ICMIC2025

2025 International Conference on Modelling, Identification and Control

PROGRAM

Qingdao, China
June13–15,2025

FINAL PROGRAM

2025 International Conference on Modelling, Identification and Control (ICMIC 2025)

Qingdao, China

June 13-15, 2025

Organized by

Qingdao University of Science and Technology

Sponsored by

College of Automation and Electronic Engineering,
Qingdao University of Science and Technology

Key Laboratory of Knowledge Automation for Industrial Processes of
Ministry of Education, University of Science and Technology Beijing

Big Data System and Simulation Committee of China Simulation Federation

Beijing Key Laboratory of Future City Artificial Intelligence Metrology Technology

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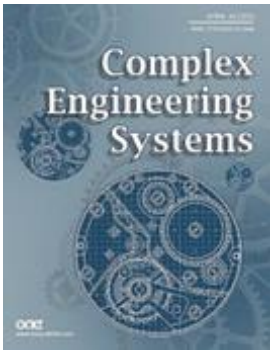

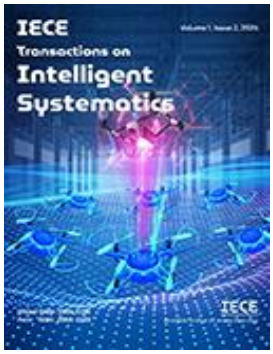

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ICMIC 2025
Qingdao, China 中国・青岛
2025.6.13-6.15

Friday, June 13, 2025, Qingdao Blue Horizon Hotel 青岛蓝海大饭店		
10:00 – 20:00	**Onsite Registration 现场签到注册**	
	Young Scientist Forum 青年科学家论坛 —— Venue: Bei Hai Hall 地点：北海厅 Chairs: Qiang Chen, Shubo Wang, Yang Liu	
13:00 - 13:15	**Welcome Speech and Group Photo 开场致辞与合影**	
13:15 – 13:45	**Talk 1**: Understanding Control Theory from the Perspective of Similarity: A Case Study on Adaptive Iterative Learning Control, **Prof. Ronghu Chi**	
13:45 – 14:15	**Talk 2**: Nonlinear Analysis of Frictional Jointed Beams with Dynamic Vibration Absorber, **Prof. Baiyang Shi**	
14:15 – 14:45	**Talk 3**: Some Studies on Data-Driven Control of Networked Systems, **Prof. Zhen Wang**	
14:45 - 15:15	**Talk 4**: A Preliminary Study on Data-Driven Control of Switched Systems, **Prof. Yanzheng Zhu**	
15:15 – 15:40	**Coffee Break 茶歇**	
15:40 - 16:10	**Talk 5**: Modeling and Optimal Control of Industrial Cyber-Physical Systems Driven by Explainable Artificial Intelligence, **Prof. Xiangpeng Xie**	
16:10 – 16:40	**Talk 6**: Intelligent Swarm Cooperation of Unmanned Systems Based on Human-in-the-Loop, **Prof. Hongjing Liang**	
16:40 – 17:10	**Talk 7**: Synchronous Learning and Planning Strategies for Redundant Robots, **Prof. Long Jin**	
17:10 – 17:40	**Talk 8**: Identification and State Estimation for a Class of Nonlinear Systems, **Prof. Xiao Zhang**	
	Invited Sessions Organized by Qingdao University of Science and Technology	
	Room 1 —— Bo Hai Hall (渤海厅)	**Room 2 —— Huang Hai Hall (黄海厅)**
13:45-15:15	**FRIA01**	**FRIA02**
	Intelligent System Modeling and Adaptive Control Methods I Chair: Fangkun Zhang	**Intelligent Perception and Visual Computing for Various Applications I** Chair: Zidong Ai
15:15-15:40	**Coffee Break 茶歇**	
15:40-17:10	**FRIB01**	**FRIB02**
	Intelligent System Modeling and Adaptive Control Methods II Chair: Xiaoqian Mao	**Intelligent Perception and Visual Computing for Various Applications II** Chair:Xianjun Zhang
18:00-20:00	**Dinner 晚餐 —— Location: Aegean Sea cafeteria 地点：爱琴海自助餐厅**	

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Session 2: Intelligent Control and Optimization Strategies
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Chair: Jianhua Zhang</td><td>AI-Powered Perception, Sensing, and Path Planning in Intelligent Environments I
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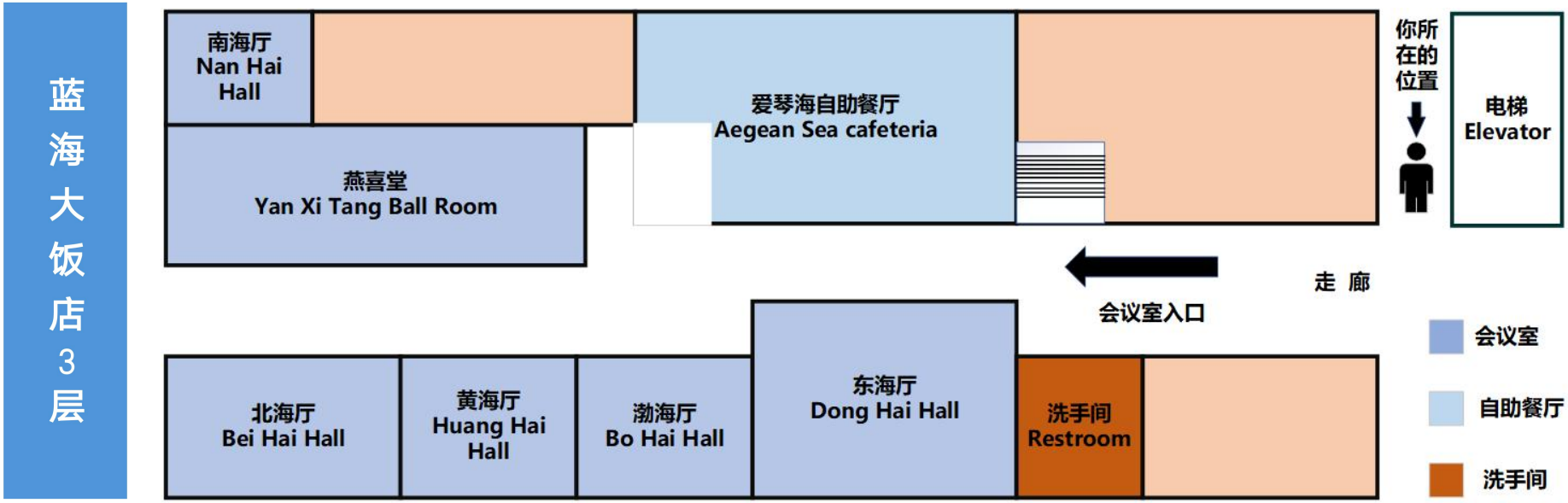
8:30-9:15	**Plenary Talk 4**: Distributed Model Predictive Control for CPS under Complex Temporal Logic Tasks, **Prof. Yuanyuan Zou, Chair: Prof. Ronghu Chi**
9:15-10:00	**Plenary Talk 5**: Control of Nanopositioning Systems – My journey thus far! **Prof. Sumeet S. Aphale, Chair: Prof. Jing Na**
10:00-10:20	**Coffee Break 茶歇**
10:20-11:05	**Plenary Talk 6**: Energy Management and Coordinated Control of Long-Endurance Flying Car Hybrid Power Systems, **Prof. Yue Ma, Chair: Prof. Qiang Chen**
11:05-11:50	**Plenary Talk 7**: Carbon Capture, Utilization and Storage (CCUS) Full-Chain Optimization, **Prof. Dongya Zhao, Chair: Prof. Feng Ding**
11:50-12:10	**Closing Ceremony 闭幕式**
12:10-14:00	**Lunch 午餐 —— Venue: Aegean Sea cafeteria 地点：爱琴海自助餐厅**

会场所在楼层平面图



Welcome Address from General Chairs 欢迎辞

Shaoyuan Li
General Chair of ICMIC 2025

Quanmin Zhu
General Chair of ICMIC 2025

Dear Friends and Colleagues,

On behalf of the Organizing Committee, we warmly welcome all of you to attend the 2025 International Conference on Modelling, Identification and Control (ICMIC 2025), in Qingdao, China, June 13-15, 2025. This is a small scale, cosy, and professional series conference to promote, beginning researchers, to progress in academic research, collaboration, and career development, along the route following the most conventional international conferences.

Historically ICMIC started from Shanghai Jiaotong University, China in 2008. Since then it has been hosted by Okayama University, Japan (2010), Shanghai Jiaotong University, China (2011), Huazhong University of Science and Technology and Wuhan University of Science and Technology (2012), Caro University, Egypt (2013), Swinburne University of Technology, Australia (2014), University of Al Qayrawan, Tunisia (2015), University of MEDEA, Algeria (2016), Kunming University of Science and Technology, China (2017), Guizhou University, China (2018), Civil Aviation University of China, China (2019). Although it has been paused for a while due to the unexpected Covid-19, we finally made it to run again in Datong last year, where ICMIC 2024 was successfully organized by North University of China and Shanxi Datong University together. Fundamentally, we have achieved what we setup with MIC (Mission, Integration and Connection) targets, in promoting young participants from many countries; inviting senior colleagues to deliver plenary speeches, guide presentations, and encourage research progression; promoting academic/industry exchanges; building up research collaboration networks. Surely the events also have provided opportunities for participants to visit local history, heritage, and natural surroundings. We do believe that many of us have benefited from such local culture visits.

The 17th International Conference on Modelling, Identification and Control (ICMIC 2025) is sponsored by Qingdao University of Science and Technology, University of Science and Technology Beijing, China, Big Data System and Simulation Committee of China Simulation Federation, and Beijing Key Laboratory of Future City Artificial Intelligence Metrology Technology. It provides an international forum for professionals, academics, and researchers over the world to present latest developments from interdisciplinary theoretical studies, computational algorithm developments and applications. Different from last year, the accepted papers of ICMIC2025 are not only from China, but also from some foreign countries as well. Furthermore, the whole process of the organization,

operations, and etc has well reflected the international participations from UK, Italy, Canada, USA, Singapore, Brazil, Pakistan, Saudi Arabia, Greece, Germany, Iran, and so on. The Technical Program Committee (TPC) has organized all submissions reviewed and the finally accepted papers have been assigned in 10 oral sessions and 3 poster sessions for presentation.

We would like to thank our Organizing Committee for its invaluable assistance in arranging the diverse offerings at the conference, from registration, local arrangements to technical programs. We would also like to thank the local organizer, Qingdao University of Science and Technology, for its great support. We thank all of colleagues for your long-lasting and strong support, without these, the success of ICMIC events is not possible. We are grateful to our friends and family members who have helped with the conferences directly or indirectly, one way or another.

It is our great honour to have the opportunity to thank all the organizers and numerous researchers worldwide who have helped to review and comment the submitted papers.

We will continue to organize ICMICs around the world, and welcome to follow our permanent conference website (http://www.icmic-conf.com) for the latest news about us.

Once again welcome to the conference ICMIC2025, Qingdao University of Science and Technology, the city of Qingdao, and the country of China. We wish you a fruitful, rewarding, enjoyable and memorable conference.

Professor Shaoyuan Li
General Chair of ICMIC 2025
Vice-President of Qingdao University of Science and Technology,
No.99 Songling Road, Qingdao, Shandong, P.R.China, 260061

Professor Quanmin Zhu
General Chair of ICMIC 2025
School of Engineering
University of the West of England
Cold harbour Lane, Bristol BS16 1QY UK

June 2025

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Ni Bu	**Xue Lin**
Yanmei Hu	**Sihong Li**
Yingrui Zhou	**Yingying Zhang**

Accommodation and Venue 住宿与会场

Blue Horizon Hotel（青岛蓝海大饭店）

酒店地址/Address:

No.9-2 Miaoling Road, Laoshan District, Qingdao, Shandong 266101, China.

（青岛崂山区苗岭路 9-2 号, 266101）

住宿标准/Accommodation fee: 450 RMB per room per night (450 元/间·晚)

ICMIC2025 的全部会议活动均在青岛蓝海大饭店举行，包括青年论坛、大会报告、分组报告及晚宴。

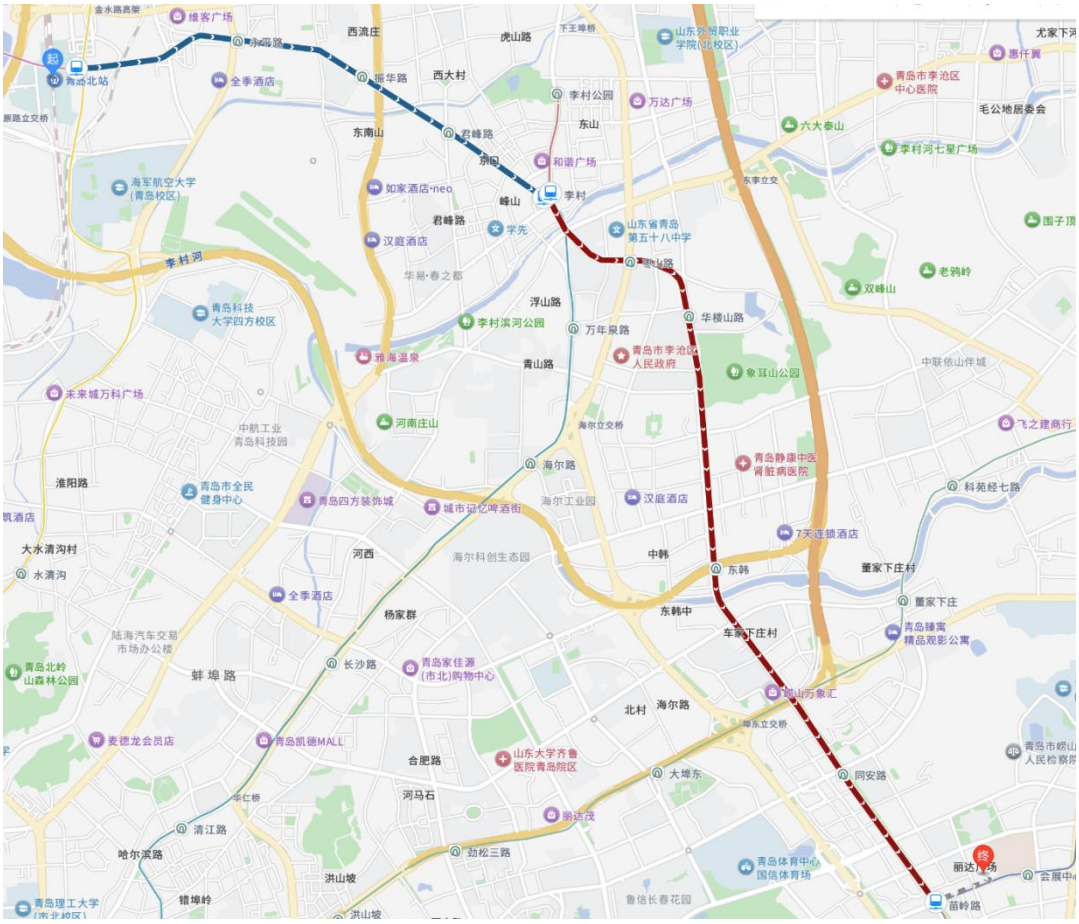
All conference activities of ICMIC 2025 will be held at Qingdao Blue Horizon Hotel, including the Youth Forum, plenary sessions, oral sessions, poster sessions and the banquet.

Transportation Information 交通信息

1、Qingdao North Railway Station → Qingdao Blue Horizon Hotel Laoshan

青岛北站→ 蓝海大饭店（崂山店）

Route 1**:** Public transport
Route: From the exit of the **Qingdao North Station**, it is a 947-meter walk to the subway station. Take the subway Line 3. After four stops, get off at **LiCun Station.** Walk 148 meters inside the station, transfer to Line 2. After six stops, get off at **MiaoLingLu Road Station**. Exit through the B entrance and walk 800 meters to reach **Qingdao Blue Horizon Hotel Laoshan**.
Ticket price: 4 yuan.
Distance: About 16 km
Time: About 45 minutes
路线 1：公共交通
路线：**青岛北站**下车站内步行 947 米到地铁站，乘坐地铁三号线，乘坐四站，**李村站**下车，站内步行 148 米，换乘二号线，乘坐六站，**苗岭路站**下车，从 B 口出，步行 800 米到达**蓝海大饭店（崂山店）**。
票价：4 元
距离：约 16 公里
时间：约 45 分钟



Route 2: Taxi or Express Saver

Directions: From **Qingdao North Station**, follow the station signs to reach the **East Square** or the **West Square**. Then, follow the instructions to take a taxi at the taxi area and get off at the **Qingdao Blue Horizon Hotel Laoshan**.

Ticket price: about 50 yuan or 24 yuan

Distance: About 16 km

Time: About 27 minutes

路线 2：出租车 或 特惠快车

路线：从**青岛北站**按照车站路标指引前往**东广场**或者**西广场**，按照指引到出租车区域乘坐出租车，在**蓝海大饭店（崂山店）**下车

票价：约 50 元 或 24 元

距离：约 16 公里

时间：约 27 分钟

2、Qingdao Railway Station → Qingdao Blue Horizon Hotel Laoshan

青岛站→ 蓝海大饭店（崂山店）

Route 1**:** Public transport

Route: Take Metro Line 3 from **Qingdao Railway Station** (**heading towards Qingdao North Railway Station**), get off at **Wusi Square Station** after 6 stops, then transfer to Metro Line 2 (**heading towards Licun Park**) inside the station, get off at **Miaoling Road Station** after 9 stops (Exit B), and walk 740 meters to destination.

Ticket price: 4 yuan.

Distance: About 17.5 km

Time: About 50 minutes

路线 1：公共交通

路线：从**青岛站站内**乘坐地铁 3 号线（**青岛北站方向**），经过 6 站到**五四广场站，站内换乘**地铁 2 号线（**李村公园方向**），经过 9 站到**苗岭路站**（B 口出站），步行 740 米到目的地。

票价：4 元

距离：约 17.5 公里

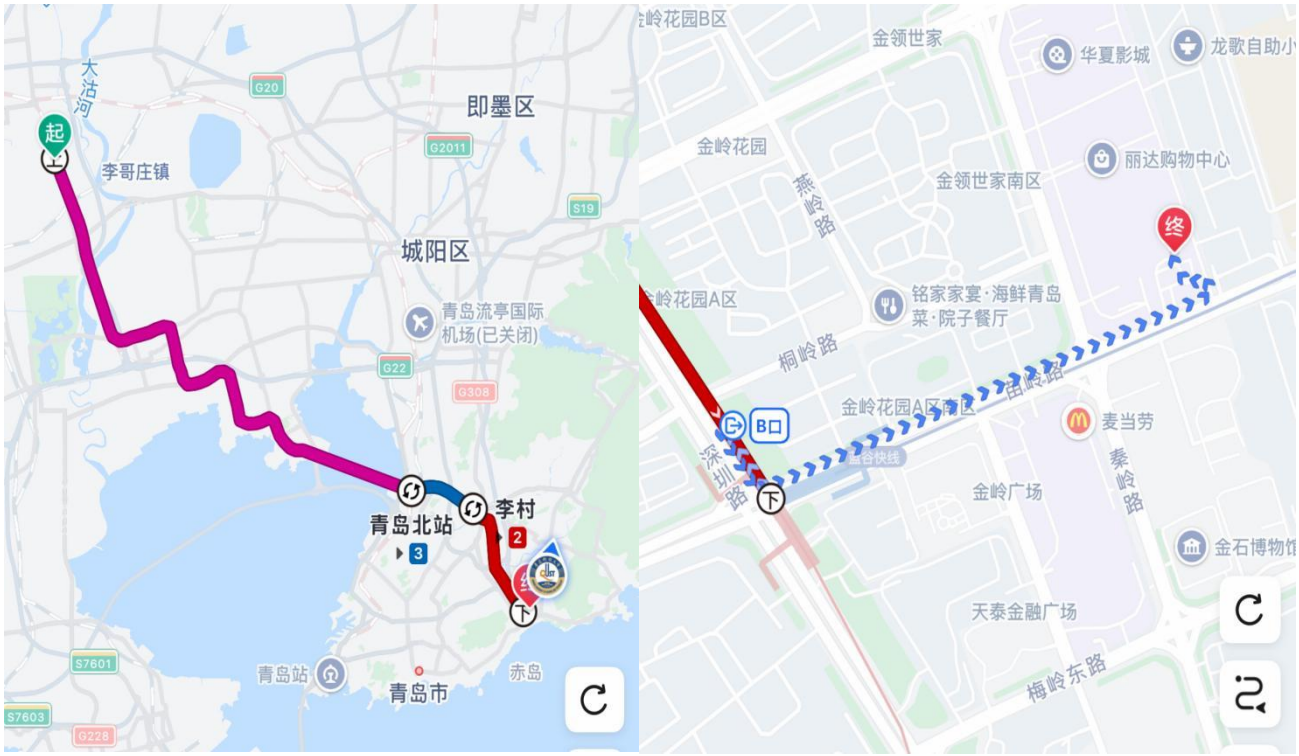
时间：约 50 分钟

Route 2: Taxi or Express Saver
Directions: Take a taxi from the exit of **Qingdao Railway Station** according to the signpost and get off at **Qingdao Blue Horizon Hotel Laoshan**
Ticket price: about 60 yuan or 25 yuan
Distance: About 17 km
Time: About 30 minutes
路线 2： 出租车 或 特惠快车
路线：从**青岛站**按照路标指引乘坐出租车，在**蓝海大饭店（崂山店）**下车。
票价：约 60 元 或 25 元
距离：约 17 公里
时间：约 30 分钟

3、Qingdao Jiaodong International Airport→Qingdao Blue Horizon Hotel Laoshan

青岛胶东国际机场→ 蓝海大饭店（崂山店）

Route 1: Public transport
Route:Take Metro Line 8 at the airport (towards **Qingdao North Railway Station**), ride for 9 stops to **Qingdao North Railway Station**. Transfer to Line 3 (towards **Qingdao Railway Station**) and take 4 stops to **Licun Station**. Then transfer to Line 2 and ride for 6 stops to **Miaoling Road Metro Station**. Finally, walk 800 meters to reach **Blue Horizon Hotel Laoshan**
Ticket price: 7 yuan
Distance: About 56 km
Time: About 90 minutes
路线 1：公共交通
路线：在机场乘坐地铁 8 号线（**青岛北站**方向），乘坐 9 站到达**青岛北站**换乘 3 号线（**青岛站**方向），然后坐 4 站到**李村站**，之后换乘 2 号线乘坐 6 站到达苗岭路地铁站后，步行 800 米到达**蓝海大饭店（崂山店）**。
票价：7 元
距离：约 56 公里
时间：约 90 分钟



Route 2: Taxi or Express Saver
Directions: Take a taxi from the exit of **Qingdao Jiaodong International Airport** according to the airport signs and get off at **Qingdao Blue Horizon Hotel Laoshan**.
Ticket price: about 76 yuan
Distance: About 56 km
Time: About 49 minutes

路线 2： 出租车 或 特惠快车
路线：**从青岛胶东国际机场**按照机场路标指引乘坐出租车，在**蓝海大饭店（崂山店）**下车。
票价：约 248 元 或 85 元
距离：约 56 公里
时间：约 49 分钟

Plenary Talks 大会报告

Plenary Talk 1

Control Engineering in Future Highly Automated Society

Prof. Wen-Hua Chen, FIEEE, CEng, FIMechE, FIET
Department of Aeronautical and Automotive Engineering
Loughborough University, Loughborough, Leicestershire, UK

Saturday, June 14, 2025
9:00-9:50
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

Driven by the need of further increasing productivity and improving well-being and enabled by recent developments in AI and other digital technologies, we are moving into an era of highly automated society. Among others, autonomous driving, unmanned aviation, healthcare robots and automatic trading, are hot topics in media and daily discussion. Are we ready? Are they safe? Will it still play a similar role in future high levels of automation, or be replaced by AI or other technologies? This talk aims to trig more debates and discussion along these lines, particularly exploring the role of control engineering in future automated economy. It argues feedback is fundamental to high levels of automation, and control theories are essential in understanding not only the interactions between key functions like perception and decision making/planning in robotics and autonomous systems, but also on their interactions with environment and human. Furthermore, the current control theories could not provide effective analysis and design tools for future highly automated automation empowered by embedded AI functions and much more research is required.

