ICCIR 5th 2025

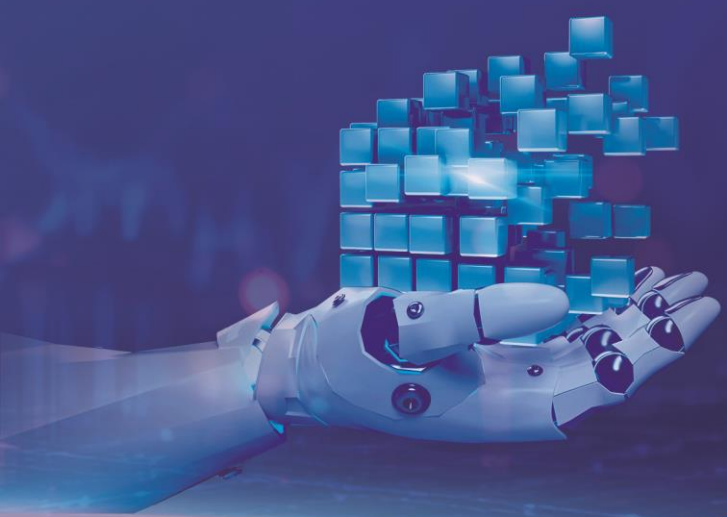
第五届控制与智能机器人国际学术会议

2025 5th International Conference on Control and Intelligent Robotics

2025年6月21-22日 I June 21-22, 2025

会议手册

CONFERENCE MANUAL



欢迎辞
Welcome Address

On behalf of the organizing committee, we would like to express our heartfelt gratitude to the experts, scholars, and guests from all over the world for sparing your valuable time to participate in our conference and share your experiences and insights.

As we all know, control and intelligent Robotics are important drivers of today's technological development, playing a more and more crucial role in various fields. With the continuous progress and innovation of technology, our life, work, and study methods have undergone tremendous changes.

It is a great honor for us to invite well-known experts and scholars from all over the world who have profound research backgrounds and rich practical experience in the field of control and intelligent robotics. ICCIR 2025 believes that their sharing and exchange will add more academic charm and practical value to our conference. Through this conference, we hope to explore the cutting-edge technologies and research results in this field, promote its further development, and make contributions to social progress and human well-being.

ICCIR 2025 will cover multiple aspects of control and intelligent robotics, including but not limited to adaptive control, complex systems co-operative control, control engineering education, fuzzy systems, robot control and micro robots and micro-manipulation, etc. We hope that through this conference, more scholars and enterprises can understand and master these cutting-edge technologies and promote the further development of control and intelligent robotics.

Finally, we would like to thank the experts, scholars, and guests once again for your participation and support of this conference. We look forward to deepening our exchanges, discussing jointly, and sharing wisdom with you at the conference. Let's work together to embrace a bright future of control and intelligent robotics!

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ICCIR 2025 第五届控制与智能机器人国际学术会议

2025 5th International Conference on Control and Intelligent Robotics

会议简介 Conference Introduction

第五届控制与智能机器人国际学术会议（ICCIR 2025）于2025年6月21-22日举行。会议旨在为从事控制与智能机器人等领域的专家学者、工程技术人员、研发人员提供一个共享科研成果和前沿技术，了解学术发展趋势，拓宽研究思路，加强学术研究和探讨的平台。本次会议由天津工业大学主办，天津工业大学控制科学与工程学院承办，天津科技大学电子信息与自动化学院协办，新加坡南洋理工大学、新加坡机器人学会、佛山大学、佛山市人工智能学会作为支持单位。大会为期两天，设置主讲报告、口头报告以及海报展示环节。专家学者将在会上共同探讨“控制与智能机器人”及相关研究领域的学术动态及发展趋势，鼓励不同研究领域前沿的信息交流，连接国内外最先进的学术资源。欢迎国内外高校、科研机构专家学者、企业界人士及其他相关人员参会交流!

2025 5th International Conference on Control and Intelligent Robotics (ICCIR 2025) is scheduled to take place from June 21 to 22, 2025. ICCIR 2025 is sponsored by Tiangong University, China. This conference aims to serve as a platform for exploring and discussing innovative ideas and remarkable achievements in control and intelligent Robotics, deepening and expanding the scope of academic cooperation, and fostering an inclusive innovation community. ICCIR 2025 warmly welcomes authors to submit their articles highlighting ongoing research results, projects, surveys, and industrial experiences that showcase significant advancements in all related areas.

组织单位 Organization

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TIANGONG UNIVERSITY

■ 承办单位 Organizer

控制科学与工程学院
School of Control Science and Engineering

■ 协办单位 Co-organizer

天津科技大学
Tianjin University of Science and Technology

电子信息与自动化学院
College of Electronic Information and Automation

■ 支持单位 Supporter

Robotics Society of Singapore

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

佛山大学 FOSHAN UNIVERSITY 1958

佛山市人工智能学会

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Conference Committee

会议组委 Conference Committee

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会议议程

Conference Agenda

ICCIR 2025 第五届控制与智能机器人国际学术会议

2025 5th International Conference on Control and Intelligent Robotics

会议议程 Conference Agenda

2025年6月21日 （周六）上午 09:00-12:05 (GMT+8)

线上参会 Zoom ID: 889 7221 3340 Password: 250621

主持人：曹风魁副研究员，中国科学院沈阳自动化研究所

Host: Associate Researcher Fengkui Cao, Shenyang Institute of Automation, Chinese Academy of Sciences

时间/Time	活动/Activity
09:00-09:05	Opening Ceremony/开幕式
09:05-09:10	Photography/大合照
Keynote Speech / 主题报告	
09:10-09:45	陈霸东 教授，国家级高层次人才，西安交通大学 Prof. Badong Chen, National High-Level Talent, Xi'an Jiaotong University, China **Title:** *Information Theoretic Learning for brain inspired computing, brain computer interfaces and brain disease diagnosis*
09:45-10:20	王浩平 教授，南京理工大学 Prof. Haoping Wang, Nanjing University of Science and Technology, China **Title:** *Ultra-local Model based Data & Intelligent Technique Driven Model Free Adaptive Prescribed Performance Control and Applications to Mechatronic Robotic Systems*
10:20-10:55	向峥嵘 教授，南京理工大学 Prof. Zhengrong Xiang, Nanjing University of Science and Technology, China **Title:** *Analysis on existence of compact set in neural network control for nonlinear systems*
10:55-11:30	马天磊 教授，河南省高层次人才，郑州大学 Prof. Tianlei Ma, High-level talent in Henan Province, Zhengzhou University, China **Title:** *Key technologies for infrared small target tracking in dynamic scenes target enhancement and clutter suppression*
11:30-12:05	孙宁 教授，国家级青年人才，南开大学 Prof. Ning Sun, National Young Talent, Nankai University, China **Title:** *Intelligent Control for Robotic Systems Driven by Pneumatic Artificial Muscles*
12:05-14:00	Lunch Break/午餐

ICCIR 2025 第五届控制与智能机器人国际学术会议

2025 5th International Conference on Control and Intelligent Robotics

会议议程 Conference Agenda

2025年6月21日 （周六）下午 14:00-16:30 (GMT+8)

线上参会 Zoom ID: 889 7221 3340 Password: 250621

主持人：陈海洋副教授，天津工业大学

Host: Assoc. Prof. Haiyang Chen, Tiangong University

Oral Presentation / 口头报告

14:00-14:10	**Yirui Mao, Civil Aviation University of China, China** **Title:** Research on Path Tracking Control of Airport Marking Vehicle Based on Adaptive Parameter MPC
14:10-14:20	**Yuanzhi Zhang, Beijing Institute of Technology, Zhuhai, China** **Title:** Optimized design of self-leveling device for 3D printer based on principle of minimum potential energy
14:20-14:30	**Jin Yang, Xi'an Jiaotong University, China** **Title:** Task-Driven Exploration: Decoupling and Inter-Task Feedback for joint Moment Retrieval and Highlight Detection
14:30-14:40	**Lu Che, Hebei University of Technology, China** **Title:** Study of Kinematics and Trajectory Planning for the Pneumatic Soft Manipulator
14:40-14:50	**Can Liu, Tiangong University, China** **Title:** Asymptotic Trajectory Tracking of Stratospheric Airships Based on RISE Controllers Under External Uncertainties
14:50-15:00	**Wenjun Cheng, Shenyang Ligong University, China** **Title:** Fault Diagnosis of Bearings under Variable Working Conditions Based on Strip Pooling VGG19
15:00-15:10	**Lulu Yue, Zhejiang University, China** **Title:** Feasibility study on carbon neutralization pathway for marine macroalgae aquaculture system in China
15:10-15:20	**Yueyuan Li, Tiangong University, China** **Title:** DAEDM: Robust Unsupervised Domain Adaptation for Street Scene Segmentation Based on Vision Mamba
15:20-15:30	**Jiaqi Wen, Hebei University, China** **Title:** Gas-liquid two-phase flow gas slug frequency prediction model based on acoustic emission sensing and GBR
15:30-15:40	**Qi Zhang, Beijing University of Posts and Telecommunications, China** **Title:** Anti-swing Control of Underactuated Rotary Cranes: An Improved Iterative Learning Scheme
15:40-15:50	**Bo-ning Li, University of Science And Technology Liaoning, China** **Title:** Finite-time trajectory tracking control of quadrotor UAV based on disturbance observer
15:50-16:00	**Yaobang Zang, Tiangong University, China** **Title:** Time-Optimal Coordination for Connected and Automated Vehicles at Intersection
16:00-16:10	**Shumin Wang, Jilin University, China** **Title:** Design of Intrinsically Safe Electrical Method System for Remote Continuous Monitoring in Coal Mines
16:10-16:20	**Bo Ning, Tianjin University of Technology, China** **Title:** Artificial Intelligence in GUI Development: Applications and Future Trends
16:10-16:30	**Junhui Wang, Beijing University of Technology, China** **Title:** EEG Microstate Analysis of Brain Dynamics During Motor Imagery in Stroke Patients

ICCIR 2025 第五届控制与智能机器人国际学术会议

2025 5th International Conference on Control and Intelligent Robotics

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2025年6月22日 （周日）上午 09:00-12:15 (GMT+8)

线上参会 Zoom ID: 889 7221 3340 Password: 250621

主持人：王翔宇副教授，南开大学

Host: Assoc. Prof. Xiangyu Wang, Nankai University

时间/Time	活动/Activity
09:00-09:05	Welcome Remarks/会议开场
09:05-09:10	Photography/大合照
Keynote Speech / 主题报告	
09:10-09:45	刘敏 教授，国家杰青，湖南大学 Prof. Min Liu, National Science Fund for Distinguished Young Scholars Hunan University, China **Title:** *Multimodal Perception for Intelligent Surgical Robots*
09:45-10:20	郑泽伟 教授，国家级青年人才，北京航空航天大学 Prof. Zewei Zheng, National Young Talent, Beihang University, China **Title:** *Nonlinear Moving Path Following Control and Application*
10:20-10:55	赵旭东 教授，国家级领军人才，大连理工大学 Prof. Xudong Zhao, Recipient of China's National Leading Talent Program Dalian University of Technology, China **Title:** *Locomotion Technology of Sea Urchin-Inspired Robots for Complex Environments*
10:55-11:30	李文玲 教授，国家级青年人才，北京航空航天大学 Prof. Wenling Li, National Young Talent, Beihang University, China **Title:** *Filtering Methods of Graphical Dynamic Systems*
11:30-12:05	刘帅 教授，国家海外高层次青年人才，山东大学 Prof. Shuai Liu, Recipient of the National Thousand Plan Program Shandong University, China **Title:** *Distributionally Robust Games under Dynamic Systems*
12:05-12:15	Closing Ceremony/闭幕式

专家介绍

Expert Introduction

主讲嘉宾 Keynote Speaker

陈霸东 教授 | 国家级高层次人才，西安交通大学

Prof. Badong Chen | National High-Level Talent
Xi'an Jiaotong University, China

Biography

Badong Chen is a professor at the Institute of Artificial Intelligence and Robotics, Xi 'an Jiaotong University and a Yangtze River scholar of the Ministry of Education. In 2008, he graduated from Tsinghua University with a doctorate in computer science. The research fields include machine learning, artificial intelligence, brain-computer interface, and robotics. He has published more than 300 academic papers in internationally renowned journals and conferences, and the papers have been cited more than 15,000 times. More than 30 national invention patents were authorized and 6 academic monographs were published. He was included in the list of top 2 % scientists in the world and Elsevier 's list of China 's highly cited scholars. It won the first prize of natural science of the Ministry of Education, the first prize of natural science of the Chinese Society of Automation, and the young scientist award of the Chinese Society of Automation. He is the director of Chinese Cognitive Science Association and the editorial board member of IEEE TNNLS / TCDS / TCSVT. He presided over the key projects of the National Natural Science Foundation of China, the key support projects of the National Natural Science Foundation of China, the key projects of the joint fund, the 973 plan project, the national key research and development plan project and other scientific research projects.

