

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

非结构化环境机器人路径规划与控制

组织者

- 1.高洪波，研究员，中国科学技术大学
- 2.刘智勇，研究员，中国科学院自动化研究所
- 3.樊渊，教授，安徽大学

个人简介



高洪波，中国科学技术大学研究员、博士生导师，国家网信创新人才支持计划入选者。2016年在李德毅院士的指导下获得北京航空航天大学计算机应用技术专业工学博士学位，后在清华大学跟随李克强院士从事博士后研究，并赴新加坡南洋理工大学任高级访问学者。长期致力于机器人、智能网联汽车、自动驾驶与协同智能等领域关键技术研发及产业化工作。主持国家自然科学基金重点项目、集成项目，以及科技创新重大项目课题和国家重点研发计划课题等多项国家/省部级科研课题 20 余项。作为第一作者或通讯作者，发表 JCR 1 区、2 区论文 100 余篇，7 篇入选 ESI 高被引论文，谷歌学术引用 4875 余次，H 因子 66，获最佳论文奖 15 次。作为第一发明人，获授权发明专利 30 余件，其中美国专利 2 件。现任智能汽车安全技术全国重点实验室学术委员会委员、中国指挥与控制学会理事、安徽省机器人学会监事长、安徽省机器人学会青年工作委员会主任。入选安徽省“特支计划”创新领军人才计划，获安徽省自然科学基金杰出青年项目资助，荣获安徽省科技进步一等奖等及省部级奖项 10 项以及多项个人学术奖励。他还担任 IEEE TNNLS 和 TASE 两大人工智能领域顶级 SCI 期刊的副主编，《国际先进机器人系统》知名 SCI 期刊的副主编，两次 EI 期刊编委，九次领域主席和客座主编。曾多次受邀参加国际和国内会议发表演讲，次数超过 5 次。



刘智勇，现任中国科学院自动化研究所多模态人工智能系统全国重点实验室研究员、博士生导师。天津大学工学本科，中国科学院自动化研究所工学硕士，香港中文大学计算机科学与工程博士，曾在香港中文大学工程学院从事博士后研究。2005年至2013年任中国科学院自动化研究所副研究员，2013年至今任中国科学院自动化研究所研究员。主要研究方向为机器人学习、机器人感知、模式分析与识别、机器人视觉、机器人自主学习、多模态大模型，以及目标检测识别、定位导航与环境建模等。IEEE高级会员，中国自动化学会机器人智能专业委员会委员。曾担任 *Neurocomputing*、*Applied Informatics* 等国际期刊编委，以及 IJCNN、ACML 等国际会议程序委员会委员。围绕模式识别、计算机视觉、图像分析、组合图优化与机器人智能等方向开展长期研究，提出渐非凸渐凹化过程 GNCCP 等组合图优化算法框架，并在独立成分分析、一维流形形状检测、机器人操作理论等方面取得研究成果。作为主要完成人之一获 2014 年度国家自然科学基金二等奖，获奖项目为“基于环境约束和多空间分析的机器人操作理论研究”。已发表多篇科研论文，其中早期公开简介显示其已发表论文 50 余篇、第一作者 SCI 国际期刊论文 20 余篇。



樊渊，安徽大学教授、博士生导师，中国科学技术大学自动化本科，中国科学技术大学和香港城市大学控制科学与工程博士。新加坡南洋理工大学和香港城市大学访问学者。获安徽省教学成果一等奖，安徽大学课程思政优秀教学案例。指导学生获“互联网+”大赛全国银奖。主持教育部协同育人项目，省级自动化专业提升改造项目，省级线下课程《自动控制理论》，参与国家一流课程《自动控制原理》。获宝钢优秀教师奖，九三学社安徽省参政议政先进个人、优秀参政议政成果一等奖，安徽大学三全育人先进个人。IEEE 高级会员，安徽省自动化学会理事，中国自动化学会全驱系统理论与应用专委会委员，中国人工智能学会智能空天系统专委会委员，中国指挥与控制学会具身智能专委会委员，中国仿真学会会员。安徽省杰青，青年皖江学者，省高校优秀青年人才。主要研究方向为机器人导航与运动控制、视觉感知与机械臂控制、强化学习与多智能体系统、储能系统检测与优化运行。主持和参与国家重点研

发计划智能机器人专项、国家自然科学基金、安徽省科技创新攻坚计划、安徽省重点研发计划等。发表科研论文百余篇，包括 IEEE Trans 汇刊、Automatica、自动化学报等权威期刊论文。获发明专利三十余项。获中国自动化学会自然科学二等奖，江苏省自动化学会科学技术一等奖。担任国家重点研发计划和国家领军人才评审专家，多省科技奖及科技项目评审专家等。