Biography

Prof. Wen-Hua Chen holds Professor in Autonomous Vehicles in the Department of Aeronautical and Automotive Engineering at Loughborough University, UK. Prof. Chen has a considerable experience in control, signal processing and artificial intelligence and their applications in aerospace, automotive and agriculture systems. In the last 20 years, he has been working on the development and application of unmanned aircraft system and intelligent vehicle technologies, spanning autopilots, situational awareness, decision making, verification, remote sensing for precision agriculture and environment monitoring. He is a Chartered Engineer, and a Fellow of IEEE, the Institution of Mechanical Engineers and the Institution of Engineering and Technology, UK. Recently Prof Chen was awarded a 5 years EPSRC (the Engineering and Physical Sciences Research Council) Established Career Fellowship in developing new control theories for next generation of control systems enabled by AI.

Plenary Talk 2

Seawater Heat Pumps (SWHPs) in 5G District Heating and Cooling (DHC) Systems

Prof. Wenjian Cai
College of Automation and Electronic Engineering
Qingdao University of Science and Technology, Qingdao, China

Saturday, June 14, 2025
10:10-11:00
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

Seawater Heat Pump (SWHP) Systems utilize seawater as a thermal energy source to enhance energy efficiency in heating, cooling, and industrial applications, serving as a critical technological pathway for achieving carbon neutrality in coastal regions. SWHP systems boast high efficiency, low-carbon operation, and sustainable characteristics, demonstrating broad application prospects as a key field for industrial-scale implementation and facilitating the transformation between traditional and new energy paradigms. However, it faces several critical technical challenges including the dynamic marine environment, frequent equipment maintenance requirements, and the need for integrated, intelligent utilization solutions. This report aims to establish a high-efficiency, safe and intelligent SWHP system that fully harnesses the potential of seawater as a renewable heat source. The goal is to create a new generation of low-carbon, smart and replicable district heating/cooling solutions, thereby providing crucial support for achieving China's "Dual Carbon" goals and implementing its clean energy strategy.

Biography

Prof. Wenjian Cai received his PhD degree from Oakland University, U. S. A., in 1992. He was a tenured professor and Director of ACMV Research Lab at Nanyang Technological University of Singapore and currently serves as Professor at Qingdao University of Science and Technology. His research has been focused on process control and optimization with applications to environment and energy fields. His research work resulted in 5 monographs, over 10 patents and more than 300 international journal and conference papers. He participated in many industries related research projects, secured more than $20 million research grants from government agencies and industries, and received three national and two international awards. Due to his expertise in the field, he was elected as fellow of Institution of Engineering Singapore (IES) and served for Singapore Government as member of APEC Environmental Technology Verification Programme Committee; the first writer for drafting the White Paper on road map of Singapore Green Building Development; and member of national ACMV standard Committee on Passive Displacement Cooling technologies. In addition, he was the chair of IEEE Singapore Industrial Electric and Electronics Chapter from 2010 to 2012 and has been invited to serve as Chair and other positions for IEEE International Conferences many times.

Plenary Talk 3

Control of Cyberphysical Systems with Prescribed Performances under DoS Attacks

Prof. Jawhar Ghommam
College of Engineering
Sultan Quaboos University, Al Khoudh, Muscat, Oman

Saturday, June 14, 2025
11:00-11:50
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

As the backbone of critical infrastructure, Cyber-Physical Systems (CPS) are increasingly vulnerable to cyber threats, with Denial-of-Service (DoS) attacks emerging as a prominent challenge. This talk will delve into the fundamentals of DoS attacks, which overwhelm system resources to disrupt operations, and their implications for CPS security. We will explore various modeling techniques, from random to periodic attack patterns, and their impact on system performance. Countermeasures, including adaptive detection mechanisms and resilient control strategies, will be discussed, offering insights into future-proofing CPS against such threats. Join us to uncover the evolving dynamics of DoS attacks and innovative defenses designed to protect the integrity and functionality of CPS.

Biography

Prof. Jawhar Ghommam has got his B.Sc. degree in Computer and Control Engineering from the National Institute and Applied Sciences and Technology (INSAT) in 2003 in Tunis. He has got his DEA (M.Sc.) degree from the University of Montpelier at the Laboratoire d'Informatique, Robotique et Micro-électronique (LIRMM, France) in 2004 and later on in 2008 a Ph.D in Control Engineering degree jointly from the National Engineering School of Sfax and the university of Orleans. From 2008 to 2017, he was with the National Institute of Applied Sciences and Technology, where he held a tenured Associate Professor at the Department of Physics and Instrumentation. In January 2018, he joined the Department of Electrical and Computer Engineering at Sultan Qaboos University in Oman. He is a member of the Control and Energy Management Lab and also an Associate Researcher at the GREPCI-Lab, Ecole de Technologie Superieure, Montreal,QC, Canada. His research interests include fundamental motion control concepts for nonholonomic/underactuated vehicle systems, nonlinear and adaptive control, intelligent and autonomous control of networked unmanned systems, team cooperation, consensus achievement, and sensor networks. He serves as a regular referee and associate editor for many international journals in the field of Control and Robotics.

Plenary Talk 4

Distributed Model Predictive Control for CPS under Complex Temporal Logic Tasks

Prof. Yuanyuan Zou
Department of Automation
Shanghai Jiaotong University, Shanghai, China

Sunday, June 15, 2025
8:30-9:15
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

Cyber-Physical Systems (CPS) are complex systems that integrate computation, networks, and physical environments. As the application scenarios for CPS continue to expand, these systems are increasingly expected to execute complex temporal logic tasks. These tasks must consider the continuous dynamic behavior of physical systems while meeting logical requirements, such as execution order and action conditions, as well as temporal requirements like duration, time points, and switching periods. The introduction of temporal logic tasks impacts the control performance of CPS. Additionally, subsystems exhibit more complex spatio-temporal coupling relationships, which also pose significant challenges to CPS coordination strategy design. This report addresses the control challenges of CPS under temporal logic tasks, exploring effective distributed model predictive controller design and coordination strategies. It highlights recent research advancements in areas such as task reconfiguration in the presence of conflicting temporal logic tasks, as well as the design of robust distributed controllers under uncertainties.

Biography

Prof. Yuanyuan Zou is a Professor with the Department of Automation, Shanghai Jiao Tong University, and has been selected for the National High-Level Talent Program's Youth Project. Her primary research focuses on optimization control for industrial systems, distributed predictive control, and related areas. She has published over 100 papers, authored an English monograph, and holds more than 10 authorized invention patents. She has led over 10 projects, including those funded by the National Natural Science Foundation of China and the Ministry of Science and Technology's key R&D programs. She has received several awards, including the First Class for Shanghai Science and Technology Progress Award and the First Class for Natural Science Prize of Chinese Association of Automation (CAA). Currently, she serves as the Secretary-General of CAA Predictive Control and Intelligent Decision-Making Committee, an Executive Committee Member of CAA Process Control Committee, and an editorial board member for journals such as IET Control Theory & Applications, Proceedings of the IMechE Part I: Journal of Systems and Control Engineering, and Digital Chemical Engineering.

Plenary Talk 5

Control of Nanopositioning Systems – My journey thus far!

Prof. Sumeet S. Aphale, CEng, SMIEEE
Director - Artificial Intelligence, Robotics and Mechatronic Systems Group (ARMS)
Programme Coordinator - MSc Industrial Robotics, MSc Robotics & AI
Equality, Diversity and Inclusion Lead
School of Engineering, University of Aberdeen, Aberdeen, Scotland, UK

Sunday, June 15, 2025
9:15-10:00
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

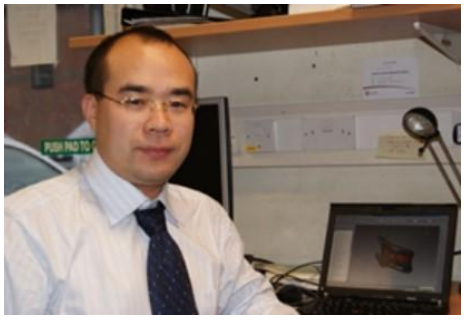
One of the research themes I have been working on for close to two decades the is control of nanopositioning systems. Though they are at the high-end of technology – being able to accurately position matter within a few nanometers – they are really nice 'candidate' systems to design new control schemes on. The reason is that they can be as simple (a second-order mass-spring-damper system) or as complex (infinite order resonant system with hysteresis and creep nonlinearities) as you want them to be! My foray into the control of these systems has led to establishing a new and popular controller for system resonances – the Integral Resonant Control – as well as several designs and optimizations for combined damping and tracking control schemes. On the side, I have also dabbled with robust control, sliding-mode control, repetitive control and suchlike – but found them to be either too finicky or too complex to be of great practical value for this application. After exhausting relevant integer-order controllers, I am currently focused on devising new fractional-order control schemes, with significant potential of impacting a wide range of technological systems. This talk will give a brief of my journey in this wide-impact area and end with introducing some problems I need help with.

Biography

Prof. Sumeet S. Aphale (Ph.D., SMIEEE, CEng, MIET) is a Chaired Professor and the Director of the Artificial Intelligence, Robotics, and Mechatronic Systems (ARMS) Group at the School of Engineering, University of Aberdeen, UK. His research specializes in the development of advanced modeling and control strategies for precision engineering applications, with a focus on active vibration control systems, high-performance nanopositioning systems, and both conventional and unconventional robotic systems. His research has been published in over 130 publications in peer-reviewed journals and conference proceedings, earning several Best Paper awards and nominations. His expertise has been recognised via invited Associate Editor roles for prestigious journals such as IEEE Control Systems Letters, Frontiers in Mechanical Engineering (Mechatronics), and as part of the IEEE CSS Conference Editorial Board (CEB).

Plenary Talk 6

Energy Management and Coordinated Control of Long-Endurance Flying Car Hybrid Power Systems



Prof. Yue Ma
Deputy Director of the National Key Laboratory for Multi-Perch Propulsion Systems
School of Mechanical Engineering,
Beijing Institute of Technology (BIT), Beijing, China

Sunday, June 15, 2025
10:20-11:05
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

The electrification, intelligence and three-dimensionality of transport has gradually become the industry consensus. Flying cars and electric vertical take-off and landing vehicles (eVTOLs), which are representative platforms for air-to-ground transportation, are also coming into view. The heavy-load and long-endurance flying car must employ the hybrid power system technology with the turboshaft engine as the core of the main power source, achieving high energy density of the fuel conversion of thermal energy and the rapid response, to break through the user's concern about the power mileage. However, unlike conventional aircraft, flying cars and electric vertical take-off and landing vehicles need to cope with the changing traffic conditions of urban traffic, and their power systems often operate at non-rated operating points, with frequent and large speed and load changes.

Biography

Prof. Yue Ma is the Distinguished Professor of Beijing Institute of Technology (BIT), Beijing, China. He obtained his BEng and MSc degree in vehicle engineering from BIT in 1999 and 2002, respectively. In 2010, he obtained his PhD degree at Bristol Robotics Laboratory in University of the West of England, UK. He serves as the Deputy Director of the National Key Laboratory for Multi-Perch Propulsion Systems. He has led numerous major and key projects, published two monographs, and authored over 80 academic papers. He has received one National Technological Invention First Prize and multiple provincial and ministerial-level awards. In terms of academic roles, he serves as a member of the Electromechanical, Human, and Environmental Division of the Chinese Society of Aeronautics and Astronautics, a member of the Intelligent Aerospace Systems Professional Committee of the Chinese Association for Artificial Intelligence, and a member of the Artificial Intelligence Simulation Technology Professional Committee of the Chinese Society for Simulation.

Plenary Talk 7

Carbon Capture, Utilization and Storage (CCUS) Full-Chain Optimization

Prof. Dongya Zhao
College of New Energy,
China University of Petroleum (East China) (UPC), Qingdao, China

Sunday, June 15, 2025
11:05-11:50
Yan Xi Tang Ball Room
蓝海大饭店燕喜堂

Abstract

Carbon dioxide emission reduction constitutes a national priority in China's dual-carbon strategic agenda. Carbon Capture, Utilization and Storage (CCUS) technology, serving as a pivotal decarbonization pathway, demonstrates dual functionalities in enhancing oil recovery and enabling large-scale carbon sequestration. However, its industrial deployment faces critical technical constraints from complex surface engineering systems.

This presentation delineates an integrated optimization methodology for CCUS surface infrastructure. Through systematic integration of system-level techno-economic modeling framework with robust optimization protocols and stochastic programming methodologies, the proposed approach successfully overcomes key technical barriers including intricate energy-mass flow coupling mechanisms, stringent operational constraints, and highly non-convex/nonlinear characteristics inherent in CCUS surface systems.

Biography

Prof. Dongya Zhao is a Professor with the College of New Energy, China University of Petroleum (East China). His research interests include the full-chain surface engineering of CCUS, process modeling and control, and nonlinear system control and analysis. He has undertaken six national-level research projects, published over 100 academic papers, authored two specialized monographs, and received multiple provincial/ministerial-level honors including the Second Prize of Science and Technology Progress Award from the Ministry of Education. In terms of academic appointments, he serves as Deputy Director of the Working Committee on Inspection of Hazardous Chemicals Atmospheric Pressure Vessels under China Association for Special Equipment Inspection, Member of the Technical Committee on Predictive Control and Intelligent Decision-Making under Chinese Association of Automation, and Associate Editor for both Journal of Mathematical Control and Information and International Journal of Modelling, Identification and Control.

Young Scientist Forum 青年科学家论坛

Young Scientist Talk 1

Understanding Control Theory from the Perspective of Similarity: A Case Study on Adaptive Iterative Learning Control

Prof. Ronghu Chi
College of Automation and Electronic Engineering,
Qingdao University of Science and Technology, Qingdao, China

Friday, June 13, 2025
13:15 - 13:45
Bei Hai Hall
蓝海大饭店北海厅

Abstract

This presentation approaches the topic from the perspective of similarity learning, reporting the development process of adaptive iterative learning control (ILC), along with its connections and mutual inspiration with adaptive control. Furthermore, it introduces a data-driven dynamic linearization method—first of its kind in China—and elaborates on its extensions to iterative learning control tasks and multi-agent network topologies. The essential similarities among these methods are highlighted, leading to a unified framework for the design and analysis of adaptive ILC based on data-driven dynamic linearization.

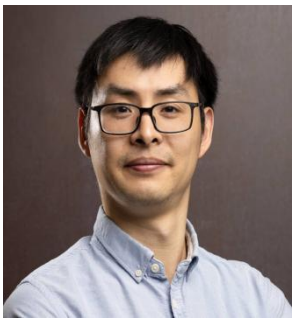
From the speaker's point of view, the core of scientific creativity lies in understanding problems at their essence, identifying them through similarity, extending them from fundamental principles, and solving them from new perspectives. Driven by this philosophy, the talk also presents advancements in data-driven dynamic linearization for controller design based on performance indices and for automatic parameter tuning, as well as methods that enhance local controller performance through desired-point learning and optimization.

Biography

Prof. Ronghu Chi is a Professor with Qingdao University of Science and Technology, Ph.D. supervisor, and Senior Member of IEEE and CAA. He received his Ph.D. degree from Beijing Jiaotong University in 2007. He serves as Program Chair of the IEEE DDCLS Conference and Vice Chair of the Technical Committee on Data-Driven Control, Learning, and Optimization of the Chinese Association of Automation (CAA), among other academic positions. He has led over 20 research projects, including those funded by the National Natural Science Foundation of China. He has published over 100 academic papers, authored two English monographs, and holds more than 10 granted invention patents. He has received several awards, including the CAA Natural Science Award and the Henan Science and Technology Progress Award. His research interests include data-driven control, adaptive and learning systems, and distributed control.

Young Scientist Talk 2

Nonlinear Analysis of Frictional Jointed Beams with Dynamic Vibration Absorber



Dr. Baiyang Shi
Department of FET - Engineering, Design and Mathematics,
University of the West of England, UK

Friday, June 13, 2025
13:45 - 14:15
Bei Hai Hall
蓝海大饭店北海厅

Abstract

This study investigates the effectiveness of inerter-based dynamic vibration absorbers (IDVAs) in suppressing vibrations within beam structures incorporating frictional joint. The governing equations are derived using the finite element method and subsequently reduced to a set of second-order ordinary differential equations via the Galerkin method. The system dynamics are analysed using the harmonic balance method with alternating frequency/time domain (HB-AFT) and the Runge-Kutta method. Several IDVA configurations are proposed, and their dynamic performance is systematically compared. The influence of varying the limit friction force on the dynamic response and energy redistribution is examined. Additionally, the study emphasizes the critical role of attachment location of the IDVA, demonstrating its substantial effect on vibration suppression and power flow along the beam. The results offer deeper insight into the behaviour of inerter-based absorbers in continuous structures and provide a foundation for their application in engineering domains such as marine shaft systems, bridge structures, and civil infrastructure.

Biography

Dr. Baiyang Shi is a Lecturer at the University of the West of England (UWE), UK. He is a Member of the Institution of Mechanical Engineers (IMechE) and a Fellow of the Higher Education Academy (HEA) in the UK. His research focuses on nonlinear dynamics, vibration control, and uncertainty quantification in complex engineering systems. He has published over ten SCI-indexed papers as first or corresponding author in leading international journals such as the International Journal of Mechanical Sciences, Nonlinear Dynamics, and Ocean Engineering, with total citations exceeding 300. He is the principal investigator of a UWE Vice-Chancellor's Early Career Researcher Development Fund project and has also participated in several research projects funded by the National Natural Science Foundation of China (NSFC).

Young Scientist Talk 3

Some Studies on Data-Driven Control of Networked Systems

Prof. Zhen Wang
College of Mathematics and Systems Science,
Shandong University of Science and Technology, Qingdao, China

Friday, June 13, 2025
14:15 - 14:45
Bei Hai Hall
蓝海大饭店北海厅

Abstract

With the deep integration of information technology and control theory, networked control systems have been widely applied in areas such as industrial automation, intelligent manufacturing, and unmanned systems. However, challenges such as difficulties in accurately modeling the controlled plant or the high complexity of its dynamics have posed significant limitations to traditional model-based control methods in practical applications. To address these challenges, data-driven control approaches—characterized by low reliance on system models and strong robustness—have emerged as a research hotspot in the field of networked systems control. This presentation focuses on data-driven control for networked systems, exploring how to design controllers and analyze performance using input/output data in the absence of explicit system models. Special emphasis is placed on stability and convergence under complex communication conditions such as delays, packet losses, and cyberattacks. The goal of this research is to provide both theoretical support and practical references for data-driven control in networked systems.

Biography

Prof. Zhen Wang has been working on the interdisciplinary areas of networked systems theory, cyber security, and data-driven control. He has published over 100 papers as first or corresponding author in top-tier journals such as Science China, IEEE TNNLS, IEEE TSMC, IEEE TCS-I, IEEE TASE, IEEE TIFS, IEEE TCNS, and IEEE TNSE. Two of his papers were selected as “China’s Top 100 Most Influential International Academic Papers.” He has received the Second Prize of the Shandong Provincial Higher Education Outstanding Scientific Research Achievement Award and the Second Prize of the Qingdao Natural Science Award. He has led two NSFC general projects, one general project funded by the Shandong Provincial Natural Science Foundation, and more than 30 other projects as principal investigator or key participant. He currently serves as a committee member of the TC on Fractional Order Systems and Control, TC on Network Science and Engineering, and TC on Systems Theory. He is also a council member of the Shandong Big Data Society, Shandong Mathematical Society, and Qingdao Mathematical Society. He has been listed among the world’s top 2% scientists by Stanford University (Lifetime Scientific Impact), named an Elsevier Highly Cited Chinese Researcher, and ranked among the global top 0.05% scientists by ScholarGPS.

Young Scientist Talk 4

A Preliminary Study on Data-Driven Control of Switched Systems

Prof. Yanzheng Zhu
College of Electrical Engineering and Automation,
Shandong University of Science and Technology, Qingdao, China

Friday, June 13, 2025
14:45 - 15:15
Bei Hai Hall
蓝海大饭店北海厅

Abstract

In modern industrial settings characterized by multimodal operation, uncertainty disturbances, and dynamic switching behaviors, classical control methods based on precise modeling have shown significant limitations. Notably, the data-driven control paradigm under the behavioral systems framework has attracted increasing attention, as it overcomes the reliance on accurate mathematical models by mining the underlying patterns from system operational data. This presentation will focus on recent progress in data-driven control for switched systems, including robust control under input saturation and asynchronous control design. Finally, simulation studies are provided to demonstrate the effectiveness of the proposed methods.

