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IERI Procedia 4 (2013) 44 – 52

Procedia IERI

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2013 International Conference on Electronic Engineering and Computer Science

Gait cycle recognition based on wireless inertial sensor network

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Abstract

This paper presents a method of recognizing gait cycle based on Wireless Inertial Sensor network. The wireless inertial sensor network is embedded in shoes with accelerometers and gyroscopes to measure inertial signal during walking. In gait analysis, gait cycle is one of the most important parameters. Based on gait cycle, we can easily calculate the step continuity, step regularity, step symmetry and so on. Especially for lots of diseases estimation, such as Parkinson's disease, the accurate time of step is a very important parameter. The commercial pedometer, which can simply give the counts of gait, cannot give the accurate time of gait cycle. Based on shoes embedded with inertia sensor, we develop one method using peak detection of combined inertia sensor signal. Experimental results show the method has less error and high precision.

Key words: Gait Cycle, Inertia Sensor, Wireless Sensor Network, Extremum Point;

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doi:10.1016/j.ieri.2013.11.008

1. Introduction

Walking may be the most important activities of our daily life. Gait as a biologic character can be used for identity recognized, health monitor, and medical evaluation. So developing cost-effective methods of gait monitor is very useful. If the gait cycle can be calculated in real time, it will be possible to detect and analyse gait characters continually.

Traditionally, lots of methods have be used for gait character detected such as using a stopwatch though measuring step speed, step length, step height and other characters of these factors. In a general way video and photo imaging systems are used for monitoring and tracking movements of human body. Those systems have highly precision and give lots of many other gait characters. But it is very expensive and can only be used in the specifically condition for gait analysis.

There are several studies that have been present about gait analysis based on the system using inertial sensors such as accelerometers, gyroscopes and so on [1,2,3]. Accelerometers and gyroscopes have been also used in many wearable computing systems for behavior classification, fall detection and gait analysis [4]. Many other systems using Accelerometers and gyroscopes are developed for measuring the physics parameters in[5,6].

This paper presents a method and designs a pair of shoes embedded inertial sensors for real-time gait cycle recognition. As a part of gait analysis, a pair of motion monitoring shoes are designed for measuring inertial signal of two feet, and upload the real-time inertial data in wireless to the computer. And we can develop the gait detection algorithm based on the gait inertial signals on PC, to get the gait cycle in real-time. Based on the gait cycle, we can easily give other gait parameters such as step continuity, step regularity, step symmetry, and so on.

2. Hardware system

This section will be dedicated to the inertial sensor network and the way the inertial sensors are set on both feet for gait analysis. The network is composed of two slave sensor nodes and one data receiver node. Each slave node is based on an InvenSense inertial sensor chip MPU-6050 which is the first solution with integrated 6-axis sensor fusion using its field-proven and proprietary fusion engine for consumer electronics applications. The MPU-6050 is an inertial sensor chip embedded 3-axis accelerometer and 3-axis gyroscope [7].

Each slave node also has a microcontroller with RF function. The sensors are connected to the data receiver in wireless. The structure of the system hardware as showed at Fig.1. The accelerometers have selectable sensitivity and range between ±4g that best fits the kind of data to be analyzed, and the gyroscope is ±750°/s. The blue print of the shoes as showed at Fig.2. The direction of inertial sensors is also given.

We embed the PCB, Ceil, and Wireless charge coil into the shoes. And the switch, USB port, LED are fixed at the back of shoes. The prototype of the wearable motion detector shoes are shown at Fig.3.

The data receiver as showed at Fig.4 communicates with PC via USB. All of inertial sensor data is uploaded to a PC via USB port for processing, analysis, recognition. The system collects the inertial signal on each sensor at 50 Hz.