals. A piecewise asymmetric denoising strategy is adopted. The training stage constructs a baseline with a high signal-to-noise ratio using median filtering. An adaptive threshold is set based on compressed quantiles. The online detection stage retains the original noise form. This approach preserves transient features when faults occur. Semi-physical experimental results show that this framework exhibits robustness under the Urban Dynamometer Driving Schedule (UDDS) condition. The method detects distinct faults in the early stage of discharge. It also identifies minor faults in the middle and later stages. The system generates no false alarms under normal operating conditions. This resolves the contradiction between sensitivity and reliability found in traditional threshold methods.

► SatB06-5 17:00–17:20

Simulated Data-based Adversarial Learning for Zero-shot Anomaly Monitoring of Pipeline Leakages

Jiang, Yu	Harbin Inst. of Tech.
Gao, Hewei	Harbin Inst. of Tech.
Huo, Xin	Harbin Inst. of Tech.
Zheng, Kai	Dalian Maritime Univ.

Fluid pipeline systems are widely used in key areas such as industrial water, petrochemical, and ship pipelines. However, pipeline systems are prone to structural failures such as leaks due to various complex factors during long-term operation. Traditional detection methods suffer from issues such as low efficiency, while existing data-driven intelligent diagnosis methods are limited by the scarcity of fault data, making it difficult to deal with unknown leaks. To address this, this paper proposes a zero-shot pipeline anomaly monitoring method combining simulation and a dual adversarial decoder. Firstly, a simulation model is built using Flowmaster software to obtain abnormal data of pipeline leaks through simulation. Subsequently, real normal samples and simulated abnormal samples are jointly used for pre-training to construct a model framework comprising a masked patch autoencoder and a dual adversarial decoder. In the inference stage, zero-shot anomaly monitoring of unknown faults is achieved by calculating reconstruction errors and dynamic thresholds. Experimental results on public datasets show that this method outperforms traditional methods in terms of accuracy, recall, and F1 score, verifying its effectiveness.

► SatB06-6 17:20–17:40

Knowledge-Constrained Multiscale Spatiotemporal Learning for Multivariate Anomaly Detection

Li, Yahui	Huazhong Univ. of Sci. & Tech.
Liu, Qingyun	Huazhong Univ. of Sci. & Tech.
Fang, Shiyu	Huazhong Univ. of Sci. & Tech.
Tian, Yuchu	Queensland Univ. of Tech.
Chen, Feng	Huazhong Univ. of Sci. & Tech.
Zhou, Chunjie	Huazhong Univ. of Sci. & Tech.

Ensuring system availability critically relies on the timely, accurate identification and handling of anomalies. Anomaly detection serves as a vital enabling technology for efficient anomaly discovery and the preservation of system stability. However, most multivariate anomaly detection methods prioritize learning statistical behavior, which makes them struggle to learn effective multiscale spatiotemporal representations consistent with the system' s governing dynamics in noisy settings. To address this limitation, we propose a novel knowledge-constrained multiscale spatiotemporal learning method for multivariate anomaly detection in process industries. Domain knowledge is embedded in an entropy-weighted spatiotemporal learning process that jointly captures multiscale dynamic dependencies consistent with prior constraints. Complex multivariate anomalies are revealed by a hybrid criterion that assesses magnitude deviations and variable-interaction drifts, ensuring reliable detection in real-world industrial environments. Extensive experiments validate the effectiveness and interpretability of the proposed method.

Sunday, May 10, 2026

SunA01 08:00–10:00 Yangguang Hall
Invited Session: Learning-Based Intelligent Control for Complex Dynamic Systems

Chair: Pan, Yingnan Bohai Univ.
Co-Chair: Cao, Liang Bohai Univ.

▶ SunA01-1 08:00–08:20
An Improved NNSO-Based Optimized Control for Robotic Manipulators under the Deception Attacks
Wang, Shuang Bohai Univ.
Zhao, Meng Bohai Univ.
Wang, Wei Bohai Univ.
Cao, Liang Bohai Univ.

An optimized tracking control strategy for robotic manipulators under deception attacks is proposed in this paper. In order to overcome the challenge of the unavailability of real system states caused by deception attacks, an improved neural network state observer (NNSO) is designed to compensate for the system states, effectively mitigating the impact of deception attacks for robotic manipulators. Meanwhile, for preventing training termination and diminishing the energy consumption during manipulator operation, a modification term based on a simplified reinforcement learning algorithm is introduced in the process of optimized control. The optimized control strategy improves the robust tracking performance, while guaranteeing all signals in the robotic manipulator system remain bounded. Finally, simulation results validate the feasibility of the proposed control strategy.

▶ SunA01-2 08:20–08:40
Asynchronous Control for T-S Fuzzy Semi-Markov Jump Neural Networks with Partially Unknown Membership Functions: A Dynamic Event-Triggered Scheme
Li, Yiru Bohai Univ.
Zhang, Linchuang Bohai Univ.
Xing, Xing Bohai Univ.
Jia, Zhichun Bohai Univ.
Zhao, Qingyi Bohai Univ.

This study focuses on the design of asynchronous controllers for Takagi-Sugeno fuzzy semi-Markov jump neural networks under the constraint of partially unknown membership functions (MFs), utilizing a dynamic event-triggered scheme (DETS). To cope with the uncertainty in MFs, a reconstruction strategy utilizing boundary information and a convex combination technique is employed. Moreover, a unified control framework embedding a DETS is formulated. This framework is designed to alleviate the communication transmission burden while tolerating mode mismatches. Based on this framework, sufficient criteria are established whereby the closed-loop system achieves stochastic stability with the H_infty disturbance attenuation level. The validity and superiority of the proposed method are finally substantiated through two numerical simulations.

▶ SunA01-3 08:40–09:00
Formation Collision Avoidance Control of Unmanned Surface Vehicle under Position Constraints
Wang, Wei Bohai Univ.
Zhao, Meng Bohai Univ.
Pan, Ziyao Bohai Univ.

This paper studies the time-varying formation control of underactuated unmanned surface vehicles (USVs) in constrained maneuvering positions while ensuring collision avoidance. Each considered USV is subject to uncertain dynamics arising from model uncertainty and external disturbances. Formation maneuvers within the constrained positions are achieved by combining a universal constraint function with parameterized paths. The selection of constraints is based on the parametric path rather than time factors. To this end, this paper proposes a time-varying formation control method integrating an artificial potential function, radial basis function neural networks, and a second-order tracking differentiator (TD). Using Lyapunov stability theory, it is demonstrated that all error signals in the closed-loop system are ultimately uniformly bounded. Simulation results further validate the effectiveness of this control approach.

▶ SunA01-4 09:00–09:20
Tracking Control and Obstacle Avoidance for Multi-USV Systems Based on Artificial Potential Field Method
Gao, Lu Bohai Univ.
Pan, Yingnan Bohai Univ.

This paper investigates the tracking and obstacle avoidance problems for multiple unmanned surface vehicle (multi-USV) systems. A barrier function designed based on an improved artificial potential field is employed to integrate the tracking errors and obstacle avoidance problems into the performance index, realizing the simultaneous optimization of the two objectives. By using an adaptive control technique and a critic-only reinforcement learning strategy, the solution to the Hamilton-Jacobi-Bellman equation is attainable. By virtue of Lyapunov stability theory, all signals in the closed-loop system are shown to be semi-globally uniformly ultimately bounded. Lastly, a simulation study is conducted to demonstrate the effectiveness of the proposed control method.

▶ SunA01-5 09:20–09:40
Impact of Wavelet Kernel Selection on Adaptive Constructive Wavelet Neural Networks for Nonlinear Systems
Huang, Dunsheng Renmin Univ. of China
Jiang, Hao Renmin Univ. of China
Shen, Dong Renmin Univ. of China

Wavelet Neural Networks (WNNs) combine time-frequency localization with learning capabilities, yet determining their optimal structure remains challenging. Constructive WNNs address this by adapting network topology online, but the critical impact of the mother wavelet kernel itself is often overlooked. This study proposes an adaptive constructive CWNN control framework to systematically evaluate this impact. We establish a unified stability analysis for both orthogonal bases and non-orthogonal frames within a Lyapunov-based design. Simulation results demonstrate that kernel topology fundamentally dictates performance trade-offs: while non-orthogonal frames accelerate transient convergence through redundancy, the orthogonal Sinc wavelet yields the most compact structure and highest steady-state accuracy for smooth nonlinear dynamics. These findings provide essential guidelines for optimizing kernel selection in adaptive neural control.

▶ SunA01-6 09:40–10:00
Dynamic Event-triggered-based Fixed-time Composite Learning Control for Nonlinear Multiagent Systems
Du, Haoran Guangdong Polytechnic Normal Univ.
Zheng, Xiaohong Guangdong Univ. of Tech.
Lin, Wenshuai Guangdong Polytechnic Normal Univ.
Guo, Zijie Guangdong Polytechnic Normal Univ.

This paper investigates the dynamic event-triggered-based fixed-time consensus control problem for a class of nonlinear multiagent systems (MASs) with unknown dynamics under communication constraints. For followers that cannot directly access the leader's information, a distributed estimator is constructed. Then, a predictor-based composite learning technique is proposed, integrating prediction errors into the neural network update law to improve the estimation accuracy of unknown nonlinearities. To reduce communication burden, a dynamic event-triggered mechanism is designed via an auxiliary dynamic variable, which decreases the controller updates while preserving system performance. A fully distributed fixed-time event-triggered controller is established in a nonsingular quadratic form. Theoretical analysis shows that all closed-loop signals are bounded within a fixed time, and a positive lower bound on inter-event intervals is guaranteed, thus excluding Zeno behavior. Simulation results confirm the effectiveness of the proposed scheme.

SunA02 08:00–10:00 Changle Hall
Invited Session: Adaptive Learning Control and Application of Complex Dynamic Systems

Chair: Liu, Yang Qingdao Univ. of Sci. & Tech.
Co-Chair: Ma, Hui Guangdong Univ. of Tech.

▶ SunA02-1 08:00–08:20
Prescribed-Time Optimal Tracking Control for Nonlinear Systems with Actuator Faults
Liu, Xiangyu Qingdao Univ.
Wang, Lijie Qingdao Univ.
Liu, Yang Qingdao Univ. of Sci. & Tech.
Zhang, Miaoxin Qingdao Univ. of Sci. & Tech.

An optimal tracking control scheme is proposed in this paper for nonlinear systems with actuator faults. Firstly, a continuous and bounded function is proposed, which is used as the time-varying feedback gain of the

controller, so that the tracking error converges to a small neighborhood of the origin in a given time. Then, an optimal problem is solved by constructing the Hamilton-Jacobi-Bellman (HJB) equation, and the unknown nonlinear issue existed in the solution of HJB equation is addressed by combining it with the reinforcement learning (RL). Moreover, both the actor and critic networks are established under the framework of the RL to execute the control action and evaluate the control performance, respectively. In addition, a series of the quadratic functions are designed to obtain the updating law of critic and actor so as to reduce the complexity of the traditional method consisted of the residual error of HJB equation. Based on prescribed-time stability theorem, a prescribed-time optimal tracking controller is developed, which not only makes all the states of the system converge to the preset range within the prescribed time, but also optimizes the overall performance of the system. Finally, the simulation results confirm the effectiveness of the presented approach.

▶ SunA02-2 08:20–08:40

Adaptive Practical Prescribed-Time Funnel Control for Nonstrict-Feedback Multiagent Systems via Composite Predictor

Li, Zhiqiang — Guangdong Univ. of Tech.
Du, Haoran — Guangdong Polytechnic Normal Univ.
Zheng, Xiaohong — Guangdong Univ. of Tech.
Luo, Ao — Guangdong Polytechnic Normal Univ.

This paper addresses the consensus tracking problem for multiagent systems with nonstrict-feedback nonlinearities and time-varying disturbances. To constrain the consensus tracking error, an error transformation function with a practical prescribed-time (PPT) funnel boundary is constructed. Using the transformed tracking error, a PPT funnel controller is designed under the backstepping framework. Meanwhile, a neural network (NN) is employed to approximate nonstrict-feedback nonlinearities, and a disturbance observer is designed to estimate the time-varying disturbance and the reconstructed error of NN. To deal with the algebraic loop problem, a composite predictor incorporating the NN and the disturbance observer is built at each step, which can obtain the predicted state for replacing the states of the subsequent step. According to the Lyapunov stability theory, all signals in the closed-loop system are bounded. Finally, the effectiveness of the proposed control algorithm is verified through simulation results.

▶ SunA02-3 08:40–09:00

Accuracy Analysis on Data-Driven Adaptive T-S Fuzzy Approximator for A Class of Unknown-structure Control System

Zhang, Miaoxin — Qingdao Univ. of Sci. & Tech.
Yan, Wen — Shanghai Jiao Tong Univ.

Takagi-Sugeno(T-S) fuzzy system has a good approximation performance for the smooth nonlinearity and strong uncertainty of the system, whose approximation is for the system model. However, the consequent parameters of the traditional T-S fuzzy system generally rely on an offline update method, which limits the real-time performance of the fuzzy control. To address this issue, an adaptive T-S fuzzy system based on state feedback is proposed, which can update the consequent parameters in real time. More specially, by using the approximation boundary analysis of the adaptive T-S fuzzy logic system, the unknown structure system can be directly approximated and modeled. Finally, a Lyapunov control experiment is designed to verify that this system can achieve high-precision control over unknown structure systems under relaxed assumptions.

▶ SunA02-4 09:00–09:20

End-edge-cloud Collaborative Architecture for Intelligent Industrial Robots in the Industrial Internet of Things

Chen, Wenyu — Guangdong Univ. of Tech.
Duan, Junzhe — Guangdong Univ. of Tech.
Cheng, Zhijian — Guangdong Univ. of Tech.
Ren, Hongru — Guangdong Univ. of Tech.
Lu, Renquan — Hangzhou Dianzi Univ.

With the rapid development of the Industrial Internet of Things, it is faced with problems such as low data processing efficiency and poor concurrency and scalability of multiple devices, and the traditional centralized cloud computing architecture is difficult to cope with the massive device access and data processing needs in the industrial Internet of Things environment. Therefore, an industrial robot system based on edge-cloud collaborative architecture is proposed and implemented in this paper. The system combines Message Queuing Telemetry Transport (MQTT) and Transport Control Protocol (TCP) communication protocols, and uses IMX6ULL embedded device for data preprocessing and protocol docking. The cloud platform uses distributed computing and hybrid database technology to realize data analysis and visualization. To verify the effectiveness of the proposed architecture, this paper applies it to a robotic arm system, and evaluates the performance of the system in terms of response time, data processing efficiency and multi-device concurrency through experiments. The results show that the system has remarkable real-time performance and stability, and can effectively support multi-device management and task execution in industrial environment, which provides an important reference for system optimization and design in the field of industrial Internet of Things.

▶ SunA02-5 09:20–09:40

Research on the Performance Degradation of Lithium-ion Batteries in Multi-Temperature Domain Based on Empirical Model Parameter Identification

Qin, Xinrui — Liaoning Univ.
Feng, Weiwei — Liaoning Univ.
Gao, Xiaoting — Liaoning Univ.
Wu, Chaoyang — Liaoning Univ.
Cui, Enchang — Liaoning Univ.

With the widespread adoption of new energy vehicles across diverse climatic regions globally, the performance stability of their core component, lithium-ion batteries, under multi-temperature conditions has become increasingly critical. To elucidate the influence of varying temperatures on battery performance degradation, this study systematically investigates the performance decay trajectory of lithium-ion batteries under constant temperature cycling conditions at multiple typical temperatures ranging from 5℃ to 25℃. Using two commercial lithium-ion batteries as test subjects, this study employs a high-precision battery testing system to collect real-time data on key performance metrics, including discharge capacity, energy density, and power density, under each preset constant temperature condition. Based on the experimental data, a correlation function model is established between temperature and performance indicators using the nonlinear least squares method. The results clearly delineate the degradation rates and patterns of battery performance within the 5℃ to 25℃ temperature range, establishing a measurable correlation between temperature and performance degradation. This provides crucial experimental data and a theoretical basis for enhancing the adaptability, safety, and lifespan prediction of electric vehicle batteries in complex temperature environments.

▶ SunA02-6 09:40–10:00

Real-time Vehicle Tracking for Complex Dynamic Environments Based on YOLO-ReID Fusion for Intelligent Transportation Systems

Liu, Yuanhao — WuHan Univ.
Lei, Zhongcheng — Wuhan Univ.

To address the challenges of occlusion, lighting variations, and cross-environment/camera interference in current vehicle detection and tracking, this paper proposes a fusion of the YOLO-based vehicle detection model and the re-identification (ReID) model. The study explores the collaborative mechanism of multi-task models, providing a new solution and methodology for improving target vehicle detection and re-identification capabilities in road monitoring. First, the powerful target detection and anchoring capabilities of YOLO are used to screen all target vehicles. Second, the ReID model is used to compare all detected vehicles with the target to obtain the final results. To improve the accuracy of target re-identification, a ResNet50 network is used in the ReID model; a triplet loss function is established and optimized through contrastive learning. Experimental results show that YOLOv8 achieves a detection accuracy of 96% mAP@50 and a ReID re-identification Rank-1 accuracy of 93% on public datasets, which demonstrates good model performance and applicability for traffic flow detection and tracking in urban roads.

SunA03 08:00–10:00 Langyue Hall

Invited Session: Cooperative Learning Control of Network Systems: Theories and Applications

Chair: Zhang, Fan — Northwestern Polytechnical Univ.
Co-Chair: Du, Mingjun — Qilu Univ. of Tech. (Shandong Acad. of Sci.)

▶ SunA03-1 08:00–08:20

A Parameter-Varying Dynamic Method for Lyapunov Equation Solving and Its Kinematic Application to Redundant Manipulators

Zhao, Shige — Zhejiang Univ. of Sci. & Tech.
Hao, Junjie — Zhejiang Univ. of Sci. & Tech.
Kong, Ying — Zhejiang Univ. of Tech.

A novel varying-parameter neural dynamics (NVPND) framework is developed to compute the time-varying Lyapunov equation. The proposed model is designed to address three critical aspects: (i) guaranteeing sta-

bility for theoretical correctness of the solution, (ii) enhancing robustness against additive disturbances, and (iii) achieving super-exponential convergence for accelerated computation.

▶ SunA03-2 08:20–08:40

DAF-DETR: Dual Adaptive Fusion DETR for Fresnel Lens Defect Inspection

Zhu, Xiaohua	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Xu, Yan	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Yu, Jie	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhao, Yongguo	Shandong Acad. of Sci.
Li, Guangliang	Shandong Yuying Optical Instrument Co., Ltd
Gong, Qingxia	Shandong Yuying Optical Instrument Co., Ltd
Ren, Xiangming	Shandong Yuying Optical Instrument Co., Ltd
Li, Guangnan	Shandong Yuying Optical Instrument Co., Ltd
Pang, Shaopeng	Qilu Univ. of Tech. (Shandong Acad. of Sci.)

During the manufacturing process of Fresnel lenses, surface defects frequently occur due to external factors, making effective automated defect detection necessary for quality control. Existing methods based on Convolutional Neural Networks and Transformers have limitations in multi-scale feature fusion, which hinders the detection of small and complex defects. To address this issue, we propose the Dual Adaptive Fusion DETR (DAF-DETR) model, which designs a DAF mechanism to enhance DETR's multi-scale processing capability for small object detection and introduces the Space-to-Depth Convolution (SPDConv) module to improve convolutional operation efficiency. The use of the GIoU loss function further refined the localization of defects, improving the precision of bounding box predictions. We validated our method on the Lens dataset, collected from actual industrial production lines, which includes common defects such as Black spot, Scratch, and Wool. To rigorously evaluate the performance of DAF-DETR, we conducted several ablation experiments, testing the impact of individual components like the SPDConv module and the GIoU loss function. Experimental results show that DAF-DETR outperforms the baseline RT-DETR, achieving a 3.2% improvement in mAP50. These findings demonstrate that each component of DAF-DETR contributes significantly to its performance. The DAF-DETR model demonstrates superior performance in both defect detection accuracy, making it a promising solution for Fresnel lens quality control applications.

▶ SunA03-3 08:40–09:00

Universal Edge Core Percolation in Complex Networks

Liu, Cheng	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhu, Xiaohua	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Yu, Jie	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Xu, Yan	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Zhao, Yongguo	Shandong Acad. of Sci.
Li, Guangliang	Shandong Yuying Optical Instrument Co., Ltd
Gong, Qingxia	Shandong Yuying Optical Instrument Co., Ltd
Ren, Xiangming	Shandong Yuying Optical Instrument Co., Ltd
Li, Guangnan	Shandong Yuying Optical Instrument Co., Ltd
Duan, Gaopeng	Peking Univ.
Pang, Shaopeng	Qilu Univ. of Tech. (Shandong Acad. of Sci.)

Core percolation provides a fundamental perspective for understanding the structural robustness and functional stability of complex networks. Existing studies have primarily focused on node-centric core percolation processes, in which the evolution and collapse mechanisms of network structures are characterized through the iterative removal of nodes. However, for networked systems in which edges serve as the primary functional carriers, the impact of edge removal on the global structure and functionality of the network has not yet been explored. Here, we propose a Universal Edge Core Percolation (UECP) model. By introducing a coupling density, the proposed model eliminates the constraint of full coupling among edges, thereby enabling the description of more universal edge interaction mechanisms. Based on this framework, we utilize local node degree information together with the coupling density to establish an exact criterion for identifying nodes that exhibit structurally unstable characteristics during the core formation process. Furthermore, we derive exact closed-form expressions for the number of unstable core nodes and for the number of core nodes when the coupling density equals one. The theoretical predictions show a good consistency with numerical simulations on both model and real networks. In addition, we systematically reveal the evolutionary behavior of unstable core nodes as a function of the coupling density across different network structures. By extending the perspective of core percolation from nodes to edges and removing the full-coupling assumption among edges, the UECP model establishes a unified and scalable theoretical foundation for understanding how edge-centric percolation mechanisms shape the robustness and resilience of complex networks.

▶ SunA03-4 09:00–09:20

Multi-Drones Active Exploration and Coverage of Uncertain Spatial Field with Limited Sensing Range

Xu, Jingwen	Northwestern Polytechnical Univ.
Zhang, Fan	Northwestern Polytechnical Univ.
Guo, Yaohua	Northwestern Polytechnical Univ.

This paper addresses the problem of simultaneous field exploration and coverage control for multi-drone systems, subjected to limited sensing range constraints. The spatial field density is assumed to be unknown a priori and must be estimated online for determining the coverage priority. To achieve a trade-off between field exploration and coverage behavior with energy consumption optimization, we propose an approximate dynamic programming (ADP)-based unified framework. In particular, we introduce an augment system description that integrates promising sample locations for field estimation, and the gradient-based movement for coverage maximization. Meanwhile, ADP solutions are provided with an persistent excitation conditions, while the stability for the discrete reference trajectory tracking and control input optimization are rigorously proven by Lyapunov-based methods. Numerical simulation results furthers illustrate the effectiveness of the control framework.

▶ SunA03-5 09:20–09:40

Mean-Square Regional Stability for One-Dimensional Switched Stochastic Linear Systems with Multiple Equilibrium Points

Yan, Zijun	Qilu Univ. of Tech.(Shandong Acad. of Sci.)
Zhu, Liying	Qilu Univ. of Tech.(Shandong Acad. of Sci.)
Hu, Guolin	Qilu Univ. of Tech. (Shandong Acad. of Sci.)

This paper investigates the mean-square regional stability of one-dimensional switched stochastic linear systems with multiple equilibrium points. First, the stochastic region Ω_e of system is determined, and the concepts of mean-square regional stability, mean-square regional asymptotic stability, and mean-square regional instability are defined for the kind of switched systems. Second, by iterating the analytical solutions of the system, this paper proposes sufficient conditions for the mean-square regional stability of the system. Finally, a numerical example is provided to verify the effectiveness of the proposed results.

▶ SunA03-6 09:40–10:00

Predefined-Time Disturbance Observer-Based Spacecraft Attitude Fault-Tolerant Control

Zhang, Jiayuan	Qilu Univ. of Tech.
Wang, Mengyi	Qilu Univ. of Tech.
Zhang, Yang	Qilu Univ. of Tech.
Huo, Baoyu	Beijing Institude of Teachnology
Du, Mingjun	Qilu Univ. of Tech. (Shandong Acad. of Sci.)

This paper addresses the attitude stabilization problem for rigid spacecraft subject to external disturbances, inertia uncertainties, and actuator failures. A sliding mode fault-tolerant control strategy based on a predefined-time nonlinear disturbance observer (PTNDO) is proposed. First, a PTNDO is constructed, enabling precise estimation of the lumped disturbance within a predefined time. Building upon this, a predefined-time attitude controller is developed using a continuous nonsingular sliding surface, which features a simple and singularity-free structure. Rigorous Lyapunov-based analysis proves that the spacecraft attitude converges to a neighborhood of the origin within a predefined time explicitly determined by design parameters, while exhibiting satisfactory fault tolerance against partial actuator failures. Numerical simulations verify that the proposed strategy achieves rapid and high-precision attitude stabilization.

SunA04 08:00–10:00 Xinghui Hall

Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (III)

Chair: Li, Jinghao Northeastern Univ.

Co-Chair: Gao, Rui Northeastern Univ.

▶ SunA04-1 08:00–08:20

Unified Time–Frequency Representation with Selective State Space for Multivariate Time Series Anomaly Detection

Xu, Yuan	Beijing Univ. of Chemical Tech.
Xie, Zeng	Beijing Univ. of Chemical Tech.
He, Yan-Lin	Beijing Univ. of Chemical Tech.
Zhu, Qunxiong	Beijing Univ. of Chemical Tech.
Zhang, Yang	Beijing Univ. of Chemical Tech.

Zhang, Ming-Qing Beijing Univ. of Chemical Tech.

For multivariate time series anomaly detection task, the periodic nature of signals and frequency domain cues are often not fully exploited when modeling long sequences, which constrains the ability to characterize complex anomaly patterns. To overcome this limitation, an unsupervised framework is presented that integrates time–frequency representation learning with efficient long-sequence modeling. Specifically, an autoencoder architecture built on a selective state space model is developed. During encoding, two complementary spectral branches are introduced to enrich feature expressiveness: a Fourier transform branch captures global periodicity and dominant frequency components, whereas a wavelet transform branch extracts multiscale transient characteristics via the continuous wavelet transform. A learnable gated fusion module is further designed to adaptively integrate these two spectral views, thereby balancing global temporal regularities with local anomalous patterns. Building on this design, the selective state space model Mamba2 is embedded to generate the final encoding, enabling parallel and scalable modeling of long-range temporal dependencies. Moreover, to increase sensitivity to subtle anomalous deviations, a two-stage training strategy with dual decoders is adopted. This strategy explicitly enlarges the reconstruction error discrepancy between anomalous and normal samples, thereby reducing both missed detections and false alarms. Experiments on four public benchmark datasets demonstrate substantial performance gains on anomaly detection task.

► SunA04-2 08:20–08:40

Semantic-Aware Smooth Path Planning with Dynamic Prediction for Mobile Robots in Complex Service Environments

Liu, Dewang Beijing Jiaotong Univ.
Jin, Shangtai Beijing Jiaotong Univ.

In complex service environments such as hospitals, mobile robot navigation requires more than collision avoidance.Robots are also expected to respect implicit semantic safety rules and to interact safely with dynamically moving humans. In practice, we observed that many grid-based global planners either ignore semantic risks or generate geometrically non-smooth paths when extended to dynamic scenarios. To address these issues, this paper presents a global smooth path planning framework that integrates semantic constraints with dynamic motion prediction.A physically consistent Gaussian semantic field is constructed using geodesic distances computed by Breadth-First Search(BFS), which ensures that semantic risks do not propagate across physical obstacles such as walls. To account for dynamic interactions, an Extended Kalman Filter(EKF) is employed to predict pedestrian motion, and a spatio-temporal decaying prediction field is introduced to model future uncertainties while avoiding excessive long-horizon conservatism. Based on the fused costmap, a semantic-aware 16-neighborhood extended A* algorithm is designed to generate a safe geometric path skeleton. The resulting path is further refined through a two-stage optimization process consisting of greedy geometric shortening and strongly constrained B-spline smoothing, producing a trajectory that satisfies continuity requirements for mobile robot execution.Simulation results in hospital-like dynamic environments show that the proposed method consistently generates collision-free global reference trajectories. Compared with Dijkstra, traditional A*, and RRT*, the proposed planner reduces the cumulative semantic risk by nearly two orders of magnitude while significantly improving path smoothness and execution stability. These results indicate that the proposed framework provides an effective and practical solution for safe and compliant navigation in human–robot coexistence scenarios.

► SunA04-3 08:40–09:00

Multi-Agent Proximal Policy Optimization Based Connected Vehicle Platoon Planning

Wang, Han Beijing Jiaotong Univ.
Jin, Shangtai Beijing Jiaotong Univ.

Abstract: Aiming at the problems existing in vehicle platoon driving, such as overtaking conflicts, difficulty in maintaining safe distance, insufficient power of the tail vehicle, and poor speed coordination, a pure CAV (Connected Vehicle) platoon path planning method based on Multi-Agent Proximal Policy Optimization (MAPPO) is proposed. The method adopts a "distributed actor-centralized critic" architecture, configuring an independent Actor network for each CAV to decide acceleration, and a Centralized Critic network to globally evaluate the platoon state. A composite reward function integrating safety, comfort, and speed tracking is designed to correct the logic conflict when the leading vehicle has no preceding vehicle, and a fixed target speed constraint is introduced to achieve cooperative speed control of the platoon. The simulation results demonstrate that the algorithm outperforms traditional methods, achieving zero collisions in the platoon. This framework provides a scalable and extensible solution for the development and adoption of connected autonomous vehicle systems.

► SunA04-4 09:00–09:20

Hierarchical Spatial-Temporal Graph Convolutional Network for Fault Detection and Diagnosis in Complex Industrial Processes

Wang, Yuanqing Central South Univ.
Wang, Sijia Central South Univ.
Wang, Kai Central South Univ.
Yuan, Xiaofeng Central South Univ.
Wang, Yalin Central South Univ.

Complex industrial processes exhibit strong coupling, nonlinear dynamics, and hierarchical structural dependencies, posing significant challenges for fault detection and diagnosis (FDD). Most existing statistical and deep learning methods treat such systems as high-dimensional time series and fail to explicitly model process topology and cross-unit interactions, which consequently limits their performance in FDD. This paper proposes a hierarchical spatial-temporal graph convolutional network (HST-GCN) that represents the industrial process as a two-layer graph structure, capturing intra-unit variable coupling and inter-unit dependencies. Specifically, a parameter-level subgraph is constructed for each production unit to model local multivariate dynamics, and a process-level hypergraph encodes global dependency relationships among different units. Furthermore, inspired by the hidden Markov model (HMM) paradigm, a temporal attention-based state transition mechanism is introduced to characterize the evolution of latent operating conditions and model fault propagation across time. Experiments on the Tennessee Eastman Process demonstrate that HST-GCN consistently outperforms conventional baselines in both fault-wise binary detection and multi-class fault diagnosis tasks, validating its effectiveness for complex industrial FDD.

► SunA04-5 09:20–09:40

Surveillance of Rod Pumping Systems Based on Load Series

Jiang, Changhao Northeastern Univ.
Li, Jinghao Northeastern Univ.
Gao, Rui Northeastern Univ.

A rod pumping system is a key component in oil exploitation and its surveillance is essential to ensure normal production and energy-efficient operation. This paper investigates the surveillance problem of rod pumping systems based on load series. First, the correlation between the load series and the operating conditions of the rod pumping systems is analyzed to reveal that load series themselves can be used to discriminate different operating conditions. Based on this observation, a single load series-based surveillance method is proposed, where an adaptive SAX is proposed to extract the structured features of load series and a similarity assessment is designed to recognize operating conditions. Moreover, the single load series-based surveillance method was further developed to deal with multiple load series. Finally, experimental results validate the effectiveness of the proposed method based on a set of field load series.

► SunA04-6 09:40–10:00

Temporal Causal Discovery with Counterfactual Data Augmentation for Automotive Fault Diagnosis

Chen, Xiaolu Anhui Polytechnic Univ.
Chen, Can Anhui Polytechnic Univ.
Wu, Wen Tai Anhui Polytechnic Univ.
Guo, Li Anhui Polytechnic Univ.
Yang, Zeyu Huzhou Univ.

Automotive fault diagnosis is challenged by temporal dependence in sensor data and severe fault-data imbalance. This paper presents a framework that combines temporal causal discovery and counterfactual data augmentation. We propose TCDI (Temporal Causal Discovery with Interventions) to discover causal relations from sensor sequences by integrating lag detection, temporal conditional independence testing, and effect-type analysis. Based on the discovered causal graph, we further propose CDA (Counterfactual Data Augmentation) to generate synthetic fault samples through causal interventions while enforcing physical constraints during sample generation. Experiments on real automotive data show that TCDI outperforms several baseline methods in causal discovery. CDA generates samples that satisfy all physical constraints, while baseline augmentation methods produce invalid samples in some cas-

es. The framework also provides interpretable causal information for fault analysis in safety-critical automotive systems.

SunA05 08:00–10:00 Meixue Hall
Regular Session: Data-Driven Modeling, Optimization, Scheduling (I)

Chair: Shen, Dong — Renmin Univ. of China
Co-Chair: Kang, Qi — Tongji Univ.

▶ SunA05-1 08:00–08:20
Iterative Learning Control for Overhead Cranes via Optimal Path Planning

Chen, Kunhong — Renmin Univ. of China
Jiang, Hao — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China
He, Xiongxiong — Zhejiang Univ. of Tech.

This paper presents a path planning and iterative learning control (ILC) framework for underactuated overhead cranes to achieve precise trolley positioning while suppressing payload swing. An optimal reference path is first generated considering transportation efficiency, energy consumption, and payload swing suppression. To compensate for deviations caused by feedback control limitations, a P-type ILC scheme is employed, which updates the actual reference path using the tracking error from previous iterations. Three types of direction regulation matrices, namely gradient-based, inversion-based, and time-based, are discussed to realize the ILC scheme and reduce computational complexity. Numerical simulations demonstrate that the proposed approach effectively improves path tracking accuracy over successive iteration, validating the advantages of the ILC-based actual reference path refinement strategy.

▶ SunA05-2 08:20–08:40
Adaptive Hierarchical Multi-Robot Path Planning and Execution with Task Allocation Schedule

Wu, Siqi — Tongji Univ.
Huang, Wangya — Tongji Univ.
Kang, Qi — Tongji Univ.

Path Planning is crucial for implementing task-level decisions. This paper investigates a variant of lifelong Multi-Agent Path Finding (MAPF) where each robot is required to execute multiple tasks in a sequence while explicitly considering operation duration. By leveraging a pre-planned schedule, an event-triggered hierarchical planning mechanism is proposed to concurrently plan and execute, thereby reducing unnecessary waiting time for robots. Considering that environmental node availability may change in practical applications, a single-layer planning approach combining conflict-based search with the incremental pathfinding algorithm D*Lite is designed to solve single or multi-point MAPF subproblems. It enables multi-robot coordinated path planning and efficient replanning. Empirical results demonstrate that the proposed method achieves faster response time while maintaining high-quality solutions compared to various lifelong MAPF solvers under static and critical node failure scenarios.

▶ SunA05-3 08:40–09:00
Day-Ahead Two-Stage Coordinated Scheduling Optimization for PSCS Considering Price-Based Demand Response

Yang, Guangshi — State Grid Bengbu Electric Power Supply Company
Dai, Wei — State Grid Bengbu Electric Power Supply Company
Wei, Jiandong — State Grid Anhui Integrated Energy Services Co., Ltd. Bengbu Branch
Kang, Yu — State Grid Bengbu Electric Power Supply Com
Li, Wei — State Grid Bengbu Electric Power Supply Company
Teng, Nan — State Grid Bengbu Electric Power Supply Company
Cheng, Xi — STATE GRID ANHUI INTERGRATED ENERGY SEVICE CO.LTD
Zhang, Xiulu — State Grid Corporation of China
Fei, Cao — State Grid Bengbu Electric Power Supply Company
Shen, Weibing — Southeast Univ.
Bai, Yunlong — State Grid Tongling Power Supply Company

To address the "peak-on-peak" effect, localized congestion, and rising station operating costs caused by the spatiotemporal aggregation of electric-vehicle (EV) charging demand, this paper proposes a day-ahead scheduling optimization strategy for a photovoltaic–storage–charging integrated charging station (PSCS) that incorporates price-based demand response. First, a demand-response model of charging load is developed using a price–load elasticity matrix, which maps price variations to corresponding changes in users' charging demand.Second, we integrate the demand response model to develop a two-stage coordinated scheduling optimization framework driven by price-based demand response.In the first stage, the improved particle swarm optimization (IPSO) algorithm performs an iterative search over candidate charging-service pricing strategies.In the second stage, for each specified service tariff, we establish a multi-objective optimization model for PSCS operation, aiming to maximize station profit, PV installed-capacity utilization, and electric-vehicle user satisfaction. Gurobi is employed to solve the model and obtain the optimal day-ahead battery charging/discharging schedule and the day-ahead grid electricity purchase/sale plan under the given service price. Subsequently, the Stage-II outcomes are returned to the Stage-I IPSO to compute the fitness, which guides the update of the charging-service price profile. Ultimately, the proposed method outputs the optimal time-of-use (TOU) tariff together with the corresponding day-ahead electricity trading and storage dispatch strategy.Case studies based on a real commissioned charging station and multi-scenario comparative evaluations demonstrate that the proposed model and method improve the economic performance of the charging station, optimize the charging load profile, and promote renewable energy utilization, thereby providing theoretical support for research on day-ahead scheduling optimization strategies for PSCS.

▶ SunA05-4 09:00–09:20
Research on Ballistic Impact Point Prediction Method Based on Group Target Resource Scheduling

Yu, Chao — College of Sci.，National Univ. of Defense Tech.
He, Zhangming — National Univ. of Defense Tech.
He, Yujie — 95859 Unit of the Chinese People's Liberation Army
Xu, Tao — Unit 95765 of the PLA
Ma, Tao — Unit 95765 of PLA
Zhou, Mo — National Univ. of Defense Tech.

In multi-target tracking missions such as UAV swarms and dense artillery and missile salvos, detection echoes from multiple targets may exist simultaneously within a single radar illumination beam, generating a large number of tracks. Independent tracking and illumination of each target would consume enormous system resources. To address the prominent resource allocation conflicts and insufficient impact point prediction accuracy in ballistic tracking of dense group targets, this paper proposes a ballistic tracking and impact point prediction method based on group target resource scheduling.The core of this method lies in introducing radar wave position clustering-based group target resource scheduling technology: it performs dynamic clustering of dense targets based on spatial distance and wave position coverage characteristics, and constructs a target ballistic motion extrapolation and impact point prediction model that integrates the ballistic mechanics model and polynomial technique, thereby realizing the integration of optimal resource allocation, accurate trajectory extrapolation, and efficient impact point prediction.From the perspective of core technical characteristics, the wave position clustering scheduling technology demonstrates significant advantages:It greatly reduces the beam switching frequency through intra-group resource sharing, effectively alleviating resource shortages in dense target scenarios;The clustering results can dynamically adapt to the targets' aggregation-separation motion states, providing continuous and stable trajectory data support for impact point prediction;The wave position coverage is highly targeted, which reduces beam overlapping interference and improves the basic accuracy of trajectory measurement.This method can provide theoretical and technical reference for rapid and accurate tracking and impact point prediction of multi-warheads.

