Estimation of Water Current profile in Deepwater using
Autonomous Underwater Vehicle SOTAB-I

Y. Yamaguchi, M. Ukita1, M. Choyekh1, N. Kato1, H. Senga2, M. Yoshië2, T. Tanaka1, E. Kobayasi3, H. Chiba5

(1) Dept. Naval Architecture and Ocean Engineering, Osaka University, Suita, Osaka, Japan
(2) Dept. New Technology Development Field, Port and Airport Research Institute, Yokosuka, Kanagawa, Japan
(3) Frontier Technology and Engineering Division, Port and Airport Research Institute, Tokosuka, Kanagawa, Japan
(4) Dept. Graduate School of Maritime Sciences, Kobe University, Higashinada-ku, Kobe, Japan
(5) Dept. Maritime Technology, National Institute of Technology, Toyama College, Imizu, Toyama, Japan

ABSTRACT

This paper describes an estimation method of water column current profile using an autonomous underwater vehicle SOTAB-I. Water currents can be usually calculated by summing up the relative current velocity measured by ADCP and the own speed of the vehicle from DVL near the seabed, or obtained by differentiating the positioning data from USBL. However, through several experiments, we’ve found that there is low accuracy of USBL positioning data because of noise and so on. Then, this paper proposes a new estimation method of the robot speed in mid-water where DVL cannot be used by use of ADCP, USBL, and integrated INS. The estimated water column current profiles were validated by comparing with mother ship ADCP data.

KEY WORDS: Water current; AUV; USBL; ADCP; DVL; IINS; Kalman filter;

ACRONYMS

ADCP: Acoustic Doppler Current Profiler
AUV: Autonomous Underwater Vehicle
CTD: Conductivity, Temperature, and Depth
DVL: Doppler Velocity Log
IINS: Integrated Inertia Navigation System
LBL: Long Baseline
SBL: Short Baseline
SLAM: Simultaneous Localization And Mapping
USBL: Ultra-Short Baseline

INTRODUCTION

Spills and blowouts of oil and gas from the seabed cause tremendous damage to the environment as well as to the marine and human life the creation of local hypoxia zones caused by oxygen depletion (Shaffer et al., 2009), and the rest is released to the atmosphere contributing to global warming as methane is highly potential greenhouse gas (Solomon et al., 2009). To prevent oil and gas spills from spreading further and causing further damage in time and space, early detection and monitoring systems should be deployed around the area where an oil and gas spill first occurred. This should be done in order to provide a rapid inspection of the area by detecting chemical substances and collecting oceanography data needed for enhancing the accuracy of convection-diffusion and drift simulating oil and gas (Takagi et al., 2012 and Takagi et al., 2015, Suzuki et al., 2015). Accurate simulation results enable us to precisely predict where the spilled oil will wash ashore and therefore to make a quick response to the disaster by adequately deploying oil recovery machines that prevent oil from spreading further. A spilled oil tracking autonomous vehicle called SOTAB-I was developed to perform in-situ measurements of chemical substances by an underwater mass spectrometry and to detect spilled oil autonomously as part of SOTAB project (M Choyekh et al., 2013). In addition, it can transmit oceanography data in real time. Water column current profile around that area is one of the most important data. SOTAB-I is equipped with a Conductivity Temperature Depth (CTD) sensor, Ultra-Short Baseline (USBL), and Acoustic Doppler Current Profiler (ADCP) with Doppler Velocity Log (DVL).

Zhang and Willcox (1997) proposed a method to measure current velocities by ADCP mounted on a cruising type AUV using CTD sensor and a Long Baseline (LBL) acoustic navigation system. An et al. (2001) measured current velocities in shallow water by ADCP mounted on a cruising type small cruising type AUV using CTD sensor and a ultra-short Baseline (USBL) acoustic navigation system. Stanway (2010) measured current profile by ADCP/DVL mounted on a cruising type AUV using CTD sensor with bottom-lock DVL measurements. Medagoda et al. (2011) proposed an alternative approach to navigation for AUV in the mid-water column where GPS and DVL are not available by using ADCP and a seafloor view-based Simultaneous Localization And Mapping (SLAM). However, few references dealing with measurements of current profile by ADCP and Short Baseline (SBL) or USBL in the mid-water column are available.

Absolute current velocity against earth in the mid-water column for the case of SOTAB-I equipped with ADCP/DVL, CTD, and USBL should be calculated by summing up the relative current velocity measured by ADCP on the vehicle and the own speed of the vehicle which is obtained by differentiating the positioning data by USBL. The robot speed can also be measured directly by DVL within the device’s range when it approaches seabed. However acoustic positioning is suffered from multpath returns and circumferential noises. Thus accuracy of USBL data for getting its own speed becomes worse as depth increases and as operation time becomes longer. In fact, this phenomenon occurred in our experimental results. To obtain accurate SOTAB-I’s speed, we propose a new estimation method using ADCP, USBL and the Integrated Inertia Navigation System (IINS) which is the method extended INS (O Hegrenaes, E Berglund, 2009). Water column current profile at water depth of 50 m off Komatsushima by the new method...