Detection of Foot Ulcer using IoT Technology

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Abstract: *Analysis of foot plantar pressure distribution is an important factor considered today in the field of healthcare. Diabetic patients generally develop the complications of foot ulcers, breaking down of the skin tissue in the case poorly controlled diabetics. To avoid long-term damage to the affected part and to accelerate the recovery period, it is necessary to keep an eye on the patient regularly following his/her rehabilitation activities not only in the hospital but also at home. Multiple techniques have been developed for quantitative gait analysis but comparatively these systematic process fails as it measures static or dynamic process for very short duration of time and space. As the number of the diabetic patient are increasing globally with the change in the lifestyle, the measures for the early detection of the diabetic related problems are gaining medical importance. Diabetic patients develop foot ulcers because of improper blood flow, loss of the sensation, and low wound healing rate. The developed system, will provide readings of the hardness level at various parts of the foot. This is done by placing the person's foot above the sensing module. With the help of Internet-of-Things(IoT), when the signal goes beyond the limit the notification will be sent to patient consulting the doctors/physiotherapist so that immediate action can be carried out further. The device can help the clinician and the patient a tool to monitor and receive condition feedback.*

Key words: IoT (Internet of Things), Diabetics, Foot ulcer detection.

I. INTRODUCTION

Diabetes is one of the major causes of premature illness and death worldwide according to the World Diabetes Foundation; approximately 300 million people in the world today have diabetes, mostly type 2. Each year the number is increasing by 7 million, reaching 438 million in the year 2030 or 7.8% of the adult population. This is the rise of 54% in 20 years. Feet provide stability support while walking, standing and running. The foot has five major functions, it is the foundation for the whole body, it can adopt to uneven ground, it acts has a shock absorber, it provides leverage for propulsion, and it absorbs transverse leg rotation. Loss of anyone of these functions can be detrimental to the patient, and is often noticed in patients with diabetes. Diabetes mellitus, commonly referred to as diabetes was first identified as a disease associated with "sweet urine", and excessive muscle loss. Elevated levels of blood glucose(hyperglycemia) lead to spillage of glucose into the urine, hence the term referred as sweet urine. Normally, blood glucose levels are highly controlled by insulin, a hormone produced by the pancreas. Insulin regulates the blood glucose level. In patients with diabetes, the absence or insufficient production of insulin causes hyperglycemia. Most common among the neuropathies are chronic sensorimotor distal symmetric polyneuropathy and the autonomic t neuropathies. The lack of protective sensation from sensory neuropathy leads to repetitive trauma resulting in ulceration and is considered as one of the major initiating risk factors in the pathogenesis of diabetic foot ulceration (FU

II. TESTING METHODS

A. Normal Blood Pressure Test

This is the first test performed for the diagnosis of diabetic foot ulcer. The blood pressure measurements are done with the help of sphygmomanometer. The sphygmomanometer consists of an inflatable rubber cuff which will be applied to the upper arms to restrict the flow of blood. In addition, it consists of mercury or a mechanical manometer to measure the pressure values. The blood pressure readings usually represent the systolic pressure and diastolic pressure. The pressure foot ankle region is also measured.

B. Doppler Test

The blood flow in the foot region is checked by Doppler test. In this process the gel will be applied on the foot area to be tested and then the device will be moved across the foot area. The sound waves in the foot region indicate the flow of blood and the absence of sound waves indicates there will be no flow of blood to the foot region.

C. Monofilament Test

It is an effective indicator of diabetic foot ulcer. The monofilament is a piece of plastic fiber, it will be touched against various parts of the soul of the feet and the ability to feel it at varying pressure will be determined. Based on these methods the foot ulcer was detected earlier even though these methods are simple it has some complexity involved in it.

III. METHODOLOGY

A. Pressure Detector

The pressure detector consists of a shoe in which the insole is placed. The insole is made up of leather material which has the shape of the normal foot. The foot structure differs according to the gender of the patients. The pressure and temperature sensors are fixed on the insoles to monitor the pressure and temperature values on the foot region.

