2026 第九届 IEEE 国际无人系统大会
特邀专题简介表

特邀专题名称

水面无人系统数智集群协同

组织者

1.张　磊，教授，哈尔滨工程大学

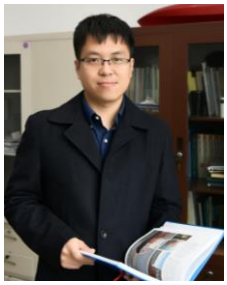
2.庄佳园，副教授，哈尔滨工程大学

3.董早鹏，副教授，武汉理工大学

4. 郑宇鑫，助理研究员，哈尔滨工程大学

个人简介

张磊，哈尔滨工程大学教授，博/硕导，海洋机器人技术研究所副所长。国家重点研发计划首席科学家，某中型艇副总师，某共用技术专家，某试验鉴定技术专家，黑龙江省造船学会理事，黑龙江省首批高层次人才，省优青，从事无人艇智能控制，集群协同技术研究。获日内瓦国际发明展金奖，国家级学会一等奖，省级二等奖等多项科技奖励。获国家出版基金资助主编著作 2 部，出版省级规划教材 2 部，发表论文 50 余篇，专利 40 余项。



庄佳园，哈尔滨工程大学副教授、博士生导师。长期从事水面无人艇技术研究，在平台总体设计、自主决策与路径规划等方面取得了系列突破。主持国家重点研发计划课题、装备预研共用技术、国家自然科学基金等科研项目 10 余项，作为技术负责人主导研制了多型无人艇样机。以第一或通讯作者在国内外高水平学术期刊和会议发表论文 30 余篇，获得发明专利授权和计算机软件著作权登记 30 余项，出版国家出版基金资助专著 2 部。获得中国造船工程学会科技进步一等奖、黑龙江省技术发明二等奖、日内瓦国际发明展金奖、中国好设计银奖等奖励多项。

董早鹏，武汉理工大学，副教授、硕士生导师。长期从事水面无人艇、水下机器人技术方面的相关工作。在海洋无人系统的编队与集群控制、操纵运动建模、数模混合驱动的智能控制等方面具有深厚的研究基础。主持国家自然科学基金面上项目、青年项目（C）、国家重点实验室基金、企业委托项目等十余项，在 ISA Transaction、Congtrol Engineering Practice、Ocean Engineering 等学术刊物及会议上发表论文 60 余篇，申请/授权发明专利 10 余项。

郑宇鑫，工学博士，哈尔滨工程大学助理研究员，中国科协首届“青年人才托举工程博士生专项计划”入选者，中国造船工程学会高级会员。主要研究方向为水面无人系统自主控制技术、集群智能技术等。主持/参研黑龙江省博士后资助项目、“新时代龙江优秀硕士、博士学位论文”项目、国家重点研发计划项目、国家重点研发计划课题、重点项目等 10 余项。近 5 年发表高水平学术论文 16 篇，申请/授权国家及国际发明专利 28 项，登记软件著作权 10 余项，国际高水平学术会议主旨报告 1 次，获中国造船工程学会科技进步奖一等奖、黑龙江省技术发明奖二等奖、日内瓦国际发明展金奖等多项科技奖励。《海军航空大学学报》青年编委。

特邀专题简介

水面无人系统数智集群协同技术对海洋权益维护、水域安全防控、应急救援处置及海洋资源开发等领域的支撑作用正日益凸显，以数字孪生赋能、智能协同调度与全域高效作业为主要特征的新一代水面无人集群协同技术，成为拓展人类在近海、内湖、河道等水域作业边界、提升作业效能的重要突破口。水面无人系统数智集群在运行过程中需面对复杂水域环境（风浪、水流扰动）下通信链路不稳定、多智能体异构性强、任务协同耦合紧密且动态不确定性突出的多重挑战。由此，围绕数智融合驱动的水面无人集群协同系统，在异构集群组网、智能调度优化、协同感知决策、动态任务分配等方面的实时性、可靠性与协同效能问题，衍生出一系列亟待突破的关键科学与技术难题。如何在复杂多变的水域环境中实现集群高效协同、动态任务适配与安全稳定运行，是当前水面无人系统数智集群协同设计与应用面临的核心问题。通过提升集群的协同

