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SMART SHOE FOR DIABETIC NEUROPATHY MANAGEMENT

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ABSTRACT

Bio medical instrumentation is a very innovative branch of engineering which offers help to medical services. Diabetes is one of the most growing diseases worldwide. As India is in leading spot of this, we need to focus more on the management and prevention of the disease than just curing it. Our system helps the Doctors as well as patients to keep an eye on a diabetic neuropathy patient using smart shoe. This system use plantar pressure to analyze the pressure distribution. It uses a low cost, small size, energy efficient embedded system along with proper communication channels and a classic set of pressure sensors.

Keywords: Diabetic, Neuropathy, Plantar Pressure, Neuropathy Management

I. INTRODUCTION

India is a second largest country having diabetic [1]. This leading Asian country also has the fastest growth rate of diabetic patients [1]. In a survey conducted by International Diabetes Federation it has been found that in 2010 50.8 million people were affected by the disease which then horrifically turn to 65.1 million (survey was limited for India). This shows the growth rate of 28%. It can be easily stated as dangerously growing. The main cause for such a hazardous growth rate in India is the changing life style of the people, unhealthy eating styles, lack of physical activity etc. Diabetes is also hereditary[2] Any family history of diabetes puts you in risk of having diabetes. In early years it was assumed that the obesity is the strong reason for the diabetes but recent findings shows that now diabetes has evolved and likely to affect anybody. The chance of getting diabetes for a thin person is almost the same as the obsessed ones. The age limits are also of the tables now a day. [3] It can affect anybody of any age starting from as low as 13 years and above.

The early detection is not that easy to detect in day to day routines if not paid attentions, for such reasons it can grow within a patient without noticing. There is a high chance of such patients to convert from diabetes to a Diabetic Neuropathy. [4] When you have diabetes for a long time, it affects some parts in the body. In most of the cases it affects nerve system.[5] This percentage of affecting nerve is as great as 42%. [6][7] This is called as neuropathy. Neuropathy's are of various types and are painful.

The most common neuropathy is Peripheral neuropathy.[8] Around 80% of neuropathy developed belongs to peripheral neuropathy.[7] Hence our entire focus is concentrated on the peripheral neuropathy since it is most commonly occurred neuropathy. It has been found in studies that increase in plantar pressure is the most common reason for developing peripheral neuropathy. This excessive increase in pressure occurs because of the

high blood sugar. These excessive pressures also lead to immobility of joints or restriction on movements in the joints. [9] It has known from Doctors, physiotherapist experiences that foot neuropathy do not occur suddenly. It is a long term process of development of neuropathy which further leads to ulcer. Those who are currently suffering from diabetes are most likely to develop this peripheral foot neuropathy. This percentage is about 42% in a country like India. [6] A patient of diabetes who has developed a neuropathy may choose an ill fitted shoe due to loss of sensations in the feet. This ill fitted shoe can lead him to ulcer. [9]

Following are the images which represents the plantar pressure points in normal foot.

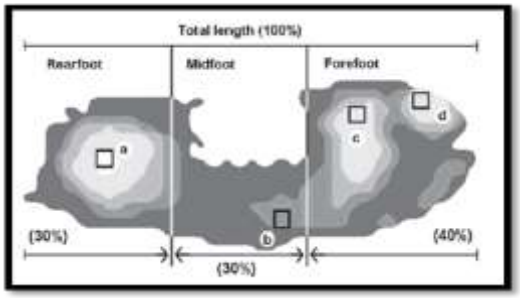

Fig. 1 Pressure regions in human foot [10]

Following Fig. 1 shoe the image which represents the plantar pressure points in normal foot to be specific these areas are concentrated by medical studies which are shown in Fig. 2 and have found following points for the consideration. It is better to consider one point rather than a whole area. Following Fig. 2 image show the points of plantar pressure. It is necessary to define the observation points from the anatomical points because it is not necessary to consider all the points for fulfilling the purpose. The point selection should be such that it must cover all the points.[11] The following figure shows the system diagram which consist all the main parts of the system. It describes the system and also gives a brief idea about the elements of the system and their co-ordination. It contains pressure sensor for the plantar pressure measurement along with the signal conditioning needed for the same, System computational element, a controller is shown in a figure. The processing element is needs to be connected with the I/O device. The Bluetooth Module is connected to the controller for the connectivity with the PC.

