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IoT Based Monitoring of Foot Pressure Using FSR Sensor

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Abstract: **The Foot Pressure Monitoring System is to create an intelligent, real-time monitoring solution to analyze and interpret foot pressure distribution using advanced machine learning(ML) techniques. This work investigates the crucial topic of diabetic foot ulcers (DFUs) and suggests a novel method for early identification that utilizes ML as well as the internet of things (IoT). A wound that is open and usually appears It is referred to as a foot ulcer beneath the feet. It might be profound and reveal the joints, tendons, and bones, or it may be less severe and superficial, showing up just below the skin's surface. A wearable shoe prototype with pressure and temperature sensors is shown in the study suggesting that diabetic foot ulcer complications may be preventable if early prophylaxis is implemented. This Internet of Things-enabled gadget makes it easier to evaluate your feet every day at home, enabling prompt detection of early signs and severity tracking. The goal of the real-time ulcer detection system is to improve proactive diabetic treatment, decrease amputations, and avoid complications by incorporating machine learning algorithms.**

Keywords: **Wearable shoes, Diabetes mellitus, Diabetic foot ulcers, Sensors, The Internet of Things, Machine Learning Algorithms and Alert Systems.**

I. INTRODUCTION

One crucial factor that is regularly assessed during gait analysis is the pressure at which the soles and the foot's plantar surface meet. There are numerous uses for this foot pressure measurement, such as preventing sports injuries in athletes, improving balance in footwear design, and screening for high-risk diabetic foot ulcers. Improved mobility, flexibility, efficiency, and lower costs have all been made possible by in-shoe foot plantar sensors. In order to monitor daily activities, the system needs to be wearable and wireless with minimal power consumption.

Due to variables like poor blood circulation, high blood sugar, and weakened skin, diabetic foot ulcers (DFUs) pose a serious risk because they hinder wound healing and provide an environment that is conducive to infection. Given the seriousness of DFUs, this work develops a novel strategy for early detection that uses The internet of things (IoT) with machine learning (ML).

Temperature and pressure sensors are easily integrated into the suggested wearable shoe prototype, enabling people to do regular foot exams from the convenience of their homes. This Internet of Things-powered gadget seeks to promptly detect early signs and closely track severity of ulcers, offering a proactive strategy to reduce the need for amputations and prevent complications. As this study progresses, it should clarify the process, design complexities, and modular architecture that support the creation of the prototype. This research imagines a scenario in which early identification is commonplace, reducing the effect of diabetic foot ulcers and transforming diabetes treatment through the use of ML and IoT. By combining health data, these platforms allow for real-time comparison to predetermined standards. This study examines the revolutionary IoT and ML's promise for early foot ulcers diagnosis as IoT usage in healthcare soars. In order to promote proactive diabetes care, the emphasis focuses on addressing problems in the healthcare sector, such concealed unemployment, and streamlining ongoing monitoring.

II. BLOCK DIAGRAM

The block diagram in Figure 1 is made up of:

Pressure Sensor: Pressure sensors are used to track the foot's pressure. The significance (Fig. 3) mentions the specific points. As seen in Fig. 4 [5], the FSR sensor is mounted in the design system under the anterior, medial, and lateral heels. Both an increase and a drop in pressure will be tracked. When monitoring, the patient's bodily posture is also taken into account.

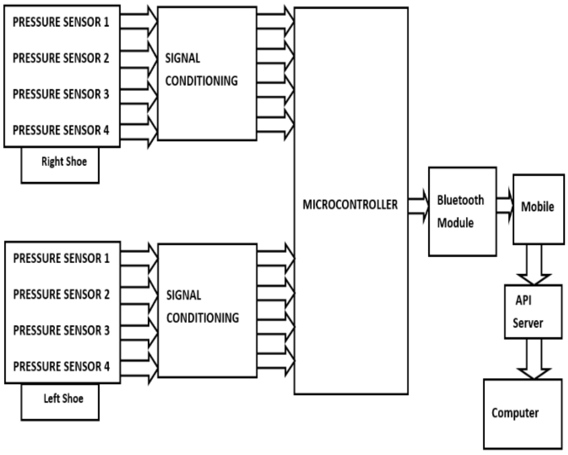


Figure 1 shows a block schematic of an Internet of Things-based insole shoe pressure monitor.

