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SMART FOOT PRESSURE MONITORING SYSTEM FOR ANOMALY DETECTION

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Abstract : Foot pressure monitoring system is to develop an intelligent real-time monitoring solution for the analysis and interpretation of foot pressure distribution, with the help of advanced technologies for machine learning. This study examines key areas of diabetic foot ulcers (DFU) and suggests an innovative approach to early detection using the Internet of Things (IoT) and machine learning (ML). A foot ulcer is an open wound that usually falls under the foot. However, diabetics may avoid complications caused by deep foot ulcers when early prevention is practiced. This study introduces a portable shoe prototype equipped with temperature and pressure sensors. This IoT-enabled device makes daily foot assessments easier at home, allowing timely identification of previous symptoms and severity monitoring. By integrating the ML algorithm, we integrate the actual recovery system to prevent complications, reduce amputations and improve the delivery of aggressive diabetes.

IndexTerms - Diabetic foot ulcer, Diabetes Mellitus, Sensors, Wearable shoe, internet of things, ML algorithms, Alert System.

1. INTRODUCTION

The interface pressure between foot plantar surface an soles is an important parameter frequently measured during gait analysis. This foot pressure measurement has wide applications, for example screening for high risk diabetic foot ulceration, footwear design improvement of balance, sports injury prevention in athletes plus many more. In-shoe foot plantar sensors have paved the way to better efficiency, flexibility, mobility and reduced cost measurement systems. For the system to be mobile and wearable for monitoring activities of daily life, the system should be wireless with low power consumption. Diabetic Foot Ulcers (DFUs) emerge as a significant risk, rooted in factors like inadequate blood circulation, hyperglycaemia, and compromised skin conditions, impeding wound healing and creating a breeding ground for infections. In response to the gravity of DFUs, this study pioneers an innovative approach employing the Internet of Things (IoT) and Machine Learning (ML) for early detection.

The proposed wearable shoe prototype seamlessly integrates temperature and pressure sensors, empowering individuals to conduct daily foot assessments from the comfort of their homes. This IoT-driven device aims to swiftly identify early symptoms and diligently monitor ulcer severity, presenting a proactive avenue to prevent complications and mitigate the need for amputations. As this research unfolds, it promises to shed light on the methodology, intricacies of design, and the modular architecture that underpins the prototype's development. Through the lens of IoT and ML, this study envisions a future where early detection becomes a routine, mitigating the impact of diabetic foot ulcers and reshaping the landscape of diabetic care. These platforms consolidate health data, enabling real-time analysis against predefined benchmarks. As healthcare witnesses a surge in IoT adoption, this paper explores the transformative potential of IoT and ML in early foot ulcer detection. The focus is on streamlining continuous monitoring and addressing challenges in the healthcare sector, such as disguised unemployment, to advance proactive diabetic care.

2. OBJECTIVES

i. **Health Monitoring:** Detect anomalies in foot pressure patterns that may indicate medical conditions such as diabetes related foot ulcers, plantar fasciitis, or arthritis.

ii. **Performance Optimization:** Analyze pressure distribution to help athletes improve their gait and overall performance by providing feedback on their foot mechanics.

iii. **Accurate Pressure Measurement**: Develop a system that accurately measures and records foot pressure distribution across different areas of the foot.

iv. **Real-time Data Acquisition**: Implement a system capable of capturing and processing foot pressure data in real-time or near real-time.

3. LITERATURE REVIEW

i. Ayat N. Hussain, Sahar A. Abboud, Basim A. Jumaa, Mohammed N. Abdullah. **“**Gait Classification Using Machine Learning for Foot Disseises Diagnosis” Technium Vol. 4, Issue 4 pp.37-49 (2022).The goal of this work was to create and evaluate an automated gait analysis system that employed lower-body motion data and machine learning techniques to differentiate between healthy and sick patients. The detection and diagnosis of foot disseises are extremely accurate because of the employment of five machine learning algorithms as classifiers

ii. The Arcelina Marques, / 1luis Ceolho, / 1mario Vaz Jodea, / 1ststatos Pahai. The technical technology of the plant in SOOBY SODE: PROPERENTIONAL PROPERTRATIONS TO START 10, 1524. The System Review to identify the shoes of diabetes..The systematic review aims to identify systems and technologies for measuring in shoe plantar pressures, focusing on the at risk diabetic foot population.

iii. **A**bdul Hadi Abdul Razak, Aladin Zayegh, Rezaul K. Begg and Yufridin Wahab. **“**Foot Plantar Pressure Measurement System” Journal of Engineering Technology Vol. 9(1): 7-13, 2021.The system is providing a device to monitor the force applied by the subject during kinematic movement.

