Magnetic Navigation in Underwater Networks

Authors : Kumar Divyendra

Abstract : Underwater Sensor Networks (UWSNs) have wide applications in areas such as water quality monitoring, marine wildlife management etc. A typical UWSN system consists of a set of sensors deployed randomly underwater which communicate with each other using acoustic links. RF communication doesn't work underwater, and GPS too isn't available underwater. Additionally Automated Underwater Vehicles (AUVs) are deployed to collect data from some special nodes called Cluster Heads (CHs). These CHs aggregate data from their neighboring nodes and forward them to the AUVs using optical links when an AUV is in range. This helps reduce the number of hops covered by data packets and helps conserve energy. We consider the three-dimensional model of the UWSN. Nodes are initially deployed randomly underwater. They attach themselves to the surface using a rod and can only move upwards or downwards using a pump and bladder mechanism. We use graph theory concepts to maximize the coverage volume while every node maintaining connectivity with at least one surface node. We treat the surface nodes as landmarks and each node finds out its hop distance from every surface node. We treat these hop-distances as coordinates and use them for AUV navigation. An AUV intending to move closer to a node with given coordinates moves hop by hop through nodes that are closest to it in terms of these coordinates. In absence of GPS, multiple different approaches like Inertial Navigation System (INS), Doppler Velocity Log (DVL), computer vision-based navigation, etc., have been proposed. These systems have their own drawbacks. INS accumulates error with time, vision techniques require prior information about the environment. We propose a method that makes use of the earth's magnetic field values for navigation and combines it with other methods that simultaneously increase the coverage volume under the UWSN. The AUVs are fitted with magnetometers that measure the magnetic intensity (I), horizontal inclination (H), and Declination (D). The International Geomagnetic Reference Field (IGRF) is a mathematical model of the earth's magnetic field, which provides the field values for the geographical coordinateson earth. Researchers have developed an inverse deep learning model that takes the magnetic field values and predicts the location coordinates. We make use of this model within our work. We combine this with with the hop-by-hop movement described earlier so that the AUVs move in such a sequence that the deep learning predictor gets trained as quickly and precisely as possible We run simulations in MATLAB to prove the effectiveness of our model with respect to other methods described in the literature.

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