FINAL PROGRAM
&
BOOK OF ABSTRACTS

18TH IEEE INTERNATIONAL CONFERENCE ON CONTROL AND AUTOMATION

(IEEE ICCA 2024)

University of Iceland, Reykjavík, Iceland
June 18-21, 2024

IEEE

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IEEE Control Systems Chapter, Singapore
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IEEE International Conference Series on Control and Automation

Past and Present

- Singapore International Conference on Intelligent Control and Instrumentation (SICICI 1992)
  February 17–21, 1992, Marina Mandarin Hotel, Singapore
- Singapore International Symposium on Control Theory and Applications (SISCTA 1997)
  July 29–30,1997, Hilton International, Singapore
- 3rd International Conference on Control Theory and Applications (ICCTA 2001)
  December 12–14, 2001, University of Pretoria, South Africa
- 4th International Conference on Control and Automation (ICCA 2003)
  June 10–12, 2003, Concordia University, Montreal, Canada
- 5th International Conference on Control and Automation (ICCA 2005)
  June 27–29, 2005, Hungarian Academy of Science, Budapest, Hungary
- 6th IEEE International Conference on Control and Automation (IEEE ICCA 2007)
  May 30–June 1, 2007, Baiyun International Convention Center, Guangzhou, China
- 7th IEEE International Conference on Control and Automation (IEEE ICCA 2009)
  December 9–11, 2009, Hotel Grand Chancellor, Christchurch, New Zealand
- 8th IEEE International Conference on Control and Automation (IEEE ICCA 2010)
  June 9–11, 2010, Asia Gulf Hotel, Xiamen, China
- 9th IEEE International Conference on Control and Automation (IEEE ICCA 2011)
  December 19–21, 2011, Park Plaza Hotel, Santiago, Chile
- 10th IEEE International Conference on Control and Automation (IEEE ICCA 2013)
  June 12–14, 2013, Zhejiang Hotel, Hangzhou, China
- 11th IEEE International Conference on Control and Automation (IEEE ICCA 2014)
  June 18–20, 2014, Evergreen Laurel Hotel, Taichung, Taiwan
- 12th IEEE International Conference on Control and Automation (IEEE ICCA 2016)
  June 1–3, 2016, Soaltee Crowne Plaza Hotel, Kathmandu, Nepal
- 13th IEEE International Conference on Control and Automation (IEEE ICCA 2017)
  July 3–6, 2017, Metropol Lake Resort, Ohrid, Macedonia
- 14th IEEE International Conference on Control and Automation (IEEE ICCA 2018)
  June 12–15, 2018, Sheraton Hotel, Anchorage, Alaska, USA
- 15th IEEE International Conference on Control and Automation (IEEE ICCA 2019)
  July 16–19, 2019, Royal College of Physicians, Edinburgh, Scotland
- 16th IEEE International Conference on Control and Automation (IEEE ICCA 2020)
  October 9-11, 2020, Virtual Conference
- 17th IEEE International Conference on Control and Automation (IEEE ICCA 2022)
  June 27-30, 2022, Ramada Naples City Centre, Naples, Italy (Hybrid Conference)
- 18th IEEE International Conference on Control and Automation (IEEE ICCA 2024)
  June 18-21, 2024, University of Iceland, Reykjavík, Iceland

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Welcome Message

On behalf of the conference organizing committee, it is with great pleasure that we present the Final Program and Proceedings of the 18th IEEE International Conference on Control and Automation (IEEE ICCA 2024). Set against the captivating backdrop of Reykjavík, Iceland, from June 18–21, 2018, this conference is jointly organized by the IEEE Singapore Control Systems Chapter, the IEEE Iceland Section, and the Hong Kong Centre for Logistics Robotics. It is technically co-sponsored by IEEE Control Systems Society and the University of Iceland. Our aim with this event is to provide a dynamic platform for scientists and engineers worldwide to share their latest research findings and ideas in the domains of control and automation.

Reykjavík, renowned as the earth's northernmost sovereign capital and coastal city, offers a captivating blend of culture, history, and natural beauty. As our host city, it promises to provide an unforgettable backdrop for our conference activities, with its vibrant atmosphere and proximity to iconic attractions such as the Golden Circle Iceland tour.

This year's conference boasts an enriching program featuring 28 technical sessions, including 8 invited sessions, 4 keynote speeches, and a plenary panel session delivered by distinguished experts in the field. Additionally, we are excited to showcase two special sessions dedicated to the Best Paper Award and the Best Student Paper Award, with 6 finalists identified for each category. The winners will be revealed during the conference banquet, adding an element of anticipation to our gathering.

IEEE ICCA 2024 represents yet another significant milestone in the evolution of our conference series. Over the years, it has traversed borders, being hosted in diverse locales such as South Africa, Canada, Hungary, USA, Italy, Scotland and more, steadily growing into a pivotal international event in the realms of systems, control, and automation. This year, we received 212 submissions from academic researchers and engineers spanning 25 countries and regions worldwide. Following a rigorous review process by our esteemed program committee and reviewers, we are proud to include 165 high-quality manuscripts in our final technical program and conference proceedings.

We extend our heartfelt gratitude to all members of the organizing committee and the program committee as well as the reviewers for their unwavering dedication and tireless efforts over the past few months. Their commitment has been instrumental in bringing this conference to fruition and ensuring its success. We are deeply appreciative of their contributions.

Last but certainly not least, we extend our sincere thanks to all our esteemed delegates for their keen interest, valuable contributions, and active participation in IEEE ICCA 2024. It is our earnest hope that this conference proves to be both intellectually stimulating and enjoyable for all attendees. We eagerly anticipate your continued support in future editions of IEEE ICCA.

Wishing you all a truly memorable and enriching experience in Reykjavík!


Ben M. Chen, Lihua Xie
General Chairs
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Hai Lin, Oleg Yakimenko
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General Conference Information

The 18th IEEE International Conference on Control & Automation (IEEE ICCA 2024) will be held in face-to-face mode Tuesday through Friday, June 18-21, 2024, in Reykjavík, Iceland. The conference is organized by IEEE Control Systems Society, Singapore Chapter, IEEE Control Systems Society, Iceland Section, Hong Kong Centre for Logistics Robotics (HKCLR), and technicaly sponsored by IEEE Control Systems Society and University of Iceland. It aims to create a forum for scientists and practicing engineers throughout the world to present the latest research findings and ideas in the areas of control and automation, and possible contributions toward sustainable development and environment preservation.

Language

The official language of the conference is English.

Registration Fees

Registration Categories	Early Registration (by April 25)	Late Registration (after April 25)	Paper Uploads with registration	Banquet	Lunches	Receptions
Full Registration, IEEE Member	SG$1,200	SG$1,500	Two (2)	Included	Included	Included
Full Registration, Nonmember	SG$1,300	SG$1,600	Two (2)	Included	Included	Included
Reduced Registration, Student	SG$600	SG$750	One (1)	Not Included	Included	Included
Reduced Registration, Retiree	SG$600	SG$750	One (1)	Not Included	Included	Included
Reduced Registration, IEEE Life Member	SG$600	SG$750	One (1)	Not Included	Included	Included

A conference registration covers admission to all technical sessions, welcome reception, coffee/tea breaks, lunches, conference dinner and conference banquet (except Student). It also includes one Program Book and one Conference Proceedings (USB) and all taxes.

Onsite Registration Hours (in Reykjavík, Iceland) and Location

Date: June 18, 2024 (Tuesday)
Time: 17:00–20:00

Venue: City Hall of Reykjavík

Date: June 19–20, 2024 (Wednesday and Thursday)
Time: 08:30–17:30

Date: June 21, 2024 (Friday)
Time: 08:30-12:00

Venue: Háskólatorg / University Centre, University of Iceland

Welcome Reception

Date: June 18, 2024 (Tuesday)
Time: 18:00–20:00
Venue: Reykjavik City Hall

Welcome Address
Date: June 19, 2024 (Wednesday)
Time: 08:30–08:45
Venue: H102, Háskólatorg / University Centre, University of Iceland

Keynote Speech

Date: June 19, 2024 (Wednesday)
Time: 08:45–14:30
Venue: H102, Háskólatorg / University Centre, University of Iceland

Plenary Panel Session

Date: June 20, 2024 (Thursday)
Time: 16:00–17:30
Venue: H102, Háskólatorg / University Centre, University of Iceland

Conference Banquet

Date: June 20, 2024 (Thursday)
Time: 19:00–22:30
Venue: Harpa (Reykjavik Concert Hall and Conference Centre) Hall: Norðurljós

Conference Lunches

Date: June 19–20, 2024
Time: 12:15–13:30 (Wednesday), 12:00-14:00 (Thursday)

Conference Tea Breaks

Date: June 19, 2024 (Wednesday)
Time: 9:45–10:15, 14:30–14;45, 16:15–16:30

Date: June 20, 2024 (Thursday)
Time: 10:00–10:30, 15:30–16:00

Date: June 21, 2024 (Friday)
Time: 10:00–10:30

Technical Sessions

Date: June 19–21, 2024 (Wednesday to Friday)
Time: 14:45–18:00 (Wednesday), 08:30–15:30 (Thursday), 08:30–12:00 (Friday)
Rooms: H101, H102, H103, H104, Háskólatorg / University Centre, University of Iceland

Program at a Glance

ICCA 2024 Technical Program on Wednesday, June 19, 2024

ICCA 2024 Technical Program Wednesday June 19, 2024			
Track T1	Track T2	Track T3	Track T4
08:30-08:45 H102 Keynote Session WeWT8 *Welcome Address*			
08:45-09:45 H102 Keynote Session WeP1T5 *Keynote Speech 1: Advancing Geoscience through Large-Scale AI and Remote Sensing with Supercomputing*			
10:15-11:15 H102 Keynote Session WeP2T6 *Keynote Speech 2: Vision-Based Control of UAV for 3D Scene Exploration and Reconstruction*			
11:15-12:15 H102 Keynote Session WeP3T7 *Keynote Speech 3: Distributed Model Predictive Control Framework for Multi-Agent Systems: Design and Applications*			
13:30-14:30 Room T9 Keynote Session WeP4T9 *Keynote Speech 4: Distributed Optimization for Addressing Emerging Challenges in the Energy Sector*			
14:45-16:15 H102 Regular Session WeAT1 *Best Paper Finalists Session*	14:45-16:15 H101 Regular Session WeAT2 *Adaptive Control*	14:45-16:15 H103 Regular Session WeAT3 *Nonlinear Systems and Control*	14:45-16:15 H104 Regular Session WeAT4 *Control Applications*
16:30-18:00 H102 Regular Session WeBT1 *Best Student Paper Finalists Session*	16:30-18:00 H101 Regular Session WeBT2 *Optimal and Learning-Based Control*	16:30-18:00 H103 Regular Session WeBT3 *Networked Control*	16:30-18:00 H104 Regular Session WeBT4 *Control Applications (II)*

ICCA 2024 Technical Program on Thursday, June 20, 2024

ICCA 2024 Technical Program Thursday June 20, 2024			
Track T1	Track T2	Track T3	Track T4
08:30-10:00 H102 Invited Session ThAT1 *Cooperative Control and Optimization for Multi-Agent Systems*	08:30-10:00 H101 Regular Session ThAT2 *Intelligent and AI Based Control*	08:30-10:00 H103 Regular Session ThAT3 *Robotics*	08:30-10:00 H104 Invited Session ThAT4 *Advanced Control and Applications*
10:30-12:00 H102 Invited Session ThBT1 *Resilient Cooperative Control and Optimization of Multi-Agent Systems*	10:30-12:00 H101 Regular Session ThBT2 *Learning Systems*	10:30-12:00 H103 Regular Session ThBT3 *Robotics (II)*	10:30-12:00 H104 Regular Session ThBT4 *Fault Detection and Diagnostics*
14:00-15:30 H102 Invited Session ThCT1 *Distributed Optimization for Networked Systems*	14:00-15:30 H101 Regular Session ThCT2 *Learning-Based Control*	14:00-15:30 H103 Regular Session ThCT3 *Robotics (III)*	14:00-15:30 H104 Invited Session ThCT4 *Unmanned System Based Sensing*
16:00-17:30 H102 Plenary Session ThDT5 *Plenary Panel Discussion*			

❖ **The Conference Banquet will be held at Harpa Concert Hall at 19:00 on Thursday, June 20, 2024.**

ICCA 2024 Technical Program on Friday, June 21, 2024

ICCA 2024 Technical Program Friday June 21, 2024			
Track T1	Track T2	Track T3	Track T4
08:30-10:00 H102 Regular Session FrAT1 *Automated Guided Vehicles*	08:30-10:00 H101 Regular Session FrAT2 *Cooperative Control Systems*	08:30-10:00 H103 Regular Session FrAT3 *Multi-Agent Systems*	08:30-10:00 H104 Invited Session FrAT4 *Modeling, Control and Estimation in Unmanned Aircraft Systems*
10:30-12:00 H102 Invited Session FrBT1 *Intelligent Optimization and Control of Robotic Systems*	10:30-12:00 H101 Regular Session FrBT2 *Estimation and Identification*	10:30-12:00 H103 Regular Session FrBT3 *Multi-Agent Systems (II)*	10:30-12:00 H104 Invited Session FrBT4 *New Trends in Intelligent Unmanned Systems*

Keynote Addresses

Advancing Geoscience through Large-Scale AI and Remote Sensing with Supercomputing

Professor Jón Atli Benediktsson (with Gabriele Cavallaro)
Fellow of IEEE
President and Rector of the University of Iceland, Iceland

Time: 08:45–09:45, June 19, 2024
Venue: H102, Háskólatorg / University Centre, University of Iceland

Chair: Professor Lihua Xie, Nanyang Technological University

Abstract: The rapid proliferation of data in the new information era has increased the complexity of data-driven problems across various fields of science and engineering. This development has led to a paradigm shift in AI, moving towards unsupervised and self-supervised representation learning, as well as multimodal learning. Significant advancements have emerged not only in mainstream Natural Language Processing and Computer Vision but also in Earth observation applications. These advancements exploit the synergies between self-supervised learning and the expanded availability of High-Performance Computing (HPC) systems, resulting in the emergence of AI Foundation Models (FMs). Originating from the concept of building upon an existing 'foundation', these models are developed by training on large and diverse datasets. This training enables them to capture a broad spectrum of informative features, making them extremely versatile and applicable across multiple domains. This keynote will provide an overview of the current efforts toward FMs for Earth observation at the 'Remote Sensing Simulation and Data Lab' of the Icelandic HPC community (University of Iceland), which collaborates closely with the Jülich Supercomputing Centre at the Forschungszentrum Jülich in Germany. The presentation will highlight the necessary tools and efforts required for the development of FMs, showcasing interdisciplinary research that intersects AI, supercomputing, and remote sensing applications. This research aims to enhance our understanding of complex Earth processes and advance the development of Digital Twins of Earth.

Professor Jón Atli Benediktsson received the Cand. Sci. degree in electrical engineering from the University of Iceland, Reykjavik, in 1984, and the M.S.E.E. and Ph.D. degrees in electrical engineering from Purdue University, West Lafayette, IN, USA, in 1987 and 1990, respectively. Currently, he is the President and Rector of the University of Iceland where he is Professor of Electrical and Computer Engineering. His research interests are in image analysis, image processing, remote sensing and biomedical analysis of signals. He has published extensively in those fields. Professor Benediktsson is a Highly Cited Researcher from 2018 (Clarivate Analysis) and received many awards for his research and publications. He was the 2011–2012 President of the IEEE Geoscience and Remote Sensing Society and Editor-in-Chief of the IEEE Transactions on Geoscience and Remote Sensing from 2003 to 2008. Professor Benediktsson, is currently Senior Editor of the Proceedings of the IEEE. He is a co-founder of the biomedical start-up company Oxymap (www.oxymap.com). Prof. Benediktsson is a Fellow of the IEEE, Fellow of SPIE and Fellow of AAIA. He is a member of Academia Europea, Sigma Xi and Tau Beta Pi.

Vision-based Control of UAV for 3D Scene Exploration and Reconstruction

Professor Chang-Wen Chen
Fellow of IEEE
The Hong Kong Polytechnic University, Hong Kong, China

Time: 10:15–11:15, June 19, 2024
Venue: H102, Háskólatorg / University Centre, University of Iceland

Chairs: Professor Hai Lin, University of Notre Dame

Abstract: This talk shall focus on recent research endeavors in the vision-based control of UAVs for 3D scene exploration and reconstruction in the spirit of object goal navigation. More specifically, this talk shall introduce a hierarchical semantic understanding approach to UAV-based exploration and 3D scene reconstruction for time-critical disaster search and rescue in an urban setting. In particular, a UAV-based geometric and semantic perception of the 3D scene is accomplished via onboard visual sensors which will be followed by a rescue task-specific semantic understanding algorithm to obtain a 3D scene graph indicating potential trapped subjects and their environments. The control of UAVs is achieved by an integrated visual servoing scheme to execute its flying missions to acquire the best new images for 3D reconstruction while flying over the scene. A graphics-based simulation platform is constructed to model disaster-stricken scenes in layered 3D structures consisting of trapped human subjects, destructed structures, and flying UAVs. Two task-specific algorithmic assessment models are also developed to evaluate the performance of the overall system. We shall also show the potential of incorporating AI generative diffusion techniques into action generation for UAVs to navigate over unknown 3D scenes.

Professor Chang Wen Chen is currently Chair Professor of Visual Computing at The Hong Kong Polytechnic University. Before his current position, he served as Dean of the School of Science and Engineering at The Chinese University of Hong Kong, Shenzhen from 2017 to 2020, and concurrently as Deputy Director at Peng Cheng Laboratory from 2018 to 2021. Previously, he has been an Empire Innovation Professor at the State University of New York at Buffalo (SUNY) from 2008 to 2021 and the Allan Henry Endowed Chair Professor at the Florida Institute of Technology from 2003 to 2007. He received his BS degree from the University of Science and Technology of China in 1983, his MS degree from the University of Southern California in 1986, and his PhD degree from the University of Illinois at Urbana Champaign (UIUC) in 1992. He has served as an Editor-in-Chief for IEEE Trans. Multimedia (2014-2016) and IEEE Trans. Circuits and Systems for Video Technology (2006-2009). He has received many professional achievement awards, including ten (10) Best Paper Awards or Best Student Paper Awards in premier publication venues, the prestigious Alexander von Humboldt Award in 2010, the SUNY Chancellor's Award for Excellence in Scholarship and Creative Activities in 2016, and UIUC ECE Distinguished Alumni Award in 2019. He is an IEEE Fellow (2005), a SPIE Fellow (2007), and a Member of Academia Europaea (2021).

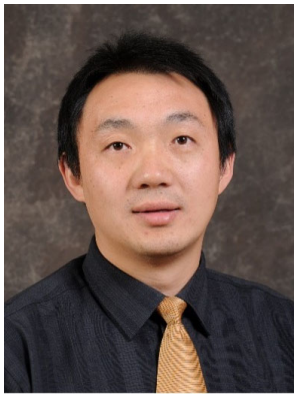
Distributed Model Predictive Control Framework for Multi-Agent Systems: Design and Applications

Professor Yang Shi
Fellow of IEEE
University of Victoria, Victoria, BC, Canada

Time: 11:15–12:15, June 19, 2024
Venue: H102, Háskólatorg / University Centre, University of Iceland

Chairs: Professor Oleg A. Yakimenko, Naval Postgraduate School

Abstract: The past decade has witnessed a phenomenal interest in developing distributed model predictive control (MPC) methods for a team of cooperative agents, e.g., a fleet of autonomous vehicles. Compared to centralized MPC, distributed MPC essentially assigns the computational load to multiple sub-controllers that are ''connected'' together and can share information via networks, thus fulfilling the real-time requirement of the overall large-scale control system. In this talk, firstly, several new design techniques of the distributed MPC design will be presented: robustness enhancement, compensation for network-induced constraints, event-triggered design. Secondly, the application of distributed MPC to autonomous underwater vehicles (AUV-s), unmanned aerial vehicles (UAV-s) will be introduced. Some of the implementation issues will be addressed. Lastly, some conclusions and comments on future research will be presented.



Professor Yang Shi received his B.Sc. and Ph.D. degrees in mechanical engineering and automatic control from Northwestern Polytechnical University, Xi'an, China, in 1994 and 1998, respectively, and the Ph.D. degree in electrical and computer engineering from the University of Alberta, Edmonton, AB, Canada, in 2005. Currently, he is a Professor in the Department of Mechanical Engineering, University of Victoria, Victoria, BC, Canada. His current research interests include networked and distributed systems, model predictive control (MPC), cyber-physical systems (CPS), robotics and mechatronics, navigation and control of autonomous systems (AUV and UAV), and energy system applications. Dr. Shi received the University of Saskatchewan Student Union Teaching Excellence Award in 2007, the Faculty of Engineering Teaching Excellence Award in 2012 at the University of Victoria (UVic), the 2023 REACH Award for Excellence in Graduate Student Supervision and Mentorship. He is the recipient of the JSPS Invitation Fellowship (short-term) in 2013, the UVic Craigdarroch Silver Medal for Excellence in Research in 2015, the 2017 IEEE Transactions on Fuzzy Systems Outstanding Paper Award, the Humboldt Research Fellowship for Experienced Researchers in 2018; CSME Mechatronics Medal (2023); IEEE Dr.-Ing. Eugene Mittelmann Achievement Award (2023). He is an IFAC Council Member; Vice President of IEEE IES, and the Chair of IEEE IES Technical Committee on Industrial Cyber-Physical Systems (2018-2022). Currently, he was Co-Editor-in-Chief of IEEE Transactions on Industrial Electronics (2017-2023); he also serves as Associate Editor for Automatica, IEEE Transactions on Automatic Control, Annual Review in Controls, etc. He is a Distinguished Lecturer of IES. He is a Fellow of IEEE, ASME, CSME, Engineering Institute of Canada (EIC), Canadian Academy of Engineering (CAE), and a registered Professional Engineer in British Columbia, Canada.

Distributed Optimization for Addressing Emerging Challenges in the Energy Sector

Professor Maria Prandini
Fellow of IEEE
Politecnico di Milano, Italy

Time: 13:30–14:30, June 19, 2024
Venue: H102, Háskólatorg / University Centre, University of Iceland

Chairs: Professor Ben M. Chen, Chinese University of Hong Kong

Abstract: The integration of renewable energy sources in the electrical grid is challenging its operators and calling for a direct involvement of prosumers to maintain a balance between energy demand and generation. In this talk, we shall illustrate recent results in distributed optimization and show their potential for impact in balancing services provision by aggregates of prosumers, addressing both privacy and scalability issues.

Professor Maria Prandini is a Full Professor and Chair of the Automation and Control Engineering Study Program at Politecnico di Milano, Italy. She received her Ph.D. degree from the University of Brescia, Italy, in 1998. She held visiting positions at Delft University of Technology (1998), Cambridge University (2000), UC Berkeley (1998-200, 2005), ETH Zurich (2006), TUM (2017), and University of Oxford (2022-25). Her research interests include stochastic hybrid systems, randomized algorithms, distributed and data-driven optimization, multi-agent systems, and the application of control theory to transportation and energy systems. She is currently IFAC President-elect. Previously, she served as Vice-President for IFAC and IEEE CSS, and as a member of SIGBED Board of Directors. She is IEEE CSS Distinguished Member and a Fellow of IEEE.

Plenary Panel Session

Trends and Opportunities in Control and Automation

Time: 16:00–17:30pm, June 20, 2024
Venue: H102, Háskólatorg / University Centre, University of Iceland

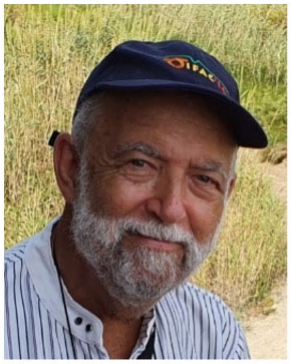
Panelists: Professor Pedro Albertos, Universitat Politècnica de València, Spain
Professor Wen-Hua Chen, Loughborough University, UK
Professor Jie Huang, The Chinese University of Hong Kong, China
Professor Hong Wang, Oak Ridge National Laboratory, USA

Chairs: Professor Wei Kang, Naval Postgraudate School
Professor Ben M. Chen, Chinese University of Hong Kong

The theme of this year's IEEE ICCA plenary session revolves around the Trends and Opportunities in Control and Automation. We are privileged to have four distinguished experts and educators in this field join our panel, where they will share their expertise, insights, and visions. Together, we will delve into the challenges facing research in control and automation, both current and emerging. Through direct dialogue with these esteemed panelists, our goal is to gain a deeper understanding of fundamental issues and emerging trends in the field.

Furthermore, this panel will serve as a platform for exchanging ideas and engaging in discussions on broader topics in control and automation. It also provides an invaluable opportunity for the audience, especially students and junior researchers, to glean insights from senior members of our community on challenges commonly encountered in the early stages of our careers or studies.

We introduce our panelists in the alphabetic order as follows.



Professor Pedro Albertos is an Emeritus Professor in Department of Systems Engineering and Control, Universitat Politècnica de València, Spain. He is Doctor Honoris-Causa from Oulu University, Finland and Bucharest Polytechnic, Rumania, Honorary Professor at North-Eastern University, Shenyang, China. Invited professors in more than 20 Universities, he delivered seminars in more than 30 universities and research centres and more than 25 Plenary talks at IFAC/IEEE conferences. Authored over 300 papers, book chapters and congress communications, co-editor of 7 books and co-author of Multivariable Control Systems (Springer 2004), Feedback and Control for Everyone (Springer 2010), which received the Harold Chesnut Best Textbook Award at the IFAC World Congress in Toulouse in 2017, and Linear Algebra Control (Springer 2020). His research areas include embedded control systems, time delays systems and control applications. He is a "Prometeo" researcher in Spain and Ecuador, and was Associated editor of Control Engineering Practice, Automatica and Editor-in-Chief of the Spanish journal RIAI.

Being IFAC President (1999-2002), he organized the XV IFAC World Congress, Barcelona, Spain. He is IEEE Life Senior Member and IFAC Fellow.

Professor Wen-Hua Chen holds Professor in Autonomous Vehicles in the Department of Aeronautical and Automotive Engineering at Loughborough University, UK. Professor Chen has a considerable experience in control, signal processing and artificial intelligence and their applications in aerospace and automotive engineering. In the last 20 years, he has been working on the development and application of unmanned aircraft system and intelligent vehicle technologies, spanning autopilots, situational awareness, decision making and verification. His specific research in autonomous vehicles include personalized smart vehicles, situational awareness in dynamic traffic environments, and decision making for autonomous emergency braking.

Professor Chen is a Chartered Engineer, and a Fellow of IEEE, the Institution of Mechanical Engineers and the Institution of Engineering and Technology, UK. Recently Prof Chen was awarded a 5 years EPSRC (the Engineering and Physical Sciences Research Council) Established Career Fellowship in developing goal-oriented control systems for robotics and autonomous systems.

Professor Jie Huang is currently the Choh-Ming Li Research Professor of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Hong Kong, China. Prof. Huang is a fellow of IEEE, IFAC, Chinese Association of Automation, and Hong Kong Institution of Engineers. He received the State Natural Science Award, Class II in 2011 for the project titled “The Nonlinear Output Regulation Problem and Internal Model Principle”. He is an editor of the International Journal of Robust and Nonlinear Control, is editor-at-large of the Communications in Information and Systems, and a member of advisory board of Transactions of the Institute of Measurement and Control. He also served as an associate editor of the Asian Journal of Control from 1999 to 2001 and held the same position at the IEEE, at its Transactions on Automatic Control. He delivered plenary/keynote speeches in numerous international conferences.

The current research interests of Prof. Huang include nonlinear control theory and applications, multiagent systems, and flight guidance and control. The talk is about his recent work with his colleagues on the design of a class of adaptive distributed observers for the cooperative output regulation problem.

Professor Hong Wang, Fellow of IET, IEEE, InstMC and AAIA, received his BSc, MS and PhD from Huainan Mining Institute and Huazhong University of Science and Technology, China, in 1982, 1984 and 1987, respectively. He was a research fellow at Salford, Brunel, and Southampton Universities before joining the University of Manchester Institute of Science and Technology (UMIST), UK, in 1992. Wang was a chair professor in process control since 2002 and is now a professor emeritus with the University of Manchester, and he was the deputy head of the Paper Science Department and director of the UMIST Control Systems Centre between 2004 and 2007. He was a member of the University Senate and General Assembly. Between 2016 and 2018, he was with Pacific Northwest National Laboratory as a lab fellow and chief scientist and was the co-leader for the Control of Complex Systems. He joined Oak Ridge National Laboratory in January 2019 as senior distinguished scientist.

Professor Wang was an associate editor for IEEE Transactions on Automatic Control, IEEE Transactions on Control Systems Technology, and IEEE Transactions on Automation Science and Engineering. He currently serves on the editorial board of IEEE Transactions on Neural Networks and Learning Systems. He is also a member of three IFAC committees. Professor Wang's research focuses on stochastic distribution control, fault diagnosis and tolerant control, and uncertain systems optimization with applications to transportation, power grid and industrial systems. In these areas he has published over 200 journal papers and 6 books.

Best Paper Award Finalists

1. **Resilient Adaptively Distributed Nash Equilibrium Seeking against Unknown False Data Injection Attacks in Noncooperative Games**

   Zhi Feng, Beihang University
   Xiwang Dong, Beihang University
   Guoqiang Hu, Nanyang Technological University
   Jinhu Lu, Academy of Mathematics and Systems Science, Chinese Academy of Sciences

2. **Distributed Nash Equilibrium Seeking with Communication Delays**

   Lupeng Liu, Beijing Institute of Technology
   Maobin Lu, Beijing Institute of Technology
   Fang Deng, Beijing Institute of Technology
   Lihua Dou, Beijing Institute of Technology
   Jie Chen, Tongji University

3. **Continuous-Time Damping-Based Mirror Descent for a Class of Non-Convex Multi-Player Games with Coupling Constraints**

   Guanpu Chen, KTH Royal Institute of Technology
   Kun Cao, Nanyang Technological University
   Karl H. Johansson, KTH Royal Institute of Technology
   Yiguang Hong, Chinese Academy of Sciences

4. **Anomaly Detection for Stochastic Networked Cyber-Physical Systems: A Statistical Approach**

   Yamin Yan, Nanyang Technological University
   Minyue Fu, Southern University of Science and Technology
   Maria M. Seron, The University of Newcastle

5. **Intuitive Teleoperation Control for Flexible Robotic Endoscopes under Unknown Environmental Interferences**

   Wei Chen, The Chinese University of Hong Kong
   Yiang Lu, The Chinese University of Hong Kong
   Bin Li, The Chinese University of Hong Kong
   Jianshu Zhou, The Chinese University of Hong Kong
   Hanwen Cao, The Chinese University of Hong Kong
   Fei Chen, The Chinese University of Hong Kong
   Yunhui Liu, The Chinese University of Hong Kong

6. **Online Cooperative Optimal Power Scheduling of Multiple Microgrids Via Hierarchical Imitation Learning**

   Yunyi Zhao, National University of Singapore
   Shuhua Gao, Shandong University
   Jing Wang, Shandong University
   Congcong Li, State Grid Shandong Electric Power Company
   Ming Yu, Nanyang Technological University
   Cheng Xiang, National University of Singapore

Best Student Paper Award Finalists

1. **Adaptive Multi-Core Real-Time Scheduling Based on Reinforcement Learning**

   Yonghui Liang, Shanghai Jiaotong University
   Hui Li, Shanghai Jiao Tong University
   Fei Shen, Shanghai Institute of Microsystem and Information Technology
   Qimin Xu, Shanghai Jiao Tong University
   Shuna Hua, North Information Control Research Academy Group Co. Ltd
   Shanying Zhu, Shanghai Jiao Tong University

2. **TRACE: Trajectory Refinement with Control Error Enables Safe and Accurate Maneuvers**

   Zihan Yang, Beihang University
   Jindou Jia, Beihang University
   Yuhang Liu, Beihang University
   Kexin Guo, Beihang University
   Xiang Yu, Beihang University

3. **NARX Model-Based Data-Driven Secure Control for UMVs under Asynchronous DoS Attacks**

   Huiying Liu, Dalian Maritime University
   Liying Hao, Dalian Maritime University
   Hui Li, Dalian Maritime University
   Tieshan Li, Dalian Maritime University
   Dan Wang, Dalian Maritime University

4. **Cooperative Source Seeking for Uncertain Networked Euler–Lagrange Systems Over Unbalanced Digraphs**

   Lu Wang, City University of Hong Kong
   Lu Liu, City University of Hong Kong

5. **Online Distributed Newton Step Algorithm for Multi-Agent Optimization Over General Unbalanced Networks**

   Jiayi Wu, Hangzhou Dianzi University
   Yu-Ping Tian, Southern University of Science and Technology

6. **Safe Stabilization with Model Uncertainties: A Universal Formula with Gaussian Process Learning**

   Ming Li, Eindhoven University of Technology
   Zhiyong Sun, Eindhoven University of Technology

Technical Program

Technical Program for Wednesday June 19, 2024

WeAT1	H102
Best Paper Finalists Session	Regular Session
Chair: Lin, Zongli	University of Virginia
Co-Chair: Shi, Yang	Canada
14:45-15:00, Paper WeAT1.1	
Resilient Adaptively Distributed Nash Equilibrium Seeking against Unknown False Data Injection Attacks in Noncooperative Games (I)	
Feng, Zhi	
Dong, Xiwang	Beihang University
Hu, Guoqiang	Nanyang Technological University
Lu, Jinhu	Academy of Mathematics and Systems Science, ChineseAcademyof Sci
15:00-15:15, Paper WeAT1.2	
Distributed Nash Equilibrium Seeking with Communication Delays (I)	
Liu, Lupeng	Beijing Institute of Technology
Lu, Maobin	
Deng, Fang	
Dou, Lihua	Beijing Institute of Technology
Chen, Jie	Tongji University
15:15-15:30, Paper WeAT1.3	
Continuous-Time Damping-Based Mirror Descent for a Class of Non-Convex Multi-Player Games with Coupling Constraints (I)	
Chen, Guanpu	
Cao, Kun	
Johansson, Karl H.	KTH Royal Institute of Technology
Hong, Yiguang	
15:30-15:45, Paper WeAT1.4	
Anomaly Detection for Stochastic Networked Cyber-Physical Systems: A Statistical Approach	
Yan, Yamin	NTU
Fu, Minyue	University of Newcastle
Seron, Maria M.	
15:45-16:00, Paper WeAT1.5	
Intuitive Teleoperation Control for Flexible Robotic Endoscopes under Unkonwn Environmental Interferences	
Chen, Wei	
Lu, Yiang	The Chinese University of Hong Kong
Li, Bin	The Chinese University of Hong Kong
Zhou, Jianshu	Chinese University of Hong Kong
Cao, Hanwen	
Chen, Fei	
Liu, Yunhui	Chinese University of Hong Kong
16:00-16:15, Paper WeAT1.6	
Online Cooperative Optimal Power Scheduling of Multiple Microgrids Via Hierarchical Imitation Learning	
Zhao, Yunyi	National University of Singapore
Gao, Shuhua	Shandong University
Wang, Jing	Shandong University
Li, Congcong	State Grid Shandong Electric Power Company Marketing Service Cen
Yu, Ming	Nanyang Technological University
Xiang, Cheng	National University of Singapore

WeAT2	H101
Adaptive Control	Regular Session
Chair: Zhang, Yuxiang	Natioanl University of Singapore
Co-Chair: Turkay, Semiha	Eskisehir Technical University
14:45-15:00, Paper WeAT2.1	
Adaptive Model-Free Sliding Mode Control with Forgetting Factor for Stratospheric Airship	
Sun, Yang	Beihang University
Zhu, Ming	Beihang University
Zhang, Yifei	Beihang University
Chen, Tian	Beihang University
Zheng, Zewei	Beihang University
Luo, Xinting	Beihang University
15:00-15:15, Paper WeAT2.2	
Model Predictive Control of Superbuck Converter Based on Digital Triplet	

Xia, Qian	Tongji University
Zhu, Peng	Tongji University
Cui, Zhexin	Tongji University
Yue, Jiguang	Tongji University
Wu, Chenhao	Tongji University

15:15-15:30, Paper WeAT2.3	
Symbolic Regression Data-Model-Informed Eco-Control for Maritime Carbon Emissions Reduction	
Leng, Yunze	National University of Singapore
Zhang, Yuxiang	Natioanl University of Singapore
Liu, Jiahang	National University of Singapore
Ge, Shuzhi Sam	National Univ. of Singapore
How, Bernard Voon Ee	Singapore Institute of Technology

15:30-15:45, Paper WeAT2.4	
Disturbance Observer and Fault Estimator-Based Tracking Control of Wheeled Mobile Robot	
Wu, Hao	Huazhong University of Science and Technology
Wang, Shuting	Huazhong University of Science and Technology
Zhang, Hongyang	Huazhong University of Science and Technology
Zhang, Sai	Huazhong University of Science and Technology
Jin, Jian	Huazhong University of Science and Technology
Xie, Yuanlong	Huazhong University of Science and Technology

15:45-16:00, Paper WeAT2.5	
MIMO-SLS Identification from Input-Output Data	
Bencherki, Fethi	Lund University
Turkay, Semiha	Eskisehir Technical University
Akcay, Huseyin	Anadolu University

16:00-16:15, Paper WeAT2.6	
A Strong Tracking and Robust Kalman Filter	
Cong, Shuang	University of Sci. & Tech. of China
Song, Kangning	USTC

WeAT3	H103
Nonlinear Systems and Control	Regular Session
Chair: Xu, Xiang	Southern University of Science and Technology
Co-Chair: Iftar, Altug	Eskisehir Technical Univ

14:45-15:00, Paper WeAT3.1	
Controller Design Using Extension for Nonlinear Time-Varying Systems	
Iftar, Altug	Eskisehir Technical Univ
Turkay, Semiha	Eskisehir Technical University

15:00-15:15, Paper WeAT3.2	
Prescribed Time Attitude Tracking Control of Unmanned Aerial Vehicles under Unknown Attacks and Input Saturation	
Wang, Liping	South China University of Technology
Pei, Hai-Long	South China University of Technology

15:15-15:30, Paper WeAT3.3	
Observer-Driven Practical Stabilization of Switched Linear Autonomous Systems	
Wang, Miaomiao	AMSS, CAS
Sun, Zhendong	Shandong University of Science and Technology

