2024 第七届 IEEE 国际无人系统大会
特邀专题简介表

特邀专题名称

无人系统中的数字孪生与数据驱动关键技术

组织者

1. 虞文武，教授，东南大学

2. 公鑫，副研究员，东南大学

3. 沈俊，教授，南京航空航天大学

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个人简介

虞文武，东南大学首席教授、博士生导师，入选教育部长江学者、青年长江、国家“万人计划”青年拔尖人才、国家优秀青年科学基金获得者。主要从事系统科学与人工智能交叉-分析、控制、优化、学习等相关研究，发表 IEEE 汇刊文章 100 余篇；Google 和 SCI 引用过 2 万次，SCI H 指数 60；相关研发核心技术支撑人工智能新兴产业的无人系统、智能电网、智能交通、大数据、智慧城市等领域。相关成果获国家自然科学二等奖 1 项，省科学技术奖/自然科学奖一等奖 2 项及国家一级学会科学技术奖一等奖 1 项等奖项；曾任 IEEE Trans. Systems, Man, and Cybernetics: Systems、IEEE Trans. Industrial Informatics、IEEE Trans. Circuits and Systems II、中国科学信息科学、中国科学技术科学、自动化学报、智能科学与技术等杂志编委。

公鑫，博士，东南大学副研究员，硕士生导师。2022 年获得香港大学控制工程专业博士学位，围绕高效集群和安全集群两大主题，从理论、模拟和实验方面对集群系统的分布式定位与估计、控制与优化开展了长期的研究工作。目前研究聚焦于基于分布式估计和数字孪生的复合网络攻击与防御；基于博弈论的隐蔽攻击与防御；基于几何规划的恶意拓扑攻击下的防御资源分配。 工程方面，他率先开展了无人集群在隐蔽

攻击和复合攻击下的攻防实验工作，相应成果已发表在 IEEE Trans. Industr. Inform.、和 IEEE/CAA J. Autom. Sin.等国际权威期刊上。近年来，累计在决策与控制领域的国际权威期刊或国际会议上发表论文发表论文 30 余篇，其中包含 17 篇 IEEE 会刊。

沈俊，南京航空航天大学教授，博导。博士毕业于香港大学机械工程系。在香港大学攻读博士期间，获得 University Postgraduate Fellowship，Mechanical Engineering Outstanding Research Postgraduate Student 等学术奖项。博士论文获香港大学优秀博士论文并入选 Springer 优秀博士论文系列丛书。入选自动化学院优秀青年骨干教师和南京航空航天大学长空学者计划。获 2019 年度中国自动化学会自然科学二等奖（第一完成人）和 2020 年江苏省优秀青年基金项目。

杨雪飞，哈尔滨工业大学航天学院副教授，博导。从事时滞系统，非线性系统及极值搜索优化理论研究及相关应用，目前已在相关领域发表论文 30 余篇，其中包括控制理论领域顶级期刊 IEEE Trans. on Automatic Control、Automatica 以及国际控制顶会 IEEE CDC 和 IFAC World Congress 等多篇论文。担任中国控制与指挥学会青年工作委员会委员、智能控制与系统专业委员会委员等学术职务。近五年主持国家自然科学基金青年 1 项，2019 年度中国博士后创新人才支持计划 1 项，以色列 PBC 政府博士后项目 1 项，以及哈工大特色学科基础研究项目与前沿探索基金各 1 项。获得第二十二届哈尔滨工业大学优秀博士学位论文奖， 哈尔滨工业大学（深圳）优秀博士后以及 2023 年 IEEE-CYBER 国际会议“最佳会议论文奖”等荣誉称号。

特邀专题简介

随着控制与计算机技术的飞速进步，无人车和无人机等无人系统已跃居智能化技术发展的尖端。得益于数字孪生技术和数据驱动优化的广泛应用，这些无人系统能够在纷繁复杂的环境中胜任各类艰巨任务。这两项前沿技术不仅重

