INSOLE PLANTAR DEVICES IN THE GAIT ANALYSIS BY MEASURING FOOT PRESSURES

S. Seachang, W. Samruamram, N. Thammakhankhom
Information and Communication Engineering
Mae Fah Luang University
Chiang Rai, Thailand
Suchada.sea13@lamduan.mfu.ac.th

ABSTRACT

An objective of this work is to build insole plantar devices to measure foot pressures, which imply the balance of the body. Imbalance of the human body is a several causes of Rheumatology and bone diseases. By using the proposed devices, the users can monitor their foot pressures. We use sensors called force sensitive resistors connected to NodeMCU microcontrollers to measure the users' foot pressures. The measured data will be sent to a web server. We have created a web application such that the users can monitor their foot pressures online. The data can be shown as either the recent foot pressures or those in the past.

Index Terms *– NodeMCU; force sensitive resistor; gait analysis; body balance; Internet of Things.*

1. INTRODUCTION

Generally, almost half of people do not know what the balance of their body is. Therefore, it is a reason why people do not take care their body's balance. Imbalance of the human body is a several causes of Rheumatology and bone disease. The balance of the body can be implied by the foot pressures when people stand or walk. When people walked, their feet will have force pressures about 120% of their torso. When they run, their bases will have force pressure about 275% of their torso. Consider a man who has weight equal 68 kilograms. If he walks, each foot will get weight equal 63.5 kilograms. If he runs, each foot will get weight equal 100 kilograms.

To be able to monitor the foot pressures, we have implemented insole plantar devices by using force sensitive resistors (FSR) connected to NodeMCU microcontrollers. The NodeMCU microcontrollers will read the foot pressures from the FSRs and, then, send these values to a web server. The users can monitor their foot pressures via the web application we have provided.

This paper is organized as follows. Related work is reviewed in Section 2. The proposed insole plantar devices are explained in Section 3. The details of the insole plantar devices, its web application, and experiments are described in Section 4. We show the conclusion of this paper in Section 5.

2. RELATED WORK

2.1 Insole Plantar Pressure Systems in the Gait Analysis of Post-Stroke Rehabilitation [1]

This work presents the application of an insole plantar pressure sensor system in recognition and analysis of the hemiplegic gait in stork patients. It uses tailor to make 3D for designed and fabricated. This 3D shows relationships between the foot and insole.

2.2 Design and Development of SMART Insole System for Pressure Measurement Humen Body and Heavy activities [2]

This work presents the application which can check the balance of the human body. It can assess the treatment and improve sport's skill. This system uses the wireless system for communicating between the insoles and the graphical user interface with PC, laptop, and smart phone.

2.3 An Ambulatory System Force Gait Monitoring Based on Wireless Sensitized insole [3]

This work presents the system of gait analysis via a mobile application. It is able to detect different types of walking movement such as turning, walking backwards, lateral walking, etc.

2.4 Gait Analysis Using a Shoe-Integrated Wireless Sensor System [4]

This work presents a shoe-integrated wireless sensor system. There are 3 sensors: accelerometer, gyroscope, and force sensitive resistors. The work was built to be worn in any shoes. It is designed to collect the data in any environment and long period of time. The shoes can detect the heel-strike and toe-off.

2.5 Insole-Based Gait Analysis [5]

This work presents an insole based gait analysis. The authors implemented a prototype with 32 force sensitive resistors (FSR) inside shoes. The sensors are placed in the ideal locations to get the most accurate measurement. They choose FSR because these sensors are low-cost, very cost

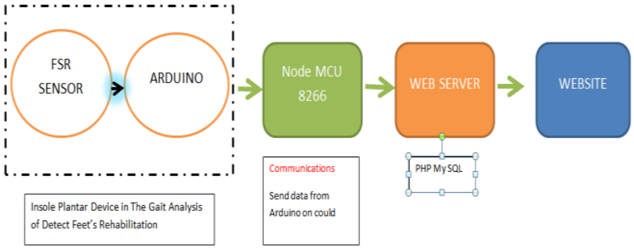

Fig. 1 A block diagram of the proposed system.

Fig. 3 Locations of the FSRs placed in the insoles.

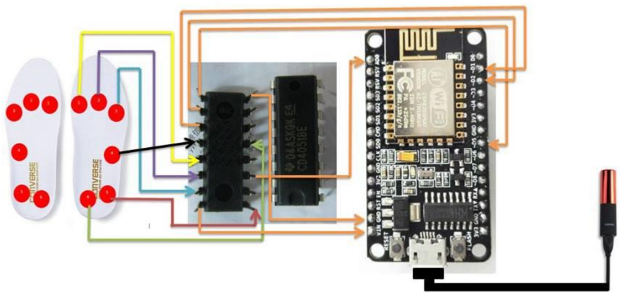

Fig. 2 The circuit connection.