15:30-15:45, Paper WeAT3.4	
Analysis and Control of Chaotic Behaviour in Buck-Boost Converters Based on the Caputo-Fabrizio Fractional Derivative	
Liao, Xiaozhong	Beijing Institute of Technology
Wang, Yong	Beijing Institute of Technology
Yu, Donghui	Beijing Institute of Technology

15:45-16:00, Paper WeAT3.5	
High-Precision Tracking Control of Modular Dielectric Elastomer Actuators through Kalman Filter Base Self-Adaptive Direct Inverse Hysteresis Compensation	
Xiao, Bohao	Shanghai Jiao Tong University
Gu, Guo-Ying	Shanghai Jiao Tong University
Zou, Jiang	Shanghai Jiao Tong University

16:00-16:15, Paper WeAT3.6	
Distributed Time-Varying Optimization with Equality Constraints	
Yang, Zheng	Xiamen University
Ma, Ji	City University of Hong Kong

Xu, Xiang	City University of Hong Kong

WeAT4	H104
Control Applications	Regular Session
Chair: Duan, Haibin	Beihang University
Co-Chair: Rodrigues, Luis	Concordia University
14:45-15:00, Paper WeAT4.1	
Unmanned Aircraft Path Planning Using Air Traffic Density	
Li, Steven	Concordia University
Chang, Josh	Carleton University
Chavda, Nishkarsh	Carleton University
Borshchova, Iryna	NRC
Laliberte, Jeremy	Carleton University
Rodrigues, Luis	Concordia University
15:00-15:15, Paper WeAT4.2	
Development and Implementation of a Wastewater-Treatement-Plant Model for Optimization Purposes	
Karer, Gorazd	University of Ljubljana
Vrecko, Darko	Department of Systems and Control, Jozef Stefan Institute
Hvala, Nadja	Jožef Stefan Institute, Jamova Cesta 39, 1000 Ljubljana
Skrjanc, Igor	University of Ljubljana
15:15-15:30, Paper WeAT4.3	
Fuzzy System-Based Enhanced Active Disturbance Rejection Control in Application to High Precision Tracking Systems with Disturbances and Measurement Noises	
Wang, Haolin	Institute of Optics and Electronics, Chinese Academy of Sciences
Mao, Yao	Chinese Academy of Sciences
Bao, Qiliang	Institute of Optics and Electronics, Chinese Academy of Sciences
Deng, Jiuqiang	Chinese Academy of Sciences
15:30-15:45, Paper WeAT4.4	
Prescribed Performance Evolution Control for VTOL UAVs Tracking a Moving Ship	
Yuan, Yang	Beihang University
Wei, Chen	Beijing University of Aeronautics and Astronautics
Duan, Haibin	Beihang University

15:45-16:00, Paper WeAT4.5	
Pseudo Youla-Kucera Parameterization for Nonminimum-Phase System: Application to Line-Of-Sight Stabilization	
Deng, Jiuqiang	Chinese Academy of Sciences
Duan, Qianwen	Institute of Optics and Electronics, Chinese Academy of Sciences
Bao, Qiliang	Institute of Optics and Electronics, Chinese Academy of Sciences
Mao, Yao	Chinese Academy of Sciences
16:00-16:15, Paper WeAT4.6	
Electromechanical Product Service Optimization in Cloud-Based Design: A Two-Stage Method for Task Allocation	
Tao, Wei	Tongji University
Cui, Zhexin	Tongji University
Yue, Jiguang	Tongji University
Wu, Chenhao	Tongji University

WeBT1	H102
Best Student Paper Finalists Session	Regular Session
Chair: Shi, Yang	Canada
Co-Chair: Lin, Zongli	University of Virginia
16:30-16:45, Paper WeBT1.1	
Adaptive Multi-Core Real-Time Scheduling Based on Reinforcement Learning	
Liang, Yonghui	Shanghai Jiaotong University
Li, Hui	Shanghai Jiao Tong University
Shen, Fei	Shanghai Institute of Microsystem and Information Technology, Ch
Xu, Qimin	Shanghai Jiao Tong University
Hua, Shuna	North Information Control Research Academy Group Co., Ltd
Zhu, Shanying	Shanghai Jiao Tong University
16:45-17:00, Paper WeBT1.2	
TRACE: Trajectory Refinement with Control Error Enables Safe and Accurate Maneuvers (I)	
Yang, Zihan	Beihang University
Jia, Jindou	Beihang University
Liu, Yuhang	Beihang University
Guo, Kexin	Beihang University

Yu, Xiang	Beihang University

17:00-17:15, Paper WeBT1.3	
NARX Model-Based Data-Driven Secure Control for UMVs under Asynchronous DoS Attacks	
Liu, Huiying	Dalian Maritime University
Hao, Liying	Dalian Maritime University
Li, Hui	Dalian Maritime University
Li, Tieshan	Dalian Maritime University
Wang, Dan	Dalian Maritime University

17:15-17:30, Paper WeBT1.4	
Cooperative Source Seeking for Uncertain Networked Euler–Lagrange Systems Over Unbalanced Digraphs	
Wang, Lu	City University of Hong Kong
Liu, Lu	City University of Hong Kong

17:30-17:45, Paper WeBT1.5	
Online Distributed Newton Step Algorithm for Multi-Agent Optimization Over General Unbalanced Networks	
Wu, Jiayi	Hangzhou Dianzi University
Tian, Yu-Ping	Southern University of Science and Technology

17:45-18:00, Paper WeBT1.6	
Safe Stabilization with Model Uncertainties: A Universal Formula with Gaussian Process Learning (I)	
Li, Ming	Eindhoven University of Technology
Sun, Zhiyong	Eindhoven University of Technology

WeBT2	H101
Optimal and Learning-Based Control	Regular Session
Chair: Li, Yuzhe	Northeastern University, China
Co-Chair: Fu, Minyue	Southern University of Science and Technology

16:30-16:45, Paper WeBT2.1	
Decentralized Optimal Control for Linear Stochastic Systems with Control Signals Subject to Unknown Noises	
Zhang, Zhaorong	University of Newcastle
Xu, Juanjuan	Shandong University
Fu, Minyue	Zhe Jiang University

Li, Xun	Hong Kong Polytechnic University

16:45-17:00, Paper WeBT2.2	
Neural-Network-Based Optimal Guidance for Lunar Vertical Landing	
Wang, Kun	Zhejiang University
Chen, Zheng	Zhejiang University
Lu, Fangmin	Zhejiang University
Li, Jun	Zhejiang University

17:00-17:15, Paper WeBT2.3	
Learning-Based Optimal Guidance for Hypersonic Reentry Using a Barrier Function	
Ma, Haoran	Zhejiang University
Chen, Zheng	Zhejiang University
Wang, Kun	Zhejiang University

17:15-17:30, Paper WeBT2.4	
Learning-Based Optimal Entry Guidance with Path Constraints	
Lu, Fangmin	Zhejiang University
Chen, Zheng	Zhejiang University
Wang, Kun	Zhejiang University

17:30-17:45, Paper WeBT2.5	
Multi-Objective Derivative-Free Optimization Based on Hessian-Aware Gaussian Smoothing Method	
Chen, Ran	Northeastern University
Li, Yuzhe	Northeastern University, China
Chai, Tianyou	Northeastern University

17:45-18:00, Paper WeBT2.6	
Practical Prescribed-Time Edge-Based Fully-Distributed Nash Equilibrium Seeking Based on Time Base Generator	
Chen, Yiyang	Beihang University
Hua, Yongzhao	Beihang University
Feng, Zhi	Beihang University
Dong, Xiwang	Beihang University

WeBT3	H103
Networked Control	Regular Session
Chair: Zhu, Bing	Beihang University

16:30-16:45, Paper WeBT3.1	

Game-Theoretic Demand-Side Management and Robust Optimal Control for a Class of Networked Smart Grid	
He, Yuxuan	Beihang University
Zhu, Bing	Beihang University
16:45-17:00, Paper WeBT3.2	
Deep Reinforcement Learning-Based Behaviour Generation Algorithm for Air Combat Escape Intention	
Wang, Xingyu	Nothwestern Polytechnical University
Yang, Zhen	Nothwestern Polytechnical University
Li, Xiaoyang	Nothwestern Polytechnical University
Chai, Shiyuan	Nothwestern Polytechnical University
He, Yupeng	Nothwestern Polytechnical University
Zhou, Deyun	Nothwestern Polytechnical University
17:00-17:15, Paper WeBT3.3	
Dynamic Event-Triggered Prescribed Performance Control for Quadrotor Aggressive Flight	
Wu, Zeliang	Beijing Institute of Technology
Song, Tao	Beijing Institute of Technology
Ye, Jianchuan	Tsinghua University
17:15-17:30, Paper WeBT3.4	
Performance-Guaranteed Multi-Train Cooperative Control Using Event-Triggered and Sign-Rectified Regressor	
Zheng, Yue	Beijing Jiaotong University
Gao, Shigen	Beijing Jiaotong University
Zhang, Zixuan	Beijing Jiaotong University
Song, Xiying	Beijing Jiaotong University
Dong, Hairong	Beijing Jiaotong University
17:30-17:45, Paper WeBT3.5	
Robust Data-Driven Control against Actuator FDI for Unknown Linear Systems	
Liu, Wenjie	Beijing Institute of Technology, Beijing, China
Sun, Jian	Beijing Institute of Technology
Deng, Fang	Beijing Institute of Technology
Wang, Gang	Beijing Institute of Technology
Chen, Jie	Tongji University

17:45-18:00, Paper WeBT3.6	
A Segmented Sliding Window-Based Comprehensive Periodic Feature Extraction Method for APT Classification	
Song, Wei	Southeast University
Wu, Tiejun	Southeast University
Zhang, Ya	Southeast University
WeBT4	H104
Control Applications (II)	Regular Session
Chair: Yakimenko, Oleg A.	Naval Postgraduate School
Co-Chair: Skrjanc, Igor	University of Ljubljana
16:30-16:45, Paper WeBT4.1	
Optimization Based MPC Concept for Plate Heat Exchanger Plant	
Vegelj, Aleksander	University of Ljubljana
Skrjanc, Igor	University of Ljubljana
16:45-17:00, Paper WeBT4.2	
Skyhook Controller Design for the Lateral and Vertical Suspension of a Railway Trailer	
Leblebici, Asli Soyic	Osmangazi University
Turkay, Semiha	Eskisehir Technical University
17:00-17:15, Paper WeBT4.3	
Robust Adaptive Finite-Time Attitude Tracking with an Unknown Inertia Matrix and Disturbance	
Garanayak, Chinmay	IIT Bombay
17:15-17:30, Paper WeBT4.4	
A Non-Singular Terminal Sliding Mode Control Approach for a 7 Degree-Of-Freedom Hydraulic Manipulator	
Shanahan, Declan	Lancaster University
Montazeri, Allahyar	Lancaster University
17:30-17:45, Paper WeBT4.5	
Traffic Signal Control for Large-Scale Urban Traffic Networks: Real-World Experiments Using Vision-Based Sensors	
Park, Jiho	New York University
Liu, Tong	New York University
Wang, Chieh	Oak Ridge National Laboratory
Wang, Hong	Oak Ridge National Laboratory

Wang, Qichao	National Renewable Energy Laboratory
Jiang, Zhong-Ping	New York University
17:45-18:00, Paper WeBT4.6	
Efficiency, Reliability, and Resilience of Diesel Generator Based Isolated Microgrids	
Yakimenko, Oleg A.	Naval Postgraduate School

ThAT1	H102
Cooperative Control and Optimization for Multi-Agent Systems	Invited Session
Chair: Fang, Hao	Beijing Institute of Technology
Organizer: Fang, Hao	Beijing Institute of Technology
08:30-08:45, Paper ThAT1.1	
A Coupling Algorithm for Task and Path Planning of Multi-UGVs under Environmental Inspiration (I)	
Xu, Bochen	Beijing Institute of Technology
Fang, Hao	Beijing Institute of Technology
Mao, Yuchen	Beijing Institute of Technology
Wei, Yujie	Beijing Institute of Technology
Yang, Qingkai	Beijing Institute of Technology
Zhou, Lei	Beijing Institute of Technology
Gao, Zhi	Wuhan University
08:45-09:00, Paper ThAT1.2	
Fine-Grained Cooperative Instruction Architecture for Heterogeneous Unmanned Swarms in Dynamic Task Scenarios (I)	
Bao, Kanghua	Southwest Computer Co., Ltd
Shi, Tao	Southwest Computer Co., Ltd
Yang, JunYi	Southwest Computer Co., Ltd
Zhang, Wei	Southwest Computer Co., Ltd
09:00-09:15, Paper ThAT1.3	
AMPC-ASO Strategy for Tracking Nonlinear Systems with Uncertainty (I)	
Zhao, Xiangdan	Tongji University
Dou, Lihua	Beijing Institute of Technology
Ding, Yulong	Tongji University
He, Bin	Tongji University
Wang, Biao	Nanjing University of Aeronautics and Astronautics
Li, Gang	Tongji University
Liu, Xiaoqin	Tongji University
Zhou, Yanmin	TONGJI UNIVERSITY
Wang, Zhipeng	Tongji University
Jiang, Shuo	Tongji University
Jiang, Yongkang	Tongji University
09:15-09:30, Paper ThAT1.4	
Distributed Algorithm for Time-Varying Convex Optimization with Fixed-Time Convergence (I)	
Shen, Yuanchu	Beijing Institute of Technology
Chen, Chen	Beijing Institute of Technology
Zeng, Xianlin	Beijing Institute of Technology
Chen, Wenjie	Beijing Institute of Technology
09:30-09:45, Paper ThAT1.5	
Event-Triggered Fixed-Time Sliding Mode Control for Leader-Follower Consensus of Nonlinear Multi-Agent Systems (I)	
Yang, Yixi	Beijing Institute of Technology
Xin, Bin	Beijing Institute of Technology
Dou, Lihua	Beijing Institute of Technology
Gan, Ming-Gang	Beijing Institute of Technology
09:45-10:00, Paper ThAT1.6	
Quadrotor Attitude Control Based on Modified Linear Active Disturbance Rejection Control (I)	
Wang, Biao	Nanjing University of Aeronautics and Astronautics
Tang, Chaoying	Nanjing University of Aeronautics and Astronautics
Yao, Zhennan	Nanjing University of Aeronautics and Astronautics
Yang, Feng	Aviation Key Laboratory of Science and Technology on Aero Electr

ThAT2	H101
Intelligent and AI Based Control	Regular Session
Chair: Wang, Hong	Oak Ridge National Laboratory
Co-Chair: Su, Wencong	University of Michigan-Dearborn
08:30-08:45, Paper ThAT2.1	
Parameter Estimation of Synchronous Generator Using Neural Controlled Differential Equations	
Yin, Zhun	The Department of Electrical and Computer Engineering at New Yor
Wang, Hong	Oak Ridge National Laboratory
Jiang, Zhong-Ping	New York University
08:45-09:00, Paper ThAT2.2	
PTC-FOZNN: A Strictly Predefined-Time Convergent Fractional-Order Recurrent Neural Network for Solving Time-Variant Quadratic Programming	

Yang, Yi	Chinese University of Hong Kong
Li, Weibing	Sun Yat-Sen University
Zhou, Jianshu	Chinese University of Hong Kong
Huang, Junda	Chinese University of Hong Kong
Hu, Jinfei	Chinese University of Hong Kong
Voyles, Richard	Purdue University
Ma, Xin	Chinese University of Hong Kong

09:00-09:15, Paper ThAT2.3	
Application of Non-Stationary Ship Roll Motion Prediction and Compensation Control Based on VMD-GRU-EC	
Zhang, Qin	Shanghai Maritime University
Li, Jiabin	Shanghai Maritime University
He, Ang	Shanghai Maritime University
Hu, Xiong	Shanghai Maritime University

09:15-09:30, Paper ThAT2.4	
Digital Twin Empowered Operational Status Monitoring of High-Power Induction Furnaces: A PINN-Based Approach	
Zhang, Zhao	Zhejiang University
Li, Shen	Zhejiang University
Mao, Wei-Jie	Zhejiang University

09:30-09:45, Paper ThAT2.5	
Fast Accurate Phasor Estimation in Less Than One Cycle Using Neural Networks	
Mohammadi, Sina	University of Michigan-Dearborn
Haghighi, Rouzbeh	University of Michigan-Dearborn
Hassan, Ali	University of Michigan-Dearborn
Bui, Van-Hai	University of Michigan-Dearborn
Wang, Mengqi	University of Michigan-Dearborn
Su, Wencong	University of Michigan-Dearborn

09:45-10:00, Paper ThAT2.6	
Finite-Time Convergence Missile Terminal Guidance Law Based on Deep Neural Network	
Li, Guilin	Jiangsu Normal University
Zhou, Wei	Jiangsu Normal University
Luan, Shengyang	Jiangsu Normal University

ThAT3	H103
Robotics	Regular Session
Chair: Chen, Tan	Michigan Technological University
Co-Chair: Lau, Darwin	Chinese University of Hong Kong

08:30-08:45, Paper ThAT3.1	
UAV-Enabled Smart Coastal Environment Monitoring for Marine Litter	
Zhang, Jihan	The Chinese University of Hong Kong
Zhou, Xunkuai	Tongji University
Huang, Yijun	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

08:45-09:00, Paper ThAT3.2	
Indoor Hydroponics Robot System for Automated Seeding and Logistics	
Hui, Hon Kit	The Chinese University of Hong Kong
Lee, Jimmy	The Chinese University of Hong Kong
Sum, K.W.	The Chinese University of Hong Kong
Lau, Darwin	Chinese University of Hong Kong

09:00-09:15, Paper ThAT3.3	
Adaptive Velocity Control for a Walking Robot in Low-Traction Environments	
Krajicek-Allard, Mathieu	Concordia University
Selmic, Rastko	Concordia University

09:15-09:30, Paper ThAT3.4	
UMeshSegNet: Semantic Segmentation of 3D Mesh Generated from UAV Photogrammetry (I)	
Liu, Xinyi	Wuhan University
Zhang, Yongjun	Wuhan University
Liu, Zihang	Wuhan University
Gao, Zhi	Wuhan University
Tan, Yuhui	Wuhan University

09:30-09:45, Paper ThAT3.5	
Control of Biped Sideways Walking with Two-Periodic Gait Design	
Chen, Tan	Michigan Technological University

09:45-10:00, Paper ThAT3.6	
Active View Planner for Infrastructure 3D Reconstruction	
Gao, Chuanxiang	The Chinese University of HongKong
Yang, Guidong	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

ThAT4	H104
Advanced Control and Applications	Invited Session
Chair: Chen, Xi	The Chinese University of Hong Kong
Co-Chair: Shi, Yang	Canada
Organizer: He, Tianyi	Utah State University
Organizer: Chen, Xiang	University of Windsor

08:30-08:45, Paper ThAT4.1	
Performance Assessment for Stochastic Anomaly Detectors in Industrial Alarm Systems (I)	
Zhou, Jing	University of Alberta
Shang, Jun	Tongji University
Chen, Tongwen	University of Alberta

08:45-09:00, Paper ThAT4.2	
Complementary Orientation Control for Spherical Motors (I)	
Mohammed, Thasnim	University of Windsor
Chen, Xiang	University of Windsor

09:00-09:15, Paper ThAT4.3	
Adaptive Distributed Lyapunov-Based Model Predictive Control for Multi-UAV Formation Tracking with Weighted Directed Graphs (I)	
Xu, Binyan	University of Victoria
Dai, Yufan	University of Victoria
Suleman, Afzal	University of Victoria
Shi, Yang	Canada

09:15-09:30, Paper ThAT4.4	
Pathway to a Smart Campus Framework: A Review and Case Study	
Hong, Wenxing	Xiamen University
Huang, ZhenFeng	Xiamen University, Department of Automation
Zhang, Jihan	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

09:30-09:45, Paper ThAT4.5	
Model-Free Adaptive Control for Discrete-Time Nonlinear Systems with Partially Known Structures	
Li, Fanghui	Qingdao University
Hou, Zhongsheng	Beijing Jiaotong University

09:45-10:00, Paper ThAT4.6	
Job Flow Control for Buffers in a Job-Shop Manufacturing System	
Qian, Yangyang	University of Virginia
Lin, Zongli	University of Virginia

ThBT1	H102
Resilient Cooperative Control and Optimization of Multi-Agent Systems	Invited Session
Chair: Feng, Zhi	Beihang University
Co-Chair: Dong, Xiwang	Beihang University
Organizer: Feng, Zhi	Beihang University
Organizer: Dong, Xiwang	Beihang University
Organizer: Wen, Guanghui	Southeast University
Organizer: Tang, Yang	East China University of Science and Technology

10:30-10:45, Paper ThBT1.1	
Distributed Prescribed-Time Formation Tracking for General Linear Multiagent Systems (I)	
Shi, Zhexin	Beihang University
Yang, Yikun	Beihang University
Yu, Jianglong	Beihang University
Dong, Xiwang	Beihang University
Li, Qingdong	Beihang University
Ren, Zhang	Beihang University

10:45-11:00, Paper ThBT1.2	
Trajectory Re-Planning Method of Hyper-Sonic Vehicles Facing Sudden Threats (I)	
Ren, Jie	Beihang University
Yu, Jianglong	Beihang University
Dong, Xiwang	Beihang University
Ren, Zhang	Beihang University
11:00-11:15, Paper ThBT1.3	
Cooperative Task Reconstruction Allocation for Unmanned Swarm Systems Based on MGGA and SAA (I)	
Yu, Jintong	Beihang University
Hua, Yongzhao	Beihang University
Dong, Xiwang	Beihang University
Li, Qingdong	Beihang University
Ren, Zhang	Beihang University
11:15-11:30, Paper ThBT1.4	
Robust Cooperative Formation Tracking Guidance for Uncertain Missile Systems (I)	
Sun, Yang	Tsinghua University
Huang, Peinan	Tsinghua University
Deng, Ruiliang	Tsinghua University
Shi, Zongying	Tsinghua University
Zhong, Yisheng	Tsinghua Univ
11:30-11:45, Paper ThBT1.5	
Predefined Output Containment for Heterogeneous Euler-Lagrange Systems with Multiple Uncertain Nonidentical Leaders (I)	
Wang, Qing	Beihang University
Dong, Xiwang	Beihang University
Shi, Zhexin	Beihang University
Wang, Jiayi	Beijing Bank
Feng, Zhi	Beihang University
11:45-12:00, Paper ThBT1.6	
Fast Incremental ADMM for Decentralized Consensus Multi-Agent Optimization	
You, Yang	KTH, Royal Institute of Technology
Yu, Ye	Southwest University
Xiao, Guoqiang	Southwest University
Xu, Qianwen	KTH Royal Institute of Technology

ThBT2	H101
Learning Systems	Regular Session
Chair: Chen, Xi	The Chinese University of Hong Kong
Co-Chair: Yin, Xiang	Shanghai Jiao Tong University
10:30-10:45, Paper ThBT2.1	
Formal Control Synthesis Via Safe Reinforcement Learning under Real-Time Specifications	
Lv, Peng	Shanghai Jiao Tong University
Luo, Guangqing	Shanghai Jiao Tong University
He, Zhou	Shaanxi University of Science and Technology
Li, Xianwei	Shanghai Jiao Tong University
Yin, Xiang	Shanghai Jiao Tong University
10:45-11:00, Paper ThBT2.2	
Self-Distillated DETR for Object Detection in Complex Environments	
Niu, Mohan	Beijing University of Technology
Li, Fangyu	Beijing University of Technology
Huang, Yanting	Beijing University of Technology
Han, Honggui	Beijing University of Technology
11:00-11:15, Paper ThBT2.3	
From Simulation to Prediction: Enhancing Digital Twins with Advanced Generative AI Technologies	
Huang, Yijun	The Chinese University of Hong Kong
Zhang, Jihan	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Lam, Alan Hiu-Fung	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong
11:15-11:30, Paper ThBT2.4	
Online Learning of Linear Quadratic Gaussian Controllers from Noisy Data	
Wang, Lingi	Beijing Institute of Technology
Liu, Wenjie	Beijing Institute of Technology, Beijing, China
Li, Yifei	Beijing Institute of Technology

Sun, Jian	Beijing Institute of Technology
Wang, Gang	Beijing Institute of Technology

11:30-11:45, Paper ThBT2.5	
Deep Learning for Remote Monitoring of Power System	
Kozak, Elana	U.S. Navy
Smith, Philip	U.S. Navy
Kang, Wei	Naval Postgraduate School
Martinsen, Thor	U.S. Naval Postgraduate School

11:45-12:00, Paper ThBT2.6	
CUBIT-Det: High-Definition Multi-Scenario Defect Dataset for Infrastructures Fully Evaluated with Deep Learning Processes	
Zhao, Benyun	The Chinese University of Hong Kong
Zhou, Xunkuai	Tongji University
Yang, Guidong	The Chinese University of Hong Kong
Wen, Junjie	The Chinese University of Hong Kong
Zhang, Jihan	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

ThBT3	H103
Robotics (II)	Regular Session
Chair: Albertos, Pedro	Univ. Politecnica De Valencia
Co-Chair: Moallem, Mehrdad	Simon Fraser University

10:30-10:45, Paper ThBT3.1	
Markless Visual Servoing for 3C Product Assembly with Quotient Kinematics Manipulator	
Xie, Yixin	Harbin Institute of Technology, Shenzhen
Fu, Qiang	Harbin Institute of Technology Shenzhen
Yang, Xiansheng	Harbin Institute of Technology Shenzhen
Li, Zhibin	Shenzhen Polytechnic University
Li, Yanjie	Harbin Institute of Technology Shenzhen
Lou, Yunjiang	Harbin Institute of Technology, Shenzhen

10:45-11:00, Paper ThBT3.2	
Realization of Efficient Rotational Springs and Series Elastic Actuators Using DC Motors	
Farjah, Amin	Simon Fraser University Surrey
Moallem, Mehrdad	Simon Fraser University

11:00-11:15, Paper ThBT3.3	
PI Tracking Control of a Single Link Manipulator	
Albertos, Pedro	Univ. Politecnica De Valencia
Wei, Cui	Nanjing Tech University
Casanova, Vicente	Universidad Politécnica De Valencia
Crespo, Alfons	UPV

11:15-11:30, Paper ThBT3.4	
IoT-Cloud Based Control of a Flexible Assembly/Disassembly Mechatronic System in the Framework of Industries 4.0 and 5.0	
Filipescu, Adrian	Lower Danube University of Galati
Stamatescu, Iulia	University Politehnica of Bucharest
Simion, Georgian	“Dunărea De Jos” University of Galați
Ionescu, Dan	“Dunarea De Jos” University of Galati
Filipescu, Adriana	Low Danube University of Galati

11:30-11:45, Paper ThBT3.5	
First Principle Modeling of a Morphable Unmanned Aerial-Aquatic Vehicle: Mirs-Alioth	
Huang, Dongyue	Chinese University of Hong Kong
Dou, Minghao	Chinese University of Hong Kong
Liu, Xuchen	The Chinese University of Hong Kong
Yan, Ruixin	The Chinese University of Hong Kong
Gao, Songgun	The Chinese University of Hong Kong
Liu, Zixuan	Peng Cheng Lab
Wang, Biao	Nanjing University of Aeronautics and Astronautics
Dou, Lihua	Beijing Institute of Technology
Chen, Ben M.	Chinese University of Hong Kong

11:45-12:00, Paper ThBT3.6	
Autonomous Cooperative Mapping of GPS-Denied Cluttered Environments Using Gaussian Process Regression	
Mansfield, David	Lancaster University
Sadeghzadeh-Nokhodberiz, Nargess	Qom University of Technology
Montazeri, Allahyar	Lancaster University
ThBT4	H104
Fault Detection and Diagnostics	Regular Session
Chair: Zhang, Youmin	Concordia University
10:30-10:45, Paper ThBT4.1	
An Insulator Missing Defect Detection Method Based on Unmanned Aerial Vehicles	
Zhang, Yulong	Xi'an University of Technology
Zhou, Zhongxian	Xi'an University of Technology
Mu, Lingxia	Xi'an University of Technology
Xue, Xianghong	Xi'an University of Technology
Xin, Jing	Xi'an University of Technology
Zhang, Youmin	Concordia University
10:45-11:00, Paper ThBT4.2	
The Fault Detection and Isolation Design for the Stratospheric Airship Based on the Interval Observer Method with Zonotope Analysis	
Hu, Jichen	Beihang University
Zhu, Ming	Beihang University
Zheng, Zewei	Beihang University
Chen, Tian	Beihang University
11:00-11:15, Paper ThBT4.3	
Countering Spoofing Attacks for Unmanned Aerial Vehicles Using Multi-Constellation GNSS	
Yan, Xinhao	The Hong Kong Polytechnic University
Huang, Hailong	Hong Kong Polytechnic University
11:15-11:30, Paper ThBT4.4	
A Fault-Detection Method of MEMS Micromirrors with Hysteresis	
Tan, Yonghong	Shanghai Normal University
Li, Xinyuan	Shanghai Normal University
Ke, Changzhong	Donghua University
Dong, Ruili	Donghua University
Tan, Qingyuan	University of Windsor
Gu, Ya	Shanghai Normal University
11:30-11:45, Paper ThBT4.5	
A Mismatch Correction Method Based on Two-Way Strategies of Spatial Vector Feature	
Ma, Zixuan	Beijing Institute of Technology
Wang, Bo	Beijing Institute of Technology
Bi, Ran	Beijing Institute of Technology
11:45-12:00, Paper ThBT4.6	
Predictive Control of Vehicle Dynamics Equipped with Intelligent Tire Sensors Via Gaussian Process Regression of Lateral Tire Force	
Ryu, Kunhee	Hyundai Motor Company
Kim, Jinsung	Hyundai Motor Company
Han, Minkyu	Hyundai Motor Company
Back, Juhoon	Kwangwoon University
ThCT1	H102
Distributed Optimization for Networked Systems	Invited Session
Chair: Yang, Tao	Northeastern University
Co-Chair: Zhu, Shanying	Shanghai Jiao Tong University
Organizer: Yang, Tao	Northeastern University
Organizer: Wen, Guanghui	Southeast University
Organizer: Hong, Yiguang	Chinese Academy of Sciences
14:00-14:15, Paper ThCT1.1	
Non-Cooperative Game-Based Formation Tracking Control of Unmanned Surface Vessels under Markovian Switching Topologies (I)	
Ren, Jianxiang	Southeast University
Fang, Xiao	Southeast University
Yang, Tao	Northeastern University
Wen, Guanghui	Southeast University
14:15-14:30, Paper ThCT1.2	
Almost Sure Convergence to Approximate Nash Equilibrium in Zero-Sum Extensive-Form Games with Noisy Feedback (I)	
Zhu, Kui	Beijing Institute of Technology
Zeng, Xianlin	Beijing Institute of Technology
14:30-14:45, Paper ThCT1.3	

Quantized Tracking Capacity for Unstable Dynamics in Distributed Estimation under Data Rate Limitation (I)	
Li, Peizhe	Shanghai Jiao Tong University
Chen, Cailian	Shanghai Jiao Tong University
Zhu, Shanying	Shanghai Jiao Tong University
Guan, Xinping	Shanghai Jiao Tong University
14:45-15:00, Paper ThCT1.4	
Compressed Distributed Zeroth-Order Gradient Tracking for Nonconvex Optimization (I)	
Xu, Lei	Northeastern Univeristy
Yi, Xinlei	KTH
Sun, Jiayue	Northeaster University
Wen, Guanghui	Southeast University
Chai, Tianyou	Northeastern University
Yang, Tao	Northeastern University
15:00-15:15, Paper ThCT1.5	
A Communication-Efficient Stochastic Gradient Descent Algorithm for Distributed Nonconvex Optimization (I)	
Xie, Antai	Shanghai University
Yi, Xinlei	KTH
Wang, Xiaofan	Shanghai Jiao Tong University
Cao, Ming	University of Groningen
Ren, Xiaoqiang	KTH
15:15-15:30, Paper ThCT1.6	
An Adaptively Distributed Algorithm for Noncooperative Games of High-Order Integrator Systems (I)	
Du, Xixiang	North China Electric Power University
Xiao, Feng	North China Electric Power University
Yu, Mei	North China Electric Power University
ThCT2	H101
Learning-Based Control	Regular Session
Chair: Guo, Zongyi	Northwestern Polytechnical University
14:00-14:15, Paper ThCT2.1	
Rapid Generation of Hypersonic Entry Flight Trajectories under Uncertainty Using Transfer Learning	
Li, Haochen	Beihang University
Chen, Haibing	Beihang University
Su, Xu	Beihang University
14:15-14:30, Paper ThCT2.2	
Physics-Informed Neural Networks-Based Uncertainty Identification and Control for Closed-Loop Attitude Dynamics of Reentry Vehicles	
Yuan, Ruizhe	Institute of Precision Guidance, and Control, Northwestern Polyt
Guo, Zongyi	Northwestern Polytechnical University
Cao, Shiyuan	Northwestern Polytechnical University
Henry, David	Universite Bordeaux
Cieslak, Jérôme	University of Bordeaux
Oliveira, Tiago Roux	State University of Rio De Janeiro - UERJ
Guo, Jian-guo	Northwestern Polytechnical University
14:30-14:45, Paper ThCT2.3	
Actor-Critic Enhanced Neural Network Optimizer for Mixed-Integer Optimal Control: A Case Study on Eco-Driving Control	
Cheng, Yifan	Tongji University
Luo, Xi	Tongji University
Dong, Shiying	Jilin University
Hong, Jinlong	Tongji University
Guo, Lulu	Jilin University
Hu, Jia	Tongji University
Gao, Bingzhao	Jilin University
Chen, Hong	Tongji University
14:45-15:00, Paper ThCT2.4	
Sliding Mode-Based Two-Dimensional Iterative Learning Control for Systems with Uncertainties and External Disturbances	
Yu, Yaru	Shanghai Jiaotong University
Li, Dewei	Shanghai Jiao Tong University
Ma, Aoyun	Shanghai Jiao Tong University
Gao, Furong	Hong Kong University of Science & Technology
15:00-15:15, Paper ThCT2.5	
UAV Cooperative Air Combat Maneuvering Decision-Making Using GRU-MAPPO	
Chen, Caiyi	Xiamen University

Guo, Zhengyu	National Key Laboratary of Air-Based Information Perceptian And
Luo, Delin	Xiamen University
Xu, Yang	Northwestern Polytechnical University
Duan, Haibin	Beihang University

15:15-15:30, Paper ThCT2.6	
Data-Based Iterative Learning Control: A Nonconservative Approach Via LMI Techniques	
Wang, Chenchao	School of Automation Science and Electrical Engineering, Beihang
Meng, Deyuan	Beihang University (BUAA)
Cheng, Long	Chinese Academy of Sciences

ThCT3	H103
Robotics (III)	Regular Session
Chair: Duan, Haibin	Beihang University

14:00-14:15, Paper ThCT3.1	
Fixed-Wing UAVs Formation Flight Experiments with Intelligent Autonomous System Teaching Platforms	
Duan, Haibin	Beihang University
Wu, Tongyan	Beihang University
Wei, Chen	Beijing University of Aeronautics and Astronautics
Deng, Yimin	Beihang University
Huo, Mengzhen	School of Automation Science and Electrical Engineering, Beihang

14:15-14:30, Paper ThCT3.2	
A Guided-To-Autonomous Policy Learning Method of Deep Reinforcement Learning in Path Planning	
Zhao, Wang	Northwestern Polytechnical University
Zhang, Ye	Northwestern Polytechnical University
Li, Haoyu	Northwestern Polytechnical University

14:30-14:45, Paper ThCT3.3	
A Cost-Effective Cooperative Exploration and Inspection Strategy for Heterogeneous Aerial System	
Xu, Xinhang	Nanyang Technological University
Cao, Muqing	Nanyang Technological University
Yuan, Shenghai	NanYang Technological University
Nguyen, Thien Hoang	Nanyang Technological University
Nguyen, Thien-Minh	Nanyang Technological University
Xie, Lihua	Nanyang Technological University

14:45-15:00, Paper ThCT3.4	
Vibration Suppression Trajectory Planning of Flexible Manipulator Based on Hierarchical Self-Adjusting Constrained Optimization	
Xie, Yuanlong	Huazhong University of Science and Technology
Wang, Yan	Huazhong University of Science and Technology
Wang, Shuting	Huazhong University of Science and Technology
Li, Hu	Huazhong University of Science and Technology

15:00-15:15, Paper ThCT3.5	
A 3D Point Attacker for LiDAR-Based Localization	
Yi, Shiquan	Northwestern Polytechnical University
Gao, Jiakai	Northwestern Polytechnical University
Lyu, Yang	Northwestern Polytechnical University
Hua, Lin	Northwestern Polytechnical University
Pan, Quan	Northwestern Polytechnical University

15:15-15:30, Paper ThCT3.6	
Mobile Cooperative Robot Safe Interaction Method Based on Embodied Perception	
Wang, Sicheng	AIRS
Cheng, Xu	Tianjin University of Technology
Zhang, Tianwei	The Chinese University of Hong Kong-Shenzhen

ThCT4	H104
Unmanned System Based Sensing	Invited Session
Chair: Gao, Zhi	Wuhan University
Co-Chair: Lu, Maobin	Beijing Institute of Technology
Organizer: Gao, Zhi	Wuhan University

14:00-14:15, Paper ThCT4.1	
Small Object Detection in Unmanned Aerial Vehicle Images Leveraging Density-Aware Scale Adaptation and Knowledge Distillation (I)	
Wan, Yu	Wuhan University
Lan, Zekai	Nanjing Normal University
Hu, Jianqiu	Jiangsu Automation Research Institution
Ji, Hong	Wuhan University
Song, Weiwei	Peng Cheng Laboratory
Gao, Zhi	Wuhan University
14:15-14:30, Paper ThCT4.2	
SUAS-Based Multispectral Imaging in Support of Detection of Camouflaged Targets and Battlefield Anomalies	
Barmpas, Stergios	Hellenic Army
Yakimenko, Oleg A.	Naval Postgraduate School
14:30-14:45, Paper ThCT4.3	
DynaVIG: Monocular Vision/INS/GNSS Integrated Ego and Object Localization in Dynamic Scenes (I)	
Jin, Ronghe	Wuhan University
Wang, Yan	Wuhan University
Mei, Tiancan	Wuhan University
Niu, Xiaoji	Wuhan University
Liu, Jingnan	Wuhan University
Hu, Yu	Guangdong Laboratory of Artificial Intelligence and Digital Econ
He, Jiazhou	Jiangsu Automation Research Institute
Hu, Jianqiu	Jiangsu Automation Research Institution
14:45-15:00, Paper ThCT4.4	
PLPD-SLAM: Point-Line-Plane-Based RGB-D SLAM for Dynamic Environments (I)	
Dong, Juan	Beijing Institute of Technology
Lu, Maobin	Beijing Institute of Technology
Xu, Yong	Zhejiang University
Deng, Fang	Beijing Institute of Technology
Chen, Jie	Tongji University
15:00-15:15, Paper ThCT4.5	
Efficient Air-To-Air Drone Detection with Composite Multi-Dimensional Attention	
Yin, Xingyu	Beijing Institute of Technology
Ren, Jin	Beijing Institute of Technology
Lin, Defu	Beijing Institute of Technology
15:15-15:30, Paper ThCT4.6	
Robust RGB-D SLAM in Dynamic Environments Using Geometry and Semantic Information (I)	
Xiao, Yao	Wuhan University
Zou, Junjie	Wuhan University
Jin, Ronghe	Wuhan University
Mei, Tiancan	Wuhan University