▶ SunA05-5 09:20–09:40
Optimization Method for Catalytic Reforming Process Operating Path Based on Virtual Guide Points and Smoothing Strategy

Xu, Zikang — China Univ. of Petroleum, Beijing
Fang, Yaning — China Univ. of Petroleum (Beijing)
He, Renchu — China Univ. of Petroleum

To Address the high-dimensional nonlinear characteristics and dynamic complexity of operating condition transitions in catalytic reforming processes, this paper proposes an optimization method for catalytic reforming operating paths based on virtual guide points and smoothing strategies. Unlike traditional methods that focus solely on optimizing static operating points while neglecting the dynamic safety of operating condition transitions, this study first constructs a three-dimensional visualization model based on Principal Component Analysis (PCA). Building upon this, an improved Ant Colony Optimization (ACO) algorithm integrating a virtual guide point mechanism and a smoothness strategy is proposed. By introducing a turning angle constraint, the stability of oper-

ating condition transitions is optimized. Simulation results demonstrate that this method not only significantly enhances aromatics yield but also substantially improves the smoothness of operating condition transitions. Compared to traditional Ant Colony Optimization (ACO) algorithm in three-dimensional space, the improved algorithm reduces path length by 11.8% and lowers the average turning angle by 20.3%. By ensuring economic viability while effectively enhancing the smoothness of operating condition switching, this method holds significant engineering application value.

► SunA05-6 09:40–10:00

Wind Power Prediction Integrating Transformer Deep Learning Model with Random Forest

Fang, Lei — Jiangsu Univ. of Tech.
Li, Feng — Jiangsu Univ. of Tech.

This paper proposes a wind power forecasting method that integrates a Transformer deep learning architecture with Random Forest (RF) error correction. Firstly, the isolation forest algorithm is employed for anomaly detection and data cleaning. Subsequently, a multi-head self-attention-based Transformer model is constructed for initial forecasting, and the prediction error sequence is extracted. On this basis, RF is utilized to model the error sequence, achieving dynamic correction. Finally, K-means clustering is introduced to partition operating conditions, and kernel density estimation is combined to fit the probability distribution of corrected errors under different conditions, generating prediction intervals at different confidence levels. Experimental results based on measured data from a wind farm demonstrate that the proposed method outperforms traditional benchmark models in terms of prediction metrics such as MAPE, RMSE, and MAE. Moreover, the interval prediction satisfies validity requirements at both 90% and 95% confidence levels, verifying its comprehensive forecasting performance and engineering applicability.

SunA06 08:00–10:00 Guibin Hall

Regular Session: ADP and RL Based Learning Control (I)

Chair: Ren, Qinyuan — Zhejiang Univ.
Co-Chair: Zhao, Feng-Liang — Sun Yat-Sen Univ.

► SunA06-1 08:00–08:20

Motion Simulation-enhanced Data Scaling for Integrated Prediction and Planning of Autonomous Driving

Gao, Bitao — Beihang Univ.
Li, Ding — Beihang Univ.
Wang, Ziyan — Beihang Univ.
Xia, Qi — Beihang Univ.
Zhang, Qichao — Chinese Acad. of Sci.
Xia, Zhongpu — Chinese Acad. of Sci.
Yu, Guizhen — Beihang Univ.

Integrated prediction and planning of autonomous driving leverages imitation learning (IL) to mimic rational motion behaviors from a wide span of expert demonstrations. However, real-world data collected from human experts are commonly dominated by common cases, causing the learning-based model to suffer from distribution shift under rare, non-trivial cases. To address this problem, we unlock motion simulation data scaling properties and propose a novel motion simulation-enhanced imitation learning framework to significantly improve generalization and adaptivity of integrated prediction and planning models in challenging, highly-interactive driving scenarios. In this work, we first propose a motion simulation-enhanced data generation engine to rollout diverse and interactive multi-agent motion states as pseudo-expert data for later action supervision. Further, we develop a real-sim co-training strategy to optimize integrated prediction and planning models upon both real-world and simulated motion samples. Finally, extensive experiments conducted on large-scale open-pit motion datasets demonstrate that the proposed motion simulation-enhanced imitation learning framework improves planning safety and feasibility in challenging scenarios.

► SunA06-2 08:20–08:40

Comparative Evaluation of PPO and SAC for Robust Autonomous Low-Thrust Transfers in Cislunar Space

Ul Haq, Izhar — Northwestern Polytechnical Univ.
Dai, Honghua — Northwestern Polytechnical Univ.
Shahid, Faizan — HIT

Autonomous low-thrust trajectory planning in the Earth-Moon circular restricted three-body problem (CR3BP) is challenged by strong nonlinearities, sensitivity to initial conditions, and bounded initial-state uncertainty in cislunar operations. Conventional optimal-control methods can produce high-quality open-loop solutions, but they often rely on expert-generated initial guesses and provide limited closed-loop autonomy during transfer execution. These limitations motivate the use of deep reinforcement learning (DRL) to learn feedback-driven guidance policies directly from interaction with the environment. This paper presents a controlled comparison of two DRL algorithms, Proximal Policy Optimization (PPO) and Soft Actor-Critic (SAC), for low-thrust transfers between planar L2 Lyapunov orbits in the Earth-Moon CR3BP. Both methods are evaluated under an identical training and testing setup using metrics including training efficiency, nominal transfer behavior, and Monte Carlo robustness to initial-state perturbations. The results show that SAC reaches high reward earlier in training steps and reduces propellant consumption by approximately 6%, whereas PPO achieves approximately 2.7x higher simulation throughput, tighter terminal accuracy, and slightly stronger robustness under severe perturbations. These findings provide benchmark-specific guidance for selecting DRL algorithms in autonomous cislunar low-thrust guidance.

► SunA06-3 08:40–09:00

Reference-Guided Soft Actor-Critic for Unmanned Surface Vehicle Navigation in Constrained Waterways

Ma, Hanyang — Beijing Univ. of Chemical Tech.
Li, Dazi — Beijing Univ. of Chemical Tech.

Unmanned Surface Vehicle (USV) navigation in constrained waterways is challenging due to complex channel geometry, dense obstacles, and sparse reinforcement learning (RL) rewards. Pure deep RL methods often suffer from slow convergence and unstable behaviors without global guidance. This paper proposes a Reference-guided Soft Actor-Critic (RG-SAC) framework, integrating clearance-aware A* path planning with deep RL for USV navigation. The A* algorithm generates a globally feasible reference path, whose geometric attributes (local tangent direction and curvature) are incorporated into the reward function to guide policy learning. Experiments in an OSM-based narrow waterway environment compare RG-SAC with DDPG, PPO, SAC, and TD3 baselines. Results show that RG-SAC achieves faster convergence, more stable navigation, and smoother trajectories with fewer training episodes, validating the effectiveness of combining clearance-aware planning with RL for constrained USV navigation.

► SunA06-4 09:00–09:20

Learning-Enhanced Distributed Self-Triggered Consensus of Heterogeneous Nonlinear Multi-Agent Systems

Ke, Jiachen — Tongji Univ.
Zhou, Yanmin — Tongji Univ.
Wang, Zhipeng — Tongji Univ.
Wang, Zhongjie — Tongji Univ.
Cheng, Bin — College of Electronics & Information Engineering, Tongji Univ.

This paper addresses a distributed self-triggered consensus control problem of heterogeneous nonlinear multi-agent systems via adaptive critic learning. To enhance the resource utilization of communication and computation, a novel dynamic self-triggered scheme containing an adjusting factor is proposed with the Zeno-excluded analysis. This scheme eliminates the requirement for continuous state monitoring inherent in conventional event-triggered mechanisms. A single-critic structure with aperiodic weight tuning is adopted to estimate the optimal cost function, which circumvents the repeated approximation and computational burden. On basis of the developed intelligent approach, the local consensus error and weight estimation error are guaranteed to be uniformly ultimately bounded. Eventually, the simulation results of multiple pendulum systems validate the effectiveness of distributed self-triggered control scheme.

► SunA06-5 09:20–09:40

Safe and Informative Battery Excitation via Constrained Reinforcement Learning: A Budget-Aware Approach

Li, Junyi — Shandong Univ.
Li, Yan — Shandong Univ.
Wang, Qiaoling — Shandong Univ.

Accurate parameter identification is essential for simulation analysis and optimal control of lithium-ion batteries. Under strict safety constraints, designing input excitation signals that maximize Fisher information (FI) remains challenging. Standard excitation profiles, such as constant-current (CC) operation and the Federal Urban Driving Schedule (FUDS), are primarily designed for operation and often yield limited information for identification. Meanwhile, a reinforcement learning (RL) baseline that enforces safety through fixed penalty terms, namely Soft Actor-Critic (SAC),

can suffer from unstable constraint satisfaction near safety boundaries. This paper proposes a two-stage Optimal Experimental Design (OED) framework based on constrained RL. The excitation generation is formulated as a constrained Markov decision process (CMDP) and solved using Lagrangian Soft Actor-Critic (L-SAC). The policy is learned on a fast surrogate model and then audited on a higher-fidelity fractional-order model to improve robustness to structural model mismatch. Experiments on two single-parameter identification tasks show that, under identical budgets and constraints, the proposed method achieves zero safety violations in the reported tests and consistently improves FI-per-charge efficiency over the soft-constrained baseline. The results further demonstrate stronger safety preservation and more efficient information utilization than the compared reference methods under the same operating budgets.

▶ SunA06-6 09:40–10:00

Learning-Based Active Compliance Control for Peg-in-Hole Assembly via a Policy Distillation

Li, Shenyuan — Zhejiang Univ.
Lang, Yilin — Zhejiang Univ.
Zhu, Wenxin — Zhejiang Univ.
Zhao, Yuhong — Inst. of Industrial Intelligence & Sys. Engineering
Ren, Qinyuan — Zhejiang Univ.

Peg-in-Hole (PiH) assembly remains a challenging contact-rich task in industrial automation. The core difficulty lies in the small assembly clearance, while the complex contact dynamics result in a non-unique mapping from force feedback to relative poses. In this paper, a data-driven, dual-layer control scheme is proposed to resolve such contact ambiguities under environmental uncertainties. It couples a high-level planning policy with a low-level admittance controller for better safety and robustness. Offline Bayesian Optimization is applied to configure the admittance controller's stiffness and damping parameters, establishing a reliable stability baseline. On this basis, a Teacher-Student learning scheme is designed to address the ambiguous force mapping. An MPPI planner generates expert demonstrations, which are used to train a TCN-based student policy. By analyzing historical interaction sequences, this student network infers active trajectory corrections and feeds them as reference inputs to the underlying admittance loop. Simulation experiments on a UR5 manipulator across four typical environmental stiffnesses validate the proposed method. The results show that peak contact forces are effectively suppressed, and the mean success rate is improved by approximately 34% compared to a baseline combining spiral search with fixed admittance control.

Poster Session SunA07
May.10, 8:00–10:00
Front Hall

▷ SunA07-01

Robust Model Predictive Control Based on Equivalent Input Disturbance for Speed Control with Unknown Disturbances

Feng, Yingchao — China Nuclear Lndustry 23 ConstructionCO.,LTD
Sun, Qiuyang — China Nuclear Industry 23 ConstructionCO.,LTD
Sun, Liuqing — Nuclear Industry Engineering Research & Design Co., Ltd
Fang, Jiang — Nuclear Industry Engineering Research & Design Co., Ltd
Liu, Jinping — Nuclear Industry Engineering Research & Design Co., Ltd
Li, Zhuyuan — Nuclear Industry Engineering Research & Design Co., Ltd
Liu, Kangtai — Nuclear Industry Engineering Research & Design Co., Ltd
Han, Changren — Nuclear Industry Engineering Research & Design Co., Ltd

In high-precision motion control systems, external disturbances and modeling uncertainties significantly degrade control performance, necessitating speed control strategies that combine robustness with high accuracy. This paper proposes robust model predictive control (RMPC) based on equivalent input disturbance (EID) to achieve precise speed control of servo systems with unknown disturbances. First, a linear EID estimator for real-time disturbance compensation, coupled with a disturbance-rejection performance index that is incorporated into the RMPC optimization, effectively reduces the effect of disturbances on system output. Then, a tracking performance index is proposed that incorporates real-time disturbance compensation into the optimization process, enabling the calculation of effective optimal control sequences under disturbed conditions within the predicted time domain. Further, by combining error enhancement states with penalized soft input constraints, tracking accuracy is enhanced and smoother optimal control actions are ensured. Finally, experiments conducted on a dual-servo platform and comparisons with other methods demonstrated the effectiveness and superiority.

▷ SunA07-02

Algorithm Unrolling for Discrete-time Periodic Sylvester Matrix Equations with Unknown Parameters

Sun, Yuge — North China Univ. of Water Resources & Electric Power
Lv, Lingling — North China Univ. of Water Conservancy & Electric Power

To tackle the computational difficulties in solving periodic Sylvester matrix equations, this paper introduces a data-driven deep learning method. The approach is based on an algorithm unrolling architecture. This method maps each iteration of the traditional algorithm to a single layer of a neural network, and constructs an end-to-end network by updating learnable weight and step-size parameters. Through supervised training on large-scale random samples and their corresponding high-precision numerical solutions, the network autonomously learns the underlying coupled dynamics and iterative convergence mechanisms from input-output observational data. Consequently, it achieves efficient solutions without requiring explicit knowledge of the system matrices. The experimental results confirm that the proposed method achieves convergent solutions purely through input–output data observations, thereby eliminating dependency on precise matrix inversion or large-scale decomposition operations inherent in conventional approaches. This further validates the superiority of data-driven architectures in solving complex matrix equations.

▷ SunA07-03

Model-Free Adaptive Formation Control for Multi-UAV Systems with Unknown Dynamics

Chen, Hao — Dalian Maritime Univ.
Weng, Yongpeng — Dalian Maritime Univ.
Zhu, Jiaxing — Shenyang Aircraft Design & Research Inst.
Wang, Huanyu — State Grid Liaoning Electric Power Co.,Ltd.Dalian Jinzhou New District Power Supply Branch

Formation control is a critical enabler for multi-UAV systems to perform complex collaborative tasks in both military and civilian domains. However, the inherent nonlinearity, underactuation, model uncertainties, and external disturbances of quadrotor UAVs render traditional model-based control methods impractical due to the difficulty of obtaining accurate mathematical models. To overcome these limitations, this paper proposes a full-form dynamic linearization-based model-free adaptive formation control (FFDL-MFAFC) method. First, a compact equivalent data model is established using a non-parametric dynamic linearization technique to address the unavailability of an accurate system model. Building on this data model, a distributed formation controller is designed at the kinematic level, relying solely on the input/output data of neighboring UAVs. Subsequently, a model-free adaptive attitude controller is developed to track the reference attitude angles derived from the kinematic level. Finally, theoretical analysis and simulations demonstrate that the proposed method ensures system stability, adaptability, and strong disturbance rejection, thereby significantly enhancing the formation control performance of multi-UAV systems.

▷ SunA07-04

A Data-driven Model-free Adaptive Control Method under Non-periodic DOS Attack

Ren, Bing — Lanzhou Jiaotong Univ.

This paper investigates the security control issue of discrete-time nonlinear systems under aperiodic Denial-of-Service (DoS) attacks. First, the characteristics of aperiodic DoS attacks are analyzed and modeled, which block communication channels at unpredictable frequencies and cause state information loss and control signal abnormalities. Second, based on the Model-Free Adaptive Control (MFAC) algorithm, a controller integrated with a compensation mechanism and an adaptive observer is proposed, utilizing only the input/output data of the system to address the state information loss caused by attacks, enhance the system's resistance to aperiodic DoS attacks, and ensure the control security and stability of discrete-time nonlinear systems. As a result, theoretical analysis reveals that the proposed control scheme can maintain the

system's tracking performance of the desired output even when control signals are lost due to attacks, and improve the system's robustness against aperiodic DoS attacks. Finally, the effectiveness of the proposed control strategy is demonstrated by simulation results on a steam-water heat exchanger system.

▷ SunA07-05

Risk-Decision-Based Sliding Mode and Model-Free Hierarchical Control for Combined Aircraft

Wen, Qifeng	Huazhong Univ. of Sci. & Tech.
Liu, Lixin	Huazhong Univ. of Sci. & Tech.
Fan, Huijin	Huazhong Univ. of Sci. & Tech.
Liu, Lei	Huazhong Univ. of Sci. & Tech.
Wang, Bo	Huazhong Univ. of Sci. & Tech.

A combined aircraft refers to a reconfigurable system formed by combining two or more aircraft units with specific functions through dedicated docking and separation mechanisms. In diverse environments and missions, combined aircraft face challenges such as multi-source external disturbances, interactions between unmodeled dynamic uncertainties, and mutual coupling, exhibiting strong time-varying and highly nonlinear characteristics. Traditional control systems are no longer applicable. Therefore, this paper proposes a hierarchical decision control approach based on sliding mode and model-free techniques. First, the hierarchical control scheme integrates an online decision switching architecture, a sliding mode controller (SMC) with rapid tracking capability, and a cascaded model-free adaptive controller (MFAC) with excellent robustness. Second, an online decision switching architecture based on capability characteristics and risk prediction is constructed to evaluate the control capability of the current state of the combined aircraft. The designed sliding mode controller achieves rapid command tracking under minor disturbances, while the cascaded MFAC ensures stable attitude transitions for the combined aircraft in complex and adverse environments. Finally, simulation results validate the effectiveness of the proposed scheme.

▷ SunA07-06

Model-free Adaptive Quadrotor Control with Full-form Dynamic Linearization

Zhang, Lei	Shenzhen Univ.
Yang, Zunyao	Beijing Jiaotong Univ.
Yu, Xian	Shenzhen Univ.
Zhong, Xiaopin	Shenzhen Univ.

Quadrotor is an underactuated and highly nonlinear system, facing challenges such as model uncertainties and time-varying characteristics. The fixed control gain form of typical PID cannot adapt well to this situation due to the time-varying factors of the quadrotor system. The model-free adaptive control (MFAC) provides us the tool of tackling the challenges due to its adaptive ability for uncertain nonlinear systems. In this paper a MFAC approach is applied to the quadrotor, where the dynamic relationship between position and velocity in height direction is transformed into the parameterized data model by using the full-form dynamic linearization approach. Then a data-driven quadrotor control law is achieved under the framework of minimizing a control input criterion function with the adaptive estimation of model parameters. The simulation results show that, in comparison with the typical PID, the applied MFAC quadrotor controller achieved 27.62% higher tracking accuracy.

▷ SunA07-07

Adaptive Sliding Mode Control for Position and Velocity Tracking in MEMS Gyroscope

Li, Xinsuo	Guangxi Univ. of Sci. & Tech.
Hao, Yiran	Guangxi Univ. of Sci. & Tech.
Li, Fapeng	Guangxi Univ. of Sci. & Tech.
Xu, Dengguo	Guangxi Univ. of Sci. & Tech.

This paper presents an adaptive tracking control scheme based on a sliding mode mechanism for micro-electromechanical system (MEMS) gyroscope subject to parametric uncertainties. We designs a novel sliding mode surface (SMS) to constrain the system states to a specific dynamic manifold, thereby guaranteeing asymptotic convergence of the tracking error. This control method innovatively introduces virtual parameters and a core function structure, eliminating the need for traditional function approximation techniques when processing the nonlinear dynamics of the gyroscopes. Leveraging Lyapunov stability theory, we construct an adaptive controller and corresponding parameter update laws that provide a rigorous proof of asymptotic stability for the closed-loop system. Simulation results demonstrate that the proposed method not only effectively suppresses the impact of parametric uncertainties but also exhibits trajectory tracking accuracy and robust performance.

▷ SunA07-08

DS-STAE: Dual-Stream Spatio-Temporal Transformer for Context-Aware Anomaly Reconstruction in UAVs

Chen, Yinchao	AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)
Cui, Xiaojing	AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)
Liang, Zhaoxin	AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)
Tan, Zheng	AVIC Chengdu Aircraft Design & Research Inst. (611 Inst.)

Reliable anomaly detection in multivariate flight time series of unmanned aerial vehicle (UAV) is essential for safety-critical operations, as undetected abnormal sensor behaviors can compromise control and stability. Traditional autoencoder models generally fail to capture both long-range temporal dependencies and complex inter-sensor correlations, while existing transformer approaches relying solely on raw sensor signals may miss subtle or gradually evolving anomalies such as sensor drift. To address these limitations, we propose a dual-stream spatio-temporal transformer autoencoder (DS-STAE) that jointly models raw sensor measurements and temporal differences between consecutive observations. This dual-stream design enhances sensitivity to both abrupt and slowly evolving anomalous behaviors. Evaluated on a multi-anomaly UAV flight dataset, our model achieves an area under the curve (AUC) of 0.9808 and an F1-score of 0.9688, proving its effectiveness in early warning and safety monitoring.

▷ SunA07-09

Dynamic Event-Triggered Model-Free Adaptive Control for Longitudinal Cooperative Control of Connected and Automated Vehicle Platoons

Ji, Honghai	North China Univ. of Tech.
Zhai, Limin	North China Univ. of Tech.
Liu, Shida	North China Univ. of Tech.
Ren, Ye	North China Univ. of Tech.
Wang, Li	North China Univ. of Tech.

To address the unmodeled nonlinear dynamics and limited vehicle-to-everything communication resources in connected and automated vehicle platoons, a dynamic event-triggered model-free adaptive cooperative control approach is proposed. This method eliminates the need for precise physical models of vehicle dynamics and achieves online equivalent modeling and control of unknown dynamics using only input-output interaction data. To balance global formation consistency and local collision-avoidance responsiveness, a dual cooperative error model involving both position and velocity is constructed under a mixed leader-predecessor communication topology. On this basis, a dynamic event-triggered mechanism with an exponentially varying tolerance threshold and adaptive dead-zone self-regulation is designed, which significantly reduces the frequency of network interactions. Numerical simulations demonstrate that the proposed DET-MFAC algorithm effectively suppresses nonlinear disturbances and ensures high-precision, smooth, and stable platoon following. Moreover, it saves 92.26% of communication resources while maintaining control quality, thereby providing a data-driven solution for efficient cooperative platoon control in complex traffic scenarios.

▷ SunA07-10

A CMPC-PI Controller for Series Battery Packs Based on Dual-layer Equalization Topology

Xing, Xiangzhao	Shandong Univ.
Wang, Shun	Shandong Univ.
Li, Yan	Shandong Univ.

This article designs a constrained model predictive control –proportional integral (CMPC-PI) controller based on a dual-layer equalization topology for mitigating inconsistencies within the battery pack. CMPC can optimize the direction of current, while PI control can adjust the magnitude of current. Considering the voltage and current constraints of the switching devices, a multi-objective gain-scheduling mechanism is integrated into the CMPC to regulate the balancing currents of both layers. This method enables each individual cell in the lithium battery pack to reach an equalization state efficiently and quickly. MATLAB/Simulink simulations involving a system of four lithium-ion batteries and two packs demonstrate that the CMPC-PI controller effectively optimizes the equalization current and improves the equalization speed.

▷ SunA07-11

ADRC-PID Based Cascade Control for Multi-Temperature-Zone System-

s with Large Inertia

Li, Xiangyang	South China Uni. of Tech
Xu, Zhitian	South China Univ. of Tech.
Wang, Bingbing	Changji Univ.
Ai, Wei	South China Univ. of Tech.

To address the control challenges of large inertia, pure time delay, strong coupling, and parameter uncertainty in multi-temperature-zone tubular furnaces for photovoltaic chemical vapor deposition (CVD), this paper proposes a cascade control strategy based on Active Disturbance Rejection Control (ADRC) and Proportional-Integral-Derivative (PID). The architecture employs a dual-loop design. To leverage the fast response and simple structure of PID, the inner loop regulates the outer wall temperature using a PID controller. The outer loop controls the internal product temperature using ADRC, where an Extended State Observer (ESO) estimates and compensates in real time for the "total disturbance" caused by large thermal capacitance, heat transfer lag, inter-zone coupling, and gas flow variations, enabling robust control without requiring an accurate mathematical model. Furthermore, to mitigate the pure time delay inherent in the outer-loop plant, a differential prediction module is introduced in the feedback path to attenuate phase lag. Simulation results show that the proposed method can precisely track the setpoint of 500℃ within approximately 800 seconds without overshoot, and has strong anti-disturbance capability in the face of different types of disturbances. This work provides a highly stable and robust temperature control solution for photovoltaic thin-film growth processes.

▷ SunA07-12

Graph Attention Network-Based Fault Diagnosis for Multiple Unmanned Helicopters

Ning, Hanlin	Anhui Polytechnic Univ.
Qi, Darui	Anhui Polytechnic Univ.
Li, Runze	Anhui Polytechnic Univ.
Su, Zhengyang	Anhui Polytechnic Univ.
Guo, Li	Anhui Polytechnic Univ.

Multiple unmanned helicopters have stringent requirements for safety and stability in practical operations. To address this demand and the issue of diagnostic accuracy degradation caused by individual differences, this paper proposes a Graph Attention Network (GAT)-based diagnosis method. First, the K-Nearest Neighbors (KNN) algorithm is utilized to construct a spatiotemporal topological graph to capture the nonlinear correlations among sensor data. Second, an attention mechanism is introduced to adaptively aggregate the fault features of key nodes. Finally, a collaborative diagnosis strategy utilizing ensemble learning is designed to effectively overcome the performance limitations of single models when dealing with data with individual variability. Experiments conducted on a high-fidelity simulation platform demonstrate that the proposed method accurately identifies various fault modes and significantly outperforms main algorithms in diagnostic accuracy.

▷ SunA07-13

Aeroacoustic Damage Detection for Wind Turbine Blades Based on Masked 1D U-Net and AS-YOLO

Chen, Junming	Changsha Univ. of Sci. & Tech.
Yang, Ke	Changsha Univ. of Sci. & Tech.
Wang, Chengyu	Changsha Univ. of Sci. & Tech.
Xiong, Yong	College of Computer Sci., Hunan Univ. / Hunan Lianzhi Tech. Co., Ltd
Tang, Mingzhu	Central South Univ.
Luo, Jiawei	Changsha Univ. of Sci. & Tech.
Li, Zhimin	Changsha Univ. of Sci. & Tech.

The health monitoring of wind turbine blades plays a crucial role in ensuring the stable operation of wind turbines. This paper proposes a high-precision damage detection method based on a cascaded masked 1D U-Net and attention-enhanced spatial fusion YOLO (AS-YOLO) to achieve more accurate health condition detection of wind turbine blades from acoustic signature signals under complex noise interference. First, a time-domain masked 1D U-Net is developed to suppress background noise while preserving periodic aerodynamic features. It integrates a masking mechanism with an encoder-decoder architecture. Second, an AS-YOLO network is built for spectrogram-based damage detection, where the Attention Feature Enhancement Module (AFEM) enhances the extraction of low-contrast micro-damage features and the Spatial Re-weighting Feature Fusion Module (SFFM) replaces the conventional neck structure to improve multi-scale feature fusion. By integrating dynamic channel weighting and spatial context fusion, it effectively suppresses noise interference. Experimental results show that AS-YOLO achieves an mAP@0.5 of 96.2%, outperforming the baseline by 2.9%. It surpasses mainstream YOLO algorithms in both precision and recall, providing an effective solution for non-contact online monitoring.

▷ SunA07-14

Multi-Modal Feature Driven Adversarial Domain Adaptation Method for Bearing Fault Diagnosis

Qin, Xinghua	National Univ. of Defense Tech.
Yang, Chenxi	National Univ. of Defense Tech.
Zhang, Yiyin	National Univ. of Defense Tech.
Wu, Jialong	National Univ. of Defense Tech.
Ruan, Yirun	National Natural Sci. Foundation of China

To address the core challenges of data distribution discrepancy and target domain label scarcity in high-speed train axle box bearing fault diagnosis, this study proposes a multimodal feature-driven adversarial domain adaptation framework. Based on national bearing standards, target domain parameters are assumed to calculate fault characteristic frequencies, and fault-sensitive features are systematically extracted from time, frequency, and time-frequency domains with wavelet transform and short-time Fourier transform. High-precision source domain models are built using LightGBM, XGBoost, BiLSTM-Attention, and ResNet18, achieving nearly 100% accuracy. Domain adaptation technologies such as DANN and MMD enable knowledge transfer from test bench to real operational data, completing fault classification for 16 unlabeled target domain samples. Model interpretability is enhanced through MMD loss monitoring, t-SNE visualization, attention mechanism, and Grad-CAM, aligning decisions with bearing fault physical mechanisms. This framework provides an effective solution for intelligent operation and maintenance of industrial equipment under data-scarce scenarios.

▷ SunA07-15

Accurate Capacity Estimation of Retired Lithium-ion Batteries Based on Electrochemical Impedance Spectroscopy

Sun, Huayi	Shandong Univ.
Liu, Xuefeng	Shandong Univ.
Kang, Yongzhe	Shandong Univ.
Li, Changlong	Shandong Univ.
Duan, Bin	Shandong Univ.

Lithium-ion batteries (LIBs) have become crucial for the development of electric vehicles. However, with the expanding deployment of LIBs, a peak in LIB retirement is anticipated in the coming years. Capacity, as a core parameter of LIBs, plays a key role in their precise estimation for retired battery echelon use. To address this challenge, this paper extracts health features that reflect the nonlinear capacity degradation characteristics of batteries based on correlation analysis between capacity and Electrochemical Impedance Spectroscopy as well as the Distribution of Relaxation Times. A data-driven model for capacity estimation of retired LIBs is subsequently established. The results show that the proposed method achieves a mean absolute error and a root mean square error of 0.0091 Ah and 0.0144 Ah, respectively, for capacity estimation. Compared to decision tree-based models, the accuracy of capacity estimation is doubled, demonstrating high accuracy and adaptability for retired lithium-ion batteries.

▷ SunA07-16

Research on Trend Anomaly Diagnosis Based on Variational Autoencoder

Xu, Peng	China Univ. of Petroleum, Beijing
Wang, Zhu	China Univ. of Petroleum (Beijing)

Anomaly detection is a critical component in the petrochemical industry, playing a key role in ensuring the safe operation of enterprises. To address the problem of trend anomaly detection in the petrochemical industry, this paper proposes a chemical process anomaly detection method based on power spectrum data feature extraction and Variational Autoencoder (VAE). By utilizing Autocorrelation Function (ACF) analysis and Fast Fourier Transform (FFT), raw time-series data are transformed into power spectrum data, effectively suppressing high-frequency random noise and enhancing the frequency-domain features of the signals. Subsequently, a VAE model is employed to learn and reconstruct the power spectrum data. On this basis, this paper proposes a differential discrimination strategy. By calculating the difference in reconstruction loss between mixed data and baseline normal data, the characteristic signals of abnormal states are significantly amplified, thereby achieving sensitive detection of trend anomalies. Experimental results based on actual production data from a large domestic chemical plant demonstrate

that the proposed method possesses good robustness and accuracy under complex operating conditions and can effectively improve the safety monitoring level of chemical processes.

▷ SunA07-17

An ITransformer-based Approach for UAV Anomaly Detection via Sensor Correlation Learning

Yuan, Haoxuan	Dalian Maritime Univ.
Liu, Jingxiang	Dalian Maritime Univ.
Wang, Jianyu	Sichuan Univ.

Appropriate methods for unmanned aerial vehicle (UAV) anomaly detection are crucial for safety in realistic scenarios. However, conventional models like long short-term memory and time-series mixer often struggle with capturing the complex relationships among multiple sensors. To address this limitation, this study presents a novel UAV anomaly detection framework by leveraging the iTransformer architecture, which redefines the modeling perspective of multivariate time series. By treating sensors as tokens and capturing their dynamic correlations through an inverted Transformer structure, the method effectively identifies abnormal patterns in monitoring signals. Experimental results on engine and elevator datasets demonstrate superior performance over conventional sequence modeling approaches, which reach 0.9460 and 0.9052 in precision when detecting engine and elevator faults, providing practicality in safety monitoring.

▷ SunA07-18

Structure-aware Graph Contrastive Low-Rank Adaptation for Cross-Domain Few-Shot Fault Diagnosis

Qi, Hongfei	Huzhou Univ.
Yang, Zeyu	Huzhou Univ.
Yu, Jiaxin	City Univ. of Hong Kong
Ye, Lingjian	Huzhou Univ.

Deep learning has achieved remarkable success in machinery fault diagnosis; however, its effectiveness typically relies on the assumption that source and target data share identical distributions and sufficient labeled samples. In practical industrial scenarios, cross-operating-condition or cross-sensor settings often induce significant distribution shifts, while the target domain usually suffers from severe label scarcity. These challenges render conventional transfer learning methods prone to overfitting or negative transfer under few-shot conditions. Motivated by these challenges, we propose a parameter-efficient few-shot cross-domain framework termed SaGC-LoRA. First, vibration signals are transformed into graph-structured representations to capture intrinsic topological relationships. A graph contrastive pre-training strategy is then employed to learn domain-robust structural embeddings. Subsequently, a Low-Rank Adaptation (LoRA) mechanism is introduced, where the pre-trained backbone is frozen and only lightweight low-rank matrices are optimized for target adaptation. This design significantly reduces trainable parameters while preserving source-domain knowledge. Experiments on the CWRU bearing dataset under cross-sensor transfer demonstrate that SaGC-LoRA maintains strong diagnostic performance even with only 1–5 labeled samples per class, outperforming Fine-tuning, ADDA, and DANN in both accuracy and training stability.

▷ SunA07-19

Iterative Learning Consensus Control for Nonlinear Multi-Agent Systems with Random Initial States

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This paper proposes an improved distributed iterative learning control protocol for nonlinear multi-agent systems with random initial states and time-varying switching communication topologies, aiming to achieve consistent tracking over a finite time interval. The proposed protocol integrates a time-varying initial state compensation mechanism with a topology adaptive update law: a time-domain compensation term with an attenuation correction interval is designed to gradually eliminate the influence of random initial errors, and a distributed learning law based on neighbor errors is constructed by using the switching topology information. Based on the contraction mapping principle and the λ-norm tool, it is demonstrated that under the condition of appropriate learning gains, the outputs of all agents can uniformly converge to the desired trajectory over the entire time interval as the number of iterations increases. Numerical simulations using the verify the effectiveness and robustness of the proposed algorithm.

▷ SunA07-20

Spatial-Repetitive-Learning-Based Disturbance Rejection Model Predictive Control for Rotational Systems

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Xia, Jingkang	Hunan Univ. of Sci. & Tech.
Li, Meiliu	Hunan Univ. of Sci. & Tech.
Xiao, Wenbin	Hunan Univ. of Sci. & Tech.

This paper presents a disturbance-rejection model predictive control (MPC) scheme based on spatial-domain repetitive learning compensation for rotational systems subject to both position-dependent periodic disturbances and aperiodic disturbances, aiming to enhance disturbance rejection performance and robustness. First, an extended state observer is designed to estimate and compensate for aperiodic disturbances in real time. Meanwhile, a spatial-domain repetitive controller incorporating an internal model of position-dependent periodic signals is constructed to learn and compensate for such periodic disturbances. Next, a prediction model and a cost function are formulated, and a nominal MPC algorithm is developed under system state and input constraints. Then, the compensation signals for both periodic and aperiodic disturbances are fed forward to augment the nominal MPC input, thereby forming the overall control law. Finally, the proposed method is applied to speed control of a permanent magnet synchronous motor. Comparative simulations demonstrate the effectiveness and superiority of the proposed method.

▷ SunA07-21

Iterative Learning Control for Linear Singular Fractional-order Systems under State Disturbances

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Xin, Jiaqi	South China Univ. of Tech.

Aiming at the iterative learning control (ILC) problem of singular fractional-order systems with state disturbances, this paper focuses on the difficulties such as singular characteristic of system matrices and effects of state disturbances on tracking performance. First, the mathematical model of the system is established based on Caputo fractional-order derivative. Then, a P-type fractional-order ILC update law is designed, and the convergence condition of tracking error is derived. Finally, an instance is presented to show the performance in tracking the trajectory.

▷ SunA07-22

Optimizing Weight Matrix Estimation via Biased Methods for Data Driven Modeling

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Zhou, Mo	National Univ. of Defense Tech.
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Parameter estimation is a fundamental step in data-driven modeling and system identification, where accuracy and stability directly determine model interpretability and predictive performance. In the presence of collinearity or ill conditioned design matrices, biased estimation methods often achieve better mean squared error (MSE) than unbiased ones by balancing bias and variance. This paper proposes a one step optimal biased estimation method based on a weight matrix, which performs linear correction on the least squares estimate through the construction and optimization of a data driven weight matrix. The method attains an explicit analytical solution within a linear framework and exhibits theoretically superior MSE performance compared to classical biased estimators. To validate its effectiveness, numerical simulations are conducted under varying noise levels and parameter settings. Results demonstrate that the proposed approach significantly enhances estimation accuracy, stability, and computational efficiency.

▷ SunA07-23

Bias-Compensated Recursive Least Squares for LPV Models with Scheduling-Dependent Input Coefficients

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This paper proposes a bias-compensated recursive least squares (BCRLS) algorithm for the online identification of LPV models with scheduling-dependent input coefficients in the presence of additive output measurement noise. In such identification problems, conventional recursive least squares methods may suffer from significant estimation bias due to the combined effects of scheduling-dependent parameter variations and noise-induced correlation in the regression data. To overcome this limitation, a bias-compensation mechanism is systematically incorporated into the recursive least squares framework, resulting in the proposed BCRLS algorithm. The proposed method preserves the

computational efficiency of standard RLS while effectively reducing estimation bias. Its effectiveness and superiority are demonstrated through comprehensive numerical simulations, which show noticeably improved tracking accuracy and enhanced robustness for fast time-varying parameters under noisy conditions.

▷ SunA07-24

Robust Estimate Based on Lp Norm for Doppler Velocimetry

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This paper investigates the robustness of parameter estimation within the lp-norm framework when measurement data contain outliers. Unlike traditional outlier removal methods that rely on prior thresholds, robust estimation techniques accommodate outliers through objective functions inherently insensitive to anomalies. We systematically analyze the robustness-efficiency trade-off by varying the norm parameter p. For linear models, explicit relationships between estimator efficiency and p are derived. Simulations based on Doppler velocity measurement verify that the robustness of estimation under the 1-norm, 2-norm, and 1/2-norm is positively correlated with p. The findings offer theoretical and practical guidance for selecting p in real-world applications.

