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Precise UUV Positioning Based on Images Processing for Underwater Construction Inspection

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ABSTRACT

The algorithms of unmanned underwater vehicle motion detection based on image processing are considered in the paper. The approach is based on detection of the same objects on the consecutive frames and their joint displacement calculation. The motion detection system structure and algorithms of their operation onboard of UUV TSL are considered and results of marine trials are supplemented.

KEY WORDS: Unmanned underwater vehicle; motion detection; image processing.

INTRODUCTION

High precise motion detection of unmanned underwater vehicle /UUV/ is important task for UUV station-keeping or docking in the presence of various types of disturbances such as underwater currents or sea waves. The station-keeping mode is intended for maintaining of particular position and orientation of UUV without continuous operator supervision. This mode is a critical UUV capability for inspection and repair of underwater construction, bottom data collection and surveillance missions.

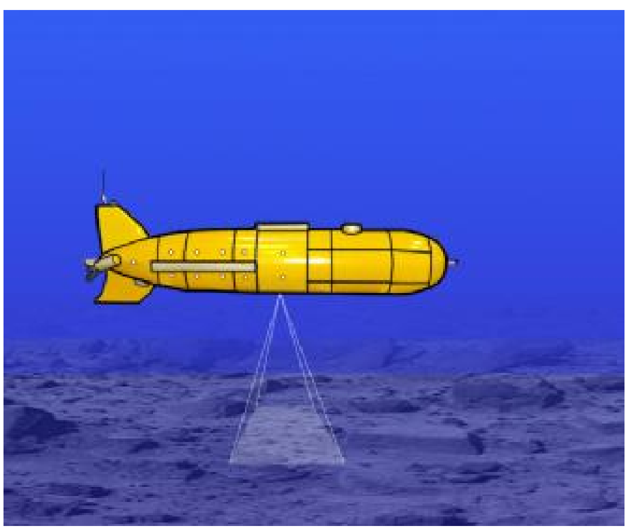

Fig.1. Shooting of the bottom using UUV digital photo system.

Usually the UUV navigation system is based on autonomous onboard reckoning system. It consists of velocity log (absolute or relative), heading meter (flux gate or gyro compass) and depth meter. UUV position is estimated by velocity components calculation and integration. The constant error in velocity measuring $d\boldsymbol{v}$ leads to the error $d\boldsymbol{r} = t*d\boldsymbol{v}$ in position estimation. Doppler velocity log /DVL/ is usually used for UUV speed measuring. Modern DVL has the precision of about 0.2% ± 1 mm/sec. The error of position estimation is about 8 meters per hour of operation when the UUV velocity is 1 m/s.

The constant error in heading dj leads to the error in the vehicle location of about $d\boldsymbol{r} \approx t*\boldsymbol{v}*dj$ **.**The heading error of 2° is usual for magnetic transducer allowing for deviation. It can reach up to 10° and more in the regions of anomaly or near the big mass of magnetic materials. Miscalculation of vehicle position is about 126 meters per hour for the heading error of 2° and the UUV motion speed of 1 m/s. Recent years small in size and economic in power fiber optical gyrocompasses /FOG/ are used on the board of some underwater vehicles. Modern FOG has the precision in heading measurement of about ±0.2°sec(φ). The vehicle location error is about 18 meters per hour for latitude of 43° and motion speed of 1 m/s. However, currently FOG has not been widely used on the mean cost UUV because of its high price.

The precision of autonomous onboard reckoning systems is not sufficient for UUV keeping in the vicinity of the bottom objects during its inspection. As it follows from the above discussion, onboard reckoning and inertial navigation systems possess the high precision on the short time intervals but their accuracy decreases essentially on the long time of the UUV operation. It is expedient to use visual information for elimination of the growing in time UUV position errors. It allows receiving the error in UUV coordinate detection restricted in time.

In the common situation the system for high precise UUV motion detection based on video data processing must operate stably using images including accidental objects without artificial tokens application. The problem of mobile robot motion detection was investigated both for land and for underwater vehicles (Aggarwal, 1988; Negahdaripour, 1999; Negahdaripour, 2003; Gracias, 2003; Hue, 1990; Maki, 2006). There are two main approaches for the problem decision. One is based on the optical flow estimation (Negahdaripour, 1999; Negahdaripour, 2003; Gracias, 2003). The other approach consists of detection of the same objects on the consecutive images