主讲嘉宾 Keynote Speaker

陈霸东 教授 | 国家级高层次人才，西安交通大学

Prof. Badong Chen | National High-Level Talent
Xi'an Jiaotong University, China

Speech Title **Information Theoretic Learning for brain inspired computing, brain computer interfaces and brain disease diagnosis**

Abstract

Information theory has been widely applied in the field of machine learning and has attracted increasing attention from scholars. Researchers have proposed various information theoretic learning methods for different learning problems, such as the minimum error entropy (MEE) criterion in supervised learning and the information bottleneck (IB) principle in representation learning. This talk introduces the basic concepts of Information Theoretic Learning (ITL), elaborates on new learning paradigms and methods, and explores the applications of ITL in brain inspired computing, brain computer interfaces, and brain disease diagnosis.

主讲嘉宾 Keynote Speaker

王浩平 教授 | 南京理工大学

Prof. Haoping Wang | Nanjing University of Science and Technology, China

Biography

Haoping Wang is currently IEEE Senior member, Professor and Ph.D Supervisor at Automation School, Nanjing University of Science and Technology (NJUST), China. He received Ph.D. degree in Automatic Control and Computer Science from Lille University of Science and Technology (LUST), France. His research interests include the theory and applications of hybrid systems, data driven model free adaptive control, state observation design, visual servo control, renewable energy systems optimal control and rehabilitation and augmented exoskeletons design and intelligent control, etc. He was/is the Principal Investigators and coordinators of Chinese National key R & D projects of national international science and technology cooperation Project, National Science Foundation of China Projects, Chinese-French project of Cai Yuanpei, etc. He has published over 277 refereed international journal and conference papers, in which 147 SCI journal papers, authored 2 books, 15 patents, and co-author 5 chapters in books.

Prof. Wang is the editor of SCIE journal IJAMCS, and served as the General Chair of ICRCV2024-20233, Publication Chair of ICCAD2024, Co-chair of the ICRCV2021, Co-Chair of Program Committee of the 27th IEEE Int. Conf. on Robot and Human Interactive Communication (ROMAN'2018), and participation to more than 30 conference organization. He was selected as World's Top 2% Scientists, based on Stanford and Elsevier Data, in 2024, and enlisted also in 'Jiangsu Provincial 333 High-Level Talent Training Program', 'Jiangsu Provincial Project Blue: Young Academic Leader', 'Six Talent Peaks of High Level Talents', etc. Prof. Wang is currently Dean of Zhizhi Academy of NJUST, Executive deputy Director of the Sino-French International Joint Laboratory of Automatic Control and Signal Processing, Deputy Director of the Jiangsu Enterprise Development Engineering Association, and Deputy Director of the Rehabilitation Medicine Engineering and Transformation Committee of the Jiangsu Rehabilitation Medicine Association, member of Chinese Association of Automation (CAA), Committee member of Data Driven Control Learning and Optimization Professional Committee (DDCLS-CAA), and the Committee member of the energy Internet Committee –CAA, etc.

主讲嘉宾 Keynote Speaker

王浩平 教授 | 南京理工大学

Prof. Haoping Wang | Nanjing University of Science and Technology, China

Speech Title **Ultra-local Model based Data & Intelligent Technique Driven Model Free Adaptive Prescribed Performance Control and Applications to Mechatronic Robotic Systems**

Abstract

With the advancement of new technology and industrial transformation, complex mechatronic systems (CMS) which integrate advanced sensors, control algorithms, artificial intelligence, and other technologies are being widely applied in industrial production, smart manufacturing, power-assisted systems, and surgical medicine robots. Compared to traditional mechatronic systems, CMS possess intelligent sensing, execution, and control capabilities, enabling them to better adapt to complex and dynamic working environments and task requirements. This significantly enhances industrial mass production efficiency and standards, driving the high-quality development of the real-world intelligent manufacturing industry. However, due to their complex structure and multiple degrees of freedom, CMS are susceptible to input nonlinearities such as backlash, input saturation, dead zones, actuator failures, complex friction, and quantization, making it highly challenging to achieve high-precision trajectory tracking control. Therefore considering the referred CMS affected by different input nonlinearities and frictions, under an ultra local model based data-driven model-free control framework, this lecture focuses on the introduction and development of a new data and intelligent technique driven model-free adaptive trajectory tracking prescribed performance control.

主讲嘉宾 Keynote Speaker

向峥嵘 教授 | 南京理工大学

Prof. Zhengrong Xiang | Nanjing University of Science and Technology, China

Biography

Zhengrong Xiang (Member, IEEE) received the B.S degree in theoretical physics and the M.S. degree in fundamental mathematics from Xinjiang University in 1989 and 1995 respectively, and received the Ph.D. degree in control theory and control engineering from the Nanjing University of Science and Technology in 1998.

He was appointed as a Lecturer and an Associate Professor at the Nanjing University of Science and Technology in 1998 and 2001, respectively. Since 1998, he has been a Faculty Member with the Nanjing University of Science and Technology, where he is currently a Full Professor. He has coauthored around 380 journal and conference papers, many of which are highly-cited status, ESI 1%. One paper was selected as one of the "China's 100 most influential international academic papers". His main research interests include switched systems, nonlinear control, multi-agent systems, reinforcement learning, and networked control systems.

Prof. Xiang was the recipient of many prestigious international awards and recognitions such as the CAA Outstanding Doctoral Dissertation Nomination and Mentor Award in 2022 and the Excellent Doctoral Dissertation Supervisor in Jiangsu Province in 2021.

主讲嘉宾 Keynote Speaker

向峥嵘 教授 | 南京理工大学

Prof. Zhengrong Xiang | Nanjing University of Science and Technology, China

Speech Title **Analysis on existence of compact set in neural network control for nonlinear systems**

Abstract

Neural network method is an effective tool for approximating the unknown function in controller design for nonlinear systems. To guarantee the validity of the approximation, state variables in approximated unknown functions need to stay in a compact set. However, in most existing results, the existence of the compact set has not been correctly proven; therefore, the proof is not actually complete in these existing works. In this talk, we analyze the existence of compact sets for two typical nonlinear systems with novel neural network-based controllers and show the strict proof for the semi-global uniform ultimate boundedness of the closed-loop system.

主讲嘉宾 Keynote Speaker

马天磊 教授 | 河南省高层次人才，郑州大学

Prof. Tianlei Ma | High-level talent in Henan Province
Zhengzhou University, China

Biography

Ma Tianlei, Ph.D., Professor and Doctoral supervisor at Zhengzhou University, Director of the Experimental Center of the School of Electrical and Information Engineering at Zhengzhou University, Outstanding postdoctoral researcher in national innovation and entrepreneurship, Excellent guiding teacher of the National Graduate Electronic Competition, High-level talent in Henan Province, Outstanding young talent in Central Plains, Science and technology innovation talent in Henan Province, Young scientist of the Henan Province Science and Technology Research and Development Plan Joint Fund, Young talent in Henan Province, Young backbone teacher in Henan Province, Deputy director of the Henan Digital Organization Engineering Technology Center, and Excellent bachelor's/master's thesis guiding teacher in Henan Province. Engaged in long-term research on artificial intelligence and multimodal perception, focusing on issues such as multi-dimensional information fusion and intelligent detection and recognition of targets, multimodal perception and decision-making of robots, proposing basic theoretical methods to promote the development of target recognition and robotics.

主讲嘉宾 Keynote Speaker

马天磊 教授 | 河南省高层次人才，郑州大学

Prof. Tianlei Ma | High-level talent in Henan Province
Zhengzhou University, China

Speech Title **Key technologies for infrared small target tracking in dynamic scenes: target enhancement and clutter suppression**

Abstract

As one of the core technologies of infrared systems, tracking small infrared targets has a wide range of applications in precision guidance, target monitoring and reconnaissance, security, and other fields. However, due to the inherent characteristics of infrared small targets, such as weak energy, low brightness, sparse pixels, lack of key information such as color, texture, and edges, as well as dynamic changes in target states and strong and constantly changing background clutter interference, fast and accurate tracking of infrared small targets has become a highly challenging task.

To address the above challenges, the report focuses on the problem of tracking small infrared targets in dynamic and complex scenes, aiming to overcome the difficulties of tracking failure caused by dim targets, dynamic changes in targets, strong and changing backgrounds, etc. Through in-depth research and analysis of existing visual target tracking methods, this report proposes infrared small target tracking methods based on target feature enhancement and adaptive updating, as well as infrared small target tracking methods based on background compensation suppression and global search, targeting both the target itself and its background. Improve the robustness and accuracy of infrared small target tracking, and provide effective solutions for infrared small target tracking in complex scenes.

主讲嘉宾 Keynote Speaker

孙宁 教授 | 国家级青年人才，南开大学

Prof. Ning Sun | National Young Talent
Nankai University, China

Biography

Ning Sun is a Young Scholar of the Changjiang Scholars Program and a professor with Nankai University, Tianjin, China, and the Shenzhen Research Institute of Nankai University, Shenzhen, China. He received the B.S. degree in measurement & control technology and instruments from Wuhan University, Wuhan, China, in 2009, and the Ph.D. degree in control theory and control engineering from Nankai University, Tianjin, China, in 2014; he was a Japan Society for the Promotion of Science (JSPS) Fellow from 2018 to 2019. His research interests include intelligent control for mechatronic/robotic systems with an emphasis on (industrial) applications. Dr. Sun received the 2021 IEEE Transactions on Industrial Electronics Outstanding Paper Award, the Machines 2021 Young Investigator Award, the 2019 Wu Wenjun Artificial Intelligence Excellent Youth Award, the ICCAR 2022 Young Scientist Award, the 2024 IEEE Transactions on Systems, Man, and Cybernetics: Systems Outstanding Associate Editor Award, the 2023 International Journal of Control, Automation, and Systems Best Associate Editor, the 2024 IEEE Transactions on Industrial Electronics Distinguished Reviewer, and several outstanding journal/conference paper awards. He serves as an Associate Editor for several journals, including the IEEE Trans. Industrial Electronics, IEEE Trans. SMC: Systems, IEEE Trans. Intelligent Transportation Systems, IEEE/ASME Trans. Mechatronics. He is a Senior Member of the IEEE.

主讲嘉宾 Keynote Speaker

孙宁 教授 | 国家级青年人才，南开大学

Prof. Ning Sun | National Young Talent
Nankai University, China

Speech Title **Intelligent Control for Robotic Systems Driven by Pneumatic Artificial Muscles**

Abstract

With the rapid development of rehabilitation robots and the growing demands for human-robot interaction, modeling and intelligent control of pneumatic artificial muscle (PAM) robots have increasingly attracted the attention of many researchers. It is a challenging research topic to overcome the effects of PAMs' inherent defects (e.g., high nonlinearities, hysteresis, time-varying characteristics, etc.), despite the merits of lightness, safety, and high power-to-weight/volume ratios of PAMs. To this end, we aim to achieve accurate modeling and advanced control for PAM robots, which may contribute to their further theoretical research and practical applications. Specifically, for single-PAM robots, there exist some difficulties as follows: 1) PAM systems are susceptible to unknown external disturbances due to their high nonlinearities, creep, hysteresis, etc. 2) PAM robots usually suffer from parameter uncertainties and unmodeled dynamics. 3) The ultimate control inputs (corresponding to the pressurized air) of PAM robots should be constrained to be nonnegative. To solve these problems, we propose a disturbance estimation-based nonlinear control method, a neuroadaptive control method with system uncertainties, and an adaptive control method with unidirectional input constraints, respectively. Further, for multi-PAM robots, the following issues should be considered: 1) Since torques/forces are generated by air pressure and are not the ultimate control inputs, the torque models of PAM robots are not direct and effective. 2) To ensure safety, the system state variables (e.g., contracted lengths of muscles, ranges of robots' movements, etc.) are usually limited. To this end, we propose an accurate dynamic modeling method and a nonlinear control method with overshoot constraints, respectively. Some future research directions will also be discussed.

主讲嘉宾 Keynote Speaker

刘敏 教授 | 国家杰青，湖南大学

Prof. Min Liu | National Science Fund for Distinguished Young Scholars, Hunan University, China

Biography

Min Liu, Professor at Hunan University. He serves as Lead PI of China's National Key R&D Program and core member of NSFC's Creative Research Group. He received B.S. degree from Peking University and Ph.D. degree from UC Riverside. Currently, he holds leadership roles including Vice Chair of Hunan Association of Automation, Director of the Ministry-level Key Laboratory of Advanced Manufacturing Visual Inspection & Control Technology, and Deputy Director of the Youth Committee in China Society of Image and Graphics. His pioneering research has secured 2 National Key R&D Programs and 1 NSFC Key Program, yielding 50+ first/corresponding-author papers in IEEE Transactions and 5 provincial/ministerial awards.

