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An Accurate Wireless Data Transmission and Low Power Consumption of Foot Plantar Pressure Measurements

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Abstract

The need for an accurate real time measurements for the foot plantar pressure, especially in gait analysis, is important and always under research because its flow in human health. This work proposes an accurate, very low power consumption wireless data transmission for monitoring and analyses the diagnosis based on two XBee S1RF Modules, one function as a base (receiver) which is connected to PC while the other collects the force/pressure sensors output and acts as a remote (data acquisition unit). The developed system consists of 4 resistive pressure sensors attached to an insole. Sensors are placed at four effective pressure points and interfaced with a wireless node and suitable conditioning circuit board. High speed rate and very low power consumption of data process made this technique useful for this application. Light weight lithium ion polymer, 16 gm, 2.96 W.h, 3.6V can operate the data acquisition and RF remote circuit with about 22.4 hours. A graphical user interface using MATLAB is used to plot data curves for different measurements.

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*Keywords:*pressure sensor; foot plantar measurement; data acquisition system;

1. Introduction

Wireless sensor networks (WSNs) technologies have been implemented in healthcare/medical application for many years[1–3]. It is driven by technology advances in low power system and medical sensors.

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This network consists large number of small sensors and multi-nodes. It also has one or more base stations to collect data from each sensor node to the user. The main features of WSNs are real-time transmission, accuracy, and comprehensive[2].

There are many wireless technologies nowadays, e.g. Bluetooth, ZigBee, radio frequency identification, Wi-Fi, 3G, and others. Zigbee is a new technology based on wireless standard 802.15.4. Zigbee has many advantages over other technologies such as good security as it provides data validation using encryption algorithm, low cost, low power consumption, large network capacity up to 255 devices, flexible working bandwidth (2.4GHz, 915MHz, and 868MHz), and the range covered from 10m to 100m, and etc. In medical application, foot plantar pressure has gained the interest of many researchers because it is useful in various applications, e.g. gait analysis[4–6], rehabilitation and support system[7], athletes' performance analysis[8,9], and etc. Many devices have been developed to measure plantar pressure. However, there are significant differences in data acquisition system, and configuration of sensors (i.e. the number and arrangement of pressure sensor used in the devices based on application)[10]. In many applications, real-time and continuous monitoring i.e.: gait analysis, daily activities, etc. is required. Thus, wireless data transmission is recommended with limited cabling for on-line data transfer to a remote computing/storing unit[10]. Wireless data transmission allows the subject to feel comfortable, safe, and walk or stand in natural gait condition. In foot plantar pressure measurement, Crea *et al.*[4]have developed a foot insole using optoelectronic pressure sensitive technology for real-time monitoring during walking. A wireless transmission used to transmit the data via Bluetooth connection. Very low current absorption allows the system to be operated continuously for 20 hours with a capacity of battery 2000 mAh. Research done by Mazumder *et al.*[11]design a wireless insole foot pressure for various physical activities using capacitive force sensors. The system used wireless RF module XBEE for data transmission. A wearable plantar pressure measurement system has been developed by X. Wang *et al.*[12] The system designed for locomotion recognition, for example walking, standing, sitting, and etc. This system transmits the signal wirelessly at 434 MHz with a data rate of 250 kbps. Results show that the system has a high accuracy rate above 90% using the confusion matrix. Saito *et al.*[13]developed an insole with seven pressure-sensitive conductive rubber sensors with wireless data transmission. The power source used lithium battery, 3V, 850mAh can operate continuously for 20 hours. The device is low cost and can be prepared to fit many shoe sizes. Wahab *et al.*[14] developed a low power gait measurement system. The system is used Inertia Measurement Unit, ultrasonic sensors, ceramic based piezoelectric sensors array, Xbee module, and Arduino as processing unit. The research is focuses on design and development of low power ultra-portable shoe using MEMS technology. The system used lithium polymer battery that can be used up to 4 hours and it is rechargeable. The gait measurement system can be used outdoor/indoor environment. The research[15] has been adopted as an enhancement tool in electronic design phase of this research, while we've addressed the researches[16-18], that were produced by the sub authors of this research, as guide when the sensors calibration and destruction over the insole has been implemented.

The objectives of the research are as follows; To investigate best solution for data transmission from the insole planter prototype and the data analysis station. To achieve a high sampling rate that fulfill the transfer of the data accurately. To ensure that the power consumption is smaller than past because low power consumption components has almost light weight and compact in size. To enhance the diagnosis procedure with a suitable GUI and hardware user flexibility. To make the patient or user more comfort when he/she uses or wear this shoe.

2. System Components and Data Acquisition System Design

2.1. System Components and Block Diagram

The main diagram of the proposed system can be demonstrated as shown in Fig. 1. A four force/pressure sensors were connected in a specific effective location over the touch insole area. The sensors were calibrated in such a way that its relative conditioning circuit output has a maximum value at that point, that's mean the calibration procedure has been implemented individually based on several trials to estimate the maximum force which might applied on that location. As mentioned above, the gain setting of the conditioning circuit is not identical, but it is governed by the test point location. This type of calibration enhances the accuracy of the measurements.