Single Beacon Autonomous Underwater Vehicle Navigation

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Accurate navigation of autonomous underwater vehicles is far more complicated than navigation of surface or aerial vehicles because there is no underwater equivalent of the Global Positioning System (GPS). Due to the rapid absorption of electromagnetic radiation in the ocean, acoustic rather than radio transmissions are used for underwater applications. Acoustic long baseline (LBL) navigation systems are often used for precision underwater vehicle navigation.

The basic principle of LBL systems is to triangulate the position of the vehicle by calculating the range between the vehicle and multiple transponders with known locations. A typical LBL system incorporates between four and twelve acoustic transponders. The vehicle interrogates the beacons acoustically and calculates the range to each beacon based on the roundtrip travel time of the interrogation and report. Along with data from its depth sensor, the vehicle can use the range data from two or more of the acoustic transponders at any point in time to determine its position.

However, for accurate underwater navigation, the location of each deployed transponder in the array must be precisely surveyed prior to conducting autonomous vehicle operations. Surveying the location of the transponders is a costly and time-consuming process, especially in cases where underwater vehicles are used in survey operations covering a number of different locations in succession. In these long survey operations, the transponders need to be deployed, surveyed, and retrieved in each location, adding significant time and, consequently, significant cost to any operation. Therefore, being able to accurately navigate underwater using a single location transponder would provide dramatic time and cost savings for underwater vehicle operations.

This thesis presents a simulation of autonomous underwater vehicle navigation using a single transponder. Similarly to LBL systems, ranges are calculated between the vehicle and the transponder, but the vehicle position is determined by advancing multiple ranges from a single transponder through time and space. Vehicle position is then triangulated using successive ranges between the vehicle and the transponder in a manner analogous to a 'running fix' in surface ship navigation. Navigation data from bottom survey operations of an underwater vehicle called the Autonomous Benthic Explorer (ABE) were used in the simulation. The results of this simulation are presented along with a discussion of the benefits, limitations, and implications of its extension to real-time operations. A cost savings analysis was also conducted based both on the idea that a single surveyed beacon could be deployed for underwater navigation and on the further extension of this problem that the 'single beacon' used for navigation could be located on the ship itself.