▷ SunA07-25

K-STGCT: A Causal-Enhanced Spatio-Temporal Gated Convolutional Transformer with KAN-based Positional Encoding for Industrial Soft Sensor Forecasting

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Accurate process modeling is increasingly challenged by the high dimensionality, non-linearity, and inherent time-lag effects of modern industrial data. Current models often fail to account for causal directionality and suffer from ” temporal rigidity” in their positional encodings, inevitably constraining the capturing of long-range dependencies and results in accumulated prediction errors. To address these critical limitations, a Causal-enhanced Spatio-Temporal Gated Convolutional Transformer with KAN-based positional encoding (K-STGCT) is proposed. First, a Causal-Guided Input Alignment (CGIA) module utilizes Transfer Entropy (TE) to quantify information flow and identify physical time lags, achieving causal alignment to rectify the ” causal-agnostic” nature of traditional inputs. Subsequently, a Multi-scale Spatio-Temporal Embedding (MSTE) module employs Gated Convolutional Units (GCU) to capture local temporal dynamics while filtering out high-frequency industrial noise. Third, a Kolmogorov-Arnold Networks (KAN)-driven Adaptive Positional Encoding (KAPE) module leverages splinebased function fitting to learn a continuous temporal manifold, overcoming temporal rigidity with superior resolution for large look-back windows. Finally, a Global Dependency Aggregation and Parallel Prediction (GAPP) module integrates global spatiotemporal dependencies via self-attention and generates multi-step forecasts through a parallel regression head. In comparisons involving multiple benchmarks, K-STGCT is shown to exceed the capabilities of existing high-performance Transformer variants and advanced neural architectures. Comprehensive ablation analysis further corroborates that KAPE effectively mitigates positional ambiguity in long sequences, while the CGIA mechanism ensures physical consistency under complex lagging conditions. This research provides a robust and interpretable solution for large-scale industrial spatio-temporal modeling.

▷ SunA07-26

Large Language Model-assisted Optimal Scheduling Method for Electric Vehicle Charging and Discharging Based on PER-DDPG Algorithm

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Liu, Siyuan	Tieling Power Supply Company, State Grid Liaoning Electric Power Company
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With the large-scale integration of electric vehicles (EVs), stochastic charging and discharging behaviors pose significant challenges to the operational security and economic efficiency of distribution networks. To address the multi-constraint and uncertainty issues in EV charging/discharging scheduling, an EV charging/discharging optimal scheduling model is first established with a unified objective that accounts for system load fluctuations, users’ charging costs, and carbon-emission revenues. Then, a large language model (LLM)-assisted prioritized experience replay deep deterministic policy gradient (PER-DDPG) algorithm is developed to solve the problem. By leveraging domain knowledge, the LLM dynamically generates the reward calculation function, alleviating the difficulty of reward-function design in conventional reinforcement learning and thereby improving convergence stability. Finally, comparative experiments are conducted, and simulation results demonstrate that, compared with conventional DDPG and PER-DDPG methods, the proposed approach achieves superior peak shaving and valley filling performance, lower overall cost, and faster convergence. The optimized scheduling strategy effectively smooths the system load profile and enables orderly coordination of EV charging and discharging while satisfying travel-demand and battery-safety constraints.

▷ SunA07-27

MTAMformer: Multi-scale Threshold Filtering Attention Mixture of Experts Transformer for Multi-Step Time Series Forecasting

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Liu, Xiang	Jiangnan Univ.

Multi-step time series forecasting aims to model temporal dynamics and predict multiple future steps, with wide applications in finance, traffic, meteorology, and industrial process optimization. However, existing methods often struggle to capture multi-scale patterns and tend to retain low-contribution responses in attention outputs, which can accumulate as redundant representations and degrade robustness. To address these issues, we propose a multi-scale framework that integrates the stationary wavelet transform (SWT) with a mixture-of-experts (MoE) architecture. Firstly, SWT is employed to decompose the input series into multi-scale components, and a MoE module is introduced for each component. Then, a threshold filtering attention mechanism is designed in the expert network for suppression of low-contribution responses. Finally, for each scale component, the aggregated MoE features are fed into a Transformer Decoder with the same filtering mechanism to generate component-wise forecasts. Experiments on five datasets for 10-minute and 30-minute forecasting tasks demonstrate that the proposed method consistently outperforms state-of-the-art models, validating its effectiveness.

▷ SunA07-28

Large Language Model-Assisted State Transition Algorithm for Solving Sensor Network Localization Problem

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Node localization is a fundamental problem in Wireless Sensor Networks (WSNs), which aims to estimate the coordinates of unknown sensors using anchor nodes and distance measurements. While intelligent optimization algorithms are widely utilized in sensor network localization problem, traditional improvement strategies are often restricted by their reliance on extensive domain knowledge and manual trial-and-error in heuristic design. This paper proposes a novel Large Language Model(LLM)-assisted State Transition Algorithm (STA) for this problem. Through the leverage of Retrieval-Augmented Generation (RAG) and Chain-of-Thought (CoT) reasoning, STA is systematically enhanced across three aspects: hyperparameter optimization, automatic operator generation, and adaptive operator scheduling. Simulation results demonstrate that the proposed method achieves significantly reduced localization errors through hyperparameter tuning and operator design. Furthermore, the LLM-driven scheduling strategy significantly improves convergence efficiency, outperforming the baseline STA in complex deployment scenarios.

▷ SunA07-29

From Multi-Source Indicators to Reaction–Diffusion PDEs: Interpretable Cybercrime Risk Forecasting

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Cybercrime risk exhibits strong spatial heterogeneity (hotspots) and temporal non-stationarity driven by connectivity spillovers, local amplification/decay, and event-like shocks. Purely statistical forecasts can be effective in the short term but often provide limited mechanism-level interpretability, whereas mechanistic spatio-temporal models require careful construction of measurable coefficients and practical calibration. This

paper proposes a unified measurement-to-model-to-simulation framework for spatio-temporal cybercrime risk forecasting. We summarize heterogeneous multi-source measurements into two interpretable composite indices: a Cybersecurity Exposure Index (CEI) and a Web/Cybercrime Index (WCI). These indices, together with auxiliary covariates, parameterize a reaction–diffusion (RD) risk-field PDE with an exogenous forcing term that captures shocklike events. Model parameters are identified via regularized least-squares calibration using discrete noisy risk proxies. For numerical simulation, we present a straightforward 2D finite-difference discretization and explicit time-marching scheme to generate risk-field evolutions and hotspot forecasts. On a region-level monthly benchmark with continuous-field interpolation, the RD-PDE model improves one-year-ahead forecasting accuracy and hotspot identification compared with standard baselines.

▷ SunA07-30

Centroid-Prediction-Assisted Dynamic Multi-Objective Optimization with Transformer Surrogates for Flotation

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Hematite flotation is a nonlinear and time-varying industrial process characterized by strong coupling and feed disturbances. Key performance indicators, including concentrate Fe grade, SiO2 content, and reagent consumption, are inherently conflicting, making setpoint optimization a dynamic multi-objective problem. This study develops a Transformer-based surrogate model using industrial time-series data to predict concentrate Fe and SiO2 grades, while reagent consumption is evaluated analytically. A centroid-prediction-assisted dynamic optimization framework is constructed under stepwise feed-grade changes. An SVR-based response strategy predicts the decision-space centroid after environmental transitions to accelerate Pareto-front tracking. Experimental results demonstrate that the proposed MOEA/D-CSVR achieves faster convergence recovery and improved Pareto-front tracking compared with MOEA/D-DM under dynamic environments.

▷ SunA07-31

FTPS²: Future Timestamp-Aware Patchified Diagonal State Space Model for Time Series Forecasting

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He, Yan-Lin	Beijing Univ. of Chemical Tech.
Zhu, Qunxiong	Beijing Univ. of Chemical Tech.
Zhang, Yang	Beijing Univ. of Chemical Tech.
Zhang, Ming-Qing	Beijing Univ. of Chemical Tech.

Multivariate time series forecasting is essential in applications such as power dispatching, meteorological analysis, and industrial monitoring. However, existing methods inadequately exploit periodic priors embedded in future timestamps. This limitation often leads to cycle misalignment in long-term forecasting scenarios, typically manifested as peak–trough shifts and cumulative errors as the prediction horizon extends. To address this challenge, we propose a novel dual-branch time series forecasting framework termed FTPS², which integrates Patchified Diagonal State Space Model (PS4D) branch with a Future Timestamp-aware Module (FTM) branch. Specifically, we design a PS4D branch that introduces a diagonal state space model on top of patchified representations. PS4D branch models temporal dynamics along the token dimension, enabling efficient capture of long-range dependencies while maintaining low computational complexity. Meanwhile, to fully exploit timestamp information during forecasting, an FTM branch is constructed that directly takes future timestamp features as input. FTM branch combines multi-layer perceptrons with one-dimensional convolutions to model local temporal structures within the forecasting horizon, enabling the model to effectively extract and learn timestamp-driven periodic priors. Extensive experiments on multiple public benchmark datasets demonstrate that FTPS²achieves the best performance in multivariate time series forecasting.

▷ SunA07-32

Establishment and Application of A Calculation Model for Silicon Carbide Epitaxial Layer Thickness Based on Infrared Interference Method

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As an emerging semiconductor material, silicon carbide’ s epitaxial layer thickness is crucial for accurate measurement. Based on the infrared interference method, this paper establishes a dual-beam interferometric thickness model and optimizes the solving algorithm. Firstly, under the condition that only single reflection and transmission occur at the interface between the epitaxial layer and the substrate, the optical path difference is calculated according to the Sellmeier equation and Snell’s law, clarifying that the net additional phase caused by half-wave loss remains constant in the spectral range. Secondly, reflectivity is calculated using the Fresnel formula, and an analytical expression for thickness is derived based on the interference maxima condition and wavenumber differences between adjacent maxima. In the solving process, a semi-automatic data processing workflow is adopted: a stable spectral range is first selected, interference peaks are detected automatically and then manually screened for confirmation, and wavenumber differences is obtained through linear fitting, from which the thickness is subsequently calculated. Finally, the calculated thickness results under different incidence angles are in good agreement, and both fall within the conventional thickness range of silicon carbide epitaxial layers. This indicates that the method has good self-consistency and provides a foundation for subsequent precision validation.

▷ SunA07-33

Hierarchical Context-Based Meta-Learning for Stochastic LPV System Identification

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Mao, Yawen	Jiangnan Univ.
Huang, Hanyan	Sun Yat-Sen Univ.
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Multitask identification of linear parameter-varying (LPV) systems under process and measurement noise remains an open problem, as existing methods lack principled handling of scheduling-dependent stochastic state distributions, task-specific adaptation within a shared framework, and tractable optimization. We propose SMS-HCL, a data-driven framework that unifies scheduled meta-state space representation with hierarchical context learning. Under a bijective mapping assumption, scheduling-dependent state distributions are compressed into finite-dimensional meta-states, yielding deterministic transition dynamics and GMM based output distributions. The task context is split into state-transition and observation sub-vectors, each feeding a dedicated hypernetwork, so that new tasks can be adapted by updating only the relevant context. Bilevel optimization is stabilized via an exponential moving average on shared parameters, avoiding second-order derivatives. Experiments on a four-task discrete-time LPV system show that SMS-HCL outperforms CNN, BiLSTM, MAML, and FOMAML on held-out tasks; selective adaptation of the observation context alone attains comparable performance to full adaptation, supporting the hierarchical design.

▷ SunA07-34

Variable Population Differential Evolution Algorithm Driven by Multiple Indicators

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The importance of data-driven optimization problems has become increasingly prominent in fields such as artificial intelligence, automation, and data science. Differential evolution has attracted considerable attention as an efficient optimization method; however, it often suffers from limitations such as insufficient search accuracy. To address the challenges faced by differential evolution algorithms, this paper proposes a multi-indicator-driven adaptive differential evolution algorithm. The proposed algorithm introduces a dynamic population size adjustment mechanism and a dual-population cooperative co-evolution framework, while integrating a dual-parameter adaptive mechanism jointly guided by fitness and dispersion metrics. Through experimental evaluations against five DE variants on 20 benchmark functions, the results demonstrate that the proposed algorithm exhibits superior performance in terms of solution accuracy and stability.

▷ SunA07-35

Adaptive Clustering-Based Federated Learning for Non-Intrusive Load Monitoring Across Multiple Users

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The efficient and stable operation of smart grids relies on accurate iden-

tification of electrical loads to achieve load regulation, fault warning, and energy optimization management. However, most existing Non-Intrusive Load Monitoring (NILM) methods are trained for single-user scenarios, making it difficult to simultaneously address data heterogeneity, privacy protection, and model generalization in multi-user settings. To tackle such challenges, this paper proposes a Federated Adaptive Clustering (FedAC) based NILM method. First, a client-server federated learning framework is established, along with strategies for local and global model updates, ensuring that raw power consumption data never leaves the user premises. Then, a bidirectional gated network based on multi-head attention mechanisms is deployed on the client side to extract and learn electrical load characteristics. Subsequently, the Tanimoto similarity coefficient is used to measure differences in load behaviors among users, dynamically optimizes the number of clusters, and performs proximal federated averaging within each cluster. Simulation results demonstrate that FedAC-NILM significantly improves recognition accuracy in multi-user scenarios, providing a privacy-friendly, accurate, and scalable new approach for load monitoring in smart grids.

▷ SunA07-36

Study on An Improved Spectral Clustering Based Semi-supervised Anomaly Pattern Detection Method

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Industrial streaming data presents typically high-dimensionality, nonlinearity and scarcity of labeled information, posing challenges for traditional cluster and anomaly pattern detection methods due to limited similarity adaptability, information loss and reliance on labeled data, which limit the potential pattern mining of complex industrial streaming data, and affect the accuracy of condition monitoring and fault warning. To address these issues, this paper proposes a semi-supervised anomaly pattern detection method for industrial processes based on improved spectral clustering. It combines Minkowski distance and cosine similarity for enhanced similarity measurement, employs locally linear embedding for nonlinear feature extraction, and generates pseudo-labels refined through confidence-based optimization with limited real labels. Finally, a lightweight XGBoost model is trained with the optimized pseudo-labels to detect anomaly patterns. Experiments on three-phase flow industrial process demonstrate strong detection performance with limited labeled data.

▷ SunA07-37

A Magnetic Source Imaging Registration Method Based on Keypoint Self-Supervised Constraints and Multi-View Differentiable Rendering

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Han, Qiuyu	Beihang Univ.
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In magnetic source imaging systems, precise registration between sensor arrays and individual anatomical structures critically impacts source localization accuracy. Existing mainstream registration methods typically rely on structured light or laser scanning to acquire head point clouds for geometric fitting. While achieving high accuracy under ideal conditions, these approaches generally suffer from complex acquisition workflows, lengthy data collection times, and high equipment costs, limiting their practical application in engineering and clinical settings. This paper proposes a multi-view RGB image-based magnetic source imaging registration method. It models the registration problem as a self-supervised optimization process for rigid body parameters with clear physical meaning, eliminating the need for 3D point cloud reconstruction. The method directly establishes the relationship between the 3D head model and 2D image observations through a geometric projection model, using keypoint reprojection error as the primary constraint. It simultaneously incorporates keypoint confidence weighting and robust kernel functions to effectively suppress false detections and occlusion effects on the optimization process. Experimental results demonstrate that data acquisition is completed in just 30 seconds, achieving processing speeds 4 to 10 times faster than structured light and laser scanning methods. In simulated head model experiments, it achieves a translation error of 0.33 mm and an attitude error of 0.11 degrees of pose error, significantly outperforming structured light solutions while matching the order of magnitude of laser scanning methods. In real-human experiments, it achieved 0.85 mm translation error and 0.21 degrees pose error. By relying solely on a monocular camera, this method maintains millimeter-level and sub-degree-level registration accuracy while reducing equipment costs to 1/10 to 1/20 of traditional scanning solutions, significantly simplifying the system workflow and demonstrating strong engineering and clinical application potential. It demonstrates strong potential for both engineering and clinical applications.

▷ SunA07-38

Semi-Supervised Incremental Learning Method with Partitioned Genetic Exemplar Selection for Smart Grid Device Identification

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The Smart Grid is evolving into a complex Cyber-Physical System, where precise device identification is fundamental for maintaining situational awareness and security. In open environments, however, the continuous emergence of new devices renders static models inefficient, often necessitating computationally intensive full retraining. To address this, we propose a Semi-supervised Incremental Learning (SSIL) framework. It employs a lightweight Autoencoder to learn generic representations from massive unlabeled traffic, followed by supervised fine-tuning to construct robust feature spaces. Additionally, a Partitioned Genetic Algorithm (PGA) is utilized for optimal exemplar replay to mitigate catastrophic forgetting. Experimental results demonstrate that the proposed method achieves superior identification accuracy compared to baselines and maintains high stability throughout sequential tasks, offering a scalable solution for self-evolving IoT security monitoring.

▷ SunA07-39

Physically Information-driven Graph Convolutional Networks for Multivessel Trajectory Prediction

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Multivessel trajectory prediction plays an important role in maritime traffic monitoring and collision-risk mitigation. However, existing data-driven methods often neglect the physical motion constraints of vessels, which limits their ability to capture complex interaction patterns and spatiotemporal dependencies in dynamic maritime environments. To address this issue, this paper proposes a physically information-driven graph convolutional network (PI-GCN) for multivessel trajectory prediction. Specifically, three physically motivated graph structures, namely a social graph, a collision risk graph, and a view distance graph, are constructed to describe intervessel relationships from complementary perspectives. On this basis, a multigraph spatiotemporal learning framework is developed, where multihead attention is introduced to adaptively fuse heterogeneous graph features, and a temporal convolutional module is employed to model temporal evolution and generate future trajectories. The experimental results show that PI-GCN consistently achieves the best prediction performance across 10-step, 20-step, and 30-step forecasting tasks, demonstrating its effectiveness for multivessel trajectory prediction in complex maritime scenarios.

▷ SunA07-40

A Social Feedback Framework for Distributed Machine Learning

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Distributed machine learning over wireless or IoT networks frequently encounters heterogeneous data quality and unreliable local updates, which can markedly impair learning effectiveness and convergence behavior. A wide range of existing distributed learning algorithms implicitly rely on assumptions of homogeneous and high-quality local data, rendering them vulnerable to noisy labels and uneven model reliability across agents. To tackle these challenges, we propose emphSocial Feedback Machine Learning (SFML), a robust distributed learning framework that embeds performance-aware social feedback within the learning process. In SFML, each agent independently trains a local model and exchanges compact feedback signals that represent its training posterior and validation accuracy. Using these feedback signals, a dynamic weighting

mechanism adaptively modulates each agent's influence based on recent empirical performance, thereby attenuating the effect of low-quality or poorly performing local models without requiring centralized coordination. Comprehensive experiments on real-world datasets show that SFML delivers enhanced robustness, faster convergence, and superior accuracy under label noise and data heterogeneity when compared with existing baselines, including SML, AdaBoost, and RobustBoost.

▷ SunA07-41

Towards Intelligent Construction: A Hybrid ANN-NSGA-II Framework for Compressive Strength Prediction Toward 3D Concrete Printing

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Liu, Chao	Xi 'an Univ. of Architecture & Tech.

Accurate strength prediction is important for intelligent construction and future 3D concrete printing (3DCP) applications. However, conventional machine learning models often rely on manual hyperparameter tuning and usually lack interpretability. To address these limitations, this study proposes a hybrid framework integrating an artificial neural network (ANN) with the Non-dominated Sorting Genetic Algorithm II (NSGA-II) for architecture optimization, while combining SHAP, PDP, and ICE for interpretability analysis. A benchmark concrete compressive strength dataset containing 1,030 samples was adopted as a proxy dataset for methodological validation. After preprocessing, the proposed model achieved a correlation coefficient (R) of 0.97 and an RMSE of 3.69 MPa on the independent test set, outperforming XGBoost, SVM, and RF. Interpretability analysis identified cement content, curing age, and blast furnace slag as the most influential factors, and further revealed the negative effect of water and the strong interaction between age and cement. Although the current dataset does not include 3DCP-specific process variables, the proposed framework provides a methodological basis for future 3DCP-oriented strength prediction and mix design studies.

▷ SunA07-42

Neural Network-Based Improved Fuzzy Adaptive Controller for Multi-Objective Control of Gas Turbines

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As a typical multi-input and multi-output (MIMO) system, the operation of a gas turbine involves the coordinated regulation of multiple objectives such as the control of the rotational speed and the exhaust temperature, presenting significant control challenges. Due to the characteristics of gas turbines, including strong nonlinearity, significant channel coupling, and frequent disturbances, this paper proposes a fuzzy adaptive controller based on neural network for the joint control of rotational speed and exhaust temperature of gas turbines. A control structure with fuel flow and inlet guide vane (IGV) opening as dual inputs is constructed to achieve multivariable closed-loop regulation of the gas turbine. Besides, a neural network is designed to adjust network weights online, dynamically outputting adjustment quantities based on real-time collected speed error and exhaust temperature error. Instead of manual empirical rules in the traditional control strategies, the proposed method enhances the adaptive capability of the gas turbine under different operating conditions. A nonlinear model of the gas turbine was built in the Simulink environment, and typical variable load conditions are set to verify the performance of the proposed control method. Comparative studies with a model predictive control (MPC) method are conducted to evaluate its regulation capability and control effectiveness under complex conditions.

▷ SunA07-43

Gradient-Based Neural Dynamics for Kinematic Control of Soft Robots

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This paper presents a gradient-based neural dynamics controller for high-precision trajectory tracking in soft robots. The method combines gradient descent tuning with velocity compensation to eliminate tracking lag in soft robots. The involved velocity compensation is regulated at the velocity level, which implements the Jacobian matrix inverse estimation, thereby enhancing the control precision. Besides, a Lyapunov based analysis guarantees global exponential convergence of the end-effector position error. Furthermore, simulations on a soft robotic platform demonstrate that the proposed scheme reduces the tracking error, confirming its effectiveness and suitability for embedded implementation.

▷ SunA07-44

Adaptive Tracking Control for Railway Inspection by Quadrotors Based on Neural Networks

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Wang, Jian	Beijing Jiaotong Univ.
Cai, Bai-Gen	Beijing Jiaotong Univ.

This paper proposes a quadrotor trajectory tracking control method based on a universal barrier function and neural network-based adaptive compensation. It aims to address the time-varying error constraints and unknown composite disturbances inherent in railway inspection tasks, while ensuring the quadrotor's tracking accuracy and stable velocity. Traditional methods are often limited to constant constraints, struggling to adapt to the dynamically changing tracking precision and constraint boundaries encountered in inspection environments. This paper introduces a time-varying performance function to construct a generalised barrier Lyapunov function with constraint-enhancing properties, strictly confining tracking errors within preset time-varying boundaries. By designing a neural network to perform online approximation of system nonlinearities and external disturbances, combined with an adaptive weight update rule, robust control is achieved under model uncertainty and persistent disturbances. Simulation results demonstrate that under time-varying constraints and composite disturbances, this method ensures the tracking error consistently meets the predefined performance criteria while rapidly converging to a bounded neighbourhood. This effectively enhances the trajectory tracking accuracy and reliability of quadrotors in complex railway environments.

▷ SunA07-45

Osteoporosis Risk Prediction Method Based on TCN-Transformer

Xiao, Le	Wuhan Univ. of Sci. & Tech.
Liu, Yimin	Wuhan Univ. of Sci. & Tech.

Early identification and intervention of osteoporosis are critical to improving the patient's prognosis. This paper proposes a hybrid architecture based on a Transformer-enhanced Temporal Convolutional Network (TCN) for constructing an osteoporosis risk prediction model. By incorporating a multi-scale feature extraction mechanism, the model effectively captures both local temporal dependencies and global correlations in clinical data, thereby significantly enhancing the prediction performance for osteoporosis risk. To address the issues of limited sample size and class imbalance in medical data, a data augmentation strategy is introduced to improve the model's generalization capability. Experimental results demonstrate that the proposed hybrid model effectively handles temporal dependencies and class imbalance in medical datasets, exhibiting superior performance in predicting osteoporosis risk. Compared to traditional machine learning methods, our model offers a reliable tool for more accurate early-stage risk stratification, contributing positively to intelligent prevention and clinical decision support for osteoporosis.

▷ SunA07-46

HCAT-SAC: A Hybrid Cross-Attention Transformer Framework for Efficient Mapless Navigation

Zhang, Xu	Zhejiang Univ.
Zhou, Kehan	Zhejiang Univ.
Chen, Yibo	PipeChina
Zhu, Qian	Zhejiang Univ. Robotics Inst.
Zhu, Ce	Yuyao Robot Research Center
Zhang, Jianming	Institution of Cyber-Sys. & Control

Deep reinforcement learning has achieved remarkable progress in mapless autonomous navigation. However, effectively fusing high-dimensional visual observations with physical goal instructions remains a critical challenge. Conventional approaches typically rely on implicit feature concatenation, which often fails to capture the semantic correlation between the navigation target and the visual scene, leading to poor data efficiency and unstable decision-making. In light of this, we present a novel Hybrid Cross-Attention Transformer enabled Soft Actor-Critic framework to realize efficient and robust navigation. Unlike previous methods, we propose a decoupled perception-interaction architecture that treats navigation as an active querying process. Specifically, a Kinematics-Aware Query mechanism is designed to incorporate robot dynamics into the attention module, enabling the agent to actively retrieve goal-relevant visual features based on its current motion state. Furthermore, a Dual-Stream fusion strategy is implemented to inte-

grate the goal-conditioned features with global environmental contexts. Subsequently, this highly condensed scene representation is fed into the Soft Actor-Critic algorithm as the state input. The reinforcement learning agent then processes these features to generate continuous velocity commands for the robot. Extensive simulation experiments demonstrate that our approach significantly outperforms state-of-the-art baselines in terms of convergence speed, navigation success rate, and trajectory smoothness. The results confirm that the explicit interaction mechanism is essential for trustworthy autonomous nav-igation.

SunB01 10:10–12:10 Yangguang Hall
Invited Session: Learning-Based Optimal Control and Applications

Chair: Lv, Yongfeng — Taiyuan Univ. of Tech.
Co-Chair: Huang, Yingbo — Kunming Univ. of Sci. & Tech.

▶ SunB01-1 10:10–10:30
Inverse Optimal Control of Unknown Linear Systems

Zhang, Xuhai — Taiyuan Univ. of Tech.
Xue, Kaiwen — Taiyuan Univ. of Tech.
Lv, Chenle — Taiyuan Univ. of Tech.
Li, Linwei — Zhengzhou Univ. of Light Industry
Lv, Yongfeng — Taiyuan Univ. of Tech.

This paper investigates an inverse optimal control method based on the reinforcement learning scheme for continuous-time linear systems. First, the system dynamics are estimated offline from expert trajectory data, and regression equations satisfying the Hamilton-Jacobi-Bellman (HJB) conditions are constructed to recover physically feasible initial values for the value matrix and the cost weight matrix. Subsequently, an online adaptive inversion and gain-matching mechanism is designed, in which an expert gain-consistency constraint is introduced, enabling the learner to gradually approximate the expert control policy under unknown model conditions. This method simultaneously achieves learning of system parameters, estimation of the cost matrix satisfying optimality conditions, and guarantees consistent convergence of the optimal feedback gain. As a result, the proposed method effectively avoids numerical divergence caused by parameter non-uniqueness while significantly improving learning efficiency. Finally, numerical experiments are conducted to verify the effectiveness and stability of the proposed method.

▶ SunB01-2 10:30–10:50
An Improved Gradient-based Estimation Algorithm for Hammerstein Neural Network Systems

Li, Linwei — Zhengzhou Univ. of Light Industry
Zhou, Mo — State Grid Henan Marketing Service Center (metrology Center)
Li, Bingyang — State Grid Henan Electric Power Company
Lv, Yongfeng — Taiyuan Univ. of Tech.
Shi, Kunfeng — Zhengzhou Univ. of Light Industry

Hammerstein system is capable of capturing the dynamic characteristics of a large group of nonlinear systems, its system identification is an open topic. Gradient and improved algorithms are one of the more practical and widely used identification methods. However, classical multi-innovation gradient (MIG) algorithm has slow convergence speed and multi-innovation ength issue. To improve these problems, in this paper, we introduce an improved MIG identification method for identifying the parameters of Hammerstein neural network systems. Based on semi-substitution technique, an identification regression model is established, avoiding the redundant problem of parameter estimation. In terms of algorithm design, the multi-innovation correction method in classical MIG method is converted into a single-innovation correction modality, so that the multi-innovation length issue is resolved. Afterwards, an activate update method is used to update the initial values of the parameter estimation, such that the convergence speed is accelerated. Finally, the proposed MIG scheme is evaluated and its effectiveness confirmed using examples.

▶ SunB01-3 10:50–11:10
Heterogeneous Knowledge Fusion via Series–Parallel Integrated Neural Networks

Shen, Jianzhao — Xiadian Coal Mine of Lu'an Chemical Group Cilinshan Coal Industry Co., Ltd
He, Guodong — Taiyuan Univ. of Tech.
Guo, Jianhua — Taiyuan Univ. of Tech.
Lv, Qing — Taiyuan Univ. of Tech.

Ontology matching aims to identify correspondences between entities in heterogeneous ontologies. Due to its complex network structures and powerful learning capabilities, Deep Learning(DL) has been widely applied in the field of ontology matching. However, the majority of DL-based matching methods neglect the study of the uniqueness of semantic features across different descriptions and are overly reliant on specific knowledge bases, which ultimately reduces the matching accuracy. To address these limitations, this paper proposes a novel matching method based on the Series–Parallel Integrated Neural Network (SPINN). Specifically, to extract semantic features from descriptions of varying lengths, this paper proposes a parallel architecture consisting of two serial deep networks, which are aimed at identifying different alignments. Additionally, a new method for alignment integration is proposed that combines the distinct alignment results by taking into account the semantic and structural correlations between the descriptions. Finally, to reduce the potential for overfitting in the network and ensure that the different serial deep networks can learn the unique semantic features of various descriptions, a hierarchical sampling method is proposed to construct a diverse training set. The experimental results demonstrate that SPINN outperforms most state-of-the-art systems on the benchmark dataset of the Ontology Alignment Evaluation Initiative (OAEI).

▶ SunB01-4 11:10–11:30
Plant-Oriented Rolling Day-Ahead Scheduling under Rigid Monthly Targets for Hydrometallurgical Zinc Production

Li, Mou — Kunming Univ. of Sci. & Tech.
Zhang, Yangjie — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Zhang, Faxiang — Kunming Univ. of Sci. & Tech.
Na, Jing — Kunming Univ. of Sci. & Tech.

Day-ahead scheduling in hydrometallurgical zinc production must meet rigid monthly output requirements while remaining executable under disturbances, shutdown constraints, and strong cost pressures. This paper develops a plant-oriented rolling scheduling framework that jointly optimizes daily throughput plans and their cost implications. The framework coordinates three objectives: (i) month-end target attainment under an asymmetric policy that strictly penalizes underproduction while permitting limited overproduction, (ii) schedule smoothness under capacity and ramp-rate limits, and (iii) cycle-level reduction of zinc powder consumption and electrowinning energy usage. On each decision day, a finite look-ahead throughput trajectory is optimized and only the current-day dispatch is released in a receding-horizon manner, enabling continuous disturbance absorption throughout the monthly cycle. To support high-frequency rolling decisions, callable zinc-powder and energy evaluators are embedded for fast cost assessment. Industrial data-driven offline replay on three consecutive production months shows that total zinc powder consumption is reduced from 2308.430 t to 2165.060 t (6.21%) and total electrowinning energy is reduced from 15553.140 to 15096.680 (in 104 kWh, 2.93%), while maintaining hard-constraint feasibility and stable execution, demonstrating the practical savings potential of the proposed framework.

▶ SunB01-5 11:30–11:50
Interactive Attention-Based Hybrid Temporal Modeling for Online Ion Prediction in Hydrometallurgical Zinc Purification

Xiao, Yiming — Kunming Univ. of Sci. & Tech.
Yang, Chunxi — Kunming Univ. of Sci. & Tech.
Wang, Xian — Kunming Univ. of Sci. & Tech.
Zhang, Faxiang — Kunming Univ. of Sci. & Tech.
Wu, Long — Kunming Univ. of Sci. & Tech.

In hydrometallurgical zinc production, impurity concentrations in the purification stage are difficult to measure online and suffer from sampling and laboratory delays. To address this problem, this paper proposes a data-driven soft-sensing framework for online prediction of Co2+ and Ge4+ concentrations using historical process data.Considering the strong temporal dependence, nonlinear dynamics, and cross-variable coupling in industrial purification processes, an interactive attention-based hybrid temporal model, named IA-TCN-GRU, is developed. The model combines a temporal convolutional network and a gated recurrent unit to capture long-range dependencies and local dynamic behaviors, respectively. Process variables are classified into primary and auxiliary sets based on maximal information coefficient analysis and mechanism knowledge, and an interactive attention mechanism is introduced to fuse the corresponding features.Validation on real industrial data demonstrates that the proposed IA-TCN-GRU achieves higher prediction accuracy than conventional TCN- and RNN-based baseline models, indicating its effectiveness for impurity concentration monitoring in hydrometallurgical zinc purification.

▶ SunB01-6 11:50–12:10

Adaptive High-Gain Observer with Time-Scale Separation for Nonlinear Parametric Systems

Chen, Lun — Kunming Univ. of Sci. & Tech.
He, Haoran — Kunming Univ. of Sci. & Tech.
Huang, Yingbo — Kunming Univ. of Sci. & Tech.

This paper proposes an adaptive high-gain observer with time-scale separation for the joint estimation of states and parameters in a class of second-order nonlinear parametric systems. By employing an explicit high-gain design, the proposed framework constructs a hierarchical structure where the state estimation dynamics (fast subsystem) are decoupled from the parameter adaptation law driven by auxiliary filtering variables (slow subsystem). Rigorous theoretical analysis based on singular perturbation theory demonstrates that the state estimation error admits a tunable exponential convergence rate with steady-state accuracy inversely proportional to the high-gain parameter, while the parameter estimation error remains globally uniformly ultimately bounded under the persistent excitation condition. Validation is performed using high-fidelity AQWA simulation data for a wave energy converter. Comparative results against the Standard Adaptive High-Gain Observer (SAHGO) highlight a critical advantage: the proposed explicit time-scale separation effectively mitigates the parameter oscillation inherent in traditional coupled designs caused by unmodeled dynamics, thereby achieving superior estimation accuracy and robustness.

SunB02 10:10–12:10 Changle Hall

Invited Session: Data-Driven Modelling and Adaptive Learning Control

Chair: Chen, Qiang — Zhejiang Univ. of Tech.
Co-Chair: Kong, Ying — Zhejiang Univ. of Tech.

▶ SunB02-1 10:10–10:30

A Novel Complete Electromechanical Coupling Modular Modeling Framework for PMSM-Driven Circuit Breaker Systems

Zhi, Yiming — Shandong Univ. of Sci. & Tech.
Gao, Xuehui — Shandong Univ. of Sci. & Tech.

A comprehensive electromechanical coupled simulation model for a Permanent Magnet Synchronous Motor (PMSM)-driven circuit breaker system is established in this paper, addressing the issue of simulation distortion caused by the decoupling of electrical and mechanical dynamics in traditional research. Existing circuit breaker models often treat the motor as an ideal torque source and simplify the spring as a rigid connection, neglecting the mutual coupling in real systems among the dq-axis electrical dynamics of the PMSM, the damping characteristics of the spring, and the motion of the breaker mechanism. To address this, we construct a unified modeling framework comprising four core subsystems: a detailed PMSM dynamic model based on dq-transformation, a spring load model considering elasticity and damping, a circuit breaker mechanism model integrating contact status and arc effects, and a dual-loop PID current/position controller. The model is implemented modularly in Simulink, with system parameters managed uniformly through parameterized scripts to support rapid configuration and extension. Simulation verification demonstrates that the model can accurately reproduce the current surges, mechanical oscillations, and contact dynamics during the breaker's opening and closing operations, thereby providing a high-fidelity benchmark platform for the subsequent development and validation of adaptive control algorithms.

▶ SunB02-2 10:30–10:50

Adaptive Parameter Estimation of Fuel Cell Humidity

Fu, Yifan — Shandong Univ. of Sci. & Tech.
Zhao, Ziliang — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.
Ma, Duo — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Jia, Jingyu — Shandong Univ. of Sci. & Tech.

The internal humidity of fuel cells seriously affects their working efficiency and service life, but it is difficult to observe in real time through sensors. This study proposes an adaptive estimation algorithm that utilizes Taylor series to linearize and expand the fuel cell system model, and uses parameter estimation errors to directly drive adaptive law updates, thereby achieving online observation of fuel cell humidity and electrochemical reaction area. Through experimental verification, the proposed algorithm exhibits good convergence and accuracy under excitation conditions. The humidity of the fuel cell stack converges within 1 second, and the humidity estimation fluctuation during the variable load process is less than 1%, providing a new approach for fuel cell humidity estimation.

▶ SunB02-3 10:50–11:10

Humidity State Observer for Proton Exchange Membrane Fuel Cells Based on Dual Kalman Filter

Zhao, Ziliang — Shandong Univ. of Sci. & Tech.
Ma, Duo — Shandong Univ. of Sci. & Tech.
Guo, Bin — Shandong Univ. of Sci. & Tech.
Wang, Zhangu — Shandong Univ. of Sci. & Tech.
Zhao, Jun — Shandong Univ. of Sci. & Tech.
Fu, Yifan — Shandong Univ. of Sci. & Tech.
Jia, Jingyu — Shandong Univ. of Sci. & Tech.

To address the issue of unmeasurable internal humidity in proton exchange membrane fuel cells, this study proposes a humidity state observer for proton exchange membrane fuel cells based on a dual Kalman filter (DKF). The state space equations were established based on the 150kW system AMESim model. The designed dual cascading algorithm includes an upper-level linear Kalman filter to achieve noise suppression and step smoothing, as well as a lower-level unscented Kalman filter to achieve real-time humidity estimation. Step load simulation shows that compared with the traditional UKF, DKF improves the estimation accuracy of the cathode and anode by 0.56% and 0.33% respectively, and can effectively replace physical humidity sensors.

▶ SunB02-4 11:10–11:30

GraspNet-Baseline-Based 6D Robotic Grasp in Multi-Object Scenes

He, Xuanmian — Zhejiang Univ. of Tech.
Chen, Peng — Zhejiang Univ. of Tech.
Jin, Luyang — College of Information Engineering
Huo, Dongrui — Zhejiang Univ. of Tech.
Lu, Zhuoyi — Zhejiang Univ. of Tech.
Chen, Qiang — Zhejiang Univ. of Tech.

With the continuous development of robotic manipulation technologies, the success rate of robotic grasping has been steadily improved. However, top-down planar grasping suffers from severe pose constraints, and existing works on 6D grasp pose estimation and execution often lack a detailed description of the pose transformation process required for robotic grasping. To address the limitations of planar top-down grasping and the insufficient explanation of pose transformations, this paper proposes a 6D grasp pose estimation method for robotic manipulators based on GraspNet-Baseline. The proposed approach alleviates the pose constraints of planar grasping by enabling 6D grasp pose estimation, and provides a detailed formulation of the pose transformation process by integrating homogeneous transformations with robotic arm modeling.In addition, single-object and multi-object grasping experiments are conducted to evaluate the proposed method. Compared with YOLO-based top-down planar grasping, the proposed approach achieves higher grasp success rates, especially for irregular objects, thereby validating the effectiveness of applying GraspNet-Baseline to robotic grasping tasks.