Biography

Prof. Yanzheng Zhu is a Ph.D. supervisor and Associate Dean of the College of Electrical Engineering and Automation. His main research interests include control theory and methods for switched systems, fault diagnosis and fault-tolerant control, and their applications in autonomous operation and control of complex equipment. He has published over 100 SCI-indexed journal papers, including more than 50 in journals such as Automatica and various IEEE Transactions. He has authored two English monographs published by Springer and holds eight granted Chinese invention patents as the first inventor. He has led over 20 research projects, including the National Science Fund for Excellent Young Scholars (NSFC), subprojects of the National Key R&D Program of China, major basic research projects of the Shandong Provincial Natural Science Foundation, and the Shandong Provincial Distinguished Young Scholars Program. His work has received multiple awards, including the Second Prize of the Shandong Natural Science Award, the First Prize of the Qingdao Natural Science Award, and the Second Prize of the CAA Natural Science Award. He currently serves as an editorial board member for IEEE Control Systems Letters and Journal of the Franklin Institute. He is a Senior Member of IEEE and CAA, Deputy Secretary-General of the Technical Committee on Fault Diagnosis and Safety in Process Control (CAA), Member of the CAA Education Working Committee, Member of the IEEE CSS Technical Committee on Intelligent Control, and Council Member of the Shandong Association of Automation.

Young Scientist Talk 5

Modeling and Optimal Control of Industrial Cyber-Physical Systems Driven by Explainable Artificial Intelligence

Prof. Xiangpeng Xie
School of Internet of Things,
Nanjing University of Posts and Telecommunications, Nanjing, China

Friday, June 13, 2025
15:40 - 16:10
Bei Hai Hall
蓝海大饭店北海厅

Abstract

Amid the growing emphasis on green industrial development, the study of rule-based explainable artificial intelligence (XAI) techniques is both timely and critical for enhancing the intelligence level of industrial cyber-physical systems (CPS). This presentation explores several key research directions. It begins with data-driven modeling and evolutionary characterization of CPS, targeting the dynamic interrelations of all production factors. By redefining the paradigm of integrating data with expert knowledge, a novel high-order self-organizing hierarchical fuzzy modeling approach is proposed—one that combines rules and learning to achieve high interpretability, precision, and generalization. Inspired by the Ebbinghaus forgetting curve, a multi-instant homogeneous matrix polynomial gain scheduling mechanism is introduced, which quantitatively characterizes the energy analysis functional evolution and enhances the interpretability and adaptability of the core control algorithms. Finally, preliminary applications of these theoretical findings in domains such as steel metallurgy and human–machine shared driving are briefly presented.

Biography

Prof. Xiangpeng Xie is a Professor and Ph.D. supervisor with the school of Internet of Things in NJUPT. He is also a Senior Member of IEEE, CAAI, and CAA. His research focuses on intelligent perception and control of cyber-physical systems and explainability in artificial intelligence. He has led over ten national and provincial-level projects, including the National Natural Science Foundation of China (NSFC) Excellent Young Scientists Fund and several major talent programs. He has received numerous academic honors, including the CAA Youth Science and Technology Award, Second Prize of the Shanghai Natural Science Award, First Prize of the CAA Natural Science Award, First Prize of the China Simulation Society Natural Science Award, the “Top 100 Most Influential International Academic Papers of China,” First Prize in the national final and Special Prize in the Jiangsu regional competition of the 18th "Challenge Cup" National Student Academic Science and Technology Competition (as first advisor), the CAA Excellent Master's Thesis Supervisor Award, and Second Prize of the CAA Higher Education Teaching Achievement Award.

Young Scientist Talk 6

Intelligent Swarm Cooperation of Unmanned Systems Based on Human-in-the-Loop

Prof. Hongjing Liang

School of Automation Engineering,

University of Electronic Science and Technology of China, Chengdu, China

Friday, June 13, 2025

16:10 - 16:40

Bei Hai Hall

蓝海大饭店北海厅

Abstract

Cooperative control of unmanned swarm systems has demonstrated great potential across various domains. However, existing methods still face challenges in meeting performance constraints and ensuring coordination efficiency. Traditional prescribed performance control can guarantee tracking accuracy but struggles to satisfy the strict sign constraints on tracking errors required by complex tasks such as spacecraft docking, posing potential collision risks. Moreover, most current studies focus on fully autonomous systems and overlook the critical role of human decision-making in complex scenarios, leading to limited adaptability in the face of unexpected events or mission changes. To address these issues, this report proposes a performance-guaranteed cooperative tracking control strategy based on human-in-the-loop (HIL). A dynamic error transformation mechanism is developed to maintain the sign of the tracking error throughout the task, effectively eliminating safety risks caused by sign reversals in traditional methods. Additionally, by embedding HIL into controller design through a master–slave consensus architecture, human operators can adjust the reference trajectory in real time, enabling the unmanned swarm to combine autonomous behavior with human decision-making flexibility.

Biography

Prof. Hongjing Liang is a Professor with the University of Electronic Science and Technology of China (UESTC), Ph.D. supervisor, Clarivate Highly Cited Researcher, recipient of the National Science Fund for Excellent Young Scholars, Tianfu Emei Young Scholar of Sichuan Province, and Distinguished Young Scholar of Sichuan Province. His main research interests include intelligent adaptive control of multi-agent systems and swarm intelligence. He has led three national-level projects, including NSFC General Programs, and participated in two additional NSFC projects. He serves on the editorial boards of IEEE Transactions on Systems, Man, and Cybernetics: Systems and IEEE Systems, Man, and Cybernetics Magazine. He has published (including accepted) over 100 academic papers in internationally recognized journals, with more than 40 SCI papers as first or corresponding author. Among them, 23 papers have been selected as ESI Highly Cited Papers, and 5 as ESI Top Hot Papers.

Young Scientist Talk 7

Synchronous Learning and Planning Strategies for Redundant Robots

Prof. Long Jin
School of Information Science & Engineering,
Lanzhou University, Lanzhou, China

Friday, June 13, 2025
16:40 - 17:10
Bei Hai Hall
蓝海大饭店北海厅

Abstract

In complex environments, variations in robotic kinematic parameters often lead to reduced control accuracy, posing a key challenge to the autonomy of intelligent systems. To address this issue, this presentation focuses on structure-unknown robotic systems and introduces structure learning techniques applicable to redundant robots, visual servoing, and motion – force control. The talk will delve into innovative methods that integrate neural dynamics modeling, fuzzy logic reasoning, and intelligent control algorithms, demonstrating how robots can achieve autonomous motion planning and control in unknown environments through online learning.

Biography

Prof. Long Jin is a Professor and Ph.D. supervisor at Lanzhou University, selected for a national-level youth talent program. He has led four projects funded by the National Natural Science Foundation of China (NSFC), one subproject of the National Key R&D Program, and multiple provincial and ministerial-level projects, including Key Projects and Distinguished Young Scholars Programs of the Gansu Provincial Natural Science Foundation. Since 2020, he has been recognized annually as an Elsevier “Highly Cited Chinese Researcher.” As the first contributor, he has received four awards from national-level academic societies and provincial ministries. More than ten of his students' theses have been recognized as Excellent Doctoral or Master’s Dissertations by national societies and the Gansu Provincial Government, as well as selected for NSFC’s Excellent Doctoral Student Support Program. He currently serves as Associate Editor for several SCI journals, including IEEE Transactions on Industrial Electronics (TIE), IEEE Transactions on Intelligent Vehicles (TIV), IEEE/CAA Journal of Automatica Sinica (JAS), and Neural Networks. His research interests include neural networks, robotics, distributed systems, and intelligent computing.

Young Scientist Talk 8

Identification and State Estimation for a Class of Nonlinear Systems

Prof. Xiao Zhang
School of Internet of Things Engineering,
Jiangnan University, Wuxi, China

Friday, June 13, 2025
17:10 - 17:40
Bei Hai Hall
蓝海大饭店北海厅

Abstract

In recent years, the identification and state estimation of nonlinear systems have played a significant role in control theory, signal processing, and engineering applications. This report focuses on a special class of nonlinear systems—bilinear systems—and explores theoretical approaches and implementation techniques for parameter identification and state estimation. First, to address the challenge of parameter – state coupling, a data-driven identification strategy is proposed by leveraging system separability and hierarchical identification techniques. This method effectively overcomes limitations of traditional approaches under coupling conditions. Second, to deal with the issue of unmeasurable system states, observer-based estimation methods such as the Extended Kalman Filter (EKF) and Rauch – Tung – Striebel (RTS) smoother are investigated to estimate unknown states. Furthermore, a joint optimization framework for identification and estimation is discussed, aiming to improve both model accuracy and state estimation performance through coordinated enhancement. The effectiveness of the proposed methods is validated through simulation studies.

Biography

Prof. Xiao Zhang is currently an Associate Professor with the School of Internet of Things Engineering, Jiangnan University, and a Jiangsu Province Science and Technology Associate. She received both her B.E. (2016) and Ph.d. (2021) degrees in engineering from Jiangnan University. Her research interests include system identification and modeling, state estimation, and filtering. She has led one project funded by the National Natural Science Foundation of China, one project by the Jiangsu Provincial Natural Science Foundation (Youth Program), and one by the Fundamental Research Funds for the Central Universities (Youth Program). She has also participated in a General Program of the NSFC. She received the Third Prize of the Jiangsu Provincial Science and Technology Award (2022), the First Prize of the China Petroleum and Chemical Automation Industry Science and Technology Award (Natural Science Category, 2022), the First Prize of the Jiangsu Higher Education Science Research Achievement Award (Natural Science Category, 2021), and the Second Prize of Wuxi Excellent Academic Paper in Natural Sciences (12th edition, 2020–2021). In the past five years, she has published over 20 papers in journals including Automatica and IEEE Signal Processing Letters.

Oral Sessions 口头报告

June 13-14, 2025

FriA01 **Bo Hai Hall**
Invited Session: Intelligent System Modelling and Adaptive Control Methods I **13:45-15:15**

Chair: Fangkun Zhang Qingdao University of Science and Technology

13:45-14:00 **FriA01-1**
Enhanced Haze Removal Method by Fusing Improved Atmospheric Scattering Model and Retinex
Han Zhao Qingdao Univ. of Science and Tech.
Xiaoqian Mao Qingdao Univ. of Science and Tech.
Chenwei Xie Qingdao Univ. of Science and Tech.
In complex environments with local light sources, the method based on atmospheric scattering model is not accurate enough to estimate atmospheric parameters, and has limitations in dealing with uneven lighting scenes and reflective materials. Therefore, this paper proposes the enhanced haze removal method by fusing improved atmospheric scattering model and Retinex. Firstly, to solve the problem that the traditional atmospheric scattering model ignores the local light source, this paper introduces the space-direction dependent atmospheric light field modelling. We estimate the light source direction through the particle swarm optimization algorithm, construct an anisotropic diffusion equation to solve the light source intensity field, and adjust the scattering coefficient adaptively in combination with the local gradient. This method improves the estimation accuracy of atmospheric parameters in complex scenes. Secondly, aiming at the problems of uneven illumination scenes and the treatment of reflective materials, this paper fuses the Retinex theory to expand the reflectance decomposition model. The observed image is separated into the base reflectance, the illumination modulation factor, and the illumination field. The illumination field reconstruction is realized through an alternating optimization and guided filter. This method effectively deals with the issues of non-uniform illumination and high light residues. Experimental results show that the proposed method can effectively preserve edge details and improve colour authenticity, and it is superior to the contrast algorithm in defogging effect and image quality in complex environment.

14:00-14:15 **FriA01-2**
Multi-Objective Model Predictive Control with Adaptive Weighting for Batch Crystallization Process
Zimu Diao Qingdao Univ. of Science and Tech.
Fangkun Zhang Qingdao Univ. of Science and Tech.
Qilei Xu Qingdao Univ. of Science and Tech.
Baoming Shan Qingdao Univ. of Science and Tech.
This study proposes an adaptive weight multi-objective model predictive control (AW-MOMPC) framework for batch cooling crystallization process, dynamically adjusting objective weights to balance product quality and energy efficiency. By correlating the weight with real-time supersaturation levels, the algorithm prioritizes crystal growth suppression during early-stage nucleation while minimizing energy consumption in later phases. Compared to linear cooling, the multi-objective model predictive control (MOMPC) strategy reduces fine crystal volume by 24% and energy consumption by 25.6% without compromising product quality. However, fixed-weight MOMPC faces challenges in multi objective equilibrium, leading to suboptimal performance. In contrast, AW MOMPC achieves near-identical fine crystal suppression as single-objective MPC but reduces energy consumption by 14.2%. The adaptive mechanism effectively resolves the trade-off between crystal size distribution and operational costs, validated by third-order moment analysis and final crystal density profiles. This work demonstrates the viability of weight-adaptive MPC in enhancing both economic and quality outcomes for complex crystallization systems.

14:15-14:30 **FriA01-3**
Data-Driven Denoising and Feature Modeling of NIRS with Dynamic Attention Synergy
Shun Li Qingdao Univ. of Science and Tech.
Fangkun Zhang Qingdao Univ. of Science and Tech.
Baoming Shan Qingdao Univ. of Science and Tech.
Qilei Xu Qingdao Univ. of Science and Tech.
In this paper, we propose a Near-Infrared (NIR) spectral data processing method (CDAE-DHA) based on the fusion of Convolutional Denoising Autoencoder and Dynamic Hybrid Attention. which aims to obtain highly robust low-dimensional spatial features through denoising and feature extraction. The method employs CDAE to perform noise reduction on spectral data and combines Dynamic Hybrid Attention to adaptively focus on the key feature regions in the spectral data, to extract more representative features. The extracted features were applied to the Support Vector Regression (SVR) model for fitting to improve the predictive performance of the model. Through comparative experiments with traditional denoising methods and other modeling methods, the advantages of CDAE-DHA in denoising effect and feature extraction capability are verified. In addition, this study also analyzes the interpretability of the attention mechanism and reveals its action mechanism in the process of feature extraction, providing a new idea and method for data-driven NIR spectroscopy modeling.

14:30-14:45 **FriA01-4**
An Auxiliary Model Gradient Algorithm with Forgetting Factor for Parameter Estimation of Nonlinear Fractional-Order Models in Colored Noise

Naishuo Yan Qingdao Univ. of Science and Tech.
Yan Ji Qingdao Univ. of Science and Tech.
Wen Zheng Qingdao Univ. of Science and Tech.
This article focuses on the parameter estimation issues for the nonlinear fractional-order model with colored noise. The fractional-order equivalent circuit model can reflect the internal reaction mechanism of a lithium-ion battery well. In order to reduce the complexity of the model and produce the estimates of the parameters, the auxiliary model gradient descent algorithm is used to handle unknown data. Furthermore, the forgetting factor is introduced to improve the convergence rate. Finally, the simulation examples test the effectiveness of the proposed algorithm.

14:45-15:00 **FriA01-5**
Indoor Road Positioning Based on RWKV-TS
Wenjian Wang Qingdao Univ. of Science and Tech.
Wennan Chai Qingdao Univ. of Science and Tech.
Zhongke Wu Qingdao Univ. of Science and Tech.
Qingdang Li Qingdao Univ. of Science and Tech.
Fanyu Li Qingdao Univ. of Science and Tech.
To address the challenges of low accuracy and susceptibility to environmental interference in traditional positioning technologies, particularly in indoor scenarios such as underground parking garages, this study proposes an indoor positioning method based on the RWKV-TS network. This method integrates Inertial Measurement Unit (IMU) data, non-visual semantic landmarks, and Wi-Fi fingerprints to achieve precise positioning. The RWKV-TS network, with its enhanced time-series processing architecture, effectively captures long-term dependencies in the data. It also offers advantages in terms of low time complexity and memory usage, making it well-suited for real-time applications on edge devices. Experiments conducted in the underground parking garages of two shopping malls demonstrate that the model achieves road recognition accuracy rates of 0.931 and 0.868, with Mean Absolute Errors (MAE) of 4.245 meters and 4.171 meters, respectively. The performance of the model significantly exceeds that of traditional deep learning models, meeting the practical requirements for applications such as smart parking guidance.

15:00-15:15 **FriA01-6**
Energy Efficiency Optimization for Distributed Flexible Job Shop Scheduling under Time-of-use Electricity Pricing
Chuanbing Xu Qingdao Univ. of Science and Tech.
Xiaohong Yin Qingdao Univ. of Science and Tech.
Yanmei Hu Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Time-of-use electricity pricing has become a critical topic in modern energy management, particularly within the manufacturing sector and large-scale industrial production environments. Focusing on distributed flexible job shop scheduling under time-of-use pricing, this study proposes an improved arctic puffin optimization algorithm to minimize total electricity costs and reduce the production costs of enterprises. First, the latin hypercube sampling is employed to gain a more diverse and uniformly distributed initial population. Second, a dynamic parameter adjustment strategy based on Lévy flight is employed to achieve a balance between the global exploration and local exploitation phases of the algorithm. Next, the ranked order value decoding method is employed to choose low-power processable machines. Finally, a delay processing strategy for the job is proposed to address the scheduling under time-of-use electricity pricing constraints. The results of comparison experiments and industrial case studies demonstrate that this method exhibits excellent performance and stability in solving the distributed workshop scheduling problem under time-of-use electricity pricing constraints.

FriB01 **Bo Hai Hall**
Invited Session: Intelligent System Modelling and Adaptive Control Methods II **15:40-17:10**
Chair: Xiaoqian Mao Qingdao University of Science and Technology

15:40-15:55 **FriB01-1**
Real-time Scheduling Optimization for Dynamic Flexible Job Shop with Machine Breakdowns
Wentao Song Qingdao Univ. of Science and Tech.
Xiaohong Yin Qingdao Univ. of Science and Tech.
Yanmei Hu Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Machine breakdowns can lead to scheduling disruptions, causing production stagnation, order delivery delays, and other cascading issues that severely impact the operational efficiency of manufacturing systems. This paper proposes an efficient dynamic scheduling strategy to enhance scheduling stability and production efficiency. First, the strategy introduces a Latin hypercube-based initialization mechanism. This enhances solution diversity and accelerates convergence. Secondly, the paper establish a failure-driven dynamic response strategy by incorporating strong perturbation operations, aiming to achieve rapid and effective rescheduling in response to disruption events. Finally, the paper introduces a greedy ascending order encoding rule to dynamically adjust operation priorities, thereby enhancing the robustness of the scheduling scheme. Experimental results demonstrate that the proposed strategy outperforms particle swarm optimization and grey wolf optimizer in both efficiency and stability.

15:55-16:10 **FriB01-2**
Lightweight Prediction Model for Rubber Width Using Knowledge Distillation
Jinsong Yan Qingdao Univ. of Science and Tech.
Xiaohong Yin Qingdao Univ. of Science and Tech.
Yingrui Zhou Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.

Accurate prediction of calendering width is critical to ensuring product quality and production efficiency in the rubber calendering process for tire manufacturing. However, traditional deep learning models have high computational costs and slow inference speeds, making it difficult to meet the real-time prediction requirements in actual production. To address this issue, this paper proposes a lightweight modelling method based on knowledge distillation to reduce computational costs and im-prove inference efficiency. First, a teacher model with a Transformer-MLP architecture is constructed, fully utilizing the self-attention mechanism to extract complex dynamic features in the calendering process. Then, knowledge distillation technology is used to transfer the knowledge of the teacher model to a lightweight MLP student model, maintaining high prediction accuracy while reducing computational complexity. Experimental results demonstrate that, the proposed method achieves a substantial increase in inference speed, while significantly reducing model size, thereby enhancing its practicality for industrial applications with constrained computational resources.

16:10-16:25 **FriB01-3**

Non-Canonical Adaptive Filters Driven by Maximum Versoria Criterion

Yifei Wang Qingdao Univ. of Science and Tech.
Kaili Yin Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.

Acoustic coupling in communication devices poses a substantial threat to voice communication fidelity primarily due to the emergence of echo problems. Conventional adaptive filtering algorithms based on mean square error (MSE) exhibit critical stability limitations under non-Gaussian interference conditions, particularly when confronted with concurrency of impulsive noise disturbances and time-varying double-talk scenarios. To address this problem, this paper proposes a non-canonical finite impulse response (NCFIR) structure based on the maximum versoria criterion (MVC), termed NCMVC. The NCMVC enhances robustness and reduces system latency by strategically reconstructing critical signal processing paths. Distinct from conventional FIR filters, the proposed NCFIR architecture optimizes delay paths, enabling high-frequency real-time processing. Additionally, the MVC-based adaptation ensures robust convergence even in impulsive noise scenarios. Simulation results demonstrate the superior performance of the NCMVC algorithm compared to existing approaches.

16:25-16:40 **FriB01-4**

Neural Network-based Direct Iterative Learning Control for Multi-Agent Systems

Huiming Peng Qingdao Univ. of Science and Tech.
Na Lin Qingdao Univ. of Science and Tech.

This paper proposes a neural network-based direct iterative learning control (NN-DILC) method for unknown nonlinear multi-agent systems (MASs). First, the inherent consensus dynamics relationship is established between the consensus output and the control input. Then, an iterative linear data model is derived to equivalently reformulate the such a relationship. Further, a radial basis function neural network estimation algorithm along the iterative axis is designed to estimate unknown linearization parameters online, and subsequently, a NN-DILC scheme is proposed. The proposed NN-DILC is a purely data-driven control approach that does not rely on any model information. The simulation results verify the effectiveness of the proposed method by comparing with the model-free adaptive ILC.

16:40-16:55 **FriB01-5**

Temporal Convolutional Network-Based Long Short Term Memory and Its Application for Soft Sensor Modelling

Runze Xing Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.
Yingrui Zhou Qingdao Univ. of Science and Tech.

In the modern industrial process, soft sensor modeling is crucial in solving the problem of unmeasurable key quality indicators and achieving real-time dynamic monitoring. However, traditional data-driven methods struggle to capture the complex spatial and temporal dynamics in industrial time-series data. This study proposed a hybrid deep learning framework that integrates temporal convolutional network (TCN) for robust spatial feature extraction with long short-term memory (LSTM) networks for effective temporal dependency modeling. By incorporating batch and control input embeddings, the model adeptly handles inter-batch variability and diverse operational conditions. Evaluated on sulfur recovery and penicillin fermentation datasets, the pro-posed TCN-LSTM framework demonstrates superior predictive accuracy and robustness compared to baseline models, including standalone TCN, LSTM, and other neural architectures.

