Special Session

Biologically Inspired Neural Networks and Learning Systems for Robotics and Mechatronics

2025 International Joint Conference on Neural Networks

Objectives of Special Session:

The aim of this special session is to bring together research that advances the integration of biologically inspired neural networks and learning systems for robotics and mechatronics. Biologically inspired neural models, such as neural dynamics, have shown promising applications in solving complex problems in robotics, including motion planning, localization, navigation, and mapping.

Biologically inspired intelligence represents a crucial and expanding field within computational intelligence, significantly advancing robotics and autonomous systems. The rapid growth in the autonomous robot and mechatronics industries has profoundly impacted both the economy and society, a trend poised to accelerate with the integration of biologically inspired intelligence techniques. These approaches, such as biologically inspired neural networks and learning systems (BNNLS), leverage insights from nature to solve complex challenges in real-world robotics, and mechatronics and autonomous systems. By mimicking natural processes and neural architecture, these models enhance robotic functionality and adaptability in dynamic environments. In mechatronic systems, bio-inspired neural networks and learning systems play a critical role in optimizing sensor configuration, improving robot design, advancing motion control, and enabling autonomous system capabilities. Recent advancements in bio-inspired systems for robotics and mechatronics have spurred international research efforts focused on creating adaptive, efficient, and intelligent systems. Key areas include biologically inspired neural network algorithms, brain-inspired neural networks, and emerging deep learning models like deep reinforcement learning, which facilitate complex decision-making and autonomous adaptation. Additionally, swarm intelligence techniques such as swarm intelligence-based neural networks, socially guided neural learning, when fused with BNNLS, yield innovative solutions for cooperative tasks, navigation, and dynamic problem-solving in robotics.

This session seeks papers that contribute novel models and methodologies for applying bio-inspired neural approaches to robotics and mechatronics, focusing on both theoretical advancements and practical applications. The goal is to highlight the interdisciplinary potential of these approaches in creating efficient, adaptable, and robust systems, fostering discussions on current challenges, emerging trends, and future directions in this field. This special session highlights and promotes the growing interest in emerging research, development, and applications within the dynamic fields of biologically inspired neural networks and learning systems. The session will focus on innovative algorithms and approaches for enhancing robotics, mechatronics, and autonomous systems (such as autonomous robots, unmanned underwater vehicles, and unmanned aerial vehicles), and mechatronics.

Further integration of BNNLS with biologically inspired evolutionary algorithms enables advancements across essential applications, including machine vision, pattern recognition, motion control, and sensor-motor coordination. These developments extend to crucial functions such as autonomous motion planning, movement control, and learning in adaptive, time-sensitive environments. As biologically inspired intelligence and learning systems continue to evolve, they promise to enhance the sophistication and functionality of robotic, mechatronics, and vehicle systems, shaping the future of autonomous technologies.

Scope and Topics

Original research papers are invited in the areas of biologically inspired neural networks and learning systems (BNNLS) for robotics and mechatronics. Submissions to this Special Session should emphasize theoretical advancements or innovative applications of biologically inspired computational intelligence algorithms in robotics and mechatronics. Topics may include the theory, design, and application of neural networks and brain-like learning systems in robotics, autonomous systems, and mechatronic applications.

Specific **topics** for the special session include but are not limited to:

- Biologically inspired neural networks for robotics and mechatronics.
- Brain-like learning systems for robots and mechatronics.
- Bio-inspired intelligence and reinforcement learning systems for robots and mechatronics.
- Bio-inspired systems on computer vision and image progressing for robotics and mechatronics.
- Human-like learning systems for robotics and mechatronics.
- Brain-inspired neural networks and learning systems for robotics and mechatronics.
- Neuro-dynamics based models for robots, vehicle systems and mechatronics
- Swarm intelligence with BNNLS for robotics and mechatronics.
- Learning systems and neuro-computing for robotics and mechatronics.
- Bio-inspired system on machine learning, intelligent systems design for robotics and mechatronics.
- Biological-inspired self-organizing neural networks with adaptation robotics and mechatronics.

- Goal-directed cognitive mapping and neuromorphic computing with BNNLS for robotics and mechatronics.
- Biological-inspired learning for predictive maintenance for robotics and mechatronics.
- Brain-inspired spiking neural networks with BNNLS for robotics and mechatronics.
- Deep neural networks and learning systems for robotics such as motion planning, navigation, mapping, localization, and image processing, etc.

Organizers:
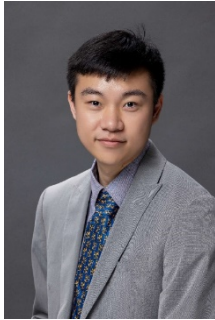
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Dr. Lei's Short CV: Tingjun Lei received his Ph.D. degree in electrical and computer engineering with the Department of Electrical and Computer Engineering, Mississippi State University, Mississippi State, MS, USA., in 2023, his M.S. degree in electrical and computer engineering from the New York Institute of Technology, Old Westbury, NY, USA, in 2016, and the B.S. degree in intelligent transportation engineering from Shanghai Maritime University, Shanghai, China, in 2014. Dr. Tingjun Lei is currently an Assistant Professor with the School of Electrical Engineering and Computer Science, University of North Dakota, Grand Forks, ND, USA. Dr. Lei received the Best Paper Award in 2022 International Conference on Swarm Intelligence and American Society for Engineering Education (2024 ASEE ECE Division). His two papers have been selected and featured as cover articles on the *Intelligence and Robotics* Journal. He received the ECE Best Graduate Researcher Award from the Department of Electrical and Computer Engineering, Mississippi State University in 2023. He received the Research Travel Award from Bagley College of Engineering, Mississippi State University in 2023. He won six oral and poster presentation awards at multiple conferences. Dr. Lei serves as Editorial Board Member of *Intelligence and Robotics*. He is the Publicity Chair of CVPRAI 2025 and Session Chair of IEEE CARS 2024. Dr. Lei has served on the technical program committee for numerous international conferences, such as IEEE-CEC, IEEE-IJCNN, ICSI, and PRIS, etc. His research interests include robotics and autonomous systems, human robot interaction, deep learning, intelligent transportation systems, and evolutionary computation.