塑了无人系统的设计与操作模式，更引领了其在维护和升级方面的深刻变革。数字孪生技术依托先进的计算模型，精准地创建了物理实体在数字世界中的虚拟映射。这使得我们能够在不影响实际系统运行的情况下，在虚拟环境中对复杂或极端任务进行高度逼真的模拟和预测，并对新的优化理论和控制策略进行验证。这一创新不仅显著降低了成本，还极大提升了创新和应用的速度与安全性。与此同时，数据驱动优化通过融合传统数据分析和人工智能的新兴方法，优化了决策过程，并提出了更为精准的估计或控制方案。在无人车的城市导航、无人机的灾难响应等实际应用场景中，这一技术使得系统能够迅速适应多变的环境条件。此外，当数字孪生技术与数据驱动优化相结合时，无人系统的自主性和适应性得以进一步提升。通过模拟和预测各种操作场景，数字孪生技术为系统开发者提供了深入洞察无人车和无人机在特定条件下的表现的机会，从而设计出更加智能化和灵活多变的控制策略。同时，数据驱动的优化方法在系统运行过程中不断完善这些策略，确保无人系统在面临未知挑战时能够迅速作出最佳反应。

本特邀专题邀请以下与以下主题相关的包含创新思想、概念、新发现、改进以及新应用的原创论文，以期在无人系统的设计、估计和控制等领域开启新的篇章：

- 数字孪生技术驱动的无人系统；
- 虚实结合的无人系统仿真、态势分析与在线优化技术；
- 无人系统中基于数据驱动的优化方法；
- 大模型时代模型驱动的无人系统；
- 极值搜索算法在无人系统设计和控制中的应用；
- 复杂环境（对抗、非合作）下基于采样的无人系统决策与控制方案；
- 无人系统中的基于模型的人工智能方法和应用。

IEEE ICUS 2024
Invited Session Summary

Title of Session

Digital Twins and Data-Driven Key Technologies in Unmanned Systems

Organizers

1. Prof. Wenwu Yu

Southeast University, China

2. Assoc. Prof. Xin Gong

Southeast University, China

3. Prof. Jun Shen

Nanjing University of Aeronautics and Astronautics, China

4. Assoc. Prof. Xuefei Yang

Harbin Institute of Technology, China

Biosketches of Organizers

Dr. Wenwu Yu is a Chief Professor and Doctoral Supervisor at Southeast University. He has been recognized as a Changjiang Scholar by the Ministry of Education, a member of the Youth Changjiang Scholars Program, a Young Top-tier Talent under the National "Ten Thousand Talents Program," and a recipient of the National Science Fund for Distinguished Young Scholars. His research focuses on the intersection of system science and artificial intelligence, encompassing analysis, control, optimization, and learning. Dr. Yu has published over 100 articles in IEEE journals, with over 20,000 citations on Google and SCI, and an SCI H-index of 60. His core research technologies support emerging artificial intelligence industries in areas such as unmanned systems, smart grids, intelligent transportation, big data, and smart cities.His achievements have been recognized with various awards, including the Second Prize of the National Natural Science Award, two First Prizes of Provincial Science and Technology Awards/Natural Science Awards, and a First Prize of the National First-level Society Science and Technology Award. Dr. Yu has served as an editorial board member for various journals, including IEEE Transactions on Systems, Man, and Cybernetics: Systems, IEEE Transactions on Industrial Informatics, IEEE Transactions on Circuits and Systems II, Science China

Information Sciences, Science China Technological Sciences, Acta Automatica Sinica, and Intelligent Science and Technology.

Dr. Xin Gong is currently an Associate Professor with the School of Cyber Science and Engineering, Southeast University, Nanjing, China. He is an IEEE member and served as a Section Chairman of IEEE IECON 2021. He received his PhD degree in control theory and engineering with the University of Hong Kong in 2022. His research interests include efficient and resilient control of multi-agent systems, distributed optimization, game theory, and their experiments in UAV swarms. In recent 4 years, he has published about 30 papers in international journals and conferences in the field of robotics and control, including 17 papers on IEEE Transactions.

