ID14- BARES WAVE SENSOR

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Abstract – The aim of this article is to show how the Bares sensor works. This sensor has a microcontroller, an accelerometer, a gyroscope, a magnetometer and a communication board. It is designed to measure the displacements of the marine free surface for finally obtain the ocean parameters that describe the state of the sea. Currently these sensors are very expensive and it is necessary to reduce the costs. We made the Bares sensor with modern low costs components but with good features.

Keywords – Wave sensor, low cost wave sensor, monitoring of the ocean, wave height, wave period.

SYSTEM DESCRIPTION

General description of operation

The Bares sensor has an IMU (Inertial Measurement Unit) board with nine degrees of freedom. The IMU provides the accelerations and the Euler angles (also known as navigation angles, yaw, pitch and roll). As a first step, we transform the accelerations from a moving coordinate system to a fixed coordinate system [4] and we record the accelerations (twenty minutes time series). In the second step, we perform a double digital integration of accelerations [1][2] to obtain velocities and displacements. In the last step we obtain the time domain parameters and the spectral domain parameters of the free marine surface [3][5].

Hardware and software overview

We use open hardware compatible with Arduino. Our IMU board has a digital MEMS accelerometer, a digital MEMS gyroscope, a digital magnetometer and an Atmega328 microcontroller. This board is connected to an Arduino Mega ADK board that records the accelerations and the angles series and sends through a communication shield.

The software of the Bares sensor has two different parts. The first part works in the Atmega328 microcontroller. This part corrects the sensors values, merges data from the sensors to obtain Euler angles [6] and transforms the accelerations from the moving coordinate system to the fixed coordinate system [4]. The second part of the software performs digital integration [1][2] and calculate the free marine surface parameters [3][5] works in ours servers. Initially the software of the second part was developed and tested in Matlab, then was migrated to C/C++.

Coordinate system transformations

Many applications need to describe the movements of an object in space. In this kind of applications is necessary to use fixed coordinate systems with a fixed coordinate origin. Frequently, the sensors of this kind of applications measure the accelerations in a moving coordinate system (because the measurement axes are moving) and is necessary to transform the accelerations. To perform this transformation we multiply the accelerations with a matrix [4] composed with sines and cosines of the Euler angles.

Digital integration

This is the most critical part of the software. As we said, to obtain the velocities and the displacements we need to perform a double digital integration. Theoretically it seems simple but actually appear many problems[1]: unknown initial conditions of the differential equations, low frequency noise and drift of the MEMS accelerometer, sampling errors, digital integration errors, etc. These errors affect the lower frequencies and the solution is to filter these frequencies. We perform the following steps [2]: we filter the accelerations, we integrate the accelerations to obtain the velocities, we filter the velocities, we integrate the velocities to obtain the positions and finally we filter the positions. Is necessary to indicate that the choice of the cut-off frequency of the filter is not trivial.

Calculation of the parameters of free marine surface

Once the displacements of free marine surface are obtained we can calculate the parameters that describe the state of sea. On the one hand we calculate the time domain parameters simply applying the statistical theory of this field [5]. In the other hand we calculate the spectral domain parameters which are not trivial [5][3]. The most important issue to do this with success is to perform a correct power spectral density (PSD) estimation and cross power spectral density estimation.

CONCLUSIONS

In our research we install the Bares sensor and the Triaxys wave sensor in the same buoy. The comparative results are very good and show us that we go in the right direction. We conclude that today is possible to access to this technologies with a lower cost and with very accurate results. In the next figure we show the significant wave height obtained with both sensors, the light gray signal corresponds to our sensor and the dark gray signal corresponds to Triaxys sensor.

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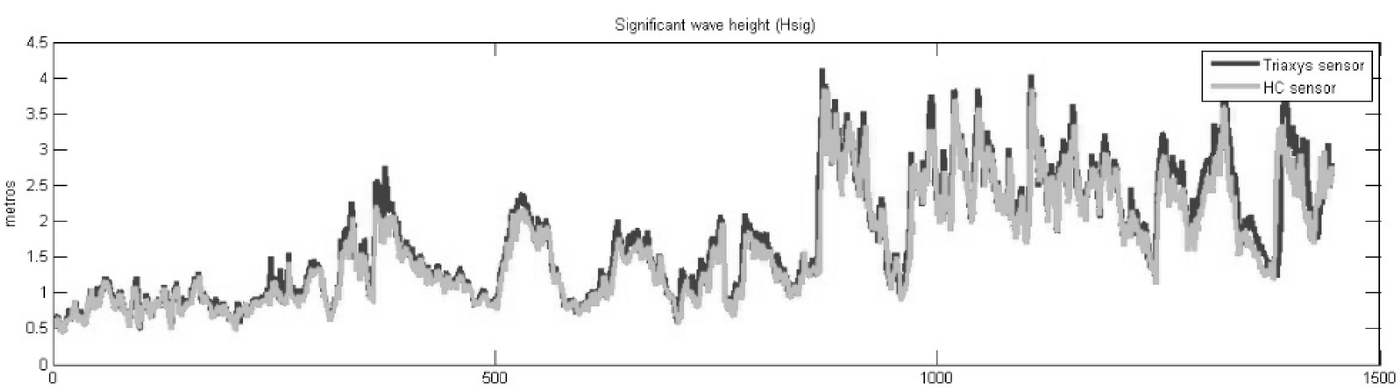

Fig. 1. Significant wave height from Bares sensor (light gray) and Triaxys (dark gray)