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Research of Single Mobile Acoustic Beacon Motion Algorithm for Accurate AUV Navigation

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ABSTRACT

This paper addresses the autonomous underwater vehicle (AUV) positioning by means of a single mobile acoustic beacon. It is assumed that beacon is towing by autonomous surface vehicle (ASV) in the operation area and its coordinates are determining by means of GPS. As the range measurement allows to localize AUV only in radial direction, the algorithm of beacon motion relative AUV is suggested. According with this algorithm, the mobile beacon moves in a circle around the moving AUV. Presented simulation results verify that using such technique allows to hold position error in desired bounds and to achieve adequate navigation accuracy of AUV.

KEY WORDS: autonomous underwater vehicle; single-beacon navigation; motion algorithm.

INTRODUCTION

Navigation support is a critical importance for successful execution of the missions by autonomous underwater vehicle (AUV). That is the reason why one of the main problems facing the researchers is development of reliable and precise navigation systems for AUV.

Commonly AUV uses integrated positioning system (IPS) which based on reckoning navigation system or/and inertial navigation system (INS). IPS fuses data from many different sensors namely depth meter, Doppler velocity log (DVL), attitude and angular velocity sensors (heading, pitch and roll), global positioning system (GPS) receiver etc.

The main disadvantage of INS and reckoning navigation system is performance degrading as time goes by. Hence, to guarantee long-term stable operation of AUV it is necessary to periodically correct its coordinates by means of any drift-free positioning system. Since seawater is opaque to the radio waves, GPS can be used by AUV only for surface position fix. Therefore, various acoustic positioning systems (APS) are commonly used in IPS for position error correction.

The modern underwater robotics is confronted with tasks, demanding not only accuracy but also high mobility and cost effectiveness from underwater robotic system. Among these are search and inspection of stretched objects (e.g. pipe lines, cables etc.), ecological monitoring and many other underwater investigations.

Classical approaches to the underwater navigation in general case cannot provide great precision, high mobility and cost effectiveness together. Thus, for example, short baseline (SBL) and ultra-short baseline (USBL) APS distinguish high mobility, but navigation accuracy greatly decreases at a great distance (1 km and more). On the contrary, long baseline (LBL) APS is able to provide high accuracy of AUV positioning, but it needs deployment of seafloor transponders network, its calibration and afterwards beacons gathering. In case of large scale operations these manipulations are very difficult and time consuming. As a result, LBL systems distinguish small cost effectiveness and very low mobility.

To overcome all these problems, new types of acoustic positioning systems are developed. One of the ways consists in using the network of mobile surface beacons instead of fixed transponders (*Matos et al., 2005; Curcio et al., 2005; Twiggs et al., 2006; Santos et al., 2008*). Each beacon in that case is an intelligent GPS buoy (IGB), which calculates own position by means of GPS.

Other more economical approach of mobile navigation support development supposes application of APS with synthetic long base line (SLBL) that uses ship towed single antenna as navigation beacon. The operation of this positioning system is based on modem communicational link. It allows synchronous exchanging by parcel with navigation data between AUV and supporting ship and simultaneously measuring of the acoustical signal propagation time between them (*Scherbatyuk, 2007; Eustice et al., 2007; Eustice et al., 2011; Vaulin et al., 2007; Hageh et al., 2009;* Webster *al., 2009; Ferreira et al., 2010; Vaulin et al., 2011*).

AUV exchanges by navigation data with supporting ship during operation. Information parcel from supporting ship includes the current coordinates of towed beacon calculated using data from ship GPS. The AUV coordinates are calculated on board of the vehicle using towed beacon position information and measured distances data received during several cycles of SLBL APS operation. Calculated AUV position together with measured AUV speed, heading and depth are transmitted to the supporting ship in the answer informational parcel. Since range measurement allows to localize AUV only in radial direction, it is necessary to develop and to apply special motion algorithms of mobile beacon to guarantee beacon favourable attitude relative AUV (*Chitre, 2010; Teck et al., 2011*).