智能水平与任务适配能力，可有效推动水面无人系统数智集群在复杂水域场景中的规模化应用与工程落地，进而在海事监管、环境监测、应急保障与海洋工程等领域发挥重要支撑作用。

本特邀专题邀请以下与“水面无人系统数智集群协同”主题相关的包含创新思想、新发现、概念、改进、关键技术及新应用的原创论文，主要接收（并不限于）以下方向的研究论文：

- 水面无人集群异构平台协同组网与通信技术
- 水面无人集群数字孪生建模与虚实融合调控
- 水面无人集群智能调度与动态任务分配方法
- 水面无人集群协同感知、定位与环境建模
- 水面无人集群鲁棒协同控制与抗干扰技术
- 水面无人集群自主决策与智能作业协同机制
- 水面无人集群多目标协同跟踪与围控技术
- 水面无人集群可靠性、安全性与测试评估方法
- 水面无人集群与空、水下无人平台跨域协同技术
- 复杂水域环境下集群自适应协同与动态避障技术
- 水面无人集群数智化能源管理与长时协同运行技术
- 水面无人集群自主协同与容错控制
- 水面无人集群群体智能与分布式协同优化方法
- 水面无人集群典型场景应用验证

IEEE ICUS 2026
Invited Session Summary

Title of Session

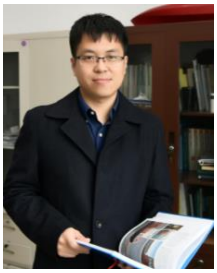
Digital-Intelligent Swarm Cooperation for Unmanned Surface Systems

Organizers

1. Prof. Lei Zhang
Harbin Engineering University, China
2. Assoc. Prof. Jiayuan Zhuang
Harbin Engineering University, China
3. Assoc. Prof. Zaopeng Dong
Wuhan University of Technology, China
4. Dr. Yuxin Zheng
Harbin Engineering University, China

Biosketches of Organizers

Prof. Lei Zhang, is Doctoral and Master's Supervisor at Harbin Engineering University; Deputy Director of the Institute of Marine Robotics Technology. Principal Investigator of the National Key R&D Program, Deputy Chief Designer for a medium-sized craft, expert in general shared technologies and test & evaluation technologies, Director of the Heilongjiang Society of Shipbuilding Engineering. He is among the first batch of High-Level Talents in Heilongjiang Province and recipient of the Heilongjiang Provincial Outstanding Youth Fund. His research focuses on intelligent control and swarm cooperation technology of unmanned surface vehicles (USVs). He has won numerous scientific and technological awards including the Gold Medal of the Geneva International Invention Exhibition, First Prize of a national-level academic society, and Second Prize at the provincial level. He has authored 2 monographs funded by the National Publication Fund and compiled 2 provincial-level planned textbooks. To date, he has published over 50 academic papers and granted more than 40 patents.



Assoc. Prof. Jiayuan Zhuang is a Ph.D. supervisor at Harbin Engineering University.His research focuses on unmanned surface vehicle (USV) technology, with distinctive academic achievements and technological breakthroughs in overall platform design, autonomous decision-making, path planning and related key technologies. He has undertaken over 10 research projects as the principal investigator, covering the National Key R&D Program of China, general equipment pre-research projects, and programs supported by the National Natural

Science Foundation of China. Serving as the technical director, he has led the development and engineering implementation of multiple USV prototypes. He has published more than 30 high-quality papers in top-tier domestic and international journals and conferences as the first author or corresponding author. Additionally, he has been granted over 30 authorized invention patents and software copyrights, and published two monographs funded by the National Publication Foundation. He has been conferred with a number of provincial and ministerial-level as well as international academic awards, including the First Prize of Science and Technology Progress by the Chinese Society of Naval Architects and Marine Engineers, the Second Prize of Heilongjiang Provincial Technological Invention Award, the Gold Medal of the Geneva International Exhibition of Inventions, and the Silver Award of China Good Design.

Zaopeng Dong is an associate professor and master's supervisor at Wuhan University of Technology. He has long been involved in research on unmanned surface vehicles (USVs) and autonomous underwater vehicles (AUVs). His research expertise lies primarily in formation and swarm control of unmanned marine systems, maneuvering and motion modeling, and hybrid data-model driven intelligent control. He has led over ten projects, including projects supported by the National Natural Science Foundation of China, projects funded by State Key Laboratory grants, and industry-commissioned projects. He has published more than 60 papers in journals and conference proceedings such as ISA Transactions, Control Engineering Practice, and Ocean Engineering, applied for and granted over 10 invention patents.

