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THESIS

To obtain the diploma of **Engineering Degree**

Field: **Computer Science**
Specialty: **Artificial Intelligence and Data Science (IASD)**

Optimizing Swarm Drone Coordinated Motion Using Graph Neural Networks

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Abstract

Swarm robotics seeks to achieve coordinated collective behavior among multiple autonomous agents through local interactions and distributed decision-making. This thesis investigates the use of **Graph Neural Networks (GNNs)** for modeling and learning coordination mechanisms in drone swarms. Specifically, it explores how graph-based representations can effectively encode spatial relationships and how temporal modeling enhances the prediction of collective motion.

A simulation framework was developed to generate multi-agent trajectories using interaction-based controllers grounded in physical models such as Gaussian and Lennard–Jones potentials. These expert demonstrations were used to train a **Graph Attention Network with Gated Recurrent Units (GAT–GRU)**, enabling the prediction of control forces from observed drone positions.

Experimental evaluation across multiple swarm configurations demonstrated that the trained model reproduces expert-like behavior with minimal performance loss while maintaining stable formation and goal convergence. The findings highlight the potential of graph-based learning approaches to generalize swarm coordination policies across varying team sizes and environmental conditions.

Keywords: Swarm Robotics, Drone Coordination, Graph Neural Networks, Multi-Agent Systems, Spatiotemporal Learning, Decentralized Control.