Prof. Jun Shen received the B.Sc. and M.Sc. degrees from Southeast University, Nanjing, China, in 2008 and 2011, respectively, and the Ph.D. degree from the Department of Mechanical Engineering, the University of Hong Kong, Hong Kong, in 2015. He is currently a full Professor in the College of Automation Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing, China. He is Associate Editor or Editorial Board Member of Journal of the Franklin Institute , Cogent Engineering, IET Journal of Engineering, Guest Editor of IET Control Theory & Applications. He is a Senior Member of IEEE and a Member of IET. His current research interests include positive systems, monotone systems, fractional order systems, model reduction, and robust control and filtering.

Dr. Xuefei Yang is an associate professor and doctoral supervisor at the School of Astronautics, Harbin Institute of Technology. His research focuses on the theoretical study and related applications of time-delay systems, nonlinear systems, and extremum seeking optimization. He has published over 30 papers in relevant fields, including top journals in control theory such as IEEE Trans. on Automatic Control, Automatica, as well as papers presented at prestigious international control conferences like IEEE CDC and IFAC World Congress. Dr. Yang holds academic positions as a member of

the Youth Working Committee of the Chinese Association of Automation, and the Committee of Intelligent Control and Systems. In the past five years, he has presided over a project funded by the National Natural Science Foundation of China for young scholars, a Postdoctoral Innovation Talent Support Program awarded by China in 2019, a postdoctoral project funded by the PBC government of Israel, as well as basic research projects and frontier exploration funds unique to Harbin Institute of Technology. Dr. Yang has received numerous honors and awards, including the 22nd Excellent Doctoral Dissertation Award of Harbin Institute of Technology, the Outstanding Postdoctoral Award from Harbin Institute of Technology (Shenzhen), and the Best Conference Paper Award at the 2023 IEEE-CYBER International Conference.

Details of Session

With the rapid advancement of unmanned systems technology, such as unmanned vehicles and drones, these advanced systems have taken the forefront of intelligent technology development. Benefiting from the widespread application of digital twin technology and data-driven optimization, these unmanned systems are capable of undertaking various arduous tasks in complex and dynamic environments. These two cutting-edge technologies not only reshape the design and operational modes of unmanned systems but also lead profound changes in their maintenance and upgrade aspects.Digital twin technology relies on advanced computational models to accurately create virtual mappings of physical entities in the digital realm. This enables us to conduct highly realistic simulations and predictions of complex or extreme tasks in virtual environments without affecting the operation of actual systems, and to validate new optimization theories and control strategies. This innovation not only significantly reduces costs but also greatly enhances the speed and safety of innovation and application. Meanwhile, data-driven optimization, by integrating emerging methods of traditional data analysis and artificial intelligence, optimizes the decision-making process and proposes more precise estimation or control schemes. In practical application scenarios such as urban navigation for unmanned vehicles and disaster response for drones, this technology enables systems to rapidly adapt to changing environmental conditions. Furthermore, when digital twin technology is combined with data-driven optimization, the autonomy and adaptability of unmanned systems are further enhanced. By simulating and predicting various operational scenarios, digital twin technology provides developers with

opportunities for in-depth insights into the performance of unmanned vehicles and drones under specific conditions, thereby designing more intelligent and flexible control strategies. At the same time, data-driven optimization methods continually refine these strategies during system operation to ensure that unmanned systems can respond optimally to unknown challenges.

This special issue invites original papers with innovative ideas, concepts, new discoveries, improvements, and new applications related to the following topics, with a view to opening a new chapter in the design, estimation, and control of unmanned systems:

- Unmanned systems driven by digital twin technology
- Unmanned system simulation, situational analysis and online optimization technology based on the combination of virtual and real worlds
- Optimization methods based on data-driven in unmanned systems
- Model-driven unmanned systems in the era of large models
- Application of extreme value search algorithm in the design and control of unmanned systems
- Decision and control scheme for sampling-based unmanned systems in complex environment confrontation and non-cooperation
- Model-based artificial intelligence methods and applications in unmanned systems