特邀专题简介

随着机器人技术的快速发展，机器人正逐步应用于巡检、救援、物流、农业、服务和特种作业等复杂场景。与结构化工业环境相比，非结构化环境通常存在地图信息不完整、障碍物动态变化、地形条件复杂、通行空间受限和任务目标不确定等问题，对机器人自主路径规划、运动控制和安全执行能力提出了更高要求。

路径规划与运动控制是机器人实现自主作业的关键环节。面对复杂非结构化环境，机器人不仅需要根据环境信息生成安全可行的运动路径，还需要结合自身运动学约束、动力学特性和执行机构能力，实现稳定、平滑和高效的轨迹跟踪与控制。现阶段，传统搜索规划、采样规划、优化控制、模型预测控制以及学习型方法正在不断融合，为提升机器人在复杂环境中的自主性、适应性和稳定性提供新的研究思路。

本特邀专题邀请以下与“非结构化环境机器人路径规划与控制”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。

- 非结构化环境机器人路径规划
- 动态障碍环境下的实时避障
- 机器人运动控制与轨迹跟踪
- 模型预测控制与安全约束控制
- 学习增强的机器人导航方法
- 复杂地形机器人运动控制
- 机器人自主作业系统与应用验证

IEEE ICUS 2026
Invited Session Summary

Title of Session

Robot Path Planning and Control in Unstructured Environments

Organizers

1. Prof. Hongbo Gao

University of Science and Technology of China

2. Prof. Zhiyong Liu

Institute of Automation, Chinese Academy of Sciences

3. Prof. Yuan Fan

Anhui University, China

Biosketches of Organizers



Dr. Hongbo Gao, Researcher and Doctoral Supervisor, University of Science and Technology of China, is a recipient of the National Cyberspace Innovation Talent Support Program. He received the Ph.D. degree in Computer Application Technology from Beihang University in 2016 under the supervision of Academician Deyi Li. He subsequently worked at Tsinghua University as a postdoctoral researcher under the guidance of Academician Keqiang Li, and served as a Visiting Research Fellow at Nanyang Technological University, Singapore. He has long been dedicated to the research and industrialization of key technologies in fields such as robotics, intelligent connected vehicles, autonomous driving, and collaborative intelligence. He has presided over more than 20 national, provincial, and ministerial research projects, including Key Programs and Integrated Programs of the National Natural Science Foundation of China (NSFC), subjects of Major Science and Technology Innovation Projects, and subjects of the National Key Research and Development Program of China. As first author or corresponding author, he has published over 100 papers in JCR Q1 and Q2 journals, 7 of which are ESI Highly Cited Papers. He has received more than 4,875 citations on Google Scholar, with an h-index of 66, and has won 15 Best Paper Awards. As the first inventor, he holds over 30 granted invention patents, including 2 US patents. He currently serves as a member of the Academic Committee of the National Key Laboratory of Intelligent Vehicle Safety Technology, a council member of the Chinese Institute of Command and Control (CICC), the Supervisor-General of the Anhui Robotics Society, and the Director of the Youth Working Committee of the Anhui Robotics Society. He was selected as the Innovation Leading Talent of Anhui Province TeZhi Plan, supported by the Anhui Province Natural Science Funds for Distinguished Young Scholar, and

awarded the First Prize of Anhui Provincial Science and Technology Progress Award, together with 10 provincial and ministerial-level awards and several individual academic honors. He also serves as an Associate Editor for two top-tier SCI journals in artificial intelligence: *IEEE Transactions on Neural Networks and Learning Systems* (TNNLS) and *IEEE Transactions on Automation Science and Engineering* (TASE), as well as for the well-known SCI journal *International Journal of Advanced Robotic Systems*. He has twice served as an editorial board member for EI-indexed journals, and nine times as an Area Chair and Guest Editor. He has been invited to deliver more than 5 talks at international and domestic conferences.



Dr. Zhiyong Liu, Research Professor and Doctoral Supervisor at the State Key Laboratory of Multimodal Artificial Intelligence Systems, Institute of Automation, Chinese Academy of Sciences. He received his B.E. degree from Tianjin University, his M.E. degree from the Institute of Automation, Chinese Academy of Sciences, and his Ph.D. degree in Computer Science and Engineering from The Chinese University of Hong Kong. He conducted postdoctoral research at the Faculty of Engineering, The Chinese University of Hong Kong. From 2005 to 2013, he served as an Associate Research Professor at the Institute of Automation, Chinese Academy of Sciences, and since 2013, he has served as a Research Professor at the Institute of Automation, Chinese Academy of Sciences. His main research interests include robot learning, robot perception, pattern analysis and recognition, robot vision, autonomous robot learning, multimodal large models, object detection and recognition, localization, navigation, and environmental modeling. He is an IEEE Senior Member and a member of the Technical Committee on Robot Intelligence of the Chinese Association of Automation. He has served as an editorial board member of international journals such as *Neurocomputing* and *Applied Informatics*, and as a Program Committee member for international conferences such as IJCNN and ACML. Dr. Liu has long been engaged in research on pattern recognition, computer vision, image analysis, combinatorial graph optimization, and robot intelligence. He proposed the Graduated Nonconvexity and Concavity Procedure (GNCCP), a combinatorial graph optimization framework, and has made research contributions to independent component analysis, one-dimensional manifold shape detection, and robot manipulation theory. As one of the principal contributors, he received the Second Prize of the 2014 State Natural Science Award for the project “Robot Manipulation Theory Based on Environmental Constraints and Multi-Space Analysis.” He has published multiple research papers; according to earlier public profiles, he had published more than 50 papers, including