4. SYSTEM OVERVIEW

The proposed system consists of three primary components: the Force Sensitive Resistor (FSR) sensors, the microcontroller, and the cloud-based platform with a CNN algorithm for data analysis.

FSR Sensors: The FSR sensors are placed at key points on the foot: the heel, arch, and toe. These sensors are highly sensitive to pressure and provide an analog resistance change when pressure is applied. As the user stands or walks, the FSR sensors measure the pressure exerted on these specific regions of the foot, offering a detailed map of pressure distribution. The FSR sensors' data will be collected by the microcontroller and transmitted to a cloud-based system for processing and analysis.

Microcontroller: The microcontroller (such as an Arduino or Raspberry Pi) is responsible for collecting the pressure data from the FSR sensors. It also communicates with the cloud-based platform to send the data for analysis. The microcontroller will process the sensor readings, convert them into meaningful pressure values, and send the data to the cloud using wireless communication protocols like Wi-Fi or Bluetooth.

Cloud Platform and CNN Algorithm: The cloud-based platform serves as the central hub for data storage, analysis, and real-time monitoring. The pressure data is sent from the microcontroller to the platform, where it is processed by a Convolutional Neural Network (CNN). CNNs are particularly effective at recognizing patterns in data and are widely used in image and sensor data analysis. By training the CNN model with labeled foot pressure data (normal and abnormal), the system can classify pressure patterns and identify areas where abnormal pressure is exerted. The CNN algorithm can then alert users or healthcare professionals if abnormal pressure distributions are detected, signaling potential foot health issues that need attention.

5. METHODOLOGY

Foot pressure monitoring is an important aspect of healthcare, sports science and ergonomics. The distribution of pressure on the feet provides valuable insight into potential diseases such as gait disorders, postural disorders, and diabetic foot ulcers and plantar fascia. Traditional foot pressure analysis is based on manual observation and pressure mapping platforms, which can be expensive and inaccessible to many people. With advances in artificial intelligence and embedded systems, deep learning has proven to be a powerful tool for automating foot pressure monitoring. Deep Learning Foot Pressure Monitoring Systems can analyze foot pressure distribution, recognize abnormalities, predict potential health risks, and provide real-time feedback. The system consists of three main components: Hardware for data collection, software for data processing and machine learning, and user interface for visualization.

The architecture of the foot pressure monitoring system includes hardware components, software components and user interfaces. The hardware setup includes a pressure sensor array, a flexible thin film sensor embedded in a thin film sensor, which measures pressure in different foot areas. Microcontrollers such as the Nodemcu ESP8266 and Raspberry Pi collect sensor data and transmit it wirelessly. A rechargeable battery is supplied to the system, and Wi-Fi or Bluetooth modules ensure real-time data transmission to the processing unit. The software pipeline includes data collection, preprocessing, deep learning models, and anomaly detection. The foot pressure values are collected in real time and converted into a structured matrix, followed by pre-processing steps such as cleaning, normalization, and formatting for analysis. Use folding networks (CNNs) to classify foot pressure patterns, recognize irregular distributions, and predict potential health risks. Folding Networks (CNNS) are used to analyze foot pressure patterns due to their ability to effectively extract spatial properties. The CNN model handles the pressure matrices of the feet and classifies them into different gear patterns.

The model architecture consists of input layers while taking foot pressure matrix, folding layers, extracting spatial patterns, reducing dimensions, maintaining essential features, fully connected layers that perform classification, probability values for normal foot pressure conditions, and frictional distributions of fashion model models. This includes noise removal using filters for the removal of sensor artifacts, normalization for normalization of pressure values, redesigning sensor data into a structured 2D matrix, and data augmentation techniques to improve dataset diversity and model reverberation. The microcontroller transfers print data for processing to a cloud server or local system to ensure seamless data calls and analysis via the write API. The user interface provides intuitive visualizations for users, historical data tracking, heatmap generation and personalized recommendations.

This system has several applications for healthcare, sports science and ergonomics. Healthcare systems are used for monitoring foot diabetics through high pressure zones that can lead to ulcers, capturing rehabilitation by pursuing changes in foot pressure during physical therapy, and orthopaedic analysis to assess the effectiveness of corrective bumps. Sports Science helps you optimize your walk by analyzing your running and hiking, improving footwork balance and accuracy, and improving sports training by preventing injuries caused by biomechanical reviews. Workplace ergonomics and security benefits from this system by capturing inappropriate weight distributions in a constant occupation, identifying risks from continuing reputation, and assisting in the risk of posture correction.