主讲嘉宾 Keynote Speaker

刘敏 教授 | 国家杰青，湖南大学

Prof. Min Liu | National Science Fund for Distinguished Young Scholars, Hunan University, China

Speech Title **Multimodal Perception for Intelligent Surgical Robots**

Abstract

Breakthroughs in core technologies and the comprehensive intelligent transformation of high-end medical equipment, such as surgical robots, constitute a critical national strategic imperative. This mission aligns with global scientific frontiers, addresses major national needs, and safeguards public health. These advancements provide decisive safeguards and robust support for overcoming the technological monopolies held by Europe and the U.S. in high-end digital medical equipment. However, existing surgical robots lack effective multimodal perception systems for surgical targets. This deficiency severely hinders their widespread adoption and application within critical national emergency response systems, including defense security and epidemic/disaster management. To address these challenges, this presentation delves into the fundamental principles and key methodologies of multimodal perception in surgical robots across all perioperative phases: pre-operative, intra-operative, and post-operative. Furthermore, we highlight some of our team's latest advancements in this field, offering crucial support for enhancing surgical safety and reducing major medical incidents in China.

主讲嘉宾 Keynote Speaker

郑泽伟 教授 | 国家级青年人才，北京航空航天大学

Prof. Zewei Zheng | National Young Talent
Beihang University, China

Biography

Zewei Zheng is a professor at Beihang University and a national young talent. His main research fields include flight control, intelligent control, etc. He has presided over more than 30 scientific research projects, such as the National Natural Science Foundation of China, Beijing Municipal Natural Science Foundation, National Key R&D Program, and National Science and Technology Major Project. He has published more than 100 academic papers, including over 70 SCI papers, 3 of which are selected as ESI highly cited papers, and has published 1 academic monograph. He has won 1 first prize and 2 third prizes of provincial and ministerial scientific and technological progress awards, as well as 1 Outstanding Paper Award for Young Scientists from the International Committee on Space Research. He has been shortlisted in the list of top 2% of the world's top scientists in lifetime scientific influence and annual scientific influence.

主讲嘉宾 Keynote Speaker

郑泽伟 教授 | 国家级青年人才，北京航空航天大学

Prof. Zewei Zheng | National Young Talent
Beihang University, China

Speech Title **Nonlinear Moving Path Following Control and Application**

Abstract

In the research of traditional path following control, the desired trajectory or path does not change with time. However, in the practical application of unmanned systems, there are many scenarios where time-varying paths need to be tracked. At this time, traditional path following methods cannot effectively handle the time-varying characteristics of the moving path, which will reduce the control performance of the closed-loop system. Taking fixed-wing aircraft as the application object, this report proposes a new nonlinear control method based on moving path following, and extends it to various constrained situations such as prescribed performance, three-dimensional scenarios, and fault-tolerant control.

主讲嘉宾 Keynote Speaker

赵旭东 教授 | 国家级领军人才，大连理工大学

Prof. Xudong Zhao | Recipient of China's National Leading Talent Program, Dalian University of Technology, China

Biography

Professor Xudong Zhao is a full professor and doctoral supervisor at Dalian University of Technology, serving as Deputy Director of the Key Laboratory of Intelligent Control and Optimization for Industrial Equipment (Ministry of Education). He is a recipient of China's National Leading Talent Program, specializing in switched systems, uncertain systems, and stability analysis, robust control, and intelligent control of nonlinear systems with critical applications in aero-engines, robotics, and complex military aerospace engineering systems. With over 150 publications in journals like Automatica and the IEEE Transactions series (including 20+ in top-tier outlets such as IEEE Transactions on Automatic Control), his research has garnered over 20,000 citations and multiple ESI Highly Cited Papers. As Chief Scientist, he has led the National Science and Technology Major Project, National Key R&D Program, NSFC Key Projects, the National Excellent Young Scientist Fund, a specific engineering project under the JKW Program, and major projects under the Aero Engine & Gas Turbine Major Project, among other important initiatives. Awarded the Web of Science Highly Cited Researcher, USERN Young Scientist Award, and seven national honors including the MOE Natural Science Second Prize, he has authored two English monographs and holds nine patents. A standing committee member of the Chinese Association of Command and Control's intelligent control committee, he also serves on editorial boards for Acta Automatica Sinica, IEEE Transactions on Systems, Man, and Cybernetics: Systems, and other journals pivotal to aerospace control technology.

主讲嘉宾 Keynote Speaker

赵旭东 教授 | 大连理工大学

Prof. Xudong Zhao | Dalian University of Technology, China

Speech Title **Locomotion Technology of Sea Urchin-Inspired Robots for Complex Environments**

Abstract

In response to the mobility needs of covert reconnaissance missions in complex terrains like shoals and reefs during amphibious landing operations, this work leverages the inherent advantages of bionic unmanned systems—high concealment, casualty immunity, and rapid deployability in dangerous, harsh environments or spaces inaccessible to manned forces. Specifically, this study focuses on the overall technology of adaptive sea urchin-inspired robots and control strategies based on deep learning & autonomous learning, develops a principle-based prototype, and conducts experimental validation. This report presents key research outcomes, including design inspiration, hardware design, dynamics-based motion control, reinforcement learning-driven motion control, alongside simulation analyses and prototype tests.

主讲嘉宾 Keynote Speaker

李文玲 教授 | 国家级青年人才，北京航空航天大学

Prof. Wenling Li | National Young Talent
Beihang University, China

Biography

Wenling Li is currently a Professor with School of Automation Science and Electrical Engineering at Beihang University (BUAA). He is a IEEE Senior Member. His research interests include state estimation, stochastic optimization, machine learning, and target tracking. He published more than 100 papers, authorized 12 patients, and published 2 monographs. He is a Principal Investigator of four National Natural Science Foundation projects. He won Wu Wenjun Artificial Intelligence Award as the first author. He serves as a deputy director of the Intelligent Automation Committee of CAA, deputy secretary-general of the Intelligent Service Committee of CAAI, a member of the Artificial Intelligence and Pattern Recognition Committee of CCF, and an editorial board member of three SCI journals, etc.

主讲嘉宾 Keynote Speaker

李文玲 教授 | 国家级青年人才，北京航空航天大学

Prof. Wenling Li | National Young Talent
Beihang University, China

Speech Title **Filtering Methods of Graphical Dynamic Systems**

Abstract

Kalman filtering has become one of the most successful algorithms in the field of automatic control since 1960s. Its main feature is to express the state estimation with a linear form of the measurement, and calculate the gain matrix by optimizing a certain performance index function. This report discusses several types of improved Kalman filtering algorithms. To address the unknown noise distributions in dynamic systems, a nonlinear-form filter is introduced from an optimization perspective, to remove the constraints of linear-form in the Kalman filter. Then, a graph filtering algorithm that jointly estimates the system state and graph topology matrix is designed for graphical dynamic systems, in which the estimation of the system state and graph topology matrix are determined by using the Kalman filtering algorithm and the ADMM algorithm, respectively. Moreover, multiple model estimation algorithm is proposed for Markov jump interconnected systems. The estimation performance of graph filters is verified via vehicle following system.

主讲嘉宾 Keynote Speaker

刘帅 教授 | 国家海外高层次青年人才，山东大学

Prof. Shuai Liu | Recipient of the National Thousand Plan Program , Shandong University, China

Biography

Shuai Liu is a Qilu Distinguished Professor at the School of Control Science and Engineering, Shandong University. He obtained his Ph.D. degree from Nanyang Technological University, Singapore, in 2012. From 2011 to 2017, he served as a Senior Research Fellow at the Berkeley Education Alliance for Research in Singapore (a joint research center between Singapore and the University of California at Berkeley). He is a recipient of the National thousand plan Program, a Taishan Scholar Distinguished Expert of Shandong Province, an Outstanding Young Scholar of Shandong University.

His research interests encompass distributed control, estimation, and optimization of networked systems, as well as energy systems. He has published over 100 SCI papers and holds more than 20 patents. As the principal completer, he has been awarded the Second Prize of the Shandong Provincial Natural Science Award, the Second Prize of the Chinese Association of Automation Natural Science Award, the First Prize of the Shandong Automation Society Natural Science Award, and the Technology Invention Award of the Chinese Instrument and Control Society. His work has also been recognized with the Best Paper Award at the 18th IEEE Conference on Industrial Electronics & Applications 2023, the Best Paper Award from the IEEE Control Systems Society Smart Cities Technical Committee 2023, and two Best Paper Awards at the 7th Chinese Conference on Swarm Intelligence and Cooperative Control 2023.

He serves as an editorial board member for several control journals, including IEEE Transactions on Cybernetics (IEEE T-CYBER), IEEE/CAA Journal of Automatica Sinica (IEEE JAS), ISA Transactions, and Unmanned Systems. He is also a member of the Conference Editorial Board of the IEEE Control Systems Society, as well as a member of the IEEE Control Systems Society Nonlinear Systems and Control Technical Committee and the IEEE Control Systems Society Smart Cities Technical Committee. He has frequently served as a Regional Chair, Program Chair, Invited Chair, and Publicity Chair for international conferences in the field of control. Additionally, he holds committee positions in several Committees of the Chinese Command and Control Society and the Chinese Association of Automation, as well as serving as the Deputy Director of the Intelligent Fault Detection Professional Committee of the Shandong Automation Society.

主讲嘉宾 Keynote Speaker

刘帅 教授 | 国家海外高层次青年人才，山东大学

Prof. Shuai Liu | Recipient of the National Thousand Plan Program , Shandong University, China

Speech Title **Distributionally Robust Games under Dynamic Systems**

Abstract

With the rapid advancement of cyber-physical systems, dynamic game theory has found wide applications in energy systems, transportation networks, security infrastructures, and financial markets, attracting sustained interest from academia and industry. As one of the central challenges in cyber-physical systems, dynamic games involve intricate dynamic constraints and multi-agent interactions, posing significant difficulties in modeling and computation. Equilibrium seeking serves as a fundamental solution paradigm, widely adopted for characterizing strategic evolution, evaluating decision optimality, and ensuring system stability. Existing studies predominantly focus on equilibrium computation under known and decoupled dynamics, which are inadequate for handling complex games involving nonlinear coupling and unknown system behaviors. To address these limitations, this work aims to establish a novel theoretical framework and develop a practical learning-based algorithmic architecture for equilibrium seeking in games governed by complex and uncertain dynamic systems.

主持人 Host

曹风魁 副研究员 | 中国科学院沈阳自动化研究所

Associate Researcher Fengkui Cao
Shenyang Institute of Automation, Chinese Academy of Sciences

Biography

Fengkui Cao (Member, IEEE) received the bachelor's degree in vehicle engineering from Shandong Agricultural University and the Ph.D. degree in control science and engineering from Dalian University of Technology. He is currently working at the State Key Laboratory of Robotics, Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang, China.

His research interests include unmanned ground vehicles' autonomous navigation and long-term localization, simultaneous localization and mapping (SLAM), and robotic vision.

主持人 Host

陈海洋副教授 | 天津工业大学

Assoc. Prof. Haiyang Chen | Tiangong University

Biography

Haiyang Chen (Member, IEEE) received the B.E. degree in automation and the Ph.D. degree in control theory and control engineering from Zhejiang University, Hangzhou, China, in 2013 and 2018, respectively. He is currently with the School of Control Science and Engineering, Tiangong University, Tianjin, China, where he is an Associate Professor. His research interests include networked Markov jump systems, event-triggered mechanism, power systems, and autonomous mobile robot. Dr. Chen is currently a Young Editorial Board Member of Journal of Artificial Intelligence & Control Systems.

主持人 Host

王翔宇副教授 | 南开大学

Assoc. Prof. Xiangyu Wang, Nankai University

Biography

Dr. Xiangyu Wang received dual B.E degrees in intelligent science and technology, and applied mathematics from Nankai University in 2017, and the Ph.D. degree in control science and engineering from Nankai University in 2022, under the supervision of Prof. Jianda Han and Prof. Yongchun Fang. He is currently an Associate Professor at the College of Artificial Intelligence, Nankai University (Tianjin) and the Institute of Intelligence Technology and Robotic Systems, Shenzhen Research Institute of Nankai University (Shenzhen), China. His research interests include interventional surgery robots, nonlinear estimation and control, and tendon-sheath mechanism. He has published over 20 papers in well-recognized journals and conferences, including Automatica, IEEE TIE, IEEE/ASME TMech, IEEE TASE, IEEE TIM, IEEE TMRB, IEEE/RSJ IROS. His research has been recognized with several conference paper awards, including the Conference Best Paper Finalist Award at IEEE ROBIO 2021, IEEE RCAR 2024 and IEEE CYBER 2024.

