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An Automatic Assessment System of Diabetic Foot Ulcers using Sensors

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Abstract: ***Diabetic foot ulcer is also one of the major complications caused due to Diabetes Mellitus. Diabetic Foot Ulcers are caused due to improper circulation of blood to a person's feet. This leads to the formation of gangrene and loss of sensations in the patient's foot. Majority of the diabetics ignore this problem because of diabetic complications such as neuropathy, diabetic patients do not feel any pain in their feet. Due to this they are neglecting the formation of an ulcer or wound on their feet, which ultimately leads to low leg amputation. To overcome this problem, the proposed system brings a solution in the form of "An Automatic Assessment System of Diabetic Foot Ulcers using Sensors" it is a device that is developed and evaluated to identify the patient's foot ulcers at an early stage. This is accomplished by placing five pressure sensors in different pressure points of the foot. The patient foot pressure readings are converted into corresponding voltage output by the sensors. Then the sensor value feed to the microcontroller, the microcontroller receives the input value and compare those value with the setpoint and triggers the indication message to the user and doctor when the actual value exceeds the set value. Here the Internet of Things is used as a mediator between the microcontroller and the users. The readings are transmitted to the doctor/patient using a wireless communication system, making the task easier. Also stores the input and output value on the cloud. Finally, based on the output of the values, it is possible to find whether the person has the probability to develop a diabetic foot ulcer or not.***
Key words: Diabetes Mellitus, Diabetic foot ulcer, Low leg amputation, Internet of Things, Cloud.

I. INTRODUCTION

Diabetic Mellitus is a type of metabolic disorder caused by high blood sugar levels. The sugar level increases by defects in insulin secretion or action in the human body. All around the world, diabetic mellitus is a commonly known disease with no permanent cure. As per 2016 data from the World Health Organization (WHO) 422 million adults are living with diabetes mellitus worldwide approximately. The major causes of diabetic mellitus are stroke, blindness, heart attacks, kidney failure, and lower limb amputation. At the year 2030 WHO projects that diabetes will be the seventh leading cause of death worldwide. One of the serious causes of diabetes is Diabetic Foot Ulcers. Diabetic Foot Ulcers are red sores that can occur most on the pad of the foot or the bottom of the big toe. They occur due to various factors, such as mechanical changes in the conformation of the bony architecture of the foot, peripheral neuropathy, and atherosclerotic peripheral arterial disease. Diabetes is the leading cause in India, with approximately 8% of diabetic Medicare beneficiaries have a foot ulcer and 1.8% have an amputation.

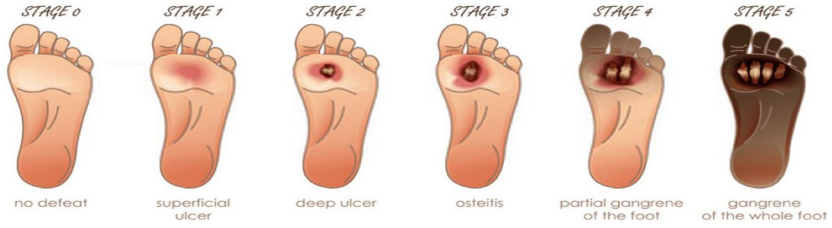

Figure 1: Stages of Diabetic Foot Ulcer

Figure 2: Foot Ulcer

As a human beings, we all have to protect our body parts from such those types of serious chronic diseases. Early identification of diabetic foot complications is necessary for preventing the chronic diseases, such as foot ulcers and amputation. Diabetic patients must check their foots regularly. Prevention is better than cure, likely one of the best methods to prevent the foot ulcer is daily inspection. Mechanical changes in the human foot are also a type of diabetic foot ulcer symptom, and this can be monitored by monitoring the foot pressure applied by the diabetic patient. The main aim of our project is to design a pressure pad, used to detect the foot pressure value of diabetic victims and alerting them to their corresponding output values. Day-to-day monitoring of mechanical changes in feet is very important and this can be done by the internet of things. A wide range of sensors is available for sensing the various. The modern method of solving a lot of problems by applying the system with the internet of things. If the system is applied to the IoT platform, then it gives a good performance, and control and also it permits transparency. Node MCU is used as a microcontroller that is connected with the various pressure sensors which detect the various applied pressures. The humidity and temperature sensors are also used to monitor environmental factors. If the applied pressure is increased in any piezoelectric sensor above the set value, it sends the alert message to the user, and the LED blinks continuously, which indicates the mechanical changes of the foot. The accuracy and speed of sending data must need high and thus the internet of things is used for transmitting and receiving data. The monitoring of applied pressures in real-time by using the internet of things can be improved the ability to detect mechanical changes of the foot.