16:55-17:10 **FriB01-6**

Research on Backstepping Control for Autonomous Underwater Vehicles Based on Disturbance Observer

Xuanyi Cui Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.
Chengwei Bao Qingdao Univ. of Science and Tech.
Tong Zhao Qingdao Univ. of Science and Tech.

Underactuated autonomous underwater vehicles (AUVs) frequently suffer from motion instability caused by thruster failures and environmental disturbances, including ocean currents and waves, which significantly degrade trajectory tracking performance. To address these challenges, this study develops a robust backstepping control scheme incorporating an adaptive error observer

to enhance motion stability under adverse conditions. A simplified horizontal-plane dynamic model is first established to facilitate controller synthesis. An advanced disturbance observer is then designed to estimate and compensate for uncertainties arising from both thruster malfunctions and external perturbations. The proposed nonlinear controller, derived via backstepping methodology, is systematically integrated with the AUV dynamics. Lyapunov-based stability analysis rigorously proves the global asymptotic convergence of the closed-loop system. Extensive numerical simulations demonstrate the controller's exceptional robustness against simultaneous thruster faults and environmental disturbances, exhibiting superior disturbance rejection capabilities compared to conventional approaches. The results conclusively validate the proposed method's effectiveness in maintaining precise trajectory tracking and operational reliability for underactuated AUVs operating in complex marine environments with multiple uncertainties.

FriA02 **Huang Hai Hall**

Invited Session: Intelligent Perception and Visual Computing in Industrial and Transportation Systems I

13:45-15:15

Chair: Zidong Ai Qingdao University of Science and Technology

13:45-14:00 **FriA02-1**

Research on Vehicle Speed Estimation Based on In-Vehicle Smartphone and 1D CNN-LSTN Network

Wenlong Ma Qingdao Univ. of Science and Tech.
Weilong Song Qingdao Univ. of Science and Tech.
Hao Wu Qingdao Univ. of Science and Tech.
Xujun Cao Qingdao Univ. of Science and Tech.
Wennan Chai Qingdao Univ. of Science and Tech.

With the development of indoor positioning technology, the Inertial Measurement Unit (IMU) in smartphones has been widely applied to vehicle speed estimation. To improve the accuracy of vehicle speed estimation in complex underground parking environments and the user experience of indoor navigation with the in-vehicle smartphone, this paper proposes a fusion model combining a 1D Convolutional Neural Network (1DCNN) and Long Short-Term Memory (LSTM) network based on smartphone IMU data. The model combines a 1DCNN for spatiotemporal feature extraction and uses LSTM to handle temporal dependencies, significantly enhancing the accuracy of speed estimation. Experimental results show that, in four different underground parking scenarios, the model's average error is 0.741 m/s, significantly outperforming traditional methods. The study demonstrates the broad application potential of deep learning models based on smartphone IMUs, particularly in intelligent transportation and autonomous driving fields.

14:00-14:15 **FriA02-2**

Enhancing Target Recognition Performance by a 3D-SSVEP Based BCI

Chenwei Xie Qingdao Univ. of Science and Tech.
Xiaoqian Mao Qingdao Univ. of Science and Tech.
Hao Song Qingdao Univ. of Science and Tech.
Han Zhao Qingdao Univ. of Science and Tech.

Most SSVEP (Steady-State Visual Evoked Potentials) based BCI (Brain Computer Interface) systems rely on computer displays, which are not convenient to integration so the application of visual-based BCI is limited in daily life. VR (Virtual Reality) technology not only can provide a realistic 3D (three-dimension) visual stimulus, but also has wearable and portable devices integrated with independent monitors, which has great potentials for the applications of visual-based BCI. Therefore, this paper introduces a VR glass to display 3D-SSVEP stimuli. By modelling a 3D-SSVEP based BCI, the subjects can be deeply immersed in BCI systems. To validate the performance enhancement of 3D-SSVEP based BCI, this paper used four classification methods to compare the target recognition results between 3D and 2D visual stimuli, and the experiment results showed that the highest recognition accuracies of 3D and 2D paradigms by CCA, MSI, FBCCA, and TRCA were 93.26% and 87.12%, 93.71% and 85.51%, 96.52% and 91.97%, and 98.72% and 96.3% respectively. Moreover, under the 3D visual stimuli with a duration of 1 second, the TRCA method achieved a maximum information transfer rate of 78.15 bits/min. The results indicated that 3D-SSVEP by VR performed better than 2D paradigm, and TRCA showed the best recognition performance. This research verified that 3D visual stimuli can effectively enhance the target recognition performance of SSVEP, which provides new insights for the application of VR devices in the visual-based BCI systems.

14:15-14:30 **FriA02-3**

Lightweight Small Target Detection in SAR Images Based on Improved RT-DETR

Tanqing Sun Qingdao Univ. of Science and Tech.
Xianjun Zhang Qingdao Univ. of Science and Tech.
Ziyu Li Qingdao Univ. of Science and Tech.
Na You Qingdao Univ. of Science and Tech.

Synthetic Aperture Radar (SAR) target detection suffers from complex environments and small target sizes. The number of baseline model RT-DETR parameters is high. Aiming at the above problems, this paper proposes a lightweight small target detection in SAR images based on improved RT-DETR(LSTRT-DETR). Firstly, a lightweight additive convolutional GLU backbone network (LACGBNet) is designed to capture remote dependencies and optimize the feature extraction process to cope with complex scenes while achieving model lightweighting. Secondly, the algorithm proposes a small target feature fusion network (STFFN), which introduces SPD-Conv to process the P2 feature layer to enrich the small target feature information. And the shallow feature

fusion module (SDFM) is introduced to enhance the detection capability of small targets. Experimental results on the joint dataset consisting of SSDD, HRSID, and SARAIRcraft show that the mAP50 and mAP50-95 of LSTRT-DETR reach 92.5% and 63.8%, respectively, which are improved by 0.4% and 3%, respectively, and the number of parameters is reduced by 4.1 M compared to the original model RT-DETR. This sufficiently demonstrates its effectiveness and efficiency in the SAR image target detection task.

14:30-14:45 **FriA02-4**

RGB-T Tracking Method with Dual-stream Encoder Structure

Ziyu Li Qingdao Univ. of Science and Tech.
Xianjun Zhang Qingdao Univ. of Science and Tech.
Tanqing Sun Qingdao Univ. of Science and Tech.
Na You Qingdao Univ. of Science and Tech.

Due to the poor quality of RGB images in complex scenes, leading to bad tracking performance. Therefore, the introduction of an infrared (TIR) modality complementary to RGB is crucial to overcome the limitations of single-modality tracking. To address this issue, we propose an RGB-T tracking method based on a dual-stream encoder structure, which aims to achieve multi-modality tracking by combining RGB and TIR. Its main contributions are as follows: Firstly, a dual-stream encoder structure based on an adapter fine-tuning strategy is proposed to reduce training cost while achieving cross-modality feature prompting. Secondly, a Modality Spatial Fusion (MSF) module is added after the backbone, which uses cross-attention mechanisms to enhance the learning ability of complex features and address tracking challenges in complex scenes. Our method was evaluated on the LasHeR and GTOT datasets, and a visual comparison with state-of-the-art algorithms was performed on the LasHeR dataset. The experimental results show that this method effectively addresses the performance limitations of single-modality tracking.

14:45-15:00 **FriA02-5**

Targeted Detection of Unsafe Behavior of Factory Personnel Based on YOLOv5

Lianchao Liu Qingdao Univ. of Science and Tech.
Longen Liu Qingdao Univ. of Science and Tech.
Baoming Shan Qingdao Univ. of Science and Tech.

The assurance of factory personnel safety has become increasingly emphasized in the contemporary industrial system. Modern industrial construction necessitates a comprehensive personnel safety assurance system, and the ability to achieve real-time monitoring of factory personnel behavior is a prerequisite for establishing an effective safety system. In this paper, we present an improved YOLOv5s model to handle complex occlusions and the broad size range of detection targets commonly found in real-world production settings. By incorporating Deformable Convolutional v4 (DCNv4) into the C3 module, a new C3-DCNv4 module is created to improve the model's adaptability to complex environments. Additionally, the Bidirectional Feature Pyramid Network (BiFPN) structure is integrated into the neck of the network to enhance the model's detection capabilities for targets of varying scales. The experiment shows that on the factory safety dataset, the improved model's mean Average Precision (mAP) for detecting unsafe behaviors is 85.2%, representing a 3.8% increase over the benchmark model. Additionally, the computational load decreases by 0.6 GFLOPS. The enhanced model delivers outstanding detection results with fewer computational parameters, making it an efficient choice for real-time industrial safety monitoring.

15:00-15:15 **FriA02-6**

DyPLS-SLAM: A Dynamic Visual SLAM System for Indoor UAVs Utilizing Point, Line, and Semantic Information

Qiqi Sun Qingdao Univ. of Science and Tech.
Linan Zu Qingdao Univ. of Science and Tech.

To improve the accuracy of Unmanned aerial vehicles (UAVs) per-forming Simultaneous Localization and Mapping (SLAM) tasks in dynamic indoor scenes, this paper proposes a visual SLAM system added line features and semantic information based on point features, termed DyPLS-SLAM. Initially, the system employs semantic segmentation to detect potential dynamic objects and conducts motion consistency checks on these objects based on the epipolar constraint. Subsequently, line features are subjected to inter-frame consistency checks based on depth information. Furthermore, keyframes significantly affected by dynamic objects are filtered based on their spatial distribution. Final-ly, we validated the performance of DyPLS-SLAM system using dynamic sequences of the TUM dataset, demonstrating a significant improvement in accuracy compared to classical algorithms.

FriB02 **Huang Hai Hall**

Invited Session: Intelligent Perception and Visual Computing in Industrial and Transportation Systems II **15:40-17:10**

Chair: Xianjun Zhang Qingdao University of Science and Technology

15:40-15:55 **FriB02-1**

MMW-YOLO: Research on an Improved Vehicle Recognition Algorithm Based on MobileViT

Tianyu Liang Qingdao Univ. of Science and Tech.
Linan Zu Qingdao Univ. of Science and Tech.

This paper addresses the challenges of vehicle occlusion and insufficient real-time identification in the context of target recognition for autonomous driving scenarios. It proposes a lightweight improved target recognition algorithm based on YOLOv8n, named MMW-YOLO. The algorithm employs a more streamlined MobileViTv3 structure, significantly reducing the number of model parameters while maintaining accuracy. Furthermore, it

embeds the Multiscale convolutional attention (MSCA) module to enhance recognition accuracy. Lastly, the Wise-IoU loss function is utilized to boost the model's generalization. Experiments conducted using the KITTI dataset demonstrate that MMW-YOLO achieves a 5.2% improvement in average precision over the original model and a 53% reduction in parameter count. The experiments verify the superior performance of the MMW-YOLO algorithm for target recognition tasks in autonomous driving scenarios.

15:55-16:10 **FriB02-2**

A Stem Cell Image Segmentation Method Based on Adaptive Preprocessing and PSO-Optimized Dual-Threshold Otsu

Zhipeng Wang Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Ni Bu Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.

Cell confluency, as an important parameter for evaluating cell growth status and determining the timing of cell processing, reflects the degree of coverage of cells on the culture surface. However, traditional manual estimation of confluency has strong subjectivity, and stem cell images under the microscope are often affected by image blur and uneven illumination, which influence the segmentation results. To address these challenges, this paper proposes a dual-threshold Otsu cell image segmentation method combining adaptive preprocessing and PSO optimization. Initially, the adaptive weighted multi-scale Retinex detail enhancement technique is used to preprocess the original cell images for illumination balance and cell feature enhancement. Subsequently, an improved PSO algorithm is used to accelerate the dual-threshold Otsu method to segment the preprocessed images, followed by post-processing to optimize the segmentation, and finally the cell confluency is calculated. The proposed method is validated using images of umbilical cord stem cells during the proliferation phase. Results show that the calculated confluency values align closely with ex-pert evaluations. In addition, the method improves computational efficiency, re-duces manual subjectivity and error, and provides a practical solution for auto-mated stem cell culture analysis.

16:10-16:25 **FriB02-3**

Small-Sample Lifetime Prediction Based on an Enhanced iTransformer Approach

Ying Sun Qingdao Univ. of Science and Tech.
Xiaohong Yin Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.
Sihong Li Qingdao Univ. of Science and Tech.

Accurate remaining useful life (RUL) prediction of critical components plays a vital role in enhancing the reliability, safety, and operational efficiency of industrial systems. However, the lack of fault-related data in real-world production processes, combined with the inherent time-delay and coupling characteristics of the data, poses significant challenges to the accurate RUL prediction of critical components. To address this small-sample limitation, this study proposes a novel hybrid framework that integrates Gaussian noise-based data augmentation (GDA) with an improved Transformer architecture, aiming to enhance model robustness and representation learning. The GDA mod-ule generates synthetic failure patterns through controlled noise injection, effectively expanding training datasets. Then the proposed inverted Transformer incorporates temporal attention mechanisms to model long-range dependencies in multivariate time-series degradation signals. Experiments on the PHM2012 dataset demonstrate that this method effectively alleviates the small sample problem and improves the prediction accuracy to 0.9813.

16:25-16:40 **FriB02-4**

Dual-channel 3DCNN-LSTM Fault Detection for Industrial Processes

Jinlong Han Qingdao Univ. of Science and Tech.
Ni Bu Qingdao Univ. of Science and Tech.
Xiaohong Yin Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.

With the increasing complexity of industrial processes, fault detection has become crucial for ensuring equipment safety and production efficiency. Traditional methods fail to capture intricate relationships in nonlinear scenarios and struggle with processing large-scale complex industrial datasets. This paper pro-poses a fault detection model, called 3DCNN-LSTM, that combines a three-dimensional convolutional neural network (3DCNN), long short-term memory net-work (LSTM), and multi-head attention mechanism. The model extracts spatiotemporal features using 3DCNN, captures long-term temporal dependencies with LSTM, and enhances the perception of key feature correlations through the attention mechanism. The TE (Tennessee Eastman) dataset, a benchmark for chemical process simulation, contains multivariate time-series data with 21 predefined fault modes and is extensively utilized for evaluating the performance of process monitoring, fault detection, and diagnostic algorithms. The proposed method demonstrates significantly higher diagnostic accuracy on this dataset compared to existing approaches.

16:40-16:55 **FriB02-5**

MLSTM-based Residual Gating and Spatio-temporal Attention Mechanisms Fault Detection Method for Complex Industrial Processes

Hongquan Li Qingdao Univ. of Science and Tech.
Shaoyuan Li Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.
Ni Bu Qingdao Univ. of Science and Tech.

With the rapid proliferation of devices, deep learning-based fault detection methods have attracted significant attention in industrial applications. Among these, long short-term memory network (LSTM)-based

approaches have been extensively explored for fault detection in chemical processes. This article proposes a fault detection method for industrial processes using residual gated mLSTM and dynamic feature fusion. Firstly, a hybrid model integrating parallel LSTM architecture and spatiotemporal attention mechanisms is proposed to enhance the capture of temporal dependencies and spatial correlations in industrial process data. Simultaneously, residual gating is designed to mitigate the vanishing gradient problem. The proposed fault detection algorithm is validated on the TE Process benchmark, demonstrating its effectiveness through experimental results in an industrial process context.

SatA01 **Bo Hai Hall**
Advanced Modeling, Identification, and Control Strategies in Complex Systems I **13:30-15:30**
Chair: Jianhua Zhang
Qingdao University of Technology

13:30-13:45 **SatA01-1**
Delay-Compensated Control for α -Leader in PDE-Based Multi-Agent 2-D Surface Formation Containment
Hao Chen Beijing Institute of Technology
Shenzhen MSU-BIT University
Zhengjie Wang Beijing Institute of Technology
Haoran Yue Shenzhen MSU-BIT University
Qiyuan Cheng Shenzhen MSU-BIT University
This paper investigates the formation-containment control problem for PDE-based multi-agent systems under input delays and spatial information decay. A novel three-layer hierarchical control framework is proposed, with particular emphasis on stabilizing the α-leader—a key agent subject to delayed control inputs. An integral-type delay compensation law is constructed using kernel functions derived from backstepping transformations and equivalence principles. The leader dynamics are governed by a reaction–diffusion–advection partial differential equation (PDE). Rigorous theoretical results establish the boundedness, invertibility, and exponential stability of the closed-loop error system. Numerical simulations validate the effectiveness of the proposed strategy, demonstrating accurate convergence to the desired encirclement formation under dual damping boundary conditions and time-delay effects. The findings offer valuable insights into the design of robust and scalable formation control strategies for spatially distributed multi-agent systems operating under realistic constraints.

13:45-14:00 **SatA01-2**
Neural Network-Based Adaptive Tracking Control for Nonlinear Systems with Multi-Actuator Constraints
Yang Li Qingdao Technological University
Yaqi Yu Qingdao Technological University
Zhanyang Yu Qingdao Technological University
Jianhua Zhang Qingdao Technological University
In real physical systems, too large control inputs can easily cause serious accidents, so it is of great practical significance to study the control problems of nonlinear systems with input dead zones and saturations. In this paper, an adaptive NNs command filter tracking control algorithm for multi-actuator constrained nonlinear systems based on backstepping method is designed based on finite time stability theory. By introducing a second-order command filter, the complexity explosion problem of the traditional backstepping method for designing controllers is solved. The designed control algorithm ensures good tracking control of the controlled system under the corresponding saturation and dead zone input environments. With the neural network command filtering control scheme, all variables in the controlled system are ensured to be bounded and the output tracking error fluctuates within a small domain of the equilibrium point. Simulations demonstrate the feasibility of the designed control scheme.

14:00-14:15 **SatA01-3**
Neural-Network-Based Adaptive Predefined-Time Control for Interconnected Nonlinear Systems
Xuan Yu Qingdao Technological University
Jianhua Zhang Qingdao Technological University
Zhanyang Yu Qingdao Technological University
Yaqi Yu Qingdao Technological University
This article introduces a new adaptive predefined time neural network tracking control method for nonlinear interconnected systems. The approach employs an adaptive backstepping technique to handle unknown system uncertainties in predefined time settings. Neural networks are utilized to estimate these unknown uncertainties. The findings indicate that, with the proposed control method, each system state can converge to small regions around zero within a predefined time, as shown through Lyapunov stability analysis. A simulation example is also provided to demonstrate the practical effectiveness of the proposed approach. Additionally, a step-by-step guide for engineers in industrial process applications is included, highlighting the significance of predefined time stability for achieving optimal performance.

14:15-14:30 **SatA01-4**
Robust Identification of Multi-model Systems Based on the Adaptive Suppression Mechanism
Ronghuan Li Jiangnan University
Xuhang Zhang Jiangnan University
Junxia Ma Jiangnan University
Weili Xiong Jiangnan University
Outliers frequently occur during data collection, introducing deviations that can significantly degrade system identification performance. To address this issue, an adaptive suppression mechanism based the expectation-maximization algorithm is deduced. By incorporating a penalty on the outlier vector and assigning individual weights to each data point, the

algorithm ensures that outlier weights are lower than normal samples. Consequently, outliers are excluded from the contaminated data without requiring prior knowledge, thus minimizing estimation bias. The deduced algorithm is validated through a mass-spring-damper system.

14:30-14:45 **SatA01-5**

A Varying Interval-Based Robust Multi-Innovation Identification Method for Hammerstein-Volterra Nonlinear Systems

Junwei Wang Jiangnan University
Weili Xiong Jiangnan University
Xudong Shi Jiangnan University
Feng Ding Jiangnan University
Holderbaum William University of Reading
Metropolitan Manchester University

For traditional identification method, it is difficult to identify a system with measurements including both missing data and outliers. Thus, we propose a robust parameter estimation method to address these issues. First, a varying-interval-based sampling method is designed to address missing measurements by adjusting sampling intervals. Then, the outlier detection problem is converted into a matrix decomposition problem, in which the information matrix is refreshed by innovation-window. Subsequently, a varying-interval robust multi-innovation gradient-based iterative algorithm is derived, in which missing data and outliers can be handled simultaneously. Finally, the effectiveness of the proposed method is demonstrated through a numerical case.

14:45-15:00 **SatA01-6**

Predetermined Performance Control of Dual Motor Servo System Based on State Predictor

Shubo Wang Kunming Univ. of Science and Tech.
Jiacheng Ding Qingdao University
Haoran He Kunming Univ. of Science and Tech.
Xian Wang Kunming Univ. of Science and Tech.
Jing Na Kunming Univ. of Science and Tech.
Chunxi Yang Kunming Univ. of Science and Tech.

A new controller is proposed for a dual motor servo system with nonlinear dead zone. The proposed controller consists of a tracking controller and a synchronization controller. The tracking controller combines the predetermined performance function (PPF) and the state predictor into the neural dynamic surface, so as to ensure the transient and steady state responses within the preset boundary of the tracking error. Different from the traditional adaptive control method, the proposed control method updates the neural network weight by predicting the error, which can quickly and smoothly approximate the nonlinear disturbance without causing high-frequency vibration. In addition, an optimal sliding mode synchronization controller based on the average deviation coupling strategy is proposed to solve the coupling problem between synchronization and tracking. Finally, the effectiveness of the design method is verified by simulation.

15:00-15:15 **SatA01-7**

Sample-Based Confidence Polytope for Linear Regression Model with Endogenous Regressors Guaranteed Probabilistic Lower Bounds

Xiaopuwen Wang Chengdu Technological Univ.
Jintao Ding Chengdu Technological Univ.
Ping Yue Chengdu Technological Univ.
Li Zheng Chengdu Technological Univ.

This paper presents a novel sample-based method for constructing confidence polytopes in linear regression models with endogenous regressor. Our approach uses independent noise sequence samples and an ordering property to form confidence regions that contain the true system parameter with a user-specified lower bounded probability, regardless of sample size. By intersecting multiple regions derived from this ordering, we obtain a conservative estimate that guarantees a lower probability bound. The desired probability bound can be flexibly adjusted by selecting appropriate rational numbers. Moreover, a scenario-based method called the wait-and-judge technique is used to evaluate the probability that the true system parameter is included within the sampled convex hull. Numerical simulation is provided to help illustrate the theorem.

15:15-15:30 **SatA01-8**

Stability Analysis and Control Design for 2-D Switched Affine Systems

Geng Chen Shandong Univ. of Science and Tech.
Yuanyuan Liu Shandong Univ. of Science and Tech.

