A STUDY OF LOWER LIMB MOTIONS USING INERTIAL MEASUREMENT UNITS

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Declaration

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters Dissertation under my supervision.

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Abstract

Lower limb motions are vital for human to maintain their everyday life. However, ability of the lower limb movements can be affected by different problems. Due to many reasons there are large numbers of the population live with various lower limb disabilities. For these people, sometimes it is not an easy task to perform their normal daily life activities. On the other hand, as potential solutions, lower limb prosthetics have been proposed for lower limb amputees and lower limb exoskeletons have been proposed for assisting and rehabilitation processes for the lower limb disabled individuals. However, design and development of the control techniques for such bio-robotics devices is not a straight forward task. Often study and analysis of lower limb motions are important for design and development of the control techniques. Among several methods of studying lower limb motions, Inertial Measurement Units (IMU) based methods have been able to gain lots of attention due several advantages over other methods. Moreover, IMUs can be used in control approaches of bio-robotics applications such as prosthetics or exoskeletons as potential input sources. In this context, the objective of this thesis was to study about the lower limb motions using IMUs and investigate the potentials of IMUs to be used in control approaches of bio-robotics applications such as lower-limb prosthetics and exoskeletons.

First half of this thesis focused on analyzing the human lower-limb motions using IMU sensors mounted over the thigh, shank and foot of subjects. IMU sensor data were recorded during walk on horizontal floor, stair ascending and stair descending motions. Comprehensive analyses of lower limb motions were conducted based on recorded accelerometer, gyroscope data of IMUs and sensor fused data. Furthermore, signals from the accelerometer which mounted over the foot were used to detect the heel strike event of the lower limb motions. Based on this heel strike recognition, recorded data were segmented and analyze between each gait cycle.

The second half of this thesis, mainly attempted on classification/prediction of walking mode (i.e walk vs stair ascending vs stair descending)and continuous estimation of the impaired leg's foot motions using an IMU mounted over the sound leg's foot to be used in control approaches of bio-robotics applications such as ankle exoskeletons and lower-limb prosthetics. All the proposed methods were experimentally validated and results highlighted the potential use of IMUs in lower limb motion capturing and control approaches of bio-robotics.

Dedication

To my loving parents.

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LIST OF ABBREVIATIONS

Abbreviation	Description
ANN	Artificial Neural Network
EMG	Electromyography
FNR	False Negative Rate
FPR	False Positive Rate
IMU	Inertial Measurement Unit
MEMS	Micro Electrical Mechanical Systems
RMSE	Root Mean Square Error
SVM	Support Vector Machine