FrAT1	H102
Automated Guided Vehicles	Regular Session
Chair: Su, Rong	Nanyang Technological University

08:30-08:45, Paper FrAT1.1	
A Path Following Control Method for Underactuated Unmanned Surface Vehicles Based on Output Redefinition	
Xu, Zishi	Zhejiang University
Xiang, Ji	Zhejiang University, Yuquan Campus

08:45-09:00, Paper FrAT1.2	
An Incremental Planning Strategy-Based Genetic Algorithm for Integrated Scheduling and Routing Optimization in Smart Manufacturing	
Yao, Jiarong	Nanyang Technological University
Guo, Yao	NanyangTechnological University
Li, Jiangpeng	Nanyang Technological University
Su, Rong	Nanyang Technological University
Ling, Keck-Voon	Nanyang Technological University
Han, Boon Siew	Nanyang Technological University
Wong, Hong Yee Alvin	Nanyang Technological University

09:00-09:15, Paper FrAT1.3	
A MILP Model for Conflict-Free Routing Problem with Partial Charging in Multiple-AGV System	
Guo, Yao	NanyangTechnological University
Yao, Jiarong	Nanyang Technological University
Su, Rong	Nanyang Technological University
Ling, Keck-Voon	Nanyang Technological University
Han, Boon Siew	Nanyang Technological University
Wong, Hong Yee Alvin	Nanyang Technological University

09:15-09:30, Paper FrAT1.4	
Dynamic Route Planning for a Data Collecting Luggage Transportation Service	
Voelkl, Jakob	Ostbayerische Technische Hochschule Regensburg
Melzer, Matthias	Ostbayerische Technische Hochschule Regensburg
Dünnweber, Jan	Ostbayerische Technische Hochschule Regensburg
Sarkar, Amitrajit	Canterbury University

09:30-09:45, Paper FrAT1.5	
Boundary Approximation and Area Coverage Using Fourier Analysis and Lissajous Curves	
Nath, Suryadeep	Indian Institute of Science
Ghose, Debasish	Indian Institute of Science

09:45-10:00, Paper FrAT1.6	
Topological Risk-Based Path Selection in Dynamic Environments	
Xu, Erpei	Beijing Institute of Technology
Yu, Chengpu	Beijing Institute of Technology Chongqing Innovation Center
Liu, Yixuan	Beijing Institute of Technology

FrAT2	H101
Cooperative Control Systems	Regular Session
Chair: Dong, Xiwang	Beihang University
Co-Chair: Kumar, Bhim	Indian Institute of Technology Mandi

08:30-08:45, Paper FrAT2.1	
Finite-Time Stability of Positive Switched Impulsive and Multi-Agent Systems with Event-Triggered Controller on Non-Uniform Time Domains	
Kumar, Bhim	Indian Institute of Technology Mandi
Malik, Muslim	Indian Institute of Technology Mandi

08:45-09:00, Paper FrAT2.2	
Distributed Optimization-Based Formation Tracking for Multi-Agent Systems with a Privacy-Preserving Mechanism	
Su, Lingfei	Beihang University
Hua, Yongzhao	Beihang University
Dong, Xiwang	Beihang University
Ren, Zhang	Beihang University

09:00-09:15, Paper FrAT2.3	

Research on Collaborative Task Planning Method for Split Delivery Vehicle Routing Problem	
Zhang, Jia	Beijing Institute of Technology
Hong, Rui	Beijing Institute of Technology
Dong, Qichen	Beijing Institute of Technology
09:15-09:30, Paper FrAT2.4	
Two-Stage Multi-Robot Task Allocation Algorithms in Local Communication Scenarios	
Shan, Shilei	Beijing Institute of Technology
Peng, Zhihong	Beijing Institute of Technology
Zeng, Xianlin	Beijing Institute of Technology
09:30-09:45, Paper FrAT2.5	
Leader-Follower Consensus on Matrix-Weighted Switching Networks	
Wang, Kai	Shanghai Jiao Tong University
Pan, Lulu	Shanghai Jiao Tong University
Shao, Haibin	Shanghai Jiao Tong University
Li, Dewei	Shanghai Jiao Tong University
Li, Yuanlong	Shanghai Jiao Tong University
He, Shaoying	Shanghai Jiao Tong University
09:45-10:00, Paper FrAT2.6	
Decentralized Task Allocation for Redundant Multi-Robot Systems: An Iterative Consensus Approach	
Govoni, Lorenzo	Sapienza University of Rome
Cristofaro, Andrea	Sapienza University of Rome
FrAT3	H103
Multi-Agent Systems	Regular Session
Co-Chair: Yakimenko, Oleg A.	Naval Postgraduate School
08:30-08:45, Paper FrAT3.1	
Fully Distributed Practical Fixed-Time Time-Varying Formation Tracking Control for General Linear Multiagent Systems	
Li, JinSheng	BeiHang University
Yu, Jianglong	Beihang University
Hua, Yongzhao	Beihang University
Dong, Xiwang	Beihang University
Li, Qingdong	Beihang University
Ren, Zhang	Beihang University
08:45-09:00, Paper FrAT3.2	
A Fully Distributed Event-Triggered Average Tracking Protocol with Discrete Communication and Control Updating	
Dai, Xinyue	Southeast University
He, Haibin	Southeast University
Xu, Wenying	Southeast University
Yang, Shaofu	Southeast University
09:00-09:15, Paper FrAT3.3	
Ratio-Of-Distance-Based Adaptive Formation Control of Wheeled Robot Networks with Unknown Parameters and External Disturbances	
Wang, Yujie	Shandong University
Liu, Shuai	Shandong University
09:15-09:30, Paper FrAT3.4	
Distributed Strategies for Pursuit-Evasion of High-Order Integrators	
Zhou, Panpan	KTH Royal Institute of Technology
Hu, Xiaoming	Royal Institute of Technology
Wahlberg, Bo	KTH Royal Institute of Technology
09:30-09:45, Paper FrAT3.5	
Enhancing Urban Unmanned Ground Vehicle Operations through Machine Learning	
Moore, Hyatt	U.S. Naval Postgraduate School
Yakimenko, Oleg A.	Naval Postgraduate School
09:45-10:00, Paper FrAT3.6	
Proximal Policy Optimization Based Decentralized Networked Multi-Agent Reinforcement Learning	
Liu, Jinyi	Beijing University of Technology
Li, Fangyu	Beijing University of Technology
Wang, Jingjing	Beijing University of Technology
Han, Honggui	Beijing University of Technology
FrAT4	H104
Modeling, Control and Estimation in Unmanned Aircraft Systems	Invited Session
Chair: Hu, Jinwen	Northwestern Polytechnical University
Co-Chair: Guo, Kexin	Beihang University
Organizer: Hu, Jinwen	Northwestern Polytechnical University

Organizer: Yang, Tao	Northwestern Polytechnical University
Organizer: Xu, Zhao	Northwestern Polytechnical University
Organizer: Yu, Huangchao	National University of Defense Technology
Organizer: Guo, Kexin	Beihang University

08:30-08:45, Paper FrAT4.1	
Dogfight Advantage Occupancy Method Based on Imperfect Information Self-Play (I)	
Wang, Dinghan	Northwestern Polytechnical University, School of Electronics And
Ji, Longmeng	Northwestern Polytechnical University, School of Electronics And
Wang, Jingbo	AVIC Chengdu Aircraft Design and Research Institute
Shi, Zhuoyong	Northwestern Polytechnical University
Zhang, Jiandong	Northwestern Polytechnical University
Yang, Qiming	Northwestern Polytechnical University
Shi, Guoqing	Northwestern Polytechnical University
Wu, Yong	Northwestern Polytechnical University
Zhu, Yan	Northwestern Polytechnical University
Hu, Jinwen	Northwestern Polytechnical University

08:45-09:00, Paper FrAT4.2	
Multi-UAVs Collaborative Task Allocation Based on Improved Consensus-Based Grouping Algorithm (I)	
Ma, Yunhong	Northwestern Polytechnical University
Li, Xinyi	Northwestern Polytechnical University
Wang, Haiquan	Northwestern Polytechnical University
Kang, Yongxiang	Northwestern Polytechnical University
Tianhang, Cao	Northwestern Polytechnical University
Zhang, Yaozhong	Northwestern Polytechnical University
Yang, Jie	Northwestern Polytechnical University

09:00-09:15, Paper FrAT4.3	
Large-Scale UAVs Autonomous Rendezvous Using Partially Observed Mean-Field Reinforcement Learning (I)	
Zhang, Yaozhong	Northwestern Polytechnical University
Ding, Meiyan	School of Electronic Information, Northwestern Polytechnical Uni
Wu, Zhuo ran	Northwestern Polytechnical University
Zhang, Jiandong	Northwestern Polytechnical University
Shi, Guoqing	Northwestern Polytechnical University
Yang, Qiming	Northwestern Polytechnical University
Ma, Yunhong	Northwestern Polytechnical University
Zhu, Yan	Northwestern Polytechnical University

09:15-09:30, Paper FrAT4.4	
ISANet: An Interactive Self-Attention Network for Cropland Image Change Detection (I)	
Sijun, Dong	Wuhan University
Yanrui, Chen	Wuhan University
Fann, Wu	Wuhan University
Gao, Zhi	Wuhan University
Xiaoliang, Meng	Wuhan University

09:30-09:45, Paper FrAT4.5	
SLAM in Low-Light Environments Based on Infrared-Visible Light Fusion (I)	
Wang, Haiwei	AVIC XAC Commercial Aircraft CO. LTD
Gao, Chenqi	Northwestern Polytechnical University
Gao, Tianyu	Northwestern Polytechnical University
Hu, Jinwen	Northwestern Polytechnical University
Xu, Zhao	Northwestern Polytechnical University
Han, Junwei	Northwestern Polytechnical University
Zhu, Yan	Northwestern Polytechnical University
Wu, Yong	Northwestern Polytechnical University

09:45-10:00, Paper FrAT4.6	
Autonomous Lifeguard Unmanned Aerial Vehicle Prototype for Information-Weighted Optical Flow Analysis and Rip Current Detection with Depth Risk Models	
Kim, Angelina	The Bishops School
FrBT1	H102
Intelligent Optimization and Control of Robotic Systems	Invited Session
Chair: Xin, Bin	Beijing Institute of Technology
Co-Chair: Cui, Jinqiang	Peng Cheng Laboratory
Organizer: Xin, Bin	Beijing Institute of Technology
Organizer: Cui, Jinqiang	Peng Cheng Laboratory
Organizer: Cheng, Lan	Taiyuan University of Technology
Organizer: Zheng, Zhi	Fujian Normal University
Organizer: Zhang, Chunmei	Taiyuan University of Science and Technology

10:30-10:45, Paper FrBT1.1	
Research on the Coalition Formation of Multi-Agent Systems for Forest Fire Prevention and Control Tasks (I)	
Wu, Ruotong	Beijing Institute of Technology
Zhang, Jia	Beijing Institute of Technology
Xin, Bin	Beijing Institute of Technology

10:45-11:00, Paper FrBT1.2	
TPML: Task Planning for Multi-UAV System with Large Language Models (I)	
Cui, Jinqiang	Peng Cheng Laboratory
Liu, Guocai	Peng Cheng Labotoary
Wang, Hui	Peng Cheng Laboratory
Yu, Yue	Peng Cheng Laboratory
Yang, Jiankun	Peng Cheng Laboratory

11:00-11:15, Paper FrBT1.3	
A Learning Framework Combining Distillation-Generated Replay and Development Network in Continual Visual Scene Cognition for Autonomous Robot (I)	
Zhang, Yuyang	Fujian Normal University
Zheng, Zhi	Fujian Normal University

11:15-11:30, Paper FrBT1.4	
Improved Reinforcement Learning Based on Angle Search for Route Planning of the Hospital Inspection Robot (I)	
Ding, Long	University
Zhang, Chunmei	Taiyuan University of Science and Technology
Guo, Hong ge	Taiyuan University of Science and Technology

11:30-11:45, Paper FrBT1.5	
Localization of UGV Guided by UAV Using Visual Inertia Sensors and UWB (I)	
Qian, ShengYi	Taiyuan University of Technology
Cheng, Lan	Taiyuan University of Technology
Xu, XinYing	Taiyuan University of Technology
Ren, Mifeng	Taiyuan University of Technology
FrBT2	H101
Estimation and Identification	Regular Session
Chair: Huang, Biao	University of Alberta

10:30-10:45, Paper FrBT2.1	
Suboptimal Bayesian Filters for Markov Jump Linear Systems with Unknown Noise Covariance	
Gao, Shuang	Jiangnan University
Luan, Xiaoli	Jiangnan University
Huang, Biao	University of Alberta
Zhao, Shunyi	Jiangnan University
Wan, Haiying	Jiangnan University
Liu, Fei	Jiangnan University

10:45-11:00, Paper FrBT2.2	
A Total Secrecy Coding Scheme with True Random Sequences for Remote Estimation against Eavesdroppers with Anti-Coding Mechanisms	
Yang, Yake	Northeastern University
Yang, Tao	Northeastern University
Li, Yuzhe	Northeastern University, China

11:00-11:15, Paper FrBT2.3	
Approximating the System Behavior with Input Uncertainty Using Big Data	
Yan, Yitao	University of New South Wales
Bao, Jie	The University of New South Wales
Huang, Biao	University of Alberta

11:15-11:30, Paper FrBT2.4	
Multi-Target Tracking in Distributed Wireless Sensor Networks with Packet Dropout	
Bu, Lingchao	Northwestern Polytechnical University
Li, Huiping	Northwestern Polytechnical University

11:30-11:45, Paper FrBT2.5	
Air-To-Air Detection and Tracking of Non-Cooperative UAVs for 3D Reconstruction	
Liu, Yang	Beijing Institute of Technology
Xi, Lele	Beijing Institute of Technology
Sun, Zhihao	Beijing Institute of Technology
Zhang, Lele	Beijing Institute of Technology
Dong, Wei	Beijing Institute of Technology
Lu, Maobin	Beijing Institute of Technology
Chen, Chen	Beijing Institute of Technology
Deng, Fang	Beijing Institute of Technology

FrBT3	H103
Multi-Agent Systems (II)	Regular Session
Chair: Lee, Donghwan	KAIST

10:30-10:45, Paper FrBT3.1	
Time-Varying Output Group Formation Tracking Control for Heterogeneous Multiagent Systems with Switching Topologies	
Zhou, Shiyu	City University of Hong Kong
Sun, Dong	City University of Hong Kong
Feng, Gang	City Univ. of Hong Kong

10:45-11:00, Paper FrBT3.2	
Heterogeneous Control Method of Multi-Cluster Manned-Unmanned System Over Passive Switching Topology	
Huo, Mengzhen	School of Automation Science and Electrical Engineering, Beihang
Duan, Haibin	Beihang University
Wu, Hao	China Academy of Electronics and Information Technology, China E

11:00-11:15, Paper FrBT3.3	
An Entropy-Based Path Planning Method for Crowd Evacuation in Complex Environments	
Dong, Shiyu	Harbin Engineering University
Huang, Ping	Harbin Engineering University
Wu, Fan	China Ship Development and Design Center
Wang, Wei	Harbin Engineering University

11:15-11:30, Paper FrBT3.4	
Continuous-Time Distributed Dynamic Programming for Networked Multi-Agent Markov Decision Processes	
Lee, Donghwan	KAIST
Lim, Han-Dong	Korea Advanced Institute of Science and Technology
Kim, Do Wan	Hanbat National University

11:30-11:45, Paper FrBT3.5	
The Stabilization of Cohen-Grossberg BAM Neural Network System	
Guo, Peiyu	Southeast University
Cao, Yang	Southeast University
Liu, Xin-ge	Central South University

FrBT4	H104
New Trends in Intelligent Unmanned Systems	Invited Session
Chair: Zhao, Shiyu	Westlake University
Co-Chair: Tan, Guan Zhong John	National University of Singapore
Organizer: Zhao, Shiyu	Westlake University
Organizer: Lin, Feng	National University of Singapore

10:30-10:45, Paper FrBT4.1	
Omnibot: A Scalable Vision-Based Robot Swarm Platform (I)	
Ma, Zhao	Westlake University
Liang, Jiachen	Westlake University
Wang, Hongyi	Westlake University
Guo, Shiliang	Westlake University
Huo, Peidong	Westlake University
Zhang, Yin	Westlake University
Zhao, Shiyu	Westlake University

10:45-11:00, Paper FrBT4.2	
A Robust and Efficient Visual-Inertial SLAM for Vision-Degraded Environments (I)	
Zhao, Xuhui	Wuhan University
Gao, Zhi	Wuhan University
Wang, Jialiang	Wuhan University

Lin, Zhipeng	The Chinese University of Hong Kong
Zhou, Zhiyu	Wuhan University
Huang, Yue	Wuhan University

11:00-11:15, Paper FrBT4.3	
A Model Predictive Control Approach for USV Autonomous Cruising Via Disturbance Learning (I)	
Cheng, Maotong	Zhejiang University
Yao, Jinke	Zhejiang University
Ren, Qinyuan	Zhejiang University

11:15-11:30, Paper FrBT4.4	
EAI-SIM: An Open-Source Embodied AI Simulation Framework with Large Language Models (I)	
Liu, Guocai	Peng Cheng Labotoary
Sun, Tao	Shenzhen Institute of Artificial Intelligence and Robotics for S
Li, Weihua	Beihang University
Li, Xiaohui	Peng Cheng Laboratory
Liu, Xin	Peng Cheng Laboratory
Cui, Jinqiang	Peng Cheng Laboratory

11:30-11:45, Paper FrBT4.5	
Gestelt: A Framework for Accelerating the Sim-To-Real Transition for Swarm UAVs (I)	
Tan, Guan Zhong John	National University of Singapore
Sun, Tianchen	National University of Singapore
Lin, Feng	National University of Singapore
Teo, Rodney	National University of Singapore
Khoo, Boo Cheong	National University of Singapore

11:45-12:00, Paper FrBT4.6	
Lite-HRPE: A 6DoF Object Pose Estimation Method for Resource-Limited Platforms	
Liu, Xin	Shanghai Jiao Tong University
Qi, Guan	Shanghai Jiao Tong University
Xue, Shibei	Shanghai Jiao Tong University
Zhao, Dezong	Loughborough University

Technical Program for Wednesday June 19, 2024

WeAT1	H102
Best Paper Finalists Session	Regular Session
Chair: Lin, Zongli	University of Virginia
Co-Chair: Shi, Yang	Canada

14:45-15:00, Paper WeAT1.1	
Resilient Adaptively Distributed Nash Equilibrium Seeking against Unknown False Data Injection Attacks in Noncooperative Games (I)	
Feng, Zhi	Beihang University
Dong, Xiwang	Beihang University
Hu, Guoqiang	Nanyang Technological University
Lu, Jinhu	Academy of Mathematics and Systems Science, ChineseAcademyof Sci

Keywords: Adaptive Control, Estimation and Identification, Multi-agent Systems

Abstract: This paper addresses an attack-resilient adaptively distributed Nash Equilibrium (NE) seeking issue for noncooperative games under malicious false data injection (FDI) attacks. Different from the distibuted NE seeking in many existing literature under ideal environments, it is challenging to achieve distributed NE seeking under the impacts of unknown FDI attacks. An attack-resilient NE seeking framework that is distributed (i.e., independent of global information), is established by using the consensus-based gradient play together with an identifier design to compensate for the adverse impacts of FDI attacks. Lastly, numerical simulation results are presented to illustrate the designs' effectiveness.

15:00-15:15, Paper WeAT1.2	
Distributed Nash Equilibrium Seeking with Communication Delays (I)	
Liu, Lupeng	Beijing Institute of Technology
Lu, Maobin	Beijing Institute of Technology
Deng, Fang	Beijing Institute of Technology
Dou, Lihua	Beijing Institute of Technology
Chen, Jie	Tongji University

Keywords: Multi-agent Systems, Networked Control, Nonlinear Systems and Control

Abstract: This paper addresses the problem of distributed Nash equilibrium seeking in N-player games for single integrator dynamics subject to strongly connected networks and communication delays. First, we propose a distributed estimator for each player, enabling them to estimate the actions of all players. Notably, we take into account unknown bounded time delays that occur during communication between players and their neighbors. Next, we design a distributed Nash equilibrium seeking law using the gradient play technique. Then, we analyze the stability of the closed-loop system, which consists of an interconnected nonlinear subsystem and a linear time-delay subsystem. By means of designing the Lyapunov-Krasovskii functional, we demonstrate that Nash equilibrium seeking is achieved at an exponential rate, even in the presence of unknown and bounded communication delays. Finally, we provide a simulation example to illustrate the effectiveness of our proposed approach.

15:15-15:30, Paper WeAT1.3	
Continuous-Time Damping-Based Mirror Descent for a Class of Non-Convex Multi-Player Games with Coupling Constraints (I)	
Chen, Guanpu	KTH Royal Institute of Technology
Cao, Kun	Nanyang Technological University
Johansson, Karl H.	KTH Royal Institute of Technology
Hong, Yiguang	Chinese Academy of Sciences

Keywords: Multi-agent Systems, Nonlinear Systems and Control

Abstract: We study the computation of the global generalized Nash equilibrium (GNE) for a class of non-convex multi-player games, where players' actions are subject to both local and coupling constraints. Due to the non-convex payoff functions, we employ canonical duality to reformulate the setting as a complementary problem. Under given conditions, we reveal the relation between the stationary point and the global GNE. According to the convex-concave properties within the complementary function, we propose a continuous-time mirror descent to compute GNE by generating functions in the Bregman divergence and the damping-based design. Then, we devise several Lyapunov functions to prove that the trajectory along the dynamics is bounded and convergent.

15:30-15:45, Paper WeAT1.4	
Anomaly Detection for Stochastic Networked Cyber-Physical Systems: A Statistical Approach	
Yan, Yamin	NTU
Fu, Minyue	University of Newcastle
Seron, Maria M.	The University of Newcastle

Keywords: Networked Control, Fault Detection and Diagnostics, Signal Processing

Abstract: In this paper, we investigate the anomaly detection problem within stochastic networked cyber-physical systems. We introduce an anomaly detection scheme centered on estimator design employing a statistical approach. Specifically, we extend the statistical method recently developed for single systems to networked control scenarios. Additionally, we analyse the detection of several representative anomalies through this statistical approach. We then apply our anomaly detection strategy to a power network system exposed to such anomalies. Our findings demonstrate that the proposed design effectively detects these anomalies, which simpler methods relying solely on residual assessment with a threshold fail to identify.

15:45-16:00, Paper WeAT1.5	
Intuitive Teleoperation Control for Flexible Robotic Endoscopes under Unkonwn Environmental Interferences	
Chen, Wei	The Chinese University of Hong Kong

Lu, Yiang	The Chinese University of Hong Kong
Li, Bin	The Chinese University of Hong Kong
Zhou, Jianshu	Chinese University of Hong Kong
Cao, Hanwen	The Chinese University of Hong Kong
Chen, Fei	The Chinese University of Hong Kong
Liu, Yunhui	Chinese University of Hong Kong

Keywords: Robotics, Control Applications, Motion Control
Abstract: Teleoperation control has been taken a pivotal role in robot-assisted surgical interventions. Unlike hand-eye coordination employed in the conventional laparoscopic systems, the eye-head coordination challenge arises with flexible robotic endoscopes, necessitating a distinct intuitive decision-making approach. In this paper, we introduce an intuitive teleoperation control scheme to address the eye-head coordination intricacies inherent in continuum endoscopic robots. The method achieves field of view (FOV) control consistent with surgeons' intuition for the robots based on the modeling of a virtual workspace (VW). By leveraging accurate shape feedback from embedded multi-core fiber Bragg gratings (FBGs), an observer-based anti-interference algorithm is implemented allowing a stable line of sight for robust motion control, even in challenging operational conditions with unknown disturbances. A class of robotic flexible endoscopes commonly used is analyzed specifically and deployed to validate the proposed approach. The efficacy and superiority of the proposed algorithm have been demonstrated through experimental results performed on a urology robotic system, encompassing trajectory tracking and disturbance resistance tasks.

16:00-16:15, Paper WeAT1.6	

Online Cooperative Optimal Power Scheduling of Multiple Microgrids Via Hierarchical Imitation Learning

Zhao, Yunyi	National University of Singapore
Gao, Shuhua	Shandong University
Wang, Jing	Shandong University
Li, Congcong	State Grid Shandong Electric Power Company Marketing Service Cen
Yu, Ming	Nanyang Technological University
Xiang, Cheng	National University of Singapore

Keywords: Energy Efficiency, Intelligent and AI Based Control, Optimal Control
Abstract: This paper looks into the issue of optimal power scheduling of multiple microgrids using hierarchical imitation learning. The system is designed to be a hierarchical learning model towards a two-level microgrid community (MGC) structure. The upper-level MGC agent uses an imitation learning algorithm to schedule exchange power between different microgrids, while lower-level microgrid agents are controlled by individual energy management systems using mixed-integer linear programming (MILP). In this paper, we focus on achieving economic dispatch in a large microgrid community while maintaining the privacy of the local microgrids. A simulation study of hierarchical imitation learning is provided based on an MGC system. Our results show the outstanding performance of the designed algorithm with a cost close to the centralized optimal results, about 10% improvement compared to the offline method, and very fast execution, which would be suitable for online power scheduling.

WeAT2	H101
Adaptive Control	Regular Session
Chair: Zhang, Yuxiang	Natioanl University of Singapore
Co-Chair: Turkay, Semiha	Eskisehir Technical University

14:45-15:00, Paper WeAT2.1	

Adaptive Model-Free Sliding Mode Control with Forgetting Factor for Stratospheric Airship

Sun, Yang	Beihang University
Zhu, Ming	Beihang University
Zhang, Yifei	Beihang University
Chen, Tian	Beihang University
Zheng, Zewei	Beihang University
Luo, Xinting	Beihang University

Keywords: Adaptive Control
Abstract: This work proposes a model-free adaptive sliding mode control strategy incorporating an adaptive forgetting factor for attitude stabilization of stratospheric airships subject to model uncertainties. First, to mitigate overshoot, oscillation, and slow convergence issues associated with the compact-form dynamic linearization based MFAC (CFDL-MFAC) technique for attitude regulation, an adaptive forgetting factor is introduced into the CFDL-MFAC architecture, constituting the CFDL-MFAC with variable forgetting factor method. Second, sliding mode control is synergistically integrated to ensure convergence properties of the overall scheme, with stability analysis provided to prove convergence. Finally, numerical simulations are conducted to validate the efficacy of the proposed adaptive model-free sliding mode control approach.

15:00-15:15, Paper WeAT2.2	

Model Predictive Control of Superbuck Converter Based on Digital Triplet

Xia, Qian	Tongji University
Zhu, Peng	Tongji University
Cui, Zhexin	Tongji University
Yue, Jiguang	Tongji University
Wu, Chenhao	Tongji University

Keywords: Adaptive Control, Control Applications, Intelligent and AI Based Control
Abstract: Long-term operation of the power converter causes flexible changes in its state, and the model predictive control (MPC) always fails to update the predictive control model and weights to guarantee control performance. Considering the conventional digital twin (DT) structure, the virtual model is hard to simulate the physical entity with high fidelity, establishing a highly matchable predictive control model. This paper proposes a model predictive control method of Superbuck converter based on digital triplet through the optimized weight factors. The proposed digital triplet constructs a parallel triplet between digital devices in the virtual twin and physical entity to enhance the fidelity of the overall DT system. It constructs the predictive control model and weights based on the dual optimization of the virtual twin and parallel triplet, achieving a

higher fidelity for the physical entity. Through the comparison of control performances on Superbuck converter between conventional MPC and DT, the proposed digital triplet empowers a more reliable and superior controller.

15:15-15:30, Paper WeAT2.3

Symbolic Regression Data-Model-Informed Eco-Control for Maritime Carbon Emissions Reduction

Leng, Yunze	National University of Singapore
Zhang, Yuxiang	Natioanl University of Singapore
Liu, Jiahang	National University of Singapore
Ge, Shuzhi Sam	National Univ. of Singapore
How, Bernard Voon Ee	Singapore Institute of Technology

Keywords: Adaptive Control, Energy Efficiency, Control Applications

Abstract: This paper proposes eco-control optimization with consideration of the physics model informed by data-model to emphasize the maritime carbon emissions reduction problem. More specifically, our work centers on developing and utilizing physics and symbolic regression data-model that capture the dynamics of ship engines and vessels. These models are then integrated with the optimization algorithm to plan the optimal trajectories. The primary objective is to enhance the environmental sustainability of maritime operations by significantly decreasing carbon emissions. To this end, we explore various aspects of ship dynamics, including the interactions between the hull, propeller, and engine, especially under the influence of regular wave patterns in acceleration mode. Symbolic regression is used to model fuel consumption parameters. Our approach leverages the power of optimized control, taking into account the continuous variability in external conditions and the need for adaptive response mechanisms. The results demonstrate that this method is critical in achieving greener maritime transportation without compromising on operational efficiency. This study not only contributes to the theoretical advancements in eco-friendly ship control but also provides a practical framework for implementing these strategies in real-world maritime operations.

15:30-15:45, Paper WeAT2.4

Disturbance Observer and Fault Estimator-Based Tracking Control of Wheeled Mobile Robot

Wu, Hao	Huazhong University of Science and Technology
Wang, Shuting	Huazhong University of Science and Technology
Zhang, Hongyang	Huazhong University of Science and Technology
Zhang, Sai	Huazhong University of Science and Technology
Jin, Jian	Huazhong University of Science and Technology
Xie, Yuanlong	Huazhong University of Science and Technology

Keywords: Automated Guided Vehicles, Motion Control, Adaptive Control

Abstract: This paper proposes the robust and accurate sliding mode tracking control problem of wheeled mobile robot (WMR) systems with uncertain disturbances and actuator faults. In the first part, an adaptive disturbance observer (ADOB) is designed to handle the uncertainties of the disturbance, without requiring any assumptions about disturbance boundary information. In the second part, a fault estimator is designed to estimate the actuator fault using the Lyapunov stability theory. It is presented that when ADOB and fault estimator-based SMC are applied, then the robustness and the tracking performance improve. This novel sliding mode tracking controller is robust toward uncertainty and fault, and reduces chattering. Simulations and experiments demonstrate the advantages of the tracking control performance and system robustness.

15:45-16:00, Paper WeAT2.5

MIMO-SLS Identification from Input-Output Data

Bencherki, Fethi	Lund University
Turkay, Semiha	Eskisehir Technical University
Akcay, Huseyin	Anadolu University

Keywords: Estimation and Identification, Nonlinear Systems and Control, Modeling and Control of Complex Systems

Abstract: In this paper, we propose a framework to identify discrete-time, multi-input/multi-output (MIMO), switched-linear systems (SLSs) from input-output data. The key step is an observer-based transformation to a switched auto-regressive with exogenous input (SARX) model. This transformation has a nontrivial kernel complicating identification, but it converts the state-space identification problem to a SARX model identification. Issues resulting from the transformation are carefully addressed by considering equivalance classes.

16:00-16:15, Paper WeAT2.6

A Strong Tracking and Robust Kalman Filter

Cong, Shuang	University of Sci. & Tech. of China
Song, Kangning	USTC

Keywords: Estimation and Identification, Adaptive Control, Control Applications

Abstract: In practical applications, only the output noise, but not the disturbance of the system, can be measured directly. In this case, the effectiveness of the designed Kalman filter is poor and even diverges because of the disturbance. In this paper, we make use of the improved Sage-Husa state disturbance statistical estimators to estimate the mean and variance of the system state disturbance in real time. To provide more robustness, the strong tracking Kalman filter algorithm is introduced to improve the variance of state prediction in time. For the velocity model of the gyro-stabilized platform with different positive and negative velocity model parameters, we verify the superiority and practicability of the algorithm proposed through comparative experiments under different system conditions in the simulation experiments. This paper designs a better Kalman filter with process disturbances and noise and provides a deep study and investigation by means of a comparative analysis of performance.

WeAT3	H103
Nonlinear Systems and Control	Regular Session
Chair: Xu, Xiang	Southern University of Science and Technology
Co-Chair: Iftar, Altug	Eskisehir Technical Univ

14:45-15:00, Paper WeAT3.1

Controller Design Using Extension for Nonlinear Time-Varying Systems

Iftar, Altug	Eskisehir Technical Univ
Turkay, Semiha	Eskisehir Technical University

Keywords: Nonlinear Systems and Control, Modeling and Control of Complex Systems

Abstract: Inclusion and extension principles are defined for nonlinear time-varying (NLTV) systems. Contractibility of dynamic NLTV controllers is also discussed and overlapping decompositions and controller design using overlapping decompositions are also presented. The approach involves first expanding an overlappingly decomposed NLTV system such that the expanded system is an extension of the original system. Since the subsystems of the expanded system appear as disjoint, a local controller can easily be designed for each subsystem. These local controllers form a decentralized controller for the overall expanded system. This overall controller can then be contracted for implementation on the original system. It is shown that, if the controller for the expanded system is designed to stabilize the expanded system, then the contracted controller stabilizes the original system.

15:00-15:15, Paper WeAT3.2

Prescribed Time Attitude Tracking Control of Unmanned Aerial Vehicles under Unknown Attacks and Input Saturation

Wang, Liping	South China University of Technology
Pei, Hai-Long	South China University of Technology

Keywords: Nonlinear Systems and Control, Modeling and Control of Complex Systems

Abstract: This paper addressed the prescribed time performance attitude tracking control problem of unmanned aerial vehicles under unknown attacks and input saturation. The attitude error dynamic model is constructed under the framework of Lie group SO(3). By integrating a prescribed time performance function with coordinate transformation, the tracking error can remain within a given region in a prescribed time. In the backstepping design process, a first-order sliding mode differentiator is given to overcome the explosion of complexity problem, and nonlinear disturbance observer is developed to deal with the unknown attacks and input saturation. A prescribed time performance attitude tracking control method is designed to ensure that all of the closed-loop signals are bounded. Finally, the superiority and effectiveness of the designed controller are stated by the simulation results.

15:15-15:30, Paper WeAT3.3

Observer-Driven Practical Stabilization of Switched Linear Autonomous Systems

Wang, Miaomiao	AMSS, CAS
Sun, Zhendong	Shandong University of Science and Technology

Keywords: Linear Systems, Nonlinear Systems and Control

Abstract: For a switched linear autonomous system with measured output, the design of an observer-driven stabilizing switching law is investigated. The problem is challenging due to the fact that the introduction of an observer might lead to the Zeno phenomenon of the switching signal. In this work, we propose an observer-driven switching strategy to make the switched system practical stable as well as to prevent the switching from chattering. A numerical example is presented to verify the effectiveness of the proposed scheme.

15:30-15:45, Paper WeAT3.4

Analysis and Control of Chaotic Behaviour in Buck-Boost Converters Based on the Caputo-Fabrizio Fractional Derivative

Liao, Xiaozhong	Beijing Institute of Technology
Wang, Yong	Beijing Institute of Technology
Yu, Donghui	Beijing Institute of Technology

Keywords: Nonlinear Systems and Control, Modeling and Control of Complex Systems, Control Applications

Abstract: This paper investigates the chaotic behavior of a transformer circuit using the proposed discrete iterative mapping of Caputo-Fabrizio definition-based fractional-order Buck-Boost converter, and proposes a chaos control method based on slope compensation.Initially, a discrete-time iterative mapping model for the Caputo-Fabrizio definition-based fractional-order Buck-Boost converter is established. Subsequently, the influence of inductor and capacitor orders on circuit bifurcation and chaotic behavior is analyzed using the Lyapunov exponents. Finally, a chaos control method based on slope compensation is proposed. Simulation results demonstrate consistency between the circuit's chaotic behavior and theoretical analysis, and the proposed chaos control method effectively extends the stable period-1 operation of the Caputo-Fabrizio definition-based fractional-order Buck-Boost converter.

15:45-16:00, Paper WeAT3.5

High-Precision Tracking Control of Modular Dielectric Elastomer Actuators through Kalman Filter Base Self-Adaptive Direct Inverse Hysteresis Compensation

Xiao, Bohao	Shanghai Jiao Tong University
Gu, Guo-Ying	Shanghai Jiao Tong University
Zou, Jiang	Shanghai Jiao Tong University

Keywords: Nonlinear Systems and Control, Modeling and Control of Complex Systems, Robotics

Abstract: This work proposes a Kalman filter based direct inverse hysteresis compensation approach for modularized dielectric elastomer actuators (DEAs) with rate-dependent viscoelasticity, mechanical vibration, and individual variation. To this end, we firstly investigate the dynamics of three modularized DEAs, including viscoelasticity, mechanical vibration, and their individual variation. Then, based on a rate-independent phenomenological hysteresis model, a direct inverse hysteresis compensation (DIHC) is established to eliminate the hysteresis effect. Further, a feedback controller is adopted to remove the creep and model uncertainty. Lastly, a Kalman filter is employed to automatically adjust the parameter of the DIHC, capable of achieving high-precision tracking control of modular DEAs within a wide frequency range. To verify the effectiveness of our control strategy, three modularized DEAs are employed to track periodical trajectories with different frequencies (in a range of 0.1Hz to 10Hz). The experimental results demonstrate that the Kalman filter based controller can fully eliminate the rate-dependent viscoelasticity, mechanical vibration, and individual difference, achieving high-precision tracking control of modular DEAs in a wide frequency range. The maximum error and root mean square error are reduced from 20.16% and 11.44% to 9.87% and 5.22%, respectively.