This paper focuses on stability analysis for 2-D discrete-time switched affine systems. Utilizing the Lyapunov-Metzler inequalities technique, sufficient stability conditions together with a state-dependent switching function are designed, which will guarantee the desired equilibrium points' practical stability. The whole reachable equilibrium points are provided. Two different models representing 2-D discrete-time switched affine systems are discussed including the Fornasini-Marchesini local state-space type and the Roesser type. Furthermore, the transformation relationship between the two models is presented. At last, a numerical example is provided to demonstrate our methods.

SatB01 **Bo Hai Hall**

Advanced Modeling, Identification, and Control Strategies in Complex Systems II **15:50-17:50**

Chair: Shuzong Xie Zhejiang University of Science and Technology

15:50-16:05 **SatB01-1**

Nonlinear Dynamics Adjustment in Robotic Trajectory Control with Accelerated Convergence

Wei Dou Lanzhou University

Controlling a robot arm without an accurate system model is challenging. This paper introduces a nonlinear dynamics tuning mechanism to improve trajectory control. Applied to the PUMA 560 robot arm, the method enhances nonlinearity and accelerates convergence, with parameters optimized experimentally. Simulations demonstrate rapid error reduction and high-precision tracking, offering a promising solution for complex scenarios.

16:05-16:20 **SatB01-2**

Sliding Mode Control of T-S Fuzzy Switched Systems with Multi-node Stochastic Communication Protocol

Wendi Wang Qingdao Univ. of Tech.
Haijuan Zhao Qingdao Univ. of Tech.
Wei He Qingdao Univ. of Tech.

This paper addresses sliding mode control(SMC) for Takagi-Sugeno (T-S) fuzzy switchied systems under a multi-node stochastic communication protocol(MSCP). Sensor and actuator access is modeled by two Markov chains, merged via a mapping into a single equivalent chain. A scheduling-dependent fuzzy sliding mode controller is designed, and MFD-based conditions are derived to guarantee mean-square exponential stability and sliding surface reachability. Numerical simulations validate the effectiveness of the proposed method under MSCP scheduling and switching constraints.

16:20-16:35 **SatB01-3**

Sliding Mode Control of Uncertain Switched Systems with Stochastic Communication Protocols

Wei He Qingdao Univ. of Tech.
Haijuan Zhao Qingdao Univ. of Tech.
Wendi Wang Qingdao Univ. of Tech.

This paper investigates sliding mode control for uncertain discrete-time switched systems under a stochastic communication protocol (SCP) and average dwell-time switching. A token-dependent SMC law is designed to ensure that each transmission grants network access to a single actuator, thereby avoiding data collisions. By utilizing token-dependent Lyapunov functions and linear matrix inequalities (LMIs), we establish the reachability of the sliding surface and mean-square exponential stability of the closed-loop system. Numerical simulations demonstrate the effectiveness of the proposed method under SCP scheduling and switching constraints.

16:35-16:50 **SatB01-4**

Fuel Cell Fault Diagnosis Based on Data Mining

Bin Guo Shandong Univ. of Science and Tech. & Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Haoyi Yu Shandong Univ. of Science and Tech. & Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Ziliang Zhao Shandong Univ. of Science and Tech. & Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety

Due to their clean reaction product—water, fuel cells (FCs) are increasingly used as power sources for vehicles and ships. However, they are prone to faults during typical degradation conditions like vehicle start-stop and variable loads, some of which can cause irreversible damage. Early fault diagnosis is crucial for extending FCs' lifespan. Current research often involves extensive fault experiments and accelerated life tests to create private datasets. This leads to excessive hydrogen consumption and increased carbon emissions, contradicting the goal of clean energy. This study adopts a data mining method, focusing on electrochemical impedance spectroscopy (EIS). It explores the EIS evolution patterns of FCs under different states, uses these patterns for data filling, and minimizes external disturbance from EIS. By dynamically expanding real-time impedance data for a lifecycle phase and generating a novel spatial map of impedance over time, it achieves fault diagnosis.

16:50-17:05 **SatB01-5**

Recursive Parameter and State Estimation of Dynamical Models for Errors-in-Variables State-Space Systems

Jingsheng Chen Jiangnan University
Xiao Zhang Jiangnan University
Feng Ding Jiangnan University
Yanjun Liu Jiangnan University
Siyu Liu Zhejiang Normal University

This paper focuses on the parameter and state estimation problems for linear single-input single-output errors-in-variables systems, which are modeled through observable canonical state-space representations. The system dynamics are subject to process disturbances, while the input and output measurements are corrupted by white noise. A parametric model structure is constructed for the parameter estimation. Based on the bias compensation principle and Kalman filtering technique, a hybrid algorithm is developed to jointly estimate system parameters and states. The numerical simulation example tests the effectiveness of the proposed algorithm.

17:05-17:20 **SatB01-6**

Partial Format-based Model-Free Sliding Mode Control Design for Fused Magnesium Furnaces Electrode Systems

Chong Zhang Shenyang Jianzhu University
Qiuxia Qu Shenyang Jianzhu University
Juan Wang Shenyang Jianzhu University
Jiaqi Zhai Shenyang Jianzhu University

The electrode of a fused magnesia furnace is characterized as a nonlinear discrete system with time-varying parameters and multiple disturbances. Traditional control algorithms, which rely on precise mathematical models, are difficult to design effectively. To address this issue, a model-free control algorithm based on input/output data is proposed. A model-free adaptive controller is constructed by integrating the Model-Free Adaptive Control (MFAC) algorithm with

the Sliding Mode Control (SMC) algorithm using a partially structured dynamic linearization model. The stability of the proposed controller is verified through theoretical analysis. Simulation experiments are conducted to compare the performance of the proposed control algorithm with a PID controller. The results indicate that a fast response, high robustness, and smooth output are achieved, demonstrating the suitability of the proposed method for electrode regulation in fused magnesia furnaces.

17:20-17:35 **SatB01-7**

Optimized MPGA-Based Variable Domain Fuzzy PID Current Control Design for Electricity Melt Magnesium Electrode System

Wenyu Yang Shenyang Jianzhu University
Qiuxia Qu Shenyang Jianzhu University
Juan Wang Shenyang Jianzhu University

Aiming at addressing the issues of energy efficiency loss and quality fluctuation caused by insufficient electrode current control accuracy in the production process of electricity melt magnesium, a variable domain fuzzy PID control strategy based on multi-population genetic algorithm (MPGA) optimization is proposed. Firstly, the adaptive adjustment of the fuzzy domain is realized by constructing the dynamic contraction-expansion factor function, and the control accuracy under small deviation conditions is enhanced. Then, a multi-population co-evolution and elite migration mechanism is designed to optimize the controller parameters, which overcomes the local premature convergence issues of the traditional single-population genetic algorithm. Finally, comparative experiments with conventional control methods demonstrate that the proposed strategy significantly improves key performance metrics, including adjustment accuracy, response speed and anti-interference ability. Thus, the robustness of the system is significantly improved under complex conditions of raw material composition fluctuation and load disturbance. This methodology offers a novel approach for precise control and energy efficiency optimization of electricity melt magnesium smelting process.

17:35-17:50 **SatB01-8**

Output Tracking Control for Discrete-Time Switched Affine Systems

Faxun Huang Shandong Univ. of Science and Tech.
Yanzheng Zhu Shandong Univ. of Science and Tech.
Xiaozeng Xu Shandong Univ. of Science and Tech.
Shasha Zhao Shandong Univ. of Science and Tech.

This paper investigates the output tracking control issue for discrete-time switched affine systems. To achieve effective tracking performance, a novel Lyapunov function is constructed, which incorporates both the tracking error dynamics and switching characteristics to establish comprehensive stability criteria. Sufficient conditions for stability are established using a switching Lyapunov function, which are expressed in the form of linear matrix inequalities. The proposed control strategy significantly enhances the dynamic response performance, ensuring the system state can track the target trajectory within a specified time. Finally, the effectiveness and feasibility of the method are verified through numerical examples.

SatA02 **Huang Hai Hall**

AI-Powered Perception, Sensing, and Path Planning in Intelligent Environments I **13:30-15:30**

Chair: Shuangyi Hu

Zhejiang University of Technology

13:30-13:45 **SatA02-1**

A Huber-Based Hybrid Filtering Approach for Enhanced CT Imaging in Scoliosis Diagnosis

Shaoxuan Xi Kunming Univ. of Science and Tech.
Guanbin Gao Kunming Univ. of Science and Tech.
Yu Cui Kunming Univ. of Science and Tech.
Cheng Hou Kunming Univ. of Science and Tech.
Shubo Wang Kunming Univ. of Science and Tech.

Scoliosis diagnosis relies heavily on CT imaging, but existing filtering methods often struggle to balance noise reduction and edge preservation. To address this issue, this paper proposes a novel hybrid filtering approach based on the Huber penalty function, which combines median filtering and partial histogram equalization. The method enhances image quality by effectively reducing noise while preserving structural details and edge clarity. Evaluations demonstrate the proposed method's superiority over conventional techniques. Moreover, the enhanced image quality improves the accuracy of Cobb angle measurements, reducing manual annotation errors. These findings highlight the potential of this approach for clinical diagnosis of scoliosis.

13:45-14:00 **SatA02-2**

Optimization of the Clustering Allocation Strategy for Police Agents in the RoboCup Rescue Simulation System

Zixuan Yin Southeast University
Bingya Zhao Southeast University

In recent years. a number of major earthquakes have occurred around the world, which seriously threaten human life. The RoboCup Rescue Simulator System, a multi-agent system, simulates disaster scenarios to conduct collaborative rescue operations. Police agents play a crucial role in rescue operations, and the task allocation of police agents is one of the most important parts in obstacle clearing. However, existing clustering allocation methods for police tasks still require further efforts to enhance efficiency. To address this, this paper optimizes the clustering allocation strategy for police agents by combining the K-means++ algorithm for building clustering with the Hungarian algorithm for optimal task allocation of unburied police agents,

enabling them to operate in different areas. Experimental results demonstrate that this strategy improves the rationality of police allocation and significantly enhances rescue efficiency across various map scenarios, offering a valuable reference for multi- agent collaboration in disaster rescue.

14:00-14:15 **SatA02-3**

RACL U-Net: Leveraging Enhanced Global Context for Novel Wound Image Segmentation

Xian Li Guizhou University
Hong Luo Beijing Jishuitan Hospital Guizhou Hospital
Xiaoyan Liu Guizhou University
Tao Zhang Guizhou University
Mei Zhang Guizhou University

This article introduces a new adaptive predefined time neural network tracking control method for nonlinear interconnected systems. The approach employs an adaptive backstepping technique to handle unknown system uncertainties in predefined time settings. Neural networks are utilized to estimate these unknown uncertainties. The findings indicate that, with the proposed control method, each system state can converge to small regions around zero within a predefined time, as shown through Lyapunov stability analysis. A simulation example is also provided to demonstrate the practical effectiveness of the proposed approach. Additionally, a step-by-step guide for engineers in industrial process applications is included, highlighting the significance of predefined time stability for achieving optimal performance.

14:15-14:30 **SatA02-4**

A Generative Model of Multi-step Temporal Difference Method Based on Reinforcement Learning

Liu Yang Shenyang City Univercity
Hao Wang Wenzhou Shifeng Technology Co., Ltd.
Chengxiang Xu Zhejiang Hongsheng Technology Information Service Co., Ltd.
Shaoxin Sun Chongqing University
Xiaoxian Li Liaoning Dinghan Quickhigh Electronic System Engineering Co.Ltd.
Yuliang Cai Liaoning University

In intelligent control, artificial intelligence (AI) pattern recognition further demonstrates the convenience of human-machine interaction in operational processes. By combining control theory with recognition technology, speech recognition can more accurately control the parameters and state of the model, thereby improving the accuracy and robustness of the model. With the introduction of reinforcement learning systems, speech recognition patterns can autonomously learn and optimize model parameters through continuous trial and error and feedback, achieving more efficient speech recognition. Facing the introduction of speech recognition functions in various AI devices, the adoption of a distributed computing mode can not only solve the problem of device intelligence but also improve the accuracy of speech recognition. By using a multi-step temporal difference method to update the correlation program between speech data and iterating optimization with neural networks, the cloud interconnection mode of devices can be initiated to store and back up adequate information reasonably. Combining intelligent control with reinforcement learning attached to the speech recognition process reduces training costs and complexity, providing a new research approach for the recognition technology of massive texts.

14:30-14:45 **SatA02-5**

Research on Optimal Deployment of Jammer Based on PSO-HHO Hybrid Algorithm

Jie Yang Xi'an Univ. of Posts and Telecom.
Jiahui Feng Xi'an Univ. of Posts and Telecom.
Jing Zhang Xi'an Univ. of Posts and Telecom.

This paper addresses the optimization deployment of jamming devices for efficiently disrupting enemy communication networks. It innovatively integrates Particle Swarm Optimization (PSO) with Harris Hawk Optimization (HHO) algorithms to propose a hybrid strategy (PSO-HHO). This approach aims to dynamically adjust the spatial distribution of jamming devices, significantly enhancing coverage efficiency and interference intensity on key nodes. Intelligent optimization algorithms have become research hotspots due to their global search capabilities and strong adaptability; however, single algorithms face limitations in complex multi-objective optimization problems. To address this, the paper combines PSO and HHO algorithms, employing dynamic inertia weight adjustment, introducing crossover mutation, and incorporating early stopping mechanisms. This ensures a balance between global search and local exploitation capabilities while designing multidimensional fitness functions and incorporating distance penalty terms to strengthen constraint satisfaction. Simulation results demonstrate that the hybrid algorithm can quickly find optimal solutions in jammer optimization deployment and effectively adapt to different battlefield environments, thereby improving interference effectiveness.

14:45-15:00 **SatA02-6**

Positioning Design Methodology for Electronic Warfare Aircraft in Stand-off Jamming Operations

Jie Yang Xi'an Univ. of Posts and Telecom.
Ruyi Zhang Xi'an Univ. of Posts and Telecom.
Yuandong Xie Xi'an Univ. of Posts and Telecom.

When the jamming aircraft executes a jamming mission against the radar target, the research primarily about the position design problem of electronic warfare aircraft in stand-off jamming operations. Based on the jamming equation, a racetrack-pattern positioning design model is developed, covering two sub-models: positioning azimuth design and positioning altitude design. Firstly, by analyzing the geometric relationships between the mission area and target area, along with the azimuth

design constraints, a position model satisfying azimuth requirements is established. Subsequently, combined with the altitude constraints caused by the pitch coverage range, a position altitude design model was formed. Finally, through the construction of simulation scenarios, the model's effectiveness is empirically verified by comparing the calculated parameters from the model with the actual parameters, which are found to be consistent. The results demonstrate that the model provides clear guidance for the jamming positioning configuration of electronic warfare aircraft, enabling them to accurately determine optimal positions in stand-off jamming operations.

15:00-15:15 **SatA02-7**

Research on Data Imputation Method of Pumping Unit with Dynamic Sparse Activation

Guobin Li China Univ. of Petroleum (East China)
Dongya Zhao China Univ. of Petroleum (East China)
Jiehua Feng Sun Yat-sen University
Fei Li China Univ. of Petroleum (East China)
Yingqiang Yan China Univ. of Petroleum (East China)

The pumping unit is the core equipment of oilfield production, and the lack of its power data seriously affects the accuracy of oilfield equipment condition monitoring. To address the limitations of traditional imputation methods in temporal data imputation —limited modeling capacity, sample homogeneity in generative models, and computational inefficiency, this paper propose the Dynamic Sparse Activation Conditional Diffusion Model (DSAN-CSDI). This framework integrates conditional diffusion models' probabilistic generation with dynamic sparse attention mechanisms through two innovations: 1) incorporating a dynamic sparse gating module that adaptively activates featurecritical neurons to minimize computational redundancy; 2) developing a validation-loss-driven adaptive sparsity strategy that dynamically optimizes accuracy-efficiency equilibrium. The methodology establishes an efficient framework for high-dimensional industrial time-series restoration tasks.

15:15-15:30 **SatA02-8**

DMA-MD: A DiagMasked Attention for Missing Data Imputation in Non-Stationary Time Series

Tingli Su Beijing Tech. and Business Univ.
Gongxin Wang Beijing Tech. and Business Univ.
Xuebo Jin Beijing Tech. and Business Univ.
Jianlei Kong Beijing Tech. and Business Univ.
Yuting Bai Beijing Tech. and Business Univ.

To address the challenge of missing value imputation in time series data, especially the complexities of non-stationary time series, this paper proposes a novel framework DMA-MD (DiagMasked Attention for Non-stationary Time Series Imputation). This method aims to enhance imputation accuracy and model robustness, adapting to various data distribution changes in real-world applications. Firstly, DMA-MD employs a diagonal masking attention mechanism to improve imputation capability. This ensures that the model does not directly use target time point data for prediction but relies on information from other time steps, enhancing robustness and accuracy. Additionally, a stabilization module increases the model's adaptability to different data distributions, effectively mitigating the impact of non-stationarity and accelerating the training process. Extensive experiments on multiple real-world datasets, including Air Quality and ETT, demonstrate that DMA-MD significantly outperforms state-of-the-art methods such as Transformer and RNN-based approaches in imputation accuracy. Furthermore, ablation studies confirm the effectiveness of each component, showcasing DMA-MD's superior performance in handling complex non-stationary time series with missing data.

SatB02 **Huang Hai Hall**

AI-Powered Perception, Sensing, and Path Planning in Intelligent Environments II **15:50-17:50**

Chair: Xiao Zhang Jiangnan University

15:50-16:05 **SatB02-1**

Distributed Electronic Reconnaissance Coverage and Optimized Deployment

Jie Yang Xi'an Univ. of Posts and Telecom.
Jing Zhang Xi'an Univ. of Posts and Telecom.
Jiahui Feng Xi'an Univ. of Posts and Telecom.

The effect of electronic reconnaissance has a direct influence on the war form and battlefield situation. This paper focuses on the problem of full coverage of target area in electronic reconnaissance, aiming to achieve resource optimization by optimizing the distribution of stations, using the least base stations to achieve the required coverage effect, so as to improve the overall efficiency of
the reconnaissance system. Therefore, this paper proposes an optimal deployment method of reconnaissance base station based on intelligent optimization algorithm. These algorithms optimize the layout of reconnaissance base stations by limiting the minimum safe distance from enemy radar and controlling the number of reconnaissance base stations. The experimental results show that the proposed method has significant advantages in improving the effectiveness, security and resource saving of the reconnaissance base station deployment, and the comparative analysis of different algorithms further verifies the feasibility and effectiveness of the proposed method.

16:05-16:20 **SatB02-2**

Research on Unmanned Aircraft Route Planning Based on Improved Ant Colony Algorithm

Jie Yang Xi'an Univ. of Posts and Telecom.
Yuandong Xie Xi'an Univ. of Posts and Telecom.
Ruyi Zhang Xi'an Univ. of Posts and Telecom.

Aiming at the problems of slow convergence speed, easy to fall into local optimum and insufficient path

smoothness in the traditional ant colony algorithm in UAV route planning, an improved ant colony algorithm is proposed. Firstly, the direction continuity reward factor and the dynamic weight of altitude difference are introduced into the heuristic function to optimize the path smoothness and environmental adaptability; secondly, the adaptive pheromone weight factor and the heuristic function weight factor are adopted, and the parameters are dynamically adjusted in combination with the number of iterations, so that the algorithm balances the ability of global exploration with that of local exploration; lastly, the upper and lower limits of pheromone concentration constraints are designed, and the pheromone concentration is updated based on the comprehensive path evaluation indexes to enhance the guidance of quality paths. pheromone to enhance the guiding effect of high-quality paths. The algorithm significantly improves the robustness and practicability of UAV route planning, and can provide theoretical support for autonomous navigation in dynamic environments.

16:20-16:35 **SatB02-3**

Distributed Flight Arrays (DFAs) control and formation stabilization - Theoretical part

Jiale Zhang University of West England
University of Bristol

Distributed Flight Array (DFA) is a concept in robotics and unmanned aerial vehicles (UAVs) in which multiple smaller aircraft work together to achieve a common goal. In this paper, the theoretical framework of DFA control and formation stabilization is investigated. The paper presents a case study containing a practical implementation of a multi-rotor UAV using DRA, including the steps to fabricate a functional prototype. The model is established in Matlab/Simulink. The main contributions of the paper are the design of specialized modular modules and the development of generalized control strategies.

16:35-16:50 **SatB02-4**

Distributed Flight Arrays (DFAs) control and formation stabilization - Simulation Demonstration

Jiale Zhang University of West England
University of Bristol

The Distributed Flight Array (DFA) is a modular multipropeller cooperative flight vehicle in which multiple single-rotor flight units work together to achieve cooperative flight and complex maneuvers. This paper presents distributed control and flight stabilization of DFA, especially involving different structures and the number of units that make up different structures. In this paper, the DFA simulation platform based on the theoretical part is used to conduct simulation tests. The effectiveness of the designed control algorithm (PID control combined with trajectory control) and the response ability of the system to external interference in dynamic environment are verified under different formation structures.

16:50-17:05 **SatB02-5**

EUSDE-based Trajectory Planning and Tracking Control for the Hip Exoskeleton with Enhanced Gait Symmetry

Jinyuan Liu Kunming Univ. of Science and Tech.
Yashan Xing Kunming Univ. of Science and Tech.
Jing Na Kunming Univ. of Science and Tech.
Guanbin Gao Kunming Univ. of Science and Tech.

Gait asymmetry in stroke patients severely impairs their mobility and exoskeleton-assisted rehabilitation therapy is an efficient solution for gait recovery. However, existing research primarily focuses on improving gait symmetry, with little consideration given to the potential risks associated with the human-robot interaction (HRI) force. To address this issue, this paper proposes a dynamic planning method for symmetric gait trajectories in exoskeleton-assisted rehabilitation based on the HRI force. This method dynamically generates symmetric gait trajectories to improve gait symmetry while keeping the HRI force within a tolerable range. The HRI force is estimated using an enhanced unknown system dynamics estimator (EUSDE) and the gait information is extracted through an adaptive oscillator. The EUSDE-based tracking controller is developed for the imparied side in order to enhance gait symmetry. Finally, simulations validate the effectiveness of the proposed method.