II. LITERATURE REVIEW

This section discusses the existing systems. An embedded wearable device is used for monitoring the different parameters of the foot and using it for predicting the possible occurrence of ulcers in diabetic patients[1]. By using mobile phone technology. Flexi force sensor along with the GSM setup is used for screening diabetic foot ulcer in the early stage[2]. Leveraging smart technologies and mobile health technologies are used to improve the management of diabetic foot ulcers[3]. Based on wound area determination, color segmentation, and healing score evaluation, an automatic assessment of diabetic foot ulcer is obtained[4]. Foot pressure measurement is carried out for early detection of ulcer formation in diabetic patients by measuring various parameters of diabetic patient's foot and using the LabVIEW for analyzing the data[5].

III. PROPOSED SYSTEM

Diabetic patients are increasing day by day, and the effects caused by diabetics are also increasing, in order to reduce that serious chronic effects, early detection of the disease is most necessary. This proposed system is helpful for that.

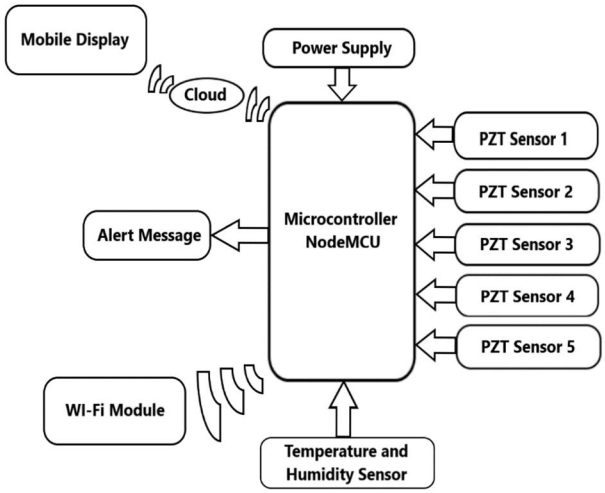

Figure 3: Block Diagram of An Automatic Assessment System of Diabetic Foot Ulcers using Sensors with IoT.

An automatic assessment system of diabetic foot ulcers using sensors consist of three major components as shown in figure 3

1) 5 Piezoelectric Sensor and temperature and humidity sensor.
2) Wi-Fi module.
3) Microcontroller.

An automatic assessment system of diabetic foot ulcers using sensors and by using IoT is shown in above figure 3. The system consists of five Piezoelectric sensors placed at different parts of the model. By using these sensors, the pressure from each part of the foot is taken into account, when a person walks or steps on a floor while wearing the proposed model. Those sensors are connected to the microcontroller. Then the sensor value feed to the microcontroller, the microcontroller receives the input value and compare those value with the setpoint and triggers the indication message to the user and doctor when the actual value exceeds the set value. Then the corresponding readings are from the sensors when a person walks. Based on these readings, the doctor can guess whether the person is walking normally, applying equal pressure on all parts of the foot, or whether there is something wrong with movement. If the doctor finds something wrong, then there is a chance of a diabetic foot ulcer being present in that part of the foot. The temperature and humidity sensor used to measure the working climate of piezoelectric sensors. Here the IoT is used as a mediator between the microcontroller and the users. The readings are transmitted to the doctor/patient using a wireless communication system, making the task easier. Also stores the input and output value on the cloud. Therefore the results are displayed on the Blynk app.

IV. HARDWARE DESCRIPTION

This section gives a brief description of hardware components

A. NodeMCU[ESP8266]

The open-source to design an IoT application at low cost with a less integrated circuit is NodeMCU. The inbuilt Wi-Fi module is present in the NodeMCU of ESP8266module. It consists of analog pins, digital pins, and serial communication protocols. It can be programmed easily with scripted language. Usually, the input voltage which is given to the nodeMCU is 5volts.