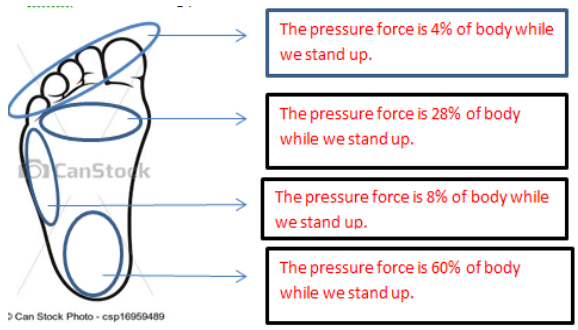

Fig. 4 Foot zones of points getting the weight of the body.

effective, thin, and robust. The 32 sensors are placed inside the footprint of size 10 men's shoes. They cover the entire area of the footprint and they are dense in the important locations such as under the great toe.

3. PROPOSED INSOLE PLANTAR DEVICES IN THE GAIT ANALYSIS

In this work, we have implemented insole plantar devices (put in shoes) to measure the foot pressures when the users stand or walk. These pressure values are then sent to a web server via WiFi connection. In addition, we have created a web application such that users can monitor these pressures values online. The pressure values also can be useful for physicians who would like to monitor their patients' standing and walking pattern and, then, find a suitable treatment.

A block diagram of the proposed system is shown in Fig. 1 and can be described as follows. On each insole plantar (we have created two for a pair of shoes), six FSRs are connected to a NodeMCU microcontroller. Since there is only one analog pin, we use an analog MUX IC (CD4051BE) to receive the pressure values from these six FSRs. The circuit connection among the FSRs, the analog MUX IC, and the NodeMCU microcontroller is shown in Fig. 2. We write an Arduino code to read the pressure values from the analog pin A0. Thereafter, the NodeMCU microcontroller send these values to a web server via a WiFi connection.

Fig. 5 The proposed insole plantar devices.

The six FSRs are placed on each insole as shown in Fig. 3. We have divide the foot area into three zones: ball zone, middle zone, and heel zone. Three FSRs are placed on the heal zone, one FSR is placed on the middle zone, and two FSRs are placed on the heel zone. We choose these three zones because almost of the weight of human presses over here as shown in Fig. 4.

4. RESULTS

The complete work and experiment results can be shown as follows.

4.1 Proposed System

We have placed six FSRs on an insole (as shown in Fig. 3) and, then, put this insole inside a shoe. These shoes are shown in Fig. 5. The power supply for each shoe is from a power bank.

We have created a web page to introduce our work and related details as shown in Fig. 6. In addition, we have provided a web application such that the users and their physicians can access to monitor these pressure values. The web application consists of the following steps. To access the web application, the users have to log into the system via the Log-in page (as shown in Fig. 7). If the user is logging in as a physician, he/she will be able to see the data of many users as shown in Fig. 8. The users can choose to view these data as Summary and a line chart as shown in Fig. 9.

4.2 Experiments

In this section, we will show the pressure values when we do the following scenarios.

1) Scenario 1: a user stands on the right foot only. The result is shown in Fig. 10, where the foot pressure value from the left foot is zero.
2) Scenario 2: a user walks. The result is shown into three graphs (Figs. 11 – 13): the foot pressures on the ball zone, the foot pressures on the middle zone, and the foot pressures on the heel zone.

5. CONCLUSION AND FUTURE WORK

In this work, we have built an Internet of Things application consisting of insole plantar devices (to measure foot pressures) and a web application (to monitor these pressures online). Our insole plantar devices can measure foot pressures by using FSRs. We have placed six FSRs on each insole. These FSRs are placed at the ball zone, middle zone, and heel zone. Thereafter, we use a NodeMCU microcontroller to read these pressures and send them to a web server. Users, which are physicians and patients, can monitor these data by logging into our web application. The users can choose to see the recent foot pressures and the foot pressures recorded in the past.

Our work can be improved further in many ways. The following three ways are promising. First, based on the same framework, we might apply an idea to monitor other walking abnormalities. Second, in addition to using FSRs, we might apply other sensors such as Gyro sensors to get more data. Third, we might focus more on analyzing and interpreting the data recorded.

