CORTEX WALK – SMART SHOES FOR MONITORING FOOT PRESSURE IN DIABETIC PATIENTS

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Abstract - Diabetics causes neurovascular complications which leads to development of high pressure areas in the feet. Diabetic neuropathy causes severe nerve damage, which may ultimately lead to ulcerations. This paper discusses about the detection of foot neuropathy as early as possible, from a home based environment. Flexi force sensors are used to measure the pressure in different areas of our foot and it will be displayed on the hand held device. The vibrating motors can be used to stimulate vibrations at different frequencies at the desired locations thus improving the blood flow. Thus a low-cost foot pressure and foot movement analysis and blood flow stimulation system, is developed which a patient can wear at any place to monitor his or her foot pressure distribution.

Keywords: **Neurovascular, neuropathy, ulcerations.**

1.INTRODUCTION

Diabetics is one of the major reasons of illness and deaths in the world.Diabetics leads to the development of high pressure areas in the human limbs. In 2012, a survey on "Economic costs of Diabetes in US" showed that 9.3% of its population was afftected by diabetics. It also revealed that 25.9% of people above the age of 65
(11.8 million seniors) were afftected by diabetes. In 2010, around 69,071 death certificates listeddiabetes as the underlying cause of death. Diabetics causes neurovascular complications which leads to development of high pressure areas in the feet. Diabetic neuropathy causes severe nerve damage, which may ultimately lead to ulcerations. As a remedy sending imperceptible vibrations through the feet of diabetics and stroke patients significantly improves the damaged nerves and stimulates the blood flow, according to a study conducted by a biomedical university in America. Diabetic Neuropathy is a serious medical disorder and can be prevented by the early detection of abnormal pressure patterns under the foot. Although equipment to measure foot pressure distribution is available in India and elsewhere, these are still not readily accessible for a large segment of the population, are too expensive to own, and are too bulky to be portable. The foot pressure monitors are also not readily available in less developed countries which are home to many communities with a high prevalence of diabetes. This project not only enables early detection but also provides treatment and prevention of Diabetic Neuropathy which is a serious medical disorder. Equipment to measure foot pressure distribution is either too expensive to own or too bulky to be portable. The system design in our project is such that the sensors and actuators can be fitted within the shoe unit and the monitoring unit a simple handheld device allowing to overcome the previous drawback.Thus our project will be cheaper and readily available in less developed countries which are home to many communities with a high prevalence of diabetes.Large external memory allows the system to continuously store data from the smart shoe even for several weeks.Advanced Color Graphical User Interface with the help of a TFT LCD and Touchscreen Panel.Next generation ARM Cortex-M3 architecture is the chosen hardware platform, ideal when low power and high performance is needed.

1.1 Related work

Benoit Mariani, Mayt´e Castro Jim´enez, Franc¸ois J. G. Vingerhoets, and Kamiar Aminian, Member, IEEE (2012) "On-Shoe Wearable Sensors for Gait and Turning Assessment of Patients With Parkinson's Disease". This paper presents an innovative technology based on wearable sensors on-shoe and processing algorithm, which provides outcome measures characterizing PD motor symptoms during TUG and gait tests. Our results on ten PD patients and ten age-matched elderly subjects indicate an accuracy±precision of 2.8±2.4 cm/s and 1.3 ±3.0 cm for stride velocity and stride length estimation compared to optical motion capture, with the advantage of being practical to use in home or clinics without any discomfort for the subject. In addition, the use of novel spatio-temporal parameters, including turning, swing width, path length, and their inter cycle variability, was also validated and showed interesting tendencies for discriminating patients in ON and OFF states and control subjects.

1.2 Existing solution

- Diabetic neuropathy is a serious medical disorder and can be prevented by the early detection of abnormal pressure patterns under the foot. Although equipment to measure foot pressure distribution is available in India and elsewhere, these are still not readily accessible for a large segment of the population, are too expensive to own, and are too bulky to be portable. The foot pressure monitors are also not readily available in less developed countries which are home to many communities with a high prevalence of diabetes.

2. Proposed system

This project not only enables early detection, but also provides treatment and prevention of Diabetic Neuropathy.Sensor and actuators can be fitted within the shoe unit and the monitoring unit is a simple handheld device which is portable and less expensive.Thus our project will be cheaper and readily available in less developed countries.The large external memory allows the system to continuously store data from the smart shoe even for several weeks.

2.1 Hardware description

The system consists of two components

- Footwear unit
- Handheld unit

The footwear unit has the a 3-axis MEMS Accelerometer to monitor the foot movement. The foot pressure distribution is measured by a set FlexiForce pressure sensors located on the insole of the shoe. To improve the blood flow the smart footwear has a set of miniature Vibrating Motors. The footwear unit measures the pressure sensor outputs and transmits the information using IEEE 802.15.4 wireless transceiver to the handheld monitoring unit.

