

Title:

From Bird Flocks to Drone Swarms: Learning Collective Intelligence from Nature

Abstract:

Nature demonstrates how coordinated global behavior can emerge from simple local interactions, as observed in bird flocks, fish schools, and other biological systems. Inspired by these principles, this talk presents a decentralized AI framework for autonomous drone swarms based on Spatio-Temporal Graph Neural Networks (STGNNs). The framework integrates multi-hop graph learning, finite-horizon trajectory prediction, and imitation learning to capture both spatial interactions and temporal dynamics, enabling each drone to make decisions using only local observations while achieving coordinated global behavior without centralized control. By combining predictive planning with reactive obstacle avoidance, the framework supports robust flocking, rigid formation control, leader following, formation reconfiguration, and collision-free navigation in complex and dynamic environments. Extensive simulations and real-world drone experiments demonstrate scalable, adaptive, and resilient swarm coordination under communication constraints and environmental uncertainties, highlighting the potential of nature-inspired AI for search and rescue, environmental monitoring, infrastructure inspection, smart transportation, and next-generation autonomous multi-agent systems.

Bio:

Chang-Tien Lu is a Professor of Computer Science at Virginia Tech, where he serves as Curriculum Lead for the Institute for Advanced Computing and Associate Director of the Sanghani Center for Artificial Intelligence and Data Analytics. He received his Ph.D. in Computer Science from the University of Minnesota in 2001. An ACM Distinguished Scientist and IEEE Fellow, Dr. Lu's research interests include artificial intelligence, data mining, spatial informatics, urban computing, autonomous systems, and intelligent transportation systems. He has published more than 250 papers in leading journals and conferences, with research supported by the NSF, NIH, DoD, and DoE. Dr. Lu serves on the editorial boards of ACM Transactions on Spatial Algorithms and Systems, Data & Knowledge Engineering, IEEE Transactions on Big Data, and GeoInformatica. He has held numerous leadership roles in the research community, including General Co-Chair of ACM SIGSPATIAL (2009, 2020, 2021), SSTD 2017, IEEE Big Data 2024, and IEEE ICDM 2025. He also served as Secretary of ACM SIGSPATIAL from 2008 to 2011 and Vice Chair from 2011 to 2014, contributing significantly to the advancement of spatial data science and the broader computing research community.