▶ SunB02-5 11:30–11:50

Prescribed-Time Adaptive Position and Attitude Tracking Control for Patrol Quadrotor UAV

Chen, Junyu — Zhejiang Univ. of Sci. & Tech.
Xie, Shuzong — Zhejiang Univ. of Sci. & Tech.
Hou, Beiping — Zhejiang Univ. of Sci. & Tech.
Xiao, Liyang — Zhejiang Univ. of Sci. & Tech.
Dong, Jianwei — Zhejiang Univ. of Sci. & Tech.
Yang, Jun — Zhejiang Univ.

This paper addresses the challenging problem of high-precision and robust trajectory tracking control for a quadrotor unmanned aerial vehicle (QUAV) operating in complex power grid environments. First, an Euler-angle-based QUAV model considering external disturbances is established. Then, a novel non-piecewise time-varying gain function is constructed by introducing polynomial and exponential terms, thereby mitigating the control abruptness and non-smoothness inherent in traditional gain functions. Based on this, an adaptive prescribed-time controller is systematically proposed to guarantee the rapidly convergence of tracking errors irrespective of initial conditions, which enhances inspection efficiency. Moreover, an adaptive update law is designed to online estimate and compensate for lumped disturbances, including inherent model uncertainties and external environmental perturbations. Finally, the closed-loop stability is rigorously established via Lyapunov theory, and the effectiveness of the proposed control strategy is verified through numerical simulations.

▶ SunB02-6 11:50–12:10
Adaptive Iterative Learning Control for Robotic Manipulator Systems with Non-Uniform Trajectories
Guan, Haiwa — Wenzhou Univ.
Chen, Kaijie — Wenzhou Vocational College of Sci. & Tech.
Xie, Shuzong — Zhejiang Univ. of Sci. & Tech.

In this paper, an iterative learning control scheme based on backstepping algorithm is proposed for the non-uniform trajectory tracking of robot manipulators. First, a correction reference trajectory is constructed to relax the conditions that the desired trajectory is fixed in traditional iterative learning control. Then, a polynomial function is employed to design the correction factor, which reduces the computational burden and simplifies the modification of the reference trajectory. Based on the Lyapunov-like theory, an iterative learning controller is developed to ensure accurate tracking of a non-uniform desired trajectory by the robot manipulator over a specified interval. Finally, an example of a two-degree robotic manipulator is presented to demonstrate the effectiveness of the proposed scheme.

SunB03 10:10–12:10 Langyue Hall

Invited Session: Intelligent Fault Detection, Diagnosis, and its Applications

Chair: Cai, Li — Southwest Jiaotong Univ.
Co-Chair: Qian, Quan — Univ. of Electronic Sci. & Tech. of China

▶ SunB03-1 10:10–10:30
Intracranial Pressure Prediction Using Phase-Aligned Multimodal Physiological Signals and Multi-Scale Temporal Modeling
Wang, Rui — Chongqing Univ.
Cai, Li — Southwest Jiaotong Univ.

Accurate prediction of intracranial pressure (ICP) from routinely monitored physiological signals is important in neurocritical care, as sustained ICP elevation and rapid fluctuations are associated with secondary brain injury and poor outcomes. Because invasive ICP monitoring is costly, restrictive, and prone to complications, non-invasive data-driven prediction has attracted increasing attention.

A multimodal deep temporal framework is developed for one-step-ahead ICP prediction using ICU dynamic signals. High-frequency ECG and PPG waveforms are combined with low-frequency vital signs. Phase alignment is first applied to ECG, PPG, and ICP waveforms to improve temporal consistency. For high-frequency signals, a lightweight enhancement module incorporates smoothing, first-order differential features, and compact spectral descriptors. A dual-branch temporal encoder with multi-scale 1D convolutions, bidirectional GRUs, and Transformer blocks is then used to capture both local waveform patterns and long-range temporal dependencies.

Experiments on 126 patients from the MIMIC-III matched waveform cohort achieve an average MAE of 1.24 mmHg using only one hour of data per patient, demonstrating the effectiveness of phase-aligned multimodal temporal modeling for practical ICP prediction.

▶ SunB03-2 10:30–10:50
State of Charge Estimation for Lithium-ion Batteries Based on Singular Spectrum Analysis and BiLSTM
Guo, Jiayuan — Southwest Jiaotong Univ., School of Electrical Engineering
Hu, Yuanjiang — Southwest Jiaotong Univ.
Cai, Li — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.

Accurate State of Charge (SOC) estimation is critical for the safety and reliability of Battery Management Sys- tems (BMS) but is challenged by nonlinear temporal characteristics and measurement noise. To enhance estimation accuracy and robustness, this paper proposes an SOC estimation model (SSA-A-BiLSTM) based on Singular Spectrum Analysis (SSA) and an attention-based bidirectional Long Short-Term Memory network (A-BiLSTM). SSA is employed to decompose battery time-series data for effective noise suppression and feature extraction. Subsequently, the BiLSTM with an attention mechanism processes these features to capture critical temporal dependencies. Experimental results demonstrate that this purely data-driven approach achieves superior accuracy and robustness, maintaining RMSE below 1.6% and R2 above 98.6% under varying oper-ating conditions.

▶ SunB03-3 10:50–11:10
Online Fault Diagnosis under Missing Data via Multi-Kernel Learning
Cai, Li — Southwest Jiaotong Univ.
Zhang, Peng — Chongqing Univ.
Jiang, Weijie — Chongqing Univ.
Gui, Yuyang — Chongqing Univ.
Mo, Renpeng — Chongqing Univ.

In industrial monitoring systems, sensor failures often lead to missing data, resulting in dynamic variations in the feature space. Traditional data-driven fault diagnosis methods generally assume a fixed feature space, which makes them ineffective when coping with dynamically changing features caused by missing data and often requires frequent model retraining, thereby degrading diagnostic performance. To address this challenge, this paper proposes an Online Multi-Kernel Fault Diagnosis (OMKFD) method designed for scenarios with missing data. OMKFD performs fault diagnosis through online model updating. Specifically, a random mapping mechanism is introduced to project features into a unified latent subspace, within which a classifier is constructed for fault identification. Furthermore, a biconvex optimization strategy is developed to update model parameters. Experimental results on publicly available industrial process monitoring datasets demonstrate the effectiveness of the proposed method.

▶ SunB03-4 11:10–11:30
Fuzzy State Observer-Based Cooperative Trajectory Tracking Control for Marine Surface Vehicles with Prescribed Performance
Wang, Hao — Anhui Univ.
Huang, Darong — Anhui Univ.
Wang, Xuerao — Anhui Univ.
Ouyang, Yuncheng — Southeast Univ.
Sun, Changyin — Southeast Univ.

This study investigates cooperative trajectory tracking control for marine surface vehicles (MSVs) under prescribed performance, while accounting for model uncertainties and unmeasured state variables. To compensate for the lack of velocity measurements, a nonlinear fuzzy state observer is constructed to estimate the unmeasured velocity states using position measurements while approximating unknown nonlinear dynamics. Subsequently, a prescribed performance transformation is incorporated into the formation tracking errors to reshape the constrained tracking problem into an unconstrained one. On this basis, a cooperative control scheme is formulated to achieve formation trajectory tracking while guaranteeing compliance with the predefined performance specifications. Lyapunov-based analysis is employed to rigorously establish the stability properties of the resulting closed-loop system and to ensure that the cooperative tracking errors evolve within the prescribed bounds. Numerical simulations are finally provided to demonstrate the feasibility and effectiveness of the proposed approach.

▶ SunB03-5 11:30–11:50
Neuro-Fuzzy Wiener System Identification for Photovoltaic Power Prediction
Ma, Yao — Jiangsu Inst. of Tech.
Li, Feng — Jiangsu Univ. of Tech.
Li, Jinqiang — Jiangsu Univ. of Tech.

With the continuous deepening of power market reforms, the proportion of renewable energy in power market transactions continues to rise. Photovoltaic power generation, due to its abrupt and fluctuating output characteristics, poses certain risks to power system operation. To improve the prediction accuracy of photovoltaic power output, this paper proposes a parameter identification and forecasting method based on a Neuro-Fuzzy Wiener system. The system consists of a series connection of a dynamic linear module and a static nonlinear module, where the linear part is described by an autoregressive moving average (ARMA) model, and the nonlinear part is represented by a neural-fuzzy network. To identify the parameters of these two modules, a specialized test signal composed of Gaussian and random signals is employed. First, the linear module is identified through correlation analysis of Gaussian signal data. Subsequently, the nonlinear module parameters are determined based on random signal data, combining clustering algorithms and an auxiliary error probability density function method. The established model is used to forecast photovoltaic power output, achieving a generalized control model with linear characteristics. Simulation results demonstrate that the proposed method can effectively identify the neural-fuzzy Wiener model and achieve accurate prediction of photovoltaic power output.

▶ SunB03-6 11:50–12:10
Hopf Bifurcation Analysis of A Bistable Duffing System with Washout Filter Delayed Feedback
Zhai, Lihong — Qingdao Univ. of Sci. & Tech.

Cheng, Zunshui Qingdao Univ. of Sci. & Tech.
Xin, Youming Qingdao Univ. of Sceince & Tech.
Shang, Yun Qingdao Univ. of Sci. & Tech.
Lin, Xue Qingdao Univ. of Sci. & Tech.
Xiao, Min Zhejiang Normal Univ.

This paper investigates the Hopf bifurcation control of a bistable Duffing system using delayed feedback with a washout filter. Unlike traditional methods, the washout filter regulates oscillations without altering equilibrium points. We analytically derive the existence conditions for Hopf bifurcations at the non-trivial equilibria E±based on the analysis of the transcendental characteristic equation and transversality conditions. Numerical simulations verify that the proposed strategy effectively induces stable periodic oscillations and enables bifurcation anti-control. These results provide theoretical support for vibration control in nonlinear micromechanical systems.

SunB04 10:10–12:10 Xinghui Hall
Regular Session: Data-Driven Fault Diagnosis and Health Maintenance (IV)

Chair: Zhang, Xinmin Zhejiang Univ.
Co-Chair: Huang, Darong Anhui Univ.

▶ SunB04-1 10:10–10:30
Distributed Fault-Tolerant Optimal Consensus for Nonlinear Multi-Agent Systems via Stackelberg Min–Max Control

Liu, Fuyang Anhui Univ.
Zhao, Dong Anhui Univ.
Huang, Darong Anhui Univ.
Ren, Wenjing Hefei Univ. of Tech.

This paper proposes a robust distributed control strategy for near-optimal consensus in nonlinear leader–follower multi-agent systems with uncertain actuators and adversarial disturbances. The problem is formulated as a Stackelberg differential game under directed topologies, where followers compute disturbance-attenuating controls via local min–max optimization, and the leader optimizes its control by considering followers' optimal responses. Quadratic disturbance penalties enable explicit derivation of worst-case disturbances using Hamiltonian optimization, leading to sequential equilibrium-inspired control laws Additive and multiplicative actuator faults are compensated through adaptive estimation with damping and projection mechanisms. To reduce computational burden, a critic-only adaptive dynamic programming scheme with normalized updates is adopted. Lyapunov analysis guarantees uniform ultimate boundedness of all signals, and simulations validate the effectiveness of the proposed method.

▶ SunB04-2 10:30–10:50
Fast Adaptive Count Data Regression and Its Application to Defects Prediction in Industrial Process

Zhao, Lili Zhejiang Univ.
He, Bocun Zhejiang Univ.
Zhang, Xinmin Zhejiang Univ.

In the machine learning field, many real-world applications can be modeled as count data regression problems. However, the existing count data regression models have some deficiencies: 1) they build an offline, static, and global prediction model, so they not only ignore the local information of the data but also cannot update the model automatically; 2) they usually assume that the dependent variable obeys a specific distribution like Poisson; 3) they are not suitable for large-scale count data. To handle the above deficiencies, this paper proposes a fast adaptive count data regression (FACDR) modeling framework. Firstly, the architecture of FACDR is formulated based on the multi-probe hashing and just-in-time learning strategies. Secondly, a gradient boosting machines model with the tree-based weak learner and Poisson loss is employed. Experimental results on the real-life datasets have proven the superiority of the proposed method in prediction accuracy and computational efficiency as compared to other existing methods.

▶ SunB04-3 10:50–11:10
Enhanced Semantic Segmentation of Road Cracks and Potholes Based on Improved SegNeXt

Liu, Yuanhao Harbin Inst. of Tech.
Yin, Yunfei Harbin Inst. of Tech.
Chen, Jiangchuan Harbin Inst. of Tech.
Li, Mingwu School of Transportation Sci. & Engineering
Abaho, Gershome Univ. of Rwanda
Dong, Zejiao Harbin Inst. of Tech.

Automated pavement defect detection is essential for road maintenance, yet remains challenging due to the irregular geometry of cracks and potholes and the severe class imbalance between defect and background pixels. To address these challenges, this paper proposes DS-SegNeXt, an improved semantic segmentation framework built upon SegNeXt, with three principal contributions. First, a geometry-adaptive deformable encoder is introduced by replacing fixed-kernel depth-wise convolutions in the Multi-Scale Convolutional Attention (MSCA) module with Deformable Convolution v4 (DCNv4), yielding a Deformable MSCA (DMSCA) that enables spatially adaptive feature sampling conforming to the irregular morphology of road cracks and potholes. Second, a content-aware decoder is designed by substituting bilinear interpolation with DySample, a lightweight dynamic upsampler that preserves fine-grained defect boundary details during multi-scale feature reconstruction. Third, a composite loss function combining Cross-Entropy, Dice, and Lovász-Softmax losses is formulated to provide balanced, IoU-aligned gradient supervision under severe class imbalance, substantially improving detection sensitivity for minority defect categories. Experiments on a combined CRACK500 and UDTIRI dataset demonstrate that DS-SegNeXt achieves 74.14% mIoU, outperforming the SegNeXt baseline by 1.68% and surpassing U-Net, DeepLabV3+, and SegFormer under identical training conditions.

▶ SunB04-4 11:10–11:30
Neural Network with Weighted Jensen-Shannon Divergence on Key-Performance-Indicator-Related Process Monitoring

Gao, Sheng Beijing Univ. of Chemical Tech.
Wang, Haoqian Beijing Univ. of Chemical Tech.
Haotian, Zhang Beijing Univ. of Chemical Tech.
Ge, Jinhao Beijing Univ. of Chemical Tech.
Wang, Youqing Beijing Univ. of Chemical Tech.
Ma, Xin Beijing Univ. of Chemical Tech.

In complex industrial processes, the existing process monitoring methods related to key performance indicators (KPIs) largely rely on the covariance structure to divide KPI-related and KPI-unrelated subspaces, without considering the extraction of more detailed potential relationships between process variables and KPIs from the distribution level. In response to the above mentioned limitations, this work proposes a neural network with weighted Jensen-Shannon divergence on key-performance indicator-related process monitoring method, named NNW-JSD. During the training stage, features are extracted from the coding space at the distribution level through JSD, enabling the system to better learn the high-order statistical features between process variables and KPIs, and predict the values of KPIs through the KPI mapping layer. At the online monitoring stage, a dynamic KPI correlation indicator is introduced to enable the system to further adaptively distinguish between KPI-related faults and KPI-unrelated faults, and to construct comprehensive statistical indicators for corresponding detection of the two types of faults. The experiment shows that this method maintains a high detection rate for KPI-related faults while having almost no false alarms for KPI-unrelated faults.

▶ SunB04-5 11:30–11:50
A Multi-source Data Weighted Fusion Root Cause Analysis Method for Microservices

Zhang, Shaokai Inst. of Computer Application China Acad. of Engineering Physics
Zhang, Chuming Inst. of Computer Application China Acad. of Engineering Physics
Cheng, Jianfeng China Acad. of Engineering Physics
Zhang, Yangjing China Acad. of Engineering Physics
Chen, Siyu China Acad. of Engineering Physics
Ren, Qiang China Acad. of Engineering Physis

The distributed nature of microservice architecture leads to complex fault propagation paths, and existing root cause analysis methods suffer from poor scenario adaptability, high deployment complexity, or insufficient real-time performance. To address these challenges, we propose a Multi-source Data Weighted Fusion Root Cause Analysis algorithm (MWF-RCA), achieving deep integration between the observability system and root cause analysis. This method is based on a four-layer architecture of "data collection–preprocessing–model inference–result output", with core innovations including: introducing an alarm scenario-aware dynamic weight allocation mechanism to dynamically assign weights to three types of observability data (logs, metrics, and traces), and filtering associated data by combining alarm context to improve inference efficiency. To verify the effectiveness of the method, three mainstream methods are selected as baselines, and comparative

experiments are conducted on a self-built microservice fault dataset. Experimental results show that the Top-1 precision of MWF-RCA in three core scenarios (response timeout, sudden increase in error rate, and service unavailability) all exceeds 60%, the Average Root Cause Analysis Time (ART) is less than 3 seconds, and its comprehensive performance is significantly superior to baseline methods. MWF-RCA does not require complex model training, can be quickly deployed in actual microservice clusters, and provides efficient and accurate root cause analysis support for operation and maintenance personnel.

▶ SunB04-6 11:50–12:10

Self-Adaptive Health-State Assessment and Suboptimal-Factor Tracing for Complex Industrial Process Control Systems

Cao, Huichao	Lanzhou Univ. of Tech.
Li, Kangyi	Lanzhou Univ. of Tech.
Jiang, Dongnian	Lanzhou Univ. of Tech.
Dai, Hang	Lanzhou Univ. of Tech.
Du, Honghe	Lanzhou Univ. of Tech.

For online health-state assessment of complex industrial process control systems with strong nonlinearity and nonstationary dynamics, existing methods often suffer from insufficient adaptivity, limited assessment accuracy, and unclear causes of suboptimal operating conditions. To address these issues, this paper proposes an online self-adaptive health assessment method based on an Adaptation Deep Gradient Radial Basis Function (ADGRBF), together with an intelligent suboptimal-factor tracing approach based on SHAP. First, an STA-BiGRU model is adopted to extract deep features that significantly affect the process health state. Then, a cascaded Gradient Radial Basis Function (GRBF) adaptive tracker is introduced, where an online update strategy with on-demand replacement of weights and nodes is designed to rapidly track the nonstationary dynamic properties of the system. Next, combined with a classifier, the ADGRBF assessment model is constructed to accomplish online self-adaptive health-state evaluation. Finally, SHAP-based interpretability is employed to perform tracing analysis of factors leading to suboptimal system states. Simulation studies on a benzene–olefin ratio control system platform verify the effectiveness and superiority of the proposed method.

SunB05 10:10–12:10 Meixue Hall

Regular Session: Data-Driven Modeling, Optimization, Scheduling (II)

Chair: Li, Yan, Shandong Univ.

Co-Chair: Yuan, Xiaofeng, Central South Univ.

▶ SunB05-1 10:10–10:30

A Dynamic Graph Convolutional Transformer Network for Product Quality Prediction in Industrial Processes

Huang, Zichen	Central South Univ.
Wang, Kai	Central South Univ.
Yuan, Xiaofeng	Central South Univ.
Wang, Yalin	Central South Univ.
Yang, Chunhua	Central South Univ., China

Soft sensors are increasingly being applied for quality prediction in complex industrial processes, which typically exhibit spatiotemporal characteristics involving complex inter-variable couplings and continuous intra-variable fluctuations. However, existing soft sensing models often struggle to effectively extract spatiotemporal features from multi-coupled complex process data and fully leverage these features to enhance prediction performance. To address these limitations, this paper proposes a Dynamic Graph Convolutional Network-based modeling approach (DGT). The proposed model utilizes attention mechanisms to generate dynamic feature maps that incorporate multivariate spatial information, while simultaneously leveraging the superior architecture of Transformer-encoders (retaining all structural components except the attention layer) to extract intra-variable temporal features. Performance evaluation on a real industrial process dataset demonstrates the superiority of the proposed DGT approach compared to other state-of-the-art methods.

▶ SunB05-2 10:30–10:50

A Logging Data Classification Method Based on Implicit Spectral Embedding and Tree-Deep Learning Heterogeneous Ensemble

Li, Junhang	Huazhong Univ. of Sci. & Tech.
Zhang, Bocheng	Huazhong Univ. of Sci. & Tech.
Yuan, Li	Huazhong Univ. of Sci. & Tech.
Zhou, Kaibo	Huazhong Univ. of Sci. & Tech.

Well logging data under complex geological conditions exhibit strong nonlinearity, class imbalance, and limited feature representation, posing challenges to lithology identification. To address these issues, this paper proposes a frequency-oriented implicit spectral feature enhancement method combined with a tree–deep learning heterogeneous ensemble framework. Local window construction and random frequency mapping are used to generate high-dimensional representations, while physical prior features are incorporated to improve geological consistency. Multiple deep models (LSTM, 1D-CNN, Transformer) and tree-based models are integrated using a Macro-F1-squared weighted probability fusion strategy. Experiments on real-world logging data demonstrate that the proposed method achieves an F1-score of 0.7826 with stable performance across different classes. The framework provides an effective engineering solution for intelligent lithology identification.

▶ SunB05-3 10:50–11:10

Multiscale Feature Fusion Extraction Framework for Multivariate Time Series Forecasting

Meng, Jing	Beijing Univ. of Tech.
Chai, Wei	Beijing Univ. of Tech.

To effectively fuse temporal, spatial, and frequency features of multivariate time series (MTS), this paper proposes a multiscale feature fusion extraction (MFFE) framework. A multiscale decomposition module based on stationary wavelet transform (SWT) is proposed to decompose MTS into multiscale components. Concurrently, a scale-component parallel feature extraction module is introduced to capture local temporal and spatial dependencies. For each scale component, one-dimensional convolutional neural networks (1DCNNs) are employed for feature extraction. Furthermore, a scale attention feature fusion module utilizing long short-term memory (LSTM) networks with a scale attention mechanism is proposed to integrate multiscale features, where the attention mechanism adaptively weights salient scales for frequency feature extraction while the LSTM captures global temporal dynamics. Experimental results on Solar-Energy and Traffic datasets demonstrate that the proposed MFFE achieves root mean square error (RMSE) reductions of 7.52% and 33.33% over TPA-LSTM, 7.19% and 35.85% over LSTNet, and 39.69% and 55.26% over DSANet, respectively, demonstrating the effectiveness of the proposed framework for MTS forecasting.

▶ SunB05-4 11:10–11:30

Collaborative Construction of A Lunar Surface Energy Station by Heterogeneous Robots Based on Virtual Simulation

Gao, Zimeng	Automation Major,School of Mechanical & Electrical Engineering & Automation,Shanghai Univ.
Wang, Xiaoyu	Shanghai Univ.
Meng, Chen	Inst. of Aerospace Sys. Engineering Shanghai (ASES)
He, Yuena	Shanghai Univ.
Qiu, Wenwei	Shanghai Univ.
Shi, Hang	Shanghai Univ.

Lunar surface energy station construction can be formulated as a multi-stage heterogeneous cooperative control problem under complex terrain conditions and stringent precision assembly constraints. To address the lack of integrated closed-loop verification for continuous construction tasks, this paper proposes a physics-based hierarchical collaborative control framework and develops a full-process ROS-Gazebo simulation platform. The proposed framework integrates terrain modeling, crater target estimation, cooperative navigation, layered regolith excavation and backfilling planning, and high-precision truss assembly into a unified closed-loop architecture spanning the task, path, and execution levels. A 3D regolith discretization and clustering-based coverage strategy is introduced to transform irregular excavation regions into load-constrained layered task units. In addition, a semantic-geometric iterative pose refinement method is developed to achieve millimeter-level assembly accuracy under monocular vision. Simulation results demonstrate stable multi-robot coordination in low-gravity terrain, efficient layered excavation planning, and assembly localization errors within 0.1 mm, with normal deviation below 0.3 deg, thereby validating the effectiveness and robustness of the proposed framework.

▶ SunB05-5 11:30–11:50

Sensitivity-Assisted Dual-Objective Parameter Identification for An Electrochemical-Thermal-Aging Coupled Battery Model

Wang, Qiaoling	Shandong Univ.
Li, Yan	Shandong Univ.
Zeng, Yi	Shandong Univ.
Li, Junyi	Shandong Univ.

Accurate modeling and reliable parameterization are essential for char-

acterizing battery internal states, yet identifying parameters in multi-physics models is complicated by high dimensionality and physical trade-offs. This study proposes a sensitivity-assisted identification method designed to facilitate accurate parameter estimation for an electrochemical-thermal-aging coupled model (ETACM). To reduce the dimensionality of the identification problem, a one-factor-at-a-time (OFAT) sensitivity analysis is conducted to screen influential variables based on their impact on model responses. This process identifies four dominant parameters as the primary contributors to the model's output variability. Subsequently, an Improved Grey Wolf Optimizer (IGWO) is implemented for dual-objective optimization, utilizing a weighted fitness function with strategically assigned coefficients to balance the fitting accuracy of both voltage and temperature. Validation using experimental data from commercial LG INR21700M50LT cells demonstrates that the proposed method effectively captures battery dynamics, achieving a terminal voltage RMSE of 0.0350 V and a surface temperature RMSE of 0.2516 ℃. These results substantiate the efficacy of the integrated method in ensuring accurate multi-physics estimation, providing a reliable foundation for state monitoring and performance assessment in practical battery applications.

▶ SunB05-6 11:50–12:10

Sliding-Mode Control Based on LQR for Markov Jump Systems with Partially Unknown Dynamics

Cheng, Shengrui — Shanghai Univ. of Engineering Sci. (SUES)
Chen, Bei — Shanghai Univ. of Engineering Sci.
Zhang, Ning — East China Univ. of Sci. & Tech.

For Markov jump systems with partially unknown dynamics and bounded disturbances, this paper develops an integral sliding-mode control framework based on coupled algebraic Riccati equations (CAREs), which is integrated with a two-step policy iteration approach rooted in adaptive dynamic programming (ADP). By constructing an integral sliding manifold, the resulting control law consists of a LQR-equivalent component together with a robust term to compensate for uncertainties and mitigate chattering. To avoid explicit identification of the mode-dependent state matrices Ai, a data-driven policy evaluation step is devised to estimate the matrices Pi via an integral identity, followed by a policy improvement step that updates the corresponding feedback gains Ki. On the basis of Lyapunov-based stability analysis, this paper establishes the reachability of the sliding manifold, and further proves the stochastic stability of the closed-loop system. Finally, simulation studies are provided to demonstrate the effectiveness of the proposed control method.

SunB06 10:10–12:10 Guibin Hall

Regular Session: ADP and RL Based Learning Control (II)

Chair: Shi, Jia — Xiamen Univ.
Co-Chair: Wang, Xin — Southwest Univ.

▶ SunB06-1 10:10–10:30

A Meta-Learning and Physics-Informed Reinforcement Learning Framework for Multi-UGV Cooperative Defense

Chen, Dingxuan — Dalian Univ. of Tech.
Liu, Jinze — Dalian Univ. of Tech.
Jin, Feng — Dalian Univ. of Tech.
Zhao, Jun — Dalian Univ. of Tech.
Wang, Wei — Dalian Univ. of Tech.
Sun, Kaibiao — Dalian Univ. of Tech.

The widespread deployment of low-altitude, slow-speed, small unmanned aerial vehicles (LSS-UAVs) in battlefield reconnaissance and precision strike missions has made them a primary threat to force protection, and the efficient countermeasures against such targets have become a pressing challenge in modern warfare. In cooperative counter-UAV tasks involving multiple unmanned ground vehicles (UGVs), multi-objective optimization must be achieved simultaneously for obstacle avoidance, accurate neutralization of intruding UAVs, and energy consumption control. However, conventional multi-agent reinforcement learning (MARL) typically relies on fixed reward weights, which is difficult to adapt to dynamic battlefield environments, and it lacks explicit modeling of physical motion constraints, resulting in insufficient policy robustness and task adaptability. To address these issues, this paper proposes a centralized training and decentralized execution (CTDE) framework that integrates meta-learning and physics-informed neural networks (PINN) into the multi-agent deep deterministic policy gradient (MADDPG) algorithm, termed Meta Dynamic Reward Weight MADDPG-PINN (MetaDRW-MADDPG-PINN). A dynamic reward-weight predictor based on model-agnostic meta-learning (MAML) outputs, in real time, the "mission –safety –energy" weights that match the current scenario. The PINN module converts physical constraints, including UGV kinematics and collision avoidance, into residual losses and incorporates them into the MADDPG optimization process. Simulation results demonstrate that, compared with MADDPG baselines, the proposed framework improves the obstacle-avoidance safety rate by 21.9% and the counter-UAV success rate by 31.1%, while reducing energy consumption by 34.1%, thereby effectively enhancing the coordination performance and robustness of multiple UGVs in dynamically complex battlefield settings.

▶ SunB06-2 10:30–10:50

A Path Planning Algorithm Based on Deep Reinforcement Learning and Ant Colony Optimization

Huang, Haolei — Xi'an Polytechnic Univ.
Xu, Da — Xi'an Polytechnic Univ.
Wu, Lvyuan — Beihang Univ.
Li, Pengfei — Xi'an Polytechnic Univ.
Zhang, Hongwei — Zhejiang Univ.

This paper proposes a path planning algorithm, DQN-ACO, which combines deep reinforcement learning and evolutionary computation. The algorithm aims to address the issues of premature convergence and instability commonly found in traditional swarm intelligence algorithms when applied to complex 3D voxel environments. DQN-ACO introduces a Deep Q Network (DQN) into the action sampling and pheromone update processes of Ant Colony Optimization (ACO), enabling deep integration of value estimation and pheromone mechanisms. This enhances the global search capability and local adaptability of swarm intelligence. Furthermore, this paper designs an advantage signal-driven local/global pheromone update mechanism to optimize the search process in a more granular way. Experiments conducted on multiple 3D voxel maps of varying complexities demonstrate that DQN-ACO outperforms traditional methods in path planning performance, convergence stability, and real-time efficiency. The results show that DQN-ACO achieves fast convergence in complex dynamic environments while significantly reducing computation time, thereby improving path quality and stability.

▶ SunB06-3 10:50–11:10

Adaptive Optimal Control with Online Learning for Variable-Rope-Length 2D Bridge Crane

Liu, Ben — Zhejiang Univ. of Tech.
Chen, Zhongtian — Zhejiang Univ. of Tech.
Li, Yuanhao — Zhejiang Univ. of Tech.
He, Xiongxiong — Zhejiang Univ. of Tech.

This paper addresses the optimal control problem for a two-dimensional variable-rope-length overhead crane system by proposing an adaptive dynamic programming approach. In this method, a neural network is incorporated as an essential component of the control system, and an online learning mechanism is employed to replace offline parameter tuning. The control strategy is combined with a reference model to achieve swing suppression. An improved cost function is designed to more precisely coordinate the objectives of system tracking and energy optimization. In the design of the update law, a novel stability term is constructed, which effectively enhances the stability and convergence speed of the learning process. Additionally, a speciffc set of basis functions is provided to better capture the coupling relationships among system states. The Lyapunov method is applied to prove the stability of the closed-loop system, demonstrating that the controller achieves near-optimal performance within a ffnite bound. Finally, the effectiveness of the control method was veriffed through simulation

▶ SunB06-4 11:10–11:30

On Switched Event-triggered Full State-constrained Formation Control for Multi-vehicle Systems

Li, Zihan — Southwest Univ.
Wang, Ziming — The Hong Kong Univ. of Sci. & Tech., Guangzhou
Wang, Xin — Southwest Univ.

Vehicular platoon control is an important component of intelligent transportation systems. In practical applications, the control design needs to satisfy multiple state constraints, including inter-vehicle spacing and vehicle speed. When system states approach the constraint boundaries, control singularity and excessive control effort may arise, which limits the practical applicability of existing methods. To address this problem, this paper investigates a class of nonlinear vehicular platoon systems with uncertain dynamics and develops a switched event-triggered control framework. A smooth nonlinear mapping is first introduced to transform the constrained state space into an unconstrained one, thereby avoiding singularity near the constraint boundaries. A radial basis function neural

network is then employed to approximate the unknown nonlinear dynamics online, based on which an adaptive controller is constructed via the backstepping technique. In addition, a switched event-triggered mechanism is designed to increase the control update frequency during the transient stage and reduce the communication burden during the steady-state stage. Lyapunov-based analysis proves that all signals in the closed-loop system remain uniformly bounded and that Zeno behavior is excluded. Simulation results verify that the proposed method achieves stable platoon formation under prescribed state constraints while significantly reducing communication updates.

▶ SunB06-5 11:30–11:50

Reinforcement Learning-Enhanced Tube-based MPC Control Scheme for Uncertain Systems

Jiang, Shan — Xiamen Univ.
Wei, Zixuan — Xiamen Univ.
Shi, Jia — Xiamen Univ.

Tube-based model predictive control (TMPC) is a robust MPC method proposed for uncertain systems. It ensures robustness by introducing tube invariants and constraint tightening mechanisms. However, TMPC often adopts overly conservative control strategies while guaranteeing robustness. To address this issue, this paper proposes a reinforcement learning (RL)-enhanced TMPC control scheme, termed RL-TMPC. This method explicitly embeds the policy actions generated by the RL agent into the TMPC control loop, forming an auxiliary compensation action that is superimposed on the TMPC control action before application to the actual system. Within this framework, RL optimizes the compensation policy online via model-free learning through interaction with the environment, dynamically adapting to system uncertainties and state changes to effectively reduce TMPC's conservatism. Simultaneously, TMPC's robust constraint satisfaction mechanism compensates for RL's difficulty in strictly enforcing constraints, thereby ensuring system safety. This paper presents a complete algorithmic workflow for RL-TMPC, encompassing offline tube computation, online TMPC optimization, and RL policy updates. Simulation validation on inverted pendulum system demonstrates that the proposed method significantly enhances control flexibility and dynamic response performance while guaranteeing constraint satisfaction and robust stability.

▶ SunB06-6 11:50–12:10

Ratio-Constrained Gradient Projection Torque-Cost Optimization for Dual-Policy Decomposed Humanoid Control

Zhi, Yuhao — Jiangnan Univ.
Xu, Zhong — JiangNan Unversity
Xu, Chen — Jiangnan Univ.
Yang, Huizhong — Jiangnan Univ.

In high degree of freedom humanoid robots control, improving task performance and reducing whole-body joint torque load often conflict. This paper proposes a task-prioritized cooperative torque-cost optimization method for upper-lower body dual-policy decomposed reinforcement learning control. To improve training stability when jointly optimizing task performance and the coupled whole-body torque cost under the dual-policy architecture, this paper constructs a global torque-cost critic. Gradient conflicts between the primary task objective and the torque-cost objective are addressed by projecting the torque-cost gradient onto the orthogonal subspace of the task gradient. Furthermore, this paper introduces a ratio constraint to limit the magnitude of the torque-cost gradient correction term. Physics-based simulation experiments on Unitree G1 for standing and walking demonstrate that, relative to a linearly weighted baseline, the proposed method reduces the mean output torque across all joints while preserving task performance, and improves motion smoothness.

Poster Session SunB07
May.10, 10:10–12:10
Front Hall

▷ SunB07-01

Prediction of Melt Index of Batch Polypropylene Based on Data Characteristics and Regression Modeling

Zhang, Yiyu — China Univ. of Petroleum
Wang, Jinmiao — China Univ. of Petroleum (Beijing)
Wang, Zhu — China Univ. of Petroleum (Beijing)

Due to the delay in the test results of the melt index of the polypropylene batch process, the production personnel cannot observe the change of the melt index in time and guide the next batch of production. In order to obtain the melt index value in time, this paper proposes a melt index prediction method based on the combination of data characteristics and regression modeling. Firstly, the process variables affecting the melt index are determined by analyzing the process mechanism, and the relevant historical number data are collected. Then, in the offline training stage, the expert rules based on the process mechanism are constructed, the historical batch data are extracted and the batch melt index is fused. Secondly, for the extracted long-term sequence data, it is converted into a spatio-temporal matrix, and the singular value decomposition technique (SVD) is used to extract the data features, and the BP neural network is used for prediction. In the online prediction stage, incremental single-sample prediction is performed and data adaptive preprocessing is added, and mean absolute percentage error (MAPE) is introduced. This study explores the combination of mechanism and quality modeling prediction, and achieves better quality prediction results through BP neural network training.

▷ SunB07-02

Research on Dynamic Position Management for Commodity Futures Trend Strategies Based on Deep Reinforcement Learning

Li, Chengjin — Qingdao Univ. of Sci. & Tech.
Liu, Xiangpeng — Qingdao Univ. of Sci. & Tech.

Traditional position management in futures trading struggles to adapt to non-stationary market fluctuations and effectively control risks. This paper proposes a hybrid architecture for dynamic position management based on deep reinforcement learning (DRL). The framework modularizes technical indicator signal generation and agent-based position management, while designing an adaptive reward function based on trend strength to guide the agent toward heavy positions in strong trends and light positions in ranging markets. Taking corn futures as an example, the study compares the backtest performance of a traditional position strategy against dynamic position strategies using four mainstream DRL algorithms: DQN, QR-DQN, SAC, and TQC. Results show that DRL-based dynamic strategies significantly outperform the baseline in Sharpe ratio, Calmar ratio, and maximum drawdown. Specifically, the DQN strategy achieves a cumulative return of 268.21%, demonstrating strong profit amplification in trending markets. The SAC strategy, through smooth adjustment in continuous action space, limits maximum drawdown to 21.10% and attains the highest Sharpe ratio, achieving the best risk-return balance. Further analysis reveals that, in noisy financial environments, structurally simple and robust algorithms (DQN and SAC) outperform more complex distributional variants (QR-DQN and TQC). This study confirms the effectiveness and practical value of deep reinforcement learning for dynamic position management in futures, providing theoretical and empirical support for intelligent quantitative trading systems.

▷ SunB07-03

A Safe Reinforcement Learning Algorithm with Adaptive Lagrangian Multipliers

Jin, Jiangnan — Huzhou Univ.
Ye, Lingjian — Huzhou Univ.
Qin, Jingsheng — Huzhou Univ.
Zheng, Jiaqing — Huzhou Univ.
Xu, Xiaoyu — Huzhou Univ.
Wang, Longyan — Huzhou Univ.
Lin, Senyang — Huzhou Univ.
Xia, Yuhang — Huzhou Univ.
Miao, Jiawei — Huzhou Normal Univ.
Huang, Jiawei — Huzhou Universdity

The safety constraints in existing safe reinforcement learning methods are mainly defined on the expectation of initial states, but allow certain specific states to remain unsafe, which is unsatisfactory for practical safety-critical tasks. This paper proposes a TD3-based method with adaptive state-wise Lagrangian multipliers (TD3-ADAPT) algorithm that can prevent unsafe behaviors during the training process. Firstly, we introduce an additional neural network to approximate the Lagrangian multiplier for each state, thereby constructing a state-dependent Lagrangian function to ensure the safety of each state. Secondly, we construct two safety cost critic networks with identical architectures and adopt a clipped Double Q-learning variant to estimate the action value function, thus mitigating the overestimation of long-term safety costs. We validate the effectiveness of the proposed algorithm on a numerical example.

▷ SunB07-04

Energy-Efficient Speed Profile Optimization for Maglev Trains Based on Proximal Policy Optimization

Zheng, Yuhang — Beijing Jiaotong Univ.

