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Technical Review Paper

ECE 4011-A05

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Underwater Mapping and Navigation

Introduction

Underwater and nautical robotics is a new field with rapid research efforts being done to explore and study the world's oceans and lakes. Mapping and navigating above ground has been studied and researched heavily, with professors all over the world contributing to the algorithms behind SLAM [1]. Many rovers use sensors to measure the roughness of terrain, detect obstacles, highlight features in the landscape, and provide a complete map with a relative location of the robot. Many of the same sensors cannot be used underwater due to the physics of underwater motion. This technical review briefly summarizes existing technology for mapping, efforts by others to advance the technology, and proposes an approach to implementing underwater mapping.

Existing technologies used for mapping

One of the most widely used sensors, in commercial application and research, is Microsoft's Kinect sensor. The original Kinect sensor makes use of an IR Emitter, IR depth sensor, color sensor, camera, and accelerometer to obtain information about the world and publish it as sensory input. One of the limitations of the original Kinect was its inability to work in outdoor environments, and its inability to measure beyond depths of 8 meters [3, 6]. The Kinect 2.0 sensor allows for enhanced 3D visualization and depth measurements independent of lighting [4]. This new and improved Kinect 2.0 sensor may potentially be usable in outdoor environments, but the IR-based depth sensing will still run into issues with excess radiation [3, 4].

3D Sonar is another existing technology that is used for mapping both above sea level and underwater. The technology behind using sonar for mapping is well documented and has been around for nearly 30 years [5]. One of the ideas to perform SLAM underwater is to take 3D sonar data and utilize it for terrain sensing and obstacle avoidance. However, the issue with 3D sonar systems is the size of the sensor and associated hardware. Bulky hardware would potentially interfere with underwater and sea-level research and exploration.

Advancing the technology

Project Tango is a research effort by Google to provide a complete and immersive 3D visualization, using hardware that can fit in a tablet. Project Tango utilizes custom sensors and software to perform motion tracking, area learning, and depth perception [7]. One of the key benefits of project tango the small hardware. Project Tango's sensors still only work indoors and without interference; and underwater application at this moment would be infeasible.

Other researches are using 3D sonar and other sensors for navigation and obtaining information on the operating environment [8]. Commercial products exist for sensors designed to be used in localization and mapping applications underwater, however these sensors, again, are bulky and do not fit in the size profile of a tablet or similar-sized object. Other researchers have used computer vision to perform SLAM underwater. However, these results are only a smaller improvement over dead-reckoning [9].

Approaching underwater SLAM

Implementing a sensor package with enough fidelity and resolution to provide usable information for SLAM while underwater is an inherently complex issue. Many sensors above ground use IR-based depth perception and vision to localize and map the area. Underwater, these efforts turn to large sensors or methods that only slightly improve dead-reckoning [9]. However, the goal of this team and perhaps some others in the RoboSail group is to develop a sensor package capable of fitting in the profile of a tablet, which can gather all of the necessary data to perform SLAM. One approach we will be considering is to include vision, sonar, and IMU sensors in combination. The sensors will provide feedback for one another and used to output data similar to Google's Project Tango. With this information, the underwater robot will be able to map the depths of the ocean for exploration and research.

References

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