16:00-16:15, Paper WeAT3.6

Distributed Time-Varying Optimization with Equality Constraints

Yang, Zheng	Xiamen University

Ma, Ji	City University of Hong Kong
Xu, Xiang	City University of Hong Kong

Keywords: Nonlinear Systems and Control, Multi-agent Systems
Abstract: In this paper, we consider the distributed timevarying optimization problem with coupled equality constraints over a connected undirected network. To address this issue, we design a novel distributed constraint optimization algorithm, and establish its ISS stability with external disturbances and tracking errors as the input and state, respectively. Moreover, the obtained result includes distributed constrained optimization with static objective functions as a special case. In comparison to existing relevant works, the proposed algorithm demonstrates exponential convergence for cases involving static objective functions. Finally, the theoretical results are validated via a numerical example.

WeAT4	H104
Control Applications	Regular Session
Chair: Duan, Haibin	Beihang University
Co-Chair: Rodrigues, Luis	Concordia University

14:45-15:00, Paper WeAT4.1	

Unmanned Aircraft Path Planning Using Air Traffic Density

Li, Steven	Concordia University
Chang, Josh	Carleton University
Chavda, Nishkarsh	Carleton University
Borshchova, Iryna	NRC
Laliberte, Jeremy	Carleton University
Rodrigues, Luis	Concordia University

Keywords: Control Applications
Abstract: Path planning algorithms that can account for the complexity of the airspace are imperative for operations of unmanned air traffic in Advanced Air Mobility applications such as parcel delivery, air taxis, and medical transport. This paper proposes an algorithm based on Rapidly-exploring Random Trees Star (RRT*) to plan paths for unmanned aircraft navigating in environments with solid and permeable obstacles. Thresholding in the collision-checker and distance-dependent penalties in the objective function of RRT* are introduced in the algorithm. The path planner is applied to the case where estimated air traffic density data is used to define the permeability of obstacles. The capabilities of the algorithm and the applicability to the air traffic density case study are demonstrated through simulations of flight scenarios around an international airport.

15:00-15:15, Paper WeAT4.2	

Development and Implementation of a Wastewater-Treatement-Plant Model for Optimization Purposes

Karer, Gorazd	University of Ljubljana
Vrecko, Darko	Department of Systems and Control, Jozef Stefan Institute
Hvala, Nadja	Jožef Stefan Institute, Jamova Cesta 39, 1000 Ljubljana
Skrjanc, Igor	University of Ljubljana

Keywords: Control Applications, Fuzzy and Neural Systems, Estimation and Identification
Abstract: Wastewater treatment facilities represent intricate systems designed to mitigate the environmental impact of wastewater discharge. However, their operation necessitates substantial energy input. Therefore, it is imperative to ensure both the adequacy of treated water quality and the minimization of energy consumption.

In this study, we introduce a methodological framework for developing a neuro-fuzzy model tailored for optimization applications within wastewater treatment plants. We have leveraged this model within a straightforward optimization scheme, implementing it on the standardized BSM2PSFe benchmark model of wastewater treatment plant. Through comparative analysis, our algorithm demonstrates tangible enhancements in performance over the conventional approach currently used in practice. These findings suggest the feasibility of extending our proposed methodology to broader applications across diverse wastewater treatment plant configurations.

Given the intricate nature of the BSM2PSFe model and the successful development of a practical model using our proposed approach, it is reasonable to anticipate favorable outcomes upon its application to various real-world wastewater treatment facilities.

15:15-15:30, Paper WeAT4.3	

Fuzzy System-Based Enhanced Active Disturbance Rejection Control in Application to High Precision Tracking Systems with Disturbances and Measurement Noises

Wang, Haolin	Institute of Optics and Electronics, Chinese Academy of Sciences
Mao, Yao	Chinese Academy of Sciences
Bao, Qiliang	Institute of Optics and Electronics, Chinese Academy of Sciences
Deng, Jiuqiang	Chinese Academy of Sciences

Keywords: Control Applications, Fuzzy and Neural Systems, Motion Control
Abstract: In the control task of high precision tracking system (HPTS), the line-of-sight (LOS) stabilization is severely affected by disturbances and measurement noises. Inspired by the successful use of active disturbance rejection control (ADRC) in HPTS, based on the framework of cascade control, we propose a fuzzy system-based ADRC strategy. Besides, by rationally designing the inner-loop velocity controller we realize the equivalent reduce-order of the position-controlled plant and the ADRC-based strategy is taken in the outer loop to improve the disturbance rejection ability. Compared with ADRC, the proposed method takes the structure of the cascade control which has excellent disturbance rejection ability by stacking the disturbance rejection ability of inner and outer loops. Considering the measurement noises, by introducing a fuzzy system in the ADRC, the outer loop controller is transformed into a novel fuzzy self-tuning structure to filter high-frequency noise. Several experiments and simulations have to prove the effectiveness of the proposed method.

15:30-15:45, Paper WeAT4.4	

Prescribed Performance Evolution Control for VTOL UAVs Tracking a Moving Ship

Yuan, Yang	Beihang University
Wei, Chen	Beijing University of Aeronautics and Astronautics
Duan, Haibin	Beihang University

Keywords: Control Applications, Motion Control
Abstract: An output constrained control method for the vertical take-off and landing (VTOL) unmanned aerial vehicles (UAVs) tracking a moving ship is proposed in this paper. The evolution path theory is introduced to narrow down the convergence region of the prescribed performance control (PPC) to obtain better dynamic performance. In addition, the ffxed-time observer is adopted to deal with the external disturbance and actuator failure, and the ffxed-time fflter is used as reference model. The stability of the proposed method is veriffed by the Lyapunov function, and the comparative simulation has exhibited its superiority.

15:45-16:00, Paper WeAT4.5	

Pseudo Youla-Kucera Parameterization for Nonminimum-Phase System: Application to Line-Of-Sight Stabilization

Deng, Jiuqiang	Chinese Academy of Sciences
Duan, Qianwen	Institute of Optics and Electronics, Chinese Academy of Sciences
Bao, Qiliang	Institute of Optics and Electronics, Chinese Academy of Sciences
Mao, Yao	Chinese Academy of Sciences

Keywords: Control Applications, Motion Control
Abstract: The disturbance reduces the pointing accuracy of line-of-sight (LOS) stabilization system. The current Youla-Kucera (YK) parameterization is unstable for the nonminimum-phase LOS stabilization system. This work proposes a novel pseudo Youla-Kucera (PYK) parameterization that is appropriate for the nonminimum-phase system. A rectified controller is presented to correct the undesirable nonminimum-phase characteristics. Of the proposed PYK parameterization, the YK parameterization is a particular instance. For both the minimum-phase and nonminimum-phase systems, the PYK parameterization is appropriate. Since the nonminimum-phase LOS stabilization system has a higher bandwidth than the minimum-phase one, the PYK parameterization delivers stronger disturbance suppression performance, as shown in experiments.

16:00-16:15, Paper WeAT4.6	

Electromechanical Product Service Optimization in Cloud-Based Design: A Two-Stage Method for Task Allocation

Tao, Wei	Tongji University
Cui, Zhexin	Tongji University
Yue, Jiguang	Tongji University
Wu, Chenhao	Tongji University

Keywords: Fuzzy and Neural Systems, Control Applications, Integrated Manufacturing
Abstract: Cloud-based design (CBD) aims to achieve collaborative design based on crowdsourcing and efficient resource configuration. However, with the increasing complexity of electromechanical product, and a large number of knowledge-based labor resources with significant differences in expertise, the difficulty of task allocation in cloud platforms has surged. The problems such as time-consuming computation, and poor matching are highlighted. Efficient and precise task allocation faces great challenges. This article proposes a two-stage method for task allocation to optimize the matching between tasks and labor resources. To simplify the allocation complexity, the task module and candidate service pool are established based on relationship analysis, fuzzy clustering, and service aggregation in the first level. The second level proposes the capability and collaboration-based task allocation (CCBTA) model to achieve matching and collaboration of design resources. Besides, an improved adaptive genetic algorithm (IAGA) is presented to enhance the global optimization performance of the CCBTA model. Finally, a case study for the design task allocation of the tailplane control system is performed to verify the effectiveness of the proposed method.

WeBT1 **Best Student Paper Finalists Session**	H102 Regular Session
Chair: Shi, Yang	Canada
Co-Chair: Lin, Zongli	University of Virginia

16:30-16:45, Paper WeBT1.1	

Adaptive Multi-Core Real-Time Scheduling Based on Reinforcement Learning

Liang, Yonghui	Shanghai Jiaotong University
Li, Hui	Shanghai Jiao Tong University
Shen, Fei	Shanghai Institute of Microsystem and Information Technology, Ch
Xu, Qimin	Shanghai Jiao Tong University
Hua, Shuna	North Information Control Research Academy Group Co., Ltd
Zhu, Shanying	Shanghai Jiao Tong University

Keywords: Real-time Systems, Linear Systems
Abstract: With the transformation towards industrial intelligence, multi-core processors are increasingly being applied in real-time networked control systems to ensure secure execution of sensing, computing and actuating tasks under time constraints. However, exiting scheduling methods result in either low CPU utilization or many missed task deadlines in dynamic systems. In this paper, we propose a two-layer scheduling architecture to address this issue by fully exploring the complex dependency between real-time tasks. To be specific, the local layer determines task execution priorities considering both dependency between tasks and deadline constraints by utilizing a reinforcement learning approach. Moreover, to better utilize the parallel capabilities of multi-core processors and reduce temporal collisions, this paper minimizes the requested core count for the task set based on a greedy strategy. The global layer designs a scheduling algorithm based on the preempt method and provides schedulability analysis of multiple task sets. Experimental results validate the correctness of the proposed scheduling approach, and efficiency is demonstrated through comparisons with baseline method.

16:45-17:00, Paper WeBT1.2	

TRACE: Trajectory Refinement with Control Error Enables Safe and Accurate Maneuvers (I)

Yang, Zihan	Beihang University
Jia, Jindou	Beihang University
Liu, Yuhang	Beihang University

Guo, Kexin	Beihang University
Yu, Xiang	Beihang University

Keywords: Optimal Control, Nonlinear Systems and Control, Robotics

Abstract: Normal trajectory optimizations are carried out without the consideration of the closed-loop feasibility and performance. During aggressive flights, bias from the nominal trajectory could trigger feedback with larger control inputs, which might break through the actuator constraints, inducing stability issues. By leveraging the idea of TRAjectory refinement with Control Error (TRACE) for higher closed-loop performance, we develop a post-trajectory optimization approach for safe and accurate tracking control. A closed-loop model is established combining both control policy and saturations in order to model the dynamic progress of trajectory tracking. Subsequently, a time-varying optimal control problem (OCP) is constructed to enhance the tracking performance by weighted minimizing the tracking error and the variation from the nominal trajectory progress. Meanwhile, a flatness-based method is presented to provide aggressive time-optimal trajectories with high-order derivatives of the reference states. Examples show the effectiveness of our approach in refining aggressive trajectories, where safe and accurate tracking can be done using a baseline controller without fine-tuning and further control allocation design.

17:00-17:15, Paper WeBT1.3	

NARX Model-Based Data-Driven Secure Control for UMVs under Asynchronous DoS Attacks

Liu, Huiying	Dalian Maritime University
Hao, Liying	Dalian Maritime University
Li, Hui	Dalian Maritime University
Li, Tieshan	Dalian Maritime University
Wang, Dan	Dalian Maritime University

Keywords: Intelligent and AI Based Control

Abstract: In this paper, based on nonlinear auto-regressive model with exogenous inputs (NARX) neural network, a resilient data-driven multi-step error feedback secure control method is designed for unmanned marine vehicles (UMVs). And the asynchronous DoS attacks are considered in Sensor-Controller channel and Controller-Sensor channel. Significantly, the success probability of these DoS attacks varies due to energy constraints across distinct channels. To mitigate the negative impart of DoS attacks, an NARX model-based predictor is devised. And the predict error are considered to design control scheme, enhancing the control effect for UMVs under asynchronous DoS attacks. What's more, a resilient partial form multi-step error feedback control (PFMSEFC) method is designed by incorporating the proportional control term, the different control term, and the quadratic difference control term, which improves the utilization of historical tracking error information and enhance the flexibility of the control scheme. Finally, the effectiveness of the proposed resilient NARX predictive model-based PF-MSEFC scheme is demonstrated through a simulation example.

17:15-17:30, Paper WeBT1.4	

Cooperative Source Seeking for Uncertain Networked Euler–Lagrange Systems Over Unbalanced Digraphs

Wang, Lu	City University of Hong Kong
Liu, Lu	City University of Hong Kong

Keywords: Optimal Control, Multi-agent Systems, Nonlinear Systems and Control

Abstract: This work investigates the cooperative source seeking problem for uncertain networked Euler–Lagrange (EL) systems over unbalanced digraphs. The objective is to drive all agents towards the source of scalar fields. To achieve this, a novel distributed control protocol is proposed, which consists of two components: a distributed optimizer that generates a virtual reference trajectory towards the source, and a trajectory tracker that drives each agent exponentially towards this trajectory. Complemented by the exponential trajectory tracker, the stochastic extremum seeking techniques can be employed to estimate the gradient information from the strength of the scalar field in the optimizer. However, this approach introduces a new coupling term to the optimizer at the same time, which requires careful consideration in the convergence analysis. Leveraging stochastic averaging theory, the exponential practical stability then can be guaranteed for the entire closed-loop system. Finally, the effectiveness of the proposed control protocol is demonstrated by a numerical example.

17:30-17:45, Paper WeBT1.5	

Online Distributed Newton Step Algorithm for Multi-Agent Optimization Over General Unbalanced Networks

Wu, Jiayi	Hangzhou Dianzi University
Tian, Yu-Ping	Southern University of Science and Technology

Keywords: Multi-agent Systems

Abstract: This paper studies distributed online optimization over multi-agent networks. Agents work together to optimize the global loss function, which can be expressed as the sum of the local loss functions of all agents. All local loss functions change with time, and information about the loss function can only be obtained after the agent has made a decision. For such a scenario, the performance of many current algorithms will be challenged if the communication topology is unbalanced because, in this case, the contribution share of each agent in the optimization process is not equal to its share in the total loss function. We designed a distributed online Newton step algorithm in unbalanced networks, which add an additional auxiliary variable to scale the share of each agent's contribution in the algorithm. The algorithm uses only row-stochastic matrix instead of double stochastic matrix, and guarantees the logarithmic convergence of regret for α-exp concave loss functions. Simulation results show the effectiveness of the proposed algorithm in unbalanced topology.

17:45-18:00, Paper WeBT1.6	

Safe Stabilization with Model Uncertainties: A Universal Formula with Gaussian Process Learning (I)

Li, Ming	Eindhoven University of Technology
Sun, Zhiyong	Eindhoven University of Technology

Keywords: Nonlinear Systems and Control, Robotics, Learning-based Control

Abstract: A combination of control Lyapunov functions (CLFs) and control barrier functions (CBFs) forms an efficient framework for addressing control challenges in safe stabilization. Developing an analytical control strategy, known as the universal formula approach, which integrates CLF and CBF conditions, is recognized as a computationally efficient method for achieving safe stabilization. However, successful implementation of this universal formula relies on an accurate model, as any mismatch between the model and the actual system can compromise stability and safety. In this paper, we propose a new universal formula that leverages Gaussian processes (GPs) learning to address the safe stabilization problem in the presence of model uncertainty. By utilizing the results related to bounded learning errors, we achieve a high probability of stability and safety guarantees with the proposed

universal formula. Additionally, we introduce a probabilistic compatibility condition to evaluate conflicts between the modified CLF and CBF conditions with GP learning results. In cases where compatibility assumptions fail, we propose a modified universal formula that relaxes stability constraints. We illustrate the effectiveness of our approach through a simulation of adaptive cruise control (ACC), highlighting its potential for practical applications in real-world scenarios.

WeBT2	H101
Optimal and Learning-Based Control	Regular Session
Chair: Li, Yuzhe	Northeastern University, China
Co-Chair: Fu, Minyue	Southern University of Science and Technology

16:30-16:45, Paper WeBT2.1	

Decentralized Optimal Control for Linear Stochastic Systems with Control Signals Subject to Unknown Noises

Zhang, Zhaorong	University of Newcastle
Xu, Juanjuan	Shandong University
Fu, Minyue	Zhe Jiang University
Li, Xun	Hong Kong Polytechnic University

Keywords: Learning Systems, Optimal Control, Linear Systems
Abstract: Decentralized strategies have been extensively applied to LQ optimal control problems, whereas stochastic systems with unknown random parameters have not been comprehensively studied. In this paper, we consider a class of stochastic systems with a decentralized configuration consisting of multiple controllers which have access to Gaussian noises with unknown statistical information. The stabilizing and optimal control strategies are acquired by designing a novel stochastic approximation algorithm recursively evaluating the zero points of certain matrix equations, which is confirmed to be equivalent with solving the corresponding Riccati equations. The proof of convergence and boundness of the proposed algorithm is presented.

16:45-17:00, Paper WeBT2.2	

Neural-Network-Based Optimal Guidance for Lunar Vertical Landing

Wang, Kun	Zhejiang University
Chen, Zheng	Zhejiang University
Lu, Fangmin	Zhejiang University
Li, Jun	Zhejiang University

Keywords: Optimal Control, Learning-based Control, Automated Guided Vehicles
Abstract: This paper addresses an optimal guidance problem concerning the vertical landing of a lunar lander with the objective of minimizing fuel consumption. The vertical landing imposes a final attitude constraint, which is treated as a final control constraint. To handle this constraint, we propose a nonnegative small regularization term to augment the original cost function.This ensures the satisfaction of the final control constraint in accordance with Pontryagin's Minimum Principle. By leveraging the necessary conditions for optimality, we establish a parameterized system that facilitates the generation of numerous optimal trajectories, which contain the nonlinear mapping from the flight state to the optimal guidance command. Subsequently, a neural network trained by the mapping is able to generate the optimal guidance command in milliseconds. Finally, numerical examples are presented to validate the proposed method, showing that the vertical landing can be achieved with the cost of negligible extra fuel consumption.

17:00-17:15, Paper WeBT2.3	

Learning-Based Optimal Guidance for Hypersonic Reentry Using a Barrier Function

Ma, Haoran	Zhejiang University
Chen, Zheng	Zhejiang University
Wang, Kun	Zhejiang University

Keywords: Optimal Control, Learning-based Control, Intelligent and AI Based Control
Abstract: This paper investigates the optimal guidance for hypersonic vehicles to achieve the maximum downrange. To handle the complex constraints during the reentry flight, we design a novel barrier function. By incorporating it into the cost function, the optimal control problem with state and control constraints is converted into a non-constrained optimal control problem. Utilizing the optimal conditions derived from Pontryagin's Minimum Principle, a parameterized differential system is established so that the propagation of the differential system gives an extremal trajectory. By traversing the system parameters, numerous optimal trajectories can be generated, which contains sufficient state-control samples. A neural network trained by the samples is capable of approximating the mapping from states to optimal guidance commands. Finally, the performance of the proposed method is validated through numerical simulations.

17:15-17:30, Paper WeBT2.4	

Learning-Based Optimal Entry Guidance with Path Constraints

Lu, Fangmin	Zhejiang University
Chen, Zheng	Zhejiang University
Wang, Kun	Zhejiang University

Keywords: Optimal Control, Learning-based Control, Nonlinear Systems and Control
Abstract: This work is dedicated to generating optimal guidance commands for entry vehicles subject to path constraints. A multi-constrained nonlinear optimal control problem for maximizing the terminal speed of the entry vehicle is formulated and converted into a regularized equality-constrained one using the saturation function method. Subsequently, a parameterized system is established based on the necessary conditions derived from Pontryagin's Minimum Principle. This enables the efficient generation of optimal state-control samples, crucial for training Neural Networks (NNs) in the supervised learning framework. Finally, the performance of the learning-based entry guidance algorithm is numerically presented.

17:30-17:45, Paper WeBT2.5	

Multi-Objective Derivative-Free Optimization Based on Hessian-Aware Gaussian Smoothing Method

Chen, Ran	Northeastern University
Li, Yuzhe	Northeastern University, China
Chai, Tianyou	Northeastern University

Keywords: Process Automation, Modeling and Control of Complex Systems
Abstract: Most deterministic multi-objective optimization algorithms

assume that the analytical objective functions and multi-objective gradients are available. However, there may be no available or explicit mathematical model for many real-world optimization problems. These problems are difficult to handle since the evaluations of gradients are inexact or even infeasible, which are termed derivative-free (or zeroth-order) optimization problems. While extensive research in multi-objective optimization has been considered to tackle such problems, in most cases, the computational complexity may increase when the number of decision variables is large, which may also lead to a worse performance of solutions. In this work, a multi-objective derivative-free optimization problem was studied. We proposed a Hessian-aware Gaussian smoothing method to evaluate descent direction and produce new candidates for searching the Pareto front. The corresponding convergence rate of candidates produced by the Hessian-aware Gaussian smoothing method was analyzed explicitly. In particular, we compared different multi-objective optimization algorithms and illustrated their performance on 70 benchmarks, showing the proposed algorithm's effectiveness.

17:45-18:00, Paper WeBT2.6	

Practical Prescribed-Time Edge-Based Fully-Distributed Nash Equilibrium Seeking Based on Time Base Generator

Chen, Yiyang	Beihang University
Hua, Yongzhao	Beihang University
Feng, Zhi	Beihang University
Dong, Xiwang	Beihang University

Keywords: Multi-agent Systems, Adaptive Control
Abstract: This paper proposes a practical prescribed-time edge-based fully-distributed Nash equilibrium seeking algorithm where no global gain is utilized. In order to achieve practical prescribed-time convergence, the time base generator (TBG) is involved in the gradient descent part, the observation part and the parameter updating part of the algorithm. The update rates of the two types of adaptive parameters are coupled with the information of the edges of the communication graph. Besides, an exponential parameter is designed and the parameter increases more mildly by utilizing the TBG. A Lyapunov function is constructed to show the practical prescribed-time convergence property. The simulation results of an energy consumption game are provided to illustrate the effectiveness of the algorithm.

WeBT3	H103
Networked Control	Regular Session
Chair: Zhu, Bing	Beihang University

16:30-16:45, Paper WeBT3.1	

Game-Theoretic Demand-Side Management and Robust Optimal Control for a Class of Networked Smart Grid

He, Yuxuan	Beihang University
Zhu, Bing	Beihang University

Keywords: Energy Efficiency, Networked Control, Optimal Control
Abstract: In this paper, a robust optimal control algorithm is proposed for the demand-side management of a class of smart grid in case of the uncertainties which are due to fake information of grid users. By using matrix semi-tensor product, the smart grid under consideration is modeled into networked evolutionary game. In the proposed method, the robust closed-loop control by using stacked structural matrix is upgraded with dynamic programming, such that the transient performance of the network can be improved in the presence of uncertainties. The feasibility of the method is proved and supported by a numerical example.

16:45-17:00, Paper WeBT3.2	

Deep Reinforcement Learning-Based Behaviour Generation Algorithm for Air Combat Escape Intention

Wang, Xingyu	Nothwestern Polytechnical University
Yang, Zhen	Nothwestern Polytechnical University
Li, Xiaoyang	Nothwestern Polytechnical University
Chai, Shiyuan	Nothwestern Polytechnical University
He, Yupeng	Nothwestern Polytechnical University
Zhou, Deyun	Nothwestern Polytechnical University

Keywords: Intelligent and AI Based Control, Motion Control, Networked Control
Abstract: Although deep reinforcement learning applied to air combat has achieved good results, it still faces a series of challenges such as reward design, convergence of suboptimal solutions, and poor stability. In this regard, this paper proposes a behaviour generation algorithm based on Dueling-Noisy-Multi-step DQN for air combat under escape intent. By analysing the air combat confrontation process, we extract the escape intention features and establish the corresponding reward model; for the problem of poor stability and slow convergence of deep reinforcement learning algorithms in large-scale state-action space, we propose the Dueling-Noisy-Multi-step DQN algorithm, which improves the accuracy of the value function fitting and at the same time increases the efficiency of spatial exploration and network generalization. Comparison with other algorithms through simulation experiments, the results reflect the excellent performance of this paper's algorithm.

17:00-17:15, Paper WeBT3.3	

Dynamic Event-Triggered Prescribed Performance Control for Quadrotor Aggressive Flight

Wu, Zeliang	Beijing Institute of Technology
Song, Tao	Beijing Institute of Technology
Ye, Jianchuan	Tsinghua University

Keywords: Nonlinear Systems and Control, Control Applications, Modeling and Control of Complex Systems
Abstract: Aggressive flight is the central prerequisite to expanding the application of quadrotors into complex and agile tasks. Its most notable aspect is the mutation of task commands, which demands not only flight stability but also specific constraints on the quadrotor's dynamics performance, such as convergence speed and overshoot. Although traditional prescribed performance control (PPC) methods are highly anticipated, but system divergence may occur when tracking errors exceed bounds during command mutations to the quadrotor. This paper proposes a dynamic event-triggered PPC flight controller, that overcomes this limitation and improves the quadrotor's response and convergence speed to sudden command mutations, while also suppressing overshoot. Stability analysis was completed, and the motivation behind the study was confirmed through simulation.

17:15-17:30, Paper WeBT3.4	
Performance-Guaranteed Multi-Train Cooperative Control Using Event-Triggered and Sign-Rectified Regressor	
Zheng, Yue	Beijing Jiaotong University
Gao, Shigen	Beijing Jiaotong University
Zhang, Zixuan	Beijing Jiaotong University
Song, Xiying	Beijing Jiaotong University
Dong, Hairong	Beijing Jiaotong University

Keywords: Nonlinear Systems and Control, Fuzzy and Neural Systems, Modeling and Control of Complex Systems

Abstract: This paper presents a performance-guaranteed method of cooperative tracking for multiple high-speed trains while considering computational resource limitations and security constraints. First, the prescribed performance control is employed to transform constrained train states into an unconstrained format. Radial basis function neural networks are used to efficiently approximate the unknown resistance, and an innovative sign-rectified regressor neural network update strategy is employed to significantly improve computational efficiency and ensure high estimation accuracy even with limited neuron number and weak excitation. Secondly, an event-triggered mechanism is designed to determine the timings of updates for the train controller and neural network, adapted for on-board computational resource limits. Subsequently, the triggering conditions for each train are then designed to facilitate a safe cooperative control method, which combines an event-triggered processor with a performance control protocol that ensures limited state tracking error within a predefined performance function. Finally, in order to validate the effectiveness of the proposed scheme, we applied the control strategy in simulation experiments using collected data from the high-speed railway line.

17:30-17:45, Paper WeBT3.5	
Robust Data-Driven Control against Actuator FDI for Unknown Linear Systems	
Liu, Wenjie	Beijing Institute of Technology, Beijing, China
Sun, Jian	Beijing Institute of Technology
Deng, Fang	Beijing Institute of Technology
Wang, Gang	Beijing Institute of Technology
Chen, Jie	Tongji University

Keywords: Networked Control, Learning-based Control, Linear Systems

Abstract: This paper designs a data-driven controller for unknown linear systems whose actuators suffer from false data injection (FDI) attacks, using only noisy input-state data. To achieve this objective, a general FDI attack model is introduced, which imposes constraints only on the switching frequency of attack channels and the magnitude of attack matrices. A time-varying state feedback control law is designed based on offline and online input-state data, which adapts to the channel switching of FDI attacks. This is achieved by solving a data-based semi-definite programs (SDPs) on-the-fly such that stabilizing the set of subsystems consistent with both offline clean data and online attack-corrupted data. It is shown that under mild conditions on the attack and the noise, the feasibility of the proposed SDP guarantees that the controller stabilizes the attack-corrupted system. A numerical example is presented to validate the effectiveness of the proposed method.

17:45-18:00, Paper WeBT3.6	
A Segmented Sliding Window-Based Comprehensive Periodic Feature Extraction Method for APT Classification	
Song, Wei	Southeast University
Wu, Tiejun	Southeast University
Zhang, Ya	Southeast University

Keywords: Intelligent and AI Based Control, Networked Control, Fault Detection and Diagnostics

Abstract: This paper studies the classification problem of Advanced Persistent Threat (APT) attacks and proposes a comprehensive periodic feature extraction method based on sliding window division. A new data processing approach is proposed. Considering the characteristics of APT attacks, the life cycle of APT traffic data is divided into three stages. The traffic data from each stage is sampled in a piecewise manner and divided into separate training and testing sets, and then the training and testing subsets are merged. For the integrated sets, a sliding window-based partition approach is employed to obtain training and testing window samples, while extracting features from each individual sample. Then, this paper proposes a differential-based periodic feature extraction methodology to capture the dynamic information present in APT traffic and integrate it with fundamental static features, thereby forming effective comprehensive features. After combining these static and differential features, a comprehensive foundation is established for model training. Finally, the effectiveness of the algorithm is verified using decision tree model, and its superiority is demonstrated by comparing it with traditional partition methods based on data streams.

WeBT4	H104
Control Applications (II)	Regular Session
Chair: Yakimenko, Oleg A.	Naval Postgraduate School
Co-Chair: Skrjanc, Igor	University of Ljubljana

16:30-16:45, Paper WeBT4.1	
Optimization Based MPC Concept for Plate Heat Exchanger Plant	
Vegelj, Aleksander	University of Ljubljana
Skrjanc, Igor	University of Ljubljana

Keywords: Control Applications, Linear Systems, Nonlinear Systems and Control

Abstract: In this study, we present the concept of predictive functional control as a methodology for control design and investigate the influence of parameters on the closed-loop response. The control method incorporates constraint handling and calculates the optimal control signal numerically by using particle swarm optimization. The influence of the predictive functional control parameters and model parameter mismatch were investigated on a second-order linear process with input signal constraints. The influence of the parameters of the first-order linear model and the parameters of predictive functional control were also investigated on a simulated plate heat exchanger plant with input signal constraints. The methodology of control can easily be implemented for control of a real plate heat exchanger.

16:45-17:00, Paper WeBT4.2	
Skyhook Controller Design for the Lateral and Vertical Suspension of a Railway Trailer	
Leblebici, Asli Soyic	Osmangazi University

Turkay, Semiha	Eskisehir Technical University

Keywords: Control Applications, Modeling and Control of Complex Systems, Motion Control
Abstract: This paper proposes semi-active control strategies aimed at improving the ride quality of a railway trailer by addressing both lateral and vertical motion. The chosen methodology involves the utilization of the combined sky-hook control method, with the assessment of ride quality conducted through numerical simulations on the Konya-Polatl{i} high-speed mainline in Turkey. The performance evaluation of the railway trailer encompasses two configurations: one with a passive suspension system and the other with a semi-active suspension system. The numerical simulations demonstrate that the incorporation of combined lateral and vertical control allows the vehicle to attain a speed of 180 km/h while maintaining the same or even superior levels of ride quality compared to the passive configuration. The simulation results further indicate that the implementation of the semi-active control strategy eliminates the necessity for additional mechanical power to operate the active suspension.

17:00-17:15, Paper WeBT4.3	

Robust Adaptive Finite-Time Attitude Tracking with an Unknown Inertia Matrix and Disturbance

Garanayak, Chinmay	IIT Bombay

Keywords: Control Applications, Nonlinear Systems and Control
Abstract: This paper proposes a novel finite-time attitude-tracking controller when the system dynamics are affected by unknown constant disturbances. Also, the inertia matrix and the disturbances affecting the dynamics are unknown. Finite-time attitude tracking for uncertain spacecraft systems is an interesting problem. Due to the inherent non-linear nature of the problem, it becomes challenging to design finite-time attitude-tracking controllers. Hence, we have designed an adaptive control-based finite-time attitude-tracking controller. First, a fixed-time sliding surface was proposed, and hence, after reaching the sliding surface, the attitude tracking error goes to zero in fixed-time. Then, the control torque, which contains adaptive parameter updates for the unknown system inertia matrix, is designed. The control torque ensures that the attitude tracking error reaches the sliding surface in finite time despite the unknown inertia matrix and unknown constant disturbances present in the dynamics so that finite-time attitude tracking can be achieved. Simulations are presented to validate the theoretical results.

17:15-17:30, Paper WeBT4.4	

A Non-Singular Terminal Sliding Mode Control Approach for a 7 Degree-Of-Freedom Hydraulic Manipulator

Shanahan, Declan	Lancaster University
Montazeri, Allahyar	Lancaster University

Keywords: Control Applications, Nonlinear Systems and Control, Modeling and Control of Complex Systems
Abstract: This paper presents an approach for non-singular terminal sliding mode control of a 7-DOF hydraulic manipulator. Three sliding mode reaching laws including the tan hyperbolic function and a continuous power law are designed, analysed using the Lyapunov stability theory and simulated. The derivation makes use of component-wise notation to aid in coupling the multichannel inputs to the hydraulic subsystem. The performance of three control sliding surfaces, with the coupled dynamics of the manipulator links are investigated. Dynamics of the hydraulic actuator are derived along with analysis of the joint geometry to relate the control inputs to joint torques. The derived analytical model of the manipulator is validated using experimental data. Finally, the three NTSMC variants using the validated 7-DOF model of the hydraulically actuated robot are analysed/compared in MATLAB/Simulink environment.

17:30-17:45, Paper WeBT4.5	

Traffic Signal Control for Large-Scale Urban Traffic Networks: Real-World Experiments Using Vision-Based Sensors

Park, Jiho	New York University
Liu, Tong	New York University
Wang, Chieh	Oak Ridge National Laboratory
Wang, Hong	Oak Ridge National Laboratory
Wang, Qichao	National Renewable Energy Laboratory
Jiang, Zhong-Ping	New York University

Keywords: Control Applications, Optimal Control, Sensor/Data Fusion
Abstract: Effective control of traffic signals plays a critical role in ensuring smooth vehicle flow in urban areas. Traffic signal controllers that are expertly engineered can considerably minimize travel delays and enhance sustainability. In this paper, the team proposes the Model Predictive Control (MPC) traffic signal control strategy using real-time traffic flow data from a vision-based camera as feedback information. The primary aim is to reduce the number of vehicles across all links in the controlled area, thereby optimizing traffic flow and reducing energy consumption. To validate the proposed method, several real-life experiments were conducted at 24 intersections in Chattanooga, Tennessee. These experiments demonstrated significant performance improvements in comparison to the existing method.

17:45-18:00, Paper WeBT4.6	

Efficiency, Reliability, and Resilience of Diesel Generator Based Isolated Microgrids

Yakimenko, Oleg A.	Naval Postgraduate School

Keywords: Energy Efficiency
Abstract: This paper aims at showing the dependence of a chosen isolated microgrid (MG) architecture and key design parameters on its cost efficiency, reliability, and resilience. Specifically, it presents a fraction of the on-going analysis of a variety of MGs and offers a theoretical framework to analyze a notional baseline MG design employing diesel generators only to correctly account for real-world limitations imposed on them to choose a nominal power output based on the demand and demand variability throughout a year. Based on a big picture of MG composition (not talking about transmission, control, etc.), this paper discusses several basic concepts, presents analytical derivations of key performance parameters, and illustrates their applicability using operational data available for several isolated MGs.

ThAT1	H102
Cooperative Control and Optimization for Multi-Agent Systems	Invited Session
Chair: Fang, Hao	Beijing Institute of Technology
Co-Chair: Xin, Bin	Beijing Institute of Technology
Organizer: Fang, Hao	Beijing Institute of Technology

08:30-08:45, Paper ThAT1.1

A Coupling Algorithm for Task and Path Planning of Multi-UGVs under Environmental Inspiration (I)

Xu, Bochen	Beijing Institute of Technology
Fang, Hao	Beijing Institute of Technology
Mao, Yuchen	Beijing Institute of Technology
Wei, Yujie	Beijing Institute of Technology
Yang, Qingkai	Beijing Institute of Technology
Zhou, Lei	Beijing Institute of Technology
Gao, Zhi	Wuhan University

Keywords: Automated Guided Vehicles, Multi-agent Systems, Robotics

Abstract: The Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) is a representative model for multi-UGVs task planning. It describes the allocation for tasks of several unmanned vehicles, considering the capacity of each vehicle and the requirements, as well as the time windows, of various tasks. However, existing studies primarily focus on the task assignment and do not consider the connection between path costs and obstacles in complicated scenarios. In this paper, we propose a coupled task and path planning algorithm for multiple unmanned vehicles under environmental inspiration. We introduces a novel path cost function and achieve seamless integration of solutions from the task level to the path level. Experimental results indicate that, in static obstacle environments, our algorithm module can provide more accurate task assignment and path planning results with smaller costs under similar time consumption.

08:45-09:00, Paper ThAT1.2

Fine-Grained Cooperative Instruction Architecture for Heterogeneous Unmanned Swarms in Dynamic Task Scenarios (I)

Bao, Kanghua	Southwest Computer Co., Ltd
Shi, Tao	Southwest Computer Co., Ltd
Yang, JunYi	Southwest Computer Co., Ltd
Zhang, Wei	Southwest Computer Co., Ltd

Keywords: Multi-agent Systems, Networked Control, Process Automation

Abstract: Aiming at the new requirements and challenges faced by task planning and collaborative control in the dynamic scenario of heterogeneous unmanned swarms, such as scalability, task diversification, command and control interoperability, as well as the characteristics and difficulties of swarm system control under heterogeneous units, complex space, difficult collaboration and diverse constraints, this paper defines the concept and connotation of fine-grained collaborative instruction architecture for task planning and collaborative control in heterogeneous unmanned swarms, a three-tier instruction architecture consisting of task instruction layer, action instruction layer and load instruction layer is proposed, the directory and collection of constraint and effect instructions are constructed, presents the instruction layer generation model. The instruction architecture can comprehensively consider the complexity and constraints of heterogeneous unmanned swarms' collaborative task execution, and plan a reasonable and feasible task sequence, action sequence and load sequence in the dynamic task scenario, it provides theoretical support and design reference for improving the information processing and instant decision-making ability of swarm command.

09:00-09:15, Paper ThAT1.3

AMPC-ASO Strategy for Tracking Nonlinear Systems with Uncertainty (I)

Zhao, Xiangdan	Tongji University
Dou, Lihua	Beijing Institute of Technology
Ding, Yulong	Tongji University
He, Bin	Tongji University
Wang, Biao	Nanjing University of Aeronautics and Astronautics
Li, Gang	Tongji University
Liu, Xiaoqin	Tongji University
Zhou, Yanmin	TONGJI UNIVERSITY
Wang, Zhipeng	Tongji University
Jiang, Shuo	Tongji University
Jiang, Yongkang	Tongji University

Keywords: Adaptive Control, Estimation and Identification, Robotics

Abstract: This paper proposes a control strategy for solving the trajectory tracking control problem with uncertainty in nonlinear systems. Considering the uncertainties and state estimation of the system, an adaptive state observer (ASO) is proposed to solve the estimated problem and ensure the model is adaptive. ASO allows nonlinear systems to be theoretically modelled as linear systems with estimated parameters. Moreover, to satisfy the constraint of adaptive MPC (AMPC) for trajectory tracking control, a parameter identification method for chance-constrained optimization is proposed and uses prediction parameters to compensate for the system's uncertainty by interval estimation and parameter optimization with chance constraints. Finally, the proposed scheme is verified by a quadrotor attitude control simulation. The simulation results show that the AMPC-ASO strategy has perfect tracking control performance.

