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Optimized Foot Plantar Pressure Measurement System

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Abstract: Diabetic Foot complications represent a tremendous challenge for patients, caregivers, and the health care system. Studies also show that up to 25% of diabetic individuals will develop a foot ulcer during their lifetime. Peripheral Neuropathy that affects the legs and feet is the most common type of nerve damage. Many of these patients eventually must undergo amputation as a result of infection due to foot ulcers. With the help of current technology, in-shoe monitoring systems monitor at-risk ulceration sites based on known indicators such as peak pressure. The most important parameters in designing a pressure-sensing insole include the number, location, and size of the sensors. In this project proposal, we aim at showing the criticality of sensor architectural trade-off in developing the in-shoe plantar pressure monitoring systems. We evaluate this trade-off by using our custom-made platform for data collection during normal walking.

Keywords: MQTT, Neuropathy, Foot Ulcer.

I. INTRODUCTION

Diabetic Foot Ulcer is the most devasting complication of diabetes mellitus. The prevalence of diabetes is more common, leading to neurovascular complications and increasing pressure among the foot regions. Foot Ulceration and lower-extremity amputation are devasting stages of diabetes. Foot ulceration affects 25% of patients with diabetes during their lifetime, and 85% proceed to lower amputation. Diabetes is a disease in which the body does not properly process food for energy. Most of the food we eat is turned into glucose or sugar for our bodies to use for energy. The pancreas is an organ that is located near the stomach, makes a hormone called insulin to help glucose get into the cells of our bodies. A diabetic foot ulcer is a significant complication of diabetes. Ulcers form due to some factors such as lack of feeling in the foot, poor circulation, foot deformities, irritation, trauma, and the duration of diabetes. So patients suffer from sensational loss and lead to injury. In patients with diabetic neuropathy, loss of sensation in the feet leads to repetitive minor injuries from internal or external causes and may lead to foot ulceration. So prevention of diabetic foot ulcers is needed. Regular examinations by a doctor are essential to prevent infections, amputations, and deformities. This project aims to prevent severe ulceration and provides feasible regular checkups of diabetic patients. The proposed system acquires the foot pressure with the help of sensors (Piezoelectric sensors) and variations among the different regions are calculated. It helps in earlier diagnosis of foot ulceration at an earlier stage, thereby preventing foot ulceration.

II. SYSTEM OVERVIEW

The prototype designed consists of three piezoelectric sensors and a pedometer sensor which is used to detect the condition known as diabetic neuropathy. This is a serious condition which may lead to amputation if not treated. The system has the piezoelectric sensor which is used to monitor the patient's pressure levels on foot. If the pressure level increases past a particular threshold value the patient is said to be suffering from diabetic neuropathy. The pedometer that is fixed in the prototype can be used to calculate the distance walked by the patient by calculating the steps taken. By calculating the steps , a clear output can be taken which can be used to get a detailed report.

From the above figure, it can be clearly seen that the pressure and steps sensed by the sensors are given to the node MCU which is then displayed in an app known as MQTT. MQTT stands for message queuing telemetry transport. MQTT is a lightweight publish-subscribe network protocol that is used to transfer messages between devices. The protocol used here is the TCP/IP protocol. Suppose a broker receives a message on a topic for which there are no current subscribers; the broker discards the messageunless the publisher of the message designated the message as a retained message. A retained message is a standard MQTT message with the retained flag set to true. The broker then stores the received message and the quality of service of the service selected. Each client that subscribes to a topic pattern that matches the case of the enclosed message receives the retainedmessage immediately after they subscribe. It allows new subscribers to a topic to receive the most current value rather than waiting for the next update from a publisher.

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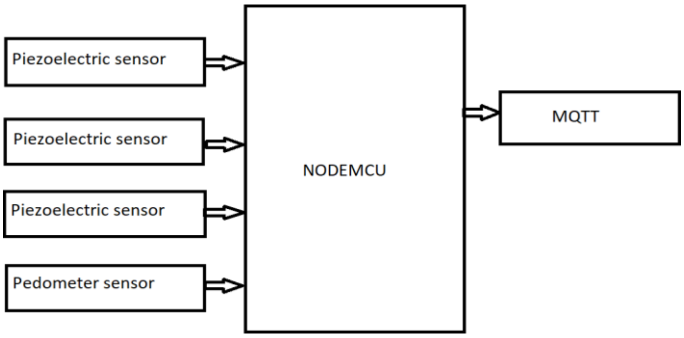

Fig 1 Block Diagram

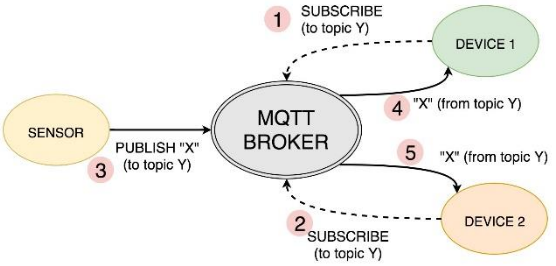

Fig 2 MQTT Architecture
(https://www.norwegiancreations.com/2017/07/mqtt-what-is-it-and-how-can-you-use-it/)

2.1 Piezoelectric sensor

A sensor that works on the principle of piezoelectricity is called a piezoelectric sensor. Thequantities measured by the piezoelectric sensor are pressure and acceleration.Both pressure and acceleration sensors work on the same principle of piezoelectricity, but the main difference is how force is applied to their sensing element.