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Dr. Chaomin Luo's Short CV: Dr. Chaomin Luo (*Senior Member, IEEE*) received his Ph.D. from the Department of Electrical and Computer Engineering at the University of Waterloo, Canada, in 2008. He earned his M.Sc. in Engineering Systems and Computing from the University of Guelph, Canada, and his B.Eng. in Electrical Engineering from Southeast University, Nanjing, China. He is currently an Associate Professor in the Department of Electrical and Computer Engineering at Mississippi State University, USA. His research interests include Computational Intelligence and Neural Networks, Intelligent Systems, Robotics and Automation, and Embedded Systems. Dr. Luo also has extensive industry experience, having worked as a Research Engineer, Hardware Designer, and Director of the Embedded Systems and Intelligent Instrument Lab.

Dr. Luo has demonstrated significant leadership both nationally and internationally in his research field. He served as the General Co-Chair of the inaugural IEEE International Workshop on Computational Intelligence in Smart Technologies (IEEE-CIST 2015) and was the Journal Special Issues Chair for the IEEE 2016 International Conference on Smart Technologies (IEEE-SmarTech) in Cleveland, OH, USA. He has also held key roles in other major IEEE conferences, including Program Co-Chair for the 2018 IEEE International Conference on Information and Automation and Publicity Chair for the 2011 IEEE International Conference on Automation and Logistics. In addition, Dr. Luo contributed as a Conference Committee Member for the 2012 IEEE International Conference on Information and Automation, as well as the International Symposium on Biomedical Engineering, and once again served as Publicity Chair for the 2012 IEEE International Conference on Automation and Logistics.

He has also taken on leadership roles within IEEE's SEM chapter, including Chair and Vice Chair of the Computational Intelligence Chapter and Chair of the Education Committee. Dr. Luo's editorial contributions include serving on the Editorial Boards of the *Journal of Industrial Electronics and Applications*. He is also an Associate Editor for the *International Journal of Robotics and Automation*, the *International Journal of Swarm Intelligence Research (IJSIR)* and the *IEEE Transactions on Cognitive and Developmental Systems*.

Dr. Luo has organized and chaired numerous special sessions on topics such as Intelligent Vehicle Systems and Bio-inspired Intelligence at prestigious IEEE conferences, including WCCI, IEEE-IJCNN, and IEEE-SSCI. He has an extensive publication record in leading journals and conferences, such as *IEEE Transactions on Neural Networks*, *IEEE Transactions on SMC*, *IEEE Transactions on Cybernetics*, IEEE-ICRA, and IEEE-IROS. Additionally, he

served as a panelist for the U.S. Department of Defense's NDSEG Fellowship program (2015-2017) and for the NSF GRFP Panelist program in 2017. He received the Best Paper Award in the *IEEE International Conference on Information and Automation* (IEEE ICIA2017), and the Best Paper Award in the American Society for Engineering Education (ASEE) Conference 2024. He is Associate Editor in 2019 *IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS 2019). He is Tutorials Co-Chair in the 2020 IEEE Symposium Series on Computational Intelligence.

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Dr Yang's short CV: Erfu Yang (Senior Member, IEEE) received his Ph.D. degree in Robotics from the School of Computer Science and Electronic Engineering, University of Essex, Colchester, UK, in 2008. He is currently a Senior Lecturer in the Department of Design, Manufacturing and Engineering Management (DMEM), University of Strathclyde, Glasgow, UK. His main research interests include robotics, autonomous systems, mechatronics, manufacturing automation, signal and image processing, computer vision and applications of machine learning and artificial intelligence, etc. He has over 180 publications in these areas, including more than 80 journal papers and 10 book chapters. Dr. Yang has been awarded over 15 research grants as PI (principal investigator) or CI (co-investigator). He is the Fellow of the UK Higher Education Academy, Member of the UK Engineering Professors' Council, Senior Member of the IEEE Society of Robotics and Automation, IEEE Control Systems Society, Publicity Co-Chair of the IEEE UK and Ireland Industry Applications Chapter, Committee Member of the IET SCOTLAND Manufacturing Technical Network. He is also an associate editor for the Cognitive Computation journal published by Springer.

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Dr Bi's short CV: Zhuming Bi (*Senior Member, IEEE*) received the Ph.D. degrees from the Harbin Institute of Technology, Harbin, China, and the University of Saskatchewan, Saskatoon, SK, Canada, in 1994 and 2002, respectively. He has international work experience at National Institute of Standards and Technology (NIST) (2016), Northern Ireland Technology Centre (NITC) (2008), National Research Council Canada (2003-2007), City University of Hong Kong (1997), and Nanjing University of Science and Technology (1994-1998). He is currently a professor of mechanical engineering at Purdue University Fort Wayne, Fort Wayne, IN, USA. His recent interests include robotics, mechatronics, Internet of Things (IoT), digital manufacturing, automatic robotic processing, and enterprise information systems.