09:15-09:30, Paper ThAT1.4

Distributed Algorithm for Time-Varying Convex Optimization with Fixed-Time Convergence (I)

Shen, Yuanchu	Beijing Institute of Technology
Chen, Chen	Beijing Institute of Technology
Zeng, Xianlin	Beijing Institute of Technology
Chen, Wenjie	Beijing Institute of Technology

Keywords: Optimal Control, Multi-agent Systems, Nonlinear Systems and Control

Abstract: Distributed time-varying (TV) convex optimization has wide applications in coordinating multiple mobile robots and sensing

networks. The global cost function varies over time and is allocated to multiple agents, each communicating with neighbors to solve the global problem. Pioneering works have relied on identical Hessian matrices and time derivatives of the gradient. This paper proposes a solution to the issue by designing a distributed algorithm that integrates distributed average tracking techniques with the prediction-correction interior point method. Specifically, we present a Distributed Prediction-Correction Algorithm with Fractional-Order Dynamics, which attains fixed-time convergence without necessitating real-time computation of partial time derivatives of the gradient. Numerical simulations demonstrate the efficacy of the proposed algorithm.

09:30-09:45, Paper ThAT1.5	

Event-Triggered Fixed-Time Sliding Mode Control for Leader-Follower Consensus of Nonlinear Multi-Agent Systems (I)

Yang, Yixi	Beijing Institute of Technology
Xin, Bin	Beijing Institute of Technology
Dou, Lihua	Beijing Institute of Technology
Gan, Ming-Gang	Beijing Institute of Technology

Keywords: Multi-agent Systems, Nonlinear Systems and Control, Networked Control

Abstract: In this paper, we investigate the fixed-time consensus control problem for nonlinear multi-agent systems with unknown bounded disturbances under directed topology. Firstly, a terminal integral sliding mode manifold with fast convergence speed is designed. Secondly, a consensus control protocol based on an event-triggered mechanism is developed to ensure that nonlinear multi-agent systems achieve fixed-time consensus while also conserving network resources. Thirdly, the stability analysis is presented by employing the Lyapunov theory, and the Zeno phenomenon is excluded by utilizing the proposed event-based fixed-time consensus controller. Finally, simulation experiments are given to demonstrate the validity of the proposed control method.

09:45-10:00, Paper ThAT1.6	

Quadrotor Attitude Control Based on Modified Linear Active Disturbance Rejection Control (I)

Wang, Biao	Nanjing University of Aeronautics and Astronautics
Tang, Chaoying	Nanjing University of Aeronautics and Astronautics
Yao, Zhennan	Nanjing University of Aeronautics and Astronautics
Yang, Feng	Aviation Key Laboratory of Science and Technology on Aero Electr

Keywords: Control Applications, Motion Control

Abstract: Attitude control of a quadrotor unmanned aerial vehicle is still a hot research topic. Active disturbance rejection control attracts more attention recently. This paper takes into account the dynamics of the propulsion system and designs a higher-order active disturbance rejection controller with compensation of partial model information. Simulation and experiment demonstrate that the proposed controller presents better performance and robustness compared with the traditional active disturbance rejection controller.

ThAT2	H101
Intelligent and AI Based Control	Regular Session
Chair: Wang, Hong	Oak Ridge National Laboratory
Co-Chair: Su, Wencong	University of Michigan-Dearborn

08:30-08:45, Paper ThAT2.1	

Parameter Estimation of Synchronous Generator Using Neural Controlled Differential Equations

Yin, Zhun	The Department of Electrical and Computer Engineering at New Yor
Wang, Hong	Oak Ridge National Laboratory
Jiang, Zhong-Ping	New York University

Keywords: Estimation and Identification, Learning Systems, Real-time Systems

Abstract: This paper introduces a synchronous generator modeling method based on neural controlled differential equations (neural CDEs) using online sampled data. This method begins with a fifth-order generator model, where every trainable parameter is regarded as one parameter of the fifth-order generator model. The objective is to use the real-time data to learn these parameters. A training algorithm has been formulated, and it has been shown that the combination of the proposed neural CDEs and the fifth-order model can produce desired online parameter estimations for the synchronous generator. The simulation results show that the proposed method can generate a very accurate estimation and model predictions with the mean absolute percentage error of 0.02067%.

08:45-09:00, Paper ThAT2.2	

PTC-FOZNN: A Strictly Predefined-Time Convergent Fractional-Order Recurrent Neural Network for Solving Time-Variant Quadratic Programming

Yang, Yi	Chinese University of Hong Kong
Li, Weibing	Sun Yat-Sen University
Zhou, Jianshu	Chinese University of Hong Kong
Huang, Junda	Chinese University of Hong Kong
Hu, Jinfei	Chinese University of Hong Kong
Voyles, Richard	Purdue University
Ma, Xin	Chinese University of Hong Kong

Keywords: Intelligent and AI Based Control, Motion Control, Robotics

Abstract: This study presents a Predefined-Time Convergent Fractional-Order Zeroing Neural Network (PTC-FOZNN) as an innovative solution for Time-Invariant Quadratic Programming (TIQP) and Time-Variant Quadratic Programming (TVQP) problems. This model represents a noteworthy integration of fractional calculus into recurrent neural networks for cyclic motion planning of robots. The PTC-FOZNN diverges from the conventional Zeroing Neural Network (ZNN) by implementing a conformable fractional derivative that complies with the Leibniz rule—a standard often unmet by existing fractional derivatives. Additionally, it employs a novel predefined-time stabilizer as its activation function. When compared to the traditional ZNN, the PTC-FOZNN, configured with $0<\alpha\leq 1$, exhibits enhanced convergence speed and greater positional accuracy for both TIQP

and TVQP tasks. Through meticulous theoretical and empirical validation, including simulation trials with a Franka Emika Panda robotic arm, the PTC-FOZNN model has proven its effectiveness in precise trajectory tracking and computational efficacy.

09:00-09:15, Paper ThAT2.3

Application of Non-Stationary Ship Roll Motion Prediction and Compensation Control Based on VMD-GRU-EC

Zhang, Qin	Shanghai Maritime University
Li, Jiabin	Shanghai Maritime University
He, Ang	Shanghai Maritime University
Hu, Xiong	Shanghai Maritime University

Keywords: Control Applications, Intelligent and AI Based Control
Abstract: During the installation and maintenance of sea-based wind turbines, the movement of the ship is affected by wind and waves. In particular, the installation accuracy and safety of suspended wind turbines are disturbed by the rolling motion of the non-stationary ship. Aiming at the stability of ship lifting platforms under complex sea conditions, a non-stationary ship roll motion prediction model based on VMD-GRU-EC is proposed. The model first predicts ship motion and then supports wave compensation devices in experiments to ensure safe and accurate offshore operations. Specifically, variational mode decomposition (VMD) decomposes non-stationary motion into multi-modal steady-state sequences, which are then input into a multidimensional gated recurrent unit (GRU) for prediction. Error correction (EC) incorporates prediction errors to further improve accuracy. This model is applied to the movement of a large engineering ship in the Changfeng wave spectrum and the Dalian Sea.

09:15-09:30, Paper ThAT2.4

Digital Twin Empowered Operational Status Monitoring of High-Power Induction Furnaces: A PINN-Based Approach

Zhang, Zhao	Zhejiang University
Li, Shen	Zhejiang University
Mao, Wei-Jie	Zhejiang University

Keywords: Energy Efficiency, Estimation and Identification, Process Automation
Abstract: In the realm of industrial automation and smart manufacturing, improving the efficiency of high-power induction furnaces (IFs) has become an essential goal. Precise monitoring of the operational status is indispensable for achieving targeted optimization goals. The challenges encountered in this endeavor are twofold in nature. IF, as a highly complex thermoelectric system, spans multiple disciplinary fields, complicating the achievement of precise modeling. Furthermore, its electrical dynamic parameters continuously change throughout the melting process, eluding direct measurement methods. In this paper, we introduce a novel equivalent circuit framework that simplifies the analysis of the IF operational status. Secondly, we establish a PINN-based digital twin (DT) for IF to simulate the dynamics throughout the entire melting process, thereby supporting the status monitoring. State-space constraints are introduced to overcome the deficiencies of the traditional PINNs in handling multidimensional systems. Finally, we assess the feasibility of the approach using actual operational data spanning the complete working cycle of IF.

09:30-09:45, Paper ThAT2.5

Fast Accurate Phasor Estimation in Less Than One Cycle Using Neural Networks

Mohammadi, Sina	University of Michigan-Dearborn
Haghighi, Rouzbeh	University of Michigan-Dearborn
Hassan, Ali	University of Michigan-Dearborn
Bui, Van-Hai	University of Michigan-Dearborn
Wang, Mengqi	University of Michigan-Dearborn
Su, Wencong	University of Michigan-Dearborn

Keywords: Intelligent and AI Based Control, Real-time Systems, Modeling and Control of Complex Systems
Abstract: Estimation of phasors holds significant importance within power system protection applications. Due to the inherent inductive characteristics of electric power systems, fault currents often exhibit transient oscillations, such as decaying DC offset (DDC), higher-order harmonics, and noise. Fourier analysis stands out as a widely adopted technique for phasor estimation calculations. Nevertheless, when dealing with decaying DC currents, which may persist for up to 5 cycles (in the case of a 50/60Hz system), the accuracy of Fourier analysis diminishes significantly. An inaccurate phasor estimation could lead to malfunction or misoperation of protective devices, most notably distance protection relays, an undesirable outcome. Therefore, it becomes imperative to address the issue of DC offset signal mitigation. While various analytical methods have been proposed in recent years, there exists a pressing need to explore less complicated data-driven approaches. In this paper, we aim to employ two neural network methods to estimate the current in less than one cycle, taking into account second-order DDC and system frequency deviations. Compared with other presented data-driven methods, the proposed scheme is only uses a half cycle of the fault current signal with less number of trained parameters and without applying encoder/decoder methods.

09:45-10:00, Paper ThAT2.6

Finite-Time Convergence Missile Terminal Guidance Law Based on Deep Neural Network

Li, Guilin	Jiangsu Normal University
Zhou, Wei	Jiangsu Normal University
Luan, Shengyang	Jiangsu Normal University

Keywords: Nonlinear Systems and Control, Intelligent and AI Based Control, Control Applications
Abstract: This paper proposes a finite-time convergence guidance law based on deep neural networks (DNN-FTG). The guidance law uses a large amount of simulation data from the finite time input to the state stabilization (ISS) guidance law to train the deep neural network. Then, DNN-FTG is simulated and compared with the finite-time ISS guidance law, and the guidance performance of DNN-FTG is analyzed by miss distance and energy consumption. The neural network's performance is verified by giving different initial conditions, maneuvering forms, and anti-interference tests. The results show that DNN-FTG can replace the finite-time ISS guidance law for real-time missile control, and DNN-FTG has better guidance performance, generalization, and anti-interference.

ThAT3	H103
Robotics	Regular Session
Chair: Chen, Tan	Michigan Technological University
Co-Chair: Lau, Darwin	Chinese University of Hong Kong

08:30-08:45, Paper ThAT3.1

UAV-Enabled Smart Coastal Environment Monitoring for Marine Litter

Zhang, Jihan	The Chinese University of Hong Kong
Zhou, Xunkuai	Tongji University
Huang, Yijun	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

Keywords: Robotics

Abstract: Given the progression of urbanization and industrialization, human activities are increasingly impacting the ecological environment of coastal regions. Marine litter (ML) stands out as a prominent factor, posing threats to both ecological integrity and human quality of life. This paper proposes a smart coastal management framework based on digital twins, encompassing unmanned aerial vehicle (UAV) data collection, detection, localization, and decision-making, offering a scalable, automated, real-time solution. We have curated a UAV ML detection dataset tailored for training detection models to identify small ML objects in large-scale scenarios. Simultaneously, leveraging structure from motion (SfM), we achieve synchronized ML localization and environmental modeling, providing insights into ML distribution within the environment. Lastly, a platform is developed to enable real-time data access to support activities such as litter removal. Extensive data collection conducted in Hong Kong validates the efficacy of this architecture.

08:45-09:00, Paper ThAT3.2

Indoor Hydroponics Robot System for Automated Seeding and Logistics

Hui, Hon Kit	The Chinese University of Hong Kong
Lee, Jimmy	The Chinese University of Hong Kong
Sum, K.W.	The Chinese University of Hong Kong
Lau, Darwin	Chinese University of Hong Kong

Keywords: Robotics, Automated Guided Vehicles, Smart Buildings

Abstract: In recent years, indoor hydroponics farming has been a promising new mode to ensure stable and increased density food production regardless of weather and location. However, the lack of development of hydroponic robot systems limit the automation of smaller space indoor environments where automated hydroponic mechatronic racks are not suitable nor economical. This work presents an automated robot system for exactly this purpose. It comprises of: 1) a seeding end-effector for 6 degree-of-freedom robot arms to plant small seeds; 2) a mobile robot tray logistics robot; and 3) an automated software to schedule and operate the system. The novel robot system has been implemented and in operation for over 2 years at the Controlled Environment Hydroponic Research and Development Centre in Hong Kong, showing its efficacy to minimise human labour and increase efficiency.

09:00-09:15, Paper ThAT3.3

Adaptive Velocity Control for a Walking Robot in Low-Traction Environments

Krajicek-Allard, Mathieu	Concordia University
Selmic, Rastko	Concordia University

Keywords: Robotics, Control Applications

Abstract: This paper describes the design, implementation, and control of a walking six-legged hexapod robot. The robot is 3D printed and implemented using various electronic components, including inertial measurement units (IMUs) to detect a loss of traction. The robot is controlled by a negative feedback system that dynamically controls the speed of walking on terrain with a low amount of traction. This data is used to adjust the robot's velocity such that the speed at which it travels permits it to move without losing traction. The results are verified and validated using extensive experimental results.

09:15-09:30, Paper ThAT3.4

UMeshSegNet: Semantic Segmentation of 3D Mesh Generated from UAV Photogrammetry (I)

Liu, Xinyi	Wuhan University
Zhang, Yongjun	Wuhan University
Liu, Zihang	Wuhan University
Gao, Zhi	Wuhan University
Tan, Yuhui	Wuhan University

Keywords: Smart Buildings, Smart Structures, Sensor/Data Fusion

Abstract: 3D mesh generated from UAV photogrammetry can depicts the urban scene realistically. Most of the studies on semantic segmentation of 3D mesh based on deep learning convert mesh data into point cloud or 2D image, resulting in original information lost and poor segmentation effect. To address the problem, a semantic segmentation convolutional neural network UMeshSegNet is designed in this paper based on MeshCNN, which directly processes the mesh data. The network combines geometric, elevation and texture features, and attention mechanism is also introduced to enhance the sensitivity to the feature. Experiments and analyses are conducted on public dataset SUM and our own Wuhan test data, and the experimental results indicate that UMeshSegNet can effectively segment mesh data with significantly higher semantic segmentation accuracy than previous deep learning methods.

09:30-09:45, Paper ThAT3.5

Control of Biped Sideways Walking with Two-Periodic Gait Design

Chen, Tan	Michigan Technological University

Keywords: Robotics, Control Applications, Nonlinear Systems and Control

Abstract: This paper presents a Hybrid Zero Dynamics (HZD) based control approach to achieve sideways walking for underactuated bipedal robots. As sideways walking involves no knee flexion and very small ankle pronation-supination, a two-link compass gait model can well represent the dynamics during sideways walking. Unlike forward walking (or sagittal-plane walking), which typically exhibits a 1-periodic gait (or walking orbit) due to leg symmetry, sideways walking demonstrates a 2-periodic gait consisting of two steps, the extending and contracting steps within one stride. This paper presents the invariance condition for constructing a 2-periodic gait and derives the computational results that can enforce this invariance condition. Moreover, the boundary conditions are derived for a given 2-periodic gait. Preliminary simulation on a feasible gait suggests that the controller is stable in terms of tracking the desired gait and can reject some disturbance.

09:45-10:00, Paper ThAT3.6	

Active View Planner for Infrastructure 3D Reconstruction

Gao, Chuanxiang	The Chinese University of HongKong
Yang, Guidong	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

Keywords: Smart Buildings, Robotics, Automated Guided Vehicles
Abstract: Precise 3D modeling is crucial for infrastructure inspections, monitoring, and life-cycle management. However, the efficient construction of accurate 3D models poses significant challenges. This paper addresses these challenges by presenting a novel coverage view planner specifically designed for the precise 3D reconstruction of infrastructure. The proposed method takes into account the requirements of Multi-View Stereo (MVS) matching and plans the corresponding viewpoints for reconstruction. The reconstructibility is also introduced, which serves as a predictive measure for the quality of reconstruction. In addition, this reconstructibility is used as an objective function to optimize the position and orientation of viewpoints. To validate the efficacy of the proposed approach, a series of experiments are conducted across real-world scenarios. Our evaluation and comparative analyses unequivocally demonstrate the high efficiency of our method in generating high-quality viewpoints.

ThAT4	H104
Advanced Control and Applications	Invited Session
Chair: Chen, Xi	The Chinese University of Hong Kong
Co-Chair: Shi, Yang	Canada
Organizer: He, Tianyi	Utah State University
Organizer: Chen, Xiang	University of Windsor

08:30-08:45, Paper ThAT4.1	

Performance Assessment for Stochastic Anomaly Detectors in Industrial Alarm Systems (I)

Zhou, Jing	University of Alberta
Shang, Jun	Tongji University
Chen, Tongwen	University of Alberta

Keywords: Process Automation, Control Applications, Fault Detection and Diagnostics
Abstract: In recent years, stochastic detectors have gained prominence in networked systems for anomaly detection. These detectors have demonstrated advantages over their traditional counterparts, particularly in safeguarding against data integrity attacks targeting state estimation. Despite these advancements, the impact of the detector on alarm performance—such as alarm-triggering rates at normal conditions—remains underexplored, especially in scenarios where delay timers are applied to the raw alarm sequence. This study delves into the monitoring of a correlated Gaussian process variable using stochastic detectors. An explicit formula for the alarm performance is given, highlighting how it is influenced by the duration of delay timers. The efficacy of the proposed approach is validated through numerical examples and a simplified process model.

08:45-09:00, Paper ThAT4.2	

Complementary Orientation Control for Spherical Motors (I)

Mohammed, Thasnim	University of Windsor
Chen, Xiang	University of Windsor

Keywords: Control Applications, Robust and H infinity Control, Motion Control
Abstract: In this paper, a novel approach is proposed for orientation control of spherical motors. First, a model is established for spherical motors based on the rotor dynamics and the multi-port operating principle of the motor. Then a robust complementary orientation control is presented using the developed model. The current vector is chosen to be the control variable, which are applied to drive the electromagnetic windings on the stator to generate the three dimensional electromagnetic torque acting on the rotor. Nonlinearity of motor dynamics is treated as uncertainty and it is shown that our approach is robust to the uncertainty while achieving the operating performance. Simulation results validate the effectiveness of the proposed method.

09:00-09:15, Paper ThAT4.3	

Adaptive Distributed Lyapunov-Based Model Predictive Control for Multi-UAV Formation Tracking with Weighted Directed Graphs (I)

Xu, Binyan	University of Victoria
Dai, Yufan	University of Victoria
Suleman, Afzal	University of Victoria
Shi, Yang	Canada

Keywords: Nonlinear Systems and Control, Multi-agent Systems, Adaptive Control
Abstract: This paper tackles the formation tracking control problem of multiple unmanned aerial vehicles (UAVs) with a weighted directed communication graph. A novel adaptive fully distributed model predictive control (DMPC) framework is proposed, aiming to not only ensure closed-loop stability and feasibility of the local optimization problem, but also moderate the computation and communication consumption. Each local controller comprises an outer translation control loop and an inner rotation control loop. The outer loop employs Lyapunov-based model predictive control (MPC) to determine optimal translation control actions subject to input constraints. The MPC problem is formulated using only the relative neighborhood formation error between itself and its neighbors, thereby substantially reducing the total communication traffic. An adaptive estimator is also incorporated to estimate the future evolution of neighboring vehicles. Through closed-loop analysis, sufficient stability conditions regarding the selection of control parameters are established. Simulation results are provided to demonstrate the effectiveness of the proposed design.

09:15-09:30, Paper ThAT4.4	

Pathway to a Smart Campus Framework: A Review and Case Study

Hong, Wenxing	Xiamen University
Huang, ZhenFeng	Xiamen University, Department of Automation

Zhang, Jihan	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

Keywords: Smart Buildings
Abstract: Currently, there is much literature discussing the smart campus framework, including terms, definitions, and practices used in campus. However, there are still many campuses facing issues with poor user experience, absence of integration platforms, inadequate data governance, etc. These obstacles have a direct impact on the overall quality and operational efficiency. Hence, a review is necessary to explore the suitable framework for smart campus. This study reviews the technology development of the smart campus and a human-centered framework is proposed to incorporate physical, cyber, and social parts to identify the essential elements of a smart campus. The proposed framework's feasibility and effectiveness are demonstrated by a real-world application. Overall, this paper contributes to the discussion on the current development of smart campuses and offers practical insights for their construction.

09:30-09:45, Paper ThAT4.5	

Model-Free Adaptive Control for Discrete-Time Nonlinear Systems with Partially Known Structures

Li, Fanghui	Qingdao University
Hou, Zhongsheng	Beijing Jiaotong University

Keywords: Nonlinear Systems and Control, Adaptive Control, Networked Control
Abstract: The regulation problem for a class of discrete-time nonlinear non-affine systems with partially known structures using model free adaptive control (MFAC) algorithm is investigated in this paper. The core idea is to first linearize the known parts of the system mathematical model based on traditional linearization methods, and then employ dynamic linearization technology to process the unknown structure of controlled system and the unmodeled dynamics generated by traditional linearization, for the purpose of complementary advantages and the collaborative control between the data-driven control (DDC) methods and the model-based control (MBC) strategies. Unlike the prototype MFAC algorithm, the control scheme devised in this paper fully utilizes the known structure of the system such that the control objective can be better realized. Finally, the monotonic convergence of system tracking error is rigorously proved, meanwhile, the superiorities of developed algorithm is demonstrated by the simulation comparison results.

09:45-10:00, Paper ThAT4.6	

Job Flow Control for Buffers in a Job-Shop Manufacturing System

Qian, Yangyang	University of Virginia
Lin, Zongli	University of Virginia

Keywords: Flexible Manufacturing Systems, Multi-agent Systems
Abstract: This paper investigates the job flow control problem for a network of buffers in a job-shop manufacturing system, where jobs are stored in buffers in order to supply a job demand to the job shop. For each buffer, a job flow control law is proposed, which requires that each buffer has access to the average total number of jobs stored in all buffers. It is shown that the control objectives of balancing the stock levels of the buffers and delivering the desired total job demand are both achieved if the proposed job flow control law is implemented for each buffer. Moreover, to relax the requirement of each buffer having access to the average total number of jobs among all buffers, two types of dynamic average consensus algorithms acting as distributed estimators are constructed for each buffer, each of which can provide an estimate of the average total number of stored jobs. By leveraging either type of distributed estimators, the proposed job flow control law is implemented in a distributed fashion. Simulation studies are provided to verify the effectiveness of the proposed control law.

ThBT1	H102
Resilient Cooperative Control and Optimization of Multi-Agent Systems	Invited Session
Chair: Feng, Zhi	Beihang University
Co-Chair: Dong, Xiwang	Beihang University
Organizer: Feng, Zhi	Beihang University
Organizer: Dong, Xiwang	Beihang University
Organizer: Wen, Guanghui	Southeast University
Organizer: Tang, Yang	East China University of Science and Technology

10:30-10:45, Paper ThBT1.1	

Distributed Prescribed-Time Formation Tracking for General Linear Multiagent Systems (I)

Shi, Zhexin	Beihang University
Yang, Yikun	Beihang University
Yu, Jianglong	Beihang University
Dong, Xiwang	Beihang University
Li, Qingdong	Beihang University
Ren, Zhang	Beihang University

Keywords: Multi-agent Systems, Adaptive Control, Linear Systems
Abstract: This paper studies prescribed-time formation tracking problems for general linear multiagent systems with a leader of unknown input. First, by introducing a time-varying parametric Lyapunov equation, a distributed prescribed-time formation tracking protocol is proposed for each follower to accomplish an expected formation within a prescribed time, and simultaneously follow the leader's state trajectory. Then, adaptive gains are developed to achieve formation tracking in a fully distributed manner and to compensate for the leader's unknown input. Furthermore, the prescribed-time convergence of the formation tracking error is analyzed using Lyapunov theories. Finally, the effectiveness of theoretical results is validated through a simulation example.

10:45-11:00, Paper ThBT1.2	

Trajectory Re-Planning Method of Hyper-Sonic Vehicles Facing Sudden Threats (I)

Ren, Jie	Beihang University
Yu, Jianglong	Beihang University
Dong, Xiwang	Beihang University
Ren, Zhang	Beihang University

Keywords: Automated Guided Vehicles, Learning-based Control, Process Control & Instrumentation
Abstract: Aiming at the trajectory re-planning problem of multiple hyper-sonic vehicles with the time coordination under sudden

threats, a time-coordinated fast trajectory re-planning method was proposed to avoid the no-fly zone. Firstly, the three-dimensional trajectory planning problem of the vehicle is decomposed into the longitudinal trajectory planning problem and the transverse trajectory planning problem. Secondly, a single sudden threat is regarded as a circular no-fly zone, and the circumvention of no-fly zone can only be considered in a transverse trajectory planning. Based on the in-depth study of the longitudinal trajectory planning with flight time constraints and range constraints, a reinforcement learning method is introduced into the transverse trajectory re-planning, and a fast tilting angle flipping self decision method based on the reinforcement learning is proposed. Finally, by training DQN to generate a tilting angle reversal decision maker, a fast three-dimensional trajectory re-planning method that can avoid the no-fly zone is realized. The proposed trajectory re-planning method not only has a fast trajectory re-planning speed, but also greatly improves the penetration probability against sudden threats. The simulation results show the feasibility and effectiveness of the proposed method.

11:00-11:15, Paper ThBT1.3

Cooperative Task Reconstruction Allocation for Unmanned Swarm Systems Based on MGGA and SAA (I)

Yu, Jintong	Beihang University
Hua, Yongzhao	Beihang University
Dong, Xiwang	Beihang University
Li, Qingdong	Beihang University
Ren, Zhang	Beihang University

Keywords: Multi-agent Systems, Motion Control, Optimal Control

Abstract: Multi-unmanned agent collaboration technology is a key aspect of operations. How to reasonably assign tasks to unmanned agents before operations to maximize the overall benefits is a long-standing problem for researchers. This study systematically addresses the above issues and establishes a multi-agent task reconstruction model based on the reconnaissance, strike and assessment task background. This model includes two types of task allocation algorithms. One is task pre-allocation, which is a static task allocation before task execution. A Multi-Gene Genetic Algorithm (MGGA) is proposed for this purpose. The other is Sequential Auction Algorithm (SAA), which deals with the reallocation of tasks in response to unexpected situations during task execution. Experimental results show that, compared with other algorithms, MGGA can get the lowest fitness value under various experimental conditions. Meanwhile, SAA can handle task reallocation problems caused by various dynamic events.

11:15-11:30, Paper ThBT1.4

Robust Cooperative Formation Tracking Guidance for Uncertain Missile Systems (I)

Sun, Yang	Tsinghua University
Huang, Peinan	Tsinghua University
Deng, Ruiliang	Tsinghua University
Shi, Zongying	Tsinghua University
Zhong, Yisheng	Tsinghua Univ

Keywords: Automated Guided Vehicles, Control Applications, Nonlinear Systems and Control

Abstract: The problem of cooperative midcourse guidance for a group of missiles amidst uncertainties and external disturbances is addressed. Departing from conventional optimality-based approaches, the strategies advanced herein are founded on robust formation tracking theories. The control objective is to achieve precise midcourse trajectory tracking through adjustments in thrust, angle of attack, and bank angle, while maintaining the specified intercept formation throughout the handover from midcourse to terminal guidance. A distributed tracking controller, which integrates the principles of linear quadratic regulator and robust signal compensation, is designed for the missile formation, ensuring the achievement of arbitrarily given small tracking errors. Numerical simulations are provided to verify the effectiveness of the proposed control algorithm.

11:30-11:45, Paper ThBT1.5

Predefined Output Containment for Heterogeneous Euler-Lagrange Systems with Multiple Uncertain Nonidentical Leaders (I)

Wang, Qing	Beihang University
Dong, Xiwang	Beihang University
Shi, Zhexin	Beihang University
Wang, Jiayi	Beijing Bank
Feng, Zhi	Beihang University

Keywords: Adaptive Control, Learning Systems, Control Applications

Abstract: This paper discusses the robust predefined output containment (RPOC) control problem for heterogeneous Euler-Lagrange systems having multiple uncertain nonidentical leaders. In order to solve this problem, a new kind of distributed observer-based robust predefined output containment control framework is presented. Firstly, for obtaining the information of nonidentical leaders' dynamics including uncertain parameters in leaders' system matrices and states, two kinds of adaptive observes are constructed in a fully distributed form without any knowledge of the dynamics of nonidentical leaders, exactly. Secondly, on the basis of adaptive learning technique, a new RPOC controller is then developed by using the presented observers. Furthermore, with help of Lyapunov stability theory, the RPOC criteria for the considered system under multiple uncertain nonidentical leaders are derived from the constructed controller. At last, a simulation example is provided to demonstrate the effectiveness of the proposed RPOC controller.

11:45-12:00, Paper ThBT1.6

Fast Incremental ADMM for Decentralized Consensus Multi-Agent Optimization

You, Yang	KTH, Royal Institute of Technology
Yu, Ye	Southwest University
Xiao, Guoqiang	Southwest University
Xu, Qianwen	KTH Royal Institute of Technology

Keywords: Multi-agent Systems, Networked Control, Learning-based Control

Abstract: The alternating direction method of multipliers (ADMM) has been recently recognized as well-suited for solving distributed optimization problems among multiple agents. Nonetheless, there remains a scarcity of research exploring ADMM's communication costs. Especially for large-scale multi-agent systems, the impact of communication costs becomes more significant. On the other hand, it is well-known that the convergence property of ADMM is significantly influenced by the different parameters, while tuning these parameters arbitrarily would disrupt the convergence of ADMM. To this end, inspired by the preliminary works on incremental ADMM, we propose a fast incremental ADMM

algorithm that can solve large-scale multi-agent optimization problems with enhanced communication efficiency and fast convergence speed. The proposed algorithm can improve the convergence speed by introducing an extra adjustable parameter to modify the penalty parameter rho in both primal and dual updates of incremental ADMM. With several mild assumptions, we provide the convergence analysis of our proposed algorithm. Finally, the numerical experiments demonstrate the superiority of the proposed fast incremental ADMM algorithm compared to the other incremental ADMM type methods.

ThBT2	H101
Learning Systems	Regular Session
Chair: Chen, Xi	The Chinese University of Hong Kong
Co-Chair: Yin, Xiang	Shanghai Jiao Tong University

10:30-10:45, Paper ThBT2.1	

Formal Control Synthesis Via Safe Reinforcement Learning under Real-Time Specifications

Lv, Peng	Shanghai Jiao Tong University
Luo, Guangqing	Shanghai Jiao Tong University
He, Zhou	Shaanxi University of Science and Technology
Li, Xianwei	Shanghai Jiao Tong University
Yin, Xiang	Shanghai Jiao Tong University

Keywords: Discrete Event Systems, Learning-based Control, Real-time Systems

Abstract: In recent years, reinforcement learning techniques have gained widespread application in control synthesis. However, in the context of safety-critical systems, employing trial-and-error based reinforcement learning may be unacceptable due to the potential risks it poses during the learning process. Consequently, the development of safe reinforcement learning techniques has become imperative. This paper addresses the challenge of safe reinforcement learning for controller synthesis, particularly when safety specifications are intricately linked to the real-time behavior of the system. To articulate time-sensitive requirements, we leverage Metric Interval Temporal Logic (MITL). To ensure safety throughout the learning process, we introduce an additional reactive controller called a shield. Specifically, the shield functions to reject any behavior that violates the real-time specifications, thus mitigating potential risks. The efficacy of our proposed approach is demonstrated through simulation results, highlighting its ability to satisfy safety constraints in the dynamic environment of controller synthesis.

10:45-11:00, Paper ThBT2.2	

Self-Distillated DETR for Object Detection in Complex Environments

Niu, Mohan	Beijing University of Technology
Li, Fangyu	Beijing University of Technology
Huang, Yanting	Beijing University of Technology
Han, Honggui	Beijing University of Technology

Keywords: Learning Systems

Abstract: Detection transformers (DETRs) have achieved remarkable results, but they still face challenges in generalizing to complex environments. Existing approaches primarily emphasize specific computational structural design but overlook the overall improvement of encoder structure. To improve the detection accuracy of DETR in complex environments, we propose a self-distillated DETR, which enhances encoder structural feature extraction through self-distillation. First, we develop an encoder feature self-distillation architecture, which performs deep-layer to shallow-layer knowledge transfer in the encoder structure without external instructor guidance. Second, we design the feature distillation loss function, which guides shallow encoders to acquire deep encoder feature extraction capability. We use the smoothed gradient squared deviation to calculate the corresponding token feature differences. We conduct experiments using the public object detection dataset MS COCO and the natural wildlife dataset WAID to verify the model's accuracy. The results of the experiment show the proposed model's effectiveness in multiple precision metrics.

11:00-11:15, Paper ThBT2.3	

From Simulation to Prediction: Enhancing Digital Twins with Advanced Generative AI Technologies

Huang, Yijun	The Chinese University of Hong Kong
Zhang, Jihan	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Lam, Alan Hiu-Fung	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

Keywords: Learning Systems, Man-machine Interactions, Process Automation

Abstract: The integration of Generative Artificial Intelligence (GAI) into Digital Twins (DTs) marks a revolutionary stride in the evolution of virtual replicas for physical systems. This paper explores the cutting-edge advancements brought about by the incorporation of GAI technologies, specifically Large Language Models (LLMs), into DTs. These technologies herald a significant transformation, propelling DTs beyond their current capabilities to become more dynamic, predictive, and interactive tools that can simulate complex scenarios and anticipate future conditions with remarkable accuracy. By systematically examining the levels of GAI integration within DTs, this study delves into the methodologies and strategies for embedding AI capabilities into these virtual models. It outlines how GAI can enhance the functionality of DTs, enabling them to generate synthetic datasets, simulate unprecedented events, and provide actionable insights with LLM-based agents for decision-making. Furthermore, the paper highlights the extended applications of DTs, enriched by GAI, across various domains such as healthcare, urban planning, and beyond. The implications of this integration for operational efficiency, innovation, and decision-making processes are profound. By offering a comprehensive overview of the current state of technology and projecting future trends, this paper aims to provide stakeholders with a deep understanding of the synergistic potential between GAI and DTs. It sets the stage for a new era of DT technologies, where the boundaries of what can be achieved with virtual models are continually expanding.

11:15-11:30, Paper ThBT2.4	

Online Learning of Linear Quadratic Gaussian Controllers from Noisy Data

Wang, Linqi	Beijing Institute of Technology

Liu, Wenjie	Beijing Institute of Technology, Beijing, China
Li, Yifei	Beijing Institute of Technology
Sun, Jian	Beijing Institute of Technology
Wang, Gang	Beijing Institute of Technology

Keywords: Linear Systems, Optimal Control, Robust and H infinity Control

Abstract: This paper addresses the joint state estimation and online control problems of unknown linear time-invariant systems subject to process and measurement noises. The proposal is to design an online linear quadratic Gaussian (LQG) controller from noisy data. To achieve this, a relaxed data-based semi-definite program (SDP) is constructed, upon solving which a robust Kalman observer is developed. Subsequently, leveraging a robust data-driven linear quadratic regulator (LQR), we develop a robust data-driven online LQG controller. It is shown that the proposed data-driven online LQG controller ensures robust global exponential stability (RGES) of the observer and the input-to-state stability (ISS) of the closed-loop system under standard conditions. Finally, its numerical effectiveness is demonstrated using numerical examples.

11:30-11:45, Paper ThBT2.5	

Deep Learning for Remote Monitoring of Power System

Kozak, Elana	U.S. Navy
Smith, Philip	U.S. Navy
Kang, Wei	Naval Postgraduate School
Martinsen, Thor	U.S. Naval Postgraduate School

Keywords: Sensor/Data Fusion, Learning-based Control, Control of Smart Power Delivery Systems

Abstract: The paper comprises two distinct case studies within power systems. The first case study delves into the detection of a sudden load change utilizing an FDR sensor. The second case study addresses the detection of three distinct types of faults in a 9-bus power system. In both case studies, feedforward neural networks are trained for the detection of faults and load changes in power systems. Furthermore, we assess the robustness of these neural networks through simulations and numerical validation, utilizing datasets that are either corrupted by noise or exhibit variations in the initial state probability distribution.

11:45-12:00, Paper ThBT2.6	

CUBIT-Det: High-Definition Multi-Scenario Defect Dataset for Infrastructures Fully Evaluated with Deep Learning Processes

Zhao, Benyun	The Chinese University of Hong Kong
Zhou, Xunkuai	Tongji University
Yang, Guidong	The Chinese University of Hong Kong
Wen, Junjie	The Chinese University of Hong Kong
Zhang, Jihan	The Chinese University of Hong Kong
Chen, Xi	The Chinese University of Hong Kong
Chen, Ben M.	Chinese University of Hong Kong

Keywords: Signal Processing, Smart Buildings, Robotics

Abstract: Civil infrastructure defect inspection is a critical yet intricate task. Unmanned robots integrated with the deep learning-based visual inspection are more comprehensive and efficient methods with much fewer safety concerns than manual visual inspection. Despite the success of deep learning in numerous object detection tasks, its potential for infrastructure defect inspection has not been fully explored under the lack of annotated high-quality datasets with large volumes. This paper establishes CUBIT-Det, a high-resolution infrastructure defect dataset comprising 5527 optical images with resolutions up to 8000x6000, obtained from multiple scenarios by using professional acquisition equipment on various robotic platforms. CUBIT-Det covers a broad spectrum of practical situations, backgrounds, and defect types compared to existing defect datasets. Extensive benchmarking experiments among state-of-the-art detection methods have been conducted on the proposed dataset to validate its feasibility. To the best of our knowledge, this study is the first to comprehensively benchmark infrastructure defect detection methods on annotated high-resolution defect images, laying a solid baseline for the future development of defect inspection solutions. The reliability and feasibility of our dataset have been further demonstrated by the real-world infrastructure defect inspection task.