Zhang, Xiaoji	Beijing Jiaotong Univ.
Wu, Donghua	CRRC Qingdao Sifang Co., Ltd
Tian, Yi	CRRC Qingdao Sifang Co., Ltd
Zhong, Weifeng	Beijing Jiaotong Univ.

Maglev transit, featuring high safety, low noise, and reduced maintenance requirements, is regarded as a promising direction for future rail transportation. This has motivated growing interest in energy-efficient speed profile optimization for maglev trains. Conventional optimization methods typically rely on accurate train dynamic models and well-calibrated parameters. Their performance often degrades in the presence of model mismatch or parameter uncertainty. Reinforcement learning (RL), which can generate optimal control policies through interaction with the environment without relying on an exact system model, is increasingly being applied to energy-efficient speed profile optimization for trains in recent years. Existing studies commonly adopt tabular Q-learning or deep Q-networks (DQN). However, the achievable performance is often constrained by action discretization, where the resolution–complexity trade-off may limit energy savings and induce unstable training. This paper formulates energy-efficient speed profile optimization for maglev trains as a continuous-control Markov decision process (MDP) under practical constraints, including trip time, line speed limits, track gradients, and acceleration bounds, and proposes a Proximal Policy Optimization (PPO)-based algorithm. A composite reward structure combining dense step-wise rewards with a terminal reward is designed, and curriculum learning is introduced to improve training stability. Simulation results show that the proposed method yields lower energy consumption and smaller trip-time errors than dynamic programming (DP) and DQN baselines, while exhibiting stable training behavior, thereby demonstrating its feasibility and effectiveness.

▷ SunB07-05

Two-Stage Decoupled Robust Framework for Wind Power Forecasting under Gross Errors via Dynamic Data Reconciliation

Lv, Yankang	Wenzhou Univ.
Hong, Zhihui	Wenzhou Univ.
Zhang, Zhengjiang	Wenzhou Univ.
Li, Li	Zhejiang Chint Electric Co., Ltd
Zhu, Zhiliang	Wenzhou Univ.

Accurate wind power forecasting is a cornerstone for the stable operation and economic dispatch of modern power grids. However, gross errors (e.g., outliers, bias, and drifts) in data severely constrain the robustness of traditional models. Existing approaches often struggle to balance fitting complex dynamics and suppressing anomalies. To address this, the paper proposes a novel two-stage decoupled robust framework. First, a Long Short-Term Memory (LSTM) network captures core dynamic trends to generate preliminary predictions, explicitly treated as a system state "prior estimate". Subsequently, a Dynamic Data Reconciliation (DDR) algorithm acts as an independent post-processing module. Rooted in Maximum A Posteriori (MAP) theory, DDR fuses the model prior with noisy measurements. Leveraging a Contaminated Gaussian model, it adaptively adjusts trust weights based on residual magnitude. This process performs online optimization, effectively suppressing gross errors without manual thresholding. Experiments on a real-world dataset demonstrate that DDR-Post reduces Root Mean Square Error (RMSE) by 58.7% and improves R2 from 0.956 to 0.992 over the LSTM baseline. Crucially, systematic experiments involving manually injected anomalies verify the framework's robustness for industrial deployment.

▷ SunB07-06

A Structural Optimization Algorithm with Borges Summation in TCN-NBEATS Model for SOC Estimation of Lithium-Ion Batteries

Wang, Yuhang	Liaoning Univ.
Gao, Zhe	Liaoning Univ.
An, Xianghua	Liaoning Univ.
Li, Hao	LIAONING Univ.
Zeng, Xiaowei	Liaoning Univ.
Zheng, Dongyue	Liaoning Univ.
Di, Mingzhe	Liaoning Univ.

Accurate estimation of the state of charge (SOC) of lithium-ion batteries (LIBs) is essential for ensuring the safe and stable operation. The existing data-driven methods remain sensitive to noise in the LIBs input data, and often exhibit limitations in generalization ability and model interpretation. This paper proposes a method that integrates the temporal convolutional network (TCN) with the neural basis expansion analysis for interpretable time series (NBEATS) model, along with Borges summation to solve the challenges faced by SOC estimation. In this framework, the TCN model performs feature extraction, while the NBEATS model further optimizes the temporal features. The Borges summation introduced can realize the adjustment of the model prediction output ratio in an interval. Experiments conducted on LIBs data under various complex working conditions demonstrate that the proposed TCN-NBEATS-B model consistently achieves superior estimation accuracy and robustness in SOC estimation, highlighting its practical applicability.

▷ SunB07-07

Dual-Domain Transformer with Time-Domain Multi-Scale Patching and Frequency-Domain Sparse Representation for Water Wall Tube Temperature Prediction

Mao, Dongming	Hangzhou Normal Univ.
Liu, Jiabei	Hangzhou Normal Univ.
Zeng, Jiusun	Hangzhou Normal Univ.
Yao, Le	Hangzhou Normal Univ.
Zhu, Zheren	Zhejiang Univ.

The safety and stability of water walls in coal-fired power plants are critical for the secure and economic operation of energy systems. Accurate prediction of water wall tube temperature is challenging due to the complex combustion environment, frequent load fluctuations, and significant sensor noise. Existing methods often struggle to balance the capture of local transient changes with global evolutionary trends and typically treat noise reduction as a separate offline step. To address these issues, this paper proposes a novel Dual-Domain Transformer that integrates Time-domain multi-scale patching with Frequency-domain sparse representation. First, a multi-scale patching strategy is introduced to segment time series into patches of varying lengths, enabling the simultaneous perception of fine-grained fluctuations and coarse-grained trends. Second, a learnable frequency-domain sparse extraction module is integrated, utilizing discrete wavelet transform and an adaptive soft-thresholding mechanism to purify features in an end-to-end manner. Finally, a time-frequency deep interaction encoder is constructed, employing a global token to bridge time-domain patches and frequency-domain spectral features. Experimental results on real-world data from a 350 MW subcritical unit demonstrate that the proposed method significantly improves prediction accuracy and robustness. Specifically, for the 1-minute-ahead prediction task, the model achieves 5℃and 3℃error accuracies of 99.07% and 89.49% under stable conditions, and maintains high accuracies of 93.98% and 75.62% even under fluctuating conditions.

▷ SunB07-08

Collaborative Prediction of Operation Rhythm and Gas Consumption for Hot Blast Stoves Group Based on A PC-STGNN Model

Chen, Long	Dalian Univ. of Tech., Dalian
Zhang, Yi	Dalian Univ. of Tech.
Zhao, Jun	Dalian Univ. of Tech.
Wang, Wei	Dalian Univ. of Tech.

Abstract: Accurate prediction of operation rhythm and blast furnace gas (BFG) consumption for hot blast stoves group are critical for energy conservation and consumption reduction in steel industry. Considering the spatio-temporal non-stationarity, the multi-modal, and the strong nonlinearity characteristics caused by the alternating uncertain operation of multiple stoves, this paper proposes a process-constrained spatio-temporal graph neural network (PC-STGNN) prediction model. By integrating process mechanisms, the model extracts the hot blast stove operation rhythm, the remaining state time, and the flow rate change treating as process-constrained features, i.e., the industrial expert knowledge embedded in the data input layer. In terms of architectural design, a serial spatio-temporal fusion feature extraction mechanism is constructed, which utilizes the graph attention network (GAT) to dynamically capture the spatial nonlinear coupling weights that evolve with inter-stove conditions. To address the sharp fluctuations in energy consumption patterns, a mixture of experts (MoE)-based hierarchical prediction strategy is introduced to achieve adaptive regression of consumption patterns under different modes such as on-blast, combustion, and stove-switching. Real-world data from the SCADA system of a large-scale steel enterprise in China are employed in the experiments. It demonstrates that the PC-STGNN model significantly outperforms traditional time series models. The proposed method effectively improves the prediction performance when the sudden change occurs.

▷ SunB07-09

Research on the Application Path Value-added of Data-driven Method in Engineering Materials

Ma, Yane Nil
Zhao, Yanze Beijing Univ. of Chemical Tech.
Liu, Wenbin Beijing Univ. of Chemical Tech.
Wan, Jing Beijing Univ. of Chemical Tech.

Abstract: This paper systematically discusses the application path and value-added effect of data-driven method in the whole life cycle of engineering materials research and development, production and service. By analyzing the bottleneck of traditional material research and development mode, introducing hybrid research methods, combining quantitative analysis, case study and experimental verification, a closed-loop system of ' data-model-decision ' is constructed. A full-chain four-body application framework is constructed, covering data acquisition system, model reconstruction, process optimization and performance prediction. It shows the significant value of data-driven methods in improving R & D efficiency, reducing production costs and promoting material innovation, and promoting breakthrough innovation in material properties. Based on the typical cases of metal materials, composite materials and functional materials, this paper verifies the practical application value of data-driven method, and puts forward the future development path.

▷ SunB07-10

Research on Arc Voltage Control Based on RBF Neural Network Self-Tuning PID in Automatic Welding System

Sun, Qiuyang China Nuclear Industry 23 ConstructionCO.,LTD
Feng, Yingchao China Nuclear Lndustry 23 ConstructionCO.,LTD
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In automatic welding systems, traditional PID control is difficult to adapt to the time-varying and nonlinear characteristics of arc voltage control system. And it has limited control accuracy. To solve the problem, an arc voltage control method based on RBF neural network self-tuning PID is proposed. Firstly, ARX model is adopted as the system model. RBF neural network is designed to identify the dynamic characteristics of arc voltage control system in real time, providing a basis for PID parameter self-tuning. The control output is achieved through a discrete incremental PID control law. Finally, the effectiveness of the method is verified through simulation experiments. The results show that RBF neural network can accurately track the system dynamic characteristics. And arc voltage tracking performance, control accuracy and anti-interference ability of the proposed control method are significantly better than those of traditional PID control and fuzzy PID control.

▷ SunB07-11

Data-driven Model Predictive Fault-tolerant Control for Nonlinear Batch Processes with Partial Actuator Faults

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In this article, we study the fault-tolerant control (FTC) problem for nonlinear batch processes with partial actuator faults. A novel data-driven model predictive fault-tolerant control strategy is proposed. In the beginning, a time-varying linear data-driven model is established by using the online input and output data of the controlled batch processes. The model parameter contains both actuator faults and system nonlinear dynamics information. Then, to enhance the tracking performance of the system, a modified model predictive fault-tolerant control scheme is designed, and the variation of the system tracking error is considered into the optimization criterion function. The resulting controller is independent of any system model, which can effectively deal with the issue of uncertainties and has better FTC control performance. At last, the effectiveness of the presented control approach is illustrated through a continuous stirred tank reactor system.

▷ SunB07-12

Multi-Granularity Graph Feature Fusion for Industrial Soft Sensing

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With the increasing complexity and data intensity of industrial processes, traditional soft sensing models face challenges in modeling nonlinear and time-varying systems. To capture the complex non-Euclidean dependencies among process variables, this paper proposes a multi-granularity graph feature fusion for industrial soft sensing framework (MGF). By constructing a prior graph, a coarse-grained graph, and a fine-grained graph, the proposed method models multi-level variable dependencies and extracts complementary graph features from prior knowledge, global dependencies, and local dynamic patterns. A feature fusion module based on the maximum relevance and minimum redundancy paradigm is further introduced to integrate multi-granularity features, thereby improving feature discriminability and prediction accuracy. Experimental results using data from a four-stage CO_2 compression system demonstrate the effectiveness and superior performance of the proposed approach.

▷ SunB07-13

MIF-PV: A Multi-source Heterogeneous Information Fusion Framework for Robust Short-Term Photovoltaic Power Forecasting

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Accurate short-term photovoltaic (PV) power forecasting is critical for grid operation and economic performance, yet existing methods still struggle to exploit multi-source heterogeneous data because of alignment errors, noise variation, and weak cross-modal fusion. We propose MIF-PV, a multi-source heterogeneous information fusion framework for short-term PV forecasting. It uses finite scalar quantization to denoise and regularize PV measurements, multimodal rotary position embedding to model 3D spatio-temporal cloud dynamics in satellite imagery, and gated co-attention to adaptively fuse satellite images, numerical weather prediction, and historical power data. This hierarchical uncertainty management yields robust forecasts in both stable and volatile weather. Experiments on real-world industrial data show that MIF-PV outperforms state-of-the-art methods, reducing RMSE and MAE by 13.6% and 19.5%, and remaining robust across weather conditions and zero-shot scenarios.

▷ SunB07-14

Transformer-CatBoost Serial Hybrid Prediction Modeling for Reheat Steam Temperature Process of Coal-Fired Power Units

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The reheat steam temperature (RHT) process in coal-fired power units is characterized by large thermal inertia, extensive time delays, and strong time-varying nonlinearities, posing severe challenges for traditional data-driven models to achieve high-precision forecasting. This paper proposes a serial hybrid deep learning prediction architecture integrating the Transformer network and Categorical Boosting (CatBoost) algorithm, and applies it to the dynamic modeling of the RHT. This approach effectively addresses the difficulties in extracting long-delay sequential dynamic features and mapping complex high-dimensional nonlinearities. Simulation results based on actual operational data demonstrate that the proposed approach achieves superior accuracy in single-step forecasting and exhibits exceptional robustness in long-horizon multi-step continuous tracking. The model effectively mitigates long-term prediction error degradation, providing a highly reliable predictive foundation for advanced closed-loop control systems.

▷ SunB07-15

Asymmetric Robustness in Ship AIS Spoofing Detection: A Study of Random Perturbation Stability and Adaptive Evasion Attacks

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Existing AIS spoofing detection research predominantly emphasizes classification accuracy under fixed conditions, overlooking adversarial robustness in adaptive evasion scenarios and thus overestimating true security boundaries. This paper proposes a threat-driven robustness framework to quantify detection failure mechanisms under adversarial attacks. We first construct a baseline detection model using kinematic features, achieving 99.76% accuracy and 99.47% recall in standard tests. Through noise perturbation experiments and progressive spoofing attacks with an adaptive decay factor α that simulates stealthy evasion, we uncover significant asymmetric robustness: the system withstands random noise effectively (Recall > 96%) yet proves highly vulnerable to structural feature degradation. We identify a critical collapse threshold $\alpha \approx 0.35$ and reveal that ROC-AUC exhibits "deceptive robustness" during performance deterioration, masking actual defense failures. Our findings demonstrate that high static accuracy does not guarantee adversarial security. The proposed evaluation framework and collapse threshold provide effective analytical tools for quantifying hidden vulnerabilities and establishing the realistic security boundaries for AIS spoofing detection systems.Adversarial Robustness, Adaptive Evasion Attacks, Detection Collapse Threshold

▷ SunB07-16

Predefined-Time Control with Prescribed Performance for Multi-Motor Servo System Based on Generalized Coupling Error

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Song, Jiangchao	Beijing Inst. of Tech.
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This paper proposes a predefined-time coordinated control scheme for multi-motor servo systems based on a generalized coupling error (GCE). By introducing the GCE, the motor tracking and synchronization errors are unified into a single error variable, through which the coupled tracking and synchronization problem is transformed into the convergence of the GCE.This formulation significantly simplifies the controller design and effectively avoids the mutual coupling between tracking and synchronization control loops. To explicitly guarantee the transient performance of multi-motor servo systems, a GCE-based fractional-form error transformation function is constructed, which enables direct regulation of the transient behavior of motor tracking and synchronization errors while avoiding the numerical singularities commonly encountered in traditional performance transformation methods. On this basis, a predefined-time control strategy is systematically developed to simultaneously achieve load tracking and motor synchronization. By incorporating the control framework, both the load tracking error and motor synchronization are guaranteed to converge within a predefined time. Rigorous Lyapunov-based analysis is provided to establish the predefined-time stability of the overall closed-loop system. Simulation results on a four-motor servo system validate the effectiveness of the proposed control strategy.

▷ SunB07-17

AdaCTRec: An Adaptive Collaborative Temporal Recommendation Method

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Sequential recommendation aims to capture evolving user interests by analyzing interaction sequences. However, existing methods typically focus on isolated user sequences, which limits their ability to capture global patterns in sparse data. To address this issue, we propose an Adaptive Collaborative Temporal Recommendation method (AdaCTRec) that employs momentum-based cross-user contrast learning to interconnect user behavior sequences. AdaCTRec utilizes a memory bank and momentum updates to incorporate global collaborative patterns for enhanced stability, and further incorporates an Adaptive Loss Balancing Strategy, which uses a parameter-free mechanism to dynamically adjust constraint weights, effectively mitigating the data sparsity issue. Extensive experiments on the Yelp and Beauty datasets demonstrate the effectiveness of AdaCTRec, showing significant performance improvements in terms of NDCG@10 and HR@10.

▷ SunB07-18

Energy Consumption Prediction Model for Fresh Air and Air Conditioning System Based on STGNN-TA

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Wang, Kang	Beijing Univ. of Tech.

In recent years, in pursuit of a more comfortable indoor environment, an increasing number of facilities have started using fresh air–air conditioning systems, operating in coordination to complement each other. However, the introduction of fresh air systems can also lead to an increase in building operational energy consumption. Against this backdrop, there is an urgent need to optimize and reduce their energy consumption. This paper proposes a spatiotemporal graph neural network prediction model based on STGNN-TA temporal attention to predict the energy consumption of air conditioning systems with fresh air systems. Compared to traditional methods, it more comprehensively considers the temporal features and spatial relationships of energy consumption data. This study constructed relevant relational graphs and optimized the STGNN. The results show that, compared with traditional methods such as LSTM and GRU, STGNN-TA achieves significant breakthroughs across multiple key metrics.

▷ SunB07-19

Air Conditioning Load Forecasting Based on Optimized LSTM-Multi-Head Attention Hyperparameters

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To address the challenges present in short-term air conditioning load forecasting, such as strong nonlinearity, complex temporal dependencies, and the influence of multiple exogenous factors, a forecasting framework combining LSTM with a multi-head attention mechanism, whose hyperparameters are automatically optimized based on the Dung Beetle Optimization (DBO) algorithm, is proposed and validated. This method leverages LSTM to extract temporal features from time series, employs multi-head self-attention to simultaneously capture dependencies across different time scales and feature subspaces, and globally optimizes key model hyperparameters using DBO, incorporating Lévy flights during the search process to enhance global exploration capability. Experiments, conducted on hourly simulation data generated for the entire year by DeST, show that compared with baseline LSTM and LSTM-Single-Head Attention on the same test set, the proposed method significantly outperforms in terms of RMSE, MAE, and all three integrated metrics: RMSE decreases from 5.37 to 1.57, MAE from 2.71 to 0.92, and the comprehensive score improves to 0.997. Visualization results indicate that the method can more accurately track real load changes at peaks and turning points, demonstrating its practical value for high-precision air conditioning load forecasting and providing a reliable basis for air conditioning energy savings.

▷ SunB07-20

A Hybrid Path Planning Method for Mobile Robots Based on Improved Theta and Improved APF*

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This paper designs a hierarchical path planning architecture, which combines the improved Theta* algorithm and the improved Artificial Potential Field (APF). In the global planning phase, we use uniform downsampling and corner smoothing techniques to optimize the path generated by Theta*, which can reduce redundant path points and improve the smoothness of the trajectory. In the local control stage, we designed an adaptive repulsion coefficient adjustment mechanism and a dynamic target region processing strategy, these methods can effectively alleviate the problems that the traditional APF is easy to fall into local minima and oscillation occurs. We conducted a simulation experiment on Robot Operating System (ROS) platform using Gazebo/RViz. The results show that the improved Theta* algorithm reduces the total path length by 15.19% and the number of path nodes by 28.24%, the path smoothness is increased by 27.68%. At the same time, the improved method

also reduces the total control time by 25.18% and the average angular velocity by 29.73%. This method significantly improves the path quality and navigation robustness of mobile robots on the premise of ensuring real-time performance.

▷ SunB07-21

Inland River Ship Crew Fatigue Detection Method Based on Multi-Feature Fusion with Improved RT-DETR

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In response to the problems of facial feature blurring, partial occlusion, and missed detection or misjudgment of individual facial features caused by the continuous shaking of the ship body during the operation of inland river vessels, this study proposes a lightweight crew fatigue detection framework based on the improved RT-DETR. MobileNetV4 serves as the Backbone of RT-DETR, and its built-in inverted residual bottleneck structure (UIB) enables the algorithm to be lightweight on onboard embedded devices; the introduction of the SCSA-CBAM attention module enhances the network's ability to focus on key facial feature areas, improving the model's robustness in motion-blurred environments; on this basis, a multi-feature fusion determination strategy is proposed, by adjusting the weight coefficients of eye, mouth, and head posture features, effectively reducing the missed detection problem caused by a single feature. The experimental results show that this method achieved an average precision mean (mAP50) of 89.4% on the YAWDD dataset, which is 2.2% higher than the original RT-DETR benchmark model in terms of detection accuracy. In terms of model lightweighting, the parameter size was reduced from 20.5M to 7.8M, and the computational cost was significantly reduced from 92.0G to 14.5G (a reduction of 84.2%), meeting the real-time monitoring requirements in shipborne environments. This research provides a highly robust and easy-to-deploy technical means for safety supervision in the intelligent transformation of inland waterway transportation.

▷ SunB07-22

Towards A Secure Federated Learning Based Approach for Automatic Atrial Fibrillation Detection Using ECG Benchmark Datasets

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Atrial fibrillation (AF) is the most common sign for further heart stroke. It has been a very definite reason for the cardiovascular disease that led to death. The asymptomatic nature of AF highlights the importance of early detection. Recently, there has been much research that can detect AF automatically using key techniques of artificial intelligence and deep learning. Researchers are taking it as a core signal processing problem using ECG data as input. However, when we apply it in clinical setups, the deployment of sophisticated deep learning architecture often faces many challenges. The most important challenge includes the data-driven control, as data is private and patient-sensitive data cannot be centralized. Therefore, a reliable, data-preserving, data-driven mechanism needs to be created that uses the real-world wearable devices, like the smartwatch, or any other wearable input device. In this article, we proposed a federated learning-based adaptive network enhanced by the concepts of the meta-learning approach; we named it FedAdapt-AFD. Our proposed system is a step towards privacy-preserving, collaborative, and reliable AF detection in which, first, the core model that we leverage from MP-DLNet is employed as a feature extractor on the client side that handles the variable input taken from ECG data. After that, the meta-reinforced federated learning (MetaRFA) algorithm operates across all the clients. The MetaRFA algorithm explicitly performs rapid adaptability for faster inner loop problems. As a result, it ensures the strong, adaptive control for new input data that lessens the need for local data that enhances convergence. Furthermore, a dynamic weighting scheme for each client mitigates the instability caused by noisy or non-IID clients. The proposed method has been evaluated on publicly available datasets from PhysioNet Computing in Cardiology Challenge for 2017 (CinC2017), the China Physiological Signal Challenge in 2018 (CPSC2018) and ECG data from the MIT-BIH database (MIT-BIH). The proposed research is a secure, reliable, and adaptive approach that bridges the gap between AI-based method deployment and centralized health monitoring systems in real clinical settings.

▷ SunB07-23

SPFEMAN: Structural and Propagation Feature Enhanced Multimodal Attention Network for Multimodal Fake News Detection

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Yu, Jiafeng	Harbin Inst. of Tech.
Wang, Zengyun	Hunan First Normal Univ.
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Fake news detection is a data-driven monitoring task for complex networked systems, featuring multimodal observations, sparse interaction graphs, and high-order diffusion behaviors. In this paper, we present SPFEMAN, a Structural and Propagation Feature Enhanced Multimodal Attention Network that integrates text, image, structure, and propagation signals. SPFEMAN alleviates structural sparsity by inferring latent links between semantically similar posts and employs a stance-aware graph neural network to capture stance inconsistencies. It further models diffusion via multi-view hypergraphs and a dual-attention module to learn high-order propagation patterns. Cross-modal alignment and co-attention fusion produce a unified representation for classification. On Weibo and PHEME, SPFEMAN surpasses strong baselines, reaching 0.925/0.926 and 0.896/0.897 in Accuracy/F1, respectively. The proposed framework provides a general data-driven paradigm for fake news monitoring in large-scale networked systems with incomplete topology and complex propagation.

▷ SunB07-24

Robot Path Planning in Crowded Environments Based on Geometric Navigation and Spatial-Temporal Transformer

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In complex dynamic crowded environments, mobile robots need to possess both the long-term prediction ability of pedestrian trajectories and the immediate response ability to sudden obstacles. Existing methods based on Deep Reinforcement Learning (DRL) mostly rely on Recurrent Neural Networks (RNN) to process temporal information, which makes it difficult to capture long-distance temporal dependencies. Although the direct introduction of Transformer enhances the reasoning ability, it often leads to convergence difficulties or policy collapse due to sparse training signals. To address the above problems, this paper proposes a novel navigation framework and a matching geometry-guided training strategy. First, the framework uses a heterogeneous interaction graph to extract high-dimensional spatial features and designs a spatial-temporal Transformer to replace the traditional RNN, which accurately captures the nonlinear motion intentions of pedestrians. Second, this paper proposes an adaptive residual gating mechanism that dynamically fuses temporal reasoning and immediate perception features through a dual-stream residual architecture, solving the problem of multi-modal feature competition. In addition, to solve the problem of low exploration efficiency of DRL in complex environments, a geometry-guided reward shaping mechanism based on Velocity Obstacle (VO) is introduced. This mechanism converts the traditional geometric obstacle avoidance prior into dense supervision signals, effectively guiding the model to quickly master the dynamic obstacle avoidance strategy in the early stage of training. Simulation experiments show that the proposed method can effectively learn complex navigation strategies. Ablation experiments confirm that the combination of geometry-guided reward and residual gating mechanism significantly improves training stability and convergence speed, and outperforms existing benchmark methods in both pass rate and navigation efficiency.

▷ SunB07-25

Adaptive Trajectory Tracking Control of Robotic Manipulators Based on RBF Neural Networks

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Precise trajectory tracking in robotic manipulator is critical for advanced industrial applications such as automated assembly and welding, where it directly influences key performance indicators including accuracy and quality. This paper addresses the challenge of achieving high-precision

tracking under simultaneous external disturbances and unknown system parameters. A novel composite control scheme is proposed, integrating a sliding mode adaptive controller with a nonlinear disturbance observer. To compensate for unmodeled dynamics and parametric uncertainties, an RBF neural network is employed for system approximation, facilitating the design of an adaptive law that ensures rapid convergence of both joint position and velocity to their desired trajectories. Concurrently, the disturbance observer is designed to estimate and compensate for bounded external disturbances in real time. The convergence of the tracking error to zero and the uniform ultimate boundedness of all signals in the closed-loop system are rigorously established using Lyapunov stability theory. Simulation studies conducted on a two-link robotic manipulator demonstrate the effectiveness of the proposed method, confirming its capability for accurate and fast tracking in both position and velocity domains.

▷ SunB07-26

A Model-Free Adaptive Predictive Control Strategy for VSG-Based Secondary Frequency Control in Inland Port Microgrids

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To address the frequency fluctuation problem in green inland port microgrids caused by the high penetration of distributed energy resources and the frequent switching of large-impact loads such as quay cranes and gantry cranes, a virtual synchronous generator (VSG)–based secondary frequency control strategy employing model-free adaptive predictive control is proposed. The rotor motion equation of the VSG is discretized, and a compact-form dynamic linearization approach is adopted to establish a discrete data-driven model between the VSG output angular frequency and the virtual mechanical power. On this basis, a model-free adaptive predictive controller is designed, in which the system dynamic characteristics are adaptively characterized through online updating of pseudo partial derivatives, and the optimal adjustment of the virtual mechanical power is obtained within the prediction horizon, thereby improving both the dynamic frequency response and steady-state regulation performance. Simulation studies conducted in the MATLAB/Simulink environment verify the effectiveness and stability of the proposed method under impact loads and complex operating conditions.

▷ SunB07-27

Wind Speed Assistance and Bayesian Optimization Based Wind Power Prediction

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Accurate wind power prediction is of vital importance to achieve efficient grid connection of wind energy. Wind power generation is fundamentally driven by meteorological conditions, among which wind speed directly determines the available wind energy through a cubic relationship as a key external variable. However, most current methods rely solely on historical power data for modeling, neglecting the impact of critical weather factors like wind speed in the energy conversion process. This omission often limits prediction performance under changing wind conditions. Addressing this limitation and starting from the mechanism of wind turbine dynamic energy conversion, a wind speed assistance and Bayesian optimization based wind power prediction model is proposed in this paper. Firstly, a wind speed forecasting methods based on long short-term memory network is employed to capture the dynamic evolution characteristics of the meteorological system. Then, these predicted speeds are then fused with historical power data to form the input features for a second-stage LSTM, which models the turbine's power response. This two-stage design effectively decouples the weather-driven process from power generation. What's more, Bayesian optimization is integrated to adaptively tune model hyperparameters, enhancing adaptability across different operational scenarios. Experimental results based on actual wind farm data show that, conditional on the present test setting, our method reduces root mean square error by 13.4% and mean absolute error by 14.4%, while improving the coefficient of determination R2 by 0.8%, compared to a baseline LSTM using only historical power data. The findings confirm that incorporating key physical drivers and optimizing the model structure can significantly enhance forecast accuracy.

▷ SunB07-28

Probabilistic Random Forest-Driven Fault Diagnosis for Wastewater Treatment Process

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Wastewater treatment process (WWTP) is operated with multiple conditions, so as to satisfy the discharge requirements. With the changes of operation conditions, the faults are inevitable, even the unknown faults. Aimed at this problem, a probabilistic random forest-driven fault diagnosis (PRFDFD) method is proposed in this paper. Firstly, a novel framework for fault diagnosis is designed, where the decoder of the variational autoencoder is replaced with a PRF classifier to timely optimize the selected features. Second, a fault diagnosis strategy, based on PRF, is proposed. By computing the Shannon entropy of the output probability vector of PRF, the proposed method enables to quantify the classification uncertainty and calculate the score vector. Finally, a hybrid decision logic that integrates entropy with extreme value theory (EVT) is designed, where EVT is applied to estimate the probability of unknown faults. To validate the effectiveness of the proposed method, the data from real WWTP are used. The results show that the proposed PRFDFD method can not only accurately classify the known faults but also effectively diagnose the unknown faults.

▷ SunB07-29

Reinforcement Learning for Robust Parameterized Gait Control of Two-Wheeled Bipedal Robots

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Abstract: Two-wheeled bipedal robots combine the efficiency of wheeled locomotion on flat ground with the versatility of legged motion over obstacles. Yet their high-dimensional structural parameters and strongly coupled dynamics make conventional, model-intensive design and control pipelines costly and sensitive to modeling errors, which hinders stable and near-optimal solutions in a large design space. This paper proposes a model-free reinforcement learning framework that trains stable gait policies in simulation and transfers them to a real two-wheeled bipedal robot. To mitigate the sim-to-real gap, domain randomization is adopted to improve robustness to dynamics variations. Experiments show that the learned policy achieves multiple dynamic gait behaviors and provides better stability than conventional controllers and prior learning-based methods.

▷ SunB07-30

Masked Structural Decomposition with Time Frequency Consistency for Unsupervised Multivariate Time Series Anomaly Detection

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Anomalies in time series data often serve as early indicators of potential equipment failures or systemic risks. Consequently, the development of timely and reliable anomaly detection methods is critical for ensuring the operational safety of industrial systems. However, existing unsupervised time series anomaly detection methods continue to face two primary challenges: (1) Concept drift: Real-world time series typically exhibit deterministic structures such as trends, seasonality, and cyclical patterns. When these components are modeled indiscriminately within an end-to-end framework, the training process tends to "average" them out, leading to over-smoothing of normal patterns and consequently reducing anomaly separability. (2) Training bias: Normal data are often contaminated with noise or even latent anomalies. During optimization, models may inadvertently learn such contaminated instances as normal patterns. To address these issues, we propose a time-frequency fusion framework for time series anomaly detection. Specifically, the proposed method first employs a learnable decomposition module to separate the trend and residual components in the time domain, which are then modeled separately using Mamba architectures to preserve the structural details of normal sequences. Simultaneously, a targeted masking strategy for potential anomalies is introduced during the training phase to mitigate

the influence of contaminated samples on parameter updates. Furthermore, a frequency-domain branch is incorporated to capture periodic and frequency-related variations. Time-domain and frequency-domain features are subsequently integrated via a Mamba-based fusion module, and the model is jointly optimized using a reconstruction loss and a KL divergence consistency loss. Experimental results on two real-world datasets demonstrate that the proposed method achieves superior detection performance compared to baseline methods, exhibiting strong robustness and generalization capability across different datasets.

▷ SunB07-31

Robust Invariant Sets for Switched Linear Systems with Persistent Dwell-Time Constraints and Bounded Disturbances

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This paper studies the computation of robust invariant sets for discrete-time linear switched systems subject to persistent dwell-time (PDT) constraints and bounded additive disturbances. Both unconstrained and polyhedrally state-constrained cases are considered. By exploiting the structure of PDT switching sequences, existence conditions of PDT robust invariant sets are established. A forward reachable-set–based method and a backward reachable-set–based method are proposed to approximate the robust invariant sets for the unconstrained and constrained cases, respectively. Finite-step convergence and basic properties of the resulting sets are analyzed. Numerical examples demonstrate the effectiveness of the proposed approach.

▷ SunB07-32

Adaptive Iterative Learning Control for A Class of Constrained Nonlinear Systems with Unknown Control Directions and Input Saturation

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This paper studies the adaptive iterative learning control problem for a class of constrained nonlinear systems with unknown control gains. To address the input constraint, an appropriate auxiliary system is introduced, and its states are used in the design of the control strategy. In the proposed strategy, adaptive estimation mechanisms are applied to compensate for the effects induced by input saturation and unknown non-invertible control gain matrices. Finally, the convergence of the proposed control strategy is analyzed by composite energy function, and its effectiveness is verified through a numerical simulation.

▷ SunB07-33

Multi-Target Allocation Based Reinforcement Learning for Cooperative Defense of USVs

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For scenarios involving unmanned surface vehicles (USVs) defending against targets, an effective method based on multi-agent reinforcement learning (MARL) is proposed. This approach facilitates cooperative defense by USVs. The state space, action space, and reward function for the collaborative USVs are explicitly defined. An intrusion target allocation mechanism is integrated to assign responsibilities. Simulation experiments compare this framework with conventional MARL approaches, analyzing the performance of USVs cooperative defense targets. The method demonstrates advantages in mission success rates. This research provides a reference guide for practical algorithm deployment.

▷ SunB07-34

Optimal Control of Mean-field Stochastic Systems with Wiener and Poisson Noises: A Data-driven Policy Iteration Approach

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This paper addresses the linear quadratic optimal control problem for mean-field stochastic systems with unknown dynamics. A deterministic system incorporating both Wiener and Poisson noises is first constructed, and the relationship characterizing its trajectory and the matrices to be solved is derived. Subsequently, a data-driven policy iteration algorithm is proposed based on this system to solve the optimal control problem. The convergence of the algorithm is established by demonstrating its equivalence to an existing policy iteration method. Ultimately, a financial case is presented to illustrate the validity of the proposed approach.

▷ SunB07-35

Observer-Based Prescribed-Time Consensus Tracking for Nonlinear Multi-Agent Systems

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In this work, the prescribed-time leader-follower consensus tracking problem for nonlinear multi-agent systems is investigated. A novel hybrid time-varying gain distributed observer is proposed for a class of second-order nonlinear systems under Lipschitz conditions. Subsequently, a nonsingular prescribed-time sliding surface and a corresponding distributed tracking controller are designed. Precise consensus tracking of the closed-loop system states within the prescribed time is guaranteed by the proposed control scheme, while numerical implementation issues associated with unbounded time-varying gains are avoided via a gain switching mechanism. The prescribed-time stability of both estimation and tracking errors, along with the uniform boundedness of all control signals, is confirmed through rigorous Lyapunov analysis. Finally, the effectiveness and superiority of the proposed method are demonstrated via numerical simulations.

▷ SunB07-36

Heterogeneous Ensemble Learning with Stacking Framework for Accurate Prediction of Tobacco Sheet Proportion Using Chemical Component Data

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Qian, Qifu	Yunnan China Tobacco Industry Co., Ltd
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Wang, Luoping	Raw Materials Center of China Tobacco Yunnan Industrial Co., Ltd.,
Tang, Yuyang	Process Quality Section
Yang, Shuhan	Kunming Cigarette Factory,HongyunHonghe Tobacco(Group) Co., Ltd., Kunming 650231, China

The proportion of tobacco sheet in cigarette blends is a critical process parameter that affects product quality stability. Traditional manual inspection methods suffer from low efficiency and subjective bias, while quantitative prediction models for this specific task remain underexplored. To address this gap, this study proposes a high-precision prediction model based on ensemble learning. Using 70 chemical component indicators as input features, we constructed a heterogeneous base learner ensemble comprising Partial Least Squares (PLS), XGBoost, and Random Forest (RF). We systematically compared the performance of Stacking and Blending integration frameworks combined with Ridge, Lasso, and PLS meta-learners, employing Bayesian optimization for automated hyperparameter tuning. Experimental results demonstrate that the Stacking + Ridge model achieved optimal performance on the independent test set (R^2= 0.9782, RMSE = 0.51, MAE = 0.40), representing an improvement of 0.0188 in R^2over the best single model (PLS), with significantly superior generalization stability compared to other models. The Stacking framework leverages K-fold cross-validation to fully exploit information from small samples, effectively mitigating validation set partitioning bias. The Ridge meta-learner, through L2 regularization, precisely controls the strong collinearity among base model predictions, retaining information from all base models while suppressing overfitting risks. This study not only validates the effectiveness and superiority of heterogeneous ensemble learning for small-sample, high-dimensional, strongly correlated chemical data modeling, but also provides a reproducible and highly robust methodological foundation for accurate prediction of tobacco sheet proportion and process quality monitoring, offering valuable insights for intelligent modeling of key parameters in process industries.

▷ SunB07-37

Detection of Replay Attacks in Networked Control Systems Based on Segmented Weighted Smoothing Watermark

Wang, Yuxing	North China Univ. of Tech.

This paper investigates the challenges faced by Networked Control Sys-

tems (NCSs) under replay attacks. To address the difficulties in identifying attack signals and the resulting decline in system stability, a detection scheme based on a segmented weighted smoothing watermark is proposed. By reshaping the original watermark into low-frequency continuous components, the proposed method generates a smoother excitation signal. This facilitates the monitoring of replay-induced residual variations and improves the detectability of replay attacks. Performance analysis shows that the proposed scheme can reduce control performance degradation and additional energy consumption while maintaining satisfactory detection performance. Finally, simulation results validate the effectiveness of the proposed method in detecting replay attacks.

▷ SunB07-38

Jointly Optimizing Reconstruction and Prediction for Unsupervised UAV Anomaly Detection

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Ma, Bo	Aviation Industry Chengdu Aircraft Design Inst.
Ni, Jing	Aviation Industry Chengdu Aircraft Design Inst.
Wang, Wenzong	College of Electrical Engineering, Sichuan Univ.
Wang, Jianyu	Sichuan Univ.

