Motion Estimation using Inertial Sensor Technology with Applications to Sporting Exercises

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The goal of this thesis has been to find appropriate motion algorithms that allow the implementation into PARTwear, which is a microcontroller-based inertial sensor system used to monitor the activity of human beings in different areas of interest, such as Sports and Medicine. New methods to perform drift-free displacement estimation of motion with inertial sensors have been investigated and analysis of running performance has been conducted using the PARTwear sensor.

Introduction

Biomechanical studies often use optical motion-capture systems to determine the position of an object. This approach is not ideal for many types of sports, since only a few strides may be collected per trial, and outdoor measurement systems are too bulky. Inertial sensors, by contrast, are easy to attach to the athlete, but are usually not used to obtain displacement, because of the drift due to numerical integration, integration constants and the necessity to determine the orientation of the measured accelerations. The present master thesis performs motion analysis and experiments with measurements from the available inertial sensors, and finds out whether the kind of sensors and their performances are well adapted to the problems concerning various sports activities.

Body Sensor Platform - PARTwear

Methods

On a trainers request the analysis of running performance has been conducted using the PARTwear sensor. Foot-ground contact time, as one of the most important variables that influences the maximum running speed, has been measured with different laboratory equipment. The results have been compared with acceleration data obtained from the PARTwear sensor and used to design an algorithm which can be implemented into the embedded processor.

Results

The output of this thesis are the following three main results. First of all a comparison of two different methods for displacement estimation of motion with inertial sensors is presented. Secondly an approach for correcting accelerometer drift is introduced. And finally, the third result is a new algorithm for running performance analysis, based on inertial sensor data, measured with the PARTwear sensor. The results show, that it is possible to perform reliable foot-ground contact time measurement using an inertial sensor.

Although the current study is based on a small sample of participants, the findings suggest that the algorithm can be adopted to different persons. Even so, the algorithm could be further improved with an adaption factor, which can be found using the cross-validation method. C++ code of the current algorithm state has been generated with the Embedded Coder from Matlab/Simulink®. This allows to integrate and test the algorithm on the embedded processor of the PARTwear sensor.

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