ABSTRACT

In this paper, authors proposed a practical motion estimation strategy to obtain the single static object position and the vehicle’s motion parameters simultaneously by utilizing camera and IMU (Inertial Measurement Unit), and tried several classic nonlinear parameters estimation methods on this problem based on the Matlab simulation. A lot of preliminary calibration experiments have been done to fuse the data from IMU and camera, which included: camera calibration, IMU error modeling, and relative attitude calibration between IMU and camera. The obtaining of sensor’s model made the simulation work be possible, and the PF algorithm can track the vehicle’s motion parameters and obtain the target position very well. The accuracy is centimeter level.

KEY WORDS: I-AUV; camera and IMU; nonlinear parameter estimation; particle filter; relative calibration; data fusion.

INTRODUCTION

IAUV( Intervention-Autonomous Underwater Vehicle) is a kind of special underwater vehicle which can perform the tasks autonomously, such as installing instruments on the sea floor, searching, locating, approaching and docking on the underwater device; retrieving geological/biological sampling etc (Wang,1996). Currently such tasks mostly are performed by ROV (Remotely Operated Vehicles), and only few intervention missions have been performed in the real sea environment by IAUV(Maran,Choi and Yuh,2009). In order to perform the underwater intervention missions, imaging sonar, ultralow-light camera, Inertial Navigation System, Long Base Line System, doppler sonar need to be fixed on the vehicle(Evans and Redmond, 2003), and the general intervention mission can be performed following the six stages process. 1) Launching from R/V ship. 2) Searching and navigating to the worksite(∞ m- 25m). In this stage, sonars (image sonar, multibeam sonar or sidescan sonar) are used to search the suspected targets, navigation sensors (LBL(Long Base Line), doppler sonar, INS(Inertial Navigation System), image sonar and high precision camera(Stefan and Ian, 2004)) are used to track the vehicle’s position and attitude. 3) Approaching the target(25m-2m). In this stage image sonar or dual-frequency identification sonar can be used to identify the true target. 4) Localizing the position of target (<2m). The sensor usually used in this stage is cameras. 5) Accurately docking, retrieving the sample or installing instrument by the manipulator mounted on the vehicle. 6) The task is finished, and the IAUV can continue moving to another suspected target or return to the recovery point. The research in this paper is focused in the fourth stage. The employed strategy is obtaining the position of target and optimal estimation of the motion parameters of I-AUV (position, attitude, velocity, angle rate and acceleration) simultaneously. The sensors used in the strategy are single camera and low-cost IMU. A new IAUV testbed project is underway in Shenyang Institute of Automation, C.A.S., in which the research is focused on the stage 4 and 5(Zhang, 2007).

Fig. 1 IAUV testbed

The remainder of this paper is organized as follows. In problem statement section, the target perception strategy, principle and research challenges are proposed. In sensor modeling section, the calibration of camera, IMU error modeling and relative attitude calibration between camera and IMU are described. It’s the foundation to continue the simulation of estimation problem. In estimation algorithm section, the classic EKF, UKF and PF are introduced. In the last section, the simulation and experiments are stated about sensor’s modeling and estimation results.

PROBLEM STATEMENT

It’s clearly that it’s impossible for human to feel the distance between them and one target in front of them with one eye. It’s the same with the robot vision. At least two cameras are needed to obtain the distance information by observing the same target simultaneously. Another