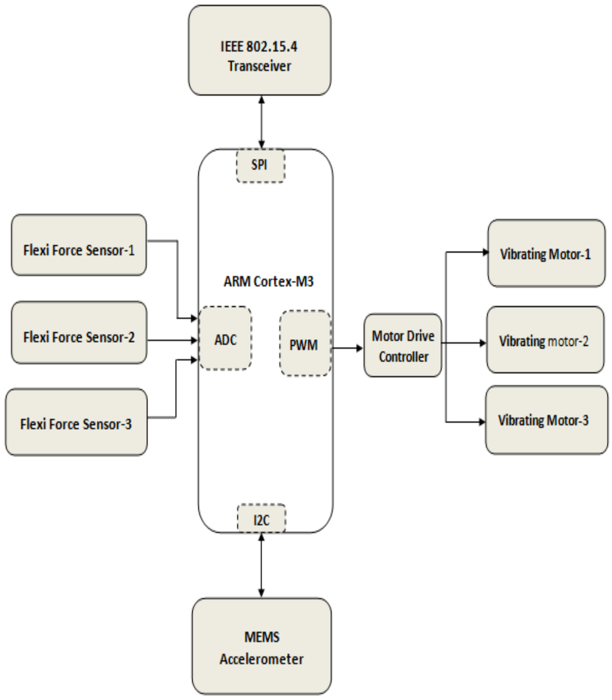

FIG 1. Circuit diagram of shoe unit

The handheld unit has equipped with a 65K Color Touchscreen TFT Display that receives the wireless data.When the accelerometer detects any anomaly, the buzzer is used to provide an alert to the patient. A 2GB memory card is utilized to store the data that is collected,

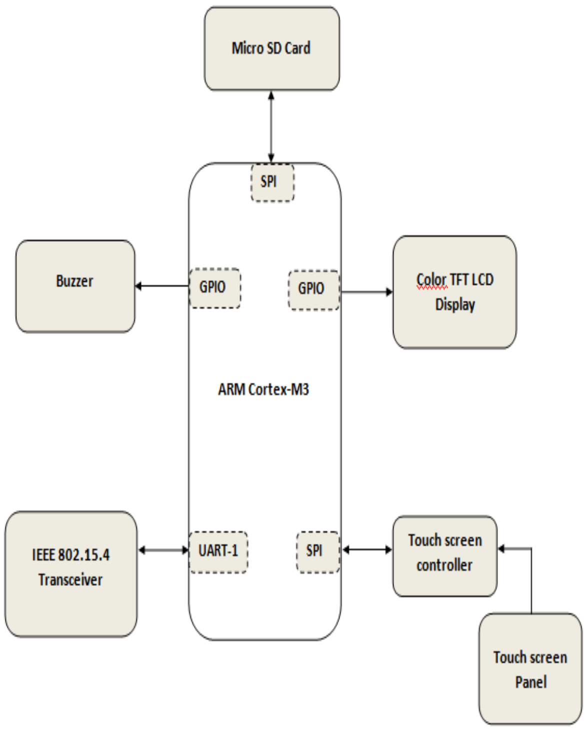

FIG 2. Circuit diagram of handheld device

2.2 Flexi force sensors

A force-sensitive resistor (alternatively called a force-sensing resistor) has variable resistance as a function of applied pressure. In this sense, the term “force-sensitive” is deceitful – a more appropriate one would be “pressure-sensitive”, since the sensor's output is dependent on the area on the sensor's surface to which force is applied. These devices are fabricated with elastic material in four layers, consisting of the following. A layer of electrically insulating plastic.An active area consisting of a pattern of conductors, which is connected to the leads on the tail to be charged with an electrical voltage. A plastic spacer, which includes an opening aligned with the active area, and an air vent through the tail. A flexible substrate coated with a thick polymer conductive film, made parallel with the active area. This polymer is very often reintegrated by a layer of FSR ink.

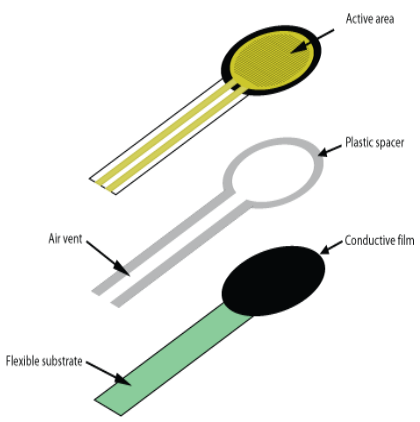

FIG 3. Flexi force sensors

2.3 Buzzer

It generally consists of a number of switches or sensors connected to a control unit. This control unit determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.