口头报告

Oral Presentation

口头报告 Oral Presentation

毛弈锐，中国民航大学

Yirui Mao, Civil Aviation University of China, China

Title: *Research on Path Tracking Control of Airport Marking Vehicle Based on Adaptive Parameter MPC*

Abstract: Airport ground markings are lines drawn on the airport surface, serving as crucial reference indicators for guiding aircraft towing, takeoff and landing processes, and directing the work of airport special vehicles. The marking vehicle is a special vehicle operating within the airport, whose primary task is to paint ground markings, providing guidance and navigation for airport ground staff, ground support vehicles, and aircraft. This paper addresses the unique ground environment of airports by establishing a two-degree-of-freedom (2-DOF) dynamic model for the marking vehicle. To overcome the reduced adaptability of traditional Model Predictive Control (MPC) controllers to complex roads, an MPC control based on parameter adaptation is proposed. The feasibility of applying this control algorithm to marking vehicles was verified through co-simulation using MATLAB/Simulink and Carsim, achieving maximum lateral and heading errors of 0.61 cm and 1.088°, respectively. Apron experimental results demonstrate that the improved MPC controller can automatically control the marking vehicle. At an operating speed of 0.5 m/s, the maximum tracking error for straight-line conditions was 2.88 cm, meeting the precision requirements for marking vehicle operation.

张苑芝，北京理工大学珠海学院

Yuanzhi Zhang, Beijing Institute of Technology, Zhuhai, China

Title: *Optimized design of self-leveling device for 3D printer based on principle of minimum potential energy*

Abstract: To address the low efficiency and poor consistency of manual leveling for Fused Deposition Modeling (FDM) 3D printers, an innovative design methodology is proposed for the self-leveling device based on the principle of minimum potential energy. With the presented approach, a suspension system is constructed by integrating a non-uniformly layered counterweight hemisphere onto the substrate backside, coupled with a bilateral linkage mechanism featuring spherical joints, achieving autonomous balance through gravitational potential energy conversion. Once placed on an inclined surface, the substrate is driven automatically by the gravitational force of the counterweight hemisphere towards the minimum potential energy state, achieving a self-leveling range of ±30°. Following leveling, a locking mechanism is performed by compressing the flexible Polyolefin Elastomer (POE) spherical joint socket with an aluminum alloy collar, effectively suppressing transverse error and ensuring printing stability. Then, the continuously attenuating strain distribution is demonstrated by SolidWorks simulations, and the structural reliability validated under extreme operating conditions. Finally, the experimental results demonstrate that the proposed design method decreases manual errors, reduces the leveling process, and offers a sensor-free and motor-free automated leveling solution for high-precision FDM systems.

口头报告 Oral Presentation

杨进，西安交通大学

Jin Yang, Xi'an Jiaotong University, China

Title: *Task-Driven Exploration: Decoupling and Inter-Task Feedback for joint Moment Retrieval and Highlight Detection*

Abstract: Video moment retrieval and highlight detection are two highly valuable tasks in video understanding, but until recently they have been jointly studied. Although existing studies have made impressive advancement recently, they predominantly follow the data-driven bottom-up paradigm. Such paradigm overlooks task-specific and inter-task effects, resulting in poor model performance. In this paper, we propose a novel task-driven top-down framework TaskWeave for joint moment retrieval and highlight detection. The framework introduces a task-decoupled unit to capture task-specific and common representations. To investigate the interplay between the two tasks, we propose an inter-task feedback mechanism, which transforms the results of one task as guiding masks to assist the other task. Different from existing methods, we present a task-dependent joint loss function to optimize the model. Comprehensive experiments and in-depth ablation studies on QVHighlights, TVSum, and Charades-STA datasets corroborate the effectiveness and flexibility of the proposed framework.

车陆，河北工业大学

Lu Che, Hebei University of Technology, China

Title: *Study of Kinematics and Trajectory Planning for the Pneumatic Soft Manipulator*

Abstract: The pneumatic soft manipulator is made of flexible materials, which has the characteristics of strong environmental adaptability, safe human-machine interaction, etc. In practice, the pneumatic soft manipulator has more and more applications in medical rehabilitation, aquaculture, pipeline maintenance, search and rescue work, etc. In recent years, the demand for pneumatic soft manipulators has increased, and higher requirements have been put forward for their flexibility and operation accuracy. However, due to the large deformation nonlinear characteristics of the pneumatic soft manipulator, its kinematic modeling is difficult. Considering this fact, this paper focuses on the kinematic modeling and trajectory planning for the pneumatic soft manipulator with three chambers. Firstly, we obtain the forward kinematic and inverse kinematic models of the pneumatic soft manipulator with three chambers through rigorous analysis and mathematical derivation. After that, based on the kinematic model, we propose a trajectory planning method for the pneumatic soft manipulator with three chambers. Finally, simulation results are given to test the satisfactory performance of the proposed method.

口头报告 Oral Presentation

刘灿，天津工业大学

Can Liu, Tiangong University, China

Title: *Asymptotic Trajectory Tracking of Stratospheric Airships Based on RISE Controllers Under External Uncertainties*

Abstract: For a stratospheric airship under internal and external uncertainties, controller strategies with robust integral sign of the error (RISE) are proposed for asymptotic trajectory tracking control. Specifically, a fully connected neural network (FCNN) is constructed with adaptive weight updating to estimate internal uncertainties of the airship system. Then, a self-tuning RISE controller is designed to track trajectories with compensating external disturbance, which enables gain adjustment in realtime according to system feedback. Based on Lyapunov technique and LaSalle-Yoshizawa corollary extension, system stability is strictly analyzed, and asymptotic convergence performance is obtained for trajectory tracking by the designed controller. More-over, a RISE controller is designed with fixed gain matrices for the airship based on classic control strategies, and asymptotic tracking is also proved. Finally, numerical simulations are con-ducted with spiral and hovering control to verify performance of the proposed strategies.

程文君，沈阳理工大学

Wenjun Cheng, Shenyang Ligong University, China

Title: *Fault Diagnosis of Bearings under Variable Working Conditions Based on Strip Pooling VGG19*

Abstract: Aiming at the problems of difficulty in extracting fault features and inaccurate classification of rolling bearings under time-varying speed in industrial production, a variable operating condition fault diagnosis model based on Strip Pooling (SP) and Visual Geometry Group (VGG) was proposed.Firstly, the original vibration signal of the bearing is normalized and converted into RGB values, and then the vibration data is stacked into RGB images. Then, the VGG19 network is improved by adopting the stripe pooling strategy, and the stacked RGB feature map is input into the SP-VGG19 diagnosis model to realize fault classification. Finally, the variable operating condition bearing dataset of the University of Ottawa in Canada is used to experimentally verify the effect of the diagnosis model.Experimental results show that the fault diagnosis model can accurately classify faults under mixed working conditions and has good generalization performance.

口头报告 Oral Presentation

岳露露，浙江大学

Lulu Yue, Zhejiang University, China

Title: *Feasibility study on carbon neutralization pathway for marine macroalgae aquaculture system in China*

Abstract: China commits to carbon neutrality by 2060, and macroalgae-derived carbon sinks are seen as a promising pathway. This study constructs a goal-driven quantitative framework to assess feasibility. Through carbon sink demand decomposition, contribution ratio allocation, and yield conversion—integrated with a three-tier evaluation system and macroalgae deposition carbon sequestration gain-loss model—it analyzes spatial, resource, and economic constraints. Post-2015 macroalgae sink growth slowed; 2020–2023 average annual rate (3.04%) fell nearly 1 percentage point below 2003–2023 mean, confirming spatial resource scarcity as core constraint. Achieving neutrality requires 71,918.6 km² annual mariculture area (3.25 × China's 2023 total), yet current mariculture nitrogen/phosphorus emissions meet only 0.05% and 0.12% of macroalgae removal demands, leaving 3–4 order-of-magnitude gap. Macroalgae-based pathway incurs $3.12 trillion annual losses (3× traditional mitigation costs), accumulating to 6.6× China's current GDP. While macroalgae farming partially supports carbon sinks, sole reliance risks unsustainable pressures, urgently necessitating composite neutrality pathways.

李悦媛，天津工业大学

Yueyuan Li, Tiangong University, China

Title: *DAEDM: Robust Unsupervised Domain Adaptation for Street Scene Segmentation Based on Vision Mamba*

Abstract: Unsupervised domain adaptation (UDA) for semantic segmentation enables models trained on labeled source domains to generalize to unlabeled target domains. In autonomous driving, cross-domain shifts caused by weather, lighting, and object often degrade segmentation performance, especially for key objects. In the paper, we propose a novel UDA framework as Domain Adaptation Encoder-Decoder Model (DAEDM). It is built upon the Vision Mamba architecture, and state space modeling mechanism is used to capture long-range contextual dependencies. Then, the domain-invariant context enhancement (DICE) module is designed to introduce statistical perturbation to low-confidence target regions, so as to enhance feature diversity and robustness. Moreover, the decoder incorporates the channel attention mechanism and the Mamba structure to improve multi-scale feature fusion and detail recovery. Three domain adaptation tasks are conducted in experiments, that are GTA5 to Cityscapes, SYNTHIA to Cityscapes, and Cityscapes to ACDC. These results demonstrate superior cross-domain generalization and practicability of the proposed framework.

口头报告 Oral Presentation

温佳祺，河北大学

Jiaqi Wen, Hebei University, China

Title: *Gas-liquid two-phase flow gas slug frequency prediction model based on acoustic emission sensing and GBR*

Abstract: Slug flow is a typical intermittent gas-liquid two-phase flow that often occurs in petroleum extraction, chemical industry, etc. The gas slug frequency serves as a core quantitative indicator of slug flow dynamics, directly reflecting the wave dynamics and interphase interaction mechanisms. Accurate prediction of slug frequency holds significant value for advancing theoretical models of multiphase flow and analyzing the evolution of operational conditions. An acoustic emission measurement system is designed to capture the dynamic flow information of slug flow in real time. A window-optimized Savitzky-Golay filtering algorithm is utilized to suppress the non-stationary noise, while the power spectrum density method (PSD) is utilized to extract the characteristic frequency information. A dimensionless parameter system (including , , , ,) is constructed based on the Strouhal number (), in where Pearson correlation analysis is employed to elucidate the synergistic effects on the St. Subsequently, a gas-slug frequency prediction model is developed using gradient boosting regression (GBR). Experimental results demonstrate that, within the range of 0.4 < < 0.8, the model achieves a relative error of less than 30%, indicating high prediction accuracy. Verification tests under varying pipe diameters (3.7-76 mm) and liquid viscosities (1-18l mPa·s) reveal a mean absolute percentage error (MAPE) of less than 30%, with 70% of experimental data points exhibiting relative errors within ±30%, confirming the model's robust extrapolation capability. This study provides a novel methodology for gas-liquid two-phase flow parameter measurement.

张琪，北京邮电大学

Qi Zhang, Beijing University of Posts and Telecommunications, China

Title: *Anti-swing Control of Underactuated Rotary Cranes: An Improved Iterative Learning Scheme*

Abstract: Rotary cranes are critical in industries such as manufacturing, military, and construction, where high safety and control performance standards are required due to complex operating environments. While existing automatic control methods have advanced in tracking and swing suppression, they often overlook valuable insights from historical data and the practical limitations of motor output torque, which complicate implementation and hinder performance. This paper proposes an improved iterative learning control scheme that utilizes non-strict repetition historical data to enhance tracking accuracy and suppress swing, even under input saturation and uncertainties. Specifically, the proposed approach incorporates refined trajectory adjustment and time scale transformation, improving the self-regulation of the control strategy in non-strict repetition iterations. Furthermore, a smoothing function is introduced to address the nonlinear effects of input saturation, simplifying controller design. The finite-time convergence of the closed-loop system is rigorously proven using a composite energy function. Simulation and experimental results demonstrate that the proposed method effectively reduces payload swings and ensures precise tracking, validating its effectiveness.

口头报告 Oral Presentation

李博宁，辽宁科技大学

Bo-ning Li, University Of Science And Technology Liaoning, China

Title: *Finite-time trajectory tracking control of quadrotor UAV based on disturbance observer*

Abstract: A novel finite-time control strategy for quadrotor UAV trajectory tracking was proposed by using a neural network disturbance observer and a command filter. This method is used to address input saturation and disturbances, ensuring that the UAV can accurately follow the desired trajectory in finite time. The neural network disturbance observer is crucial for approximating external disturbance signals within a finite time, while the finite-time backstepping scheme accelerates the convergence of tracking errors. The command filtering technique is employed to avoid the complex derivation of virtual control laws, simplifying the controller design. The importance of this method lies in its ability to achieve fast, disturbance-resistant trajectory tracking for UAVs, making the control system more robust in practical applications. Simulations were conducted, showing that the proposed control strategy enables the quadrotor UAV to track its desired trajectory effectively, with improved anti-jamming capability. Both filtering and observation errors converged to the equilibrium point, validating the effectiveness of the approach. However, internal factors like actuator failure were not considered, pointing to future work in refining the method and applying it in real-world UAV experiments.