Unsupervised anomaly detection for Unmanned Aerial Vehicle (UAV) flight data is critical for ensuring mission safety. However, existing data-driven methods typically treat spatial dependency and temporal evolution as isolated tasks. Reconstruction-based models often suffer from over-generalization, while prediction-based approaches are sensitive to environmental noise. To address these limitations, this paper proposes a Spatio-Temporal Reconstruction-Prediction Network (ST-RPN), a unified framework that jointly optimizes reconstruction and prediction objectives. ST-RPN utilizes a shared probabilistic encoder to map multivariate sensor data into a compact latent manifold. This latent representation is then processed by two parallel branches: a spatial decoder that enforces global topological consistency through signal reconstruction, and an LSTM-based predictor that captures local evolutionary trends. By minimizing a composite loss function, the model learns robust representations that are sensitive to both point anomalies and sequential deviations. Experiments on the real-world ALFA dataset demonstrate the superiority of the proposed method.

▷ SunB07-39

FPGA-Based Radar PDW Data Compression Algorithm Design

Zhang, Hanliang	Univ. of Electronic Sci. & Tech. of China
Wang, Haifeng	Aviation Industry Corporation of China, LTD
Wang, Yang	Aviation Industry Corporation of China, LTD
Xie, Feng	Aviation Industry Corporation of China, LTD

Various onboard aircraft systems continuously generate Pulse Description Words (PDWs) during flight. PDWs are crucial for determining the flight status of aircraft and making accurate decisions, imposing strict storage requirements. The generation of PDWs is characterized by high rates and density, with real-time signal processing systems imposing strict timeliness requirements for data handling. Furthermore, the communication bandwidth and storage resources of onboard systems are limited. Therefore, this paper presents an optimized compression algorithm to meet the specific storage needs of PDW data. The method is based on the lightweight LZ77 com-pression algorithm, which employs adaptive packetization and a sliding window mechanism, combined with multi-mode parallel encoding technology of FPGA. It optimizes PDW data characteristics by improving compression efficiency and significantly reducing time complexity, thereby alleviating pressure on data transmission and storage in airborne environments. Through compression rate tests, data throughput tests, and other analyses, the proposed method effectively reduces PDW data size and meets real-time requirements, significantly alleviating pressure on air-borne data transmission and storage.

▷ SunB07-40

Multi-Scale Pooling Enhanced Vision Transformer for Object Recognition on Small-Scale Datasets

Wang, Tete	Northeastern Univ.
Jiang, Lin	Univ. of Northeastern
Wen, Zhitao	Northeastern Univ.
Xu, Hang	Northeastern Univ.

Abstract: The Vision Transformer (ViT) has become a mainstream architecture in image recognition due to its superior capability in modeling global contextual information. However, ViT still has limitations in feature extraction when trained on small-scale datasets. While ViT excels at global feature extraction, it exhibits limited sensitivity to local details. In contrast, although multi-scale pooling operations are advantages for extracting local features, they struggle to model global contexts effectively. To address these challenges, this paper proposes a novel Multi-Scale Pooling Enhanced Vision Transformer architecture (MSP-ViT) for image recognition. Specifically, a multi-scale pooling module is designed to capture local features, compensating for ViT' s inherent deficiency in local feature extraction. Furthermore, a multi-branch approach is adopted to reduce parameters and floating-point operations (FLOPs), while a multi-kernel parallel strategy is utilized to enrich the representation of local features.Experimental results demonstrate that the proposed method significantly boosts the recognition performance of ViT on the target datasets, achieving an accuracy of 95.16% on CIFAR10.

▷ SunB07-41

Time Synchronization and Mapping of Multimodal Data in Weak GPS Environments

Wang, Ziming	Beijing Univ. of Chemical Tech.
Zhu, Haijiang	Beijing Univ. of Chemical Tech.
Zhao, Lina	Beijing Univ. of Chemical Tech.

Multimodal data fusion has found extensive applications in industrial vision inspection, cultural relic restoration, and urban reconstruction. However, achieving accurate synchronized multimodal data acquisition in weak GPS signal environments remains a critical challenge. To address this, we propose an improved hardware-software co-operative multimodal data synchronization method for time synchronization and mapping under weak GPS signal conditions. This method first employs a lightweight STM32F103 microcontroller as an external clock source for sensors, simulating GPRMC timing signals and external trigger signals via serial communication. Combined with software synchronization, it achieves synchronized triggering and timestamp alignment for sensors like lidar and cameras, fundamentally aligning the clocks of multiple sensors to realize time synchronization of multimodal data. Finally, the method is applied to a handheld multimodal data scanning system incorporating lidar, cameras, and other sensors. To validate its effectiveness, we utilize tightly coupled point cloud, image, and IMU multimodal data to construct a color point cloud map. Experimental results on both self-created and public datasets demonstrate the feasibility and efficiency of the proposed method.

▷ SunB07-42

A Fast Root Cause Diagnosis Method for Industry Process Based on Kernel Ridge Regression Granger

Chen, Xu	Shanghai Univ.
Wang, Jian-Guo	Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Li, Yong	Shanghai Univ.
Teng, Jia Liang	Shang Hai Univ.
Chen, Rui	Shang Hai Univ.
Yao, Yuan	National Tsing Hua Univ.
Li, Chunbiao	Baoshan Iron & Steel Co., Ltd

To address the challenges of high real-time requirements in industrial fault diagnosis, this paper proposes a fast root cause diagnosis method based on Kernel Ridge Regression Granger Causality (KRRGC). Traditional Granger causality methods rely on linear regression, which fails to capture nonlinear variable relationships and performs poorly in some nonlinear scenarios. The innovative KRRGC replaced conventional linear Granger tests, in which kernel ridge regression maps raw data to a high-dimensional space via a Gaussian kernel to effectively capture nonlinear causal relationships, while ridge regression with L2 regularization avoids overfitting. To ensure valid significance testing, a multi-causality algorithm was designed to split datasets into independent subsets, and raw data was segmented into a combined matrix for repeated causal inference, reducing false causality and enhancing result consistency. The proposed method was validated by numerical simulations and the Tennessee Eastman process, which can accurately identify fault root cause and has a runtime only 50% of that of comparative models, proving to be an efficient and accurate solution for complex industrial scenarios.

▷ SunB07-43

Nonlinear Fault Root Cause Diagnosis Method Based on LSTM-AVAR Granger Causality Analysis

Li, Yong	Shanghai Univ.
Wang, Jian-Guo	Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Chen, Xu	Shanghai Univ.
Lv, Yuxuan	Shanghai Univ.

Chen, Rui — Shang Hai Univ.
Kang, Jia-Lin — National Chung Cheng Univ.
Liao, Yan — Baoshan Iron & Steel Co. Ltd

odern industrial processes are characterized by large scale and a high degree of automation. Traditional Granger causality analysis, based on linear vector autoregressive models, faces limitations in handling nonlinear relationships and long time lags commonly present in industrial processes. To address these challenges, this paper proposes a nonlinear root cause diagnosis method based on Long Short Term Memory-Additive Vector Autoregressive (LSTM-AVAR) Granger causality. The method utilizes LSTM networks to capture complex nonlinear and long-lagged dependencies, while an additive model is introduced to enhance interpretability by decomposing the influence of multiple variables. The proposed approach is validated through numerical simulations and the industrial case study: the Tennessee Eastman process. Experimental results demonstrate that the LSTM-AVAR-based method not only accurately identifies root cause variable under nonlinear and long-lag conditions but also provides interpretable causal graphs consistent with process mechanisms, outperforming conventional Granger models.

▷ SunB07-44

Fault Root Cause Diagnosis Based on the Symbolic Characteristics of SENN Granger

Yang, Shixing — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Yao, Zan — Shanghai Univ.
Yao, Wanli — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Kang, Jia-Lin — National Chung Cheng Univ.
Li, Chunbiao — Baoshan Iron & Steel Co., Ltd

Root cause diagnosis algorithms in industrial processes often focus on extracting causal relationships from multiple failure variables, but neglect the sign of these causal relationships, which makes it difficult to provide engineers with more valuable decision-making information. This paper presents a unified approach to fault root cause diagnosis in industrial processes using Granger causality analysis and symbolic feature extraction via Self-Explaining Neural Networks (SENN). The proposed method integrates Granger causality with the SENN framework to provide an interpretable and scalable solution for fault diagnosis. By combining causal discovery with sign analysis, this method can precisely identify their causal relationships and signs, offering deeper insights into the behavior of industrial systems under fault conditions. The SENN Granger model is validated using synthetic data and applied to industrial processes, including the Tennessee Eastman process and the Three Phase Flow process, demonstrating accuracy in root cause diagnosis and causal interpretation.

▷ SunB07-45

Fault Root Cause Diagnosis for Industrial Process Using Echo State Network-Based Granger Causality

Yao, Zan — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Zhu, Jianguo — Shanghai Univ.
Chen, Zhuang — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Yao, Yuan — National Tsing Hua Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

Root cause diagnosis in large-scale industrial processes is challenging due to strong nonlinearity, complex variable coupling, and fault propagation effects. Classical Granger causality relies on linear autoregressive models and often fails to identify causal relationships in nonlinear dynamic systems. To address this issue, this paper proposes an echo state network (ESN)-based nonlinear Granger causality framework. By integrating ESN into the Granger causality framework, nonlinear temporal dependencies among process variables can be effectively captured with low computational cost. To ensure statistical reliability, the Wilcoxon signed-rank test is adopted to replace the conventional F-test. In addition, a block-diagonal reservoir structure is introduced to enhance interpretability and reduce spurious causality caused by strong variable coupling. Based on the inferred causal relationships, a direct causal graph is constructed to identify the fault root variable and propagation paths. The numerical simulation and the Tennessee Eastman Process case study demonstrate that the proposed ESN-based Granger method accurately identifies nonlinear causalities and root causes, outperforming the conventional Granger causality method.

▷ SunB07-46

A Nonlinear Root Cause Diagnosis Method Based on Deep Autoregressive Granger Analysis

Zhu, Jianguo — Shanghai Univ.
Wang, Jian-Guo — Shanghai Key Lab of Power Station Automation Tech., Shanghai Univ.
Yang, Shixing — Shanghai Univ.
Xue, Yuzhou — Shanghai Univ.
Chen, Rui — Shang Hai Univ.
Yao, Yuan — National Tsing Hua Univ.
Chen, He-Lin — Baoshan Iron & Steel Co. Ltd

In industrial processes, fault diagnosis is a core technology for ensuring the stable operation of industrial systems. Accurate identification of causal relationships between variables is crucial for root cause localization. Conventional Granger causality analysis can only capture linear causal interactions, making them unsuitable for the complex nonlinear causal relationships in industrial processes. This paper proposes a nonlinear Granger fault root cause diagnosis method based on the Deep Autoregressive Model (DeepAR). This method combines the time series probabilistic prediction model with the Granger analysis, leveraging DeepAR to model uncertainty and to learn similar time-series trends. Experiments using numerical simulation and the Tennessee Eastman process demonstrate that the proposed method can accurately identify the fault root cause variable and detect causal relationships consistent with the mechanistic analysis.

SunC01 13:30–15:30 Yangguang Hall

Invited Session: Data-Driven Adaptive and Learning Control and Applications for Unmanned Systems (I)

Chair: Yu, Wei — Peking Univ.
Co-Chair: Zhu, Panpan — Henan Univ.

▶ SunC01-1 13:30–13:50

A Multiclass Prediction Model for Estrogen Receptor Status in Breast Cancer Based on CT Radiomics and Clinical Features

Zeng, Jianfei — Southwest Jiaotong Univ.
Xu, Lulu — The Affiliated Hospital, Southwest Medical Univ.
Huang, Deqing — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.

Breast cancer is a highly heterogeneous disease, and accurate preoperative stratification of estrogen receptor (ER) status—including ER-positive, ER-low (1%–10%), and ER-negative subtypes—is crucial for personalized treatment planning. While conventional subtyping relies on invasive immunohistochemistry, we propose a non-invasive approach by developing an adaptive weighted ensemble model that integrates radiomic features from routinely acquired spectral detector computed tomography (SDCT) scans with key clinical variables. In a cohort of 370 patients with invasive breast cancer, our multimodal model achieved a micro-averaged AUC of 0.88 (95% CI: 0.813–0.909) on an independent test set for three-class ER status prediction. Decision curve analysis demonstrated significant clinical net benefit across a range of threshold probabilities, particularly for the clinically ambiguous ER-low subgroup. The fusion of CT radiomics and clinical data outperformed unimodal strategies, highlighting the value of multimodal integration for precision oncology. This framework offers a practical, non-invasive tool to support individualized therapeutic decisions using standard-of-care chest CT imaging.

▶ SunC01-2 13:50–14:10

An Improved Neural Field-Based Coverage Path Planning Algorithm for Quadruped Robots

Fan, Yinbing — Southwest Jiaotong Univ.
Cheng, Junqiang — Europe-Aisa Hi-tech & Digital Tech. Company Limited
Wei, Shuang — Southwest Jiaotong Univ.
Zhang, Muhua — Southwest Jiaotong Univ.
Qin, Na — Southwest Jiaotong Univ.
Huang, Deqing — Southwest Jiaotong Univ.

Coverage path planning (CPP) is a fundamental capability for mobile robots performing tasks such as cleaning, inspection, and environmental monitoring in indoor environments. In cluttered and partially known spaces, existing online CPP methods, including decomposition-based and frontier-based approaches, often rely on global planning, heuristic rules, or repeated replanning, which limits their robustness, efficiency,

and scalability in real-world applications.To overcome these limitations, this paper proposes an obstacle-aware neural field–based coverage path planning framework (NFCPP) that formulates the coverage process as a discrete neural dynamical system defined over a coarse-grained ROS costmap. By constructing a unified neural activation field that integrates exploration incentives, spatially distributed obstacle inhibition, and directional smoothness, the proposed framework enables coverage behavior to emerge through local interactions without explicit environment decomposition or frontier extraction.To improve navigation safety and robustness in narrow and cluttered environments, an obstacle-aware inhibitory potential with exponential spatial decay is introduced to explicitly encode obstacle geometry within the neural field. From a theoretical perspective, the resulting coverage dynamics admit a Lyapunov function whose monotonic decrease guarantees deadlock-free convergence and complete coverage of all reachable free cells. In addition, the directional selection mechanism admits an information-theoretic interpretation, providing a principled explanation for the emergent frontier-like exploration behavior observed during execution.Real-world experiments conducted on a quadruped robot platform demonstrate that the proposed NFCPP method achieves faster coverage completion, lower path redundancy, and improved deadlock avoidance compared with representative baseline planners under identical sensing and computational conditions. These results validate the effectiveness and practicality of the proposed neural-field-based framework for real-time robotic coverage applications.

▶ SunC01-3 14:10–14:30

Adaptive Iterative Learning Control for Non-Strictly Repeatable Second-Order Nonlinear Systems Subject to Deception Attacks

Chen, Qingfeng — Sun Yat-Sen Univ.,
Li, Xiao-Dong — Sun Yat-sen Univ.
Li, Xuefang — Sun Yat-sen Univ.

This paper studies the adaptive iterative learning control (AILC) problem for non-strictly repeatable second-order nonlinear systems subject to deception attacks. Sensor data corruption introduces system uncertainties and unknown control directions, while iteration-varying trial lengths violate the strict repeatability assumption. To address these issues, an AILC scheme with adaptive estimation is developed to compensate for attack-induced uncertainties, and piecewise parametric update laws are designed to handle variable trial lengths. Furthermore, an adjustable parameter is introduced to improve tracking accuracy. Under the framework of composite energy function, the convergence of the tracking error is rigorously guaranteed. Simulation results demonstrate the effectiveness of the proposed method.

▶ SunC01-4 14:30–14:50

Kalman Filter-Based Event-Triggered Iterative Learning Control for Nonlinear Multi-Agent Systems

Peng, Liu — Huaqiao Univ.
Fu, Wen-Yuan — Huaqiao Univesity

This paper investigates cooperative finite-horizon tracking for nonlinear multi-agent systems that repeatedly perform the same task in the presence of stochastic disturbances and limited communication resources. A data-driven Kalman-filter-assisted event-triggered iterative learning control (KF-ET-ILC) scheme is developed, in which full-format dynamic linearization constructs a linear time-varying input–output representation directly from measured data, while a local Kalman filter provides noise-attenuated state estimates together with the corresponding output estimates to support trial-to-trial learning updates. To reduce communication and update burden, a dual-mode event-triggering rule is incorporated into the distributed learning law and integrated with the consensus objective. Mean-square convergence of the learning process is established. Simulations show that KF-ET-ILC achieves higher tracking accuracy with fewer triggering events than representative fixed-trigger ILC methods.

▶ SunC01-5 14:50–15:10

PID-MFAILC Hybrid Speed Regulation for the Rotary Mechanism of Hydraulic Bolt Drills

Zong, Lubin — Henan Polytechnic Univ.
Liang, Jiaqi — Henan Polytechnic Univ.
Bu, Xuhui — Henan Polytechnic Univ.
Zhang, Yan — Henan Polytechnic Univ.

The drilling speed control of the rotary system in bolt drilling rigs is crucial for enhancing coal mine roadway tunneling efficiency. Bolt drilling operations exhibit inherent repetitiveness, and the drilling process often encounters complex working conditions such as sudden changes in surrounding rock. However, the system's electro-hydraulic servo mechanism possesses strong nonlinearity, time-varying parameters, and multi-source disturbance coupling, rendering high-precision control challenging to achieve. Aiming at the limitations of traditional PID control and model-free adaptive iterative learning control (MFAILC), this paper proposes a hybrid control strategy integrating PID with MFAILC. Based on the compact-form dynamic linearization (CFDL) approach, the strategy transforms the nonlinear electro-hydraulic system into a linear data-based model. Subsequently, a dual-domain feedback and learning control mechanism based on iterative memory learning and real-time feedback regulation is designed. Co-simulation results using MATLAB and AMESim verify that the proposed scheme effectively overcomes the limitations of single algorithms, exhibits excellent adaptability to internal and external system disturbances, and significantly enhances the rapidity, stability, and robustness of drilling speed tracking for bolt drilling rigs under complex operating conditions.

▶ SunC01-6 15:10–15:30

Output-Aware Latent Distribution Learning Using Variational Autoencoder for Industrial Soft Sensor

Song, Xiaolu — China Nuclear Power Engineering Co. Ltd
Zhang, Chuanwang — China Nuclear Power Engineering Co., Ltd
Zhang, Chuntao — Nettrix Information Industry (Beijing) Co., Ltd
Yu, Tao — China Nuclear Power Engineering Co., Ltd
Zhu, Panpan — Henan Univ.

Modern complex industrial processes are typically characterized by strong nonlinearity, high-dimensional coupling, and fluctuations of operating conditions, which impose higher requirements on the capability of feature representation and predictive stability of soft sensors. The Variational Autoencoder (VAE) is capable of learning latent variable distributions through probabilistic modeling and has demonstrated strong representation ability in industrial process modeling. However, the unsupervised learning paradigm of conventional VAE makes it difficult to ensure a strong correlation between latent variables and key output variables, thus limiting their predictive performance in soft sensing tasks. To address this issue, this paper proposes an output-aware latent distribution variational autoencoder (OLD-VAE). In the latent variable reparameterization process of the VAE, an output-driven distribution weighting mechanism is introduced, and an output-constrained regularization term is incorporated into the training objective to guide the learning of the parameters of the latent Gaussian distributions. By reshaping the latent distributions in an output-aware manner, the proposed model is able to automatically capture the relative importance of different latent variables to the output variable while preserving the expressive capability of the latent space, thereby yielding more predictive and discriminative latent representations. The effectiveness of the proposed method is validated using real industrial operating data collected from a reaction unit in a nuclear fuel reprocessing plant. Experimental results demonstrate that, compared with conventional soft-sensing methods, the proposed approach achieves significant improvements in reactor temperature prediction accuracy and overall modeling performance, thereby confirming its effectiveness and potential engineering applicability for temperature soft-sensing modeling in complex high-temperature nuclear chemical processes.

SunC02 13:30–15:30 Changle Hall

Invited Session: Intelligent Control and Cooperative Strategies for Complex Systems

Chair: Zhang, Faxiang — Kunming Univ. of Sci. & Tech.
Co-Chair: Zhang, Xiufeng — Kunming Univ. of Sci. & Tech.

▶ SunC02-1 13:30–13:50

Kinematic Error Analysis and Compensation for Improving Surgical Robot Registration Performance

Yang, Senyuan — Kunming Univ. of Sci. & Tech.
Gao, Guanbin — Kunming Univ. of Sci. & Tech.
Li, Yuan — Kunming Univ. of Sci. & Tech.
Li, Yingjie — Kunming Univ. of Sci. & Tech.
Hou, Cheng — Kunming Univ. of Sci. & Tech.

Surgical robot registration is critical for high-precision robot-assisted surgery (RAS). However, the impact of the robot's intrinsic kinematic errors on registration accuracy remains insufficiently quantified. This paper presents a kinematic error analysis and compensation method to improve surgical robot registration performance. First, a kinematic model of a UR5 robot was established based on the Modified Denavit-Hartenberg (MD-H) method. A least-squares parameter identification method was then employed to calibrate the kinematic parameters, which reduced the

maximum absolute positioning error from 3.406 mm to 0.371 mm, an improvement of approximately 89%. Subsequently, comparative registration experiments were conducted to evaluate the impact of the compensation. The results demonstrate that compensating for kinematic errors led to a 19.6% improvement in registration accuracy. These findings confirm that intrinsic kinematic deviations are a significant source of registration errors and that the proposed compensation strategy effectively enhances the overall precision of the surgical system.

▶ SunC02-2 13:50–14:10

Fault-Tolerant Control of Reconfigurable Flight Arrays with Suspended Payloads

Li, Tianyun	Kunming Univ. of Sci. & Tech.
Yang, Chunxi	Kunming Univ. of Sci. & Tech.
Zhang, Xiufeng	Kunming Univ. of Sci. & Tech.
Sun, Hongwei	Kunming Univ. of Sci. & Tech.
Zhang, Zexiang	Kunming Univ. of Sci. & Tech.

This paper investigates the control issues of a modular reconfigurable flight array (MRFA) transporting a cablesuspended payload, aiming to ensure safe and stable flight under various disturbances and actuator faults. A hierarchical cascade control framework is proposed by decomposing the overall control task into attitude regulation, translational motion control, and payload swing suppression. A sliding-mode-based fault-tolerant controller is first designed for attitude dynamics to accommodate actuator faults and ensure robust stabilization. For translational motion, a super-twisting sliding-mode control law is developed to enhance trajectory tracking performance in the presence of external disturbances. In addition, a nonlinear anti-swing control strategy is introduced to effectively suppress payload oscillations. Then Lyapunov-based analysis guarantees the stability of the closed-loop system. Extensive simulations on an eight-module flight array demonstrate accurate trajectory tracking and significant payload swing suppression under both fault-free conditions and partial motor failure scenarios.

▶ SunC02-3 14:10–14:30

RUL Prediction of Spent Electrolyte Pumps Using A Preference-Guided Composite Loss

Wang, Chunlai	Kunming Univ. of Sci. & Tech.
Yang, Chunxi	Kunming Univ. of Sci. & Tech.
Zhang, Xiufeng	Kunming Univ. of Sci. & Tech.
Zhang, Yangjie	Kunming Univ. of Sci. & Tech.
Zhang, Faxiang	Kunming Univ. of Sci. & Tech.

To address nonuniform sampling and safety-oriented maintenance preferences in industrial pump monitoring, this paper proposes a preference-guided remaining useful life (RUL) prediction framework based on a composite loss function. A irregular-time long short-term memory (IT-LSTM) network is employed to model multivariate degradation sequences under irregular sampling by explicitly incorporating actual time intervals. A composite loss is then constructed by integrating accuracy, relative error robustness, and asymmetric preference penalties, together with a strategy-oriented performance metric (SOPM) to characterize safety-economy trade-offs. The loss weight selection is formulated as a multi-objective optimization problem and solved via Pareto-front analysis. Validation on real operational data from multiple spent electrolyte circulation pumps demonstrates that the proposed method effectively suppresses RUL overestimation while maintaining competitive predictive accuracy, making it suitable for safety-critical maintenance planning.

▶ SunC02-4 14:30–14:50

Kinematic Calibration of Industrial Robots Based on A Q-Learning Enhanced Coati Optimization Algorithm

Shi, Junjie	Kunming Univ. of Sci. & Tech.
Liu, Fei	Kunming Univ. of Sci. & Tech.
Gao, Guanbin	Kunming Univ. of Sci. & Tech.
Zhang, Qinglong	Kunming Univ. of Sci. & Tech.

Kinematic calibration is essential for enhancing the absolute positioning accuracy of industrial robots, with metaheuristic algorithms being widely adopted for parameter identification. As a novel metaheuristic algorithm, the Coati Optimization Algorithm (COA) exhibits powerful global search capability and fast convergence through its bionic behavior mechanism. However, the fixed strategy of COA can't guarantee the convergence speed and global optimality in the identification process at the same time, which limits the efficiency and accuracy of kinematic calibration. This paper proposes a Q-learning enhanced COA (QL-COA) to address this limitation by designing an adaptive adjustment mechanism. By partitioning the search process into four distinct strategies and five iterative states, a Q-learning agent dynamically selects the optimal strategy to balance exploration and exploitation. The experimental verification on a 6-degree-of-freedom industrial robot shows that the maximum positioning error is reduced from 2.361 mm to 0.324 mm with a calculation time of 62.57 s. Compared with particle swarm optimization (PSO) and COA, QL-COA improves the positioning accuracy by 27.2% and 16.3%, and accelerates convergence by 74.8% and 57.3%.

▶ SunC02-5 14:50–15:10

Optimal Observer Design for Anion Exchange Membrane Electrolyzers Using Approximate Dynamic Programming

Yang, Lijing	Kunming Univ. of Sci. & Tech.
Li, Siyan	Kunming Univ. of Sci. & Tech.
Xing, Yashan	Kunming Univ. of Sci. & Tech.
Na, Jing	Kunming Univ. of Sci. & Tech.

Accurate real-time information of hydrogen and oxygen partial pressure is critical for the efficiency, stability, and safety of anion exchange membrane water electrolyzers (AEMWEs), as it helps prevent dangerous gas mixing. However, directly measuring these pressures is difficult and expensive. To solve this problem, this paper proposes an optimal observer utilizing approximate dynamic programming (ADP) to online estimation partial pressures in AEMWEs. First, a model of the AEMWE suitable for observer design is developed. Then, an online optimal observer using ADP is designed to enable real-time monitoring of partial pressures. Based on the dual relationship between optimal control and optimal observer design, we introduce a cost function with a discount factor and employ a critic neural network (NN) to approximate the optimal cost value. To solve the Hamilton-Jacobi-Bellman (HJB) equation online, the NN weights are updated via an adaptive law. Finally, simulation results validate the effectiveness of the proposed optimal observer.

▶ SunC02-6 15:10–15:30

An Industrial Edge-Intelligence AI Agent Based on Agentic RAG Deep Research Framework: Construction and Application

Wang, Yanhong	China Unicom Digital Tech. Co
Yu, Rui	China Unicom Digital Tech. Co
Lu, Yun	China Unicom Digital Tech. Co
Liu, Yangyu	China Unicom Digital Tech. Co
Nie, Jianlong	China Unicom Digital Tech. Co
Yu, Qianqian	China Unicom Digital Tech. Co

Aiming at the industrial edge-side perception and control problems such as inefficient access to massive devices, complex and diverse communication protocols, and complex and variable task requirements in the industrial internet of things (IIoT), as well as the demand for intelligent upgrading, this paper proposes a construction method of an industrial edge intelligent agent application based on the agentic retrieval-augmented generation (RAG) deep research framework. This method achieves end-to-end structured output from user natural language input to industrial edge-side workflows. To address the "hallucination" issue of large language models (LLMs) in industrial vertical domains and enhance the comprehensive processing capabilities of traditional RAG technology, an agent knowledge base was constructed, comprising commonly used workflow templates and thing models for the industrial edge side. Building upon this knowledge base and agentic RAG deep research framework, the industrial edge agent leverages user requirement clarification, research brief generation, research-supervision loop, and final report generation to achieve a multi-iteration, closed-loop cycle of planning, execution, and reflection. The application case analysis of the industrial edge agent within China Unicom's GeWu Industrial Internet Platform demonstrates that the proposed agent can effectively reduce development time and improve the efficiency and accuracy of workflow construction on the industrial edge side.

SunC03 13:30–15:30 Langyue Hall

Invited Session: Data-Driven Fault Diagnosis, Monitoring, and Control for Industrial Systems

Chair: Li, Jitao Harbin Engineering Univ.

Co-Chair: Qi, Qingyuan Harbin Engineering Univ.

▶ SunC03-1 13:30–13:50

Cluster-Safe Oversampling Algorithm for Inter-Class and Intra-Class Imbalance

Ma, Yu	Beijing Univ. of Chemical Tech.
Wu, Haiyan	Beijing Univ. of Chemical Tech.
Wang, Jing	North China Univ. of Tech., China

In imbalanced classification, minority class scarcity biases learning toward the majority class, and this bias is amplified when the minority

class consists of sub-clusters with distinct densities and sizes. In such intra-class imbalance settings, sparse and small sub-clusters are prone to under-coverage, and minority class recognition becomes sensitive to data splits. Conventional oversampling methods mainly rely on local interpolation and may introduce unreliable synthetic samples in the presence of overlap or noise, which can distort the decision boundary. To address both the under-coverage of minority sub-clusters and the reliability of synthetic samples, we propose Cluster-Safe-Oversampling (C-SO), a clustering-guided oversampling method. First, CSO leverages SR-PCM-HDP (Self-Regulating Possibilistic C-means with High-Density Points) to characterize the sub-clusters of minority classes and allocates generation quotas to compensate for sparse small-scale sub-clusters. Second, different from the traditional method of performing linear interpolation only using samples and their neighboring samples, CSO designs a novel sample generation strategy: this strategy integrates individual samples, their neighboring samples, and cluster centers, and generates candidate samples within each sub-cluster. Finally, subsequent to sample generation, CSO implements a post-generation consistency filter with a quantile threshold to suppress the drift of candidate samples into the neighborhoods of majority classes. Experiments on 15 public imbalanced datasets with XGBoost, evaluated by F1-score and G-mean, demonstrate improved overall performance and a reduction in performance collapse cases. An ablation study further validates the effectiveness of the key components in CSO.

► SunC03-2 13:50–14:10

An LOF-Based Weighted ADASYN Algorithm for Minority Intra-Class Imbalance

Zhang, Xiaoyang	Beijing Univ. of Chemical Tech.
Wu, Haiyan	Beijing Univ. of Chemical Tech.
Wang, Jing	North China Univ. of Tech., China

Traditional oversampling techniques alleviate class imbalance by generating synthetic samples, yet they neglect local density heterogeneity and “the small disjuncts” problem within the minority class, thus compromising their performance on complex imbalanced data. To tackle this issue and resolve intra-class imbalance effectively, this paper proposes a novel oversampling algorithm named wLOF-ADASYN. This algorithm modifies the Local Outlier Factor (LOF) algorithm for minority class density assessment, fuses the modified LOF-based weights with ADASYN’s KNN distance-driven weights through a weighted multiplication strategy, and further optimizes the sample generation phase by imposing synthetic sample quantity constraints, extending interpolation-based neighbor selection to the entire sample space, and defining a rational random coefficient range to balance the novelty and reliability of generated samples. These optimized designs enable wLOF-ADASYN to prioritize minority class boundary samples and sparse small disjunct regions during oversampling. Extensive experiments on multiple benchmark datasets and a real-world credit card fraud detection task demonstrate that the proposed algorithm outperforms state-of-the-art traditional oversampling methods across various evaluation metrics.

► SunC03-3 14:10–14:30

System Identification of A Micro-UUV Using UAV-Based Vision and Kernel Methods

Pang, Ran	Harbin Engineering Univ.
Luo, Yiting	Harbin Engineering Univ.
Li, Rongtao	Harbin Engineering Univ.
Li, Renjie	Harbin Engineering Univ.
Lu, Mingyu	Harbin Engineering Univ.
Li, Jitao	Harbin Engineering Univ.
Qi, Qingyuan	Harbin Engineering Univ.

In this paper, a data-driven system identification framework is presented for a custom-made micro unmanned underwater vehicle (UUV). To obtain accurate data, outdoor lake experiments were conducted. An unmanned aerial vehicle (UAV) was used to record the UUV from above. The ground truth data were obtained using PWM navigation data and position information from visual trajectory tracking based on Kernelized Correlation Filters (KCF). Based on the collected dataset, a method using reproducing kernel Hilbert space (RKHS) is proposed. The identification task is formulated as a robust optimization problem. It is then transformed into a convex semidefinite programming (SDP) problem. To ensure the stability of the linear system, the stable spline (SS) kernel is applied. Finally, the eigensystem realization algorithm (ERA) is used to convert the impulse responses into a finite-dimensional linear state-space model. The linear dynamic and kinematic equations of the UUV are successfully derived and verified by the experiments.

► SunC03-4 14:30–14:50

Data-Enabled Policy Optimization for Optimal Trajectory Tracking of Unmanned Underwater Vehicles

Jiang, Yijing	Harbin Engineering Univ.
Qi, Qingyuan	Harbin Engineering Univ.

Precise trajectory tracking control is regarded as critical for the autonomous operation of unmanned underwater vehicles (UUVs). However, performance degradation is often observed in traditional model-based control strategies due to the difficulty in obtaining accurate hydrodynamic coefficients and the presence of complex environmental disturbances. To address this issue, a direct data-driven control method based on data-enabled policy optimization (DeePO) is adopted to solve the linear-quadratic (LQ) optimal trajectory tracking problem for UUVs. First, the nonlinear kinematic and dynamic models of the UUV are established and linearized around the operating point to obtain the error dynamics equation. Subsequently, the system behavior is characterized directly using pre-collected offline input-output data trajectories, by which the process of explicit system identification is bypassed. The LQ optimal control problem is then reformulated as a direct optimization of the control policy within the data space. Finally, the validity of the proposed scheme is verified through simulation. It is shown that high-precision trajectory tracking is achieved by the DeePO-based controller, and superior convergence smoothness is exhibited in comparison with indirect data-driven control strategies.

► SunC03-5 14:50–15:10

Multimodal Driven Fine-tuned Large Language Model for Intelligent Inspection of Power Supplies with Multi-Scale Feature Embedding

Zhao, Changwei	Anhui Xinli Power Tech. Co. Ltd
Chen, Huan	Anhui Xinli Power Tech. Co. Ltd
Fang, Zhenbang	Anhui Xinli Power Tech. Co. Ltd
Yang, Yang	Anhui Xinli Power Tech. Co. Ltd
Li, Senlin	Anhui Xinli Power Tech. Co. Ltd
Zhang, Jian	Anhui Xinli Power Tech. Co. Ltd
Wang, Ruomin	Anhui Xinli Power Tech. Co. Ltd.,

The efficient and accurate inspection of power supplies is crucial for ensuring the safety and reliability of power grids. Traditional methods often face challenges in handling complex, unstructured textual and visual data from inspection reports, maintenance logs, and sensor outputs. For this end, this paper proposes the inference Large Language Model (LLM) for intelligent power supplies inspection. Firstly, it integrates the textual and sensor data of power supplies, constructing a domainappropriate multimodal feature extraction model, which enhances the richness of the features. Then, a fine-tuning based data reconstruction scheme is designed, which helps LLM to learn the relationships and knowledge related to specific feature parameters, thereby improving the generalization performance of power supplies inspection model. After that, a multi-scale feature embedding method is proposed to convert each fragment into the input dimension vector of the large model ChatGLM2-6B-chat. And the abnormal material data are detected through the normalization layer and the linear layer. Finally, the effectiveness and practicability of the proposed method were verified by the real-world dataset.

► SunC03-6 15:10–15:30

Prediction Model for the Quality of Weight Coating Application in Submarine Pipelines Based on BO-LightGBM

Xie, Yunhao	China Univ. of Petroleum, Beijing
Zou, Zilong	CNOOC Energy Tech. & Service
He, Renchu	China Univ. of Petroleum

Aiming at the challenges of complex process and strong parameter coupling in submarine pipeline weight coating application, as well as the insufficient accuracy of traditional models, this study proposes a coating thickness prediction method based on Bayesian Optimization and Light Gradient Boosting Machine (BO-LightGBM). Through process analysis, key process parameters including pipe diameter, pipeline axial and rotational speeds, conveying crawler speed, aggregate passing size, and concrete density are selected as model inputs. A thickness prediction model is constructed based on the LightGBM algorithm, and Bayesian Optimization is employed to adaptively adjust the model hyperparameters, thereby enhancing its fitting capability and generalization performance. Validation using actual production line data shows that compared to methods such as Support Vector Regression and unoptimized LightGBM, the BO-LightGBM model achieves significantly higher prediction accuracy, with a root mean square error of 0.19 mm, a mean absolute percentage error of 0.34%, and a coefficient of determination of

0.936. The predicted thickness and the negative buoyancy calculated based on the mechanism both fall within the engineering design range, verifying the model's applicability in practical quality control.

SunC04 13:30–15:30 Xinghui Hall
Regular Session: Statistical Learning and Machine Learning in Automation Field

Chair: Zhang, Jianming — Institution of Cyber-Sys. & Control
Co-Chair: Liu, Shan — Zhejiang Univ.

▶ SunC04-1 13:30–13:50
Self-Training Knowledge Distillation-Based Multimodal Trajectory Prediction for Pedestrians

Zhou, Kehan — Zhejiang Univ.
Mao, Yuefeng — Acad. of Engineering
Zhang, Xu — Zhejiang Univ.
Zhu, Qian — Zhejiang Univ. Robotics Inst.
Zhu, Ce — Yuyao Robot Research Center
Zhang, Jianming — Institution of Cyber-Sys. & Control

Accurate pedestrian trajectory prediction is paramount for the safe navigation of autonomous agents, yet it faces a fundamental tension between the deterministic supervision typical of deep learning paradigms and the intrinsic stochasticity of human movement. To resolve this challenge, this paper presents a novel Self-Training Knowledge Distillation Framework (SKDF) that effectively harmonizes high-precision prediction with multimodal diversity. The architecture incorporates a dynamic evolutionary mechanism, where a probabilistic Social LSTM teacher generates diverse hypothesis spaces to guide the learning of a precision-oriented Transformer student. Crucially, a decoupled dual-encoder design is introduced to distinctively capture complex spatiotemporal interactions, while an iterative self-training strategy refines the student via dual supervision —balancing deterministic regression with probabilistic distribution alignment using Dynamic Time Warping (DTW). Extensive empirical validation on the ETH/UCY benchmark demonstrates that SKDF establishes a new state-of-the-art, achieving an aggregate ADE of 0.20m and FDE of 0.33m. Qualitative analyses further confirm the model' s robustness in generating socially plausible, diverse trajectories across varying environmental densities, effectively mitigating mode collapse in complex scenarios.