ThBT3	H103
Robotics (II)	Regular Session
Chair: Albertos, Pedro	Univ. Politecnica De Valencia
Co-Chair: Moallem, Mehrdad	Simon Fraser University

10:30-10:45, Paper ThBT3.1	

Markless Visual Servoing for 3C Product Assembly with Quotient Kinematics Manipulator

Xie, Yixin	Harbin Institute of Technology, Shenzhen
Fu, Qiang	Harbin Institute of Technology Shenzhen
Yang, Xiansheng	Harbin Institute of Technology Shenzhen
Li, Zhibin	Shenzhen Polytechnic University
Li, Yanjie	Harbin Institute of Technology Shenzhen
Lou, Yunjiang	Harbin Institute of Technology, Shenzhen

Keywords: Integrated Manufacturing, Robotics, Control Applications

Abstract: Due to the small size of 3C (Computer, Communication and Consumer electronics) parts and their high assembly accuracy requirements, traditional industrial robots cannot meet the needs of flexible assembly. To address manufacturing errors and uncertainties in part poses, this study proposes a markerless visual servoing method. Through analysis of assembled 3C parts and manual assembly movements, a high-precision and flexible assembly strategy has been designed. This strategy divides assembly into into long-range approaching phase and a short-range aligning phase. To adapt to these phases, a quotient kinematic manipulator (QKM) consisting of two parallel manipulator modules was developed, along with a well-designed camera hardware system. In the long-range approaching phase, an image moment-based visual servoing method with constrained model predictive control is employed, addressing robot motion collisions and end-effector velocity constraints, resulting in collision avoidance motion trajectories. In the short-range aligning phase, a weighted image

brightness visual servoing method is proposed, utilizing surface texture features to replace geometric features, achieving high-precision alignment of components. Experimental results show the proposed servoing assembly strategy achieves high-precision collaborative manipulator assembly without artificial markers, with accuracy of 0.5mm/0.5°.

10:45-11:00, Paper ThBT3.2

Realization of Efficient Rotational Springs and Series Elastic Actuators Using DC Motors

Farjah, Amin	Simon Fraser University Surrey
Moallem, Mehrdad	Simon Fraser University

Keywords: Motion Control, Robotics, Modeling and Control of Complex Systems

Abstract: In this paper, a review of adjustable rotational springs is presented along with their application in robotic systems. To this end, the process of implementing an adjustable rotational spring using DC motors and their limitations is presented. Additionally, Series Elastic Actuators (SEAs) as one of the important applications of an adjustable spring are investigated. A review of motor parameters and their effect on achievable stiffness values is presented using available DC motors in the market. Finally, Simulations and comparative studies are presented using MATLAB/Simulink which highlight the effects of different parameters such as amplitude of the rotational deflection, angular velocity, inertia of the rotor, and gear ratio.

11:00-11:15, Paper ThBT3.3

PI Tracking Control of a Single Link Manipulator

Albertos, Pedro	Univ. Politecnica De Valencia
Wei, Cui	Nanjing Tech University
Casanova, Vicente	Universidad Politécnica De Valencia
Crespo, Alfons	UPV

Keywords: Nonlinear Systems and Control, Motion Control, Robotics

Abstract: In this paper, the tracking control design by using the Linear Algebra Based (LAB) methodology is applied to derive the PID control of a flexible single link manipulator. As an interesting feature in this methodology, the control design requirements are determined by the treatment of the control error in approaching the reference trajectory allowing the use of any controller. Thus, the tuning facilities of the PID control are exploited and a PID-LAB controller is designed. In order to validate the control design a simulated manipulator developed by using Matlab/Simulink has been used. By Simscape Multibody, the different components of the manipulator can be simulated, having access to the full state. Excellent results are reported and the experimental PID parameters tuning procedure illustrates the facilities provided in the design stage.

11:15-11:30, Paper ThBT3.4

IoT-Cloud Based Control of a Flexible Assembly/Disassembly Mechatronic System in the Framework of Industries 4.0 and 5.0

Filipescu, Adrian	Lower Danube University of Galati
Stamatescu, Iulia	University Politehnica of Bucharest
Simion, Georgian	"Dunărea De Jos" University of Galați
Ionescu, Dan	"Dunarea De Jos" University of Galati
Filipescu, Adriana	Low Danube University of Galati

Keywords: Robotics, Man-machine Interactions, Flexible Manufacturing Systems

Abstract: The aim of the work is to present the design and implementation of an IoT-Cloud based system for monitoring and controlling a mechatronic system as a flexible robotic cell (FRC) of assembly/disassembly (A/D), equipped with the 6-DOF ABB 120 industrial robotic manipulator (IRM) that satisfies the framework of Industries 4.0 and 5.0. In addition to the ABB 120 IRM, several IoT edge devices are employed, connected in a local network (LAN), for local processing and data acquisition. The system is connected to the Internet and allows remote control via Cloud and VPN. IoT dashboards, as human machine interfaces (HMIs), for remote monitoring and control of FRC status, initiation and management of A/D tasks, have been implemented. Synchronized timed Petri nets (STPN) were used as digital twin like a virtual reality (VR) representation of A/D FRC operations. Moreover, the assignment, planning and execution of A/D tasks were carried out using an augmented reality (AR) tool. The devices, which are organized in a decentralized, multilevel architecture to ensure interoperability between different subsystems, autonomy, and flexibility.

11:30-11:45, Paper ThBT3.5

First Principle Modeling of a Morphable Unmanned Aerial-Aquatic Vehicle: Mirs-Alioth

Huang, Dongyue	Chinese University of Hong Kong
Dou, Minghao	Chinese University of Hong Kong
Liu, Xuchen	The Chinese University of Hong Kong
Yan, Ruixin	The Chinese University of Hong Kong
Gao, Songqun	The Chinese University of Hong Kong
Liu, Zixuan	Peng Cheng Lab
Wang, Biao	Nanjing University of Aeronautics and Astronautics
Dou, Lihua	Beijing Institute of Technology
Chen, Ben M.	Chinese University of Hong Kong

Keywords: Modeling and Control of Complex Systems, Robotics

Abstract: This paper establishes a hybrid system model for a morphable unmanned aerial-aquatic vehicle (UAAV), named Mirs-Alioth, incorporating hydrodynamic parameters through the first principle. Unlike other current UAAVs, variable thrust tilt angles make Mirs-Alioth's model mutable. Thus, this paper directly employs geometric features of the vehicle, integrating a morphing model into a comprehensive dynamics of the vehicle and switching models between different media triggered by depth. The comprehensive model parameters including the rigid body part and the hydrodynamic part is then identified through experiments and computational fluid dynamic (CFD) methods.

11:45-12:00, Paper ThBT3.6

Autonomous Cooperative Mapping of GPS-Denied Cluttered Environments Using Gaussian Process Regression

Mansfield, David	Lancaster University
Sadeghzadeh-Nokhodberiz, Nargess	Qom University of Technology
Montazeri, Allahyar	Lancaster University

Keywords: Robotics, Multi-agent Systems, Control Applications
Abstract: Multi-agent systems can be used in a range of applications to observe and map spatial-temporal phenomena. In this paper, we have taken the first step to develop a multiagent environmental monitoring system for fully autonomous exploration and mapping of an unstructured indoor GPS-denied environment. By employing the Gmapping SLAM, the agents cooperatively map a previously unknown environment and explore its entirety. At the same time, the agents are able to successfully map and characterize the temperature distribution inside the room passively using Gaussian Process Regression. The system has been experimentally tested in an indoor cluttered environment, by operation of two Unmanned Ground Vehicles built fully in house. The experimental results show that the proposed system could successfully navigate and explore in the cluttered environment and estimate the spatial distribution of the environment by locating two independent heat sources. It was found that while a passive field prediction approach can approximate the temperature distribution in the room and identify the heat sources, the accuracy of the prediction greatly depends on the proximity of the trajectories that the robots traverse close to the sources.

ThBT4	H104
Fault Detection and Diagnostics	Regular Session
Chair: Zhang, Youmin	Concordia University
Co-Chair: Yan, Xinhao	The Hong Kong Polytechnic University

10:30-10:45, Paper ThBT4.1

An Insulator Missing Defect Detection Method Based on Unmanned Aerial Vehicles

Zhang, Yulong	Xi'an University of Technology
Zhou, Zhongxian	Xi'an University of Technology
Mu, Lingxia	Xi'an University of Technology
Xue, Xianghong	Xi'an University of Technology
Xin, Jing	Xi'an University of Technology
Zhang, Youmin	Concordia University

Keywords: Fault Detection and Diagnostics, Fuzzy and Neural Systems, Signal Processing
Abstract: In this paper, an insulator missing defect detection method is proposed based on unmanned aerial vehicles to solve the problem of glass insulator burst fault detection in high-voltage transmission lines. Firstly, the proposed method utilizes the improved Mask R-CNN (region-based convolutional neural network) algorithm to segment insulator strings in aerial images. Then, the constructed autoencoder decoder network is used to extract and reconstruct features of the insulators, resulting in residual images. Finally, the residual image preserves the location information of the fault point and obtains the result of missing insulators. The experiment shows that the proposed algorithm has high segmentation accuracy for insulators and high recognition accuracy for insulator missing faults.

10:45-11:00, Paper ThBT4.2

The Fault Detection and Isolation Design for the Stratospheric Airship Based on the Interval Observer Method with Zonotope Analysis

Hu, Jichen	Beihang University
Zhu, Ming	Beihang University
Zheng, Zewei	Beihang University
Chen, Tian	Beihang University

Keywords: Fault Detection and Diagnostics, Nonlinear Systems and Control
Abstract: This paper investigates a fault detection and isolation (FDI) scheme for the stratospheric airship (SA) flight control system under unknown external disturbances. In the design of the observer, the conventional nonlinear estimation error dynamic system is represented as Linear Parameter Varying (LPV) form mathematically. A Luenberger-type observer is designed to generate the residual for fault detection. Subsequently, the iterative zonotope method is employed to minimize the residual interval and the fault detection logical determination is developed. Furthermore, a bank of unknown input observers (UIO) is applied to realize the fault isolation issue with the zonotope analysis. Finally, the proposed method is applied on an SA control system and the result illustrates the effectiveness.

11:00-11:15, Paper ThBT4.3

Countering Spoofing Attacks for Unmanned Aerial Vehicles Using Multi-Constellation GNSS

Yan, Xinhao	The Hong Kong Polytechnic University
Huang, Hailong	Hong Kong Polytechnic University

Keywords: Fault Detection and Diagnostics, Sensor/Data Fusion, Signal Processing
Abstract: Global navigation satellite system (GNSS) is an important part of unmanned aerial vehicles (UAVs), because it can provide UAVs with real-time location information for navigation and tracking. However, due to the increasing openness of GNSS, it has become more vulnerable to various cyberattacks. The spoofing attack is a typical kind that can send fake information to confuse the operations of a UAV. It will cause serious consequences, for example, crash, thus the research on the methods of countering spoofing attacks is significant. This paper is concerned with a UAV suffering from a spoofing attack when flying on a path, while the extended Kalman filter (EKF) and the nonlinear model predictive control (NMPC) methods are respectively adopted for estimation and control. In order to counter malicious attackers, a multi-constellation GNSS is equipped for the UAV, which means the UAV can simultaneously receive multiple location information. After detecting the spoofed GNSS signal with the $\chi 2$ detector, the data from other constellations and an inertial measurement unit (IMU) will be gathered for centralized fusion state estimation, guaranteeing high estimation performance. Finally, the software simulation on a well-known platform called Gazebo is provided to show the effectiveness of the proposed methods.

11:15-11:30, Paper ThBT4.4

A Fault-Detection Method of MEMS Micromirrors with Hysteresis

Tan, Yonghong	Shanghai Normal University

Li, Xinyuan	Shanghai Normal University
Ke, Changzhong	Donghua University
Dong, Ruili	Donghua University
Tan, Qingyuan	University of Windsor
Gu, Ya	Shanghai Normal University

Keywords: Micro and Nano Systems, Estimation and Identification, Fault Detection and Diagnostics

Abstract: Electromagnetic scanning micromirror (EMSM) is a micro-electro -mechanical system (MEMS) chip used as an actuator in precision instruments. In this paper, the failure modes of the EMSM are briefly investigated. In order to suppress the effect of random noise and non-smooth hysteresis, a non-smooth dynamic state estimator (NSDSE) is proposed to estimate the states of the EMSM chip. Then, the stability of the NSDSE system is studied. Afterward, the fault detection method using the proposed NSDSE are presented. Finally, the experimental results are presented for validating the proposed fault detection method.

11:30-11:45, Paper ThBT4.5	

A Mismatch Correction Method Based on Two-Way Strategies of Spatial Vector Feature

Ma, Zixuan	Beijing Institute of Technology
Wang, Bo	Beijing Institute of Technology
Bi, Ran	Beijing Institute of Technology

Keywords: Signal Processing

Abstract: Gravity matching method is the core technology in gravity aided inertial navigation system (GAINS). The single point filter matching algorithm is widely used in underwater navigation owing to its high accuracy and real-time performance. However, due to gravity measurement errors, the mismatch points may occur and cause large position errors. In order to improve the matching accuracy, a mismatch correction method based on two-way strategies of spatial vector feature is proposed. Based on the spatial vector characteristics of the gravity field, two-way strategies of scale constraint and direction constraint is applied to detect the outliers. Vector median filtering correction method is applied to calculate the accompanied matching points. The affine transformation method with least squares optimization parameters is adopted to smooth the corrected trajectory. Simulation results show that the proposed method can effectively suppress the spatial position error and improve the positioning accuracy and robustness.

11:45-12:00, Paper ThBT4.6	

Predictive Control of Vehicle Dynamics Equipped with Intelligent Tire Sensors Via Gaussian Process Regression of Lateral Tire Force

Ryu, Kunhee	Hyundai Motor Company
Kim, Jinsung	Hyundai Motor Company
Han, Minkyu	Hyundai Motor Company
Back, Juhoon	Kwangwoon University

Keywords: Automated Guided Vehicles, Control Applications, Learning-based Control

ThCT1	H102
Distributed Optimization for Networked Systems	Invited Session

Chair: Yang, Tao	Northeastern University
Co-Chair: Zhu, Shanying	Shanghai Jiao Tong University
Organizer: Yang, Tao	Northeastern University
Organizer: Wen, Guanghui	Southeast University
Organizer: Hong, Yiguang	Chinese Academy of Sciences

14:00-14:15, Paper ThCT1.1	

Non-Cooperative Game-Based Formation Tracking Control of Unmanned Surface Vessels under Markovian Switching Topologies (I)

Ren, Jianxiang	Southeast University
Fang, Xiao	Southeast University
Yang, Tao	Northeastern University
Wen, Guanghui	Southeast University

Keywords: Learning-based Control, Multi-agent Systems, Networked Control

Abstract: This paper investigates the problem of noncooperative game-based formation tracking control for unmanned surface vessels (USVs) under Markovian switching topologies. In contrast to previous works on collaborative tracking control with fixed communication topologies, the USVs considered in this paper exhibit non-cooperative relationships, and the communication topology is subject to Markovian switching. To address these challenges, a game-theoretic approach is employed to balance the conflicting tasks of the USVs. Specifically, a distributed estimate protocol is designed to enable the USVs to estimate information about non-neighboring USVs through Markovian switching topologies. Based on this distributed estimate protocol, a distributed control law is developed to guide the USVs towards the Nash equilibrium of the non-cooperative game. The effectiveness of the proposed control law is validated through numerical simulations.

14:15-14:30, Paper ThCT1.2	

Almost Sure Convergence to Approximate Nash Equilibrium in Zero-Sum Extensive-Form Games with Noisy Feedback (I)

Zhu, Kui	Beijing Institute of Technology
Zeng, Xianlin	Beijing Institute of Technology

Keywords: Multi-agent Systems, Networked Control

Abstract: This paper proposes a regularized optimistic gradient descent-ascent algorithm to seek an approximate Nash equilibrium for zero-sum extensive-form games in noisy feedback setting, where each player only observes noisy gradients. Using a regularization technique, we establish the convergence properties of the proposed algorithm under mild assumptions. We prove that, in a noisy feedback setting, the proposed algorithm almost surely converges to an approximate Nash equilibrium, with the quality of the approximation depending on the chosen regularization parameter. Finally, we demonstrate the efficacy of the proposed algorithm through simulations on two representative extensive-form games.

14:30-14:45, Paper ThCT1.3	

Quantized Tracking Capacity for Unstable Dynamics in Distributed Estimation under Data Rate Limitation (I)

Li, Peizhe	Shanghai Jiao Tong University
Chen, Cailian	Shanghai Jiao Tong University

Zhu, Shanying	Shanghai Jiao Tong University
Guan, Xinping	Shanghai Jiao Tong University

Keywords: Multi-agent Systems, Networked Control
Abstract: This paper considers the distributed estimation of an unstable system under data rate constraint. A quantized consensus-based distributed state estimation algorithm is designed. The Quantized Tracking Capacity (QTC) is proposed to describe an upper bound on the degree of instability of the dynamical system that can be estimated by the proposed distributed algorithm. A set of sufficient conditions is derived, guaranteeing the boundedness of estimation errors. It is shown that QTC reveals the fundamental limitation on distributed estimation induced by network connectivity, limited data rate, and system dynamics. Finally, numerical simulations show that the QTC decreases as the achievable end-to-end data rate decreases, verifying our theoretical results.

14:45-15:00, Paper ThCT1.4	

Compressed Distributed Zeroth-Order Gradient Tracking for Nonconvex Optimization (I)

Xu, Lei	Northeastern Univeristy
Yi, Xinlei	KTH
Sun, Jiayue	Northeaster University
Wen, Guanghui	Southeast University
Chai, Tianyou	Northeastern University
Yang, Tao	Northeastern University

Keywords: Optimal Control, Networked Control, Multi-agent Systems
Abstract: This paper investigates a distributed nonconvex optimization problem, which aims to minimize the average value of the local nonconvex cost functions through the information exchange. Note that the communication channel often has limited bandwidth and gradient information is typically unavailable. To overcome these limitations, we propose a distributed zeroth-order gradient tracking algorithm based on general compressed communication with bounded relative compression and the random gradient estimator. To the best of our knowledge, this is among the first compressed gradient tracking algorithm without the gradient information for distributed nonconvex optimization. Furthermore, we design an appropriate Lyapunov function to analyze its convergence property. We show that the proposed algorithm can find a stationary point with a sublinear convergence rate of mathcal{O}(1/sqrt{T}) when local cost functions are smooth. Moreover, if the global cost function satisfies the Polyak--{L}ojasiewicz condition, we show that the proposed algorithm achieves sublinear convergence to the global optimum with a rate of mathcal{O}(1/T). Finally, numerical simulations are conducted to verify the theoretical results.

15:00-15:15, Paper ThCT1.5	

A Communication-Efficient Stochastic Gradient Descent Algorithm for Distributed Nonconvex Optimization (I)

Xie, Antai	Shanghai University
Yi, Xinlei	KTH
Wang, Xiaofan	Shanghai Jiao Tong University
Cao, Ming	University of Groningen
Ren, Xiaoqiang	KTH

Keywords: Networked Control
Abstract: This paper studies distributed nonconvex optimization problems with stochastic gradients for a multi-agent system, in which each agent aims to minimize the sum of all agents' cost functions by using local compressed information exchange. We propose a distributed stochastic gradient descent (SGD) algorithm, suitable for a general class of compressors. We show that the proposed algorithm achieves the linear speedup convergence rate mathcal{O}(1/sqrt{nT}) for smooth nonconvex functions, where T and n are the number of iterations and agents, respectively. If the global cost function additionally satisfies the Polyak--Łojasiewicz condition, the proposed algorithm can linearly converge to a neighborhood of the global optimum, regardless of whether the stochastic gradient is unbiased or not. Numerical experiments are carried out to verify the efficiency of our algorithm.

15:15-15:30, Paper ThCT1.6	

An Adaptively Distributed Algorithm for Noncooperative Games of High-Order Integrator Systems (I)

Du, Xixiang	North China Electric Power University
Xiao, Feng	North China Electric Power University
Yu, Mei	North China Electric Power University

Keywords: Multi-agent Systems, Modeling and Control of Complex Systems, Networked Control
Abstract: In this paper, an adaptively distributed Nash equilibrium (NE) seeking algorithm is designed for heterogeneous high-order integrators in noncooperative games. The adaptively distributed algorithm is proposed that introduces a scaling parameter with adaptive adjustments to the weights of the edges in the communication graph. The main advantage is to ensure the convergence of the algorithm to the NE without requiring the knowledge of graph's algebraic connectivity. The convergence of the designed algorithm to the NE is analyzed by the Lyapunov stability theory and input-to-state stability theory. A numerical example is given to illustrate the proposed method.

ThCT2	H101
Learning-Based Control	Regular Session
Chair: Guo, Zongyi	Northwestern Polytechnical University

14:00-14:15, Paper ThCT2.1	

Rapid Generation of Hypersonic Entry Flight Trajectories under Uncertainty Using Transfer Learning

Li, Haochen	Beihang University
Chen, Haibing	Beihang University
Su, Xu	Beihang University

Keywords: Learning-based Control, Nonlinear Systems and Control, Optimal Control
Abstract: Optimal achievement of specific mission objectives in hypersonic entry flight requires adherence to complex nonlinear flight dynamics constraints. The challenge of achieving either optimal or suboptimal flight amidst perturbations in initial flight state, environmental conditions, and model uncertainties significantly complicates rapid and effective trajectory planning. This study introduces a transfer learning-based method to improve network performance in predicting flight trajectories under uncertain hypersonic entry flight conditions. A mathematical model of uncertainty factors such as variations in initial flight state, aerodynamic coefficient deviation, and discrepancies in

atmospheric density and flight vehicle mass is established, thereby enabling the network to learn the nonlinear mapping between flight state and control actions under these uncertain conditions via transfer learning method. Given that the time-intensive training process is conducted offline, the trained model can generate a single guidance command in just 0.6 milliseconds on a PC environment. Monte Carlo simulations demonstrate that the transfer model developed in this study effectively improves the performance of the neural network as a guidance controller under uncertain flight conditions. The model maintains a consistent level of guidance precision and successfully completes flight tasks despite various uncertainties.

14:15-14:30, Paper ThCT2.2

Physics-Informed Neural Networks-Based Uncertainty Identification and Control for Closed-Loop Attitude Dynamics of Reentry Vehicles

Yuan, Ruizhe	Institute of Precision Guidance, and Control, Northwestern Polyt
Guo, Zongyi	Northwestern Polytechnical University
Cao, Shiyuan	Northwestern Polytechnical University
Henry, David	Universite Bordeaux
Cieslak, Jérôme	University of Bordeaux
Oliveira, Tiago Roux	State University of Rio De Janeiro - UERJ
Guo, Jian-guo	Northwestern Polytechnical University

Keywords: Learning-based Control, Estimation and Identification, Control Applications

Abstract: This paper investigates the application of Physics-Informed Neural Network (PINN) technique into the uncertainty identification and control issue for reentry vehicles (RV) attitude dynamics. The PINN methodology proves to obtain the solution of ordinary differential equations through incorporating the physical and data knowledges. The existing articles mainly focus on using the PINN to the inverse problem, which actually deals with the open-loop dynamics and neglects the control design. Different from that, this paper instead introduces the Euler iteration-augmented Physics-Informed Neural Networks (Euler-PINNs) to estimate unknown parameters in the RV closed-loop dynamics, meanwhile, the classical PID is designed to ensure the fine attitude track of desired commands. Furthermore, the framework of the proposed method is described in detail. Then, the sampled simulated time-series data of attitude dynamics with time-varying uncertainties is utilized for the neural network learning, and simulation results show its effectiveness. Also, the influence of control parameters on the PINN algorithm effect is discussed.

14:30-14:45, Paper ThCT2.3

Actor-Critic Enhanced Neural Network Optimizer for Mixed-Integer Optimal Control: A Case Study on Eco-Driving Control

Cheng, Yifan	Tongji University
Luo, Xi	Tongji University
Dong, Shiying	Jilin University
Hong, Jinlong	Tongji University
Guo, Lulu	Jilin University
Hu, Jia	Tongji University
Gao, Bingzhao	Jilin University
Chen, Hong	Tongji University

Keywords: Learning-based Control, Intelligent and AI Based Control, Control Applications

Abstract: This paper presents an algorithm of Actor-Critic enhanced neural network optimizer, in order to improve the optimization performance of mixed integer control problems. The proposed algorithm first utilizes an neural network optimizer with a soft-argmax operator to handle the integer variables of the optimization problem in predictive horizon. Then, considering the possible local optimality of integer control inputs, the actor-critic algorithm in predictive horizon is adopted to handle only integer variables to further enhance the optimality of the solution based on the training data from the previous optimization stage. The evaluation of algorithm performance is deployed in a case study of eco-driving control problem, and the simulation results show the superiorities over the benchmark algorithm of the cost function values in predictive horizon.

14:45-15:00, Paper ThCT2.4

Sliding Mode-Based Two-Dimensional Iterative Learning Control for Systems with Uncertainties and External Disturbances

Yu, Yaru	Shanghai Jiaotong University
Li, Dewei	Shanghai Jiao Tong University
Ma, Aoyun	Shanghai Jiao Tong University
Gao, Furong	Hong Kong University of Science & Technology

Keywords: Learning-based Control, Linear Systems, Real-time Systems

Abstract: This paper proposes a sliding mode-based two-dimensional (2D) iterative learning control (ILC) strategy for discrete-time batch process systems challenged by uncertainties and external disturbances. Considering the repetitive nature of batch process systems, the ILC method shows significant advantages. Given the presence of non-repetitive uncertainties and external disturbances in practical systems, this paper integrates the sliding mode control (SMC) scheme into the ILC design framework to ensure system robustness. A novel aspect of this study is the development of an augmented 2D model that captures the dynamic evolution in both batch and sampling time directions. Based on this 2D model, a corresponding 2D sliding mode surface and a 2D iterative learning sliding mode controller are designed, preserving the learning capabilities of ILC and the robustness of SMC against uncertainties and external disturbances. The method proposed in this paper enables the controlled system to maintain a high tracking capability in the face of non-repetitive uncertainties and external disturbances. Particularly, the stability conditions derived from this 2D model provide a broad feasible solution space, which improves the applicability. Furthermore, the correctness of the proposed method is proven and its effectiveness is validated through a simulation example.

15:00-15:15, Paper ThCT2.5

UAV Cooperative Air Combat Maneuvering Decision-Making Using GRU-MAPPO

Chen, Caiyi	Xiamen University
Guo, Zhengyu	National Key Laboratary of Air-Based Information Perceptian And
Luo, Delin	Xiamen University

Xu, Yang	Northwestern Polytechnical University
Duan, Haibin	Beihang University

Keywords: Learning-based Control, Motion Control, Multi-agent Systems
Abstract: Abstract— In this article, a GRU-Multi-agent Proximal Policy Optimization (GRU-MAPPO) algorithm was proposed to address unmanned aerial vehicle (UAV) cooperative air combat decision-making problem. This algorithm adds a layer of GRU to the Actor-Critic network framework, uses update gate to extract the historical temporal information and enhance situational awareness. Finally, experiments in our constructed UAV cooperative air combat environment demonstrate that UAVs using the algorithm proposed in this article can learn effective strategies in air combat environments and achieve high win rates.

15:15-15:30, Paper ThCT2.6	

Data-Based Iterative Learning Control: A Nonconservative Approach Via LMI Techniques

Wang, Chenchao	School of Automation Science and Electrical Engineering, Beihang
Meng, Deyuan	Beihang University (BUAA)
Cheng, Long	Chinese Academy of Sciences

Keywords: Learning-based Control, Optimal Control, Robust and H infinity Control
Abstract: This paper aims to propose a data-based iterative learning control (ILC) framework that addresses the tracking issues without imposing additional assumptions on the sufficiency of sampled data. By introducing the concepts of k-state system and robust k-stability, we establish a connection between time-domain tracking issues and iteration-domain k-stabilization. Moreover, with the application of some helpful linear matrix inequality (LMI) techniques, we convert the data-based ILC synthesis into solving equivalent LMI conditions. As a result, the tracking error is recursively corrected and satisfied tracking performances are achieved by leveraging as few sampled data as possible. To demonstrate the effectiveness of the proposed ILC framework, illustrative simulations on an injection molding process are also provided.

ThCT3	H103
Robotics (III)	Regular Session
Chair: Duan, Haibin	Beihang University

14:00-14:15, Paper ThCT3.1	

Fixed-Wing UAVs Formation Flight Experiments with Intelligent Autonomous System Teaching Platforms

Duan, Haibin	Beihang University
Wu, Tongyan	Beihang University
Wei, Chen	Beijing University of Aeronautics and Astronautics
Deng, Yimin	Beihang University
Huo, Mengzhen	School of Automation Science and Electrical Engineering, Beihang

Keywords: Control Education, Multi-agent Systems, Robotics
Abstract: A crucial challenge for autonomous systems is implementing high intelligence levels. Teaching platforms of intelligent autonomous systems is developed for fixed-wing UAVs formation. With multiple levels of autonomous circuits covered, the intelligent autonomous system achieves autonomous decisions for three levels of intelligence. Situation awareness, mission planning, collision avoidance, and guidance are implemented by designing algorithms. Formation flight experiments in the form of leader-follower were performed, with results demonstrating the effectiveness and feasibility of the developed teaching platforms.

14:15-14:30, Paper ThCT3.2	

A Guided-To-Autonomous Policy Learning Method of Deep Reinforcement Learning in Path Planning

Zhao, Wang	Northwestern Polytechnical University
Zhang, Ye	Northwestern Polytechnical University
Li, Haoyu	Northwestern Polytechnical University

Keywords: Learning Systems, Automated Guided Vehicles, Robotics
Abstract: This study introduces a Guided-to-Autonomous Policy Learning(GAPL) method that improves the training efficiency and composite optimization of Deep Reinforcement Learning(DRL) in path planning. Under this method, firstly, we introduce the concept of guiding rewards as a reward enhancement mechanism, which, based on Rapidly-exploring Random Trees(RRT) and Artificial Potential Field(APF) algorithm, effectively addresses the challenge of training efficiency. We then propose the Guided-to-Autonomous Reward Transition (GART) model to solve the combined challenges of balancing training efficiency with composite optimization problems, which lies in the evolutionary refinement of the reward structure, initially dominated by guiding rewards, shifting progressively toward a focus on rewards that emphasize composite optimization, specifically minimizing the distance and time to the end point. Simulated experiments in static obstacle settings and mixed dynamic-static obstacle environments demonstrate that: 1) guiding rewards play a significant role in enhancing training efficiency; 2) the GAPL method yields superior composite optimization outcomes for path planning compared to traditional methods, and it effectively addresses the issue of training efficiency in conventional DRL approaches.

14:30-14:45, Paper ThCT3.3	

A Cost-Effective Cooperative Exploration and Inspection Strategy for Heterogeneous Aerial System

Xu, Xinhang	Nanyang Technological University
Cao, Muqing	Nanyang Technological University
Yuan, Shenghai	NanYang Technological University
Nguyen, Thien Hoang	Nanyang Technological University
Nguyen, Thien-Minh	Nanyang Technological University
Xie, Lihua	Nanyang Technological University

Keywords: Robotics, Multi-agent Systems, Estimation and Identification
Abstract: In this paper, we propose a cost-effective strategy for

heterogeneous UAV swarm systems for cooperative aerial inspection. Unlike previous swarm inspection works, the proposed method does not rely on precise prior knowledge of the environment and can complete full 3D surface coverage of objects in any shape. In this work, agents are partitioned into teams, with each drone assign a different task, including mapping, exploration, and inspection. Task allocation is facilitated by assigning optimal inspection volumes to each team, following best-first rules. A voxel map-based representation of the environment is used for pathfinding, and a rule-based path-planning method is the core of this approach. We achieved the best performance in all challenging experiments with the proposed approach, surpassing all benchmark methods for similar tasks across multiple evaluation trials. The proposed method is open sourced at https://github.com/ntu-aris/caric_baseline, and was provided as baseline solution of the Cooperative Aerial Robots Inspection Challenge at the 62nd IEEE Conference on Decision and Control 2023.

14:45-15:00, Paper ThCT3.4	

Vibration Suppression Trajectory Planning of Flexible Manipulator Based on Hierarchical Self-Adjusting Constrained Optimization

Xie, Yuanlong	Huazhong University of Science and Technology
Wang, Yan	Huazhong University of Science and Technology
Wang, Shuting	Huazhong University of Science and Technology
Li, Hu	Huazhong University of Science and Technology

Keywords: Robotics, Optimal Control, Intelligent and AI Based Control
Abstract: For the vibration suppression trajectory planning of a flexible manipulator, it is difficult to balance the convergence speed and accuracy of the optimization algorithm, resulting in unsatisfactory vibration suppression effects. To do this, a vibration suppression trajectory planning method is proposed based on a novel hierarchical self-adjusting constrained optimization algorithm. First, with the help of a predefined fifth-order polynomial function, the vibration suppression trajectory planning is transformed into a constrained numerical optimization problem characterized by the end elastic displacement, the end residual vibration displacement, and the deviation between the reference trajectory and the candidate trajectory. Furthermore, a novel hierarchical self-adjusting constrained optimization algorithm is designed for the above problems. Its advantage lies in the adaptive adjustment of the evolutionary process through successive enhance of adaptive population size adjustment, hierarchical evolution based on constraint criteria, and self-adjustment of weighted control parameters, thereby better balancing convergence speed and accuracy. Comparative experiments with advanced methods verify the effectiveness and advancement of the proposed method.

15:00-15:15, Paper ThCT3.5	

A 3D Point Attacker for LiDAR-Based Localization

Yi, Shiquan	Northwestern Polytechnical University
Gao, Jiakai	Northwestern Polytechnical University
Lyu, Yang	Northwestern Polytechnical University
Hua, Lin	Northwestern Polytechnical University
Pan, Quan	Northwestern Polytechnical University

Keywords: Robotics, Sensor/Data Fusion, Estimation and Identification
Abstract: The safety and security issues of autonomous navigation function become the main obstacles that hinder the widespread applications of self-driving cars and unmanned systems. In this paper, we investigate the vulnerability of LiDARbased localization methods to adversarial attacks. Specifically, we developed a feature-based spoofing attack strategy to degrade the localization performance of LiDAR-based localization algorithms. Reflecting on the vulnerability, we additionally provide a resilient strategy to defend existing LiDAR-based localization methods against this attack. The proposed attack strategy is tested on the KITTI dataset to illustrate its effectiveness.

15:15-15:30, Paper ThCT3.6	

Mobile Cooperative Robot Safe Interaction Method Based on Embodied Perception

Wang, Sicheng	AIRS
Cheng, Xu	Tianjin University of Technology
Zhang, Tianwei	The Chinese University of Hong Kong-Shenzhen

Keywords: Robotics, Sensor/Data Fusion, Signal Processing
Abstract: The most crucial feature of cooperative robot is interaction safety. Ensuring safe interaction with humans is essential for improving the quality and efficiency of industrial robot production. The promotion and development of cooperative robots heavily rely on ensuring safe human-robot interaction. Therefore, this paper introduces a vision-centric cooperative robot interaction system designed for dynamic environments. Firstly, the system utilizes a highly accurate 3D camera to reconstruct the monitoring scene in three dimensions. Simultaneously, the camera mounted on the robot's head reconstructs objects within its current field of view with high precision. By merging the point clouds of these two scenes,the system achieves a comprehensive reconstruction. Secondly, the system extracts the point cloud data of human bodies in the scene and determines a safe distance between humans and the robot based on the human point cloud. This analysis allows the system to define an appropriate safety range. Finally, the system evaluates whether the human body is within the predefined safe distance from the robot and facilitates improved human-robot interactions accordingly. By implementing this approach, the system effectively ensures interaction safety in the work environment. Experimental results demonstrate the effectiveness of the proposed system in maintaining a secure interaction environment.

ThCT4	H104
Unmanned System Based Sensing	Invited Session
Chair: Gao, Zhi	Wuhan University
Co-Chair: Lu, Maobin	Beijing Institute of Technology
Organizer: Gao, Zhi	Wuhan University

14:00-14:15, Paper ThCT4.1	

Small Object Detection in Unmanned Aerial Vehicle Images Leveraging Density-Aware Scale Adaptation and Knowledge Distillation (I)

Wan, Yu	Wuhan University

Lan, Zekai	Nanjing Normal University
Hu, Jianqiu	Jiangsu Automation Research Institution
Ji, Hong	Wuhan University
Song, Weiwei	Peng Cheng Laboratory
Gao, Zhi	Wuhan University

Keywords: Sensor Networks, Sensor/Data Fusion, Signal Processing

Abstract: Small object detection remains a challenging task despite the impressive progress in general object detection over the past decade. The difficulties are attributed to the small size, severe occlusion, and variant scales. To address these challenges, we propose a novel method for small object detection, employing a coarse-to-fine approach that integrates density-aware scale adaptation and knowledge distillation. Firstly, we comprise a coarse network for global sketchy predictions in large scenes, generating adaptively scaled block regions containing potential objects. Subsequently, a fine network is utilized for precise detection in densely packed areas, where objects exhibit approximately unified scales. To enhance scale transformation, a density map, providing object distribution information, is introduced as an auxiliary task for scene classification. Moreover, a grid masked knowledge distillation strategy is proposed to facilitate the student network's feature recovery, thus promoting detection accuracy without directly mimicking the teacher network. Extensive experiments on renowned benchmark datasets, including VisDrone and UAVDT, substantiate the superiority of the proposed method for small object detection in unmanned aerial vehicle images.