Figure 4: NodeMCU 8266

B. Piezoelectric Sensor (PZT sensor)

Figure-5 shows the Piezoelectric sensor, which is also known as a piezoelectric transducer. It is a device used to measure pressure, force or strain, acceleration, temperature by converting them to electrical charge, using the piezoelectric effect. These are the latest tools for the measurement of various processes, parameters and used for process control and quality assurance in many industries. The ability of the piezoelectric material to quickly convert mechanical stress into electrical charge is called a piezoelectric effect. Generated piezoelectricity is directly proportional to the applied pressure to solid piezoelectric crystal materials.

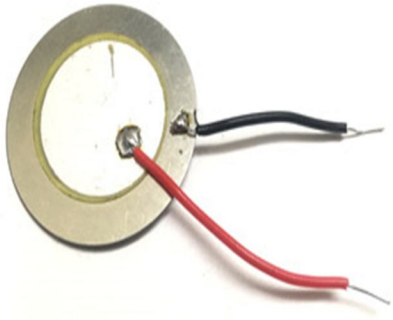

Figure 5: Piezoelectric Sensor

C. DHT11

DHT11 is a an ultra-low-cost digital humidity and temperature sensor that contains a calibrated digital output signal of humidity and temperature. DHT11 is an electronic sensor that measures and collects the data of moisture and the temperature in the environment. This sensor is connected to a microcontroller where the controller receives the input from the sensor and compares the reading with the corresponding pre-set value. It is a highly stable and reliable device.

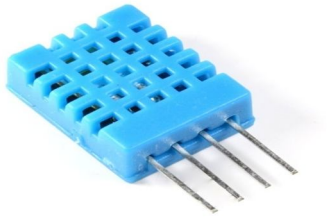

Figure 6: Humidity and Temperature sensor

V. SOFTWARE DESCRIPTION

This section gives a brief description of software requirements.

A. ARDUINO IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a text console, an area for the message, and for common functions a toolbar and menu. There are two parts i.e., editor and compiler. Required codes are written by the Former and later it compiles before uploading them to the Arduino module. IDE agrees with C and C++ language. It is open-source software that runs on Mac OS X, Windows, and Linux. It is also called as sketches. Sketches are written and saved with file extension in the text editor.

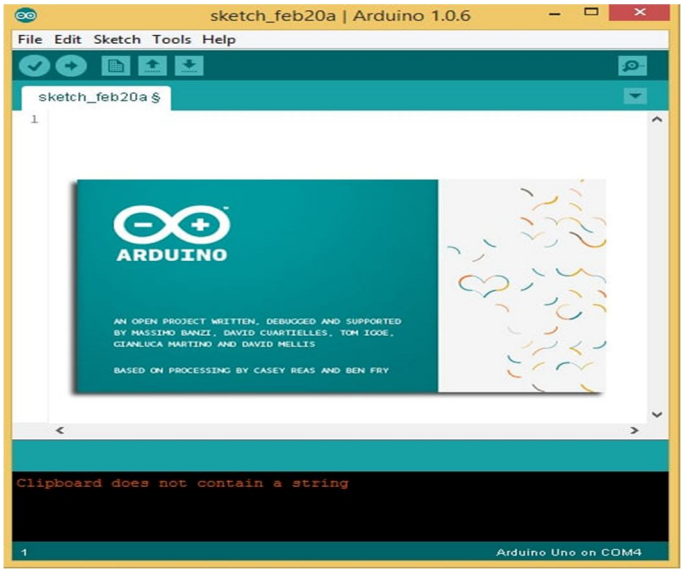

Figure 7: Arduino Software

VI. CONCLUSION

The diabetic patients are increasing day by day, and also the effects on human body parts by a diabetic are also increasing because of improper monitoring of the patient's conditions. To overcome this problem, the proposed system brings a solution in the form of "An Automatic Assessment System of Diabetic Foot Ulcers using Sensors" with an IoT platform, it is a device that is developed and evaluated to identify the patient's foot ulcers at an early stage. So that the patient can easily get the alert message and the respective precaution can be taken to avoid the foot ulcer. However, only certain mechanical changes in the foot were detected in this, but more symptoms can be achieved by using more sensors and advanced tools in future work.