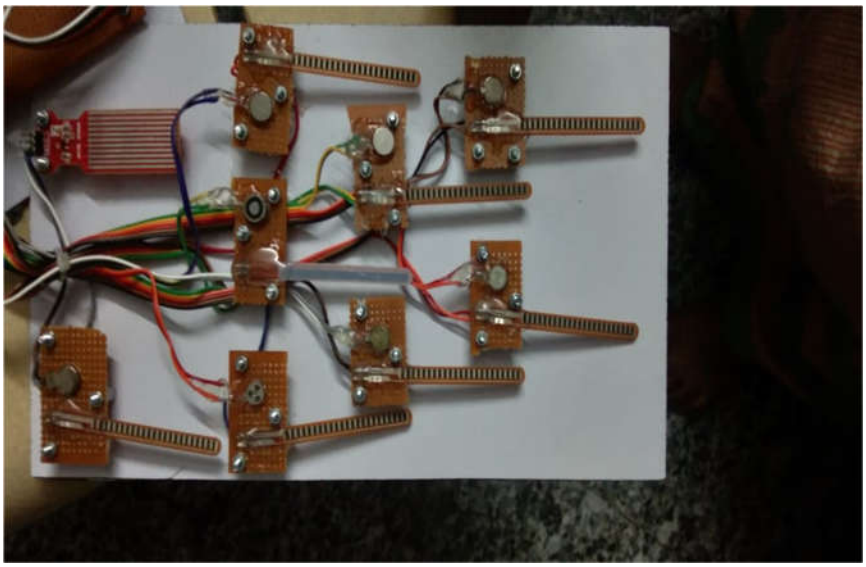

Fig. 1 Pressure Detector

The foot pressure from the pressure points can be measured using the pressure detector which consists of a Force Sensing Resistor, Moisture Sensor, Voltage divider circuit, voltage regulator to measure the foot pressure from the various parts of the diabetic patient's feet. Force Sensitive Resistor converts a physical phenomenon of applied force into voltage signal(P=F/A). The pressure from the foot region can be measured with the help of Force Sensing Resistor(FSR), in which the resistance varies with the applied force. The most essential measurement in the foot ulceration is the moisture measurement. Body moisture sensors measure the volumetric water content indirectly by using some other property of the body, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and body moisture must be calibrated and may vary depending on environmental factors such as body type, temperature, or electric conductivity. The requirements for implementing the detection of foot ulcer using pressure detector are of two types namely, Hardware requirements and Software requirements. The Hardware requirements used are Pressure sensor, Moisture sensor, Arduino, Resistor bridge, voltage regulator and power supply. The Software requirements used are Arduino IDE, NodeMCU, APACHE.

B. Pressure Sensor

A force-sensitive resistor (FSR) has a variable resistance as a function of applied pressure. In this sense, the term "force-sensitive" is misleading – 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. The flex sensor is a variable resistor like no other. The resistance of the flex sensor increases as the body of the component bends. Sensors like these were used in the Nintendo Power Glove. Left flat, these sensors will look like a 30kΩ resistor. As it bends, the resistance between the two terminals will increase to as much as 70kΩ at a 90° angle. By combining the flex sensor with a static resistor to create a voltage divider, you can produce a variable voltage that can be read by a microcontroller's analog-to-digital converter.

