Ice Detection for Under Ice AUV Navigation

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ABSTRACT
This paper focuses on addressing the problem of enabling AUVs with the ability to determine the presence of ice above the AUV. The difference between depth and altimeter measurements is used as a key indicator about the presence of ice at the surface. Due to high levels of noise in this sensing, the difference is passed through a Bayes Filter, which estimates the probability of the AUV being under ice in real time. This filter uses sensor variance characteristics modeled in response to a variety of ice types and open water. Experiments were conducted both with simulated ice sheets in Avila Beach, CA as well as a research station in Ny-Ålesund, Svalbard.

KEY WORDS: Autonomous Underwater Vehicles; Ice Navigation; Bayes Filters.

INTRODUCTION

Autonomous Underwater Vehicles (AUVs) are becoming a necessary tool in sampling a large variety of ocean parameters. The use of AUVs enables underwater measurements with high spatial resolution. When coupled with ocean parameters (e.g. temperature, salinity, currents, etc.), AUVs can aid in producing models of local ecosystems including those within the Arctic environment.

This research focuses on enabling Autonomous Underwater Vehicles (AUVs) with the ability to sample near sheets of pack ice (see Fig. 1) that can move, grow, and change shape. Motivating this application is the significant evidence that the Earth is warming at a rapid rate (IPCC, 2007). This warming is pronounced across the Arctic Ocean Basin in the northern hemisphere and along the Antarctic Peninsula in the southern hemisphere. As summer temperatures in these regions begin to fluctuate above the freezing point of glacial ice and sea ice, we are witnessing the rapid retreat of glaciers, disintegration of ice sheets, and decreases in the extent and seasonal duration of sea ice (Liu, 2004; Yuan, 2004; Serreze, 2007). With warming predicted to continue, it is imperative that we learn about the potential impacts of decreasing ice in these regions.

Of significance is the difficulty in sampling during the winter months when no light is present and ice is prevalent. This severely limits the use of more common ocean-sensing techniques, such as divers, anchored moorings, ship transects, airplanes, and satellite imaging. Hence, little data is available on the underwater polar ecosystem during the winter months. This further motivates the need for alternate methods of sampling, e.g. AUVs.

Figure 1: Pack ice in the Ny-Ålesund, Svalbard. In (a), slush and chunks float in an area where the Iver2 Autonomous Underwater Vehicle was deployed for several missions. Shown in (b) is pack ice that has moved into and solidified the harbor. A VideoRay Pro III ROV lights up the ice sheets from underneath.

In response to these needs, the authors propose the development of an ice presence estimator to enable safe AUV navigation under various types of pack ice. In line with this goal, researchers embarked on a two-week scientific expedition to the Ny-Ålesund research station in Svalbard, Norway with the ultimate goal of assessing the underwater Arctic ecosystem during the Polar Night. This expedition involved the use of divers, ROVs, AUVs, and a bottom crawling robot. As part of this expedition, researchers conducted a variety of under ice AUV deployments to help develop and validate the AUV’s ability to determine the presence of surface ice above the AUV.