臧耀邦，天津工业大学

Yaobang Zang, Tiangong University, China

Title: *Time-Optimal Coordination for Connected and Automated Vehicles at Intersection*

Abstract: For connected and automated vehicles (CAVs) at intersections, we propose a decentralized control theoretical framework based on bi-level optimization, and to formulate coordinated scheduling plans, the intersection control zone is partitioned into different control regions. Bi-level optimization theoretical framework comprises: 1. Upper-level planning (generating fixed trajectories for each CAV while determining entry and exit times for each sub-region)； 2. Lower-level control (designing optimal acceleration as control inputs for CAVs). Additionally, CAV trajectories are optimized to bypass conflict points at merging area centers. Finally, the effectiveness of the proposed scheme is validated through comparative evaluations against centralized control strategies, first-in-first-out (FIFO) control policies, and non-optimized routing schemes.

口头报告 Oral Presentation

王淑民，吉林大学

Shumin Wang, Jilin University, China

Title: *Design of Intrinsically Safe Electrical Method System for Remote Continuous Monitoring in Coal Mines*

Abstract: To establish a long-term monitoring system for water-induced hazards in underground coal mines, this study strictly adheres to the "Coal Mine Water Prevention and Control Regulations (2018)" and the "GB/T 3836.4 Intrinsically Safe Standards" to design an intrinsically safe resistivity-based prolonged monitoring system. By establishing a forward simulation model of water-conducting channel evolution, this study reconstructs the dynamic development process of water inrush events in underground coal mines. Based on the apparent resistivity calculation principle, precise quantitative characterization of electrical property differences in underground media has been achieved. To meet stringent explosion-proof safety requirements in underground coal mines, the system strictly controls output voltage below 90V and limits current within 100mA, establishing fundamental safety safeguards at the circuit energy source. Simultaneously, a host computer control program integrates data acquisition, storage management, and remote hardware control functions, enabling coordinated control of STM32-based transmission units, acquisition modules, and electrode switching systems.
Through dual verification using high-density resistivity methods in both oil shale surface and mine site environments, the system's collected data after inversion analysis can accurately identify low-resistance anomalies, with all electrical indicators meeting intrinsically safe standard requirements. This research achievement provides a reliable technical solution for early warning and risk prevention of coal mine water hazards.

宁波，天津理工大学

Bo Ning, Tianjin University of Technology, China

Title: *Artificial Intelligence in GUI Development: Applications and Future Trends*

Abstract: This report highlights three key aspects of AI integration in GUI development. First, AI demonstrates remarkable capability in rapidly generating GUI interfaces based on user requirements, producing code with high readability. By automating layout and design processes, AI eliminates the need for extensive manual coding, significantly enhancing development efficiency. Second, AI's prowess extends beyond front-end development into back-end tasks, showcasing its versatility in supporting full-stack development—from intelligent GUI generation to assisting with database design and API creation. However, thirdly, the reliance on AI poses challenges: over-dependency may erode developers' autonomous problem-solving skills and diminish their grasp of underlying programming logic and design principles. Balancing AI assistance with independent development remains crucial to maintaining technical proficiency while leveraging AI's advantages.

口头报告 Oral Presentation

王钧珲，北京工业大学

Junhui Wang, Beijing University of Technology, China

Title: *EEG Microstate Analysis of Brain Dynamics During Motor Imagery in Stroke Patients*

Abstract: Stroke is a chronic neuropsychiatric disorder with complex neuropathological features that often leads to varying degrees of consciousness impairment and limb paralysis. Understanding the dynamic changes in brain activity during motor imagery (MI) of paralyzed limbs in stroke patients is essential for exploring the neurocognitive mechanisms underlying motor function impairment. This study employed Electroencephalography (EEG) microstate analysis to characterize dynamic brain activity in stroke patients during four upper limb MI tasks: forward arm raising, forward arm lowering, lateral arm raising, and lateral arm lowering. Unlike conventional EEG analysis, microstate analysis provides millisecond-level spatiotemporal insights into neural activity. A modified K-means clustering algorithm was used to identify four representative microstate classes (A, B, C, and D). Microstate features including occurrence rate, duration, coverage, and global explained variance (GEV) were calculated to assess rapid transitions in brain states during task execution. Differences between movement directions were more pronounced than those between raising and lowering, with lateral tasks exhibiting higher microstate duration and GEV compared to forward tasks, particularly in microstate A. Compared to lowering movements, raising movements yielded higher values in microstate duration and GEV, while occurrence rate and coverage showed variability across different microstate classes. This study demonstrates the potential of microstate features as biomarkers for understanding individual differences in motor impairment in stroke patients and may contribute to more effective, personalized rehabilitation strategies.

06

海报展示节选

Selected Poster

海报展示节选 Selected Poster

Research on Multi-Objective Optimization Path Planning and Permanent Magnet Drive Integration for Robot Arm

Yufan Zhao Zhe Yang Naiqi Gong Peisen Zhang
School of Mechanical Engineering, Tianjin University of Science and Technology

Abstract

In this study, aiming at the demands of precision, energy efficiency and complex - environment navigation of robotic arms in industrial automation and medical minimally - invasive technology, an integrated framework for multi - objective optimal path planning and permanent - magnet drive of robotic arm is proposed. The kinematic characteristics of the robotic arm are described via Denavit - Hartenberg (D - H) parameter modeling, and a multi - objective optimization model encompassing terminal positioning accuracy, energy consumption, and magnetic - field stability is constructed. A hybrid gradient - descent genetic algorithm combined with the A* algorithm is utilized to achieve global - optimal joint configuration and collision - free trajectory planning, while integrating a permanent - magnet drive model to adapt to complex scenarios like magnetically - controlled capsules. Experimental results show that in a 20×20 grid environment, for sequential movement (X→Y→Z), the total energy consumption is 2589.7559 J with a total error of 103.7215 mm, while for direct movement to the target, the total energy consumption is 275.0119 J with a total error of 39.7272 mm. Compared with sequential movement, direct movement reduces energy consumption by approximately 89.4% and error by approximately 61.7%. This framework integrates a permanent - magnet drive model, addressing the dual - scale control issue in applications (e.g., oral surgery) by synchronizing macro - scale robotic - arm kinematics with micro - scale capsule control through magnetic - force/torque integration. This research promotes the development of robotic operations by providing robust solutions for multi - objective optimization and magneto - dynamic integration, enabling high - precision, energy - efficient robotic systems in complex environments.

Introduction

With the rapid advancement of industrial automation and minimally invasive medical technologies, robotic manipulators face escalating demands for precision, energy-efficient operation, and safe navigation in constrained environments [1]. Modern applications—ranging from hazardous material handling in nuclear facilities to capsule endoscopy in gastrointestinal tracts—require robotic systems to reconcile traditionally conflicting objectives: minimizing end-effector positioning errors, reducing energy consumption, and avoiding collisions in geometrically complex workspaces [2-3]. While multi-objective optimization algorithms like hybrid genetic-A* approaches have demonstrated 40-60% improvements in path planning efficiency, their isolation from emerging actuation modalities, particularly magnetic drive systems, limits applicability in scenarios necessitating dual-scale control. For instance, magnetic-driven capsule robots demand synchronized macro-scale manipulator trajectory planning and micro-scale magnetic field regulation-a challenge unaddressed by existing frameworks that treat these domains separately [4].

Current research bifurcates trajectory optimization and magnetic actuation. On one front, kinematic model based on Denavit-Hartenberg (D-H) parameters enable precise joint angle sequencing, yet predominantly focus on positional accuracy while neglecting energy dynamics. Recent studies by Gao et al. (2021) [5] revealed that conventional A* algorithms, though achieving 92% obstacle avoidance success in 20×20 grids, increase inertial energy consumption by 15 – 30% through abrupt directional changes. Conversely, magnetic drive models, such as the dipole approximation method pioneered by COSTA et al. (2010) [6], excel in localized capsule manipulation but disregard the global kinematic constraints of host manipulators. This dichotomy becomes critical in applications like transoral robotic surgery, where sudden manipulator movements disrupt magnetic field stability, causing 200 – 500 μm capsule positioning errors [7-8]. Furthermore, single-objective optimization fails to resolve inherent trade-offs: prioritizing path shortness elevates energy costs by 18 – 22%, while aggressive energy minimization degrades positioning accuracy by 9-15% [9-10].

In response to these pressing demands, this study aims to develop a comprehensive multi-objective optimization framework for a 6-degree-of-freedom robotic manipulator. By leveraging Denavit-Hartenberg (D-H) parameter modeling, the framework accurately represents the manipulator's kinematics and end-effector pose. To address the trade-offs among positioning accuracy, energy consumption, and obstacle avoidance, the study combines the strengths of genetic algorithms and A* path planning algorithms, ensuring globally optimized joint configurations and safe, collision-free trajectories. In addition, the integration of a permanent magnet drive model extends the manipulator's capabilities to magnetic-driven operations, enabling its application in complex and highly constrained environments. This comprehensive approach not only enhances the operational performance of robotic manipulators but also contributes to the broader field of industrial robotics by addressing key challenges in trajectory planning, energy optimization, and environmental adaptability [11-12].

Kinematic Modeling and Optimization Framework

2.1D-H Parameter Modeling.

Suppose the motion chain of the robotic arm is described by the D-H parameter (Table 1). The transformation matrix of each joint is derived as:

Table 1. Initial Denavit-Hartenberg (D-H) parameters of the robot arm. Table 1 lists the initial D-H parameters, where

a_i is the link length, α_i is the link twist, and d_i is the joint offset.

Joint i	a_i(mm)	α_{i-1}(°)	d_i(mm)
1	0	0	600
2	300	-90	0
3	1200	0	0
4	300	-90	1200
5	0	-90	0
6	0	-90	0
7	0	0	100

When planning trajectories in Cartesian space, a linear motion is provided between the start and target positions of the robotic arms. Each axis of rotation shall not exceed its own speed and acceleration limits. The end-effector positions [x,y,z]T calculated through matrix concatenation T-T1T2T3T4T5T6.

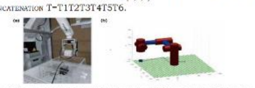

Figure1. Schematic diagram of the initial state mechanical arm. (a) Physical picture. (b) Sketch Map

To facilitate seamless integration with the permanent magnet drive system, the kinematic model is augmented with a magnetic field coordinate transformation module. This module maps the manipulator's end-effector pose (x, y, z, θ) to the spatial position of the external permanent magnet, enabling real-time calculation of magnetic force/torque on the capsule as a function of joint angles.

2.2Multi-Objective Optimization Model.

The optimization framework targets three conflicting objectives: end-effector positioning accuracy, energy consumption, and magnetic field stability for capsule control.

End position calculation: the end of the computer arm according to the joint angle and kinematic model of the robot arm. The forward kinematic formula can be used to obtain the terminal coordinates (x, y, z).

The end error E can be expressed as:

$$E=\sqrt{(x-x_t)^2+(y-y_t)^2+(z-z_t)^2} \quad (1)$$

The energy consumption generated by the robot during the movement is mainly divided into two parts. The kinetic energy consumption generated by the joint rotation and the gravitational potential energy consumption generated by the movement of the robot's center of gravity.

Kinetic energy consumption:

$$E_v=\sum_{i=1}^{6}\frac{1}{2}I_i\omega_i^2 \quad (2)$$

Where I_i is the moment of inertia of the i the joint and ω_i is the angular velocity of the i th joint.

Gravitational potential energy consumption:

$$E_g=mg\Delta h \quad (3)$$

Where m is the robotic arm mass, g is the gravity acceleration, and h is the height of the end effector.

The uniformity of the magnetic field has an important influence on the stable movement of the capsule. An uneven magnetic field may cause deviations in the movement of the capsule. Define the magnetic field uniformity index. Define the magnetic field uniformity index F_m as the mean square deviation of the magnetic field gradient:

$$M=\nabla^2B(x,y,z) \quad (4)$$

The optimization objectives are formulated as:

$$\min\left(\lambda_1\cdot E+\lambda_2\cdot E_v+\lambda_3\cdot E_g+\lambda_4\cdot M\right) \quad (5)$$

2.3Permanent magnet drive model.

By changing the position and attitude of the external permanent magnet, the movement of the capsule with the internal permanent magnet can be controlled. As shown in Fig.2, [illegible] the displacement along the axis.

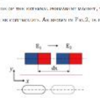

Figure 2 Permanent magnet drive picture.