Signal Conditioning : There is resistance in the pressure sensors. It is necessary to convert the resistance shift into a voltage change. The microcontroller's port cannot be driven by the pressure sensor's output alone. For the sensor to function properly, its output has to be conditioned.

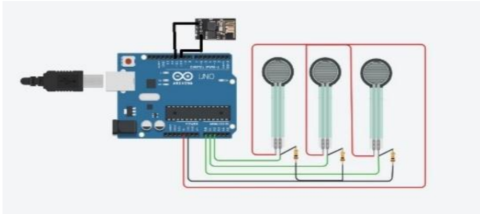
Microcontroller : The microcontroller receives what a signal conditioning system produces device. After gathering the sensor data, it will handle it appropriately.

The connectivity component of the system is the Bluetooth module. The most advanced short-range communication method is Bluetooth, which is why people use it. The data can be sent to the receiving unit, which is an application portal on the user's mobile device—by using Bluetooth connection.

Mobile Unit : We'll create a single app just for this system. The controller will provide the data to the application. Using both static and dynamic data, it will indicate the foot's status.

Computer and API Server: An application programming interface is known as an API. An API's main function is to shield data from unauthorized access. Any data that is present on the mobile device via the The physiotherapist will transfer the API server to a computer for further analysis. The fact that makes it easier for the patient and the physiotherapist to understand how the patient is recovering.

III. HARDWARE CIRCUIT



In order to measure pressure and send data wirelessly, this circuit diagram shows an Arduino Uno coupled to three Force-Sensitive Resistors (FSRs) together with a Wi-Fi module. The Arduino Uno serves as the core processing unit, a microcontroller built on the ATmega328P, reads analog data from the FSRs and transmits it through the Wi-Fi module. Depending on the force applied, the FSRs alter their resistance. To guarantee consistent readings, a pull-down resistor is connected to each FSR in a voltage divider configuration. As pressure rises, the FSR's resistance falls, resulting in a corresponding voltage change that the The analog input pins on the Arduino (A0, A1, and A2) read.

Each FSR has a 5V connection on one side, while the other side is connected to an analog input pin and a pull-down resistor that leads to ground. The circuit is powered by the Arduino's 5V supply. This guarantees that the voltage changes in proportion to the applied force. By connecting the Wi-Fi module (ESP8266 or ESP-01) to the Arduino's TX/RX pins, sensor data can be wirelessly transmitted to a local web interface, cloud server, or mobile application. Pulling the CH_PD pin HIGH activates the module, which is powered by a 3.3V or 5V supply.

When the system is operating, After reading the force values from the FSRs, the Arduino converts the voltage levels into digital values using its Analog-to-Digital Converter (ADC). The Wi-Fi module uses serial communication to process and send these readings.

IV. WORKING OF THE SYSTEM

The system functions in a simple yet sophisticated manner. A pressure sensor is a system's first block. This is the actual block that the individual comes into touch with. The pressure is detected by the pressure sensors. Resistive pressure sensors are what we're employing. As the pressure on the observation point increases, the sensor's resistance varies. A sensor's resistive output cannot power a controller. For this reason, we are converting resistive change to voltage utilizing a signal conditioning circuit. The controller can easily obtain the data after the conversion is complete. The signal conditioning device is now used to connect the sensors to the controller. After reading the sensor, the controller enters the value into the system. It creates an array by individually checking each connected sensor. The Android application must now receive this array via Bluetooth. The data is received by an Android application. An alert will be delivered to the patient's mobile device right away if they are performing incorrect exercises or actions, and the hospital will also receive the data.

V. SENSOR SELECTION

A variety of sensors, including piezoelectric, capacitive, and piezoresistive ones, are available for measuring plantar pressure [7]. Noise is less of an issue with piezoresistive pressure sensors. Additionally, this sensor is less expensive than others. When pressure is applied, the resistance of a force-sensitive resistor (FSR) varies.

A. Basic Construction and Operation of FSR

A tiny air gap separates the two membranes that make up the sensor. The two membranes' stiffness and the spacer surrounding their borders are maintained by the air gap.

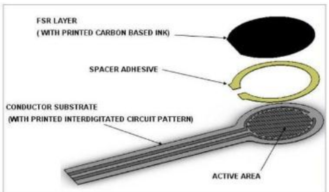


Fig. 2. Basic FSR Construction.