In this sensor the pressure is applied on a thin membrane from where the pressure is transferred to the piezoelectric element. Upon applying pressure on this thin membrane, the piezoelectric material gets loaded and starts generating electrical voltages. The produced voltageis proportional to the amount of force used. In an electrical signal the sensor can be called as a pressure transducer. Sensors are also known as primary transducers. The piezoelectric sensors are placed at three maximum pressure points in each leg. The piezoelectric sensor's top pressure points are placed at heel, toe, metatarsal1, and metatarsal2, metatarsal3. The pressure given on the piezoelectric sensor is converted into a voltage at the sensor.

Fig 3 Piezoelectric Sensor
(https://www.elprocus.com/what-is-a-piezoelectric-sensor-circuit-specifications-and- applications/)

2.2 Pedometer sensor

The pedometer is a sensor used to count the steps taken by a person by tracking the motion of the person's hips. The pedometer uses a sensor which is mechanical and a software to calculate the steps. In the olden days, the pedometer sensor that existed worked like pendulum clocks. The wheel of the gear moves one position as the pendulum rocks back

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and forth. In a see-saw manner. So the pendulum clock is the actual mechanism behind the counts.
Modern pedometers work similarly, but they are partly electronic. A metal pendulum is wired into an electronic circuit by a thin spring in this pedometer. Usually, the circuit is open, and no electric current flows through it. When a step is taken, the hammer swings across a metal contact center, completing the circuit and making the current flow. The flow of current energizes the circuit and increases the step count to one. The next step is calculated only when the hammer swings back, effectively resetting the pedometer. The pedometer sensor is placed at the heel to calculate the actions taken by the user.

Fig 4 Pedometer Sensor
(https://community.createlabz.com/knowledgebase/3-4-bpm-pulse-sensor-and-pedometer-adxl345-accelerometer-wearable-device-with-oled-display/)

2.3 Node mcu

Node MCU is an open-source IoT platform. It includes firmware that runs on the ESP8266 Wi-Fi SoC and hardware, based on the ESP-12 module. The Nodemcu operates in range of 3V to 3.6V and it has a LDO which keeps the voltage steady at 3.3V. Node MCU has 128 KB RAM and 4 MB of flash memory to store data and programs. Itcan be powered by using a micro USB jack and VIN pin. It supports UART, SPI, and 12C interface. The ESP8266 Node MCU has a total of 17 GPIO pins broken out to the pin headers onboth sides of the development board. The pins are assigned to the following :
ADC channel: A 10-bit ADC channel.
UART channel: UART interface is used to load code serially.
PWM outputs: PWM pins for dimming LEDs or controlling the motors.
SPI,12C,12S interface: SPI and 12C interface to hook up all sorts of sensors and peripherals.
12S interface:12S interface to add sound to the project.

Fig 5 Node MCU
(https://en.wikipedia.org/wiki/NodeMCU)

III. RESULTS AND DISCUSSION

After analyzing the foot pressure areas using three sensors, The output pressure values at the maximum pressure points in metatarsal 1, metatarsal 2, and metatarsal 3 is noted for normal persons as shown below:

Table 1 Normal Persons

Persons	Weight (Kg)	MT1 (Pa)	MT2 (Pa)	MT3 (Pa)
1.	37	43	20	29
2.	47	44	20	29

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3.	68	70	21	29
4.	83	88	21	29

The above voltages shown were the averaged values over a specific range. It is found that the values between the different pressure points do not vary much in the case of normal persons.
The output voltages at the maximum pressure points noted forneuropathy patients are shown below:

Table 2 Neuropathy Patients

Persons	Weight (Kg)	MT1 (Pa)	MT2 (Pa)	MT3 (Pa)
1.	65	108	69	116
2.	68	116	60	177

In the above table, it is seen that the neuropathy patients exhibit different pressure on their feet. For example, in case 2, the average output voltage is maximum at MT 3. Hence the variation between the pressure points varies much in the case of diabetic neuropathy patients.
The output pressure values at three maximum points are noted for both normal and abnormal persons, and the results were studied. It is found that the variations between the pressure points were more in the case of abnormal patients than the normal person. For normal persons, the variations between the pressure points are constant or do not vary more.

Fig 6 Project Implementation

Fig 7 Placement of hardware

Fig 8 MQTT App displaying pressure values for normal persons

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Fig 9 MQTT App displaying pressure values for neuropathy patients

IV. CONCLUSION

The experimental setup, designed to acquire a foot pressure signal, the piezoelectric sensor has an input of 12 V. The pedometer sensor has an input of 3.3V. The sensor readings are transmitted to the end-user using the MQTT protocol. The pressure is calculated using voltage The output voltage from the piezoelectric sensor is converted into a pressure unit. The values of both normal and abnormal persons were studied using thisoutput. For an average person, the sensor's output voltage variationswill be minor, whereas, for the abnormal patients, the variations willbe more. There will be an increase in pressure if there is a possibility ofgetting a foot ulcer in a particular area. So any variation in Foot pressure indicates early detection of foot ulcers. It is beneficial to the Physician for detecting foot ulcers in earlier stages and reduces footamputation possibilities.

REFERENCES

[1]. Development of Plantar Foot Pressure Distribution System using Flexi force sensors, S.L.Patil,Madhuri A.Thatte, U.M Chaskar.
[2]. Diabetic Foot Neuropathy Monitoring System, Sahana H R1. Shivani S U 1.Pallavi Badiger1.Bindu B.J1 Nagendra G L2. SUDHA.H3
[3]. A study of dynamic foot pressure measurement in diabeticpatients, Milka D Madhale, Naresh K Tyagi, Ashok S Godhi.
[4]. A real time foot pressure measurement for early detection ofulcer formation in diabetics patients using myrio, A.N.Nithyaa, R.Premkumar, S.Dhivya, M.Vennila