According to the current model with a constant magnetization:

$$\vec{F}=\int\vec{J_m}\times\overrightarrow{B_{ex}}\,ds=M\int_{z_1}^{z_2}\int_0^{2\pi}\hat{\Phi}\times\overrightarrow{B_{ex}}\,Rd\Phi'dz' \quad (6)$$

$$\vec{T}=\int\vec{r}\times(\overrightarrow{J_m}\times\overrightarrow{B_{ex}})\,ds \quad (7)$$

Where, $\vec{F}$ is force vector. $\overrightarrow{J_m}$ is the current density of the permanent magnet surface, $\vec{\Phi}$ is the unit angular vector, R is the radius of the integral surface, and $\vec{r}$ is the displacement vector from the calculated torque point to the integral surface. Enter the current model to get the formula:

$$\vec{F}=M\int_{z_1}^{z_2}\int_0^{2\pi}\cos\Phi B_z\hat{x}+\sin\Phi B_z\hat{y}-(\sin\Phi B_y+\cos\Phi B_x)\hat{z}\,Rd\Phi'dz' \quad (8)$$

$$\vec{T}=M\int_{z_1}^{z_2}\int_0^{2\pi}\begin{bmatrix}-(r_z\sin\Phi B_z+r_y\cos\Phi B_z+r_z\sin\Phi B_x)\hat{x}\\+(r_x\sin\Phi B_y+r_z\cos\Phi B_z+r_z\cos\Phi B_x)\hat{y}\\+(r_x\sin\Phi B_x+r_y\cos\Phi B_y)\hat{z}\end{bmatrix}Rd\Phi'dz' \quad (9)$$

3 RESULT AND DISCUSSION

3.1 Multi - objective optimization analysis

During the pre-optimization phase, experiments were conducted in a simplified two-dimensional grid environment with minimal obstacles and regularly distributed target points. The algorithm was tested under conditions of a 20x20 grid with sparse obstacles, a starting point, and a fixed target point. To ensure fairness and comparability of the experiments, all three algorithms (A algorithm, A-Particle Swarm Optimization fusion algorithm, and A*-Grey Wolf Optimizer fusion algorithm) were tested using the same map environment and target point settings. Each algorithm was subjected to multiple independent experiments, and the average values of relevant indicators were recorded.

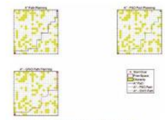

Figure 3. Optimized path graph.

As shown in Table 2 and Fig.3, it can be seen that the success rates of the three algorithms all reach 100%, indicating that in the current simple map environment, they can all [illegible] find a feasible path from the starting point to the target point. However, in terms of path length, the three algorithms perform the same. This may be because the map environment is relatively simple, and the A* algorithm itself can already find the optimal path, so the optimization strategies of the fusion algorithms fail to play a significant role. In terms of running time, the A* algorithm is the shortest because its search logic is relatively simple. In contrast, the fusion algorithms need to perform additional optimization operations, resulting in an increase in computational complexity and an extension of the running time. To more comprehensively evaluate the performance of the algorithm, the number and complexity of obstacles were increased, and the distribution and arrangement of target points were changed to make them closer to practical application scenarios. At the same time, the parameters of the fusion algorithm were adjusted to give full play to its optimization capabilities. Similarly, each algorithm was performed multiple independent experiments, and the average values of relevant indicators were recorded.

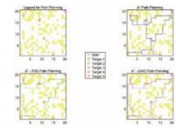

Figure 4. Optimized Path Comparison Chart

As shown in Table 3 and Fig.4, the success rate of the three algorithms remains 100% after modification, indicating that they can work stably in more complex map environment. In terms of path length, the average path length of A* is increased to 121, while the average path length of A*-PSO algorithm and A*-GWO fusion algorithm is 113, which indicates that the fusion algorithm can find a shorter path through the optimization strategy in a complex environment, reflecting its advantages. In terms of running time, the running time of A* increases, but it is still the shortest; A* -PSO is the longest, because the particle swarm algorithm requires multiple iterations and particle update operations. The running time of the A*-GWO fusion algorithm is between the two, which indicates that a good balance is obtained between the optimization effect and the calculation efficiency.

Table 3 summarizes the performance of the three algorithms.

Algorithm	Success Rate	Path Length	Running Time (s)	Smoothness	Safety
A*	100%	121	0.079905	7.854	1
A*-PSO Hybrid	100%	113	0.64967	7.854	1
A*-GWO Hybrid	100%	113	0.16161	7.854	1

Assuming the robotic arm receives a task to guide a magnet to a target point, which is located at (1500 mm, 1200 mm, 300 mm) relative to the robotic arm. Through the aforementioned path planning and joint angle optimization, the optimal motion path and joint angles for the manipulator have been obtained.

Without any optimization algorithm for Sequential Movement (X→Y→Z), the robotic arm exhibits a total energy consumption of 2589.7559 J and a total error of 103.7215 mm. In contrast, for Direct Movement to Target, the total energy consumption is 275.0119 J with a total error of 39.7272 mm. The energy difference between these two movement methods is 2314.7439 J, and the error difference amounts to 63.9944 mm.

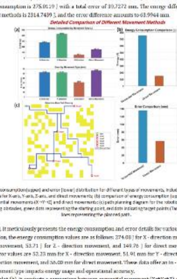

Figure 5. Energy consumption (upper) and error (lower) distribution for different types of movements, including energy consumption and error data for X-axis, Y-axis, Z-axis, and direct movements; (b) comparison of energy consumption (upper) and error (lower) between sequential movements (X→Y→Z) and direct movements; (c) path planning diagram for the robotic arm base, with yellow squares indicating obstacles, green dots representing the starting point, red dots indicating target points (Target1 - Target5), and blue lines representing the planned path.

For subplot (a), it meticulously presents the energy consumption and error details for various movement types. In the upper section, the energy consumption values are as follows: 274.08 J for X - direction movement, 424.63 J for Y - direction movement, 53.71 J for Z - direction movement, and 149.76 J for direct movement. In the lower section, the error values are 52.23 mm for X - direction movement, 51.91 mm for Y - direction movement, 30.95 mm for Z - direction movement, and 56.00 mm for direct movement. These data offer an in - depth perspective on how each movement type impacts energy usage and operational accuracy.

Regarding subplot (b), it conducts a comparison between sequential movement (X→Y→Z) and direct movement. The energy consumption comparison shows that the sequential movement has a total energy consumption of 2589.7559 J, while the direct movement consumes 275.0119 J, with an energy difference of 2314.7439 J. The error comparison reveals that the total error of sequential movement is 103.7215 mm, and that of direct

Conclusion

The multi - objective optimization framework constructed in this study effectively solves the collaborative problems of robotic arm trajectory planning, energy consumption optimization, and magnetically controlled driving. By combining D - H parameter modeling with the genetic - A* algorithm, a balance among positioning accuracy, energy consumption, and path safety is achieved, and the path planning efficiency in complex environments is significantly improved. The integration of the permanent - magnet drive model expands the application of the robotic arm in magnetically controlled scenarios and provides technical support for fields such as capsule robot control. Future research can further optimize the real - time performance of the algorithm, explore multi - modal drive fusion strategies, and promote the application of the robotic arm in high - precision and strongly constrained scenarios.

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海报展示节选 Selected Poster

Research and Application of SLAM Algorithm for Mobile Robots in Indoor Dynamic Scene

Bingyang Wang, Xin Song*, Kaichao Lu, Lei Yang
College of Engineering and Technology, Tianjin Agricultural University, China

Introduction

Visual SLAM with object detection for indoor dynamic scenes based on ORB-SLAM3
Added YOLOv8 object detection thread to filter dynamic objects
TensorRT-accelerated detection on embedded devices
Reduces dynamic object impact on camera pose estimation

Aim

1.To propose a SLAM algorithm integrating object detection based on ORB-SLAM3, aiming to enhance the positioning accuracy in indoor dynamic scenes.
2.To accelerate the object detection using TensorRT and realize real-time operation of the algorithm on embedded terminals.

Method

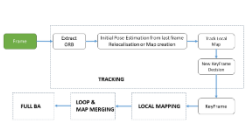
Dynamic Object Masking: Detected dynamic objects (via YOLOv8) are masked out during ORB feature extraction
Sparse but Robust Features: Extracts features only from static regions (e.g., walls, furniture)
Results: Reduces feature count by 42% while improving match accuracy to 98.7%


Before improved


Improved

Method

Dynamic scenes (e.g., moving vehicles, pedestrians, or robots) significantly degrade the performance of the Tracking Thread, leading to increased pose estimation errors, feature matching mistakes, and even tracking failure. To address this issue, we propose integrating a Target Detection Thread into the ORB-SLAM3 system. The comparative diagrams of the overall system framework before and after the improvement are shown as follows.

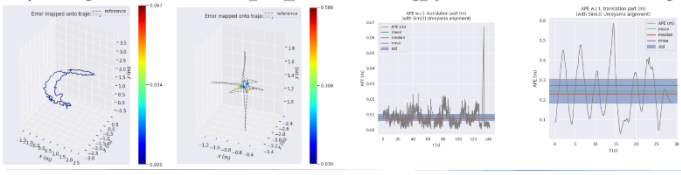


ORB-SLAM3 system framework
Improved system framework

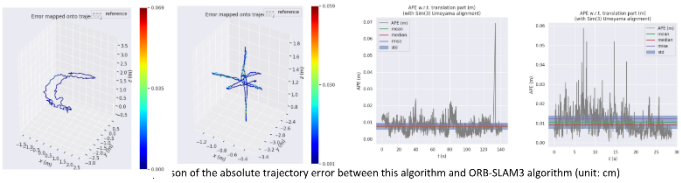
Result

Compared with the real trajectories, the camera pose estimation trajectories obtained with the ORB-SLAM3 algorithm and the improved algorithm tested on the"desk_with_person"and "walking_xyz" data set are shown in the following figures.

ORB-SLAM3 algorithm



Improved algorithm



son of the absolute trajectory error between this algorithm and ORB-SLAM3 algorithm (unit: cm)

Dataset Sequence	ORB-SLAM3			The algorithm in the paper			Enhancement percentage		
	RMSE	Mean value	SSE	RMSE	Mean value	SSE	RMSE	Mean value	SSE
desk_with_person	0.00921	0.00812	0.29958	0.00862	0.00775	0.26256	6.4%	4.5%	12.4%
walking_xyz	0.27326	0.24452	61.67688	0.01245	0.01062	0.12795	95.5%	95.7%	99.8%

Conclusion

According to the results, the average absolute trajectory error can be improved by 95.66% compared with the algorithm before improvement in high dynamic scene. In addition, the average time per frame is 0.1411s when processing the TUM data set, which basically meets the requirement of real-time operation on embedded mobile terminal.

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海报展示节选 Selected Poster

Fusion of interacting multiple model and improved particle filter for underwater bearings-only maneuvering target tracking

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Abstract

Aiming at the problems of measurement nonlinearity and model uncertainty in underwater bearings-only maneuvering target tracking, this paper proposes a novel interactive multiple model (IMM) algorithm framework that combines improved particle filters. The framework calculates and updates the model probability corresponding to each particle through Kalman filter and resampling algorithm, which realizes the effective fusion of IMM and improved particle filters (such as EFP, UPF, CPF). Furthermore, to alleviate the phenomenon of particle degradation, we design an adaptive resampling mechanism that integrates Gaussian mutation and crossover evolutionary strategies. Simulation results demonstrate that compared with conventional algorithms, the IMM-HCPF achieves significant improvements in estimation accuracy, convergence speed and real-time performance.

Introduction

Underwater target tracking systems hold significant research value in the fields of marine exploration and security defense. Underwater targets encompass diverse categories, including submarines, autonomous underwater vehicles (AUVs), and marine organisms, whose complex kinematic characteristics pose formidable challenges for real-time localization, continuous tracking, and state monitoring. Conventional tracking algorithms, grounded in single motion model assumptions, struggle to effectively address the dynamic switching of kinematic characteristics during target maneuvers, often leading to state estimation inaccuracies or even tracking failures. To address the limitations of existing maneuvering target tracking algorithms, we propose an adaptive framework that integrates enhanced particle filtering with the Interactive Multiple Model (IMM) architecture. This framework adopts modular design principles, enabling seamless integration of advanced particle filtering variants (EPF, UPF, CPF,HCPF) into the probabilistic inference workflow of IMM.

