Master's Thesis Defense Announcement
Mechanical and Aerospace Engineering Department
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Topology-Driven Performance Analyses in Consensus Algorithms for Multi-Agent Systems

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Abstract

This thesis presents a simulation-based analysis of consensus algorithms in multi-agent systems, focusing on how network topology influences convergence performance. Both first-order and second-order linear consensus dynamics were examined across a variety of network configurations, including undirected and directed versions of cycle graphs, star graphs, minimum spanning trees, and fully connected graphs. In addition to standard consensus problems, leader-follower network structures were introduced to explore the impact of leader placement on convergence behavior.

Graph-theoretic properties such as connectivity, degree distribution, and Laplacian eigenvalues were evaluated to interpret consensus speed and stability. Simulations confirmed that undirected networks consistently achieve average consensus, while directed networks require the existence of a spanning tree to reach agreement. First-order systems demonstrated faster convergence than their second-order counterparts, which exhibited expected oscillatory behavior. Results also showed that leader placement is critical in directed graphs, whereas symmetric and undirected networks were more robust to changes in leader location.

This work contributes practical insights into the design of efficient multi-agent systems by revealing the relationship between network structure and consensus dynamics. The findings may inform future control strategies, topology design, and leader selection in applications ranging from distributed robotics to sensor networks.