Each membrane possesses two interdigitated finger pairs that link to a single track on a tail and are electrically isolated from one another. FSR carbon-based ink is applied to the membrane's opposite side. As a result, the resistance and the applied force are inversely proportional.

B. Sensor Position Selection

In essence, The pressure at the targeted plantar areas in the foot is measured by the plantar pressure measurement. Two choices are involved in this section. One is to determine the sensor itself, and the other is to determine the sensor's location. Figure 3 illustrates the division of the foot pressure point into 15 sections. Five pressure points are taken into consideration in order to simplify the procedure. The plantar pressure locations in Figure 4 are depicted in the following image.

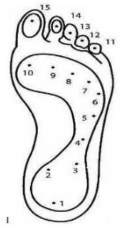


Fig. 3. Foot anatomical areas.

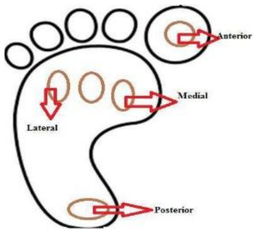


Fig 4: Selected sites of plantar pressure

C. Sensor Characterisation

There are two ways to characterize sensors: a dead-weight pressure gauge and a universal testing machine. The universal testing machine is used for the initial experiments. A force was applied to the sensor, and the computer displayed the appropriate graph. Thus, it was found that resistance diminishes linearly with increasing force. According to the relationship,

$$Force = \frac{Pressure}{Area}$$

The pressure that each foot point exerts can be determined if the region and force are known. Orthopaedicians may find these quantitative factors useful for analyzing gait. Figure 6 displays the plotted force against resistance graph.

The second trial Use of a dead-weight pressure gauge was used. Figure 7 depicts the experimental dead-weight pressure gauge setup. We can infer from both graphs (figs. 6 and 8) that resistance falls with increasing weight or power. Even if the proposed system's FSR sensor is more dependable, its linearity and repeatability are low, therefore it cannot be used..

Fig. 5. Universal Testing Machine.

TABLE I

TABLE I. READINGS OF UNIVERSAL TESTING MACHINE WITH RESPECT TO RESISTANCE AND FORCE.

Sr. No	Force(Newton)	Resistance(Kilo-
1	75	10.3
2	165	4.7
3	325	3.6
4	560	2.8
5	770	2.5
6	1600	1.9
7	2010	1.3
8	2300	0.8

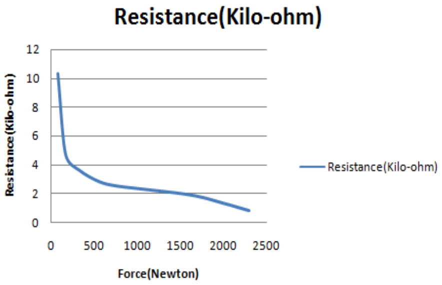


Fig. 6. Resistance versus force graph.

Using the Flexiforce sensor A201 was the next stage. A layer of conductive ink is placed after a layer of conductive material (silver) has been applied to each layer. Flexiforce sensors operate on the same idea as FSR sensors. Experiments with the Flexiforce sensor A201 were conducted using a dead-weight pressure gauge. The experimental setup resembled that shown in Figure 7.

Therefore, we may infer from the experiment using the FSsensor Flexiforce sensor A201 that it is more repeatable and linear than the FSR, as the graph (fig. 9) illustrates. The only drawback of sensor A201 is its cost.

Fig. 7. Gauge of Dead Weight Pressure

TABLE II

TABLE II. READINGS OF DEAD-WEIGHT PRESSURE GAUGE MACHINE WITH RESPECT TO RESISTANCE AND WEIGHT.

Sr. No.	Weights(Kg)	Resistance(Kilo-ohm)
1	5.7	13.26
2	8.5	11.52
3	11.3	10.8
4	14.1	8.6
5	16.9	6
6	19.7	5.5
7	22.5	4.5
8	25.3	4.03

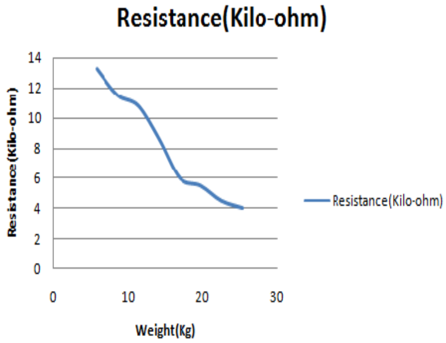


Fig. 8. Resistance versus weight graph

VI. CONCLUSION

For patients with foot deformities, fractures, etc., this approach uses an insole shoe to provide pressure variation. This assessment of plantar pressure determines whether a person has foot abnormalities, which will help the patient avoid

TABLE III

TABLE III. READINGS OF DEAD-WEIGHT PRESSURE GAUGE MACHINE WITH RESPECT TO RESISTANCE AND WEIGHT.