FIG 4. Buzzer

2.2 Description of modules

The system of working consists of three modules such as

i. Detecting anomaly in foot movement

The device monitors the user foot movement using a 3-axis MEMS Accelerometer and actively looks for situations leading to foot injuries. Once the system detects an anomaly in the user's foot pressure distribution or foot motion, it issues an alert to the handheld touchscreen device The handheld touchscreen unit communicates wirelessly with the foot attached unit and collects real-time data, stores it in the memory card for analysis by a doctor at a later time.

ii. Measuring foot pressure

.In this system, the foot pressure distribution is measured by a set FlexiForce pressure sensors located on the insole of the shoe. These sensors are based on force-sensing resistors, whose resistance varies inversely with the applied force. The footwear unit measures the pressure sensor outputs and transmits the information using IEEE 802.15.4 wireless transceiver to the handheld monitoring unit. The monitoring device is equipped with a 65K Color Touchscreen TFT Display that receives the wireless data and displays the foot pressure information on color bar graph as well as store that data in the memory card. Both the footwear unit and the handheld display unit use LPC1313, a 32-bit ARM Cortex-M3 Microcontroller from NxP Semiconductors. Apart from the application software and the device driver firmware the microcontroller also runs software such as a Graphics Library, a FAT-32 File System and an IEEE 802.15.4 Wireless Networking Protocol Stack. The handheld touchscreen unit communicates wirelessly with the foot attached unit and collects real time data, stores it in the memory card for analysis by a doctor at a later time. The footwear unit measures the pressure sensor's output and transmits the information using **IEEE 802.15.4** wireless transceiver to the handheld monitoring unit.The monitoring device is equipped with a **65K Colored Touchscreen TFT Display** that recieves the wireless data and displays the foot pressure information as well as store that data in the memory card.

iii. Improving blood flow

To improve the blood flow the smart footwear has a set of miniature Vibrating Motors that stimulate the nerves by vibrating in different amplitude that can be configured individually, started and stopped by the user using the handheld touchscreen unit. The smart footwear will collect data from foot pressure sensors and foot motion sensor and periodically transfer this data to the handheld unit where it will be stored in a 2GB MicroSD memory card for future reference or for an analysis by a doctor.

3. Working of the system

Initially when the system is on, the LCD display screen shows two options

- Data Logger
- Vibrating motors

The data logger option provides options to START_RECORD and VIEW_RESULT. The START_RECORD displays three scales A,B,C for the three flexi-force sensors. Depending on the amount of pressure applied , the display is shown on the scale. The VIEW_RESULT option provides the maximum value measured and also the average value of the system

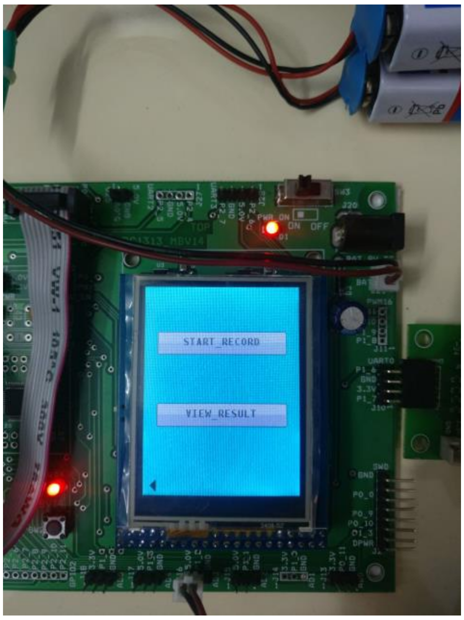

FIG 5. The options provided within data logger

The vibrating motors option enables the patient to provide vibrations to the muscles of his feet. It again displays three scales for the three vibrating motors . By adjusting the scale the frequency of the vibrating motors can be manipulated by the user itself.

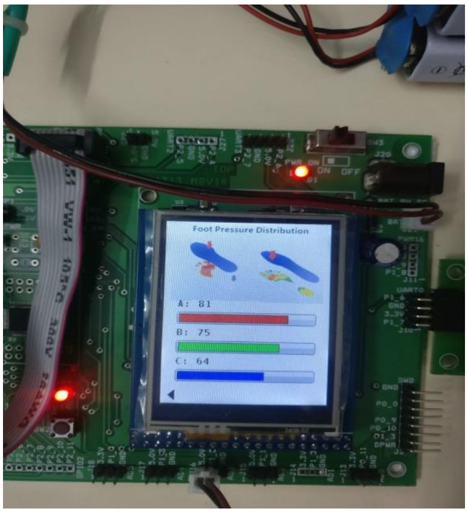

FIG 6. The pressure range in A,B,C sensors

3. CONCLUSIONS

This system has been proposed to provide a low cost, short-time remedy for the patients have diabetic disorder. It is designed to control the high pressure areas of his feet by provide vibrations of different frequency as required by the user, along the muscles of his feet. This device can be used from anywhere and anytime. The future enhancements can be made by minimizing the size of the components utilized inside the shoe to make it seem more comfortable to the user who wears it. The footwear unit can also be connected to the mobile phone.

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