17:05-17:20 **SatB02-6**

Aerodynamic Parameter Identification of Morphing Aircraft Based on Physics-Informed Neural Networks

Nanhai Huang Beijing Institute of Technology
Zhengjie Wang Shenzhen MSU-BIT University
Beijing Institute of Technology
Yuanbo Chen Xi'an Modern Control Technology Research Institute
Qiyuan Cheng Shenzhen MSU-BIT University

To enhance the aerodynamic parameter identification capabilities of morphing air-craft under complex flight conditions, this paper proposes a modeling method based on Physics-Informed Neural Networks (PINNS). By embedding physical constraint equations derived from aircraft dynamics into the loss function of the neural networks, the approach combines data-driven learning with prior physical knowledge, enabling efficient identification related parameter of aerodynamic forces and moments. The framework integrates both Computational Fluid Dynamics (CFD) data and flight simulation data to construct a unified model applicable to various flight configurations. This method ensures physical consistency and strong generalization ability, maintaining high modeling accuracy even under limited data conditions. Compared with traditional empirical or purely data-driven models, the proposed approach significantly reduces the dependence on large-scale experimental data and improves interpretability.

17:20-17:35 **SatB02-7**

Modeling and Simulation of Bionic Baffles in PEMFC Flow Fields

Ziliang Zhao Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Wenpeng He Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Bin Guo Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Jun Zhao Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Xiaojian Qin Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Ji Pu Fo shan xian hu Laboratory

The incorporation of baffle structures within the flow field of proton exchange membrane fuel cell bipolar plates plays a crucial role in enhancing mass transfer efficiency and increasing power density. To further optimize the overall performance of PEMFC systems, this study proposes a novel flow field baffle structure inspired by biomimetic airfoil design. The airfoil-shaped baffles were systematically designed and implemented in large-area PEMFC bipolar plates. Comparative analyses were conducted against conventional straight, triangular, and trapezoidal baffle configurations. The results demonstrate that the maximum power density of the proposed flow field is improved by 7.32%, 3.69%, and 5.22%, respectively. This work provides a strong foundation for structural optimization of advanced flow fields in large-area fuel cells and shows promising potential for practical engineering applications.

17:35-17:50 **SatB02-8**

Abnormal Working Condition Identification of Electricity Melt Magnesium Furnace Based on Improved YOLOv11 Lightweight Model

Xinyu Wang Shenyang Jianzhu University
Qiuxia Qu Shenyang Jianzhu University
Juan Wang Shenyang Jianzhu University

Abnormal working conditions in the production process of electricity melt magnesium furnace will lead to local overheating of furnace wall and even leakage of furnace, which seriously affects equipment safety and product quality. Because the traditional monitoring methods rely on manual observation and elec- trical parameter detection, it is difficult to meet the needs of high precision and real-time in modern industry. Aiming at the shortcomings of insufficient detection accuracy of small targets in infrared images, this paper designs a YOLO v11- MSD model based on YOLO v11 model to identify abnormal working conditions of electricity melt magnesium furnace. Firstly, the lightweight network MobileNetv3 is used to replace the original backbone network, and combined with the lightweight SDCB convolution module, the complexity and computational burden of the model can be effectively reduced. The DFformer attention mechanism is introduced to enhance the recognition ability of the model to small target areas in infrared images. Finally, through experimental verification, the FPS of the model in this paper is 110, which is 20 % higher than that of YOLOv11 (base- line). Although mAP decreases by 0.2 %, it meets the real-time constraint. Com- pared with similar models, this model achieves a better balance between accuracy and speed. It can be seen from the comparison of ablation experiments that this design sacrifices a small amount of accuracy (mAP decreases by 0.2 %) in ex- change for a significant increase in speed (+ 22 % FPS).

Award Session 最佳论文评选

June 14, 2025

Sat03 **Bei Hai Hall**

Award Session:

Best Paper Finalist **13:30-16:50**

Chair: Weicun Zhang University of Science and Technology Beijing

13:30-13:50 **Sat03-1**

Backstepping-Based Finite-Iteration Tracking Control Method for Repetitive Nonlinear Discrete-Time Systems

Jiake Wang Qingdao Univ. of Science and Tech.
Yang Liu Qingdao Univ. of Science and Tech.
Ronghu Chi Qingdao Univ. of Science and Tech.
Zhiqing Liu Qingdao Univ. of Science and Tech.

Iterative learning control (ILC) is an effective tool for repetitive systems to achieve perfect tracking tasks on a finite time interval. However, most of ILC results focus on iterative asymptotic convergence, that is the tracking performance can only be achieved when the iterative operation tends to the infinity, which is undesired in practice. Therefore, a backstepping based finite-iteration tracking control (FITC) method is designed to ensure the finite-iteration convergence (FIC) of nonlinear discrete-time systems (NDTSs). In this work, the definition of FIC of NDTSs is given for the first time. On this basis, a backstepping-based FITC approach for repetitive NDTSs is proposed by employing variable replacement, and the finite-iteration number is derived via difference inequalities. Moreover, the proposed control strategy avoids the causality contradiction from the traditional backstepping technique of NDTSs. Simulation results are used to illustrate the effectiveness of the presented scheme.

13:50-14:10 **Sat03-2**

Power Load Time Series Forecasting Based on Normalizing Flow and Variational Autoencoder

Xuebo Jin Beijing Tech. and Business Univ.
Zhizhao Zhang Beijing Tech. and Business Univ.
Jianlei Kong Beijing Tech. and Business Univ.
Yuting Bai Beijing Tech. and Business Univ.
Tingli Su Beijing Tech. and Business Univ.

With the rapid development of intelligent sensing and data storage technologies, power systems have accumulated vast amounts of time-series data characterized by strong nonlinearity and high noise levels. To address the limitations of traditional prediction models in handling complex noise interference—resulting in in-sufficient modeling capability and reduced accuracy—this paper proposes a variational autoencoder predictor integrated with normalizing flows. First, a gated re-current unit (GRU)-based recurrent autoencoder framework is constructed to dynamically extract temporal features and filter noise through its time-dependent modeling capability. Then, a planar flow layer is introduced at the encoder output, transforming latent variables into complex distribution spaces via invertible map-pings to enhance the model's adaptability to non-Gaussian noise. Experimental results show that the proposed method significantly outperforms conventional models in noise suppression and dynamic adaptation, with a 27.7% reduction in mean squared error (MSE). The study confirms that the synergistic optimization of normalizing flows and variational autoencoders effectively resolves the nonlinear modeling challenges of power time-series data. This approach provides a new technical pathway for mid-to-long-term load forecasting, contributing to grid stability and optimized energy scheduling.

14:10-14:30 **Sat03-3**

Soft Sensor Modeling Based on Dual-Stream Multi-scale GRU with Feature Fusion Mechanism

Huanqi Sun Jiangnan University
Le Yao Hangzhou Normal University
Weili Xiong Jiangnan University
William Holderbaum University of Reading
University of Salford

The multi-level coupling of industrial process technologies results in process flows with multi-scale characteristics and dynamics. Moreover, long-term dependencies between processes make it challenging to fully extract temporal features. To address this, a multi-scale GRU based soft sensing model within a dual-stream framework is proposed. On one hand, a dual-stream information extraction structure is designed to capture both local coupling relationships and global temporal dependencies, forming complementary information flows that enhance the prediction performance. On the other hand, efficient channel attention and temporal attention mechanisms are introduced in the local multiscale and global temporal perception feature extraction components, respectively. These mechanisms dynamically explore the latent correlations between input and target features, capture key features, and assess the importance of different historical time points for predicting the target time point, thereby selecting critical time point information. Finally, predictive performance of the proposed algorithm is validated through its application to wastewater treatment processes and $CO2$ absorption column.

14:30-14:50 **Sat03-4**

A Pre-compensation-based Active Disturbance Rejection Control Design for A Class of High-order inertial systems

Zihao Li Zhengzhou University
Zhenlong Wu Zhengzhou University
Yanhong Liu Zhengzhou University

To effectively address the formidable control challenges posed by the $K/(T\ s\ +\ 1)n$ -type high-order inertial systems, which are characterized by complex dynamics and inherent difficulties in achieving precise regulation, this paper proposes a novel pre-compensation-based active disturbance rejection control (PADRC) design. Subsequently, the quantitative tuning rules of PADRC, specifically tailored for the $K/(T\ s\ +\ 1)n$ - type high-order inertial systems, are derived in painstaking detail. To thoroughly verify the advantages of PADRC over other common control strategies, control strategies like proportional-integral control (PI), conventional active disturbance rejection control (ADRC), and input modified active disturbance rejection control (MADRC) are carefully designed. After conducting simulation experiments and Monte Carlo experiments in crucial aspects including tracking performance, disturbance rejection ability, and the capacity to handle system uncertainties, the comparison results clearly demonstrated that PADRC obtained the best control performance with remarkable robustness.

14:50-15:10 **Sat03-5**

Thermal Runaway Early Warning of Lithium-ion Battery based on 3-D Feature Landscape

Haoyi Yu Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Bin Guo Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Ziliang Zhao Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety
Jun Zhao Shandong Univ. of Science and Tech. Shandong Key Lab. of Hydrogen Electric Hybrid Power System Control and Safety

Against the backdrop of global energy transition and sustainable development, electric vehicles (EVs) have emerged as a critical direction in the transportation sector due to their environmental advantages. Lithium-ion batteries (LIB), as their core component, have become the mainstream choice for EVs. However, the associated safety issues of thermal runaway are drawing increasing attention. Currently, data-driven methods based on signal processing have achieved significant progress in the field of LIB fault diagnosis. However, existing studies face challenges, as 1-dimensional (1-D) signals struggle to capture sensitive fluctuations in the early stages of thermal runaway, while 2-D images suffer from information redundancy. To address these limitations, this paper proposes a thermal runaway early warning method for vehicle LIB based on 3-D feature landscape, aiming to ensure the safe and stable operation of EVs and power batteries. This method overcomes the constraints of traditional low-dimensional feature spaces. First, the generalized s-transform is employed to convert 1-D temperature signals into 2-D spectrograms. On this basis, scale invariant features are extracted to construct 3-D feature landscape and generate high information density state barcode. Finally, various machine learning methods are applied to classify the barcode data, enabling accurate identification of thermal runaway states. The proposed algorithm is evaluated using standardized datasets from Oak Ridge National Laboratory, validating its effectiveness. The results demonstrate that the signal processing method based on 3-D feature landscape significantly improves classification accuracy, with the support vector machine model achieving a precision rate of 98.10%.

15:10-15:30 **Sat03-6**

Wave Compensation Design Based on Attitude Prediction

Zongbing Jiang Shenyang Jianzhu University
Juan Wang Shenyang Jianzhu University Shenyang Institute of Automation
Peng Li Shenyang Institute of Automation
Qiuxia Qu Shenyang Jianzhu University

To address the interference caused by six-degree-of-freedom waveinduced motions during the landing of shipborne unmanned aerial vehicles (UAVs) at sea, this study proposes a double-layered Stewart platform compensation mechanism. A kinematic model of the platform is constructed using a closedloop vector method, enabling coordinated control in which the lower layer simulates wave disturbances and the upper layer performs dynamic compensation. To mitigate the effects of sensor delay and noise, a hybrid CNN-BiLSTM prediction model is developed. Using ship pitch attitude as an example, the model significantly improves the accuracy of attitude prediction. Experimental results demonstrate that the proposed approach achieves effective wave compensation, offering a viable solution for UAV landings at sea.

15:50-16:10 **Sat03-7**

Kinematic Calibration of Robots by Binocular Vision and Reflective Marker Detection

Yu Xiang Kunming Univ. of Science and Tech.
Guanbin Gao Kunming Univ. of Science and Tech.
Yuan Li Kunming Univ. of Science and Tech.

A kinematic calibration approach for improving the absolute positioning accuracy of industrial robots using a binocular vision system is proposed. Reflective marker balls attached to the robot's endeffector enable precise positional data acquisition through a binocular stereo vision measurement system. A comprehensive error model based on the Modified Denavit-Hartenberg (MD-H) parameters is developed, and the Levenberg-Marquardt optimization algorithm is applied to identify and compensate the kinematic parameters. Experimental validation conducted with an ELITE EC66 robot demonstrates enhancements in positioning performance. The validation set data shows that the maximum absolute positioning error, average error, and standard deviation

were substantially reduced from 3.56 mm, 0.73 mm, and 0.69 mm to 0.50 mm, 0.15 mm, and 0.12 mm, respectively. These results validate the efficacy of the proposed calibration method, highlighting its potential for practical applications due to its simplicity, efficiency, and costeffectiveness.

16:10-16:30 **Sat03-8**

Multi-objective Oriented Dynamic Matching Optimization of Hybrid Power System Parameters

Tianhao Jia Beijing Institute of Technology
Yue Ma Beijing Institute of Technology
Beijing Institute of Technology Chongqing Innovation Centre
Chongbing Zhang Beijing Institute of Technology
Feixiang Zhang Beijing Institute of Technology

Aiming at the problem of difficulty in matching the core components of the hybrid power system of amphibious land and air vehicles, this paper proposed a power system matching optimization strategy. Firstly, the components of the hybrid power system, including the engine, the generator, and the power battery pack, were modeled. secondly, a multi-objective optimization problem was constructed by taking the power performance, fuel economy, and battery health status as the optimization objectives, and taking the number of battery packs and the power of the engine-generator set as the optimization variables. lastly, a nondominated sorting genetic algorithm integrating Lévy flight and sine cosine algorithm (LF-SCA-GA) was proposed. The simulation results demonstrate that after power matching, the power performance, fuel economy, and battery health status are enhanced compared with the initial design of the power system.

16:30-16:50 **Sat03-9**

Printing Defect Detection on Embossed Surfaces via Modified Multiple Paired Pixel Consistency Model

Sheng Xiang Zhejiang University of Technology
Bo Zheng Zhejiang University of Technology
Defu Chen Zhejiang University of Technology
Shuangyi Hu Zhejiang University of Technology
Guanghui Yang Zhejiang University of Technology
Qiang Chen Zhejiang University of Technology

Defect detection plays a critical role in modern manufacturing by ensuring product quality and operational efficiency, particularly in precision-critical industries where microscopic imperfections can lead to significant functional failures. Our proposed framework addresses this challenge through a novel statistical framework termed Multiple Paired Pixel Consistency (MPPC), which implements systematic defect identification by analyzing structured brightness correlations between geometrically constrained pixel pairs. This methodology employs hypothesis testing to quantify correlation consistency, demonstrating exceptional sensitivity to microstructural anomalies on embossed surfaces that conventional computer vision techniques typically overlook. To optimize detection robustness, we introduce Position-Dependent Data Inhibition (PDI) – an adaptive outlier suppression mechanism employing quantile regression and spatial probability mapping to dynamically adjust detection thresholds across heterogeneous surface regions. Extensive experiments with real-world defect data demonstrate these methods' superior effectiveness and reliability.

16:50-17:10 **Sat03-10**

Data-Driven Modeling Integrating Feedstock Time Series Features for Industrial Process Quality Prediction

Sihong Li Qingdao Univ. of Science and Tech.
Xiaohong Yin Qingdao Univ. of Science and Tech.
Wentao Liu Qingdao Univ. of Science and Tech.
Kaili Yin Qingdao Univ. of Science and Tech.
Yingrui Zhou Qingdao Univ. of Science and Tech.

In Industry 4.0, optimizing production performance amidst varying feedstock properties is a key challenge. This paper presents a novel data-driven modeling approach for a distillation unit (DU), integrating feedstock property and production feature extraction. The proposed method addresses the issue of extracting meaningful features from high-dimensional, imperfect industrial data, where product quality data is often unavailable. By leveraging the dynamic characteristics of the process, the model captures feedstock properties in a data-driven, knowledgeoriented way. The PM-FP-PF model, designed with a customized network structure, effectively predicts product quality even with incomplete data. Experimental results show its strong generalization ability across different feedstocks, offering a solid foundation for optimizing industrial operations and improving production efficiency and product quality.

Poster Sessions 张贴报告

June 14, 2025

Session 1
Modeling & Perception for Complex Systems
Chair: Zhengjie Wang Beijing Institute of Technology

An Advanced YOLOv8 Hard Hat Detection Model Incorporating Double-Layer Routing Attention and Feature Fusion Mechanisms

Guanyang Wang Qingdao Univ. of Science and Tech.
Xinglu Ma Qingdao Univ. of Science and Tech.
Shengjie Ma Qingdao Univ. of Science and Tech.

In view of the difficulties faced by the helmet detection model, such as complex background, dense population and overlapping occlusion of targets, a YOLOv8 helmet detection model based on double-layer routing attention and feature fusion is proposed, which integrates the double-layer routing attention mechanism (BSAM) and the bi-directional feature pyramid network (BiFPN). The model integrates channel attention and BiFormer's double-layer routing attention through the BSAM module, and uses coarse-grained areas to filter non critical value pairs to retain the key parts of the routing area, thus enhancing the network's ability to learn the characteristics of the safety helmet; The BiFPN module is introduced into the model. By eliminating the single connected nodes in the network, the connection between the original input nodes and the output nodes in the same layer is increased, and the strategy of transferring deep semantics from top to bottom and merging shallow features from bottom to top is adopted to achieve bidirectional fusion of features and retain the details of the target; The model uses Wasserstein Loss Function (WLoss) to model the boundary box as a two-dimensional Gaussian distribution, calculate the similarity between the two boundary boxes, make the target information focus on the central area of the boundary box, and reduce the sensitivity to small target position deviation. The experimental results show that compared with YOLOv8n baseline model, the improved model achieves significant performance improvement on the SHWD dataset, with recall and accuracy increased by 9.2% and 3.4% respectively to 88.9% and 92.1%. The algorithm performs well in helmet detection in different scenarios and can adapt to complex and changeable environments.

Research on Anti-UAV Cluster Damage Assessment Technology

Zhijun Liu Beijing Institute of Technology
Jie Li Beijing Institute of Technology
Jian Shen North University of China
Norinco Group Aviation Ammunition Research Institute
Fan Liu North University of China
Ziwang Zhang North University of China
Xiaoguang Wang North University of China
Norinco Group Aviation Ammunition Research Institute
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In order to solve the problem of serious lag of anti-UAV cluster technology and application, this study takes quadrotor UAV as the object, focuses on the damage of flight control and power system from the damage assessment of single aircraft; combines with the hit probability of munitions on cluster, establishes the meeting model of typical munitions and UAV, and provides support for the high-precision damage assessment simulation platform. The simulation results show that: for a single aircraft, the optimal incidence angle of damage is 60°, at which time the limit penetration velocity of the projectile penetrating the UAV is 696.68 m/s, and the probability of damage reaches 42.80%; for a cluster, it is difficult to achieve heavy damage by a single attack, and it is necessary to increase the number of bombs received by the same UAV by multiple rounds of shooting in order to enhance the probability of damage. The UAV target vulnerability model and the cluster damage assessment framework established in the study provide the theoretical and technical basis for the optimization of anti-swarm combat.

Development of Wireless Sensor Network using Long Range Communication for Marine Environment

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Zain Anwar Ali Maynooth Int'l Engi. College
Raza Hassan Solent University
Adnan Ahmed Siddiqui MTC, NESCOM

The advancement of a robust and efficient Wireless Sensor Network (WSN) for monitoring the marine environment is crucial for improving marine resource management, monitoring climate change, and ensuring maritime safety. In this study, a WSN is deployed to integrate with Long Range Communication (LoRa) technology for real-time marine environmental monitoring. Marine environments pose significant challenges due to their vastness, harsh conditions, and the need for continuous monitoring of various parameters such as temperature, acceleration, pressure, and water quality. The proposed system cover vast marine areas through LoRa communication ensuring minimal energy consumption. The proposed study use a set of marine sensors distributed across key locations in the marine environment, capable of monitoring a range of physical parameters. Data is collected and transmitted to a central base station for processing and analysis.

Adaptive Dynamic Programming for Smart Home Energy Management

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Yang Luo China Huadian Corporation Ltd. (CHD)
Yunyun Yang Taiyuan Univ. of Tech.
Yongfeng Lv Taiyuan Univ. of Tech.

This paper proposes a residential energy optimization management method based on Adaptive Dynamic Programming (ADP), aiming to achieve the dual goals of minimizing operating costs and extending battery life. Firstly, home energy system model and the objective function are established. Then, the ADP algorithm is utilized to obtain the optimal management of the smart home energy. In order to facilitate the implementation of the proposed method, the approximation of the value function is achieved through the critic network. The method proposed in this paper omits the action network, discretizes the control within the extreme value interval, traverses the performance index for optimization, and selects the control strategy corresponding to the minimum performance index. This method reduces the computational complexity. The numerical experiments verified the effectiveness of this method.

Multi-level Dynamic Modeling and Analysis of Fuze Hitting Reverse Slope Targets at Small Impact Angle

Hao Li Beijing Institute of Technology
Yanxuan Wu Beijing Institute of Technology
Xudong Luo Beijing Institute of Technology
Haoran Yue Beijing Institute of Technology

Aiming at the issue of low firing rate when hitting reverse slope tar-gets at small impact angle, the modeling and analysis of the multi-level dynamic system were studied. Under multiple parameter conditions with impact angles below 10°, the dynamic simulation was done to ensure result accuracy. The level-I external ballistic system determines the state of the impact point. Through level-II projectile-target encounter simulation, impact overload responses are obtained and used as excitation for the level-III firing mechanism system. The results reveal firing response patterns of fuze, guiding the optimized design of inertial firing mechanism. Optimized results demonstrate successful firing, con-firming the reference value of the research.

Multi-objective Cooperative Dynamic Scheduling Model with Integrating EMPC and IJADE Optimization for Byproduct Gas in Steel Production

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Xinyue Zhang China Iron & Steel Research Inst. Group
Gang Sheng China Iron & Steel Research Inst. Group
Jinxiang Chen China Iron & Steel Research Inst. Group

By-product gas scheduling during iron and steel production is crucial to saving energy and reducing emission. However, the dynamic fluctuations of gas supply and demand, pipeline network pressure and gas cabinet capacity as well as uncertainties caused by production conditions changes often expose the disadvantages of existing scheduling models. Therefore, a multi-objective synergistic dynamic scheduling model for by-product gas is proposed, which integrates economic model predictive control (EMPC) and an improved adaptive differential evolution with optional external archive (IJADE) optimization to achieve synergistic optimization of the production system and by-product gas system. A by-product gas scheduling model is constructed by minimizing an objective function with purchased electricity cost, gas dissipation and equipment adjustment and considering constraints with balance between supply and demand of gas and power generation efficiency of unit. The model can respond quickly to changes of working conditions by using a dynamic adjustment mechanism. The global search capability and convergence speed of JADE are enhanced by using a rolling time-domain dimension reduction, an initial population improving approach with hot-startup and terminal constraints. The experimental results show that com-pared with JADE, the proportion of self-generated peak hours has been improved by 1.1%-1.7%; the cost of purchasing electricity has been reduced by 50,000 RMB/day; the gas discharge rate and the mean square error have been decreased.

