UNIVERSITY OF TECHNOLOGY, SYDNEY
Master Thesis

The Firmware Development of a Portable Inertial Measurement Unit (IMU)

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not been submitted for a degree previously nor submitted as part of requirements for a degree.

I also certify that the thesis is all written by me. Any help that I have received in my research work has been acknowledged. Finally, I certify that all reference sources and literature used in the thesis are indicated.

Signature of Student:

Date:

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ABSTRACT

In recent years, patients' monitoring during their rehabilitation procedure has become an active research area in medical care as the anticipated research outcomes have great potential to save huge amount of funds and the time/efforts of medical professionals. In particular, portable motion sensors (e.g., micro Inertial Measurement Unit, μ-IMU) which can provide posture and acceleration information of patients during rehabilitation exercise, have already been applied in some health rehabilitation centres around the world to avoid falling injuries. Although there are diversity types of μ-IMU, two commonly encountered problems have not been solved completely. Firstly, similar with most portable sensors, the accuracy of the μ-IMUs is low due to their size and weight limitations. To improve their accuracy, it is urgently needed to develop efficient algorithms to implement the modelling and calibration of μ-IMUs in real time settings. Secondly, these algorithms need to be unified.

This thesis attempts to partially address the above two problems for μ-IMUs. An IMU often has several groups of sensors to collect enough information. These sensors are defined as micro-electro-mechanical system (MEMS) which consists of accelerometer, gyroscope and magnetometer. This thesis will focus on the calibration of tri-axial accelerometers of the μ-IMU. Some classical "complex/expensive" algorithms and calibration devices are already available. However, due to various limitations of portable devices, we are aiming for developing more "efficient" algorithms and devices to improve the accuracy of μ-IMUs.

The specific target of this thesis is completing a partly finished μ-IMU prototype for motion monitoring during exercise. Specifically, it mainly focuses on the on-site calibration of accelerometers as well as its associated firmware development.

This thesis firstly builds a general software structure for various functions embedded in the μ-IMU system. Secondly, a new calibration method has been proposed and implemented to improve calibration accuracy. Thirdly, a comparison between auto-calibration and classical calibration has been carried out in terms of accuracy. Finally, the best solution for the calibration of accelerometers of the μ-IMU has been adopted, implemented and tested experimentally. In addition, the calibration methods proposed in this thesis could be applied to other similar wearable products.

Key Words: Calibration, IMU, Auto-calibration

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