Methods

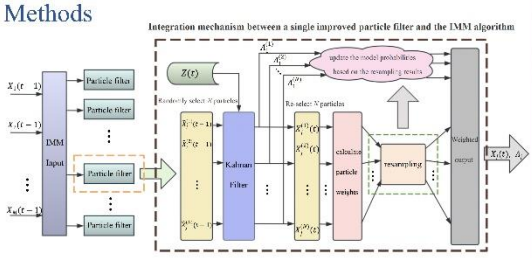
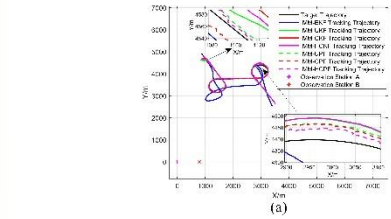


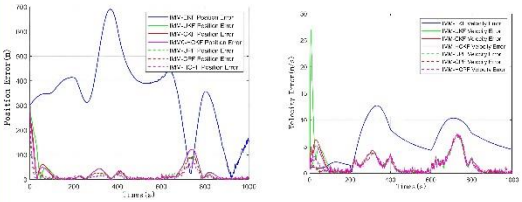
Figure 1 Integrated framework combining the IMM algorithm and improved particle filters

As shown in Figure 1, the framework first selects N particles around each motion model based on the interactive output results of IMM. Then nonlinear filtering technology (such as EKF, UKF, CKF) is used to update the particle state and calculate the model-specific probability $\Lambda_1^{(1)}, \Lambda_1^{(2)}, \cdots, \Lambda_1^{(N)}$, while subsequent particles reselection optimizes the distribution using post-filtering mean estimate and covariance. By calculating the normalized particle weights and resampling, the particles' set and are updated. Finally, the weighted fusion method is used to synthesize the resampling particles to generate the optimized state estimation and updated model probability. The architecture gives full play to the multi-model adaptive ability of IMM and the non-linear estimation advantage of particle filter. While ensuring the computational efficiency, it significantly improves the robustness to sudden maneuvering of the target, and achieves a performance breakthrough in complex tracking scenarios.

Results



(a)



(b) (c)

Figure 2 Comparison of tracking results of different algorithms: (a) Actual and estimated tracks; (b) Position error; (c) Velocity error.

Figure 4 illustrates the comparative performance evaluation results. Obviously, IMM-EKF performs the worst, especially when the model is switched every time, the RMSE of the estimated position and speed of the target increase significantly, which cannot meet the requirements of the tracking system. The developed IMM-UPF, IMM-CPF, and IMM-HCPF algorithms demonstrate substantial improvements in tracking accuracy, convergence efficiency, and robustness compared to traditional maneuvering target tracking methods. In addition, due to the inherent advantages of the HCPF nonlinear filtering architecture, the IMM-HCPF algorithm exhibits excellent performance in all evaluation methods, which can better deal with complex maneuvering dynamics and model transfer uncertainties.

Conclusions

In this study, we propose a novel hybrid framework integrating the Interacting Multiple Model (IMM) with improved particle filters to address the challenges of highly dynamic motion models and nonlinear measurements in bearings-only maneuvering target tracking. Based on the novel framework, it can effectively overcome the problem that the traditional improved particle filter (EPF, UPF, CPF) algorithm is limited to a single model, so as to obtain a variety of maneuvering target tracking algorithms with better performance. Simulation results demonstrate that compared to traditional algorithms, the proposed IMM-HCPF exhibits accelerated convergence rates under initial large-error condition, it significantly enhances tracking accuracy and robustness, demonstrating particular significance for underwater bearings-only maneuvering target tracking applications.

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海报展示节选 Selected Poster

AIDE-SLAM: Anomaly-Handling and IMU-Enhanced SLAM

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Departments of School of Cyber Science and Engineering, University of Zhengzhou University

Introduction

Visual SLAM (VSLAM) is pivotal for autonomous robots, drones, and AR systems [1]. While ORB-SLAM3 [2] (feature-based) and DSO [3] (direct method) excel in feature matching and sparse optimization, dynamic lighting, sensor noise, and motion anomalies (blur/occlusions) degrade robustness [4]. Multi-sensor fusion (LiDAR-visual-IMU [6]) and dynamic detection [7] partially mitigate issues but lack real-time anomaly recovery.CamVox [8] (LiDAR-enhanced) and VIRAL-SLAM [9] (UWB-synced) improve multi-sensor reliability. StereoVO [10] employs attention graphs for fog/lighting resilience, while Semantic-SLAM [11] boosts accuracy 17% via ConvLSTM. Key bottlenecks persist: (1) ORB's sensitivity to texture/lighting changes ; (2) high computational costs limit edge deployment .

LEVB-BioSLAM [12] combines bio-inspired vision with LiDAR, while TT-LCD [13] uses compressed Transformers for edge-compatible loop closure. UPLP-SLAM [14] unifies geometric primitives but lacks adaptive recovery for persistent anomalies and multi-sensor conflict strategies.

We present AIDE-SLAM with three key contributions:

Cascaded Anomaly Detection: Dual-stage screening combining photometric analysis and LSTM-based temporal fusion ($\alpha \in [0,1]$).

Confidence-Driven Optimization: Adaptive weighting ($\lambda = 0.5(1-\alpha)e^{(-\gamma\Delta t)}$) with IMU motion compensation (Δp_comp).

Rapid State Recovery: Keyframe spatial consistency algorithm enabling 3-frame mode transitions.

Methods

The AIDE-SLAM framework is built upon ORB-SLAM3, augmented with an anomaly-aware and multimodal collaborative architecture tailored for complex environments. As illustrated in Figure 1 (overview) and Figure 2 (detailed workflow), the system establishes a closed-loop processing pipeline through cascaded anomaly detection, dynamic optimization decisions, and adaptive mode switching.

As shown in Figure 2, the system constructs a real-time multi-sensor collaborative processing framework. Camera data undergoes preprocessing (brightness anomaly detection, motion blur assessment) to filter valid frames, which are synchronized with IMU data and input to the tracking module. Initial pose estimation is generated through feature matching and VIO motion estimation. The core innovation is the Dynamic Decision Engine, which fuses sensor discrepancies (IMU-camera pose deviation, feature reprojection errors) and tracking success rates via a bidirectional LSTM, outputting dynamic confidence scores.

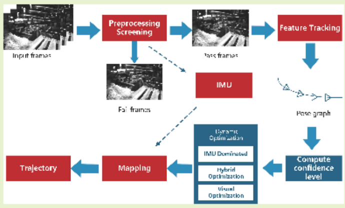

Figure.1. Overview of our proposed method.

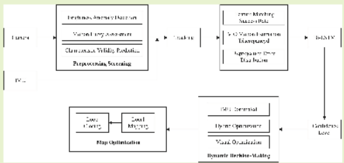

Figure.2. Detailed framework of our proposed method.

Results

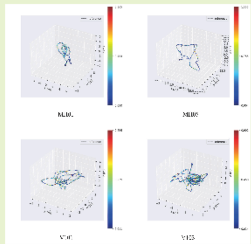

Figure 3. Comparison of the motion trajectories of AIDE-SLAM with the ground-truth trajectories for theMH01, MH05, V101, and V103 sequences of the EuRoC MAV dataset.

Table.1. mAP for different augmented methods.

Sequence	ORB-SLAM3 Monocular	ORB-SLAM3 Stereo	ORB-SLAM3 Monocular VI	ORB-SLAM3 Stereo VI	AIDE-SLAM Monocular VI	AIDE-SLAM Stereo VI
	ATE RMSE[m]	ATE RMSE[m]	ATE RMSE[m]	ATE RMSE[m]	ATE RMSE[m]	ATE RMSE[m]
[illegible]	[illegible]	[illegible]	0.063	[illegible]	0.016	0.041
[illegible]	[illegible]	[illegible]	0.097	[illegible]	[illegible]	0.017
V101X	[illegible]	[illegible]	[illegible]	[illegible]	0.040	0.025
V103X	0.237	[illegible]	[illegible]	[illegible]	0.030	0.021
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.046	[illegible]
V202X	[illegible]	[illegible]	[illegible]	[illegible]	0.024	0.021
Avg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Results

As shown in Table 1, AIDE-SLAM significantly outperforms ORB-SLAM3 in both monocular and stereo visual-inertial (VI) modes on the synthetic anomaly dataset. Compared to ORB-SLAM3 monocular VI, our method achieves an 81.6% reduction in average ATE (0.207m → 0.038m), while under extreme occlusion scenarios (e.g., V101X), the stereo VI configuration reduces errors by 93.9% (0.735m → 0.045m).

As illustrated in Figure 3, the motion trajectories estimated by AIDE-SLAM closely align with the ground-truth trajectories across the MH01, MH05, V101, and V103 sequences of the EuRoC MAV dataset, demonstrating its high tracking accuracy.

Conclusion

This paper proposes AIDE-SLAM, a robust VSLAM framework that integrates IMU-enhanced motion estimation and hierarchical anomaly handling to address performance degradation in dynamic environments. Key contributions include:

1.A cascaded anomaly detection architecture achieving 97.2% precision in identifying degraded frames.

2.A confidence-driven optimization strategy reducing inertial navigation error by 25% (0.52m → 0.39m ATE).

3.A rapid recovery mechanism enabling 3-frame mode transitions, 5.2× faster than traditional methods.

Experimental results demonstrate 37.5% lower ATE RMSE compared to ORB-SLAM3 under extreme conditions (e.g., motion blur, 40% occlusion). The system maintains sub-decimeter accuracy (0.033m avg. ATE) across diverse scenarios, proving its practicality for real-world applications. Future work will explore multi-sensor fusion and lightweight implementations for edge deployment.

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Acknowledgments

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Futher informations

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海报展示节选 Selected Poster

Research on Interactive Design Method of Radar Display and Control Interface under Time Pressure

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ABSTRACT

Research indicates that under high time pressure, an individual's decision-making mechanism is influenced by cognitive factors such as attention and memory, leading to stress responses. This often manifests as the substitution of compensatory decision-making strategies for non-compensatory ones, which, while increasing decision speed, compromises decision quality. Therefore, this study focuses on exploring information interaction design methods for individual decision-making mechanisms under time pressure, aiming to support operators in adopting compensatory decision-making strategies for critical tasks and avoiding the decline in decision quality caused by non-compensatory tendencies. Based on typical radar decision-making tasks and guided by the concept of human-machine collaboration, this study integrates cognitive factors such as attention and memory to propose an information interaction design method for display-control interfaces. The goal is to achieve information layering and reduce users' cognitive load. Taking the radar target allocation task as an example, the study applied the proposed design and conducted comparative experiments. The experimental results demonstrate that the display-control interface design strategy, grounded in human-machine collaboration, effectively mitigates the negative effects of time pressure on participants' cognitive load and task completion time. The proposed design method optimizes the decision-making interaction process, reduces operators' cognitive load, and helps counteract the adverse impact of time pressure on decision strategy selection. It supports operators in adopting compensatory decision-making strategies, thereby improving task performance under time pressure. This method can be widely applied to human-computer interaction design in radar and other industries, providing methodological support for enhancing system interaction performance.

Keywords: Time pressure; Decision-making; Interaction design; Compensatory decision strategy; Design meth.

INTRODUCTION

Existing studies on time pressure and information system design have demonstrated from different perspectives that time pressure significantly impairs individuals' cognitive performance. Therefore, this paper integrates cognitive psychology principles to examine the relationship between time pressure and user cognitive processes.

- Integrates cognitive psychology principles .
- Propose corresponding design strategies targeting key cognitive stages .
- validate these methods through a radar target allocation task in a radar information system.

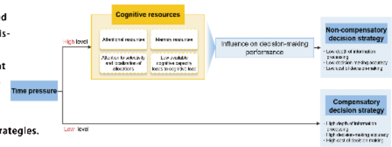
Alleviate users' emotional and cognitive fatigue caused by sustained high time pressure and heightened stress, thereby improving decision-making accuracy and enhancing system performance.

Human-machine collaboration

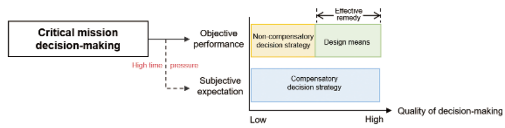
Human-machine collaboration refers to the advancement of information technology enabling computers to assume partial functions of information perception and processing. This allows for the reallocation of cognitive tasks between humans and machines, leveraging their respective advantages when handling massive dynamic information, thereby re-ducing human cognitive load and enhancing system performance. This concept has become one of the developing trends in human-computer interaction design within complex information environments.

The effect of time pressure on object decision making

Under time pressure, user's limited cognitive resources are compromis-ed, leading to cognitive overload when processing the same amount of information compared to time-pressure-free conditions.Thereby having an impact on the user's choice of task decision-making strategies.



In addition to time pressure, different task types also significantly influence people's choice of decision strategies. Existing research indicates that individuals tend to adopt compensatory decision strategies based on alternative-based processing when making important task decisions, whereas they employ non-compensatory decision strategies based on attribute-based processing for less critical tasks.



This study explores how interface design can mitigate time pressure' s negative effects on operators, helping them adopt better decision strategies under stress, reduce bias, and improve decision quality.

DESIGN STRATEGY

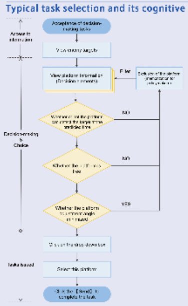
The design direction is proposed based on the concept of human-machine collaboration

(1)Information design for attention allocation: The option-based centralized display of attribute.Information is achieved through information integration, visualization processing, etc., echoing the individual's characteristic of localized distribution of attention.

(2)In response to the lack of cognitive resources, two main aspects are included: one is to reduce the flow of infor-mation to avoid information being presented in large quantities in a single time cut. The second is to offload part of the functions to the system based on the concept of human-computer collaboration, reducing the amount of information that individuals need to process and lowering the demand for their cognitive resources.