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Fig. 2 Foot anatomical areas [12]

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II. SYSTEM DIAGRAM

The following figure shows the system diagram which consist all the main parts of the system. It describes the system and also gives a brief idea about the elements of the system and their co-ordination

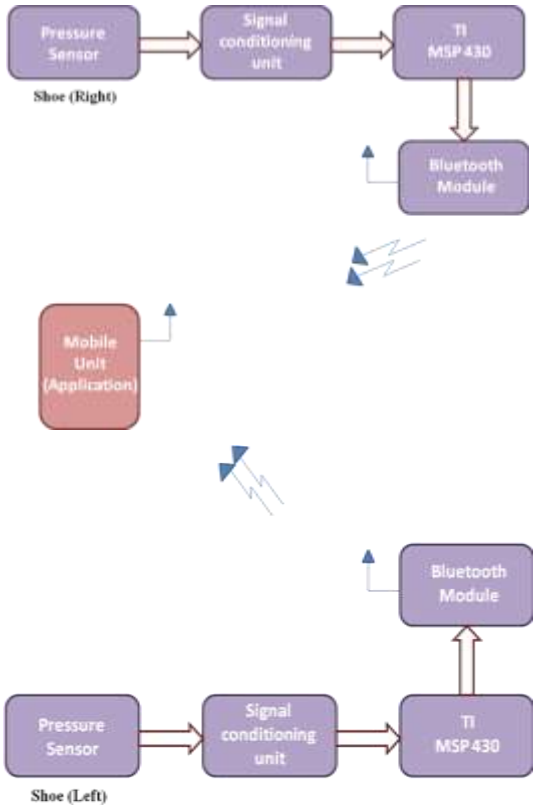

Fig. 3 System Diagram

It contains pressure sensor for the plantar pressure measurement along with the signal conditioning needed for the same. System computational element, a controller is shown in a figure. The processing element is needs to be connected with the I/O device. The Bluetooth Module is connected to the controller for the connectivity with the PC

III. PLANTAR POINT'S SELECTION

Following figure shows the points we are considering for the monitoring purpose. We have taken care of regional satisfaction for the planar pressure regions. These points are selected after a discussion with the physicians / Doctors, who have treated a neuropathy tending diabetic patient

Fig. 5 selected plantar pressure points

IV. DESCRIPTION AND WORKING

The pressure sensor is used for measuring the pressure in the foot. The specific points are mentioned in the relevance. (Fig. 6) Those are the point of measurement for the right and left foot. Those are same for both male and females.

The plantar pressure measured is basically pressure measurement of desired plantar points in the foot. This section involve two decisions one is that to decide the sensor itself and other is to decide the position of the sensor. There are number of verity in the selection of sensor we considered following sensors for the selection. We studied following sensors and based on a comparative study we have conducted, we have chosen the FSR (Force Sensing Resistors) pressure sensor.

The type of sensors choose for comparison are as follows

- Piezo-electric pressure sensor
- Strain Guage pressure sensor
- Plate type pressure Sensor
- FSR Sensor

The FSR's have the moderate size which was perfect for the application. It is light weight and can be fitted into shoe. It makes it the clear choice as it is having high robustness, which is necessary in such applications.

The controller we have chosen is MSP430 of Texas instruments. We have chosen this controller based on the comparative study we have carried out on following controllers

1. Raspberry Pi
2. MSP 430
3. Uno Arduio
4. ARM
5. PIC
6. 8051

The MSP430 is ultra low power micro controller provided by Texas. It can operate on 3.3v power supply without compromising the computational capabilities, which gives us the benefit to use low weight batteries for power supply. It is also smallest as compared with all others. The output of the pressure sensor is not sufficient

for driving the port of the controller. The output of the sensor must be conditioned, that is amplified for the proper operation purpose. We are using amplification and shaping circuit for the sensors. Bluetooth module is communication unit of the system. Reason behind using the Bluetooth is it is most sophisticated communication system for short distances. Every mobile phones, PC's, laptops now a day provided with this facility. It makes the system more useful in wide area. Using the Bluetooth communication we will be able to send the data to the receiver unit.

V. SENSOR AND SPECIFICATIONS

We have choosen a FlexiForce sensor which is shown in fig. 4, for the application whose working, signal conditioning unit and specifications are as follows

Fig. 4 FlexiForce 30056

Signal conditioning circuit for the sensors are shown in following figure

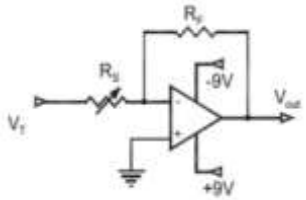

Fig 5 Signal conditioning unit using op amp

This circuit converts the resistive response to the voltage. The range of sensor is depending upon the feedback resistor R_F, the threshold voltage V_T and the operating voltage of op amp. We have used the op amp in inverting mode for better stability hence is becomes necessary to use negative threshold voltage for positive output voltage Vout otherwise need to go for multistage amplifier.