▶ SunC04-2 13:50–14:10
TriFusion-DETR: A Light-weight Real-time Detector for Smartphone Screen Glass Defects

Fan, Xin — Zhejiang Sci-Tech Univ.
Wu, Ping — Zhejiang Sci-Tech Univ.
Yu, Yicheng — Zhejiang Sci-tech Unversity
Kandel, Nabin — Zhejiang Sci-Tech Univ.
Yang, Zheming — China National Pipeline Network Group Zhejiang Natural Gas Pipeline Network Co., Ltd
He, Guojun — Zhejiang Natural Gas Pipeline Network Co., Ltd. (PipeChina)

Object detection algorithms have become ubiquitous in the field of industrial detection. However, achieving an optimal trade-off between high precision and low latency remains a significant challenge in scenarios requiring real-time processing. To address this, this paper proposes TriFusion-DETR, a specialized network for mobile phone screen defect detection. Built upon the RT-DETR framework, the proposed model optimizes the backbone by incorporating a lightweight ResNet18 structure, effectively mitigating parameter redundancy. Furthermore, the Coordinate Attention-based High-level Screening-feature Fusion Pyramid-Path Aggregation Network (CAHS-FPN-PAN) and the Convolutional Attention Feature Map Fusion (CAFMFusion) module are integrated to robustly extract feature representations of minute defects from highly noisy and complex backgrounds. Extensive evaluations on the public Smartphone Screen Glass Defect (SSGD) dataset demonstrate that TriFusion-DETR achieves a mean Average Precision (mAP) of 63.0%. Notably, with an inference latency of only 24.5 ms and a negligible increase in parameters compared to the baseline RT-DETR R18, the proposed model satisfies the stringent real-time requirements of industrial deployment.

▶ SunC04-3 14:10–14:30
A Differentiable Oblique Decision Tree for Interpretable Interval Prediction of Photovoltaic Power

Sun, Huayan — Shanghai Univ.
Jia, Li — Shanghai Univ.

Reliable photovoltaic power interval prediction is essential for scheduling and secure operation in power systems with high PV penetration. Although existing interval prediction methods can adapt to input changes, many remain black-box models with limited interpretability, making it difficult to clearly depict the correspondence between operating conditions and interval characteristics. This study proposes a differentiable oblique decision tree framework that models at the level of conditional distribution and can derive prediction intervals. By combining oblique splits with differentiable routing, the model hierarchically partitions the feature space into physically meaningful operating conditions and expresses condition rules along root-to-leaf paths. Leaf nodes adopt a Student-t distribution to capture heavy-tailed errors, and condition weights are used to form an input-dependent conditional distribution in an end-to-end manner. To enhance training stability and interpretability, a lightweight leaf-balancing constraint is introduced to mitigate responsibility collapse. Experiments show that the proposed method achieves RMSE 9.729, MAE 4.649, and R^2 0.9724 for point prediction. For interval prediction, it attains PICP of 91.20% and 95.76% at 90% and 95% confidence levels, respectively, with Winkler scores of 25.84 and 30.52, indicating an improved trade-off between coverage and width. Overall, the method delivers reliable uncertainty estimates while preserving structured interpretability for decision support.

▶ SunC04-4 14:30–14:50
Edge Feature Information Enhancement Algorithm for Small Objects Detection of Remote Sensing Images

Li, Haochen — Jiangnan Univ.
Tao, Hong-Feng — Jiangnan Univ.
Zhuang, Zhihe — Jiangnan Univ.

Within object detection in remote sensing, targets often appear at extremely small scales, frequently resulting in missed detections or false positives due to the limited visual information and complicated background interference. To solve these issues, this study proposes a novel framework named Edge Feature Information Enhancement-You Only Look Once (EFIE-YOLO). First, a Cross-Scale and Detail-Enhanced Bidirectional Detection (CSDEBD) head is designed to enhance detail perception and feature discrimination. In addition, the integration of Dynamic Snake Convolution (DSConv) enables the network to adaptively focus on elongated and curved features, improving the extraction of edge information for small objects. Second, the Multi-Scale Edge Information Select (MEIS) module is employed in the C3k2 module, which consists of an Edge Enhancement Module (EEM) and a Dual-Domain Selection Module (DSM). EEM explicitly extracts multi-scale edge features, while DSM selectively emphasizes spatially and frequency-salient regions through spatial and frequency selection mechanisms, thereby filtering out irrelevant information and enhancing feature representation. Third, a C2TSSA module is incorporated to capture global statistical dependencies across tokens, which replaces standard self-attention with a Token Statistics Self-Attention (TSSA) mechanism to enable efficient long-range modeling at linear computational complexity. Compared to the baseline YOLO11-s, experimental results on the DOTA dataset demonstrate that EFIE-YOLO achieves 4.1% and 3.4% improvements in mAP@50 and mAP@50:95, while maintaining real-time inference speed and reducing model parameters and FLOPs.

▶ SunC04-5 14:50–15:10
A Cosine Leaky Integral Echo State Network for Time Series Prediction

Xu, Wenfu — Shenyang Univ. of Tech.
Gong, Yuanpeng — Changchun Univ. of Tech.

Echo state networks (ESN) have exhibited promising potential for time series prediction. To solve the problem of low prediction accuracy in conventional ESN, this paper designs a cosine leaky integral echo state network (CL-ESN). The CL-ESN is composed of cosine neurons. Its activation function is a weighted sum of finite cosine functions, which overcomes the vanishing gradient problem caused by traditional activation functions.Three time series are selected in this paper, including the Mackey-Glass (MG) chaotic system, low-frequency sequence generator, high-frequency sequence generator, and temperature data. Simulation results verify that the CL-ESN presents superior prediction performance for time series with periodicity, chaotic characteristics and strong nonlinearity.

▶ SunC04-6 15:10–15:30
Learning A Robust Vision-Force Policy for Peg-in-hole Tasks

Fan, Xiaotian — Zhejiang Universtity
Liu, Shan — Zhejiang Univ.

The peg in hole (PIH) task is a representative contact-intensive assembly problem that requires accurate pose alignment, reliable force feedback,

and robustness to environmental uncertainties. Conventional vision-based control methods often fail in high precision insertion scenarios due to small assembly clearances, visual occlusions and limited perception accuracy, while force-only control strategies lack sufficient guidance to handle complex constraints. To address these limitations, a hybrid visual-force control strategy is proposed, which leverages reinforcement learning to acquire robust insertion skills under significant positional and orientational uncertainties. Within this framework, visual observations and force torque feedback are integrated to enable closed-loop control throughout the assembly process. To improve training efficiency, imitation learning is employed for policy pretraining, which mitigates slow convergence during early training. Experimental results demonstrate that the learned policy exhibits strong generalization under pose disturbances and low-resolution visual inputs. It can be transferred directly from simulation to a real robotic manipulator without additional fine tuning and adapts to insertion tasks with varying hole diameters.

SunC05 13:30–15:30 Meixue Hall

Regular Session: Applications of Data-Driven Methods to Industrial Processes (I)

Chair: Li, Xiangyang South China Uni. of Tech
Co-Chair: Ai, Wei South China Univ. of Tech.

▶ SunC05-1 13:30–13:50

Recognition of Flotation Abnormal Conditions Based on Multimodal Temporal-Visual Fusion

Xu, Degang Central South Univ.
Jiang, Shan Central South Univ.
Chen, Yiwei Central South Univ.

Froth flotation is a critical process in mineral processing, with its operational stability directly determining production efficiency and resource recovery. However, the frequent occurrence of abnormal conditions such as sinking and flooding poses significant challenges to stable operation. To address the issues of insufficient application and integration of multimodal data, this paper proposes a novel framework for deep fusion of temporal and visual features. The method first employs a BiLSTM network to encode the temporal features, which comprise the froth layer bottom distance from the level sensor and the graylevel difference from the tank edge image. In parallel, a multi-branch convolutional neural network is employed to encode visual features from the three key image regions. A lightweight attention and residual connections moulde is then designed to adaptively fuse these multimodal features. Validated on an industrial dataset, our approach achieved a superior overall accuracy of 95.4%, significantly outperforming conventional methods. The proposed framework demonstrates substantial potential for the early diagnosis of flotation anomalies, thereby enabling timely intervention and optimized process control.

▶ SunC05-2 13:50–14:10

Cooling Load Probability Density Prediction of Air Conditioning System Based on Temporal Gaussian Integrated Network

Liu, Nian Xi'an Univ. of Architecture & Tech.
He, Ning Xi'an Univ. of Architecture & Tech.

Accurate cooling load prediction can offer a solid guarantee for the optimal operation of air conditioning, therefore realizing energy efficient use and emission reduction. In this paper, a probability density prediction method for cooling load based on a temporal Gaussian integrated network is proposed. Different from the traditional methods that can only achieve a single point or interval value prediction for cooling load, the proposed approach can model the entire distribution of cooling load to more accurately characterize its non-stationary behaviors and stochastic uncertainties caused by factors such as solar radiation and occupancy rates. Firstly, a preprocessing method for cooling load data is proposed to lessen the noise effect on prediction accuracy and reduce the risk of overfitting that leads to excessively wide prediction intervals. Secondly, an integrated model based on time convolution network (TCN) and Gaussian process quantile regression (GPQR) for probability density prediction is constructed to quantify the uncertainties in air conditioning operation and represent the distribution properties of the cooling load data more accurately. Finally, the experimental results indicate that the method effectively captures the variation patterns of the cooling load and describes the probabilities of cooling loads across different values, achieving improved prediction precision.

▶ SunC05-3 14:10–14:30

A Hybrid Genetic-ODE Framework with Multidimensional Constraints for Time Delay Estimation and Alignment in Industrial Dynamical Systems

Liu, Ke Hangzhou Normal Univ.
Yao, Le Hangzhou Normal Univ.
Zhu, Zheren Zhejiang Univ.
Zeng, Jiusun Hangzhou Normal Univ.
Song, Zhihuan Zhejiang Univ.

Against the backdrop of accelerated industrial intelligence transformation, time delay issues in multi-channel signal transmission seriously affect system control accuracy and production efficiency. To address this, this paper proposes a multi-channel time delay estimation strategy that integrates genetic algorithm (GA) optimization with nonlinear ordinary differential equation (ODE) system prediction. By incorporating mechanisms such as hierarchical initialization, tournament selection, and adaptive crossover and mutation, the approach maintains population diversity while enhancing the algorithm's convergence rate, and establishes a multidimensional fitness function to comprehensively evaluate the effectiveness of time delay estimation. Nonlinear damped oscillators are selected as simulation objects for industrial dynamic systems, and three groups of true time delay vectors with different ranges are set for validation. Simulation results show that the estimated time delay parameters closely match the true values. After time delay compensation, the mean squared error of the predicted output signal is significantly reduced, and the Pearson correlation coefficient with the actual signal approaches 1, outperforming ODE prediction models without time delay estimation. The algorithm also demonstrates good convergence and robustness across different time delay scenarios, providing an effective solution to the time delay estimation problem in industrial automation systems.

▶ SunC05-4 14:30–14:50

An Evidential Deep Learning-Based Method for Boiler Combustion Optimization Objective Prediction

Wu, Yixi Zhejiang Univ.
Zhan, Yuling Zhejiang Univ.
Jin, Xiaohang Zhejiang Univ. of Tech.
Xu, Zhengguo Zhejiang Univ.

Improving energy efficiency and reducing pollutant emissions are key focuses in boiler combustion optimization. As the cornerstone of combustion optimization, the prediction of optimization objectives is crucial. With the rapid development of new energy, coal-fired power plants are increasingly involved in peak shaving processes. Load fluctuations make boiler prediction much more challenging. Therefore, beyond enhancing point prediction accuracy, the reliability of prediction results has become a critical concern. This study introduces the concept of uncertainty into boiler combustion objective prediction. By combining Evidential Deep Learning (EDL) with the Kernel Long Short-term Memory (Kernel-LSTM) neural network model, the proposed method learns the distribution of network outputs, enabling point and interval prediction of combustion objectives alongside quantification of their uncertainty and reliability. Validations on real power plant data demonstrate that the proposed method provides reliable objective prediction intervals and achieves significant improvements in uncertainty and reliability quantification compared to commonly used Bayesian Neural Network (BNN) model, indicating strong potential for engineering applications and valuable guidance.

▶ SunC05-5 14:50–15:10

Coal Mine Multi-Scale Object Detection Based on Multi-Layer Vision Transformer

Yang, Xiaoyu Middling Coal Tech. & Industry Group Chongqing Research Inst.
Luo, Chuan China Coal Tech. & Engineering Group Chongqing Research Inst. Co., Ltd
Liu, Yanchi China Coal Tech. Engineering Group
You, Lei CCTEG Chongqing Research Inst. Co., Ltd

Installing gas sensors at the working face in coal mine underground can provide timely early warning when gas exceeds the limit. Video monitoring can effectively monitor the standardized use of on-site sensors to ensure safe production. However, as the coal mining face moves underground, both sensors and cameras move along with the working area, resulting in changes in the size of the sensors in the images. Transformers can effectively extract features from images through the attention mechanism, but Vision Transformer (ViT) uniformly divides images into patches, which leads to its weak ability to extract features of objects with scale changes. Based on this, this paper proposes a multi-layer Vision Transformer based multi-size target detection algorithm for coal mine underground. By designing Swin Transformer modules of differ-

ent sizes, it extracts features of targets with different sizes in the image layer by layer to realize the recognition of multi-size targets; a window-moving attention calculation method is designed to avoid the problem that attention extraction in the image is always limited to a certain local area. The final experimental results show that the proposed multi-layer ViT method effectively solves the problem of accurate recognition under the condition of sensor size change in the moving scene of coal mine underground, and effectively improves the accuracy of target recognition compared with traditional methods and ViT.

▶ SunC05-6 15:10–15:30

Intelligent MPC Strategy for SCR Denitration Process Based on VMD-AWSLSTM Model

Ai, Wei — South China Univ. of Tech.
Wu, Weining — South China Univ. of Tech.
Zhang, Tong — South China Univ. of Tech.
Zhai, Shulei — South China Univ. of Tech.
Tang, Zikang — South China Univ. of Tech.
Li, Xiangyang — South China Uni. of Tech

The Selective Catalytic Reduction (SCR) denitration process exhibits nonlinearity and significant time-delay characteristics, which make it difficult to accurately predict the outlet NOx concentration and consequently limit the precision of control strategies. To tackle this issue, this paper proposes an intelligent predictive control strategy. The strategy first introduces an Adaptive Non-recursive Variational Mode Decomposition (VMD) algorithm to mitigate high-frequency noise interference. Subsequently, a VMD-AWSLSTM model is constructed by integrating a Weight-Sharing Long Short-Term Memory (WSLSTM) network with an attention mechanism, enabling accurate prediction of the outlet NOx concentration. This model is then embedded into a Generalized Predictive Control (GPC) framework, replacing traditional transfer function models, and is combined with an improved Hybrid Strategy Whale Optimization Algorithm (HWOA) to achieve rolling optimization control. Comparative experimental results demonstrate that the proposed prediction model outperforms Support Vector Regression (SVR), Recurrent Neural Network (RNN), and Long Short-Term Memory (LSTM) models in terms of evaluation metrics including Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). Under varying load conditions, the proposed control strategy significantly enhances the tracking performance and stability of the outlet NOx concentration compared to the traditional Network Communication Control(NCC) strategy.

SunC06 13:30–15:30 Guibin Hall

Regular Session: Complex Systems and Artificial Intelligence (I)

Chair: Tang, Xinxin — Chongqing Jiaotong Univ.
Co-Chair: Yao, Wen-Long — Qingdao Univ. of Sci. & Tech.

▶ SunC06-1 13:30–13:50

SAR Moving Object Detection Method Based on Improved YOLOv8 in Noisy Environment

Li, Shuang — Chongqing Jiaotong Univ.
Tang, Xinxin — Chongqing Jiaotong Univ.
Huang, Darong — Anhui Univ.

In recent years, Synthetic Aperture Radar (SAR) has been widely employed in Ground Moving Target Indication (GMTI) due to its all-weather and day-night observation capabilities. However, current SAR moving target detection faces two major challenges: the scarcity of public datasets and severe noise interference, which undermine the robustness of detection models. To address these issues, this paper constructs a specialized SAR moving target dataset through simulation and proposes an improved YOLOv8-based detection method. The approach embeds a dual-branch hybrid noise suppression module at the input stage of YOLOv8. This module performs parallel suppression of coherent speckle noise and Gaussian white noise via two dedicated branches, effectively filtering out noise while preserving target features, thereby enhancing detection performance in noisy environments. Experimental results demonstrate that the proposed method achieves an mAP50 of 0.952 under hybrid noise conditions, with detection robustness significantly outperforming mainstream comparative models.

▶ SunC06-2 13:50–14:10

Pathological Analysis of Asymptomatic Meningioma Based on CBAM-MED

Guo, Shengbo — Bjut
Li, Xiaoli — Beijing Univ. of Tech.
Wang, Kang — Beijing Univ. of Tech.
Du, Chao — Capital Medical Univ., Beijing, China
Hao, Shuyu — Capital Medical Univ., Beijing, China

Accurate preoperative non-invasive analysis of the World Health Organization (WHO) classification and key pathological indicators is crucial for individualized treatment of meningiomas, but it remains challenging in clinical practice. To address this issue, we propose an improved medical imaging detection model, CBAM-MED, based on MedYOLO and the convolutional Block Attention Module (CBAM), specifically for the pathological analysis of asymptomatic meningiomas. By integrating multi-sequence MRI inputs into the 3D perception architecture and combining with the spatial channel attention mechanism, CBAM-MED effectively captures tumor heterogeneity and hierarchical spatial features. The experimental results of the clinical meningioma MRI dataset show that our model has high accuracy in predicting WHO grades and key pathological indicators, providing a reliable framework for non-invasive preoperative assessment and personalized treatment planning.

▶ SunC06-3 14:10–14:30

DDANO: Dual-ended Dynamic Prompts Learning for Zero-Shot Anomaly Detection

Li, Qinghao — Anhui Univ.
Lu, Yixiang — Anhui Univ.
Zhu, De — Anhui Univ.

Zero-shot anomaly detection (ZSAD) aims to identify anomalies in images without relying on training data from specific categories. The key challenge is ensuring the model can generalize effectively to detect anomalies in previously unseen categories. Current methods rely on customizable learnable textual or visual prompts, but this single-modality adaptation limits transferability. To address this, Dual-ended Dynamic Prompts Learning for Zero-Shot Anomaly Detection (DDANO), a novel approach based on the pretrained CLIP model, is proposed to enhance the generalization of unknown anomaly detection. By exploiting learnable object-agnostic dynamic text prompts and generating dynamic visual prompts, the DDANO improves anomaly detection accuracy across diverse scenarios. To further enhance the precision of anomaly localization, Anomaly-Aware Semantic Fusion Module (AASFM) is introduced, which strengthens semantic fusion to effectively highlight anomalous features within the image. Experimental results on industrial and medical anomaly detection datasets demonstrate that compared to classical methods, DDANO significantly enhances ZSAD performance, showing superior generalization and robustness.

▶ SunC06-4 14:30–14:50

Observer-Based Adaptive Predefined-time Control for Uncertain Nonlinear Systems with Sensor Fault

Zhao, Weiyu — Bohai Univ.
Liu, Siwen — Bohai Univ.
Feng, Yaqi — Bohai Univ.
Wang, Huanqing — Bohai Univ.

This article discusses an observer-based adaptive sensor fault compensation predefined-time tracking control trouble for uncertain nonlinear systems. A fuzzy state observer is effectively designed to estimate unmeasurable state variables, and adaptive fault compensation solves the sensor fault question. By utilizing the adaptive control technique, a novel adaptive predefined-time controller is developed. Under the proposed control scheme, all closed-loop signals remain bounded within a preset time interval, and both observation errors and tracking error can converge to a small neighborhood near the origin. Finally, the simulation results further validate the effectiveness of the proposed method.

▶ SunC06-5 14:50–15:10

Detail-Awared Virtual Try-On via A Data-Driven Cross-Domain Transformer

Liu, Jingyun — Xi'an Univ. of Tech.
Liu, Han — Xi'an Univ. of Tech.
Tong, Shuo — Xi'an Univ. of Tech.

With the rapid growth of online apparel shopping, accurate evaluation of garment fit, style, and texture from static images remains a challenging problem. Current virtual try-on technologies often struggle with precise garment-body alignment and fine-detail preservation, particularly under complex clothing structures and diverse human poses. To address these challenges, we propose a data-driven, detail-enhanced virtual try-on network based on a cross-domain Transformer architecture. By leveraging large-scale garment-human image datasets, the framework explicitly models cross-domain interactions and long-range dependencies between garment and human features. The network comprises two key modules: a Cross-domain Transformer Alignment module (CTA) module

that improves alignment accuracy and robustness, and a Detail-Aware Generator (DAG) that refines multi-level features to preserve textures, patterns, and local garment details. Extensive experiments on the VITON dataset, including quantitative evaluation, qualitative visualization, and ablation studies, demonstrate that our method consistently outperforms state-of-the-art approaches in terms of alignment precision, visual fidelity, and overall realism. Ablation results further validate the effectiveness of each module in enhancing virtual try-on performance. The proposed approach provides a robust, scalable, and data-driven solution for realistic virtual try-on applications.

▶ SunC06-6 15:10–15:30

Grouping-based Dual-Population Co-evolutionary Algorithm for Constrained Ship Electrical Layout Optimization

Liu, Xinyuan — Qingdao Univ. of Sci. & Tech.
Zhao, Chunliang — Qingdao Univ. of Sci. & Tech.
Liu, Yuchuan — Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Wang, Qingliang — Jining Port & Shipping Development Group Co., Ltd
Yao, Wen-Long — Qingdao Univ. of Sci. & Tech.

In response to the transition of ships toward Integrated Power Systems (IPS), electrical layout design faces the challenge of fragmented solution spaces caused by high-dimensional search spaces and strong isolation constraints. This paper proposes a Grouping-based Dual-Population Co-evolutionary algorithm (GDP-CC). The algorithm employs a topological partitioning strategy based on prior knowledge, leveraging electrical connection relationships to decouple high-dimensional decision variables into coordinated low-dimensional subgroups. This architecture enables effective dimensionality reduction and addresses the convergence stagnation inherent in large-scale optimization. Coupled with a Constraint-Traction Dual-Population mechanism (CT-DP), an auxiliary population is utilized to detect infeasible regions and pull the main population across physical barriers, thereby ensuring global search capability in fragmented spaces. Experimental results demonstrate that while ensuring all hard constraints are strictly met, the proposed algorithm significantly reduces total cable length and safety risks. It exhibits superior design efficiency and convergence performance when handling large-scale layout problems, providing critical technical support for the autonomous and low-cost design of ship electrical systems.

SunD01 15:40–17:40 Yangguang Hall

Invited Session: Data-Driven Adaptive and Learning Control and Applications for Unmanned Systems (II)

Chair: Zhou, Lan — Hunan Univ. of Sci. & Tech.
Co-Chair: Zhang, Xibeng — Henan Univ.

▶ SunD01-1 15:40–16:00

Data-Driven Adaptive Tracking Control for Nonlinear Dual-Active-Bridge Systems

Wang, Yilin — Henan Univ.
Song, Haochen — Fifth Inst. of Electronics, Ministry of Industry & Information Tech.
Yang, Zhengshuo — Henan Univ.
Zhang, Xibeng — Henan Univ.

This paper investigates the output-voltage regulation problem of a dual-active-bridge (DAB) dc–dc converter in a dc microgrid. To mitigate model mismatch and the associated control-performance degradation caused by operating-mode transitions, power-injection uncertainty, and parameter drift, a recursive-least-squares-based model predictive control (MPC–RLS) strategy with dual-phase-shift (DPS) modulation is proposed. An online recursive least squares (RLS) algorithm is employed to identify an input–output model, enabling accurate prediction of the output-voltage dynamics in the next sampling interval. In addition, the proposed MPC–RLS scheme achieves start-up voltage tracking without overshoot. By integrating MPC with online RLS identification, the DAB converter attains a fast dynamic response and improved robustness to parameter variations. The effectiveness of the proposed controller is verified in Simulink, and comparative experiments are conducted against conventional PI-based voltage closed-loop control. Experimental results demonstrate the superior dynamic and steady-state performance of the proposed MPC–RLS method and are consistent with the corresponding analysis.

▶ SunD01-2 16:00–16:20

Data-Driven Iterative Learning Control for Nuclear Waste Incineration Temperature Regulation

Zhang, Chuanwang — China Nuclear Power Engineering Co., Ltd
Song, Xiaolu — China Nuclear Power Engineering Co. Ltd
Ma, Jing — China Nuclear Power Engineering Co., Ltd
Zhang, Bo — China Nuclear Power Engineering Co., Ltd
Zhu, Panpan — Henan Univ.

Precise temperature regulation in nuclear waste incineration processes (NWIPs) constitutes a formidable control challenge characterized by nonlinear thermodynamic behavior, stochastic perturbations arising from radioactive waste heterogeneity, variable batch durations induced by safety interlocks, and the inherent infeasibility of establishing accurate mechanistic models in radiation-intensive environments. This paper presents a novel data-driven iterative learning temperature control (DDILTC) methodology that concurrently addresses these four interrelated challenges. The principal contributions encompass: (1) an iterative linear data model (iLDM) that establishes batch-wise input-output correlations exclusively from operational measurements, thereby obviating the necessity for first-principles modeling; (2) an iterative linear predictive model (iLPM) that furnishes continuous control signal refinement during premature batch termination triggered by thermal protection protocols, fundamentally resolving the control input stagnation inherent in conventional approaches; (3) an iterative extended state observer (iESO) that provides unified estimation and compensation for aggregated uncertainties. Comprehensive experimental validation utilizing 72-hour operational datasets from an operational nuclear waste incineration facility substantiates the superior efficacy of DDILTC, achieving root mean square error (RMSE) of 4.8℃—representing performance enhancements of 61.3%, 40.7%, and 33.3% relative to conventional PID, P-type ILC, and model-free adaptive ILC methodologies, respectively. The cumulative tracking error index demonstrates an 82.5% reduction, while computational overhead remains within real-time constraints at 0.5 ms per iteration cycle.

▶ SunD01-3 16:20–16:40

Model-Free Adaptive Iterative Learning Control for Nonlinear Systems Using Partial Model Knowledge

Yu, Wei — Peking Univ.
Li, Zhongkui — Peking Univ.

This study proposes a hybrid-driven model-free adaptive iterative learning control (MFAILC) scheme for nonlinear systems. The system is decomposed into known and unknown dynamical components, and a hybrid pseudo-partial derivative (PPD) is constructed by fusing known model knowledge and data-driven estimates. Based on compact form dynamic linearization (CFDL), the scheme integrates prior model information to reduce error oscillation. Rigorous analysis proves that the tracking error converges to zero with increasing iterations. Comparative simulations verify that the proposed scheme outperforms traditional MFAILC in convergence speed and tracking accuracy, confirming its effectiveness for complex time-varying trajectory tracking.

▶ SunD01-4 16:40–17:00

Robust Model Predictive Control for Trajectory Tracking of Flexible-Joint Robotic Arms Based on Koopman Models

Xiang, Junchi — Hunan Univ. of Sci. & Tech.
Zhou, Lan — Hunan Univ. of Sci. & Tech.
Xia, Jingkang — Hunan Univ. of Sci. & Tech.
Xiao, Wenbin — Hunan Univ. of Sci. & Tech.
Li, Meiliu — Hunan Univ. of Sci. & Tech.

This paper presents a Koopman operator-based Tube Model Predictive Control (Tube MPC) method integrated with dynamic mechanisms to address the trajectory tracking problem of flexible-joint manipulators subject to unknown physical parameters and limited observations, aiming for high-precision and robust tracking performance. First, historical position sequences are employed to reconstruct the phase space. A sparse Koopman linear model is then constructed by incorporating the characteristics of Lagrangian mechanics. To account for model truncation errors, an error bound based on the Lipschitz continuity condition is introduced, enabling the construction of a minimal robust positively invariant set. This forms the basis of a robust Tube MPC framework that explicitly compensates for residuals and disturbances. The recursive feasibility and closed-loop stability of the proposed control scheme are rigorously established. Finally, simulation results validate the effectiveness of the method in suppressing flexible oscillations and achieving robust trajectory tracking.

▶ SunD01-5 17:00–17:20

Altitude Control of A UAV Swarm Based on Historical Acceleration Commands

Gu, Zhuoheng City Univ. of Macau
Yu, Wei City Univ. of Macau
Gong, Yunbo City Univ. of Macau
Wang, Meiyu City Univ. of Macau

Rapid maneuvering of unmanned aerial vehicle (UAV) swarms in constrained environments, such as bridge inspections and obstacle-laden navigation, demands high-precision cooperative altitude control. This paper proposes a altitude control framework that leverages historical acceleration commands to enhance tracking performance. We establish a hierarchical leader-follower architecture where the leader's trajectory dynamically guides the followers' altitude responses. By actively utilizing outdated acceleration commands, this approach effectively improves system transient response while avoiding the noise amplification associated with approximate differentiation. Finally, a high-fidelity digital twin of a realistic scenario is constructed using the Unreal Engine, and the effectiveness of the proposed altitude control algorithm is validated within the RflySim platform

▶ SunD01-6 17:20–17:40
Adaptive Event-triggered Control for Nonlinear Multiagent Systems with Communication Link Faults

Liu, Guangliang Northeastern Univ.
Liu, Jinhui Bohai Univ.
Pan, Yingnan Bohai Univ.

This paper investigates the leader-follower consensus problem for nonlinear multi-agent systems with unknown communication link faults (CLFs) under event-triggered mechanism. A distributed estimator is designed to enable all followers to accurately track the leader's trajectory, thereby eliminating the need for global information. Concurrently, a hybrid event-triggered mechanism is proposed to avoid continuous inter-agent communication. This mechanism alleviates challenges induced by CLFs by eliminating the need for exponential decay terms and simplifying the triggering condition. Based on Lyapunov theory, all closed-loop signals are proven to be semi-globally uniformly ultimately bounded. Moreover, rigorous analysis confirms that the proposed event-triggered mechanism excludes Zeno behavior despite the presence of CLFs.

SunD02 15:40–17:40 Changle Hall
Invited Session: Data-Driven Control and Learning of Multi-Agent Systems

Chair: Liang, Dong Univ. of Shanghai for Sci. & Tech.
Co-Chair: Wang, Shanshan Univ. of Shanghai for Sci. & Tech.

▶ SunD02-1 15:40–16:00
Fully Distributed Data-Driven Cooperative Output Regulation of Linear Multi-Agent Systems by Output Feedback Control

Chen, Hong Usst
Liang, Dong Univ. of Shanghai for Sci. & Tech.
Dong, Yi Tongji Univ.
Tian, Engang Nanjing Normal Univ.
Wang, Chaoli Univ. of Shanghai for Sci. & Tech.

This paper investigates cooperative output regulation for completely unknown linear discrete-time multi-agent systems (MASs) by integrating data-driven techniques. Distinct from most existing studies that presuppose state availability, the proposed framework relies solely on the input-output data of both the reference system and the followers. First, a local state-reconstruction procedure is developed to estimate each agent's state in real time from measured inputs and outputs. Secondly, the solution to the unknown regulator equations is derived using the data informativity approach without resorting to iterative learning. Third, a fully distributed adaptive observer-augmented with an online Laplacian estimator recovers the required spectral information of the communication graph online, eliminating dependence on global topology. The resulting data-driven control algorithm guarantees closed-loop stability and asymptotic tracking under minimal information assumptions.

▶ SunD02-2 16:00–16:20
Backstepping Neural Operators for $2times2$ Hyperbolic PDEs

Wang, Shanshan Univ. of Shanghai for Sci. & Tech.

DeepONet has been shown to approximate backstepping designs governed by a single Goursat-form PDE. This paper extends the framework to boundary control of coupled $2times2$ hyperbolic PDEs, where backstepping yields a coupled system of Goursat-form kernel PDEs. We prove continuity of the mapping from the plant's five functional coefficients to the kernel solutions, establish arbitrarily accurate DeepONet approximations, and show that replacing exact kernels with learned ones preserves stability. Under anti-collocated boundary actuation and sensing, the resulting L^2-globally exponentially stabilizing output-feedback design enables deep learning of both controller and observer gains and ensures semi-global practical exponential stability. The DeepONet operator accelerates gain computation by orders of magnitude, as validated by simulations.

▶ SunD02-3 16:20–16:40
Efficient Solution of the 3D Fractional Poisson Equation Using Fourier Neural Operators

Xiao, Wei Univ. of Shanghai for Sci. & Tech.
Wang, Shanshan Univ. of Shanghai for Sci. & Tech.

The fractional Poisson equation governs non-local diffusion processes that are ubiquitous in anomalous transport physics. However, solving this equation in three-dimensional (3D) space is computationally prohibitive for traditional numerical methods due to the dense nature of the discretized fractional Laplacian and the curse of dimensionality. In this work, we propose an efficient data-driven solver based on an Optimized Fourier Neural Operator (O-FNO) to address the 3D fractional Poisson equation (s=0.5). We introduce an architecture that leverages 3D Fast Fourier Transforms (FFT), residual connections, and volumetric batch normalization to learn the solution operator directly in the frequency domain. We perform a systematic comparative analysis against the DeepONet architecture on a volumetric grid. Experimental results demonstrate that the O-FNO achieves a test relative L_2 error of approximately 2.42%, significantly outperforming DeepONet, which stagnates at a high error of 49.01% due to the information bottleneck inherent in processing high-dimensional volumetric inputs. Furthermore, we demonstrate the mesh-invariant property of O-FNO via zero-shot super-resolution, achieving 96.53% accuracy on a fine 64^3 grid when trained strictly on coarse 32^3 data. These results establish the superior scalability and efficiency of spectral neural operators for high-dimensional non-local PDEs.

▶ SunD02-4 16:40–17:00
Performance-Supervised Fault Detection for Model-Free Nonlinear Systems Based on Fuzzy Approximation

Gu, Yujie Univ. of Shanghai for Sci. & Tech.
Liu, Ruijie Univ. of Shanghai for Sci. & Tech.
Nie, Kunhao Univ. of Shanghai for Sci. & Tech.

With the rapid development of industry and the increasing complexity of systems, fault detection of nonlinear systems has become an important technical means to ensure the safety and reliability of complex engineering systems. Traditional methods mostly rely on residual signals generated by system observers or statistical analysis to establish monitoring mechanisms, yet they generally overlook the impact of faults on the key performance of systems. To address the needs of real-time performance monitoring and maintenance for complex model-free systems, this paper proposes a novel data-driven approach to achieve the performance-supervised fault detection for the nonlinear systems with unknown dynamics. First, with the aid of Takagi-Sugeno (T-S) fuzzy approximation techniques, a performance residual function is constructed for the nonlinear systems. Then, a data-driven scheme is designed to identify the unknown parameters in the performance residual of model-free nonlinear systems. Finally, an evaluation function is established for the performance residual, and a proper threshold is set to ensure the trade-off between the fault detection rate and false alarm rate. Case studies conducted on a laboratory three-tank system demonstrate that the proposed method can effectively detect pipe plugging fault and sensor fault, verifying its practical applicability in engineering systems with complex dynamics.

▶ SunD02-5 17:00–17:20
Data-Driven SIR-Based Active Defensive Control for Cyber-Physical Systems with Malicious Sensor Attacks

Nie, Kunhao Univ. of Shanghai for Sci. & Tech.
Liu, Ruijie Univ. of Shanghai for Sci. & Tech.

This extended abstract investigates the critical issues of attack detection and defensive control for cyber-physical systems (CPSs) subject to malicious sensor attacks. Unlike the commonly studied additive attacks, this paper thoroughly investigates the overlooked multiplicative attacks, which intrinsically alter the functional relationship of the feedback loop. Given the inherent challenges in modeling complex systems and acquiring precise attack dynamics, the proposed strategies are implemented within a purely data-driven framework. The closed-loop attacked dynamics is fundamentally analyzed using coprime factorization techniques in the frequency domain. By utilizing data-driven stable image representations (SIRs), the inaccessible system output is dynamically reconstruct-

ed based on the Hankel matrices of an instrumental variable alongside input-output data. Then, an effective tracking performance evaluator is established to detect real-time attack-induced deviations. Subsequently, an active defensive feedforward controller is optimally reconfigured to recover the degraded tracking performance. A comprehensive case study on a boost converter circuit validates the superiority and effectiveness of the proposed methods.

▶ SunD02-6 17:20–17:40

Edge Convergence of Second-Order Nonlinear Systems

Wang, Mengyi	Qilu Univ. of Tech.
Zhang, Jiayuan	Qilu Univ. of Tech.
Wang, Xiaofan	Qilu Univ. of Tech. (Shandong Acad. of Sci.)
Du, Mingjun	Qilu Univ. of Tech. (Shandong Acad. of Sci.)

This paper investigates the problem of edge convergence for second-order nonlinear systems based on the edge Laplacian matrix. By constructing a second-order dynamic model of the edge system, a fully distributed control protocol with nonlinear dynamics is designed. Under the assumptions of a strongly connected directed graph topology and a nonlinear function satisfying the Lipschitz condition, sufficient conditions are established under which edge synchronization of the system can be achieved. Furthermore, this paper rigorously proves the equivalence between the convergence of the edge system to zero and the achievement of consensus in the node system, thereby providing a unified analytical framework based on edge dynamics for studying node consensus problems. Simulation results verify that the proposed protocol enables the edge states and node states to converge to the synchronization subspace and consistent trajectories, respectively, confirming the validity of the theoretical results.

SunD03 15:40–17:40 Langyue Hall

Regular Session: Advanced Data Driven Algorithms for Complex Process

Chair: Liu, Shan Zhejiang Univ.

Co-Chair: Zhang, Jianming Institution of Cyber-Sys. & Control

▶ SunD03-1 15:40–16:00

Model-Free Adaptive Variable Gain Predictive Vector Control for Chemical Tanker Propulsion Systems

Feng, Jianliang	Qingdao Univ. of Sci. & Tech.
Liu, Yuchuan	Penglai Zhongbai Jinglu Shipbuilding Co., Ltd
Wang, Qingliang	Jining Port & Shipping Development Group Co., Ltd
Chi, Ronghu	Foshan Univ.
Yao, Wen-Long	Qingdao Univ. of Sci. & Tech.

Aiming at the difficulties in establishing mechanism models, significant influence of load disturbances on control accuracy, and high requirements for operational smoothness of propulsion systems for chemical tankers under complex sea conditions and liquid cargo sloshing conditions, a Model-Free Adaptive Predictive Control (MFAPC) method incorporating variable-gain error feedback correction is proposed. First, the mathematical model of the chemical tanker's propulsion motor and propeller load is established. Then, based on the compact-form dynamic linearization technique, the pseudo partial derivative is identified online using system I/O data streams, reconstructing the nonlinear data-driven model and multi-step ahead prediction equations of the propulsion system. A performance index function incorporating rotational speed tracking error and control increment constraints is constructed, and the model-free adaptive predictive control law is designed through rolling optimization. Finally, to address potential control deviations caused by persistent load disturbances, a variable-gain error feedback correction term is introduced into the controller, which adjusts the feedback intensity in real time according to the rotational speed error. Simulation results demonstrate that the proposed control method effectively improves the dynamic response speed and steady-state accuracy of the chemical tanker's propulsion system, achieves smooth rotational speed regulation, and exhibits excellent control performance.

▶ SunD03-2 16:00–16:20

Dense Medium Separation Method Based on Improved Proportional-Integral Generalized Predictive Control with Active Disturbance Rejection Control

Zhang, Jingpei	Dalian Univ. of Tech.
Jin, Feng	Dalian Univ. of Tech.
Liu, Jinze	Dalian Univ. of Tech.
Zhao, Jun	Dalian Univ. of Tech.
Wang, Wei	Dalian Univ. of Tech.