14:15-14:30, Paper ThCT4.2	

SUAS-Based Multispectral Imaging in Support of Detection of Camouflaged Targets and Battlefield Anomalies

Barmpas, Stergios	Hellenic Army
Yakimenko, Oleg A.	Naval Postgraduate School

Keywords: Sensor/Data Fusion, Robotics

Abstract: In response to the extended usage of tactical- and theater-level unmanned aerial systems (UASs) for reconnaissance and surveillance in the modern battlefield, the ground forces put more and more emphasize on hiding their assets using camouflage or exploiting terrain and vegetation so that these assets are not visible using regular day/night vision sensors. The aerial multispectral (MS) imaging technology is considered as a promising remedy to rectify this situation. This paper explores the performance of commercial-off-the-shelf MS imaging sensor integrated with a small UAS to collect imagery in multiple spectral bands to potentially contribute to the detection of camouflaged targets and battlefield anomalies. In doing so it introduces a new spectral index and examines its effectiveness compared to several other methods.

14:30-14:45, Paper ThCT4.3	

DynaVIG: Monocular Vision/INS/GNSS Integrated Ego and Object Localization in Dynamic Scenes (I)

Jin, Ronghe	Wuhan University
Wang, Yan	Wuhan University
Mei, Tiancan	Wuhan University
Niu, Xiaoji	Wuhan University
Liu, Jingnan	Wuhan University
Hu, Yu	Guangdong Laboratory of Artificial Intelligence and Digital Econ
He, Jiazhou	Jiangsu Automation Research Institute
Hu, Jianqiu	Jiangsu Automation Research Institution

Keywords: Sensor/Data Fusion, Robotics, Signal Processing

Abstract: Existing ego and object localization systems, predominantly reliant on stereo or stereo-inertial methods, encounter large computation demands and are prone to error drift. These systems often assume a constant camera height and constant object velocity model, presupposing a planar and straight-line ground. We propose DynaVIG, a unified framework of ego and object localization system based on the integration of Monocular Vision, Inertial Navigation System (INS), and Global Navigation Satellite System (GNSS), aiming to provide accurate estimation of the ego and object poses with low computation and cost. A prior height model and an accurate dynamics model are constructed to forego the conventional ground assumptions. Experiments on the KITTI dataset demonstrate that our framework can achieve accurate ego and object localization with high efficiency compared to state-of-the-art methods.

14:45-15:00, Paper ThCT4.4	

PLPD-SLAM: Point-Line-Plane-Based RGB-D SLAM for Dynamic Environments (I)

Dong, Juan	Beijing Institute of Technology
Lu, Maobin	Beijing Institute of Technology
Xu, Yong	Zhejiang University
Deng, Fang	Beijing Institute of Technology
Chen, Jie	Tongji University

Keywords: Robotics, Modeling and Control of Complex Systems, Motion Control

Abstract: The majority of visual Simultaneous Localization and Mapping (SLAM) algorithms are built upon the assumption of static environmental conditions. However, this assumption limits the applicability of visual SLAM systems in real-world scenarios. Some methods use deep learning-based image segmentation to remove dynamic objects before tracking, which slows down tracking. Others relying on object detection end up with few point features left after removing those on dynamic objects, causing significant drift in the tracking trajectory. In this paper, we propose a dynamic SLAM method based on point-line-plane features. We calculate the information entropy to determine the distribution complexity of the pixels. If the information is sufficient, only point and line features are used for trajectory tracking, otherwise, plane features are added. We employ YOLOv5 for dynamic object detection, enabling robust tracking in dynamic scenarios by selecting reliable features. By performing object detection and tracking in parallel, we improve the real-time performance of the system. In sharp contrast to existing methods, the PLPD-SLAM can handle environments with dynamic objects in real-time and significantly reduce the long-term drift caused by dynamic objects. Finally, we evaluate our method using public benchmarks and our dynamic laboratory scenarios. The experimental results show that our method performs better compared to other state-ofthe-art methods.

15:00-15:15, Paper ThCT4.5	

Efficient Air-To-Air Drone Detection with Composite Multi-Dimensional Attention

Yin, Xingyu	Beijing Institute of Technology
Ren, Jin	Beijing Institute of Technology
Lin, Defu	Beijing Institute of Technology

Keywords: Sensor/Data Fusion, Man-machine Interactions, Micro and Nano Systems
Abstract: Visual UAV detection has become a key technology in areas such as formation flight, low-altitude obstacle avoidance and anti-drone operations due to its affordablility, compact size and lightweight design. Air-to-air drone detection involves more complex background, unstable motion of source and target drones, small object sizes, varied shapes, substantial intensity variation, and occlusion, making it quite challenging. The visual attention mechanism shows promise in effectively addressing many of the aforementioned challenges. While some studies have incorporated attention algorithms into drone detection systems, there remains no systematic discussion of drone detection with multiple attention mechanisms. We explore the integration of attention mechanisms across three dimensions—scale attention, spatial attention, and task attention—into drone detection. Through detailed analysis, we assess their respective contributions and propose a novel visual attention drone detector. Experimental validation is performed on NPS-Drones and DUT-Anti-UAV datasets. The results show that the proposed drone detection algorithm based on attention mechanism exhibits significant advantages in both accuracy and processing speed.

15:15-15:30, Paper ThCT4.6	

Robust RGB-D SLAM in Dynamic Environments Using Geometry and Semantic Information (I)

Xiao, Yao	Wuhan University
Zou, Junjie	Wuhan University
Jin, Ronghe	Wuhan University
Mei, Tiancan	Wuhan University

Keywords: Sensor/Data Fusion, Robotics, Signal Processing
Abstract: Enabling dynamic SLAM with cameras is challenging due to the reliance on ego-motion for dynamic object handling, which creates a paradox since accurate ego-motion calculation requires the removal of dynamic features. This paper presents a solution with a geometry-based motion detection module that uses point correlation and semantic data from real-time instance segmentation to identify moving objects. For efficiency, this module operates on keyframes while a template-based method tracks known objects. The system also eliminates invalid map points for consistent mapping and improved localization. Extensive evaluation in public TUM dataset demonstrates that it surpasses other dynamic RGB-D SLAM systems in accuracy and robustness.

FrAT1	H102
Automated Guided Vehicles	Regular Session
Chair: Su, Rong	Nanyang Technological University
Co-Chair: Dünnweber, Jan	Ostbayerische Technische Hochschule Regensburg

08:30-08:45, Paper FrAT1.1

A Path Following Control Method for Underactuated Unmanned Surface Vehicles Based on Output Redefinition

Xu, Zishi	Zhejiang University
Xiang, Ji	Zhejiang University, Yuquan Campus

Keywords: Automated Guided Vehicles

Abstract: The motion control tasks for underactuated unmanned surface vehicles (USVs) are difficult to perform due to the absence of force in sway direction. To handle the problem that available control input in the yaw direction cannot directly correspond to position errors, most current methods for underactuated USVs path following control apply line-of-sight (LOS) geometric projection to map position error to yaw angle. In this paper, a novel path following control method for underactuated USVs based on output redefinition is proposed. This method directly takes the position of a point as the control object, and the position error is demanded to converge exponentially by designing virtual velocity command at the kinematics stage. At kinetics level, thrusts are designed to track the virtual velocity command, and external disturbances are observed and compensated to improve the robustness. Compared with the LOS method, the deviations of geometric projection in complicated situations are eliminated, and the stability is guaranteed despite of parameters and disturbances. Moreover, simulation results demonstrate the effectiveness of the proposed method.

08:45-09:00, Paper FrAT1.2

An Incremental Planning Strategy-Based Genetic Algorithm for Integrated Scheduling and Routing Optimization in Smart Manufacturing

Yao, Jiarong	Nanyang Technological University
Guo, Yao	NanyangTechnological University
Li, Jiangpeng	Nanyang Technological University
Su, Rong	Nanyang Technological University
Ling, Keck-Voon	Nanyang Technological University
Han, Boon Siew	Nanyang Technological University
Wong, Hong Yee Alvin	Nanyang Technological University

Keywords: Automated Guided Vehicles, Flexible Manufacturing Systems, Integrated Manufacturing

Abstract: Production scheduling has always been an important topic in smart manufacturing especially integrated with dispatching and routing of automatic guided vehicle or autonomous mobile robots, which is generally modeled as a nondeterministic polynomial-hard integer programming problem. However, most existing studies solve this combinatorial optimization problem through decomposition, namely dealing with scheduling and routing separately, or just assuming a fixed predefined distance matrix for routing, which sacrifices the solution quality for shorter time of decision making. As for metaheuristic solution for such integrated models, the need for effective and efficient searching rules is urgent, so that the heuristics can be more fit for specific purpose and scenarios. Thus, in this paper, an integrated scheduling and routing model is proposed oriented towards the optimization of production scheduling and fleet management in smart manufacturing environment. A genetic algorithm (GA) is used to solve this problem based on incremental planning (IP) strategy which makes effect through ensemble of two local search operators considering the time windows and alternative paths for every transportation task of AGVs. The effectiveness of the proposed method is validated through a simulation case study with horizontal comparison. Results showed that the IP strategy can improve the solution quality and traffic load imbalance of the factory layout, by reducing the makespan and working time of AGV by about 11.5% and 9% respectively. About 80% of the tasks obtained a shorter makespan by adopting an alternative path, showing the ability of traffic load balancing among layout elements when the problem scale increases.

09:00-09:15, Paper FrAT1.3

A MILP Model for Conflict-Free Routing Problem with Partial Charging in Multiple-AGV System

Guo, Yao	NanyangTechnological University
Yao, Jiarong	Nanyang Technological University
Su, Rong	Nanyang Technological University
Ling, Keck-Voon	Nanyang Technological University
Han, Boon Siew	Nanyang Technological University
Wong, Hong Yee Alvin	Nanyang Technological University

Keywords: Automated Guided Vehicles, Factory Modeling and Automation, Flexible Manufacturing Systems

Abstract: Automated Guided Vehicles (AGVs) are widely used in the manufacturing industry to achieve transportation automation due to their versatility and flexibility. However, the usage of multiple AGVs can lead to traffic conflicts and increased safety risks, making intelligent AGV scheduling crucial. This paper proposes a highly integrated mixed integer linear programming (MILP) model to address the task allocation and conflict-free routing of AGVs. Compared with most models in the current literature addressing the same problem, we introduce a novel constraint to ensure the avoidance of route conflicts. This constraint breaks away from the decision variables indexed by time dimension and the common grid layout of shopfloor, allowing our model to be applicable to longer-duration scenarios and a wider range of shopfloor layouts. Considering the increasing popularity of electric vehicles and the growing emphasis on green manufacturing, our model allows AGVs to partially charge during transportation. Energy efficiency also becomes one of the metrics for evaluating the quality of AGV scheduling plans. In the simulation, we provide a simple illustrative example and a detailed AGV plan to evaluate the effectiveness of our model. Furthermore, we test more examples based on a real shopfloor layout to evaluate the efficiency of the proposed model. For small and medium-scale examples, our model can obtain a global optimum solution in an efficient time frame.

09:15-09:30, Paper FrAT1.4

Dynamic Route Planning for a Data Collecting Luggage Transportation Service

Voelkl, Jakob	Ostbayerische Technische Hochschule Regensburg
Melzer, Matthias	Ostbayerische Technische Hochschule Regensburg
Dünnweber, Jan	Ostbayerische Technische Hochschule Regensburg
Sarkar, Amitrajit	Canterbury University

Keywords: Modeling and Control of Complex Systems, Sensor Networks, Automated Guided Vehicles

Abstract: Control and Automation of services of the urban infrastructure offered to citizens and tourists are elementary parts of a smart city. But both rely on a stable supply of data from sensors spread across the whole city, e.g., the fill level sensors of waste bins needed for a waste management tool which we developed in a collaboration with the Regensburg city council for the on-demand collection of waste bins. Europe has a lot of historic cities like Regensburg with narrow streets and huge building walls, some made from granite and fieldstones, which often represents an insurmountable obstacle to wireless data transmission. The reduction of the road traffic volume poses an additional challenge for city planners. By means of networked planning and simulation software, the situation, state and efficiency of citywide logistic services can be monitored and optimized. In the course of such optimizations, we propose the combination of digital and logistic services. As an example, we show that monitoring state information, such as the waste bin fill levels, can be accomplished using the same vehicles and the same planning software, that is used for luggage transportation. Moreover, we describe how we adapted a solver for a variant of the TSP, namely the prize-collecting traveling salesman, to optimize the route planning dynamically.

09:30-09:45, Paper FrAT1.5

Boundary Approximation and Area Coverage Using Fourier Analysis and Lissajous Curves

Nath, Suryadeep	Indian Institute of Science
Ghose, Debasish	Indian Institute of Science

Keywords: Automated Guided Vehicles, Motion Control, Robotics

Abstract: In this paper, we discuss the area coverage of a closed and connected region of arbitrary shape using Lissajous curves. We approximate the boundary of the region using Fourier analysis and justify the benefits of doing so compared to other approaches. We then generate coverage paths inside the region using Lissajous curves. The radius of the circular field-of-view of the covering agent is determined analytically, along with the time required to ensure complete coverage of the region. We demonstrate extensions of our solution to problems demanding non-uniform coverage and coverage using multiple agents by splitting up a large region. The effectiveness of our strategy is ascertained by proposing two performance metrics, representing completeness and uniformity.

09:45-10:00, Paper FrAT1.6

Topological Risk-Based Path Selection in Dynamic Environments

Xu, Erpei	Beijing Institute of Technology
Yu, Chengpu	Beijing Institute of Technology Chongqing Innovation Center
Liu, Yixuan	Beijing Institute of Technology

Keywords: Automated Guided Vehicles, Robotics

Abstract: Path selection for autonomous drones in dynamic scenes poses a significant challenge. The changing environmental topology, affected by moving obstacles, can cause previously established path prone to be unsafe. This article introduces a method for selecting safe topological paths in dynamic environments without the need to model moving obstacles. This method involves generating several smooth topological paths and then choosing the safest one through calculating the risk associated with each path on a particle dynamic map. Furthermore, a replanning strategy is proposed in dynamic scenarios to proactively address upcoming obstacles, enhancing navigational safety. Finally, the proposed method is validated in both simulated and real-world environments.

FrAT2 — H101

Cooperative Control Systems — Regular Session

Chair: Dong, Xiwang — Beihang University

Co-Chair: Kumar, Bhim — Indian Institute of Technology Mandi

08:30-08:45, Paper FrAT2.1

Finite-Time Stability of Positive Switched Impulsive and Multi-Agent Systems with Event-Triggered Controller on Non-Uniform Time Domains

Kumar, Bhim	Indian Institute of Technology Mandi
Malik, Muslim	Indian Institute of Technology Mandi

Keywords: Linear Systems, Multi-agent Systems, Control Applications

Abstract: In this paper, we addressed the finite-time stability results for positive switched impulsive and multi-agent systems on time scales. First, we discussed the positivity conditions and then the stability conditions for the switched impulsive system. Further, we discussed the finite-time stability condition for switched multi-agent systems on time scales via a distributed event-triggered controller. In the end, a simulation-based example is given to verify the results for discrete and continuous time domains.

08:45-09:00, Paper FrAT2.2

Distributed Optimization-Based Formation Tracking for Multi-Agent Systems with a Privacy-Preserving Mechanism

Su, Lingfei	Beihang University
Hua, Yongzhao	Beihang University
Dong, Xiwang	Beihang University
Ren, Zhang	Beihang University

Keywords: Multi-agent Systems, Robust and H infinity Control, Linear Systems

Abstract: This paper investigates distributed time-varying optimization-based formation tracking problems for discrete-time heterogeneous multi-agent systems with unknown disturbances. Firstly, an optimization-based formation tracking problem with privacy preservation is established, which formulates the relation between the formation tracking and the distributed optimization on

the formation reference. Then, a distributed formation tracking controller composing of differential privacy mechanism and stochastic subgradient method is designed. Furthermore, the privacy, stability and optimality are proved by utilizing the discrete-time Lyapunov method. Finally, numerical simulations demonstrate the effectiveness of the proposed method.

09:00-09:15, Paper FrAT2.3

Research on Collaborative Task Planning Method for Split Delivery Vehicle Routing Problem

Zhang, Jia	Beijing Institute of Technology
Hong, Rui	Beijing Institute of Technology
Dong, Qichen	Beijing Institute of Technology

Keywords: Multi-agent Systems
Abstract: In order to solve the problem of post disaster collaborative rescue of multiple unmanned vehicles, a task planning model is designed for vehicle routing with nonlinear costs and decomposable demands. The model considers the deteriorating health condition of the awaiting victims over time and the ability of multiple vehicles to participate in the rescue. The paper proposes a hybrid heuristic algorithm that combines variable neighborhood search and tabu search to solve the problem efficiently. In the framework of the variable neighborhood search algorithm, the approach utilizes a mixed neighborhood structure to expand the search space. Additionally, a tabu table mechanism is introduced to mitigate the issue of repetitive searches in variable neighborhood searches, preventing the algorithm from getting trapped in local optima. This augmentation enhances the algorithm's optimization capabilities. The results of simulation experiments verify the feasibility and progressiveness of the algorithm.

09:15-09:30, Paper FrAT2.4

Two-Stage Multi-Robot Task Allocation Algorithms in Local Communication Scenarios

Shan, Shilei	Beijing Institute of Technology
Peng, Zhihong	Beijing Institute of Technology
Zeng, Xianlin	Beijing Institute of Technology

Keywords: Multi-agent Systems
Abstract: In robot emergency rescue scenarios, it is common for communication between robots to be restricted, allowing interaction only within localized communication ranges. However, commonly proposed task allocation algorithms with weak communication models often focus on communication quality while neglecting communication distance. Consequently, this paper introduces a Bernoulli communication model incorporating distance information as the communication model. Subsequently, a two-stage distributed task allocation algorithm is proposed based on this communication model. In the convergence stage, each robot utilizes the K-means algorithm to determine the target task group and employs a distributed bee algorithm to select the target task. In the dispersion stage, robots use an improved distributed genetic algorithm to allocate remaining tasks, exchanging optimal solutions with other robots, thereby achieving conflict-free autonomous task allocation. Finally, real-time simulations are conducted to validate that this algorithm effectively resolves the multi-robot task allocation problem within the localized communication model.

09:30-09:45, Paper FrAT2.5

Leader-Follower Consensus on Matrix-Weighted Switching Networks

Wang, Kai	Shanghai Jiao Tong University
Pan, Lulu	Shanghai Jiao Tong University
Shao, Haibin	Shanghai Jiao Tong University
Li, Dewei	Shanghai Jiao Tong University
Li, Yuanlong	Shanghai Jiao Tong University
He, Shaoying	Shanghai Jiao Tong University

Keywords: Multi-agent Systems
Abstract: This paper examines the consensus problem on leader-follower matrix-weighted undirected switching networks. First, we introduce the leader-follower matrix-weighted integral network for analyzing such a category of networks. The connection between the null space of matrix-valued Laplacian associated with the integral network and that associated with the series of switching matrix-weighted networks has been established. Under some mild assumptions, sufficient conditions for leader-follower consensus under matrix-weighted periodic switching networks are provided. Simulation results are presented to demonstrate the theoretical results.

09:45-10:00, Paper FrAT2.6

Decentralized Task Allocation for Redundant Multi-Robot Systems: An Iterative Consensus Approach

Govoni, Lorenzo	Sapienza University of Rome
Cristofaro, Andrea	Sapienza University of Rome

Keywords: Multi-agent Systems, Networked Control, Robotics
Abstract: An overactuated heterogeneous multi-robot system is considered, this being characterized by both a redundancy of the number of agents with respect to the tasks to be performed and input redundancy for each individual agent. We propose an algorithm that, based on local information only, can simultaneously assign the tasks, consistently with the different nature of each robot, and allocate the control efforts while satisfying the constraints on the actuators. The performances of the proposed method have been analysed by means of a simulation study, considering different scenarios and illustrating also the resilience of the approach with respect to faults.

FrAT3	H103
Multi-Agent Systems	Regular Session
Chair: Yakimenko, Oleg A.	Naval Postgraduate School

08:30-08:45, Paper FrAT3.1

Fully Distributed Practical Fixed-Time Time-Varying Formation Tracking Control for General Linear Multiagent Systems

Li, JinSheng	BeiHang University
Yu, Jianglong	Beihang University
Hua, Yongzhao	Beihang University
Dong, Xiwang	Beihang University
Li, Qingdong	Beihang University
Ren, Zhang	Beihang University

Keywords: Multi-agent Systems, Adaptive Control, Linear Systems
Abstract: This paper concerns the practical fixed-time time-varying formation tracking problem for multiagent systems with a leader-follower structure, where the agents have general linear dynamics. The previous works are built on a priori knowledge of global

information, which is often unavailable in many applications. For this reason, a fully distributed fixed-time time-varying formation tracking protocol is proposed. Specifically, the estimation of the required setting time is independent of the initial system states and any global information. Furthermore, within the setting time, the residual set can be reduced to any desired level. These notable properties are analyzed by means of Lyapunov functions. Besides, a detailed design procedure for this protocol is presented. The effective of the above results are validated by a simulation example.

08:45-09:00, Paper FrAT3.2	

A Fully Distributed Event-Triggered Average Tracking Protocol with Discrete Communication and Control Updating

Dai, Xinyue	Southeast University
He, Haibin	Southeast University
Xu, Wenying	Southeast University
Yang, Shaofu	Southeast University

Keywords: Multi-agent Systems, Adaptive Control, Networked Control

Abstract: This paper studies an efficient protocol for communication/control of the distributed average tracking (DAT) problem of multi-agent systems, where each agent has access only to its own reference signal and aims to track the average of all signals. To this end, we design a new adaptive event triggering mechanism (AETM) with discrete communication and control update functions, which greatly reduces the cost of communication and control and excludes Zeno behavior. Then, a fully distributed protocol is established under AETM, which exhibits high scalability by eliminating global requirements such as eigenvalues of the Laplacian matrix. Furthermore, several sufficient conditions are derived to ensure that all agents asymptotically track the average of all reference signals. Finally, the effectiveness of the designed scheme was verified through simulation examples.

09:00-09:15, Paper FrAT3.3	

Ratio-Of-Distance-Based Adaptive Formation Control of Wheeled Robot Networks with Unknown Parameters and External Disturbances

Wang, Yujie	Shandong University
Liu, Shuai	Shandong University

Keywords: Multi-agent Systems, Adaptive Control, Robotics

Abstract: In this note, the adaptive formation control for wheeled robot networks with unknown parameters and external disturbances is discussed. Unlike most existing research which utilize distance or bearing measurements to realize formation targets, ratio-of-distance (RoD) measurements are introduced into the wheeled robot networks to reach the desired formation shapes. In reality, in lieu of ideal mass-point models popularly adopted in the study of formation control, wheeled robots are described by nonholonomic kinematics which is nonlinear. To handle it better, we consider transforming the system model into an Euler-Lagrange-like system model. After system transformation, system parameters can be linearized. To simulate extensive situations, we consider these parameters are unknown, and we also consider there exist external disturbances in system. Then, we propose an adaptive distributed control law for each wheeled robot to drive the whole robotic network to acquire the desired formation shapes through RoD measurements and backstepping approach. The Lyapunov method is employed to prove the system stability.

09:15-09:30, Paper FrAT3.4	

Distributed Strategies for Pursuit-Evasion of High-Order Integrators

Zhou, Panpan	KTH Royal Institute of Technology
Hu, Xiaoming	Royal Institute of Technology
Wahlberg, Bo	KTH Royal Institute of Technology

Keywords: Multi-agent Systems, Control Applications, Linear Systems

Abstract: This paper presents decentralized solutions for addressing pursuit-evasion problems involving high-order integrators with intracoalition cooperation and intercoalition confrontation. To ensure that the control strategies independent of the relative velocities, accelerations and higher order information of neighbors, we introduce distinct error variables and hyper-variables. Consequently, this approach only requires agents to exchange position information or measure the relative positions of neighbors. The distributed strategies reflect the goals of intracoalition cooperation or intercoalition confrontation of the players. Additionally, we present the conditions for capture and formation control with exponential convergence for three cases: one-pursuer-one-evader, multiple-pursuer-one-evader, and multiple-pursuer-multiple-evader. The results show that the conditions depend on the structure of the communication graph, the weights in the control law, and the expected formation configuration. Finally, the effectiveness of the proposed algorithm is demonstrated through simulation results.

09:30-09:45, Paper FrAT3.5	

Enhancing Urban Unmanned Ground Vehicle Operations through Machine Learning

Moore, Hyatt	U.S. Naval Postgraduate School
Yakimenko, Oleg A.	Naval Postgraduate School

Keywords: Multi-agent Systems, Intelligent and AI Based Control, Automated Guided Vehicles

Abstract: This paper investigates the use of reinforcement learning (RL) to improve how unmanned ground vehicles (UGVs) explore different environments, including urban outdoor, indoor, and open terrain. The paper utilizes a simulation setup developed and explored in the previous work by the authors in attempt to assess how RL can enhance exploration strategies in terms of efficiency and adaptability in urban areas. The results show that RL-based methods improve UGVs' ability to navigate and survey urban environments compared to traditional approaches. This improvement underscores the potential of RL to advance the capabilities of autonomous systems in complex settings. While the current focus is on exploration, future work will look into using RL for more complex scenarios involving direct engagements, such as encounters with enemy forces. The goal is to develop more sophisticated RL models that can manage multiple objectives, enhancing UGVs' functionality for urban operations.

09:45-10:00, Paper FrAT3.6	

Proximal Policy Optimization Based Decentralized Networked Multi-Agent Reinforcement Learning

Liu, Jinyi	Beijing University of Technology
Li, Fangyu	Beijing University of Technology
Wang, Jingjing	Beijing University of Technology
Han, Honggui	Beijing University of Technology

Keywords: Multi-agent Systems, Learning Systems, Networked Control

Abstract: Networked multi-agent reinforcement learning (NMARL) is widely used in multi-agent systems (MASs). However, most existing NMARL algorithms share the global state and reward, which hinders their scalability in large-scale MASs. To make NMARL applicable to large-scale MASs, we propose a proximal policy optimization (PPO) based fully decentralized NMARL. First, we design a fully decentralized multi-agent reinforcement learning (MARL) framework, formulated as a networked partially observable multi-agent markov decision process (N-POMDP). The networked MAS is represented by a graph, where each agent communicates with and shares reward only with neighbors. Second, we design a gate recurrent unit (GRU) based communication strategy to learn the temporal communication correlation. Each agent exchanges observation information and hidden state with its neighbors. Finally, we conduct experiments using the multi-agent particle environment (MPE) and compare our algorithm with common MARL algorithms. Experimental results demonstrate superior performances of our algorithm in terms of the cumulative return and convergence speed in the large-scale MAS.

FrAT4	H104
Modeling, Control and Estimation in Unmanned Aircraft Systems	Invited Session
Chair: Hu, Jinwen	Northwestern Polytechnical University
Co-Chair: Guo, Kexin	Beihang University
Organizer: Hu, Jinwen	Northwestern Polytechnical University
Organizer: Yang, Tao	Northwestern Polytechnical University
Organizer: Xu, Zhao	Northwestern Polytechnical University
Organizer: Yu, Huangchao	National University of Defense Technology
Organizer: Guo, Kexin	Beihang University

08:30-08:45, Paper FrAT4.1	
Dogfight Advantage Occupancy Method Based on Imperfect Information Self-Play (I)	
Wang, Dinghan	Northwestern Polytechnical University, School of Electronics And
Ji, Longmeng	Northwestern Polytechnical University, School of Electronics And
Wang, Jingbo	AVIC Chengdu Aircraft Design and Research Institute
Shi, Zhuoyong	Northwestern Polytechnical University
Zhang, Jiandong	Northwestern Polytechnical University
Yang, Qiming	Northwestern Polytechnical University
Shi, Guoqing	Northwestern Polytechnical University
Wu, Yong	Northwestern Polytechnical University
Zhu, Yan	Northwestern Polytechnical University
Hu, Jinwen	Northwestern Polytechnical University

Keywords: Intelligent and AI Based Control, Automated Guided Vehicles, Learning-based Control

Abstract: Air-to-air close combat is a typical combat scenario, which places extremely high physiological demands on pilots during the dogfight process. In order to achieve unmanned and intelligent close combat, this paper proposes a dogfight advantage occupancy algorithm based on imperfect information self-play. Through experiments on the high-fidelity F-16 aircraft platform, the results show that the algorithm can converge to a Nash equilibrium and fully utilize the maneuverability during the combat process.

08:45-09:00, Paper FrAT4.2	
Multi-UAVs Collaborative Task Allocation Based on Improved Consensus-Based Grouping Algorithm (I)	
Ma, Yunhong	Northwestern Polytechnical University
Li, Xinyi	Northwestern Polytechnical University
Wang, Haiquan	Northwestern Polytechnical University
Kang, Yongxiang	Northwestern Polytechnical University
Tianhang, Cao	Northwestern Polytechnical University
Zhang, Yaozhong	Northwestern Polytechnical University
Yang, Jie	Northwestern Polytechnical University

Keywords: Multi-agent Systems, Robotics, Modeling and Control of Complex Systems

Abstract: The complex battlefield environment and increasing mission requirements have brought great challenges to multi-UAVs collaborative task allocation. How to accurately and efficiently implement task allocation and provide support for multi-UAVs collaborative combat in a complex adversarial environment has become an urgent problem to be solved. In this paper, the collaborative task allocation of multiple UAVs is studied, and a collaborative task assignment model of multiple UAVs is established, the model considers various constraints and actual operational requirements in the adversarial environment. An Improved Consensus-Based Grouping Algorithm (ICBGA) is proposed to solve the collaborative task allocation problem of multi-UAVs, and the relative simulation result demonstrate the proposed algorithm improves the performance of the original CBGA algorithm.

09:00-09:15, Paper FrAT4.3	
Large-Scale UAVs Autonomous Rendezvous Using Partially Observed Mean-Field Reinforcement Learning (I)	
Zhang, Yaozhong	Northwestern Polytechnical University
Ding, Meiyan	School of Electronic Information, Northwestern Polytechnical Uni

Wu, Zhuo ran	Northwestern Polytechnical University
Zhang, Jiandong	Northwestern Polytechnical University
Shi, Guoqing	Northwestern Polytechnical University
Yang, Qiming	Northwestern Polytechnical University
Ma, Yunhong	Northwestern Polytechnical University
Zhu, Yan	Northwestern Polytechnical University

Keywords: Multi-agent Systems, Motion Control, Intelligent and AI Based Control
Abstract: With the continuous development and innovation of technology, the application of Unmanned Aerial Vehicles (UAVs) in the military field is becoming increasingly widespread. In particular, the use of multiple UAVs to form a swarm for combat has become a hot topic of research in various countries. As battlefield missions become more complex, the intelligence of UAV control is an inevitable trend. To address the problem of autonomous rendezvous for large-scale UAV swarms, the Deep Deterministic Policy Gradient (DDPG) algorithm that combined with mean field game theory and partial observability constraints are introduced. By incorporating the "centralized training, distributed execution" mechanism, the Partially Observable Mean Field Deep Deterministic Policy Gradient (PO-MFDDPG) algorithm is proposed. The simulation results show that the performance of the PO-MFDDPG algorithm is superior to the previous improved algorithms.

09:15-09:30, Paper FrAT4.4	

ISANet: An Interactive Self-Attention Network for Cropland Image Change Detection (I)

Sijun, Dong	Wuhan University
Yanrui, Chen	Wuhan University
Fann, Wu	Wuhan University
Gao, Zhi	Wuhan University
Xiaoliang, Meng	Wuhan University

Keywords: Sensor/Data Fusion, Smart Structures, Signal Processing
Abstract: The change detection task is a vital research topic in the remote sensing area, particularly significant in the context of agricultural land monitoring. Currently, many researchers perform change detection tasks based on the self-attention mechanism. A common method involves applying a self-attention mechanism within single-temporal images, then fusing the feature maps of bitemporal images to decode and obtain the prediction result. We propose a bitemporal interactive self-attention (ISA) mechanism for change detection tasks, with a special focus on cropland areas where monitoring changes can lead to enhanced agricultural productivity and resource management. In the ISA module, we construct pixel dependency relationships both within single-temporal images and between bitemporal images. This allows the network to learn the feature relationship between bitemporal images through the ISA module, thus optimizing the effect of the change detection task. Moreover, we propose a hybrid convolutional feature fusion module that strengthens the learning of change features in the decoding part. Ultimately, the ISANet network we proposed surpassed other advanced algorithms on the Cropland Change Detection (CLCD) dataset. The experimental results show that the proposed ISANet network can deliver robust performance in remote sensing cropland image change detection tasks.

09:30-09:45, Paper FrAT4.5	

SLAM in Low-Light Environments Based on Infrared-Visible Light Fusion (I)

Wang, Haiwei	AVIC XAC Commercial Aircraft CO. LTD
Gao, Chenqi	Northwestern Polytechnical University
Gao, Tianyu	Northwestern Polytechnical University
Hu, Jinwen	Northwestern Polytechnical University
Xu, Zhao	Northwestern Polytechnical University
Han, Junwei	Northwestern Polytechnical University
Zhu, Yan	Northwestern Polytechnical University
Wu, Yong	Northwestern Polytechnical University

Keywords: Sensor/Data Fusion, Robotics, Signal Processing
Abstract: Traditional visual Simultaneous Localization and Mapping (SLAM) techniques are difficult to obtain effective information in non-ideal environments such as changing light or full of smoke, which leads to the performance degradation of SLAM algorithms. To overcome the aforementioned challenges, this paper proposes a visual SLAM front-end system based on infrared-visible light fusion. The system achieves precise optimization of camera poses and map point locations in non-ideal environments by jointly optimizing the reprojection errors of visible light image point features and infrared image edge features. In addition, this article further improves the robustness of the algorithm in non-ideal environments through back-end optimization of infrared-visible light and Inertial Measurement Unit (IMU) tight coupling.

09:45-10:00, Paper FrAT4.6	

Autonomous Lifeguard Unmanned Aerial Vehicle Prototype for Information-Weighted Optical Flow Analysis and Rip Current Detection with Depth Risk Models

Kim, Angelina	The Bishops School

Keywords: Robotics, Intelligent and AI Based Control, Automated Guided Vehicles
Abstract: An Unmanned Aerial Vehicle (UAV) lifeguard scout quadcopter is implemented to detect rip currents and threats. Requirements for scout UAVs are discussed and applied to the scout UAV configuration. The scout UAV is equipped with an AI-capable mission controller, triple communication and control radio links, and 6.7x9.8N thrust from actuator and propeller combination to handle additional payload such as large-capacity battery for extended flight duration. The scout UAV conducted multiple flight missions to collect 11.8k ocean images with 10.9km flight mileage. Using the collected images, optical flow is analyzed, and a new information-weighted scaling with image gradient density is developed and demonstrated for a reliable optical flow result. A channel current flow analysis with depth and risk models is proposed to estimate net channel current risk and to detect rip currents.

FrBT1	H102

Intelligent Optimization and Control of Robotic Systems	Invited Session
Chair: Xin, Bin	Beijing Institute of Technology
Co-Chair: Cui, Jinqiang	Peng Cheng Laboratory
Organizer: Xin, Bin	Beijing Institute of Technology
Organizer: Cui, Jinqiang	Peng Cheng Laboratory
Organizer: Cheng, Lan	Taiyuan University of Technology
Organizer: Zheng, Zhi	Fujian Normal University
Organizer: Zhang, Chunmei	Taiyuan University of Science and Technology

10:30-10:45, Paper FrBT1.1	
Research on the Coalition Formation of Multi-Agent Systems for Forest Fire Prevention and Control Tasks (I)	
Wu, Ruotong	Beijing Institute of Technology
Zhang, Jia	Beijing Institute of Technology
Xin, Bin	Beijing Institute of Technology

Keywords: Multi-agent Systems, Modeling and Control of Complex Systems
Abstract: The multi-agent systems (MAS) for forest fire prevention and control are large-scale, with varied structural characteristics, leading to high complexity in management. This paper delves into the Coalition Formation (CF) strategy of MAS in this scenario. Considering the characteristic and the actual utility of coalitions, as well as the multiple dimensions of constraints and optimization indicators, a model for the agent CF problem is established. A two-stage hybrid intelligent algorithm is proposed to solve the problem. The algorithm is based on the K-means Clustering algorithm, Variable Neighborhood Search (VNS) algorithm and Genetic Algorithm (GA). This method can form a high-quality feasible CF scheme, which provides support for the intelligent control of fire system resources and the implementation of subsequent task allocation.

10:45-11:00, Paper FrBT1.2	
TPML: Task Planning for Multi-UAV System with Large Language Models (I)	
Cui, Jinqiang	Peng Cheng Laboratory
Liu, Guocai	Peng Cheng Labotoary
Wang, Hui	Peng Cheng Laboratory
Yu, Yue	Peng Cheng Laboratory
Yang, Jiankun	Peng Cheng Laboratory

Keywords: Robotics, Multi-agent Systems
Abstract: Efficient task planning is pivotal for multi-UAV systems navigating dynamic environments. Traditional task planning methods face challenges in adapting to the constantly changing scenarios. The emergence of large language models (LLMs) offers promising solutions to bridge this gap. Our proposal, TPML, leverages LLMs as a command interface to comprehend operators' intentions and translate them into executable codes. Harnessing the creative capabilities of generative models, TPML can command multiple drones in both synchronous and asynchronous patterns with a single natural-language input. Experimental results are initially validated in a tailored simulation environment before transitioning to practical implementations. Successful demonstrations of both synchronous and asynchronous missions in real-world scenarios underscore the efficacy of TPML.

11:00-11:15, Paper FrBT1.3	
A Learning Framework Combining Distillation-Generated Replay and Development Network in Continual Visual Scene Cognition for Autonomous Robot (I)	
Zhang, Yuyang	Fujian Normal University
Zheng, Zhi	Fujian Normal University

Keywords: Learning Systems, Estimation and Identification, Robotics
Abstract: Continual learning for autonomous robots in complex environments is a challenging problem. Human beings have the lifelong ability to continuously acquire, adjust, and transfer knowledge. Although we tend to gradually forget previously learned knowledge throughout our lives, in very few cases does learning new knowledge catastrophically affect what we have already learned. Incremental learning aims to address a common flaw in model training: catastrophic forgetting. The primary drawback of most existing replay-based incremental learning is that they require a lot of additional computational resources and storage space to recall old knowledge. When the number of tasks keeps increasing, either the training cost becomes higher, or the representativeness of samples diminishes. In order to mitigate catastrophic forgetting and save storage space, we propose a new autonomous developmental neural network that combines distillation-generated replay(DGR-DN). Experimental results show that our approach not only has the better ability to integrate and refine new knowledge in new data, prevent significant interference from new input on existing knowledge, but also requires less storage space compared to existing generative replay networks. We verify the effectiveness of the method in the real environment scene, and also verify the generality using the MNISIT dataset. Through these experiments, it can be seen in the scene dataset that the recognition rate has increased by 300% compared to not using the generated network, and the storage space is reduced by more than 30% compared to the network that used generation. In the MNIST dataset, our approach significantly reduces storage space by over 50% , while preserving recognition rates at a level similar to the baseline.