Following are the specifications of the sensor

- Measure both static and dynamic forces Simple RC circuit interface
- Communication: Variable resistance inversely proportional to applied force
- Operating temperature: 15 to 140 °F (-9 to 60 °C)
- Dimensions: 8.00 x 0.55 x 0.008 in (203 x 9.53 x 0.208 mm)
- Versatile small size
- Ultra-thin, flexible printed circuit
- Compatible with all Parallax Microcontrollers

VI. SYSTEM WORKING DETAILS

The FSR pressure sensors will sense the pressure exerted by the subject which is known as plantar pressure. This sensed pressure then goes through the signal conditioning circuitary, the signal conditioning is shown in

Fig. 5, which will model signal with amplification. This amplified signal is given to MSP430 controller which converts the signal to digital by using ADC.

The MSP 430 now decides by processing the data, if it is above threshold level and it will send all the data to the android application with the help of Bluetooth.

VII. ANALYSIS

In the system development we must consider two major analyses for the plantar pressure measurement. The two are as follows

7.1 Static plantar pressure

Static plantar pressure is the plantar pressure measured when an object is standing still and not moving.[8] It is helpful for normal measurement purpose. For advance measurements with more accuracy one should go for Dynamic plantar pressure measurement.[14] Usually it deals with normal distribution of the pressure in the foot. The pressure plate sensor is sufficient for the static measurement.

7.2 Dynamic plantar pressure

Dynamic plantar pressure is plantar pressure measured while object is moving, walking, jumping or doing any physical activity.[15] We are focusing on the walking activity here because it will fulfill the need so do not need to go for other activities. It is most useful measurement system. It deals with dynamic distribution of the pressure.[13]

The data collection is very important for analysis. Once the data is collected, depending upon the predefined normal levels as well as patient's neuropathic history, the system will suggest the correcting actions / precautions taken by the user. These precautions involve walking pattern and daily foot care advice.

The plantar pressure is nothing but the pressure observed by the skin of the foot while walking or doing similar activities. These plantar pressure values are needed to stable all the time. If the unbalancing is happening in the plantar pressure at any 4 points mentioned then subject is likely to develop peripheral neuropathy**.**

VIII. CONCLUSION AND RESULTS

The sensor output after conditioning is given to the ADC which converts it to a digital value. The values need to be précised and accurate. The following figure indicates such plantar pressure values obtained from the designed circuit. Fig. 6 represents the result obtained at PC and Fig. 7 gives the results at the android application.

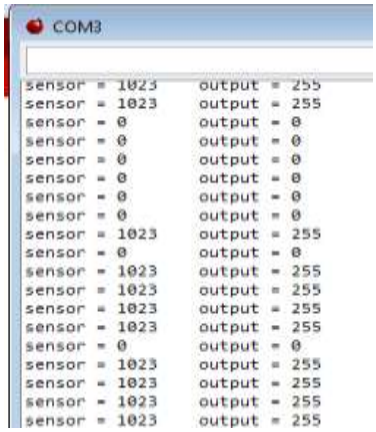

Fig 6 Plantar pressure values at PC

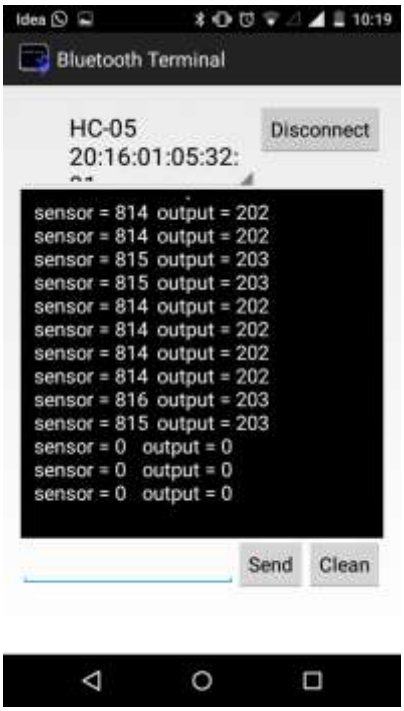

Fig 7 Plantar pressure values at Android app

The plantar pressure values have been obtained on the PC as well as on Android App for observation purpose. The initial analysis is done within processor for the recognition of pressure level.

IX. FUTURE SCOPE

In addition to above work done we can add some other features to enhance the system. It will make system more user friendly as well as more sophisticated. The full developed system will accommodate all the features. The future features are as follows

1. Android Application talk back guidance for patients walking abnormally.
2. BMI relation with plantar pressure data
3. Age and sex relations with plantar pressure of the patient
4. Alerting system for emergencies

X. ACKNOWLEDGEMENTS

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