A Production Scheduling Optimization Model that Considers Double-Chance Constraints

Yicheng Jin Kunming Cigarette Factory
Jian Xiong Northeast Electric Power University
Yunman Duan Kunming Cigarette Factory
Qingna Duan Kunming Cigarette Factory
Maorong Yao Kunming Cigarette Factory
Zhao Liu Kunming Cigarette Factory

To solve the problem of uncertainty in the operation of pro-duction equipment affecting production planning in production work-shops, a bilateral chance optimization model that considers the uncertainty of equipment operation is proposed in this paper. In this paper, we study the operation process of production equipment, establish a bi-lateral chance constraint based on second-order cone optimization, and establish the objective function of minimum operation cost. The example analysis shows that the model has better robustness and cost control than without uncertainty.

Simulation Analysis and Study on Aerodynamic Characteristics During Elevator Car and Counterweight Intersection

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This paper investigates the aerodynamic interaction between an elevator car and its counterweight during high-speed intersection using Computational Fluid Dynamics (CFD). The flow field characteristics are analyzed to evaluate the impact of aerodynamic forces on the stability and operational safety of high-speed elevator. A numerical model was established to simulate the intersection process, and key parameters such as lateral

force coefficients and pressure distributions were derived. The proposed asymmetric fairing design, which redirects airflow from the car's windward side toward the non-counterweight side, effectively reduces lateral forces during car-counterweight intersection. The study reveals critical aerodynamic phenomena during intersection, providing insights for optimizing elevator design and mitigating instability risks.

An Improved CenterNet Model and Its Application on Surface Defects Detection for Hot-rolled Strip Steels

Zhongping Li Jiangyin Xingcheng Special Steel Co., Ltd.

Surface defects detection systems (SDDSs) based on machine vision for hot-rolled steel strips (HRSSs) have been installed in many s-teel mills, but category, size and location of the surface defects of HRSSs still have been judged to look at the images from the SDDSs by operators, because the false or missed detection cases often occur when the SDDSs are applied to detect the HRSSs' surface images affected by lights, dusts, and water mists. An improved CenterNet (ICN) with convolution attention mechanism is presented in this paper, which can detect the objects on images with or without ambient lights interferences. The ICN is composed by inserting a convolution attention module and a Sigmoid activation function between Resnet 50 and Decoder of CenterNet (CN) model and replacing the loss functions of the Wh-head and Offset-head modules of CN with Smooth L1 loss function. A HRSSs surface images dataset including 8000 images is constructed, which contains the images with one or multi-category defects and the images without defects. Some of these images are those affected by lights, such as the exposed images and low-light images, and the other part are those with good lighting. The ICN model and CN model are trained, tested, and verified by the image dataset. The experiment results show that the ICN model can detect precisely the surface defects of HRSSs and has higher detection accuracy than CN model.

Analysis and Programming Implementation of Patrol Robot Kinematics Based on Mecanum's principle

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Qunfeng Zhao Tianjin Univ. of Tech.
Yu Tian Tianjin Univ. of Tech.
Rutao Wang Tianjin Univ. of Tech.

The kinematics of the patrol robot is analyzed based on the Mecanum's wheel theory. Find the kinematic inverse solution. Derive the relationship between the velocity of the four wheels of the Mecanum's wheel and the target velocity of the robot. In turn, find the relationship between the two positive solutions. Finally, the motion control of the whole robot is programmed. It provides a theoretical analysis basis for further research on the Mecanum's wheel theory patrol robot.

Analysis of the Motivations for Digital Transformation in the Logistics Industry

Lei Shen Zhijiang College of Zhejiang Univ. of Tech.
Fangyan Zhu Zhijiang College of Zhejiang Univ. of Tech.
Jiandan Shen Zhijiang College of Zhejiang Univ. of Tech.
Jianhua Zhang Qingdao Univ. of Tech.

This paper focuses on the driving factors of digital transformation in the logistics industry, analyzing the influence mechanisms of internal and external motivations on transformation to provide theoretical guidance for industry practices. Through literature analysis and empirical research, a fixed-effects model is constructed to validate the effects of variables such as technological innovation, policy support, and market competition on digital transformation. The study finds that internal motivations mainly include cost optimization pressures and demands for efficiency improvement, while external motivations encompass policy support, market competition pressures, technological innovation, and upgraded customer needs. This research offers a multi-dimensional perspective for digital transformation in logistics enterprises, suggesting that companies can integrate internal and external advantages to dynamically adjust technological investment and organizational change strategies, thereby adapting to industry competition and policy environmental changes.

SCTLine: A Ship Waterline Image Segmentation Method

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Jiangyun Li Univ. of Science and Tech. Beijing Key Lab. of Knowledge Auto. for Industrial Processes
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The accurate segmentation of ship waterline areas is critical for ship draft surveys and maritime measurement. However, existing methods are often hindered by environmental variations, low contrast between water and hull, reflections, and shadows, leading to missed or inaccurate detections. To address these challenges, this paper proposes SCTLine, a dual-branch network integrating local detail extraction and global context modeling. By simultaneously preserving edge details and overall continuity, SCTLine enhances the perception of slender and dis-continuous waterline structures. The outputs from both branches are spatially aligned and semantically fused via a lightweight decoder, yielding high-resolution, pixel-level segmentation results. Extensive experiments on a self-built dataset of 6,000 high-resolution ship images demonstrate that SCTLine achieves superior segmentation accuracy and boundary quality compared to mainstream methods, while maintaining high inference efficiency.

YOLOv7-bws: An Object Detection Method for Multi-Scale Remote

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Jianlei Kong Beijing Tech. and Business Univ.
Yuting Bai Beijing Tech. and Business Univ.
Tingli Su Beijing Tech. and Business Univ.

Multi-scale object detection in high-resolution remote sensing images faces multiple technical challenges, including missed detection of densely arranged targets, interference between features with scale variations, and insufficient recognition accuracy for small targets. This study proposes a progressive network optimization framework incorporating deformable convolutional networks to enhance deformation-aware feature representation. Furthermore, we construct a YOLOv7-bw single-stage detector implementing a dynamic gradient gain weighted Intersection over Union (IoU) loss function, which effectively balances optimization weights for anchor boxes of varying quality. Experimental results demonstrate that the proposed method outperforms mainstream detection methods in critical metrics including mean Average Precision (mAP) and F1-score, while achieving an optimal balance between model complexity and detection performance. This technical solution provides robust support for intelligent interpretation of remote sensing imagery.

Design and modeling of orchard picking manipulator

Sijie Xie Kunming Univ. of Science and Tech.
Tao Wu Kunming Univ. of Science and Tech.

In daily life, fruit has become an important source of vitamin intake. In particular, apples are rich in vitamins, minerals and zinc [1], and the picking process of apples is an extremely labor-intensive project, and the cost paid by fruit farmers to labor will gradually increase, and the demand for picking machines will appear. Demand often coexists with the market, and the research and development of a new picking robot has great economic benefits and broad market prospects [2]. Aiming at the problem to be solved by the design, it is the design of the manipulator. According to the determined scheme, the structure of the picking robot manipulator is designed and calculated, and the three-dimensional model of the picking robot manipulator is established. SolidWorks2015 was used to assemble the constructed parts to obtain the final assembly.

Advances in Optical Measurement Technologies and AI Applications for Hot-Rolled Strip Flatness Detection

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Jianheng Zhang Taiyuan Iron & Steel (Group) Co., Ltd.
Zhaohui Zhang Univ. of Science and Tech. Beijing

This paper systematically reviews the technological evolution and fundamental principles of flatness detection for hot-rolled steel strips. It provides detailed analyses of principal technical approaches including multi-point laser triangulation, laser Moiré, laser light-section, projected fringe pattern, and 3D reconstruction methods, covering their measurement principles, typical instrumentation, and industrial implementations. Comparative studies demon-strate that traditional contact-based techniques are being progressively superseded by non-contact optical measurement methods, with 3D reconstruction technology emerging as a research focus due to its capability of acquiring com-prehensive 3D topographic data of strip surfaces. The article emphasizes cut-ting-edge applications of artificial intelligence in flatness detection, particularly innovative integrations of neural networks, machine vision and deep learning algorithms. Finally, it summarizes existing technological challenges and pro-poses future development trends, highlighting multi-physics coupled measurement, intelligent compensation algorithms, and digital twin technologies as crucial research directions.

Deep-Enhanced Adaptive Visual-Inertial Odometry for Robust Localization in Complex Indoor Environments

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Jianlei Kong Beijing Tech. and Business Univ.
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Accurate and reliable localization of mobile robots in complex indoor environments presents significant challenges for visual-inertial odometry (VIO) systems. To address the limitations of conventional approaches — including their dependency on precise calibration, susceptibility to dynamic disturbances, and inadequate cross-modal feature integration — this paper proposes a deep learning-enhanced adaptive VIO framework. Our solution, the CAT-SC-VIO algorithm, introduces three key innovations: (1) a self-calibrating sensor adaptation module, (2) dynamic scene robustness enhancement, and (3) a novel cross-modal feature fusion architecture. Comprehensive evaluations demonstrate that the proposed system achieves a 17.8% improvement in translational accuracy over the baseline CAT-VIO method while maintaining exceptional robustness against sensor data degradation. The framework particularly excels in handling challenging scenarios involving occlusions, illumination variations, and moving objects in indoor environments.

EPHAD: Efficient Phased Hybrid Attention Decoder for Medical Image Segmentation

Zihang Guo Guangxi Minzu University
Ji Qiu Guangxi Minzu University

The Transformer's self-attention mechanism has proven effective in medical image segmentation by dynamically weighting global features, yet struggles with local feature correlations. To address these issues, we propose the

Efficient Phased Hybrid Attention Decoder (EPHAD), which enhances local feature fusion through integrated channel-spatial attention. While most previous works directly incorporate convolutional modules into encoder-decoder architectures, our EPHAD framework diverges by synergistically integrating attention gates and convolutional attention modules to optimize multi-stage feature aggregation. A residual-enabled framework further accelerates convergence while preserving fine-grained details. Experiments demonstrate that our EPHAD surpasses several recent medical image segmentation network baselines, achieving an 83.21% Dice score. This innovation addresses critical limitations in existing multi-scale feature fusion approaches while maintaining computational efficiency. By synergizing adaptive attention mechanisms with hierarchical feature refinement, EPHAD establishes a robust foundation for developing clinically viable segmentation tools with improved interpretability and reliability.

Research on the Mass Characteristics of Tiltrotor Aircraft in All Flight Modes

Fengrui Xu Qianwan Institute of CNITECH
Zeyu Du Zhejiang Univ. of Tech.
Xinmin Chen Ningbo Institute of Materials Technology and Engineering
Kai Xiao Ningbo Institute of Materials Technology and Engineering

This study addresses critical mass property variations in T500 tiltrotor aircraft (500kg-class) during structural reconfiguration by developing a multi-stage coordinate transformation methodology. The approach resolves inertial coupling effects, validated via multi-axis measurements showing <0.5% CG error and 92.3% inertia tensor agreement. A bivariate polynomial model achieves high-fidelity CG prediction(<3% MAC residuals, R^2=0.983), enabling 96.3% stability margin compliance in flight tests. The framework reduces certification iterations by 37%, establishing a robust foundation for variable-configuration aircraft design and control optimization.

Session 2
Intelligent Control and Optimization Strategies
Chair: Qiang Chen Zhejiang University of Technology

Fixed-time Sliding Mode Control of Robotic Manipulator Based on Neural Network-Based Observer

Guo Chenghao Qingdao University
Liu Zhen Qingdao University
Zhao Lin Qingdao University
Yan Longsheng Qingdao University

For an uncertain manipulator systems with unknown disturbances and actuator input saturation, a fixed-time sliding mode control method based on an neural network observer is proposed. First, considering the model parameter uncertainty and unknown disturbances, the system is approximated by an RBF neural network, and a fixed-time neural network observer is designed to quickly estimate the unknown joint position and velocity information, so that the system estimation error can converge to zero within a fixed time. Furthermore, based on the proposed saturation compensator scheme, a novel fixed-time sliding mode controller for the closed-loop system is designed, which not only achieves the fixed-time reachability of the sliding mode surface but also guarantees that the position tracking error signal converges to zero within a fixed time. Finally, the simulation experiment based on a two-joint manipulator system, verifies that the control scheme designed improves the tracking control performance of the manipulator.

Sliding Mode Tracking Control of UAV with Suspended Load under Specified Constraint Performance

Chengkun Dong Qingdao University
Zhen Liu Qingdao University
Fangzheng Li Qingdao University

A new trajectory fast tracking control strategy is proposed for quad-copter unmanned aerial vehicle (UAV) systems with suspended loads and specified output constraints. Firstly, a fixed-time disturbance barrier designed to estimate unknown nonlinear disturbances in real time, and a newly barrier function is constructed, from which the prescribed constrain performance of the loads is guaranteed in view of the barrier Lyapunov function method. Then, a novel nonsingular terminal sliding mode control law is developed, which not only avoids the occurrence of system singularity issue, but also ensures the fixed-time reachability of the sliding surface and the desirable property of the tracking errors. Finally, simulation results verify the effectiveness of the designed control method.

AI-based Simulation of Safety & Arming Sequence for Underwater Targets using MEMs Technology

Muhammad Shafiq Iqra University
Raza Hassan Solent University
Ghulam Nabi MTC, NESCOM
Rehan Khan MTC, NESCOM

Targeting underwater objects for defense purposes seems difficult due to various complexities present in the ocean i.e. Doppler shifts, Ocean Turbulences, Signal Attenuation, Pressure variations, Limited visibility, etc. Traditional methods are unable to find the exact target due to these complexities or have very little accuracy. Today in the era of AI, we are approaching the smart detection of underwater objects using state-of-the-art technologies integrated with AI techniques. To address the above issues and integration of AI into underwater target detection this project implemented multi-influence sensors on a simulated environment based on microelectromechanical systems to check the redundancy of the proposed work. This study provides an interactive

graphical user interface (GUI), a visual representation of the simulation outcomes, including a sequential demonstration of safety protocols, first ensuring safe distance followed by safe separation through validated settings. After achieving the safety protocols multi-influence sensors have been featured in this study. The design and simulation of this system are conducted in a MATLAB environment enabling real-time modeling for decision-making.

Finite Time Adaptive Sliding Mode Control of Multi-motor Based on Prescribed Performance

Guofa Sun Qingdao University of Technology
Fengtong Li Qingdao University of Technology
Chuangye Li Qingdao University of Technology

A preset performance control strategy combining adaptive nonsingular fast terminal sliding mode (NFTSMC) with disturbance observer (DO) is proposed for multi-motor drive servo system. The pre-scribed performance function (PPF) indirectly keeps the Angle tracking error within the preset range by controlling the boundedness of the con-version error. Improving exponential reaching law by introducing system state variables, the sliding mode adaptive control method to make the system have high robustness. Finally, the convergence in finite time are proved by Lyapunov theorem. and the simulation based on the designed controller are completed.

Adaptive Finite-Time Super-Twisting Sliding Mode Control for Robotic Manipulators with Disturbance Observer

Guofa Sun Qingdao University of Technology
Chuangye Li Qingdao University of Technology
Fengtong Li Qingdao University of Technology

This article investigates the trajectory tracking control of robotic manipulators subject to system uncertainties and external disturbances. To enhance control accuracy and robustness, an adaptive super-twisting sliding mode control (ASTSMC) strategy incorporating a radial basis function (RBF) neural network and an adaptive sliding mode disturbance observer (ASMDO) is proposed. Specifically, the RBF neural network is employed to approximate system uncertainties, while the adaptive sliding mode disturbance observer estimates and compensates for unknown disturbances in real time. The super-twisting algorithm is utilized to mitigate chattering in the control input. A Lyapunov-based stability analysis is conducted to rigorously prove the system's stability and finite-time convergence. Finally, simulation results validate the effectiveness and feasibility of the proposed control scheme.

Research on Power Control Technology of Pumping Well Group Based on Distributed Model Predictive Control

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Currently, green energy—such as wind and solar power—is increasingly integrated into oilfield operations, yet its inherent volatility and periodicity pose significant challenges. Efficient regulation of pumping well groups to consume new energy power is crucial for realizing an integrated "source-grid-load-storage" system in the oilfield. To address this, the paper proposes a distributed model predictive control (DMPC) strategy for power regulation of pumping well groups. First, a pumping well group model is developed that accounts for the global coupling of well group power. Under the safety constraints of oil well operation, the alternating direction method of multipliers (ADMM) is then employed to decompose the global optimization problem into local subsystem opti-mization problems, thereby deriving the well group control law. Additionally, a priority scheduling mechanism is designed to preferentially allocate power to high-producing wells based on their productivity differences. Simulation results validate the effectiveness of the proposed approach.

Composite Adaptive Predefined-Time Fault-Tolerant Attitude Control for Rigid Spacecraft

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In this paper, a composite adaptive predefined-time fault-tolerant attitude control strategy is proposed for rigid spacecraft with external disturbances, inertia uncertainties, and actuator faults. By establishing a practical predefined-time stability criterion, a predefined-time controller is systematically presented, allowing the upper bound of spacecraft settling time to be precisely determined by adjusting only one control parameter. To accurately compensate for lumped uncertainty, two adaptive update laws are designed. In addition, the singularity problem can be effectively avoided by constructing the hyperbolic tangent function. The efficacy of the proposed control strategy is verified through numerical simulations.

In-site Monitoring System Design and Applications

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Diabetic foot manifests as one of the major complications of diabetes. It is notably characterized by abnormally elevated local plantar pressure in its early stages. Since its early symptoms are hard to notice, many patients delay treatment until the state of symptom becomes severe, when it may be too late to prevent amputation. This paper aims to resolve this clinical dilemma by developing early warning mechanisms for plantar pressure alterations in diabetic foot patients, with particular emphasis on the transitional dynamics and early-warning threshold values between normal and pathological foot pressure. The paper collected plantar pressure data from both control and diabetic foot groups, which enabled not only the evidence-based early-warning thresholds but also the development of a remote monitoring system incorporating an iterative warning algorithm. Bench testing and clinical trials verified the system ' s robust performance and demonstrated high accuracy of its warning algorithm.

An Iteration Scheme for Solving Zero-Sum Differential Games with Control Constraints

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Traditional approaches to solving differential games, such as dynamic programming and the Pontryagin minimax principle, often rely on simplifying assumptions like infinite-horizon settings, which reduce the Hamilton-Jacobi-Isaacs (HJI) partial differential equation (PDE) to a time-invariant form. However, extending these methods to finite-horizon scenarios remains challenging due to the inherent time-dependent complexity of the HJI PDE and the lack of analytical control policies. This paper introduces a novel iterative algorithm grounded in the Pontryagin minimax principle to address finite-horizon differential games. The proposed method ensures convergence to valid solutions while adhering to input constraints.

A Linear Quadratic Regulator for Liquid Level Control of Quadruple-Tank System

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The quadruple-tank system, owing to its nonlinear and multi-variable coupling attributes, has emerged as a crucial platform for validating advanced control algorithms. This paper presents an optimized strategy integrating the Linear Quadratic Regulator (LQR) and Proportional Integral (PI) control for the liquid level control of the quadruple-tank system. Initially, the mathematical model of the system is established in accordance with the law of conservation of mass and Bernoulli's principle, and subsequently linearized in the vicinity of the equilibrium point to obtain the state-space representation. Based on this model, an LQR controller is devised to optimize the dynamic response, and a PI controller is introduced to eliminate the steady-state error and enhance the anti-interference ability. To accommodate the actual engineering demands, the continuous-time model is discretized, and the performances of the forward Euler method, backward Euler method, and Tustin method under diverse sampling times are evaluated. The simulation results indicate that the proposed LQR + PI control strategy exhibits remark-able advantages in terms of response speed, steady-state accuracy, and anti-integral saturation capability. Specifically, the Tustin method can maintain the system stability even under larger sampling intervals, show-casing its application potential in industrial scenarios with constrained resources. This study offers theoretical support and practical application references for the efficient control of the quadruple-tank system.

Cough Sound Recognition based on the PSO-GBDT-LR Model

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Cough is a vital index to evaluate the health status and post-operative recovery of patients. To realize the quantification of cough and solve the problem of excessive noise features and abnormal features in sound data during cough sound recognition, this paper proposes a PSO-GBDT-LR model to quantify cough by distinguishing cough sounds and non-cough sounds more accurately. It first leverages the Gradient Boosting Decision Tree (GBDT) to extract the leaf node index features from the original ones. Subsequently, it combines these features with the original features and puts the combined data into Logistic Regression (LR) for cough sound classification. Thanks to the powerful feature extraction of GBDT and the strong generalization ability of LR, it can effectively solve the problem of too many noisy features and abnormal features in cough recognition. Then, the hyperparameters of GBDT-LR are selected by Particle Swarm Optimization (PSO), which avoids the disadvantages of low efficiency and unsatisfactory accuracy of subjective selection of hyperparameters. In the cough recognition method flow, the cough audio signal collection device is used to collect the cough audio signals of healthy people and patients. Subsequently, the time series data is segmented using the double-threshold acoustic activity detection method. The time domain features and frequency domain features are extracted from each segment as the original features to train and test PSO-GBDT-LR. Ultimately, the effectiveness and superiority of the proposed model are demonstrated through comparison with other machine learning models. It has a mean precision of 93.965%, a mean recall of 93.93%, a mean F1 score of 93.945%, and an accuracy of 93.96%.

Data-Driven Estimation for Unmanned Surface System Position Based on Combined Informer-ESN Modeling

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Position estimation technology is a critical foundation for spatial cognition in intelligent systems. Conventional position estimation methods remain vulnerable to measurement errors and noise interference. At the same time, existing deep learning-based approaches demonstrate notable limitations in multi-source sensor data fusion, dynamic environment adaptation, and the optimization of computational complexity versus real-time performance. To address these challenges, this paper presents a novel position estimation framework based on a hybrid Informer-ESN architecture. The proposed model effectively integrates ESN's nonlinear mapping capabilities and short-term memory characteristics with the Informer network's superior temporal modeling and feature extraction capacities, thereby leveraging their complementary strengths for enhanced sequential data processing. This integrated approach demonstrates robust performance in handling complex nonlinear systems under specialized noise conditions. Experimental results indicate that our model achieves significant improvements in both estimation accuracy and robustness compared to conventional methods. Specifically, it enables more precise tracking of unmanned surface vehicles while maintaining consistent performance across varying operational sequences.

