

International Conference on Robot PRIDE 2013-2014 - Medical and Rehabilitation Robotics and Instrumentation, ConfPRIDE 2013-2014

Development of Shoe Attachment Unit for Rehabilitation Monitoring

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Abstract

The rehabilitation monitoring is a method to access and identify human body events and the measurements of dynamic and motion parameters involving the lower part of the body. This significant method is widely used in rehabilitation, sports and health diagnostic towards improving the quality of life. Thus, this research focuses on the development of a portable shoe integrated with wireless MEMS-based and recent microelectronic based system. It goes with the custom design package includes ultrasonic sensor, Inertia Measurement Unit (IMU), Xbee wireless signal transmission, microcontroller and power supply unit. The shoe system was tested and proven to satisfy the human movement analysis based on gait parameters which include foot clearance and foot orientation. From this research, it is found that the system was able to measure the movement parameter wirelessly with ease and efficient. Hence, to conclude this system can be used as the best method for real life rehabilitation monitoring system.

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Peer-review under responsibility of the Center for Humanoid Robots and Bio-Sensing (HuRoBs)

Keywords: Rehabilitation Monitoring; Gait Analysis; Arduino; Xbee

1. Introduction

Healthcare cost continues to increase globally partly due to the surge in the occurrence of falls among the human being. The important gait parameter that influences the risk of falling among the human is foot clearance. The foot-ground reaction forces of produced by human body in is very important in gait analysis [1]. It is the natural parameter of the foot during the swing phase of the gait cycle that representing the distance of shoe sole above the ground. In a recent study involving the analysis of the tripping and falling risks among the elderly and individuals during walking [2], it is found that the motion of the foot during mid-swing phase is the most critical issue that can initiate the possibility of trip-related decline. The trip or fall is an event which may lead someone to collapse

accidently due to unstable position. It is a very dangerous incident among the elderly as it may cause critical injury and death [3]. This important stage of foot movement is referred to as minimum foot clearance (MFC). Previous study in [4] shows the MFC is below than 5 cm while the foot trajectory during gait may go up to 17 cm. Unluckily, the current practice of measuring foot clearance mostly requires laboratory settings with the use of reflective and active markers. This type of foot clearance measurement may not be representative of real life based measurement in natural settings [5], such as at home or outdoors. Based on such fall prediction systems, response from caregivers may be triggered prior to most fall occurrences and accordingly prevent falls from taking place [6]. Therefore, this research is focussed on the wireless and portable shoe integrated clearance sensor system for rehabilitation monitoring system.

Nomenclature

v	velocity (m/s)
s	distance (m)
t	time (s)
l	length (m)
tof	time of flight (s)

2. System Configuration

The selections of sensors and hardware are depending on the requirement of the foot clearance measurement. The sensors that are used in this research are ultrasonic sensor and IMU for determination of the MFC as well as the orientation of foot position respectively. The monitoring system is not complete without other additional components that support the key functionality of the entire system. The hardware design consists of Arduino microcontroller, 2.4 GHz IEEE 802.15.4 XBee transceiver and power supply unit. This research used the Arduino compatible board named ArduIMU V2 Flat as processing unit which incorporated the Micro-Electro-Mechanical-System (MEMS) based IMU sensor on a single board.

2.1 Ultrasonic Sensor

Ultrasonic detectors are devices that are utilized for distance measurement which operates almost similar to how the radar is working where the distance is deduced from the total time of flight of the signal waves and the signal speed. Some ultrasonic device can transmit and receive high frequency sound waves using a single device which is also called as a transceiver. Table 1 below shows the specification of the selected ultrasonic sensor in the market for MFC measurement application and the principle of an ultrasonic sensor is shown in Fig 1.

Table 1. Specification of Ultrasonic Sensors for Minimum Foot Clearance Measurement Application

Model/ Specification	SRF05 (Devantech Ltd, 2012)
Power (V)	5
Frequency (kHz)	40
Resolution	1mm
Range	1cm-4m
Unit	Mm, cm, inch, m
Interface	Positive TTL level signal, width proportional to range
Weight	9g
Dimension (mm)	43 W x 20 D x 17 H
Manufacturer	Devantech Ltd, England

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