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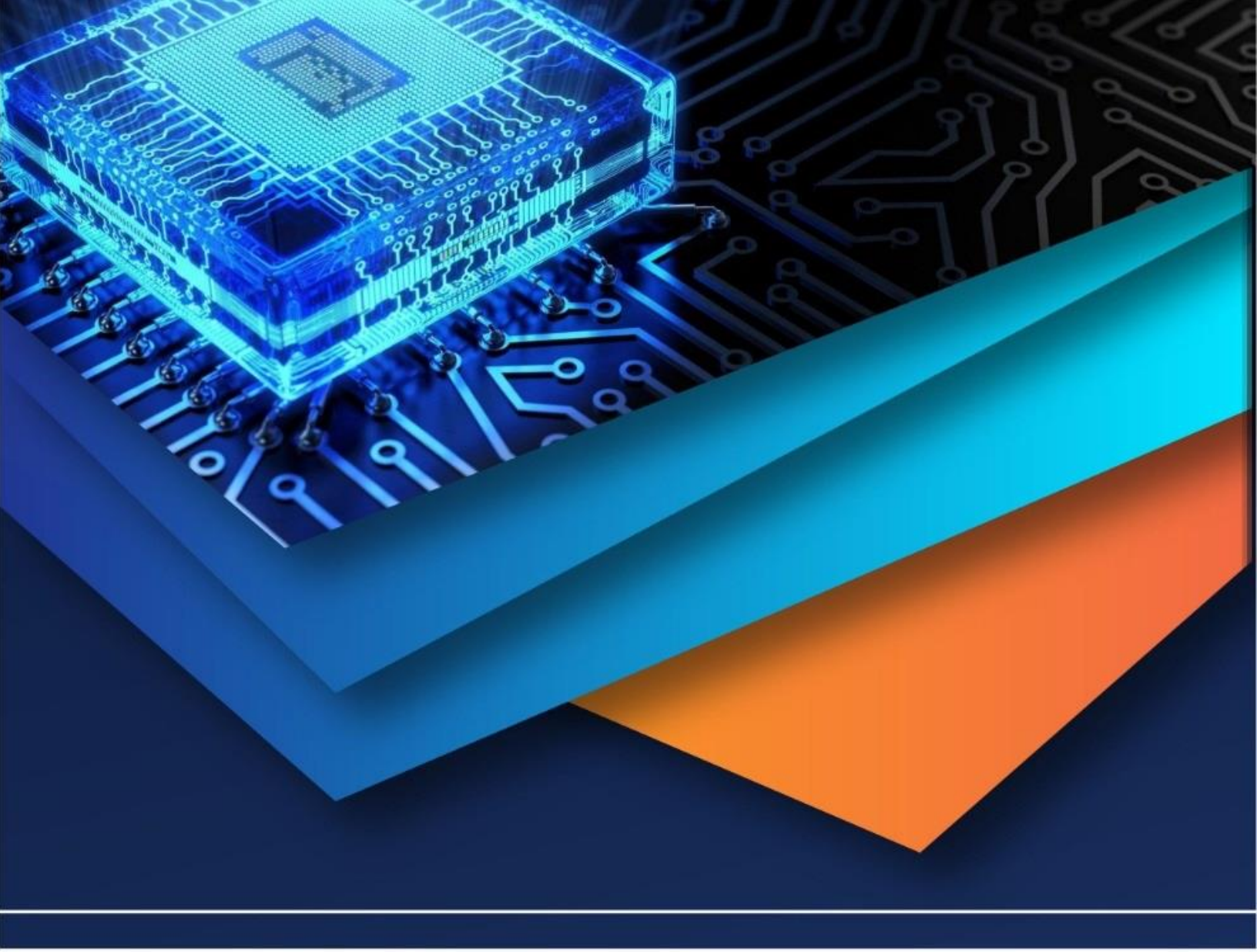

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