+

Typical task selection and its cognitive pain points



- **Information input and access**

The number of alternative radar platforms in the interface leads to a high number of options to be evaluated.The dispersed display of attributes as-sociated with the options and the time pressures result in the user having to gather the infor-mation required for decision-making over a large spatial area.

- **Information input and access**

Many manual evaluation functions, such as evaluat-ing which platforms can cover the target trajectory, the angle of platform rotation, etc., with high demand on cognitive resources.

- **Information input and access**

Long interaction paths,

Application of design strategies

	Information input and access	Status assessment and information processing	Behavioral Outputs
comparison group	Decision items are discretely distributed, leading to complex interaction paths for users	No angle, scope and other information visualization to aid decision making	Manual selection via drop-down menu
Scenario A	Decision items are discretely distributed, leading to complex interaction paths for users	No angle, scope and other information visualization to aid decision making	Integrated design of display and control: the machine automatically fills in the results of the decision; prompts for invalid decisions.
Scenario B	Decision items tiled/decentralized (manual multipoint screening)	Add visual cues for decision aids such as angle, range, etc.	Integrated design of display and control: the machine automatically fills in the results of the decision; prompts for invalid decisions.
Scenario C	Decision-making information is aggregated while machine-assisted filtering - weakening invalid options	Add visual cues for decision aids such as angle, range, etc.	Integrated design of display and control: the machine automatically fills in the results of the decision; prompts for invalid decisions.

EXPERIMENTAL MEASUREMENT

To examine how different design methods affect user performance and cognitive load levels, the experimental design progressively incorporates the proposed optimization methods across three decision stages.

Comparison group | Scenario A | Scenario B | Scenario C

Experimental data analysis

Before proceeding to the analysis of statistical differences between the experimental groups, the data were tested for normal distribution. As shown in the Table 3 all groups of data satisfy the normal distribution of data. And the homogeneity test of variance shows that all groups of data meet the homogeneity of variance ($p>0.05$).

Task duration

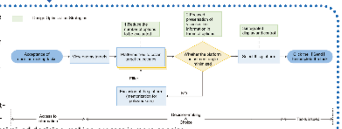
Based on the results of normality tests and homogeneity of variance tests, one-way ANOVA was conducted on the dimensional data of the four solution groups to examine whether statistically significant differences existed between the datasets. The one-way ANOVA for task completion time revealed that design strategies employing different levels of human-machine collaboration significantly affected task duration ($F=83.916$, $P=0.000$, $P<0.05$, $\eta^2=0.724$). And through multiple post-LSD comparisons, there were significant differences in the task completion time between the original scheme and the three design schemes ($P<0.05$). Among them, compared with using the first-level and second-level collaborative design schemes, users using the third-level collaborative design scheme have a faster de-cision-making speed and higher performance.

Cognitive load level

Similarly, the one-way ANOVA for cognitive load showed that design strategies with varying human-machine collabo-ration levels significantly influenced cognitive load ($F=137.710$, $P=0.000$, $P<0.05$, $\eta^2=0.700$). And the post-event multiple comparison test by LSD showed that under different levels of human-computer collaboration, there were significant differences in the cognitive load levels between the original scheme and the three design schemes ($P<0.05$;) Cohen's $d>0.8$. Among them, the cognitive load patterns of the three cooperative level designs are. Scenario A > Scenario C > Scenario B.

CONCLUSION

These methods effectively assist operators in countering time pressure by supporting the allocation of limited temporal resources to option-centered decision processes, reducing or eliminating unnecessary time consumption during decision-making. They enable comprehensive evaluation and comparison of option attributes through compensatory strategies, leading to more thorough and accurate decisions. Experimental results further confirm that solutions incorporating these design strategies significantly reduce operators' cognitive load and decision time. As shown in the figure, the optimized decision-making process is more concise.



单位介绍

Organization

承办单位 Organizer

控制科学与工程学院
School of Control Science and Engineering

天津工业大学控制科学与工程学院，始建于1972年的纺织生产自动化，1980年成立自动化系，是天津纺织工学院初建时的四系之一，2009年4月成立电气工程与自动化学院，2020年12月调整为控制科学与工程学院。经过五十多年的发展，在人才培养、科学研究、服务社会、文化传承创新和国际交流合作方面为国家做出了应有的贡献。

学院现有自动化本科专业。自动化专业是国家级一流本科专业建设点、天津市一流本科专业、天津市“十二五”首批品牌专业建设点以及“十三五”应用型专业建设点，2012年入选教育部“卓越工程师教育培养计划”，2017年通过工程教育专业认证。拥有国家级一流课程、天津市一流课程，天津市创新创业教育特色示范课程、天津市课程思政示范课程2门，天津市课程思政优秀教材3部，天津市教学团队1支，教学基本功大赛国家一等奖1项，天津市一等奖1项，二等奖2项，全国自动化类专业青年教师讲课（说课）竞赛三等奖1项，省部级以上教学成果奖励30余项。

学院拥有“控制科学与工程”一级学科博士点和“电子信息”专业学位博士点，拥有“控制科学与工程”一级学科硕士点和“电子信息-控制工程”专业学位硕士授权点。“控制科学与工程”为天津市“十二五”“十三五”重点学科，“十四五”入选天津市“顶尖学科培育计划”。

学科师资力量雄厚，拥有中国工程院院士1人，国家杰出青年基金获得者1人，“中国青年科技奖”获得者1人，何梁何利基金科学技术奖获得者1人，“新世纪百千万人才工程”国家级人选1人，全国巾帼建功标兵1人，教育部新世纪优秀人才2人，天津市特聘教授3人，天津市“131”创新型人才9人，天津市高校“中青年骨干创新人才培养计划”人选7人，天津市最美女教师1人，天津市五一劳动奖章获得者1人，天津市三八红旗手获得者1人，桑麻奖教金获得者8人。2人入选爱思唯尔中国高被引学者，2人荣获全国创新创业优秀博士后，4人荣获天津市优秀创新创业导师。

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目前学院设有高效能电机系统智能设计与制造国家地方联合工程研究中心、“电气装备智能控制”天津市重点实验室、天津市电机系统先进设计与智能控制技术工程中心、“物流安全监控与运输包装技术天津市工程中心”、“教育部IAAT认证与培训中心”、“自动化与电气工程”天津市实验教学示范中心、天津市“自动化虚拟仿真实验教学中心”；“自动控制原理”、“运动控制技术”、“过程控制技术”、“检测技术”、“电力电子技术”、“纺织综合自动化”、“电机拖动与电气传动”、“智能建筑”、“机器人技术”、“图像处理与模式识别”等专业实验室；天津工业大学—恩智浦全国“嵌入式系统设计与应用教学示范实验室”、天津工业大学—罗克韦尔自动化实验室、天津工业大学—OMRON联合实验室、天津工业大学—中纺机电联合研发中心等多个校企合作共建实验室；与恩智浦、天津纺织控股集团、天津市中环电子集团共建了三个国家级工程实践教育中心。

近年来承担有国家973项目、国家863项目、国家科技支撑项目、国家自然科学基金项目、天津市科技支撑等科研项目近60项，以及众多与企业合作的横向项目，拥有多项科研成果及专利。获国家技术发明奖二等奖1项、国家科技进步二等奖1项，全国博士后创新创业大赛国家铜奖4项、天津市技术发明奖一等奖2项，天津市科技进步二等奖3项、三等奖3项，部级二等奖2项，天津市产学研突出贡献奖1项，其它各种奖励10余项；发表SCI、EI文章500余篇。“电机系统及其智能控制”和“现代纺织检测与控制技术”获批天津市高等学校创新团队。学院积极将科技成果服务社会，主办的“点亮好奇心”短视频云上科普活动获评中国科协2021和2022年全国科普日优秀活动。学院主办的“点亮好奇心”科学成果展示系列活动，入选天津市第36届和第37届科技周市级重点活动。

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学院在教学过程中注重学生实践和创新能力的培养，建有“奥比中光追光空间站”、“智能车创新实验室”、“机器人俱乐部” 、“TI电子设计俱乐部”、“罗克韦尔工业自动化实践基地”等课外实践平台面向全体学生开放。学院引导、鼓励、支持学生积极参加创新创业竞赛。5年来，在中国“互联网+”大学生创新创业大赛，全国大学生电子设计竞赛和全国大学生智能汽车竞赛等各级各类竞赛中获奖人数达400余人，获奖率达20%以上。

学院的就业领域涉及政府部门、科研院所、工矿企业、金融、电力、建筑、通信、税务、铁道、民航、海洋与物流等行业，可从事科学研究、产品研发、营销服务、经营管理或工程项目的分析、设计、施工、运行、维护等工作。学院的毕业生就业情况良好，考研成功率达35%以上。37%的学生进入爱丁堡大学，浙江大学、哈尔滨工业大学、华中科技大学、天津大学、电子科技大学、西北工业大学、东北大学、厦门大学、南京理工大学等国内外高校深造。

学院在习近平新时代中国特色社会主义思想指引下，全面贯彻党的教育方针，坚持社会主义办学方向，坚持为党育人、为国育才，坚持改革创新，落实立德树人根本任务，努力培养德智体美劳全面发展的社会主义建设者和接班人。学院建有第二批“全国党建工作样板支部”和首批“天津市研究生党建工作先进典型样板支部”。

协办单位 Co-organizer

天津科技大学 Tianjin University of Science and Technology

电子信息与自动化学院 College of Electronic Information and Automation

天津科技大学电子信息与自动化学院始建于1985年,时名自动化工程系,2003年更名为电子信息与自动化学院。办学四十载，学院全面贯彻党的教育方针,坚持立德树人根本任务，以学科建设为重点,着重聚焦提高人才培养质量,为国家培养近万名高层次工程技术人才。

学院1985年开设“电气技术与自动化”本科专业，期间历经三次专业调整，于1997年调整为“自动化”专业，同年，获批“电气工程及其自动化”本科专业；1998年获批“测控技术与仪器”本科专业；2000年获批“电子信息工程”本科专业；2003年获批“通信工程”本科专业；2004年获批“控制工程”专业学位授权点；2006年获批“控制理论与控制工程”和“测试计量技术及仪器”硕士点；2011年获批“控制科学与工程”和“仪器科学与技术”一级硕士点；2019年增设“机器人工程”专业；2022年新设“微电子科学与工程”专业。

学院建设有“仪器科学与技术”和“控制科学与工程”2个一级学科硕士点，8个二级学科硕士点及1个“电子信息”专业学位授权点。拥有“自动化”、“电气工程及其自动化”、“微电子科学与工程”、“通信工程”、“测控技术与仪器”和“机器人工程”6个本科招生专业。自动化、测控技术与仪器和通信工程是天津市一流本科专业建设点。

学院现有教职员工110人，其中正高级15人（博士生导师7人），副高级38人，具有博士学位62人。另外，学院现有天津市海外高层次人才1人、天津市特聘讲座教授1人、天津市中青年科技创新领军人才1人、天津市特聘教授青年学者1人、海河学者特聘教授1人、天津市高校“学科领军人才”3人、天津市高校“中青年骨干创新人才”4人。

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电子信息与自动化学院 College of Electronic Information and Automation

此外，学院拥有“天津市智能制造装备信息化技术工程研究中心”（天津市工程研究中心）、“先进结构完整性国际联合研究中心”（天津市国际合作基地）等多个省部级科研及教学平台。在结构安全监测技术、成像与非成像光学过程的研究与应用、智能测量与控制技术、智慧农业信息化技术与工程、复杂系统控制与应用、轻化工过程参数智能检测与控制方向、智能机器人和新能源发电及控制技术等方面获得较大成绩。

学院以学科建设为重点，以适应社会需求的人才为宗旨，着重聚焦提高人才培养质量，学院学生每年在“中国国际大学生创新大赛”、“挑战杯”全国大学生课外学术科技作品竞赛等高水平学科竞赛中屡创佳绩。

近年来，学院承担国家级项目15项，科研到款经费3500万元以上，发表业界公认的国内外顶级或重要科技期刊100多篇，申请专利近500项，先后获得天津市科技进步奖等省部级奖励3项，2020年获得互联网+大赛国赛铜奖，2022年自动化教工党支部获批全国样板党支部。

奋斗是最鲜明的底色，实干是最嘹亮的号角，团结是最强大的力量！电信学院将自觉把学院发展融入学校“先锋计划”各项目标任务当中，提升“善”的能力，细化“作”的措施，确保“成”的效果，助力“先锋计划”各项任务落地见效，推动学院工作上水平上台阶，奋力开创高水平研究型大学建设新局面。

◆ 主办单位 ◆

天津工业大学

◆ 承办单位 ◆

天津工业大学控制科学与工程学院

◆ 协办单位 ◆

天津科技大学电子信息与自动化学院

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