Yuxin Zheng, Ph.D. in Engineering, is an Assistant Research Fellow at Harbin Engineering University. He was selected for the inaugural "Young Talent Support Project for Doctoral Students" by the China Association for Science and Technology and is a Senior Member of the Chinese Society of Naval Architects and Marine Engineers. His main research interests include autonomous control technology for unmanned surface systems and swarm intelligence. Dr. Zheng has led or participated in more than 10 research projects, including the Heilongjiang Provincial Postdoctoral Funding Project, the "New Era Longjiang Excellent Master's and Doctoral Dissertations" Project, projects and sub-projects under the National Key R&D Program of China, and other key initiatives. Over the past five years, he has published 16 papers in high-level journals, filed or been granted 28 national and international invention patents, and registered over 10 software copyrights. He has

also delivered an invited keynote speech at a prestigious international conference. His scientific contributions have been recognized with multiple awards, such as the First Prize of the Science and Technology Progress Award of the Chinese Society of Naval Architects and Marine Engineers, the Second Prize of the Heilongjiang Provincial Technological Invention Award, and a Gold Medal at the Geneva International Exhibition of Inventions. He serves as a Youth Editorial Board Member of the Journal of Naval Aviation University.

Details of Session

The technology of digital-intelligent swarm collaboration of surface unmanned systems is playing an increasingly prominent supporting role in fields such as marine rights and interests protection, water area safety prevention and control, emergency rescue and disposal, and marine resource development. The new generation of surface unmanned swarm collaboration technology, characterized by digital twin empowerment, intelligent collaborative scheduling, and full-domain efficient operation, has become an important breakthrough to expand the operational boundaries of humans in offshore, inland lakes, river courses and other water areas and improve operational efficiency. In the operation process, the digital-intelligent swarm of surface unmanned systems needs to face multiple challenges, such as unstable communication links under complex water environments (wind waves, current disturbances), strong heterogeneity of multi-agent systems, tight coupling of task collaboration, and prominent dynamic uncertainty. Therefore, focusing on the real-time performance, reliability and collaborative efficiency of digital-intelligent integration-driven surface unmanned swarm collaboration systems in aspects such as heterogeneous cluster networking, intelligent scheduling optimization, collaborative perception and decision-making, and dynamic task allocation, a series of key scientific and technological problems that urgently need to be broken through have emerged. How to achieve efficient cluster collaboration, dynamic task adaptation and safe and stable operation in complex and changeable water environments is the core problem faced in the design and application of digital-intelligent swarm collaboration of surface unmanned systems. By improving the collaborative intelligence level and task adaptation ability of the cluster, it can effectively promote the large-scale application and engineering implementation of the digital-intelligent swarm of surface unmanned systems in complex water scenarios, and then play an important supporting role in fields such as maritime supervision, environmental monitoring, emergency support and marine engineering.

This special topic invites original papers related to the theme of "Digital-Intelligent Swarm Collaboration of Surface Unmanned Systems" that include innovative ideas, new discoveries, concepts, improvements, key technologies and

new applications. It mainly accepts (but is not limited to) research papers in the following directions:

- Collaborative networking and communication technology for heterogeneous platforms of surface unmanned swarms
- Digital twin modeling and virtual-real fusion control of surface unmanned swarms
- Intelligent scheduling and dynamic task allocation methods for surface unmanned swarms
- Collaborative perception, positioning and environmental modeling of surface unmanned swarms
- Robust cooperative control and anti-interference technology for surface unmanned swarms
- Autonomous decision-making and intelligent operation collaboration mechanism of surface unmanned swarms
- Multi-target collaborative tracking and encirclement control technology for surface unmanned swarms
- Reliability, safety and test evaluation methods for surface unmanned swarms
- Cross-domain collaboration technology between surface unmanned swarms and aerial/underwater unmanned platforms
- Adaptive collaboration and dynamic obstacle avoidance technology for swarms in complex water environments
- Digital-intelligent energy management and long-term collaborative operation technology for surface unmanned swarms
- Autonomous collaboration and fault-tolerant control of surface unmanned swarms
- Swarm intelligence and distributed collaborative optimization methods for surface unmanned swarms
- Application verification of surface unmanned swarms in typical scenarios