Pedobarography Insoles with Wireless Data Transmission

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Abstract - *Pedobarography is important for kinetic gait analysis and for diagnosis of a number of neurological and musculoskeletal diseases, such as peripheral neuropathy ,peripheral vascular diseases, Parkinson etc,. Wearable plantar pressure measuring systems represent a highly useful tool in this field. The dynamic data they can provide are significant to generate real-time alerts to prevent ulceration of foot in diabetic patients, for rehabilitation, and sport applications. Efforts of our work are therefore aimed at the realization of a wireless sensor system with Force Sensing Resistors (FSR) to measure plantar pressure. The wireless sensors have been proved for its high accuracy and reliability for measuring high pressure distributions under the foot in real time. The sensed data are collected wirelessly to the base station (BS). This later displays in real time the data on a Graphical User Interface (GUI).*

Key Words**: foot plantar pressure, wireless sensors, wireless system.**

1. INTRODUCTION

The foot is the terminal link of the kinematic chain in human locomotion. During standing the foot assists in the control of the delicate muscular activity that is needed to keep balance. The functions of the foot during walking are two-fold. A passive function, providing a first stage of cushioning of the impact forces the human body is subjected to during walking and running and an active function, transferring the internal forces produced by the muscles to the ground in order to accelerate the body during push-off. Why do we need plantar pressure measurements?

According to Newton's third law action equals reaction. During walking interactive forces are transferred between the human body and the ground.

The use of force platforms is the method most commonly used to assess the interaction of the foot and supporting surface.

Although the force platform provides valuable information regarding both the vertical and shear components of the ground reaction force, it provides little information on how the planter surface of the foot is loaded with respect to the supporting surface. When evaluating patients, atypical amounts of loading or patterns of loading may be reflective of a systemic or lo-calized lower-extremity pathology and may be indicators (risk factors) for or predictors of further pathology or worsening of the existing pathology.

In addition, the force platforms are designed for accurate aim, and they have very specific requirements for attachment to the supporting surface on which data collection will occur. Such is not the case currently with the development of solu-tions for mobile systems and miniature circuits, lightweight, and energy efficient circuit solutions for healthcare sensor applications is an increasingly important research focus given in measurement instrumentation and healthcare monitoring, microfabrication processes and wireless communication.

The need for medical equipments market has attracted considerable attention by researchers in the field of biomedical instrumentation and biomechanics for this analysis of plantar pressure distribution to reveal the interface pressure between the surface of the foot and sole of shoe, for the design of shoes, ankle rehabilitation for sports injuries, improving balance control, a postural stability analysis, may help to reduce the risk of ulcer recurrence in patients with diabetes.

Wireless plantar pressure measurement systems for identify and quantify areas of high pressure it is a quick and easy way helping to diagnose the root cause of lower extremity problems, and design more effective offloading devices.

2. ALLIED WORK

In this work, we are interested first to make insole more comfortable, this is built based on three layers, also accuracy of data from sensors FSRs. Using a system to enable a global distribution of the force exerted with the foot. Second, we have interested to mobility of our system. We used a nRF24L01 radio that gives greater scope. It's very handy of the analysis of walking and real time tracking on the sports field. Finally, The system has MSP430 micro-controller with a low power consumption, dedicated for autonomous embedded systems.

3. SYSTEM DEPICTION

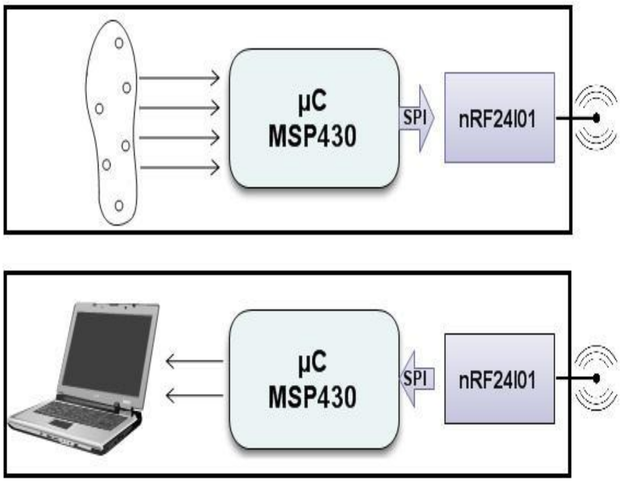

Fig. 1. Block diagram

The depicted system architecture shown in figure 1 consists of two blocks: One embedded in the shoe, and the other outside the body. In order to connect the system to the base Station, The first considered as transmitter, contains sensors which used to obtain data then transmitting via radio frequency RF. The second is used as a receiver for receiving informations and displays it on PC. Further, it will be used by the doctor afterwards for analysis and diagnosis.

4. MECHANISM DEPICTION

4.1. Pressure acquisition system

In order to measure the pressure of the foot, we have developed a sole. This later is equipped with pressure sensors (FSRs in our case). It consists of three main layers, as described in the following steps:

1) Pressure area :

To find pressure areas in high foot with contact with the soil. We have conducted an experiment using a plaster to take the impression of bare foot.

