M2 ON THE OPTIMIZATION OF STATE OBSERVERS FOR APPLICATION IN NAVIGATION OF LOW COST AUTONOMOUS VEHICLES

Javier Busquets[33], Jose Vicente Busquets[34], Francisco Pérez[35], Gonzalo Tampier[36], Christian Lazo[37], Jesus Busquets-Carbonell[38], Federico Zilic[39], Dionisio Tudela[40], Javier Gilabert[41]

Abstract
Marine Autonomous Vehicles, either Surface (ASV) or Underwater (AUV) are becoming the kingpin for ocean research and sea exploration. Long term and high persistence are highly desirable characteristics for adding to these autonomous platforms. The possibility of performing adequate tasks by using low cost underwater vehicles could multiply the number of agents in the area and therefore, providing high persistence by using multiagent relay strategies.
This paper progresses in the validation of low cost electronic components for applying in the ALBA-13 AUV. Position and velocity estimation are essential for underwater vehicles because GPS signals are not available during immersion. Some works have presented theory and applications of a state observer that integrates the 6 degree-of-freedom (DOF) signals from an Inertial Measurement Unit (IMU) for estimation of position, velocity and attitude. Filtering of noisy sensor signal in combination with non-measured signal estimation is commonly addressed by the use of Linear Kalman Filters KF, Extended Kalman Filter EKF and nonlinear passive observers.
The contribution of this paper is the implementation of the previously mentioned three observers and features comparison, by using low cost MEMs sensors in combination with different microcontrollers for the evaluation in low cost AUV and ASV requirements. Different tests have been simulated using MATLAB and SIMULINK and implemented on a high speed scaled boat for field validation.

Keywords—AUV, ASV, IMU navigation, state observer, Low cost marine autonomous Vehicle.

I. INTRODUCTION

Today commercial AUVs are complex and costly machines. Both aspects condition the consideration of a multivehicle schema missions when vehicle lost possibility is a concern. A group of AUVs working in a sequence of navigation-charging operation II in combination with advantages of multiple vehicle simultaneous deployment in an area of interest [4] will provide high frequency and density spatio-temporal measurement capabilities.
The present work is the continuation of previous research and it shows advances in a previous prototype of a low cost AUV Error: No se encuentra la fuente de referencia. This paper progresses in the definition of some important aspects for applying on autonomous vehicles for achieving its feasibility as a low cost vehicles. The validation of commercial low cost electronic components is assessed. First AUV prototypes were built in the UACh in 2012 and are being tested for its application in a cooperative schema in coordination together with an ASV II. New ASV AUV prototypes are being built in Cartagena for the evaluation of multiagent collaborative navigation schemas.

A. Hardware description

All the electronic components are governed by microcontroller Arduino Mega. This model is a robust Arduino board based on the 8 bits microcontroller, Atmel ATmega 2560 with 256 KB Flash memory, 8Kb SRAM, and delivers 16MIPS at 16Mhz.
Different sensors are used for dynamic and attitude measurements: Venus GPS for surface positioning and a MEMS micro module which integrates accelerometer, gyroscope and magnetic compass in an observer based model [2].

B. State Observer

The State Observer integrates the 9-DOF signals (gyros, accelerometers and magnetometers) provided by the IMU 9DOF from the initial position given by the GPS, to obtain position and velocity. These estimations however will drift during underwater navigation due to sensor biases and noise[5]. The challenge of this study is to integrate the inertial measurements in real-time in a 8 and 32 bits microcontroller boards, and by running different observers for providing estimation in non GMDSS environment in a scaled high speed boat for testing and validating different models, devices and observers for state estimation.

C. Algorithms

The test algorithm starts in the route first waypoint position in base of the received GPS data. The autopilot software computes the desired heading to the next waypoint and then the control regulator and observer acts maintaining the desired course calculated in surface. GPS signals are turned off and velocity and position should be estimated by observers. When a certain time is elapsed or a preestablished distance is covered, the vehicle checks its position from GPS data. Biases produced by unknown disturbances and inaccuracies are then evaluated for applying in gains and observers in the next transect. Input control signals both in heading and speed are considered in different schemas.

D. Testbed

PID controllers are useful and reliable systems for applying in navigation control [3]. Using PID controllers in combination with the different sensors are installed in test bed model boat provides a good platform as a test bed for electronic and for the evaluation of the dynamic saturation. These saturation levels will provide a reference of parameter values for its application in an adaptive hybrid PID control system for applying on the real AUV and ASV vehicles.

II. CONCLUSIONS

In this work has been proven the feasibility of the use of low cost electronic components for the navigation of ASV. It comprises IMU, GPS and microprocessor board.
This paper demonstrates that a low cost processing unit without floating point capabilities is able to filter noisy signals from the IMU by means on the use of a non lineal passive observer, rather than the more computing demand Extended Kalman Filter. This paper gives an insight on the capabilities of different observers for being applied in combination of low cost components.

REFERENCES
[1] Busquets Javier et al. "Low-cost AUV based on Arduino open source microcontroller board for oceanographic research applications in a collaborative long term deployment missions and suitable for combining with an USV as autonomous automatic recharging platform Autonomous Underwater Vehicles (AUV)", 2012 IEEE/OES Sauthampton, UK 24-27 Sept 2012 . ISSN 1522-3167.
[2] H. F. Grip, T. I. Fossen, T. A. Johansen and A. Saberi (2012). Attitude estimation using biased gyro and vector measurements with time-varying reference vectors. IEEE Transactions Automatic Control.
[3] J. Villagra, V. Milanés, J. Pérez, T. de Pedro, "Control basado en PID intigentes: aplicación al control de crucero de un vehículo a bajas velocidades" ISSN 1697-7912, UPM-CSIC 2010.
[4] Gonzalez, I et al "Accomplishment of the Underwater Robotic Experiment in the Mar Menor Coastal Lagoon", NGCUV 2012, IFAC Workshop on Navigation Guidane and Control of Underwater Vehicles (2012), Porto, Portugal
[5] FOSSEN, T.I. 2011. "Handbook of Marine Craft Hydrodynamics and Motion Control". ISBN:9781119994138.

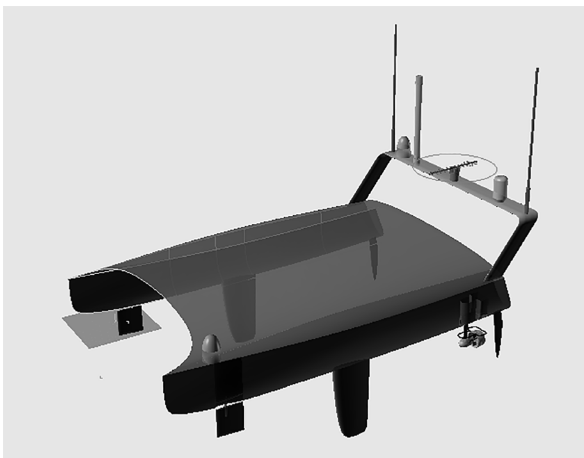

Fig. 1. ASV. Autonomous Surface Vehicle