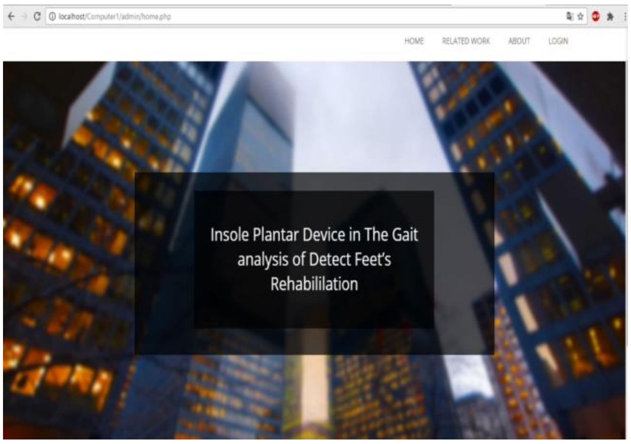

Fig.6 Home page of our work.

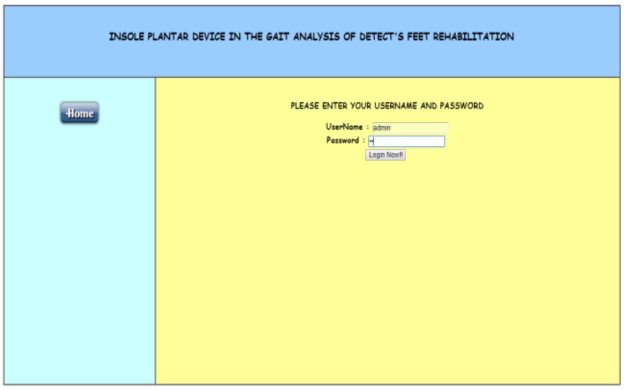

Fig. 7 Log-in page of our web application.

Fig. 8 User web page.

REFERENCES

[1] L.-Y. Qin, H. Ma, and W.-H. Liao, "Insole plantar pressure systems in the gait analysis of post-stroke rehabilitation," in *Proc. ICIA*, 2015.

[2] U. Manupibul, W. Charoensuk, and P. Kaimuk, "Design and development of SMART insole system for plantar pressure measurement in imbalance human body and heavy activities," in *Proc. BMEiCON*, 2014.

[3] I. González, J. Fontecha, R. Hervás, and J. Bravo, "An ambulatory system for gait monitoring based on wireless sensorized insoles," *Sensors*, vol. 15, no. 7, pp. 16589 – 16613, Jul., 2015.

[4] A. M. Howell, T. Kobayashi, H. A. Hayes, K. B. Foreman, and S. J. M. Bamberg, "Kinetic Gait Analysis Using a Low-Cost Insole," IEEE Trans. Biomed Engineer., vol. 60, no. 12, pp. 3284 – 3290, Dec. 2013.

[5] S. J. M. Bamberg, A. Y. Benbasat, D. M. Scarborough, D. E. Krebs, and J. A. Paradiso, "Gait Analysis Using a Shoe-Integrated Wireless Sensor System," IEEE Trans. Infor. Tech. Biomed., vol. 12, no. 4, pp. 413 – 423, Jul. 2008.

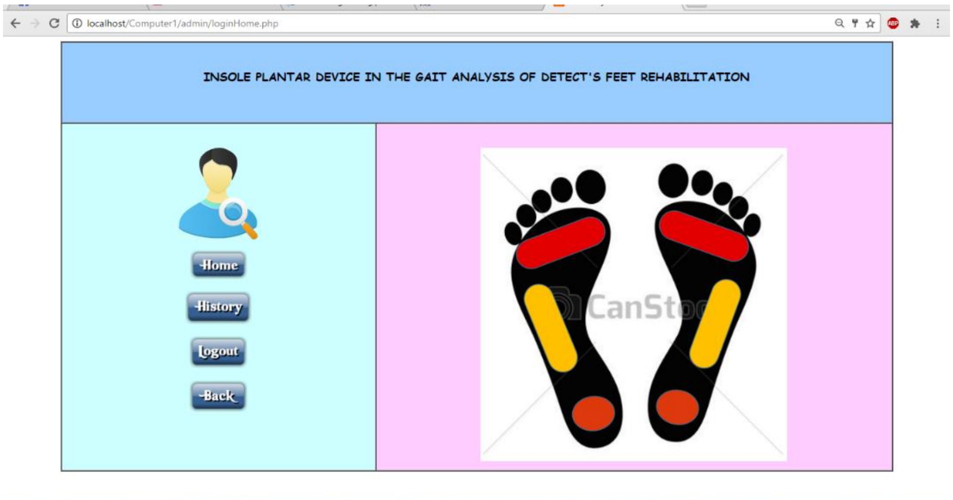

Fig. 9 User summary web page.