The data area was cropped to a rectangle according to the measured length and width the foot of the person. As presented in [6], the rectangle was partitioned into medial and lateral halves by the longitudinal foot axis and into equal thirds along the longitudinal axis to indicate the forefoot, midfoot, and heel sections. The medial and lateral heel sections were treated as a single section. Thus, five segments for the entire foot were determined: heel, medial mid-foot (MM), medial forefoot (MF), lateral mid-foot (LM), and lateral forefoot (LF) (Fig. 2)

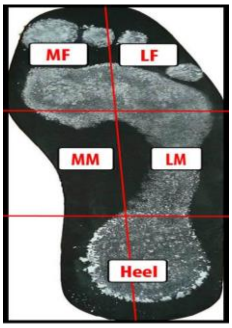

Fig. 2. Five-segment foot model. MM: medial midfoot; MF: medial forefoot; LM: lateral midfoot; LF: lateral forefoot.

2) Layers of the insole:

After detecting the pressure areas, we implemented our pressure sensors on a sole that considered the first layer. A cylindrical shape is disposed on the FSR, is aimed to have a global distribution of the force exerted by foot. Then, a second layer is added to protect the sensors and its connection. Finally, the final layer is a very thin insole for foot to comfort and avoid problems of direct contact with the sensors.

Fig. 3. Layers of the insole

3) Sensing element:

Here FSR 402 model is used, It has a single-zone Force Sensing Resistor, with interesting characteristics [7],[8] well light weight, small size and low cost, optimized for use in human touch control of electronic devices such as automotive electronics, medical systems, and in industrial and robotics applications [9]. They are robust polymer thick film (PTF) sensors that exhibit a decrease in resistance with increase in force applied to the surface of the sensor. It has a 14.7mm diameter active area, we have placed an epoxy dome over the sensing area for directing all of the applied force through the effective sensing area as shown in Figure 4

Fig. 4. Modified force sensing resistor

4) Conditioning circuit for the FSRs sensors:

A simple circuit of conditioning was realized , each sensor is mounted in a voltage divider to adjust the measuring range and is followed by a voltage follower made with TL081 op-amp for the impedance matching. The conditioning circuit illustrated in the figure 5.

5) Sensor calibration:

The new sensing element that has been realized has need the calibration for determine the range of variation of the force, in this case we made a direct etalonnage on the insole to get the real values pressure from each sensor. The conditioning circuit was equipped with a potentiometers to adjust the measuring range.

$$Vout = \frac{RM}{(RM + FSR)} V^{+}$$

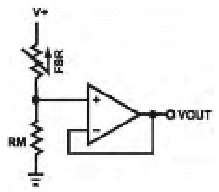

Fig. 5. The conditioning circuit for the sensor element

4.2. Processing unit

After conditioning the signal from sensors FSRs, the analog to digital conversion can be made using the ADC module of MSP microcontroller (MCUs) from Texas Instruments (TI) This Micro-controller has 16-bit, RISC-based, mixed-signal, and clock system has the ability to enable and disable various clocks and oscillators which allow the device to enter several low-power modes (LPMs). The flexible clock-ing system optimizes overall current consumption by only enabling the required clocks when appropriate. This means that MSP430 MCUs can operate for decades on a single coin cell battery.

Fig. 6. The Sensor board: Micro-controller, conditioning, Radio, with the dimensions of 55x45mm.

5. WIRELESS OUTSENDING MODULE

This emerging technology can take some physical data collected from an environment and transmit them to remote collection points[]. In this work two more Wireless was used, a sender and a receiver:

The sender node will read a data from the ADC each 10 ms, which is equivalent to a frequency of 100Hz, then send them with the nRF24L01 radio.

The reception is achieved by a receiver node using the same micro-controller and also connected to a nRF24L01 radio. Thus, the receiver receives the data and vehicle to a PC through a USB connection. These data will then be processed and then displayed on GUI.

6. USER INTERFACE

An interactive graphical user interface (GUI) is implemented to display in real time the results and implanted medical instrument information. The GUI display the areas of high pressure based a clear color-coded, which will allow the user to follow the variations in pressure, see figure 7. In the same time we have another window, to display the measurement value in N/Kg for each sensor.

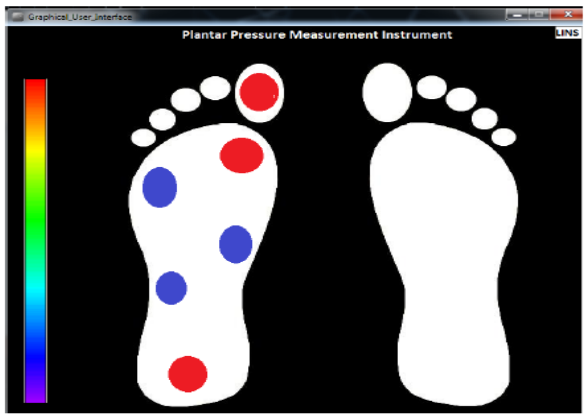

Fig.7. User Interface

7. RESULTS

From instrument that has been designed to measure the pressure affecting different region of the foot , we have canned to make the different between each types of feet, There are three different types of feet, pes planus, pes cavus and normal foot, which could influence the pressure loading on the feet. A relationship exists between foot type and foot pressure, the FSR sensor placed in the MF area indicates a higher foot pressure for people with pes planus compared to pes cavus.

The instrument plantar pressure measurement system pin-point areas of high pressure in a clear color-coded display. We can after use these accurate, high resolution images to aid in development of better treatments, so the patients feel better faster. The images also make it easier to explain diagnoses and treatments to patients and other providers.

8. CONCLUSION

We have presented in this paper, a system to wirelessly record and analyse foot pressure distribution, From the experimental results, it can conclude that purpose of measuring the pressure of the foot is to quantify the degree of deformation of the foot and foot dynamically evaluate and define areas of high pressure.

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