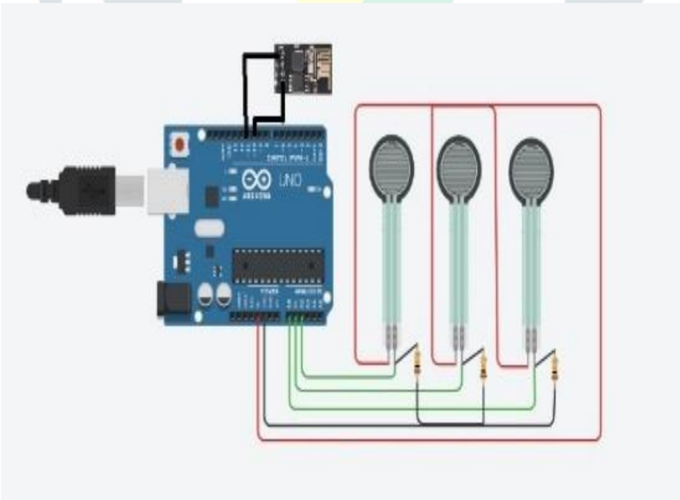
Despite its advantages, the system faces several challenges, including ensuring sensor maintenance, optimizing battery life for essential applications, and ensuring reasons for non-date access. Future progress can improve systems by integrating AI-driven wearables such as smart shoes with embedded AI analytics, developing transformation networks to improve prediction accuracy, and developing sophisticated deep learning models that extend their applications to old care and prosthetics.

6. HARDWARE CIRCUIT

To measure pressure and transmit data wirelessly, this switching diagram shows the Arduino UNO combined with three strength sensitive resistances (FSR) and Wi-Fi modules. As a central processing unit, the Arduino Uno, a microcontroller built on the

Fig 1. Hardware System Circuit

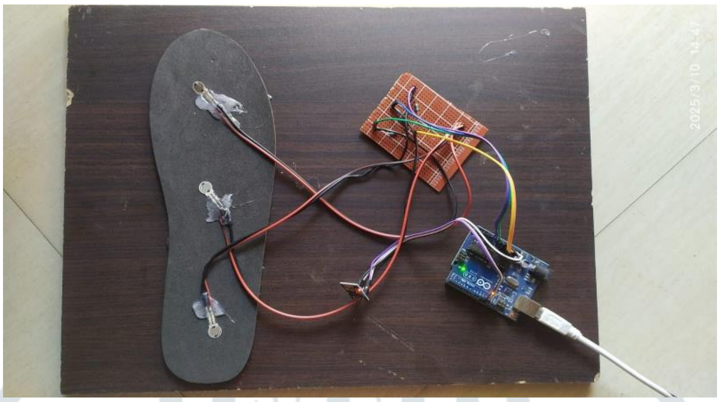
Atmega328p, reads the analog data of the FSR and transmits it via a Wi-Fi module. Depending on the force raised, the FSR changes the resistance. To ensure consistent readings, pull-down resistors in voltage split configurations are connected to all FSRs. Increased



pressure reduces the resistance of the FSR, leading to a corresponding change in the voltage that the analog input needles of the Arduino (A0, A1, A2).

