Design and Characterisation of a Wireless Inertial Measurement Unit for integration to a Wireless Network Scenario

***Andrew Lynch, Suleiman Kharmeh, John Barton, Brendan O'Flynn, Philip Angove, S C O Mathuna**
Tyndall National Institute, University College Cork, Ireland,
Tel: 021 4904299
E-mail: andrew.lynch@tyndall.ie

Abstract: This paper describes the design and characterisation of a Wireless Inertial Measurement Unit for deployment in a network. The IMU developed is an autonomous self-contained module purpose built for network integration. A software layer has been developed to characterise the units and to demonstration the units in full operation. The software application includes sensor characterisation features, real-time monitoring of sensor operation and a Kalman filter for the demonstration of the modules ability.

1. Introduction

Many of the commercially available IMU's are packaged in very compact units but are not usually wirelessly enabled [1]. The module described here utilises the functionality of the microcontroller layer of the 25mm wireless sensor network platform developed by Tyndall's MAI group [2] to produce a wireless IMU. The Tyndall25 platform is a low volume prototyping and experimentation platform [3] shown in Figure 1.

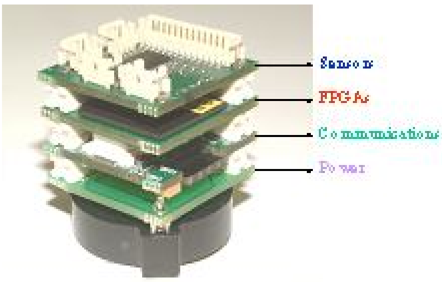

Figure 1 – Tyndall25 Platform

2. IMU Hardware

The IMU system is made up of three separate board designs. The first consists of the Accelerometer and Magnetometer sensors and some passive filtering to achieve clear analog signals. These parts are the Analog Devices dual-axis accelerometer ADXL202 [4] and a Honeywell two axis magnetometer HMC1052L [5]. These boards were designed with an off board connector layout to allow the integration to milled slots located on the motherboard. The second of the boards is the Gyroscope board, which contains the Analog Devices gyro chip ADXRS150 [4], and all its relevant conditioning passives. The motherboard houses the final gyro and the slots for each of the sensor boards to connect to.

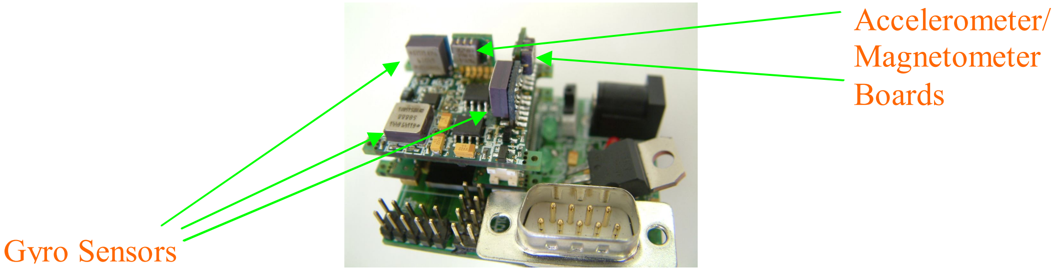

Figure2 – IMU Layer

3. IMU Software

The application developed for the system has an oscilloscope style interface, which allows viewing of each of the sensor signals in real time. It has been designed to interface to the PC serial port, which means a second 25mm wireless unit is connected to the PC as a base station. The software can monitor and log data about a given channel, which allows for characterisation of the sensor channels. The application also has a Kalman filter algorithm integrated, based on a mathematically derived model, to allow for yaw, pitch and roll to be monitored.

4. IMU Characterisation

Before the sensors could be used successfully with the Kalman filter a certain level of information has to be known about the system. Most of these performance details could have been taken from each sensor datasheet but the values that are more relevant are those generated after the wireless transmission, ADC and DAC conversion. Each sensor was exposed to certain conditions and their responses were recorded and analysed. This produced a performance specification, not only for the module, but the system including wireless communication.

5. Conclusions

This paper described the design and characterisation of an Inertial Measurement Unit for the integration to an off board Kalman filter for the accurate monitoring of roll, pitch and yaw of a given system. The system performance was characterised and wireless communication achieved. The integration of these sensor modules to a network scenario requires only the design and implementation of a networking protocol for porting to the embedded microcontrollers.

6. References

[1] MEMSense – One of the largest manufactures of MEMS based sensor systems http://www.memsense.com/content/products/

[2] Ambient Systems Group, Tyndall National Institute, University College Cork, Ireland http://www.tyndall.ie/research/mai-group/index.html

[3] Stephen J. Bellis, Kieran Delaney, Brendan O'Flynn, John Barton, Kafil M. Razeeb, Cian O'Mathuna, "Development of Wireless Sensor Networks for Ambient Systems", *Computer Communications - Special Issue on Wireless Sensor Networks and Applications,* Volume 28, Issue 13, Pages 1531-1544

[4] Analog Devices Website http://www.analog.com

[5] Honeywell Sensors Division http://www.ssec.honeywell.com/magnetic/