11:15-11:30, Paper FrBT1.4	
Improved Reinforcement Learning Based on Angle Search for Route Planning of the Hospital Inspection Robot (I)	
Ding, Long	University
Zhang, Chunmei	Taiyuan University of Science and Technology
Guo, Hong ge	Taiyuan University of Science and Technology

Keywords: Learning-based Control, Robotics
Abstract: The inspection robot is applied to assist people in carrying out autonomous inspections and reduce the pressure on hospital staff. In order to complete the inspection tasks without collision under the static environment, an improved reinforcement learning using angle search is proposed to plan the shortest route of the inspection robot. Considering the no-collision constraints, the mathematical model of route planning is established with the objective of shortest route. To improve learning efficiency, an improved reinforcement learning is presented by combining the Q learning and Shaping reward function. The Q value is updated with the heuristic potential field function. Set up the angle search strategy, select the action within a fixed search angle range, avoid the robot from performing redundant exploration actions in the middle and late stages, and improve the convergence speed of the algorithm. Experiments show that the improved algorithm has better

optimization performance than compared algorithms，enabling the hospital inspection robot to plan the route efficiently without collision.

11:30-11:45, Paper FrBT1.5

Localization of UGV Guided by UAV Using Visual Inertia Sensors and UWB (I)

Qian, ShengYi	Taiyuan University of Technology
Cheng, Lan	Taiyuan University of Technology
Xu, XinYing	Taiyuan University of Technology
Ren, Mifeng	Taiyuan University of Technology

Keywords: Control Applications, Multi-agent Systems, Robotics
Abstract: Air-ground Collaborative SLAM (CoSLAM) is particularly suitable for route planning and mapping in large scenes. However, accurate localization of an Unmanned Ground Vehicle (UGV) in CoSLAM has been a challenging task, making route planning for various applications not always reliable. In this study, we design a air-ground collaborative system, which applies Ultra Wide Band (UWB) ranging units on both Unmanned Aerial Vehicle (UAV) and UGV as additional sensors to collect range information between the UAV and the UGV. The range information is used to correct the position of the UGV provided by the UAV. The correction is realized through an extended Kalman filter. Simulation results verify the proposed method.

FrBT2 — H101

Estimation and Identification — Regular Session

Chair: Huang, Biao — University of Alberta

10:30-10:45, Paper FrBT2.1

Suboptimal Bayesian Filters for Markov Jump Linear Systems with Unknown Noise Covariance

Gao, Shuang	Jiangnan University
Luan, Xiaoli	Jiangnan University
Huang, Biao	University of Alberta
Zhao, Shunyi	Jiangnan University
Wan, Haiying	Jiangnan University
Liu, Fei	Jiangnan University

Keywords: Estimation and Identification
Abstract: The quality of measurements plays a crucial role in industrial processes. This paper proposes a novel suboptimal filter for Markov jump linear systems (MJLSs) that deals with the challenge of unknown measurement covariance. To limit the number of feasible mode sequences, variational Bayesian (VB) inference is employed to approximate the posterior Gaussian mixture distribution. This is achieved by representing it as a product of Gaussian and categorical distribution, aiming to minimize the Kullback-Leibler (KL) divergence. The resultant recursion turns out to be a new suboptimal Bayesian estimator, adept at simultaneously estimating system states, modal state, and measurement noise covariance, all within a unified probabilistic framework. The target tracking example is presented to illustrate that the proposed method is a competitive alternative to existing suboptimal estimation methods.

10:45-11:00, Paper FrBT2.2

A Total Secrecy Coding Scheme with True Random Sequences for Remote Estimation against Eavesdroppers with Anti-Coding Mechanisms

Yang, Yake	Northeastern University
Yang, Tao	Northeastern University
Li, Yuzhe	Northeastern University, China

Keywords: Estimation and Identification, Linear Systems, Sensor Networks
Abstract: In this paper, we consider the design issue of a total secrecy coding scheme on remote estimation against eavesdroppers with anti-coding mechanisms. To be more specific, a legitimate user estimates the system state based on the innovation from anchor sensors and vulnerable ones via the wireless network. Vulnerable sensors may be under eavesdropping attacks, and the data of vulnerable sensors is generally protected by a coding scheme. An illegal user aims to obtain the state utilizing a filter, and such filters combined with an anti-coding mechanism execute the update procedure using the innovation yielded by its own sensor and the one from vulnerable sensors the user eavesdrops on. To resist such illegal entities, we design a total secrecy coding scheme with true random sequences. Compared with the existing results, this scheme can reduce the cost and is difficult for attackers to infer encryption patterns. The analytical policy of the total secrecy coding scheme in scalar systems is obtained. Finally, we use a simulation to verify the effectiveness of the obtained results.

11:00-11:15, Paper FrBT2.3

Approximating the System Behavior with Input Uncertainty Using Big Data

Yan, Yitao	University of New South Wales
Bao, Jie	The University of New South Wales
Huang, Biao	University of Alberta

Keywords: Linear Systems, Estimation and Identification, Control Applications
Abstract: This paper aims to construct a representation to approximate the behavior of linear time-invariant systems from a large data set whose input contains unmeasured uncertainty and output is subject to measurement noise. Using big data combined with the statistical properties of the input uncertainty and measurement noise, the covariance of the input uncertainty and the output can be approximated. This enables the construction of an approximate covariance of the trajectories in the data set, through which a representation for the approximation of system behavior is obtained. The behavior of this representation is shown to converge in probability to the true behavior. An illustrative example is provided to show that the proposed representation is able to predict the system trajectory to a satisfactory accuracy. The result of this paper provides a potential basis for the development of data-based trajectory estimation and predictive control algorithm when the system input uncertainty is unmeasured.

11:15-11:30, Paper FrBT2.4

Multi-Target Tracking in Distributed Wireless Sensor Networks with Packet Dropout

Bu, Lingchao	Northwestern Polytechnical University
Li, Huiping	Northwestern Polytechnical University

Keywords: Sensor/Data Fusion, Sensor Networks, Signal Processing
Abstract: This paper investigates a distributed multi-target tracking (DMTT) method based on random finite sets (RFS) in distributed wireless sensor networks (DWSNs) with packet dropout. Based on the local cardinality probability hypothesis density (CPHD) filter, a consensus fusion method with information compensation (CF-IC) is proposed. The proposed method compensates the lost target information based on prior information and motion model, when some targets are lost. Finally, the performance of proposed CF-IC is evaluated through simulation experiments

11:30-11:45, Paper FrBT2.5	

Air-To-Air Detection and Tracking of Non-Cooperative UAVs for 3D Reconstruction

Liu, Yang	Beijing Institute of Technology
Xi, Lele	Beijing Institute of Technology
Sun, Zhihao	Beijing Institute of Technology
Zhang, Lele	Beijing Institute of Technology
Dong, Wei	Beijing Institute of Technology
Lu, Maobin	Beijing Institute of Technology
Chen, Chen	Beijing Institute of Technology
Deng, Fang	Beijing Institute of Technology

Keywords: Process Automation, Intelligent and AI Based Control, Robotics
Abstract: The monitoring and regulation of unauthorized, unresponsive, or uncommunicative non-cooperative UAVs is still one of the great challenges in airspace safety management. Therefore, in order to obtain the phenotypic information of these targets, we propose a 3D reconstruction system for non-cooperative UAVs based on air-to-air view image sequences. Specifically, the data-collecting UAV (pursuer) will detect, track, approach, and follow the non-cooperative UAV (target) at a fixed distance to automatically capture the image data. During the process, a lightweight object detection model and a Kalman filter-based tracking algorithm are used to recognize and continuously track the target UAV, and the boundary state constrained primitives and interval replanning are used to generate the accurate flight path, which in turn will control the pursuer UAV to approach the target UAV and follow it at a fixed distance. Finally, based on the implicit representation of the neural radiation field, the collected images will be used for 3D reconstruction and rendering of the non-cooperative UAV. In experiments, taking a quadrotor as the pursuer and a fixed-wing UAV as the target, we verify the feasibility of the proposed system in 3D reconstruction tasks.

FrBT3	H103
Multi-Agent Systems (II)	Regular Session
Chair: Lee, Donghwan	KAIST

10:30-10:45, Paper FrBT3.1	

Time-Varying Output Group Formation Tracking Control for Heterogeneous Multiagent Systems with Switching Topologies

Zhou, Shiyu	City University of Hong Kong
Sun, Dong	City University of Hong Kong
Feng, Gang	City Univ. of Hong Kong

Keywords: Multi-agent Systems, Linear Systems, Networked Control
Abstract: This article studies the time-varying output group formation (TVOGF) tracking problem for heterogeneous multiagent systems (HMASs) with switching topologies. The primary objective is to design a TVOGF tracking protocol such that the followers are driven to form the desired sub-formations and track the corresponding output of the leader in each subgroup. Firstly, distributed observers are developed to estimate the states of leaders with switching topologies. A TVOGF tracking controller is then designed based on the proposed observers. It is shown that under the distributed protocol, the TVOGF tracking control problem for HMASs with switching topologies can be solved if the average dwell time associated with the switching topologies is larger than a fixed threshold. Finally, an example is provided to demonstrate the effectiveness of the proposed protocol.

10:45-11:00, Paper FrBT3.2	

Heterogeneous Control Method of Multi-Cluster Manned-Unmanned System Over Passive Switching Topology

Huo, Mengzhen	School of Automation Science and Electrical Engineering, Beihang
Duan, Haibin	Beihang University
Wu, Hao	China Academy of Electronics and Information Technology, China E

Keywords: Multi-agent Systems, Man-machine Interactions, Modeling and Control of Complex Systems
Abstract: Multi-cluster manned-unmanned system is in urgent need for the coordination of manned aircrafts and unmanned aerial vehicles (UAV). This paper proposed the heterogeneous control method to realize the flexible topology switching in the heterogeneous team. The distributed formation controller and the cluster space controller have been proposed to conduct the formation maintenance and reconstruction. Theoretical analysis is provided to verify the feasibility of the distributed formation controller. This heterogeneous system could render motion matching of UAVs with the manned aircrafts executing human-intelligence intention as well as endow the unmanned systems with individually flexible behaviors. The simulation results obtained from the designed experimental scenario have shown the effectiveness of the system and the controllers.

11:00-11:15, Paper FrBT3.3	

An Entropy-Based Path Planning Method for Crowd Evacuation in Complex Environments

Dong, Shiyu	Harbin Engineering University
Huang, Ping	Harbin Engineering University
Wu, Fan	China Ship Development and Design Center
Wang, Wei	Harbin Engineering University

Keywords: Multi-agent Systems, Smart Buildings
Abstract: In emergencies, leaders play a crucial role in providing evacuation guidance for pedestrians. Planning an effective path for leaders is imperative, but the closest path to the exit may not always be the most optimal. Additionally, it is essential to consider the state distribution of pedestrians. This paper introduces an

entropy-based method for path planning during crowd evacuation in complex environments. First, key nodes are extracted according to the room structure, the initial leader position is determined using the maximum entropy covering method, and the evacuation priority is assigned based on the calculated urgency. An exit selection algorithm is then presented, wherein each leader selects the optimal exit as the destination according to their priority. Finally, an enhanced A* algorithm is introduced, incorporating evacuation entropy to devise the optimal evacuation guidance path for leaders. The simulation environment built by Anylogic serves to validate the efficacy of both the exit selection strategy and the enhanced path planning algorithm.

11:15-11:30, Paper FrBT3.4	

Continuous-Time Distributed Dynamic Programming for Networked Multi-Agent Markov Decision Processes

Lee, Donghwan	KAIST
Lim, Han-Dong	Korea Advanced Institute of Science and Technology
Kim, Do Wan	Hanbat National University

Keywords: Multi-agent Systems, Networked Control, Linear Systems

Abstract: The main goal of this paper is to investigate continuous-time distributed dynamic programming (DP) algorithms for networked multi-agent Markov decision problems (MAMDPs). In our study, we adopt a distributed multi-agent framework where individual agents have access only to their own rewards, lacking insights into the rewards of other agents. Moreover, each agent has the ability to share its parameters with neighboring agents through a communication network, represented by a graph. We first introduce a novel distributed DP, inspired by the distributed optimization method of Wang and Elia. Next, a new distributed DP is introduced through a decoupling process. The convergence of the DP algorithms is proved through systems and control perspectives. The study in this paper sets the stage for new distributed temporal different learning algorithms.

11:30-11:45, Paper FrBT3.5	

The Stabilization of Cohen-Grossberg BAM Neural Network System

Guo, Peiyu	Southeast University
Cao, Yang	Southeast University
Liu, Xin-ge	Central South University

Keywords: Multi-agent Systems, Networked Control, Nonlinear Systems and Control

Abstract: This paper investigates the stabilization problem of a class of Cohen Grossberg BAM neural network with time-varying delays. Instead of using matrix measure methods, linear matrix inequality (LMI) methods, and integral inequality methods, a new research approach is adopted: the differential inequality method, which utilizes the properties of higher-order polynomials. By finding two local extrema points of a function and designing an appropriate controller, based on Lyapunov function theory, the asymptotic stability criterion for CG-BAMNNs is obtained. In the application of the differential inequality method, the process of finding two local extrema points and the application of the properties of higher-order polynomials are very proficient, resulting in sufficiently novel outcomes. Finally, the reasonableness and effectiveness of this approach are verified through simulation examples.

FrBT4	H104

New Trends in Intelligent Unmanned Systems	Invited Session
Chair: Zhao, Shiyu	Westlake University
Co-Chair: Tan, Guan Zhong John	National University of Singapore
Organizer: Zhao, Shiyu	Westlake University
Organizer: Lin, Feng	National University of Singapore

10:30-10:45, Paper FrBT4.1	

Omnibot: A Scalable Vision-Based Robot Swarm Platform (I)

Ma, Zhao	Westlake University
Liang, Jiachen	Westlake University
Wang, Hongyi	Westlake University
Guo, Shiliang	Westlake University
Huo, Peidong	Westlake University
Zhang, Yin	Westlake University
Zhao, Shiyu	Westlake University

Keywords: Robotics

Abstract: Introducing vision sensing into swarms presents three challenges for developing robot platforms. First, the vision system requires a wide field of view to perceive surrounding robots. Second, vision algorithms demand high computational power, which poses a challenge for real-time vision-in-the-loop simulation. Third, as the swarm scale increases, managing the system becomes increasingly demanding. The main contribution of this paper is the development of a novel mobile robot swarm platform to overcome these challenges. 1) Each robot features a 360-degree omnidirectional vision system comprising four cameras, allowing each robot to detect and interact with the surrounding robots. 2) It has a novel ROS-based distributed swarm simulation system, which can effectively utilize the onboard computational resources of multiple robots to achieve parallel vision-in-the-loop simulation. 3) It features a novel swarm management system that allows real-time monitoring and debugging of multiple robots. These innovative designs provide a novel swarm platform that can facilitate the study of versatile vision-based swarm tasks.

10:45-11:00, Paper FrBT4.2	

A Robust and Efficient Visual-Inertial SLAM for Vision-Degraded Environments (I)

Zhao, Xuhui	Wuhan University
Gao, Zhi	Wuhan University
Wang, Jialiang	Wuhan University
Lin, Zhipeng	The Chinese University of Hong Kong
Zhou, Zhiyu	Wuhan University
Huang, Yue	Wuhan University

Keywords: Robotics, Sensor/Data Fusion, Signal Processing

Abstract: Visual challenging environments significantly threaten both the robustness and accuracy of SLAM (Simultaneous Localization and Mapping), resulting in unacceptable performance of unmanned systems. Many researchers propose various methods to overcome visual challenges, and we briefly categorize them into pure-vision-based and sensor fusion-based. The former typically has a better generalization to different vision cameras while

accompanied by a performance ceiling due to single modal data. The latter generally achieves better robustness and accuracy with sophisticated sensors and hardware, which may be unaffordable on lightweight platforms. Most current SLAM methods cannot switch these two technical routes, resulting in unsatisfying performance. Focusing on this problem and dilemma, we propose a lightweight visual-inertial SLAM with a dynamic switching mechanism according to ambient perception. The system automatically switches to visual pose estimation, inertial propagation, and motion model algorithms according to the ambient perception quality. It effectively avoids redundant computations in good conditions and robustly keeps SLAM tracking in hard conditions. Extensive experiments show the feasibility and effectiveness of our method, with better performance compared with other state-of-the-art methods.

11:00-11:15, Paper FrBT4.3	

A Model Predictive Control Approach for USV Autonomous Cruising Via Disturbance Learning (I)

Cheng, Maotong	Zhejiang University
Yao, Jinke	Zhejiang University
Ren, Qinyuan	Zhejiang University

Keywords: Robotics, Nonlinear Systems and Control, Learning-based Control

Abstract: Unmanned Surface Vehicles (USVs) are widely applied in ocean exploration and environmental protection. To ensure efficient execution of tasks, the motion control of USV is essential and critical. However, the hydrodynamics disturbances from ocean environment are commonly highly nonlinear, time-variant and impractical to model, which renders control extremely challenging. Therefore, in this paper we propose a learning-based Model Predictive Control (MPC) approach for USV course-keeping subject to disturbances and uncertainties. A relatively simplified dynamics model is augmented by a Long Short Term Memory (LSTM) residual model, which can capture complicated hydrodynamics effect and eliminate model mismatch. The resulting formulation is incorporated in MPC framework to achieve optimal real-time control. Further, the proposed approach is verified through simulation experiments.

11:15-11:30, Paper FrBT4.4	

EAI-SIM: An Open-Source Embodied AI Simulation Framework with Large Language Models (I)

Liu, Guocai	Peng Cheng Labotoary
Sun, Tao	Shenzhen Institute of Artificial Intelligence and Robotics for S
Li, Weihua	Beihang University
Li, Xiaohui	Peng Cheng Laboratory
Liu, Xin	Peng Cheng Laboratory
Cui, Jinqiang	Peng Cheng Laboratory

Keywords: Robotics, Multi-agent Systems

Abstract: In the era of embodied intelligence, developing and testing various intelligent algorithms for robots, including unmanned aerial vehicles (UAVs) and manipulators, poses significant challenges. Researchers are increasingly depends on simulation technologies to evaluate the performance of new algorithms across various conditions and applications. The advent of large language model (LLM) technology creates new demand for simulations of robotics tasks with the help LLMs. This study introduces EAI_SIM, a simulation system capable of controlling unmanned aerial vehicles (UAVs) and manipulators based on user prompts. The modular framework acts as an extension of NVIDIA Isaac Sim, facilitating real-time simulation of UAVs and manipulators in photo-realistic environments. Thanks to the modular implementation and user-friendly Graphical User Interface (GUI), it can be seamlessly integrated with the widely used PX4-Autopilot and ROS2 system. To showcase its performance, a variety of control Application Programming Interfaces (APIs) are implemented within EAI_SIM. A range of tasks can be achieved by combining different APIs. Supplementary material, including code and documentation for this framework, is provided to benefit the community.

11:30-11:45, Paper FrBT4.5	

Gestelt: A Framework for Accelerating the Sim-To-Real Transition for Swarm UAVs (I)

Tan, Guan Zhong John	National University of Singapore
Sun, Tianchen	National University of Singapore
Lin, Feng	National University of Singapore
Teo, Rodney	National University of Singapore
Khoo, Boo Cheong	National University of Singapore

Keywords: Robotics, Multi-agent Systems, Motion Control

Abstract: Research in aerial swarms have gained traction in recent years and there appears to be a lack of user-friendly frameworks with a focus on bringing swarm UAVs from simulation to actual flight. Furthermore, spatial constraints and resource challenges hinder the validation of larger-scale swarm algorithms.

To tackle these issues, we propose Gestelt, a relatively lightweight framework that accelerates the sim-to-real transition for swarm algorithms. First, the modular design of Gestelt is highlighted to illustrate it's generalization to multiple types of planning algorithms and paradigms. Next, we outline an approach to model any given quadrotor platform for use in our framework's simulation environment. Another unique feature of Gestelt is it's virtual-physical environment, which can simultaneously host both virtual and physical agents, thereby providing an intermediate platform for testing larger-scale swarm algorithms safely. Finally, we implement an asymptotically stable closed-loop control technique known as Robust Perfect Tracking (RPT) to track the reference trajectories of the swarm agents in the face of disturbances.

We demonstrate our framework through physical experiments featuring our custom swarm platform, the NUSwarm drone, where we show a swarm navigation scenario for 3 physical and 3 virtual drones. A video demonstrating the virtual-physical environment can be found at https://youtu.be/FYlwz2yZxLE

11:45-12:00, Paper FrBT4.6	

Lite-HRPE: A 6DoF Object Pose Estimation Method for Resource-Limited Platforms

Liu, Xin	Shanghai Jiao Tong University
Qi, Guan	Shanghai Jiao Tong University
Xue, Shibei	Shanghai Jiao Tong University
Zhao, Dezong	Loughborough University

Keywords: Fuzzy and Neural Systems, Learning Systems

Abstract: Accurately estimating the six-degree-of-freedom pose of objects is essential for intelligent robotics. Although significant progress has been made in this area, most studies fail to account for specific hardware limitations for model deployment, which remains a major challenge for resourceconstrained scenarios. To address this issue, we propose Lite-HRPE, a lightweight RGB-

based pose estimation method,which leverages a multi-branch parallel structure to extract spatial and semantic information of keypoints for pose estimation. Additionally, Lite-HRPE adopts the G-block and Gneck modular structure and streamlines the original feature extraction network to realize a compact network structure. This allows Lite-HRPE to strike a balance between pose estimation accuracy, parameter count, computational load, and runtime speed. Our evaluation on public dataset shows that Lite-HRPE achieves a 95.7% accuracy with only 10.8% of the number of parameters and 11.8% of the FLOPs compared to Hybridpose.

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Yi, Xinlei	ThCT1.4
	ThCT1.5
Yin, Xiang	ThBT2
	ThBT2.1
Yin, Xingyu	ThCT4.5
Yin, Zhun	ThAT2.1
You, Yang	ThBT1.6
Yu, Chengpu	FrAT1.6
Yu, Donghui	WeAT3.4
Yu, Huangchao	FrAT4
Yu, Jianglong	ThBT1.1
	ThBT1.2
	FrAT3.1
Yu, Jintong	ThBT1.3
Yu, Mei	ThCT1.6
Yu, Ming	WeAT1.6
Yu, Xiang	WeBT1.2
Yu, Yaru	ThCT2.4
Yu, Ye	ThBT1.6
Yu, Yue	FrBT1.2
Yuan, Ruizhe	ThCT2.2
Yuan, Shenghai	ThCT3.3
Yuan, Yang	WeAT4.4
Yue, Jiguang	WeAT2.2
	WeAT4.6
Z	
Zeng, Xianlin	ThAT1.4
	ThCT1.2
	FrAT2.4
Zhang, Chunmei	FrBT1
	FrBT1.4
Zhang, Hongyang	WeAT2.4
Zhang, Jia	FrAT2.3
	FrBT1.1
Zhang, Jiandong	FrAT4.1
	FrAT4.3
Zhang, Jihan	ThAT3.1
	ThAT4.4
	ThBT2.3
	ThBT2.6

Zhang, Lele	FrBT2.5
Zhang, Qin	ThAT2.3
Zhang, Sai	WeAT2.4
Zhang, Tianwei	ThCT3.6
Zhang, Wei	ThAT1.2
Zhang, Ya	WeBT3.6
Zhang, Yaozhong	FrAT4.2
	FrAT4.3
Zhang, Ye	ThCT3.2
Zhang, Yifei	WeAT2.1
Zhang, Yin	FrBT4.1
Zhang, Yongjun	ThAT3.4
Zhang, Youmin	ThBT4
	ThBT4.1
Zhang, Yulong	ThBT4.1
Zhang, Yuxiang	WeAT2
	WeAT2.3
Zhang, Yuyang	FrBT1.3
Zhang, Zhao	ThAT2.4
Zhang, Zhaorong	WeBT2.1
Zhang, Zixuan	WeBT3.4
Zhao, Benyun	ThBT2.6
Zhao, Dezong	FrBT4.6
Zhao, Shiyu	FrBT4
	FrBT4
	FrBT4.1
Zhao, Shunyi	FrBT2.1
Zhao, Wang	ThCT3.2
Zhao, Xiangdan	ThAT1.3
Zhao, Xuhui	FrBT4.2
Zhao, Yunyi	WeAT1.6
Zheng, Yue	WeBT3.4
Zheng, Zewei	WeAT2.1
	ThBT4.2
Zheng, Zhi	FrBT1
	FrBT1.3
Zhong, Yisheng	ThBT1.4
Zhou, Deyun	WeBT3.2
Zhou, Jianshu	WeAT1.5
	ThAT2.2
Zhou, Jing	ThAT4.1
Zhou, Lei	ThAT1.1
Zhou, Panpan	FrAT3.4
Zhou, Shiyu	FrBT3.1
Zhou, Wei	ThAT2.6
Zhou, Xunkuai	ThAT3.1
	ThBT2.6
Zhou, Yanmin	ThAT1.3
Zhou, Zhiyu	FrBT4.2
Zhou, Zhongxian	ThBT4.1
Zhu, Bing	WeBT3
	WeBT3.1
Zhu, Kui	ThCT1.2
Zhu, Ming	WeAT2.1
	ThBT4.2
Zhu, Peng	WeAT2.2
Zhu, Shanying	WeBT1.1
	ThCT1
	ThCT1.3
Zhu, Yan	FrAT4.1
	FrAT4.3
	FrAT4.5
Zou, Jiang	WeAT3.5
Zou, Junjie	ThCT4.6

Local Information

Conference Venue

The 18th IEEE International Conference on Control and Automation (IEEE ICCA 2024) will be held on June 18–21, 2024, the University of Iceland (Háskólatorg / University Centre), Reykjavík, Iceland.

Address: Sæmundargata 2, 102 Reykjavík, Iceland
Tel: +3545254000
URL: https://english.hi.is/university_of_iceland

Currency

The Local currency in Reykjavík is the króna (ISK). You can use all major credit cards in Iceland. As cash is seldom used in Iceland we recommend that you do not exchange currency or withdraw Icelandic cash from an ATM (ATM = Hraðbanki).

Emergency Call

Emergency Police: 112. It's important to know that you can dial 112 from anywhere in Europe and an operator will connect you to an emergency service in the country that you're visiting. Operators can answer your call in their native language.

Airport Transfer – Car Rental

The distance from Keflavík International Airport to Reykjavík is 55 km, or 45 minutes drive. There are shuttle services between hotels in Reykjavík and Keflavík airport in connection with arrivals and departures. Taxi service is also available.
For further information:
See: https://igc.tourdesk.is/Transportation
If you want to rent a car; see here: https://igc.tourdesk.is/CarRental

Language

The official language of Iceland is Icelandic, a North Germanic language similar to Old Norse. It has changed little since Iceland's settlement period. For this reason, the words and pronunciation can seem quite challenging for visitors.

Electricity

Iceland uses Northern European electrical standards (50 Hz/220 volts) so converters may be required for small electrical appliances brought from home. Iceland uses the standard Europlug socket with two round prongs.

Time

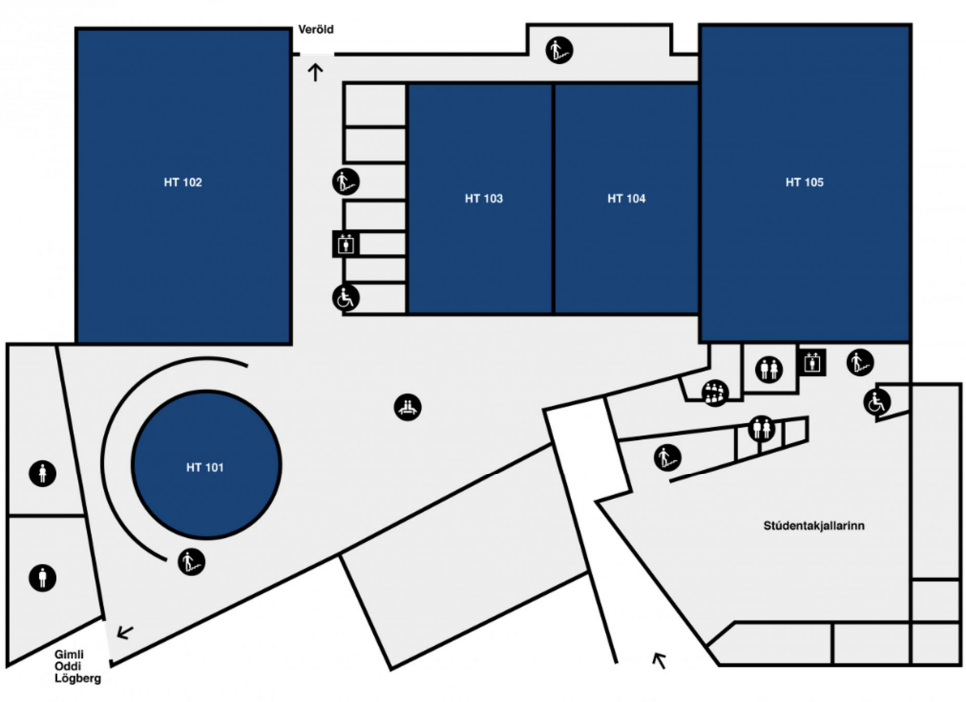
Iceland observes UTC±00:00 year-round, known as Greenwich Mean Time or Western European Time.

Weather

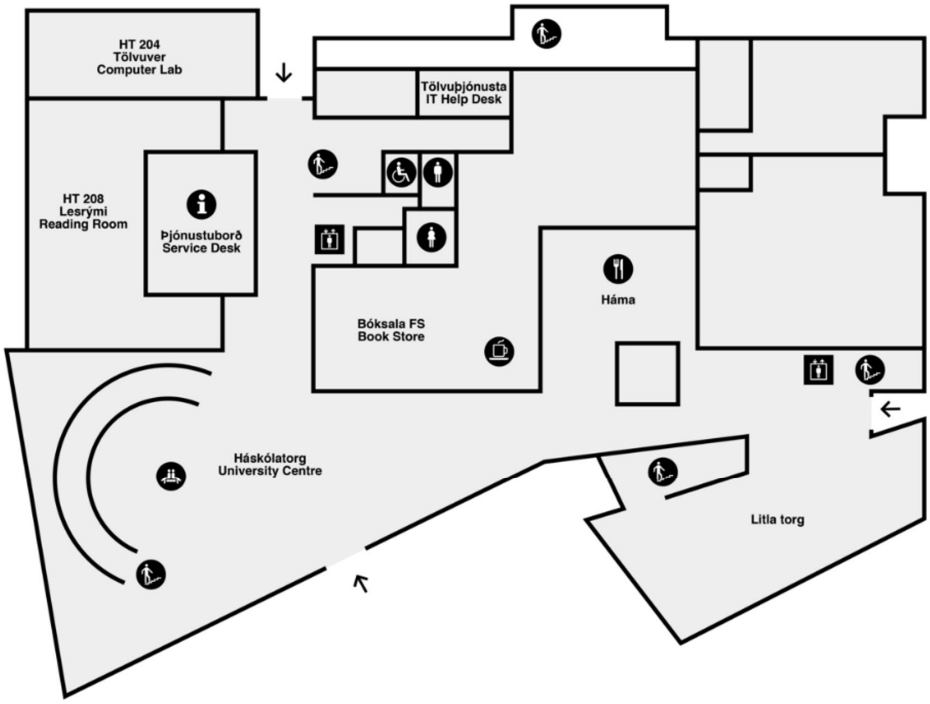
Thanks to the Gulf Stream, Iceland enjoys a cool, temperate maritime climate, cool in summer and fairly mild in winter. However, the weather is very changeable, and tourists should be prepared for the unexpected. View more at the Icelandic Met Office at https://en.vedur.is.

Conference Venue Floorplan and Maps

Háskólatorg / University Centre, University of Iceland



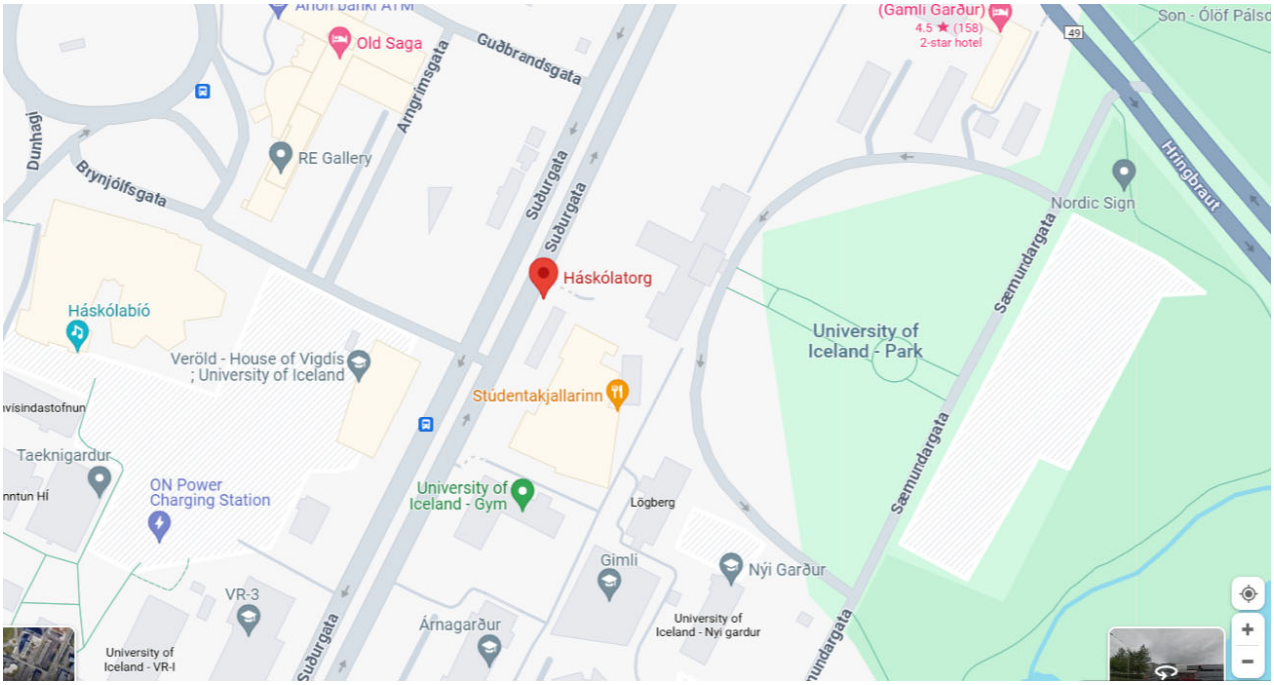
Floorplan of the Main Conference Hall



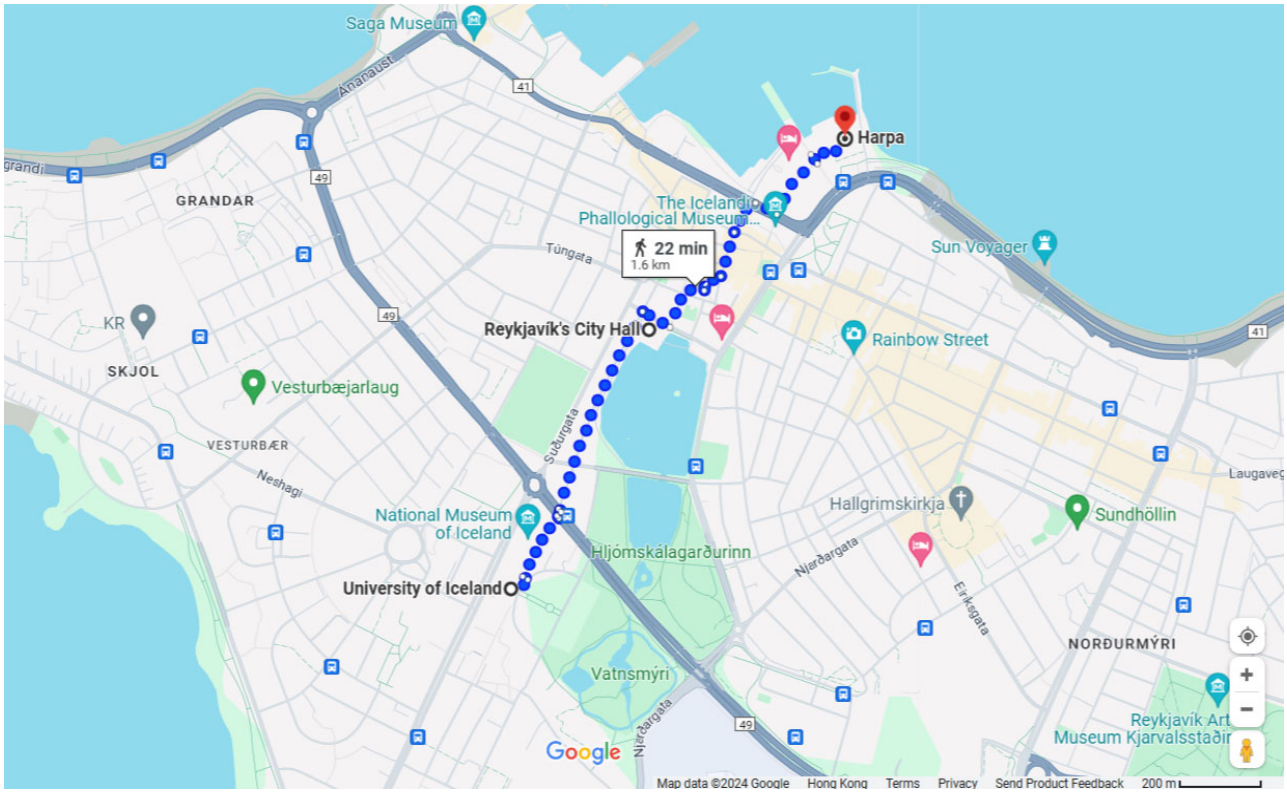
Breakout Session Areas and Additional Facilities

Conference Welcome Reception – Reykjavík City Hall

The Conference Banquet - Harpa Concert Hall and Conference Centre



Map of the University of Iceland (Háskólatorg / University Centre)



Direction of the University of Iceland to City Hall and to Harpa

Þakka þér fyrir

谢谢