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Ph.D. DISSERTATION DEFENSE

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Title:	Inference with Factor Graphs for Single and Multi-Robot Perception and Navigation
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ABSTRACT

Mobile robot perception and navigation have gained increasing attention in recent years, driven in part by the growing focus on autonomous driving. However, there are still challenges in both single and multi-robot scenarios, stemming from challenging environmental conditions, limited communication bandwidth, and the complexities of fostering efficient collaboration among neighboring robots. One valuable tool for addressing these challenges is the factor graph, a graph structure widely employed for modeling probabilistic inference problems. In this thesis, we transform common perception and navigation problems into factor graph optimization problems, offering innovative solutions that advance beyond the current state-of-the-art barriers in both single and multi-robot scenarios.

To address specific challenges in underwater environments, we introduce a Gaussian process motion planning algorithm tailored for unmanned underwater vehicles (UUVs) engaged in seafloor terrain following missions, which incorporates the influence of oceanic currents. Additionally, we present three distributed multi-robot simultaneous localization and mapping (SLAM) algorithms for range-sensing mobile robots. The first algorithm introduces a compact LiDAR descriptor, along with a two-stage global and local factor graph optimization approach. The second introduces a hierarchical scene graph for map data storage and utilizes scene graph matching for efficient inter-robot data association. The third is a distributed SLAM framework for underwater robot teams equipped with imaging sonar. This framework uses object graph matching for inter-robot data association and proposes a robust outlier detection technique to enhance collaborative mapping in complex underwater environments. Furthermore, we propose an asynchronous autonomous exploration algorithm designed for multi-robot teams. This algorithm utilizes a virtual map and employs expectation-maximization (EM) to estimate the effectiveness of a robot's potential future actions.