more than 20 SCI-indexed international journal papers as the first author.



Dr. Yuan Fan, Professor and Doctoral Supervisor at Anhui University. He received his B.E. degree in Automation from the University of Science and Technology of China, and his Ph.D. degree in Control Science and Engineering from the University of Science and Technology of China and City University of Hong Kong. He has been a visiting scholar at Nanyang Technological University, Singapore, and City University of Hong Kong. Dr. Fan has received the First Prize of Anhui Provincial Teaching Achievement Award and the Excellent Teaching Case Award for Curriculum Ideological and Political Education of Anhui University. He guided students to win the National Silver Award in the China International College Students' "Internet+" Innovation and Entrepreneurship Competition. He has presided over Industry-University Collaborative Education Projects of the Ministry of Education, a provincial-level Automation Program Upgrading and Transformation Project, and the provincial-level offline course Automatic Control Theory, and has participated in the national first-class course Principles of Automatic Control.

He has received the Baosteel Excellent Teacher Award, the Advanced Individual Award for Political Participation and Deliberation of the Jiusan Society Anhui Provincial Committee, the First Prize for Outstanding Achievements in Political Participation and Deliberation, and the Advanced Individual Award for "Three-All Education" of Anhui University. He is an IEEE Senior Member, a council member of the Anhui Association of Automation, a member of the Technical Committee on Fully Actuated System Theory and Applications of the Chinese Association of Automation, a member of the Intelligent Aerospace Systems Professional Committee of the Chinese Association for Artificial Intelligence, a member of the Embodied Intelligence Professional Committee of the Chinese Institute of Command and Control, and a member of the China Simulation Federation. Dr. Fan has been supported by the Anhui Provincial Natural Science Foundation for Distinguished Young Scholars, selected as a Young Wanjiang Scholar, and recognized as an Outstanding Young Talent in Universities of Anhui Province. His main research interests include robot navigation and motion control, visual perception and robotic manipulator control, reinforcement learning and multi-agent systems, and detection and optimal operation of energy storage systems. He has led and participated in projects including the Intelligent Robotics Special Program of the National Key R&D Program of China, the National Natural Science Foundation of China, the Anhui Provincial Science and Technology Innovation Tackling Program, and the Anhui Provincial Key R&D Program. He has published more than 100 research papers,

including papers in authoritative journals such as *IEEE Transactions series journal*, *Automatica*, and *Acta Automatica Sinica*. He has been granted more than 30 invention patents. He has received the Second Prize of the Natural Science Award of the Chinese Association of Automation and the First Prize of the Science and Technology Award of the Jiangsu Association of Automation. He has also served as a review expert for the National Key R&D Program of China and national leading talent programs, as well as a review expert for science and technology awards and science and technology projects in several provinces.

Details of Session

With the rapid development of robotics, robots are being increasingly deployed in complex scenarios such as inspection, rescue, logistics, agriculture, service applications, and special-purpose operations. Compared with structured industrial environments, unstructured environments usually involve incomplete map information, dynamically changing obstacles, complex terrain conditions, constrained traversable spaces, and uncertain task objectives, which impose higher requirements on autonomous path planning, motion control, and safe execution capabilities of robots. Path planning and motion control are key components for enabling autonomous robotic operations. In complex unstructured environments, robots are required not only to generate safe and feasible motion paths based on environmental information, but also to achieve stable, smooth, and efficient trajectory tracking and control by considering their kinematic constraints, dynamic characteristics, and actuation capabilities. At present, traditional search-based planning, sampling-based planning, optimization-based control, model predictive control, and learning-based methods are being increasingly integrated, providing new research directions for improving the autonomy, adaptability, and stability of robots in complex environments.

This invited session invites original papers presenting innovative ideas and concepts, new discoveries and improvements, and novel applications related to the topic of “**Robot Path Planning and Control in Unstructured Environments.**”

- Robot path planning in unstructured environments
- Real-time obstacle avoidance in dynamic environments
- Robot motion control and trajectory tracking
- Model predictive control and safety-constrained control
- Learning-enhanced robot navigation methods
- Robot motion control in complex terrains
- Autonomous robotic operation systems and application validation