Sr. No.	Weights(Kg)	Resistance(Kilo-ohm)
1	5.7	90.6
2	8.5	71.8
3	11.3	62.3
4	14.1	52.3
5	16.9	45.4
6	19.7	41.8
7	22.5	38.7
8	25.3	35.7

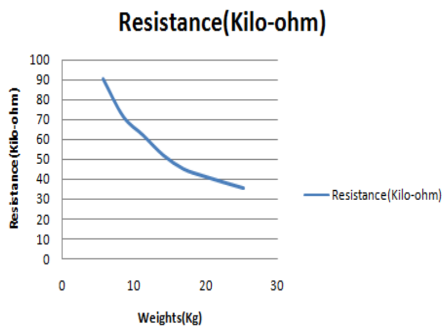


Fig. 9. Resistance versus weight graph.

from getting disease. The suggested system takes preventative measures in its design. The outcome demonstrates the dependability of the equipment, which measures the distribution of foot pressure to identify anomalies. Additionally, the sensor is incredibly tiny and simple to install on the insole. The patient can safely use the system, which has minimal cabling..

VII. FUTURE SCOPE

An Android app will be added to the suggested system in the future to receive signals from the transmitter module and notify a medical professional of any irregularities in the distribution of pressure on the foot. Additionally, In order to compare the results with a normal distribution of foot pressure, the gadget would be tested on individuals who had fractures.

VIII. REFERENCES

[1] Ayat N. Hussain, Mohammed N. Abdullah, Sahar A. Abboud, and Basim A. Jumaa. "Gait Classification Using Machine Learning for Foot Disease Diagnosis" Technium Vol. 4, Issue 4, pp. 37–49 (2022).

[2] Vijean et al. "Early Detection of Diabetic Foot ulcers through Wearable Shoe Design" 2022 4th International Conference on Artificial Intelligence and Speech Technology (AIST), Delhi, India, 2022, pp. 1-5, doi: 10.1109/AIST55798.2022.10065150

[3] Prathap and Dr. R. Jemima Priyadarsini. “Integration of IoT and MLA in Prediction of Diabetes: An Overview.” International Journal of Scientific Research in Computer Science, Engineering and Information Technology, Technoscience Academy, Nov. 2021, pp. 146–53.

[4] Tulloch Jack et al. “Machine Learning in the Prevention, Diagnosis and Management of Diabetic Foot ulcers: A Systematic Review.” IEEE Access, vol. 8, Institute of Electrical and Electronics Engineers (IEEE), 2020, pp. 198977–9000.

[5] M. Goyal, N. D. Reeves, A. K. Davison, S. Rajbhandari, J. Spragg and M. H. Yap, "DFUNet: Convolutional Neural Networks for Diabetic Foot Ulcer Classification," in IEEE Transactions on Emerging Topics in Computational Intelligence, vol. 4, no. 5, pp. 728-739, Oct. 2020, doi: 10.1109/TETCI.2018.2866254.

[6] P. Gupta, N. Gaur, R. Tripathi, M. Goyal and A. Mundra, "IoT and Cloud Based Healthcare Solution for Diabetic Foot Ulcer," 2020 Sixth International Conference on Parallel, Distributed and Grid Computing (PDGC), Waknaghat, India, 2020,

[7] Ukil, S. Bandyoapdhyay, C. Puri and A. Pal, "IoT Healthcare Analytics: The Importance of Anomaly Detection," 2016 IEEE 30th International Conference on Advanced Information Networking and Applications (AINA), Crans-Montana, 2016

[8] B N, Gowrishankar. “An Automatic Assessment System of Diabetic Foot Ulcers Using Sensors.” International Journal for Research in Applied Science and Engineering Technology, vol. 9, no. 5, International Journal for Research in Applied Science and Engineering Technology (IJRASET), May 2021, pp. 1832–36