U-Model Based Pole-Zero Pulling Control for Non-Minimum Phase Systems with an Application to Altitude-hold Autopilot

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Non-minimum phase (NMP) systems, characterized by unstable zeros or poles, pose significant challenges in control design due to their inherent in-verse response and phase lag. This paper proposes a U-model-based control framework integrated with a pulling principle to address these limitations. By leveraging infinite impulse response (IIR) filters in feedforward and feedback paths, the method relocates unstable zeros and poles through summation/subtraction operations, converting NMP systems into stable minimum-phase (MP) models without relying on error-prone multiplicative cancellations. The design decouples the NMP-to-MP conversion from controller synthesis, enabling an invariant linear controller to achieve specified closed-loop dynamics while a U-model inverter dynamically resolves the plants inverse. Key contributions include: (1) A systematic zero/pole relocation framework with proven robustness against unit-circle positioning errors. (2) A separation principle that simplifies controller tuning and enhances adaptability, and (3) Comprehensive vali-dation through MATLAB simulations on diverse NMP system of the altitude-hold autopilot. Results demonstrate superior performance compared LQG method. The approach reduces design complexity, avoids repetitive tuning, and ensures bounded-input bounded-output (BIBO) stability. This work bridges theoretical rigor with practical applicability, offering a generalized solution for NMP systems of the altitude-hold autopilot.

Adaptive Droop Control Method for Grid-Forming Energy Storage Systems Based on Load Assessment

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Droop control is widely adopted in Grid-forming energy storage systems (GFM-ESSs) for its frequency and voltage regulation characteristics, but when there is a deviation between the active power output and the setpoint of GFM-ESSs, it will lead to system frequency deviation from the rated value, thereby limiting the frequency regulation capability of GFM-ESSs. To address this issue, this paper proposes an adaptive droop control method for GFM-ESSs based on load assessment. This method injects active power disturbances to estimate the load under the rated frequency and adaptively adjusts active power setpoints of GFM-ESSs based on the assessment results. Simulation results demonstrate that in islanded mode, the proposed method enhances the frequency control accuracy and fully utilizes the frequency regulation capability of GFM-ESSs.

Fault Diagnosis Method for Solid Oxide Fuel Cells Based on CNN-SVM

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Solid oxide fuel cell (SOFC), characterized by their clean, pollution-free nature and high power generation efficiency, hold great potential for wide-spread application. However, faults in SOFCs can severely impact their performance, shorten their lifespan, and undermine their reliability in practical use. To address these challenges, this study proposes a novel diagnostic method based on convolutional neural network (CNN) and support vector machines (SVM). Initially, data involving 10 feature variables corresponding to three types of faults—hydrogen leakage, air leakage, and stack

performance degradation — were collected. CNN was employed to extract the feature information from the data, which was subsequently fed into SVM for fault diagnosis. Comparative analyses were conducted under identical conditions using alternative diagnostic methods. Experimental results demonstrated that the CNN-SVM model outperformed standalone CNN and SVM approaches, improving diagnostic accuracy by 5.82% and 13.03%, respectively. Compared to SNN, the CNN-SVM model achieved a 0.88% increase in accuracy while exhibiting a faster processing speed, with a runtime of only 3.02 seconds. The study aims to provide a highly accurate and responsive diagnostic method for SOFC system fault detection.

Study on the Braking Energy Recovery Control Strategy of Electric vehicle with Dual-Motor Coupling Powertrain

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Braking energy recovery of electric vehicle can enhance the energy using efficiency and enlarge the vehicle driving range. In this paper, it is pro-posed that the braking energy recovery control strategy of the electric vehicle with dual-motor coupling powertrain system. Firstly, the configuration and working principle of the dual-motor driving system is introduced, and its simulation model is developed using MATLAB/Simulink, which including the motor model, battery model and braking system model. Secondly, the front and rear braking force of the electric vehicle is distributed based on I curve and ECE regulation. Then the regenerative braking force distribution strategy is proposed based on fuzzy control algorithm. To validate the effectiveness of the proposed braking energy recovery strategy, the braking energy recovery control strategy is simulated under NEDC, FTP75 and CLTC driving cycles. The simulation results show that the recovery rates of the braking energy were 13.36%, 18.49% and 22.53% respectively. This study provided theoretical support for regenerative braking force control for electric vehicle.

Research on the Measurement Method of Collision Intrusion Based on HyperWorks

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To meet the requirements of intrusion measurement in crash safety simulations, this paper introduces three different measurement methods. Using the HyperWorks software platform, the study investigates the measurement techniques for vehicle crash deformation intrusion based on a side-impact simulation model. The simulation results from the three methods are compared with experimental data, showing good agreement. The findings demonstrate that the three measurement methods presented in this paper are accurate and reliable, and can all be applied in simulation analysis.

Research on Voltage Injection-Based Current Harmonics Suppression for PMSMs

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Due to the distortion of the air-gap magnetic field, the non-linear characteristic of the inverter, and the setting of the dead-time, these factors cause the high-order harmonics existing in the winding currents of the permanent magnet synchronous motors (PMSMs), thus resulting the torque fluctuations. Firstly, according to the electrical dynamic equations of the PMSMs, the mathematical model for the dominant current harmonics is presented. Secondly, based on the 6th-order Park transformation matrices, the analytical expressions for the 5th- and 7th-order harmonics are subsequently derived. Then, the DC harmonic components are extracted by incorporating the low pass filter (LPF), the PI (proportional integral)-based controllers are introduced to sup-press the current harmonics, and the calculated voltages are eventually injected into the designs of the current-loop regulators. Finally, the ad-vantages and effectiveness of the proposed current harmonic suppression strategy for PMSMs are demonstrated through the simulation results.

Session 3
System Identification, Prediction and Scheduling
Chair: Xuebo Jin Beijing Technology and Business University

Analysis of the Influencing Factors of the Coordinated Development between Regional Logistics and Regional Economy in the Yangtze River Delta Region

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This study focuses on the coordinated development of regional logistics and economy in the Yangtze River Delta, aiming to explore their coupling coordination level and influencing factors. By constructing a coupling coordination model and using multiple regression analysis, this research thoroughly analyzes the impact of factors such as logistics infrastructure construction, logistics service efficiency, technological innovation, policy support, economic development level, and industrial structure adjustment on the coordinated development of regional logistics and economy in the Yangtze River Delta. The findings reveal that both the coupling degree and coordination degree between the logistics and economic systems in the Yangtze River Delta show an upward trend, indicating an increasingly strong interdependence and interaction between the two. Particularly, technological innovation and policy support play key roles in promoting the coordinated development of logistics and economy. Based on the analysis, this paper proposes a series of policy recommendations, including increasing investment in logistics infrastructure, encouraging technological innovation, and optimizing the policy environment, aiming to further promote the high-quality coordinated development of the regional logistics and economy in the Yangtze River Delta.

Analysis for Continuation Degree of Steelmaking-Continuous Casting Process

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Continuation degree is one of key indicators to measure the material flow efficiency in steelmaking-continuous casting process, which is characterized by time distribution patterns. According to the production data of a steelmaking enterprise in China, the central tendency and discretization degree of time parameters for each operational stage in steelmaking-continuous casting process (SCCP) are analyzed, and influence factors on time distribution are explored in this paper. Analysis results show that the time distributions among intermediate stages are significantly different. The mean production time of Ladle Furnace (LF) refining stages is longest, and the fluctuation of production times is the greatest than ones of other stages, which are the important factors to affect the continuation degree of steelmaking process. The fluctuation of production time of LF refining stage is caused by heating and soft stirring, and the influence of heating is more significant. In addition, the refining process path, steel grade, and temperature are also important effect factors. The results can provide valuable insights for optimizing steelmaking-continuous casting operations and improving the continuity and stability of production process.

Electricity Demand Forecasting for FMSP Using LSTM and Attention Mechanisms

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Fused magnesia is an important strategic material. During the fused magnesia smelting process (FMSP), if the electricity demand exceeds the specified limit, one or more of the electric furnaces may be shut down to manage the load. However, during the FMSP, there is a phenomenon of demand spikes, where the demand briefly exceeds the limit and then quickly drops back below the limit. In such cases, there is no need to shut down the electric furnaces. Therefore, accurately forecasting the electricity demand is crucial for improving the quality of fused magnesia products and reducing production costs. FMSP is crucial for reducing production costs and enhancing overall production efficiency. In this paper, we adopted a demand forecasting model for the FMSP based on the long short-term memory (LSTM) network and the attention mechanism (Attention). We propose an intelligent forecasting method for demand. The effectiveness of the proposed method was validated through real data from the FMSP.

An Offline Multi-Objective Energy Management Strategy for Turbo-Electric Hybrid Propulsion System using Few Computational Time

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Traditional dynamic programming has the defects of consuming large computational resources and long computation time. This drawback is more obvious in complex models, such as multi-objective energy management strategies for turbo-electric hybrid propulsion systems. The existing modification of dynamic programming was mainly focused on the unit commitment problem instead of a large, complex

engineering model. Therefore, this paper proposes State Machine-based Dynamic Programming (SM-DP), which aims to utilize expert knowledge to narrow down the selection space of policy actions, sacrificing very small optimality for faster computation. Simulation results demonstrate that the proposed method achieves a 14.84-fold computational speed advantage over conventional dynamic programming approaches, while maintaining solution quality with merely a 0.456% optimality reduction. In addition, SM-DP in this study achieves good results in both flight routes with harsh flight environments and environments with more refined maneuver decisions.

Study on Urban Shared Bike Demand Forecasting Based on the CNN-LSTM-Attention Model

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The prediction of shared bicycle demand is a cornerstone for enterprises in the sector to operate scientifically, manage effectively, and allocate regional resources dynamically. This process plays a pivotal role in optimizing the supply of services. To predict shared bicycle demand with precision, this study utilizes shared bicycle data from Shenzhen, rasterizes the study area, and examines the significant factors influencing users' travel choices from various perspectives, including road network conditions, public transportation infra-structure, points of interest, population size, and other built-environment as-pects. This study introduces a CNN-LSTM-Attention model tailored for shared bicycle demand prediction analysis. Our findings indicate that the CNN-LSTM-Attention model exhibits a coefficient of determination (R2) of 0.97214, which surpasses the prediction accuracy of the CNN, LSTM, and CNN-LSTM models. This high level of accuracy satisfies the demands of precise prediction and further validates the rationality of our proposed prediction model. Consequently, this work offers theoretical guidance for shared bicycle enterprises to achieve optimal resource allocation.

Research on the Training Model of Artificial Intelligence Field Engineers Based on School-Enterprise Cooperation

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The rapid development of artificial intelligence technology has created an urgent need for a deep integration of theory and practice in vocational education. This paper systematically explores the theoretical framework and practical paths for talent cultivation in vocational education against the backdrop of industry-education integration, relying on the collaboration between schools and enterprises for training artificial intelligence field engineers, and proposes a ' three truths, three completeness, three innovations ' co-education model. By introducing the CDIO engineering education theory, cross-disciplinary cooperation theory, and constructivist learning theory, it reconstructs the teaching content and evaluation system, proposing a ' dual teacher, dual truth ' teaching mechanism and a 'position-course-competition-certificate' integration path. Empirical research shows that this model significantly enhances students' engineering literacy and professional adaptability through curriculum design guided by theory and innovation in school-enterprise collaboration mechanisms, providing a reference for vocational education reform that combines academic depth with practical value.

DefectFormer: A Real-Time Transformer-Based Model for Industrial Conveyor Belt Defect Detection

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The conveyor belt has a wide range of applications in industrial settings, while the defect in the conveyor belt is a critical factor that affects normal production, making the detection of the corresponding defect particularly important. However, traditional YOLO-based conveyor belt defect detection methods struggle to balance real-time performance and speed, limiting their practical application. To address this issue and provide higher detection accuracy and speed, in this work, we introduce Defect Former, a fast and accurate real-time end-to-end object detector based on transformers. We perform conveyor belt defect detection experiments using data collected from a line scanning camera, analyzing both the real-time performance and accuracy of the detection. The results demonstrate that, compared to other detectors, Defect Former strikes a balance between inference efficiency and accuracy, better meeting the demands of industrial environments.

Lithium-Ion Battery SOH Estimation Based on LSTM-Transformer

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To improve the accuracy of lithium-ion battery State of Health(SOH) estimation in optical-storage-charging systems, this paper combines the strengths of LSTM and Transformer architectures to propose a hybrid LSTM-Transformer-based SOH prediction method. The method leverages LSTM to extract local temporal features while utilizing Transformer to capture global dependencies, thereby achieving a more comprehensive understanding of sequential data. Experiments conducted on the CALCE battery dataset from the University of

Maryland demonstrate that the LSTM-Transformer model outperforms standalone LSTM and Transformer models in predicting SOH degradation trends.

MutualBEV: Bird's Eye View Semantic Segmentation Based on Enhanced Fusion

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With advancements in artificial intelligence, Bird's Eye View (BEV)-based map segmentation methods have found extensive applications across various domains. These approaches establish BEV feature spaces and leverage the powerful learning capabilities of neural networks to achieve effective seg-mentation. Sensor fusion in BEV spaces has demonstrated its practicality for tasks such as 3D detection and map segmentation. However, existing methods face challenges, including inaccuracies in camera-based BEV estimation and limited perception of distant areas due to the sparse nature of LiDAR points. In this paper, we propose an attention-based fusion/decoder mechanism that cross-enhances LiDAR features and camera information. This method improves the learning of depth estimation in the camera branch and in-duces accurate localization of dense camera features in the BEV space. It also facilitates effective BEV fusion between spatially synchronized features, addressing the limitations of current methods and advancing the precision of BEV-based map segmentation.

Dynamic Simulation and Visualization of Traffic Impact of Highway Blasting Construction Based on VISSIM

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To address the dynamic traffic impact of highway blasting construction, this study builds a simulation and visualization framework based on VISSIM. The framework integrates multi-source data fusion and Q-learning-based path planning to model and optimize traffic flow under blasting conditions. A vehicle conflict detection module based on SSAM is developed to evaluate safety risks. Simulation results demonstrate that the proposed approach accurately reflects traffic dynamics, improves rerouting efficiency, and reduces potential conflicts. The visual output enhances decision-making during construction planning.

Research on Scheduling Optimization under Workstation Allocation Constraints Based on Preceding and Succeeding Operations

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In modern manufacturing, the optimal matching of workstations be-tween sequential process steps is directly related to the continuity of production lines and overall production efficiency. Due to significant variations in pro-cessing times for different product types across various workstations, as well as the direct impact of the physical layout distances between process steps on product transfer efficiency, selecting an appropriate workstation matching strategy can enhance equipment utilization and reduce total completion time. This paper focuses exclusively on the constraint issues associated with optimal workstation matching between consecutive process steps, wherein, when the product ' s optimal workstation (i.e., the one with the shortest processing time) is occupied, evolutionary game theory is employed to decide whether to wait for the optimal workstation to become available or to proceed directly to another workstation, thus facilitating a coordinated continuous production process and reducing overall processing time. The results of simulation experiments indicate that this method is markedly effective in addressing the aforementioned issues.

Research on Single-Agent Path Planning Based on the Improved ACO-DWA Algorithm

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Automated Guided Vehicles (AGVs) play an irreplaceable role in intelligent production workshops. This paper proposes a method that combines the improved ACO algorithm with the improved DWA algorithm, namely IACO-DWA. Addressing the limitations of the traditional ant colony algorithm, this pa-per uses a pheromone map based on obstacle density as the initial pheromone distribution, adds distance heuristic factors and direction heuristic factors to the heuristic function, and adopts a hierarchical pheromone update strategy to gen-erate a global planning path for the improved DWA algorithm. The speed evaluation function of the traditional DWA is improved, and a target deviation evaluation is added, enhancing the smooth operation of AGV vehicles while dynamically avoiding obstacles. This paper aims to improve the efficiency and accuracy of AGV vehicle path planning by combining the ACO and DWA algorithms. The effectiveness of the proposed algorithm is verified through comparative experiments, and the proposed algorithm is applied to intelligent production processes.

One-Point Residual Feedback Algorithm for Distributed Online Stochastic Optimization

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This paper primarily addresses the distributed online stochastic optimization problem where the objective functions are assumed to be non-convex and the sequence of objective functions is non-stationary. We propose a distributed one-point residual feedback (ORF) algorithm to solve the online stochastic optimization problem. Then the regret bounds of proposed algorithm is analysed under the assumption that the local objective functions are Lipschitz or smooth, which implies that the regretis sublinearly increasing. The conclusion shows that the proposed algorithm can solve the distributed online stochastic problems more effective and has lower variance than traditional one-point feedback method in estimating the unknown gradient of objective function.

A Path Planing Algorithm Based on the Combination of OpenPlanner and Hybrid A*

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This paper investigates the obstacle avoidance problem of autonomous vehicles in campus environment, and proposes a path planning algorithm based on OpenPlanner and hybrid A*. In the global planning stage, OpenPlan-ner's global planner quickly plans a global path from the starting point to the destination using a vector map. In the local planning phase, OpenPlanner's local planner samples and generates local trajectory clusters, while the hybrid A* dy-namically adjusts the path based on the cost map to ensure the feasibility and safety of the path. In order to analyze the performance of the proposed planning scheme, an Autoware-based campus unmanned vehicle autopilot platform is built. The experimental results show that the unmanned vehicle successfully drives through turning intersections, complex road sections, and crossroads, and completes planning tasks such as obstacle avoidance, stopping, and cruising. Meanwhile, the success rate of obstacle avoidance is proved to be 96.67% through testing. The proposed path planning scheme can be used for automatic driving of unmanned vehicles on campus.

Advanced Marching Cubes Algorithm for Efficient 3D Reconstruction and Visualization of Tumor Target Areas

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The three-dimensional reconstruction of the tumor target areas helps in radiotherapy planning. The Marching Cubes algorithm is widely used for its simplicity and efficiency in 3D medical image reconstruction. However, traditional algorithms have problems like hole artifacts, redundant voxel computations, and rough surfaces. This study proposes an improved Marching Cubes algorithm. Leveraging surface connectivity theory in volumetric data, it avoids empty voxel regions to cut unnecessary calculations. The midpoint selection method optimizes floating-point operations, reducing the complexity of the algorithm. Windowed Sinc smoothing refines the model's outer surface for better smoothness. Experiments show that the improved algorithm cuts the number of triangular facets by more than 4% and boosts processing efficiency by more than 16%, all while maintaining reconstruction quality. It offers a new solution for real-time 3D visualization of tumor target areas.

Optimization of Multi-AGV Scheduling in Packaging Workshop Based on Genetic Algorithm and Collaborative Path Selection

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Aiming at the problems of unreasonable task matching and frequent path conflicts in the collaborative scheduling of multiple AGVs in the packaging workshop, this paper proposes an optimization method based on genetic al-gorithm and collaborative path selection. Firstly, the genetic algorithm is used to model the task allocation of multiple AGVs, with the goal of minimizing the total travel distance, to achieve the optimal matching of AGVs and packaging machine tasks. Secondly, for AGVs that retrieve pallets and transport materials, a differentiated path selection strategy is designed to reduce the risk of conflicts through path separation. Simulation experiments show that in the scenario where 6 AGVs are selected from 8 AGVs to serve 3 packaging machines, this algorithm can achieve rapid task matching and effectively reduce path overlap. This study provides an integrated solution for task allocation and path coordination optimization in workshop logistics automation, which has practical significance for improving the operational efficiency of AGV groups.

Recursive Parameter Estimation for Wireless Power Transfer Systems with Non-PE Data

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The Recursive Least Squares algorithm with exponential for-getting (RLS-EF) is capable of effectively tracking the time-varying parameters of WPT system caused by factors such as coil spacing. How-ever, under non-persistent excitation (Non-PE), the RLS-EF algorithm suffers from ill-conditioning, consequently causing the undesirable estimator windup. To address the parameter identification problem for WPT systems under Non-PE conditions, an improved RLS algorithm with

Adaptive Variable Direction Forgetting is proposed in this paper. The effectiveness of the proposed method was validated through numerical simulations and experiments conducted in actual time-varying WPT scenarios, resulting in more stable tracking of time-varying parameters.

A Path Planning Algorithm with Grey Wolf Optimizer and Intelligent Controller for Transfer Robots

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Transfer robots (TRs) all have broad application prospects in industrial production or daily life, which can intelligently transport goods from one place to another, such as molten steel sampling robots, express delivery robots, and household service robots. The path planning and stable control of the above robots can be solved by using Genetic Algorithm (GA), because it is a Traveling Salesman Problem (TSP). However, the GA often suffers from the issues of slow convergence and low accuracy. Therefore, a path planning algorithm for TRs is presented, which applies the framework of GA and includes greedy population initialization, dynamic crossover-mutation probabilities, and Grey Wolf Optimizer (GWO). An intelligent controller is proposed to control TRs to move stably along the designated trajectory, which is combined by PID controller and feed-forward neural network. Simulation results show that the presented path planning algorithm demonstrates strong optimization performance, which is better than GA. In addition, the provided intelligent controller with PID and feedforward neural network can make the controlled TRs move forward with high precision along with the planned path. Trajectory planning and high-precision control for arms of TRs will be our future work.

A GA-ACO Path Planning Algorithm and PID Controller with XGBoost Optimizer for Molten Steel Sampling Robots

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It is an inevitable industry trend to apply widely intelligent robots for molten steel sampling, because the steelmaking environment, characterized by extreme heat and airborne particulates, is hazardous to workers. However, it is a challenging problem to realize the autonomous path planning and stable control of robots. A path planning approach merging genetic algorithm (GA) and ant colony optimization (ACO) for molten steel sampling robots (MSSRs) is presented in this paper, which is named GA-ACO. Under the framework of GA, based on ACO, initial population generation, selection, crossover and mutation are improved. An intelligent PID controller with XGBoost optimizer is designed to guarantee the stability of MSSRs moving along the planned path. Simulation results show that generation average (GEN_AVR) and output average （OUT_AVR） of the GA-ACO are better than that of GA. The presented PID-XGBoost controller has higher control performance than the PID controller. The average error obtained by using the PID-XGBoost controller is -0.008m, and the average error obtained by using the PID controller is -0.023m.

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