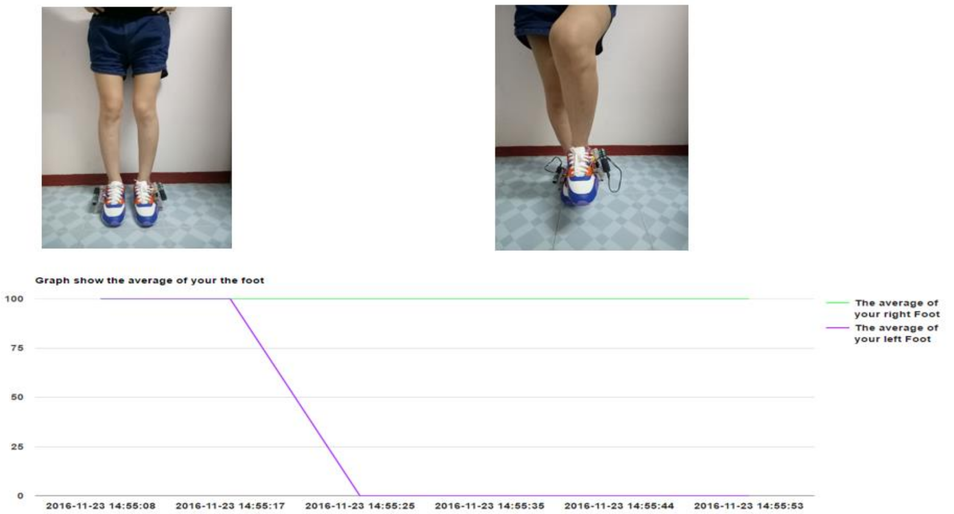

Fig. 10 Scenario 1 – the user stands on the right foot.

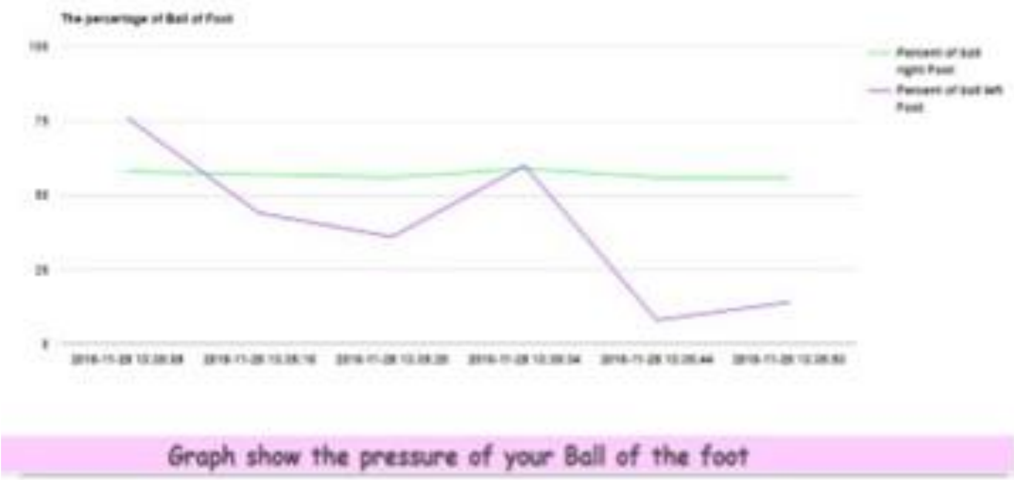

Fig. 11 Scenario 2 – pressures on the ball zone.

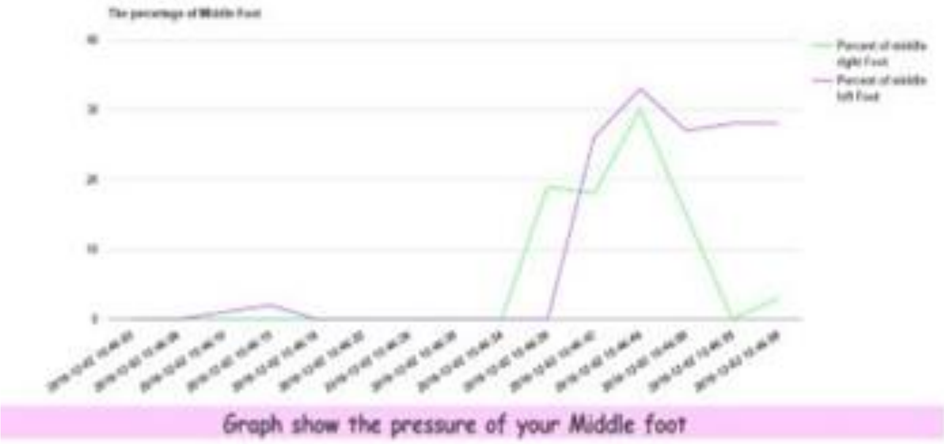

Fig. 12 Scenario 2 – pressures on the middle zone.

Fig. 13 Scenario 2 – pressures on the heel zone.