The stable control of the dense medium separation (DMS) process is vital for improving coal beneficiation efficiency and final product quality. However, achieving high-precision and robust dynamic control with traditional methods is challenging due to inherent difficulties in industrial settings, such as multivariable coupling, significant time delays, strong noise interference, and time-varying operating conditions. To address these challenges, an improved proportional-integral generalized predictive control (PI-IGPC) with active disturbance rejection control (ADRC) is proposed for DMS. This method converts multivariable systems into independent control channels through feedforward decoupling, thereby an adaptive step factor is designed to reconstruct control increment sequence that avoids matrix inversion to improve computational efficiency and numerical stability. Additionally, a linear extended state observer (LESO) is introduced to estimate the unmodeled dynamic errors of the system and external disturbances as total disturbances, enabling feedforward compensation. This significantly enhances the disturbance rejection capability and robustness of the system. Experimental results based on actual measurement data from a coal preparation plant show that the proposed method outperforms other approaches in response speed, overshoot, steady-state accuracy, and disturbance rejection capability. Moreover, ablation experiments and time-delay robustness tests validated the effectiveness and synergistic interaction of each module.

▶ SunD03-3 16:20–16:40

Predefined-Time Tracking Control for Robotic Manipulators with Input Saturation Based on Disturbance Observer

Lei, Shu	Beijing Inst. of Tech.
Ren, Xuemei	Beijing Inst. of Tech.
Song, Jiangchao	Beijing Inst. of Tech.
Zheng, Dongdong	Beijing Inst. of Tech.

This paper investigates predefined-time tracking control with prescribed performance function for robotic manipu-lators subject to lumped disturbances and actuator saturation. A prescribed performance error transformation is first employed to enforce prescribed performance tracking error bounds through time-varying performance functions. To rapidly compensate uncertainties, a disturbance observer is constructed to estimate an unknown lumped term within a user-assigned time. Based on the transformed error, a predefined-time sliding-mode controller is then developed to drive the transformed tracking error to the origin within a predefined time, while an auxiliary dynamic compensator is introduced to address the input saturation problem. Lyapunov stability analysis establishes boundedness of all closed-loop signals and predefined-time convergence. Simulations on a robotic manipulator demonstrate that tracking errors remain inside the prescribed performance bounds and that the lumped disturbance term is accurately estimated and effectively compensated in the closed-loop system.

▶ SunD03-4 16:40–17:00

A Unified Lightweight Attention Module for Road Classification and Crack Segmentation

Li, Mingwu	School of Transportation Sci. & Engineering
Yin, Yunfei	Harbin Inst. of Tech.
Li, Wantong	Harbin Inst. of Tech.
Liu, Yuanhao	Harbin Inst. of Tech.
Abaho, Gershome	Univ. of Rwanda
Dong, Zejiao	Harbin Inst. of Tech.

Automated health maintenance of transport infrastructure is pivotal for ensuring public safety and operational efficiency within intelligent transportation systems. While deep learning has revolutionized surface distress diagnosis, a critical trade-off persists between diagnostic accuracy and computational efficiency, particularly for deployment on resource-constrained edge devices. To bridge this gap, we propose the anchor gated self-attention (AGSA), a lightweight plug-and-play module. AGSA introduces sparse learnable anchors as semantic hubs to decouple global dependency modeling, reducing computational complexity from quadratic to linear. Furthermore, it incorporates a novel anchor-guided spatial gating mechanism that dynamically fuses global semantics with local spatial details, effectively highlighting fault regions while suppressing environmental noise. Extensive experiments demonstrate the superiority of AGSA across diverse tasks. In road surface classification, AGSA consistently enhances performance across multiple backbones on the large-scale road surface classification dataset benchmark and a challenging self-collected winter dataset, achieving state-of-the-art accuracy in extreme conditions such as ice and snow coverage. More-

over, in dense prediction tasks, AGSA significantly improves crack segmentation precision on the Crack500 dataset, yielding notable gains in IoU and Dice scores for subtle fracture detection. These results confirm AGSA as a scalable, high-performance solution for real-time, automated infrastructure inspection.

▶ SunD03-5 17:00–17:20

Deep Belief Network-Based MIMO Wiener System Identification for Permanent Magnet Synchronous Motor Modeling

Zhang, Yanan — Shanghai Univ.
Jia, Li — Shanghai Univ.
Li, Feng — Jiangsu Univ. of Tech.

To address the strong nonlinearities and multi-input–multi-output (MIMO) coupling commonly observed in motor current systems, this paper presents a MIMO Wiener system identification method that integrates a Sparse Deep Belief Network (Sparse-DBN) surrogate model with correlation-analysis-based linear parameter estimation. First, a Sparse-DBN surrogate is trained using real d-axis and q-axis motor current data to approximate the complex static nonlinear mapping. Then, correlation analysis is employed to identify the parameters of the dynamic linear block without requiring direct measurement of internal variables. Furthermore, the surrogate model outputs serve as intermediate variables to train the nonlinear compensator, thereby forming a complete Wiener structure. Experimental results demonstrate that the proposed Wiener–DBN method significantly improves prediction accuracy in motor current forecasting tasks. Compared with direct DBN modeling, the method achieves lower mean squared error (MSE) and mean absolute error (MAE), confirming its effectiveness and engineering applicability for complex nonlinear MIMO system modeling.

▶ SunD03-6 17:20–17:40

A Robust Coarse-to-Fine Peg-in-Hole Assembly Strategy via Visual Servoing and Compliance Control

Ni, Hao — Zhejiang Univ.
Liu, Shan — Zhejiang Univ.

To address challenges such as positioning uncertainty and complex contact forces encountered in industrial Peg-in-Hole assembly tasks, this paper proposes a "Coarse-to-Fine" assembly strategy that integrates computer vision with force feedback. The strategy comprises four core phases: First, YOLOv8 and depth information are utilized to achieve rapid coarse localization and Region of Interest extraction of the target hole. Second, a multi-step Iterative Closest Point algorithm is employed for point cloud registration to estimate the initial 6D pose of the target. Subsequently, a geometric feature-based planar visual servoing system is designed to perform precise closed-loop correction of end-effector's Yaw and positional errors. Finally, during the insertion phase, admittance control is combined with an Archimedean spiral search strategy to compensate for residual errors of the visual system and achieve compliant insertion. Experiments conducted on an xArm6 manipulator platform demonstrate the effectiveness of the proposed method. The results show that the system achieves a 100% assembly success rate under both 1.0 mm and 0.5 mm mating clearances. The average position error in the visual guidance stage is converged to within 1.0 mm, significantly reducing the force-controlled search time. The average total assembly time is 12.92s, verifying the feasibility of achieving high-precision and high reliabe automated assembly using low-cost hardware configurations.

SunD04 15:40–17:40 Xinghui Hall

Regular Session: Applications of Data-Driven Methods to Industrial Processes (III)

Chair: Yan, Fei — Xi'an Univ. of Tech.
Co-Chair: Mi, Bo — Chongqing Jiaotong Univ.

▶ SunD04-1 15:40–16:00

An IoV Access Control Model Based on Trust-Epoch-Bound CP-ABE

Wang, Xin — Chongqing Jiaotong Univ.
Mi, Bo — Chongqing Jiaotong Univ.
Huang, Darong — Anhui Univ.

In the Internet of Vehicles (IoV), data sharing is frequent and node behaviors change dynamically, making conventional ciphertext-policy attribute-based encryption (CP-ABE) with static attribute authorization insufficient to promptly constrain insider misbehavior. To address this limitation, this paper proposes a vehicular access-control model based on a trust-epoch-bound CP-ABE framework, in which attribute-level dynamic trust and epoch information are tightly bound to the leaf nodes of the access policy and the corresponding private-key components. As a result, a user's decryption capability can be adaptively adjusted according to evidence-driven trust evolution. By leveraging epoch progression, the proposed scheme achieves dynamic revocation while providing both forward and backward security. We further formalize the security model, provide a security proof, and analyze the scheme's resistance to collusion as well as its effectiveness in mitigating insider threats. Experimental results show that the encryption/decryption time and ciphertext overhead grow approximately linearly with the number of attributes. Despite introducing trust constraints and epoch-based revocation, the overall performance remains comparable to classical CP-ABE, with controllable overhead and ciphertext length essentially consistent with that of the baseline scheme.

▶ SunD04-2 16:00–16:20

Causal Disentanglement-Driven Robust Adaptive Physics-Informed Neural Network for Trajectory Prediction

He, Zhonghe — North China Univ. of Tech.
Xu, Ruosi — North China Univ. of Tech.
Ding, Baiwen — North China Univ. of Tech.
Li, Kailong — North China Univ. of Tech.
Li, Min — North China Univ. of Tech.
Zhai, Kaixuan — North China Univ. of Tech.
Su, Xiyao — North China Univ. of Tech.

Trajectory prediction is a core prerequisite for autonomous driving decision-making and planning. Existing data-driven methods suffer from insufficient physical consistency, poor robustness in out-of-distribution (OOD) scenarios, uncalibrated prediction uncertainty, and weak adaptability in information-sparse situations. To address these challenges, this paper proposes a Robust Adaptive Physics-Informed Neural Network (RA-PINN). The model separates invariant physical features from scene-related spurious features via a causal disentangled spatio-temporal encoder, constrains longitudinal car-following and lateral lane-changing behaviors through a dual-expert physics-informed decoder, and incorporates an adaptive history completion module and uncertainty calibration loss. Experimental validation on the public HighD dataset shows that RA-PINN achieves an Average Displacement Error (ADE) of 1.41 m and a Final Displacement Error (FDE) of 2.45 m within the 5-second prediction horizon, with a lane change intention recognition F1-score of 0.933. These results outperform mainstream baseline models, providing technical support for safe decision-making in conventional highway traffic scenarios.

▶ SunD04-3 16:20–16:40

A Cross-City Delay Prediction Framework for Signal Timing Optimization Integrating Floating Car Trajectories and Signal State Data

Li, Xinru — NORTH CHINA Univ. OF Tech.
Tan, Jiyuan — North China Univ. of Tech.
Li, Yi — Alibaba Group
Xie, Songming — School of Electrical & Control Engineering
Dong, Zhenning — Alibaba Group
Guo, Weiwei — North China Univ. of Tech. Beijing
Su, Yuelong — Tsinghua Univ.

Before implementing traffic signal control algorithms or timing plans at intersections, it is crucial to predict and evaluate their effects to ensure operational safety and control performance. Traditional methods —including analytical models based on traffic flow theory, microscopic simulation, and field testing—are limited in terms of generalization ability, cost, and efficiency, especially under non-stationary traffic conditions. To address these limitations, this study proposes a data-driven delay prediction framework based on a GRU-Attention architecture, which learns the mapping from signal timing parameters and traffic states to intersection control effects (average delay). The model is developed and validated using multi-source data collected from five major Chinese cities (Beijing, Shanghai, Guangzhou, Shenzhen, and Hangzhou), including floating car trajectory data and signal timing records. Through systematic dataset construction, feature engineering, and sample balancing, the proposed model achieves strong predictive performance. To provide an intuitive evaluation, prediction accuracy is defined as the proportion of samples whose relative error falls within a predefined threshold (±15%). Under this criterion, the model achieves an accuracy of approximately 85% on the validation set. Standard regression metrics are also used to ensure comprehensive evaluation. The results demonstrate that the proposed framework offers a cost-effective and scalable tool for signal timing evaluation, with strong robustness under heterogeneous traffic conditions. This study provides practical support for pre-deployment assessment and optimization of signal timing strategies in real-world urban environments.

▶ SunD04-4 16:40–17:00

A PD-Type Iterative Learning Control with Whale-Optimized Learning Gains for Urban Traffic Signals

Wang, Hao Xi'an Univ. of Tech.
Yan, Fei Xi'an Univ. of Tech.

Iterative learning control (ILC) has been widely applied to urban traffic signal control due to the repetitive characteristics of traffic flow. However, the convergence speed of ILC is highly dependent on the selection of learning gains, which are usually chosen as constants in practical applications. To address this limitation, this paper proposes a gain optimization method for PD-type ILC based on the whale optimization algorithm. By optimizing the learning gains according to tracking error information during the iterative process, the proposed method improves convergence behavior while preserving the original PDILC structure. Simulation experiments are conducted in VISSIM on a realistic urban road network under different disturbance conditions. Comparative results with constant-gain PDILC and particle-swarm-optimization-based PDILC demonstrate that the proposed method achieves faster convergence and lower tracking error, validating its effectiveness for urban traffic signal control.

▶ SunD04-5 17:00–17:20

Decentralized Spatiotemporal A2C with Graph Attention Communication Bottleneck for Multi-Agent Traffic Signal Control

Liu, Qian Xiamen Univ.
Liu, Junlong School of Electronic & Information Engineering
Shi, Jia Xiamen Univ.

Multi-agent reinforcement learning (MARL) has emerged as a promising paradigm for adaptive traffic signal control (ATSC), yet it faces persistent challenges in decentralized execution—including partial observability, non-stationarity, redundant information transmission, and static communication topology constraints. To address these challenges, this paper proposes a Decentralized Spatiotemporal Advantage Actor-Critic (A2C) framework incorporating a Graph Attention Communication Bottleneck (D-GAComm) for multi-agent traffic signal control. Grounded in the Centralized Training with Decentralized Execution (CTDE) paradigm, the framework jointly integrates spatiotemporal reinforcement learning with a graph attention–based communication module, enabling each intersection agent to dynamically select communication neighbors and adaptively allocate communication resources based on local observations and neighborhood traffic conditions. We conduct extensive empirical evaluations of D-GAComm in two representative ATSC simulation environments; results demonstrate its superior control performance and communication efficiency over state-of-the-art MARL-based approaches.

▶ SunD04-6 17:20–17:40

OSLC-based Event Synchronization Method for XBOM Model Tree

Cheng, Jianfeng China Acad. of Engineering Physics
Zhang, Yangjing China Acad. of Engineering Physics
Chen, Siyu China Acad. of Engineering Physics
Zhang, Chuming Inst. of Computer Application China Acad. of Engineering Physics
Zhang, Shaokai Inst. of Computer Application China Acad. of Engineering Physics
Ren, Qiang China Acad. of Engineering Physis

To address the lack of real-time synchronization of XBOM model tree data between PLM systems and upstream/downstream applications, this paper proposes an event-driven synchronization method based on event listening and OSLC. A three-layer architecture is constructed, consisting of "event capture - change analysis - change push". The event-listening module captures real-time operations such as node additions, deletions, and attribute modifications, while a recursive backtracking algorithm reconstructs the complete chain of changes. Version-control mechanisms ensure data integrity during trace-back, and OSLC standards enable standardized cross-system synchronization. Experimental results show that the proposed method achieves low synchronization latency and high data consistency, supporting the construction of reliable digital threads in manufacturing.

SunD05 15:40–17:40 Meixue Hall

Regular Session: Applications of Data-Driven Methods to Industrial Processes (II)

Chair: Hou, Yandong Henan Univ.
Co-Chair: Lv, Feiya Zhejiang Univ.

▶ SunD05-1 15:40–16:00

MWS-DETR: A Lightweight Model for Metal Weldment Surface Small-Scale Defect Detection

Li, Yijian Central South Univ.
Xu, Degang Central South Univ.

Small-scale defects on metal weldment surfaces not only affect surface integrity but also induce localized stress concentration. However, owing to their limited spatial extent and weak structural cues, such defects are easily suppressed during feature encoding and multi-scale fusion, while industrial inspection systems typically operate under strict real-time constraints. To address these issues, this paper proposes the Metal Weldment Surface Detection Transformer (MWS-DETR), a lightweight detection framework for small-scale defect detection on metal weldment surfaces. Specifically, a Conv-Former Block Feature Extraction Module (CFB-FEM) is designed to balance detection accuracy and computational efficiency. A Magnitude-Aware Linear Attention (MALA) mechanism is integrated into the AIFI encoder to enhance the discriminability of small-scale defects under repetitive industrial backgrounds. A Local Spatial Enhancement Block (LSEB) is introduced in the feature fusion network to preserve fine-grained defect information during multi-scale feature fusion. Experimental results on a metal weldment surface defect dataset demonstrate that MWS-DETR achieves a 3.16% improvement in mAP50 compared with the baseline method, while reducing the number of parameters and FLOPs to 16.23 MB and 51.9 G, respectively, indicating its suitability for real-time industrial inspection scenarios.

▶ SunD05-2 16:00–16:20

Knowledge-Enhanced Graph Patching Network for Fault Prediction in Chemical Processes

Zou, Chen Henu Univ.
Hou, Yandong Henan Univ.
Lv, Feiya Zhejiang Univ.

Fault prediction and early warning in chemical processes remain challenging due to strong couplings among process variables, which may delay fault discovery and reduce the available intervention window. This paper proposes a Knowledge-Enhanced Graph Patching Network (KGPN) for multivariate multi-step fault prediction. KGPN incorporates a knowledge-guided learnable topology module to improve the reliability of coupling modelling and adaptively identify latent dependencies. Moreover, a dual-branch spatiotemporal architecture is developed, where a graph-based branch captures structured spatial couplings and a patch-based temporal branch enhances multi-step forecasting by learning Variable-Patch Tokens with cross-variable self-attention. The resulting spatiotemporal features are fused through a gated mechanism to enable accurate and robust early warning. Experimental results on the Tennessee Eastman Process (TEP) benchmark demonstrate that KGPN achieves more accurate fault prediction than several advanced baseline methods. Additional experiments on real operational data from fluid catalytic cracking (FCC) units further confirm that KGPN is capable of providing reliable advance fault prediction under complex industrial conditions, highlighting its strong applicability to practical early-warning scenarios.

▶ SunD05-3 16:20–16:40

Mechanism-Informed Nonlinear Model Predictive Control with Batch-wise Parameter Re-identification: Application to the Finishing Rolling Process

Dong, Yuanye Peking Univ.
Li, Wenlong Peking Univ.
Yang, Ying Peking Univ.

In this paper, a mechanism-informed nonlinear model predictive control (MI-NMPC) method is proposed to optimize product quality in the finishing rolling process. Initially, mathematical models of strip crown and exit thickness are formulated to characterize the complex rolling dynamics. Based on the derived models, a batch-wise parameter re-identification method is introduced to estimate dynamic physical coefficients, effectively capturing process variations and overcoming the limitations of static models. By explicitly embedding these dynamic coefficients, an MI-NMPC scheme is developed to enhance control performance while preserving physical interpretability. Finally, the effectiveness of the proposed method is validated via simulations of the finishing rolling process.

▶ SunD05-4 16:40–17:00

Human-like Trajectory Evaluation Function for Autonomous Driving: Perception-aligned Structure Design and Expert Data-driven Parameter Identification

Zheng, Niannian Geely Automobile Research Inst.
Bo, Li Geely Automobile Research Inst.

Huo, Ke — Geely Automobile Research Inst.
Bo, Li — School of Automotive & Transportion Engineering
Chen, Chen — Xidian Univ.
Can, Xu — Hefei Univ. of Tech.
Li, Yue — Geely Automobile Research Inst.

The interactivity and stochasticity of dynamic traffic agents cause inherent multimodality in future scenarios, making trajectory evaluation a critical yet under-explored task in autonomous driving (AD). Existing methods fall into hand-crafted rule-based and deep network-based scoring, failing to balance human-likeness, interpretability, and adaptability. To address this dilemma, this research proposes a human-like evaluation function for AD, integrating perception-aligned structure design and expert data-driven parameter identification. Specifically, human-perceptual-matching structures are introduced to explicitly model the non-linear and asymmetric characteristics of human driving preferences, while "feature-cost pair" dataset derived from expert drivers' real-world ratings is utilized for parameter estimation. The proposed method provides an interpretable, scalable, and practical solution for multi-modal scenario evaluation in AD. The proposed technology is validated in benchmark cases, and has been deployed in Geely mass-produced vehicles, effectively selecting human-driving-consistent trajectories.

▶ SunD05-5 17:00–17:20

Virtual Damping NOILC: A Robust Two-Stage Control Framework for Underactuated Overhead Cranes

Cai, Yujin — Renmin Univ. of China
Shen, Dong — Renmin Univ. of China
He, Xiongxiong — Zhejiang Univ. of Tech.

In this work, a two-layer control framework is introduced to achieve robust performance for underactuated overhead cranes in the presence of complex parametric variations. First, the planning layer utilizes convex optimization to generate a kinetically feasible reference trajectory strictly adhering to safety constraints. Subsequently, a virtual damping norm-optimal iterative learning control (VD-NOILC) strategy is developed for the learning layer. By incorporating rate-dependent penalties, this method injects active virtual damping into the iteration domain, explicitly minimizing the generalized error kinetic energy. Simulations confirm that VD-NOILC actively dissipates residual oscillations, significantly reducing peak transient errors compared to standard control methods, and ensures robust monotonic convergence despite significant model mismatches.

▶ SunD05-6 17:20–17:40

Data-based Probability-dependent Event-triggered Control for Unknown Markovian Jump Systems

Zhang, Ning — East China Univ. of Sci. & Tech.
Niu, Yugang — East China Univ. of Sci. & Tech.
Zhao, Jiancong — East China Univ. of Sci. & Tech.
Lv, Xinyu — Qufu Normal Univ.

This study proposes a data-based event-triggered control scheme for Markovian jump systems (MJSs) subject to random packet loss. Under the resource-limited environments, a probability-dependent event-triggered controller is designed, whose triggering parameters can be adjusted online according to the system state convergence trend and packet loss probability. Then, the model-based sufficient conditions for the stochastic stability of the closed-loop system are established. Considering that system parameters may be unknown in practice, a mode-classified data collection scheme is developed. With the collected data, a data-based system representation model is established, by which the aforementioned model-based stability conditions can be transformed into fully data-dependent criteria. This enables the controller design and stability analysis to be implemented without any system parameters. Finally, the simulation results demonstrate that the proposed data-based control scheme maintains desired control performance.

SunD06 15:40–17:40 Guibin Hall

Regular Session: Complex Systems and Artificial Intelligence (II)

Chair: Ning, Nianwen — Henan Univ.
Co-Chair: Cheng, Zunshui — Qingdao Univ. of Sci. & Tech.

▶ SunD06-1 15:40–16:00

Multi-task-based Finite-time Control for Second-order Multi-agent Systems

Chen, Jiajing — Tianjin Univ. of Tech. & Education
Li, Weixun — Tianjin Univ. of Tech. & Education
Du, Chengcheng — Tianjin Univ. of Tech. & Education
Li, Zhang — Tianjin Univ. of Commerce

This work addresses the problem of finite-time multi-task control in second-order linear multi-agent systems. The leader-following control protocol is developed for second-order linear multi-agent systems by use consensus and formation control theory. Namely, the system is divided into two groups: one group of followers tracks its leader to achieve consensus control, while the other group of followers tracks another leader to achieve formation control. By employing graph theory, finite-time stability theory, and related knowledge, it is established that, under the proposed control protocol, the system attains the finite-time consensus-formation multi-task objectives. Finally, the effectiveness of the theoretical results is validated by numerical simulations.

▶ SunD06-2 16:00–16:20

Real-Time AI-Based Polyp Detection and Segmentation in Gastrointestinal Endoscopy Using Deep Learning

Aaron, Sayor — Canadian Univ. of Bangladesh
Newaz, Ashif — Canadian Univ. of Bangladesh
Abir, Sajjat Hossain — Canadian Univ. of Bangladesh
Rahman, Md. Mushfiqur — Canadian Univ. of Bangladesh
Ahosan, Nazmul — Canadian Univ. of Bangladesh
Hossain, Md Monir — Canadian Univ. of Bangladesh

Colorectal cancer is one of the leading causes of death due to cancer worldwide. Early detection of polyps that may be pre-cancerous is crucial to preventing colorectal cancer from developing. Colonoscopy is the most common method for screening for colorectal cancer. However, there are many reasons why colonoscopy is not effective enough at diagnosing colorectal cancer, including the fact that it depends on the skill of the doctor performing the procedure, fatigue during long procedures, poor quality images and because some polyps do not visually appear like other polyps. These factors contribute to "miss" rates for clinically relevant polyps, especially those that are very small or flat. This paper proposes an Artificial Intelligence (AI)-Based Computer Aided Diagnosis (CAD) framework called PolyVision that will enable a physician to detect and segment polyps in real time during gastro-intestinal endoscopy

▶ SunD06-3 16:20–16:40

Role-Oriented History-Aware Transformer for Spatio-Temporal Traffic Flow Forecasting

Guo, Chenyang — Henan Univ.
Ning, Nianwen — Henan Univ.
Feng, Yiting — Henan Univ.
Lv, Beilei — Henan Univ.
Zhu, Panpan — Henan Univ.
Li, Hengji — Henan Univ.
Li, Wei — Henan Univ.
Zhou, Yi — Henan Univ.

Modeling multi-period temporal dependencies and dynamic spatial correlations remains a central challenge in spatio-temporal forecasting. In this study, we propose the Role-Oriented History-Aware Spatio-temporal Transformer (RHSTF), an architecture featuring complementary static-dynamic encoding pathways, where structural role preservation and adaptive correlation discovery are jointly optimized for spatio-temporal pattern learning. By employing absolute role embeddings, our method establishes stable graph structural representations, while utilizing dynamic affinity matrices to capture implicit spatial correlations, thereby effectively revealing latent interaction mechanisms among functionally analogous regions. Furthermore, the proposed history-aware module implements coordinated multi-periodic temporal feature modeling: when significant deviations between predictions and historical trends are detected, autonomous dynamic calibration is triggered through adaptive attention weight redistribution. Experiments on two benchmark datasets demonstrate that RHSTF achieves superior prediction accuracy with improved computational efficiency compared to state-of-the-art methods.

▶ SunD06-4 16:40–17:00

Consensus of Multi-agent Systems Based on Sigma-Delta Quantizer under DoS Attacks

Zhang, Ting — Henan Univ. of Economics & Law
Zhao, Kai Da — HENAN Univ. OF ECONOMICS & LAW
Liu, Zisheng — Henan Univ. of Economics & Law

This paper conducts research on the secure consensus control of multi-agent systems (MAS) under denial-of-service (DoS) attacks. Considering that network attacks can disrupt the system's coordination by interrupting communication links and are limited by the bandwidth bot-

tleneck of communication channels, a Sigma-Delta (Σ) dynamic quantization mechanism with resource-saving characteristics is introduced in the paper. On this basis, an attack-resistant secure quantization control scheme is designed, and the thresholds of the frequency and duration of DoS attacks that the system can withstand to maintain consensus are determined. By combining the analysis method of switched systems and the Lyapunov stability criterion, the criteria for achieving secure consensus are derived. Finally, the effectiveness of the scheme is verifi ed through numerical simulations, and the performance advantages of the Σquantizer over the traditional static quantizer are discussed.

► SunD06-5 17:00–17:20

Stability and Hopf Bifurcation Analysis of A Complex Network Model with Heterogeneous Gamma-Distributed Delays

Gao, Wenjie	Qingdao Univ. of Sci. & Tech.
Cheng, Zunshui	Qingdao Univ. of Sci. & Tech.
Xin, Youming	Qingdao Univ. of Sceince & Tech.
Shang, Yun	Qingdao Univ. of Sci. & Tech.

This paper investigates the stability and Hopf bifurcation of a disease-spreading network model with heterogeneous Gamma-distributed delays. Two different Gamma kernels are introduced to describe the propagation delay and the nonlinear feedback delay, respectively. By employing the linear chain technique, the original distributed-delay system is transformed into an equivalent finite-dimensional ordinary differential equation system. Taking the average delay associated with the nonlinear feedback as the bifurcation parameter, we analyze the existence of a Hopf bifurcation. Furthermore, based on the center manifold theorem and normal form theory, explicit formulas are derived to determine the direction of the Hopf bifurcation, the stability of the bifurcating periodic solutions, and the variation of their period. Numerical simulations are provided to illustrate and verify the theoretical results.

► SunD06-6 17:20–17:40

A Hybrid Genetic and Dynamic Penalty-Based PSO Algorithm for Constrained Maintenance Scheduling in Distribution Networks

Liang, Yanyan	State Grid Bozhou Electric Power Supply Company
Liu, Yan	State Grid Bozhou Electric Power Supply Company
Wang, Jiaxiao	State Grid Bozhou Electric Power Supply Company
Wu, Chengcheng	State Grid Bozhou Electric Power Supply Company
Pan, Min	State Grid Bozhou Electric Power Supply Company
Zhen, Chao	State Grid Bozhou Electric Power Supply Company

The rational formulation of maintenance schedules for distribution networks is of great significance for ensuring the safe and stable operation of power systems, while also improving economic efficiency and supply reliability. To address the multi-objective and multi-constraint characteristics of distribution network maintenance scheduling, this paper proposes a multi-objective optimization model that comprehensively considers maintenance costs, power supply losses, and system operational risks. The model incorporates various practical scheduling constraints, including concurrency constraints, mutual exclusion constraints, precedence constraints, and resource limitations. On this basis, a Hybrid Genetic and Dynamic Penalty Particle Swarm Optimization algorithm (HGDP-PSO) is proposed. By dynamically adjusting the inertia weight, the algorithm enhances global search capabilities, while heuristic crossover, mutation, and multi-neighborhood local search strategies are introduced to improve the diversity and feasibility of solutions. Finally, the proposed model and algorithm are validated through simulation studies on a practical distribution network case. The results demonstrate that the proposed method outperforms traditional algorithms in terms of convergence accuracy, computational efficiency, and solution feasibility

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(C=Chair, CC=Co-Chair)

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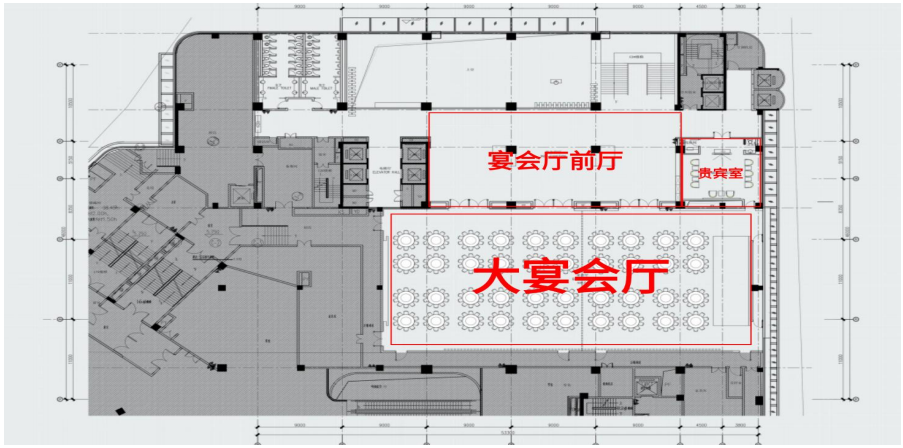
Friday, May 8, 2026, Xiangquan Sunshine Hotel, Jishou (吉首 湘泉阳光酒店)								
Time/Room	Lobby							
14:00-18:00	Register							
Saturday, May 9, 2026, Xiangquan Sunshine Hotel, Jishou (吉首 湘泉阳光酒店)								
8:00-8:20	Opening ceremony, Venue: *Grand Hall,* Chair: Prof. Jing Wang							
8:20-9:10	Keynote Address 1: Data-Driven and Learning-based Control, Prof. *Lihua Xie*, Chair: Prof. Jing Na							
9:10-10:00	Keynote Address 2: A Pathway to Industrial AI for Process Industry, Prof. *Jian Chu*, Chair: Prof. Ronghu Chi							
10:00-10:20	Tea Break							
10:20-11:50	Panel Discussion: 人工智能时代的控制理论, Panelists: Prof. Lihua Xie, Prof. Jian Chu, Prof. Guanghong Yang, Prof. Cheng Xiang, Prof. Zhongsheng Hou, Chair: Prof. Fei Liu							
12:00-13:30	Lunch							
Time/Room	Jinxiu Hall	Ruyi Hall	Yangguang Hall	Changle Hall	Langyue Hall	Xinghui Hall	Meixue Hall	Guibin Hall
13:30-15:30	SatA00	Excellent Doctoral Forum	SatA01	SatA02	SatA03	SatA04	SatA05	SatA06
13:30-14:10	Best Paper Award, Chair: Prof. Mingxuan Sun, Prof. Ronghu Chi	Speaker 1: 高效世界模型及自主导航, Prof. Gang Wang, Chair: Prof. Lei Liu	IS: Data-Driven Self-Learning Control and Optimization for Nonlinear Systems	IS: Estimation and Compensation of System Uncertainties: Methods and Applications (I)	IS: Distributed Security Cooperative Control in Complex Environments	Data-Driven Control and Its Applications (I)	Model-Free Adaptive Control	Data-Driven Fault Diagnosis and Health Maintenance (I)
14:10-14:50		Speaker 2: 基于 Mamba 的时变系统故障诊断及其在鲲龙 AG600 上的应用, Prof. Hongtian Chen, Chair: Prof. Lei Liu						
14:50-15:30		Speaker 3: 数据与知识融合驱动的高铁列车运行自主调度, Prof. Min Zhou, Chair: Prof. Lei Liu						
15:30-15:40		Tea Break						
Time/Room		Ruyi Hall	Yangguang Hall	Changle Hall	Langyue Hall	Xinghui Hall	Meixue Hall	Guibin Hall
15:40-17:40		Excellent Doctoral Forum	SatB01	SatB02	SatB03	SatB04	SatB05	SatB06
15:40-16:20		Speaker 4: Intermittent Event-Triggered Fixed/Predefined Time Cooperative Control, Prof. Jian Liu, Chair: Prof. Hongtian Chen	IS: Intelligent Model-free Adaptive Control as New Engine for UAVs and Transportation	IS: Estimation and Compensation of System Uncertainties: Methods and Applications (II)	IS: Adaptive Control Methods for Nonlinear Mechatronics Systems	Data-Driven Control and Its Applications (II)	Iterative Learning Control and Its Applications	Data-Driven Fault Diagnosis and Health Maintenance (II)
16:20-17:00		Speaker 5: 列车牵引传动系统关键部件故障诊断与延寿控制方法研究, Prof. Chao Yang, Chair: Prof. Hongtian Chen						
17:00-17:40								
18:00-20:00	Dinner							
Sunday, May 10, 2026, Xiangquan Sunshine Hotel, Jishou (吉首 湘泉阳光酒店)								
Time/Room	Ruyi Hall	Yangguang Hall	Changle Hall	Langyue Hall	Xinghui Hall	Meixue Hall	Guibin Hall	Front Hall
8:00-10:00	Distinguished Lecture	SunA01	SunA02	SunA03	SunA04	SunA05	SunA06	SunA07
8:00-8:40	Lecture 1: 逻辑引导与数据驱动的规划控制方法, Prof. Zhongkui Li, Chair: Prof. Qinglai Wei	IS: Learning-Based Intelligent Control for Complex Dynamic Systems	IS: Adaptive Learning Control and Application of Complex Dynamic Systems	IS: Cooperative Learning Control of Network Systems: Theories and Applications	Data-Driven Fault Diagnosis and Health Maintenance (III)	Data-Driven Modeling, Optimization, Scheduling (I)	ADP and RL Based Learning Control (I)	Poster Session (I)
8:40-9:20	Lecture 2:控制论思想引导的动态系统数据驱动预测控制方法, Prof. Chao Shang, Chair: Prof. Weiwei Che							
9:20-10:00	Lecture 3: 网络攻击下信息物理系统的安全性分析与安全防护, Prof. Anyang Lu,Chair: Prof. Deyuan Meng							
10:00-10:10	Tea Break							
Time/Room	Ruyi Hall	Yangguang Hall	Changle Hall	Langyue Hall	Xinghui Hall	Meixue Hall	Guibin Hall	Front Hall
10:10-12:10	Distinguished Lecture	SunB01	SunB02	SunB03	SunB04	SunB05	SunB06	SunB07
10:10-10:50	Lecture 4: Sampled-data/continuous-time model free adaptive control: modeling, design, and robustness, Prof. Hao Yu, Chair: Prof. Wenchao Xue	IS: Learning-Based Optimal Control and Applications	IS: Data-Driven Modelling and Adaptive Learning Control	IS: Intelligent Fault Detection, Diagnosis, and its Applications	Data-Driven Fault Diagnosis and Health Maintenance (IV)	Data-Driven Modeling, Optimization, Scheduling (II)	ADP and RL Based Learning Control (II)	Poster Session (II)
10:50-11:30	Lecture 5: Designs of Network Architectures and Optimization Algorithms Based on Neural Differential Equations, Prof. Long Jin, Chair: Prof. Xuhui Bu							
11:30-12:10								
12:10-13:30	Lunch							
Time/Room	Yangguang Hall	Changle Hall	Langyue Hall	Xinghui Hall	Meixue Hall	Guibin Hall		
13:30-15:30	SunC01	SunC02	SunC03	SunC04	SunC05	SunC06		
13:30-15:30	IS: Data-Driven Adaptive and Learning Control and Applications for Unmanned Systems (I)	IS: Intelligent Control and Cooperative Strategies for Complex Systems	IS: Data-Driven Fault Diagnosis, Monitoring, and Control for Industrial Systems	Statistical Learning and Machine Learning in Automation Field	Applications of Data-Driven Methods to Industrial Processes (I)	Complex Systems and Artificial Intelligence (I)		
15:30-15:40	Tea Break							

Time/Room	Yangguang Hall	Changle Hall	Langyue Hall	Xinghui Hall	Meixue Hall	Guibin Hall
15:40-17:40	SunD01	SunD02	SunD03	SunD04	SunD05	SunD06
15:40-17:40	IS: Data-Driven Adaptive and Learning Control and Applications for Unmanned Systems (II)	IS: Data-Driven Control and Learning of Multi-Agent Systems	Advanced Data Driven Algorithms for Complex Process	Applications of Data-Driven Methods to Industrial Processes (III)	Applications of Data-Driven Methods to Industrial Processes (II)	Complex Systems and Artificial Intelligence (II)
18:00-20:00	Closing Ceremony and Banquet, Chair: Prof. Dong Shen					
Monday, May 11, 2026, Jishou University, Jishou (吉首 吉首大学)						
Time/Room	Jishou University					
8:30-12:00	Exchange on Cutting-Edge Technologies and Academic Development					

Room	Room in English	Location	Location in English	Room	Room in English	Location	Location in English
大宴会厅	Grand Hall	湘泉阳光酒店二楼	The 2st floor of the Xiangquan Sunshine Hotel	锦绣厅	Jinxiu Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine
如意厅	Ruyi Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine Hotel	阳光厅	Yangguang Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine
长乐厅	Changle Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine Hotel	朗月厅	Langyue Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine
星辉厅	Xinghui Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine Hotel	美学厅	Meixue Hall	湘泉阳光酒店四楼	The 4st floor of the Xiangquan Sunshine
贵宾厅	Guibin Hall	湘泉阳光酒店二楼	The 2st floor of the Xiangquan Sunshine Hotel	宴会厅前厅	Front Hall	湘泉阳光酒店二楼	The 2st floor of the Xiangquan Sunshine

二层宴会厅平面布置图



四层会议室平面布置图