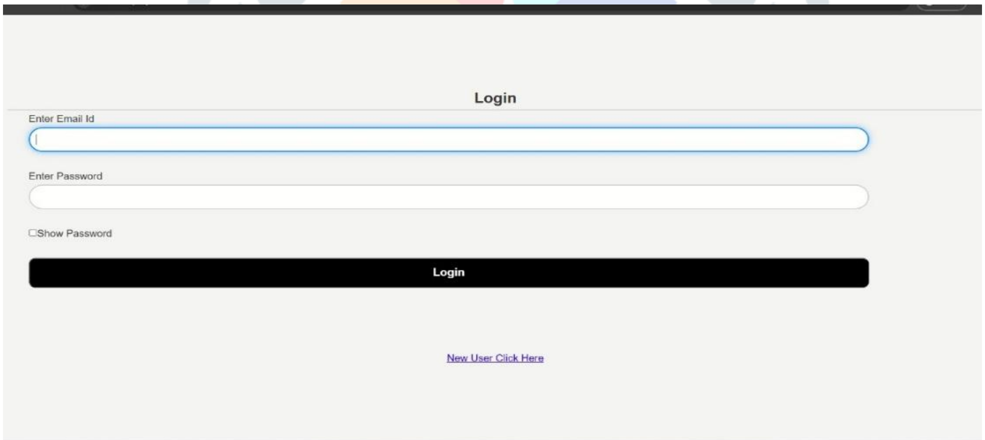
Each FSR page is connected to 5 V, with the other side connected to an analog input spin and a melted pull-down resistor connected to the floor. The circuit is equipped with the Arduino 5-V supply. This ensures that the voltage changes in relation to the force used. By connecting a Wi-Fi module (ESP8266 or ESP-01) to an Arduino's Tx/RX pencil, sensor data can be wirelessly assigned to a local web interface, cloud server, or mobile application. By pulling the CH_PD pin, the module is activated and operated with a 3.3 V or 5 V supply. When the system works, Arduino uses an Analog-to-Digital Converter (ADC) to convert the voltage level to a digital value after the FSR power value is read. The Wi-Fi module uses serial communication to process and transmit these measurements.

Hardware setup

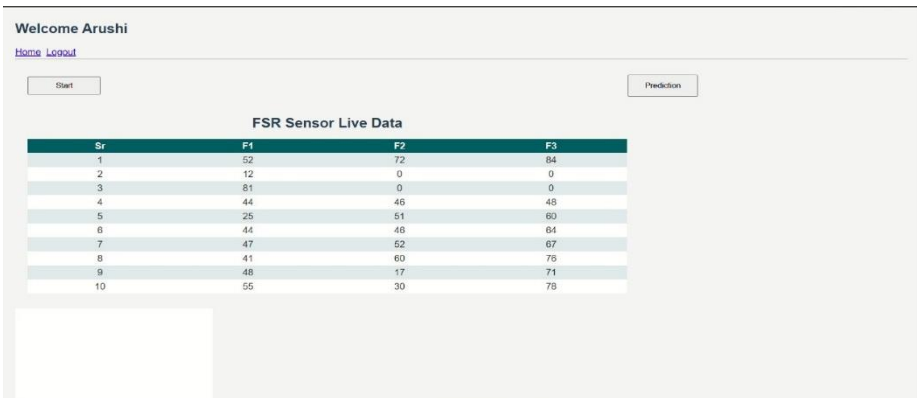


7. EXPERIMENTAL RESULTS

The image shows a login page with fields for entering an email ID and password, along with a "Show Password" checkbox, a login button, and a "New User Click Here" link.



It displays a sensor data dashboard for "FSR Sensor Live Data," showing real-time readings from three force-sensitive resistors (FSR) labeled F1, F2, and F3. The interface also includes options like Start and Prediction, suggesting some form of real-time monitoring



and possibly predictive analytics.

Welcome Arushi

Home Logout

Prediction Result

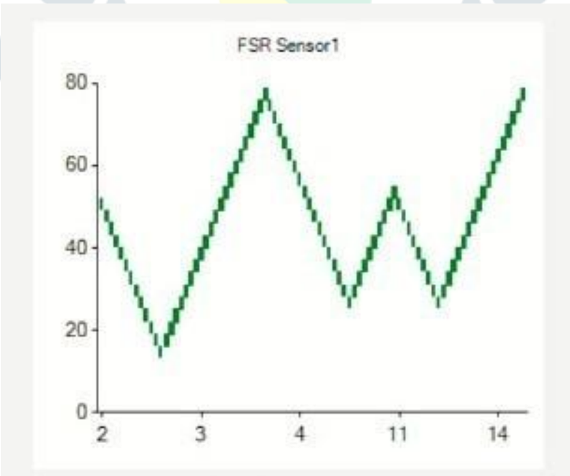
Sr	F1	F2	F3	Res
1	2	2	2	2
2	1	1	1	1
3	2	1	1	1
4	1	1	1	1
5	1	2	2	2
6	1	1	2	1
7	1	2	2	2
8	1	2	2	2
9	1	1	2	1
10	2	1	2	2
11	1	1	2	1
12	1	1	2	1
13	1	1	1	1
14	2	1	1	1

Real Foot Pressure count : 9
Mid Foot Pressure count : 5
Front Foot Pressure count : 0

