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Ph.D. DISSERTATION DEFENSE

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Title:	Situational Awareness For Low Cost Underwater Autonomy
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ABSTRACT

Underwater robots have matured over the past few decades to support the increasing need for maritime infrastructure assessment and other offshore activity. However, deploying underwater robots often involves a high startup cost associated with vehicle acquisition. It is often the case that companies not engaged in oil and gas exploration are priced out of this technology. This is primarily due to the highly accurate, often tactical-grade inertial navigation systems (INS) required to make state estimation reliable enough for long-duration autonomous operations. Moreover, sonars are the perceptual sensor of choice due to the frequent need to operate in high-turbidity water. Sonars, however, do not provide the dense 3D information required for offshore asset evaluation or autonomous navigation. In this work, we consider an underwater robot's situational awareness, i.e., the required knowledge of a robot's environment to complete its mission safely.

We propose several sub-systems that assist in bridging the situational awareness gap in low-cost underwater autonomous systems equipped with imaging sonars. Firstly, we employ a stereo pair of orthogonal sonars to recover lost 3D data. Second, we generalize the method of orthogonal sensor fusion to work in large-scale environments through object-level inference. Next, we use public domain prior information to enhance the state estimation capabilities of a low-cost underwater robot. We then use submapping to recover dense, accurate 3D maps without the need for object-level inference. Lastly, we extend our thinking to the multi-robot case. We showcase a system that performs multi-robot simultaneous localization and mapping (SLAM) using real-world underwater imaging sonar data, the first of its kind. In future work, this will enable multi-robot systems that are capable of safely operating in marine environments and cooperatively completing their tasks efficiently.