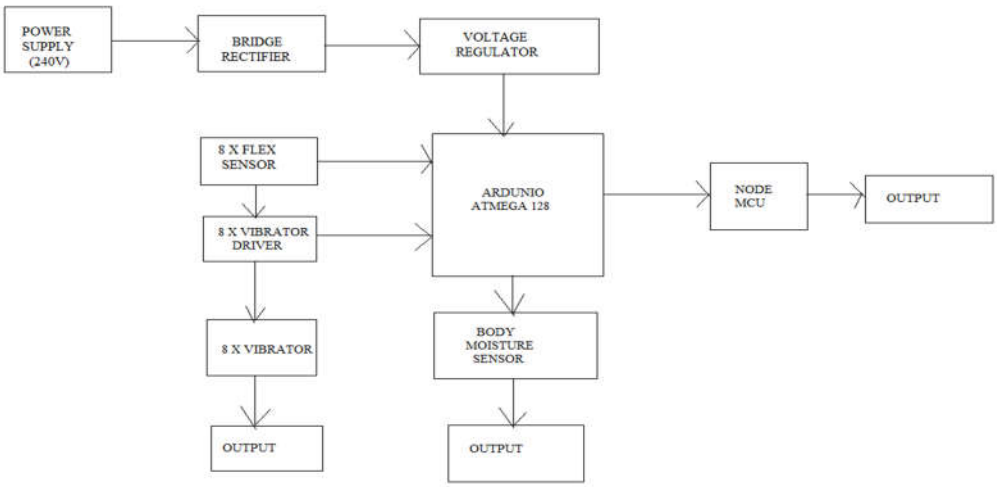

Fig.2 Block Diagram of Pressure detector

C. Moisture Sensor

BODY moisture sensors measure the volumetric water content in body. Body moisture sensors measure the volumetric water content indirectly by using some other property of the body, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. The relation between the measured property and body moisture must be calibrated and may vary depending on environmental factors such as body type, temperature, or electric conductivity. Body moisture sensors typically refer to sensors that estimate volumetric water content. Resistance value will be varied depend upon the Temperature level. Temperature varied means the resistance value also varied. If moister value increased means output also decreased. The moister value and output is inversely proportional one. Then the final voltage is given to ADC for convert the analog signal to digital signal. Then the corresponding digital signal is taken to process in microcontroller. The ADC value will increase if the temperature increased. We can measure the moister only with the help of any controller or processor.

D. Bridge Rectifier

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other.

E. Arduino IDE

Arduino uses a variety of single board microprocessors and controllers which are used for the purpose of building the digital devices and they are provided with a set of analog and digital input and output pins. They are able to sense objects. They are provided with the serial communication interfaces. In general, it is an open source hardware. Most of the Arduino boards are provided with the Atmel 8 bit AVR microcontroller. Arduino microcontrollers are preprogrammed to avoid the complexity. In general, it consists of software and a physical programming.

F. IoT Interface

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to connect and exchange data. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. **NodeMCU** is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson, and spiffs.

IV. RESULT

This paper gives a different way of approaching the foot ulcer. The foot ulcer can be detected at the earlier stage itself compared to the prior detection methods. By using the pressure detector in which the

moisture sensor and pressure sensors are attached and we can represent the sensor values in IoT in which the peak pressure values indicates that the patient has higher risk of foot ulceration.

TABLE 1 Different values of Pressure detection

S.NO	TEMPERATURE(degree Celsius)	HUMIDITY(%)	PRESSURE 1 (S1,S2)	PRESSURE 2 (S3,S4)	PRESSURE 3 (S5,S6)	PRESSURE 4 (S7,S8)
1	24.73	45.68	0.66	0.41	0.71	0.64
2	26.90	38.01	0.64	0.67	0.77	0.52
3	29.39	42.78	0.64	0.64	0.45	0.72
4	23.85	54.05	0.97	0.51	1.23	0.66
5	30.43	44.01	0.43	0.42	0.97	0.41
6	32.05	53.47	0.71	0.84	0.51	0.55
7	31.48	48.57	0.66	0.96	0.66	0.41
8	34.12	56.64	0.41	1.20	0.51	0.62
9	27.04	61.00	1.21	0.44	0.72	0.71
10	29.59	59.71	0.84	0.61	0.66	0.72

V. CONCLUSION

In this paper the pressure detector is developed for the purpose of detection of foot ulcer at the earlier stage itself without any discomfort to the patients. It alleviates the patients from the pain of detecting the disease. The earlier detection of the disease leads to early treatment which avoids the higher risk factors. The foot pressure value differs according to the factors such as gender, age, weight, history of diabetics. And the pressure given to the sensor differs according to the capacity of each and every individual.

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