Foot Result

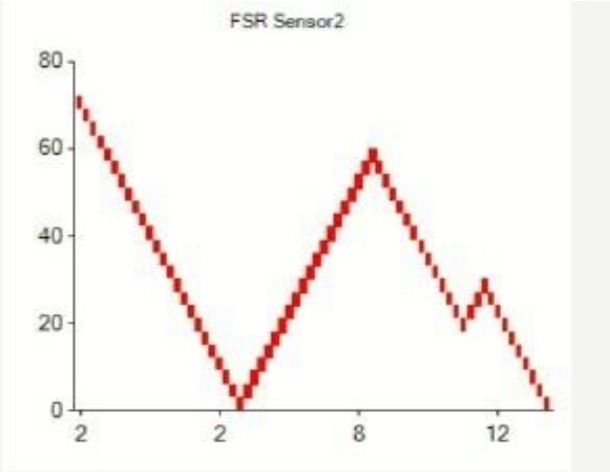
Readings of the sensors in the form of graphs is as follows:-

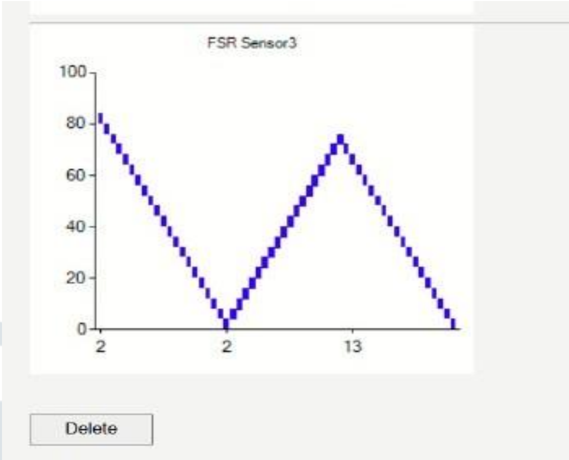
The three graphs, are representing data collected from a Force Sensitive Resistor (FSR) sensor, likely used to measure pressure in the context of the previous foot pressure analysis. The graphs plot the sensor readings against time or a related index, showing fluctuations in pressure over the observed period. The first graph, "FSR Sensor1," displays a pattern of increasing and decreasing pressure, forming a series of peaks and troughs. The second graph, "FSR Sensor2," shows a similar pattern but with a distinct inverted V-shape peak and a more gradual decline. These variations in pressure readings across the two sensors suggest different pressure distribution or loading patterns, possibly corresponding to distinct regions of the foot or differing gait phases. The numerical values along the axes likely represent pressure magnitude and time or data point index, respectively. Analyzing these graphs in conjunction with the numerical data from the previous prediction table would reveal how the model interprets and utilizes these dynamic pressure changes to classify or predict outcomes related to foot pressure.



A Force Sensitive Resistor (FSR) is a type of sensor that changes its resistance based on the applied force or pressure. It consists of a conductive polymer that exhibits a decrease in resistance as more pressure is applied. In the graph, the y-axis represents force, while the x-axis corresponds to time or another relevant variable. The upward peaks signify instances of increased force application, whereas the downward dips indicate periods of reduced or no applied pressure.

The image shows a graph titled "FSR Sensor2," which appears to represent data collected from a Force Sensitive Resistor (FSR) sensor. The x-axis and y-axis likely correspond to time and force measurements, respectively. The red data points indicate the sensor's response over time. The graph of "FSR Sensor3," shows a distinct V-shaped pattern with sharp, linear segments. This suggests a measurement or reading from a Force Sensitive Resistor (FSR) sensor over time or some other indexed variable. The sharp transitions in the graph imply a rapid change in force applied to the sensor, first decreasing linearly to a minimum, then increasing linearly to a peak, and finally decreasing again to a low value. The "Delete" button is for user interface where data points can be removed or the entire dataset cleared.





The image presents a graphical representation of foot pressure analysis, likely derived from sensor data, alongside a textual interpretation of the results and suggested actions. The "Final Result" section interprets this data, stating a "No Risk" foot health status, indicating that while there are pressure variations, they do not pose a health concern. The image likely originates from a health or fitness application designed to analyze and provide feedback on foot health based on pressure data.

8. CONCLUSION

The medial sole shoe system is designed to measure plant pressure fluctuations in patients with foot disorders, fractures, or other related diseases. By analyzing the pressure distribution of the feet while walking or standing, this system helps to identify irregularities in the foot function. People with conditions such as flat feet, diabetic foot ulcers, and malformations can benefit from this technology as they provide actual data on pressure damage. Detection of these abnormalities at the early stages allows for timely medical intervention and prevents further complications.

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