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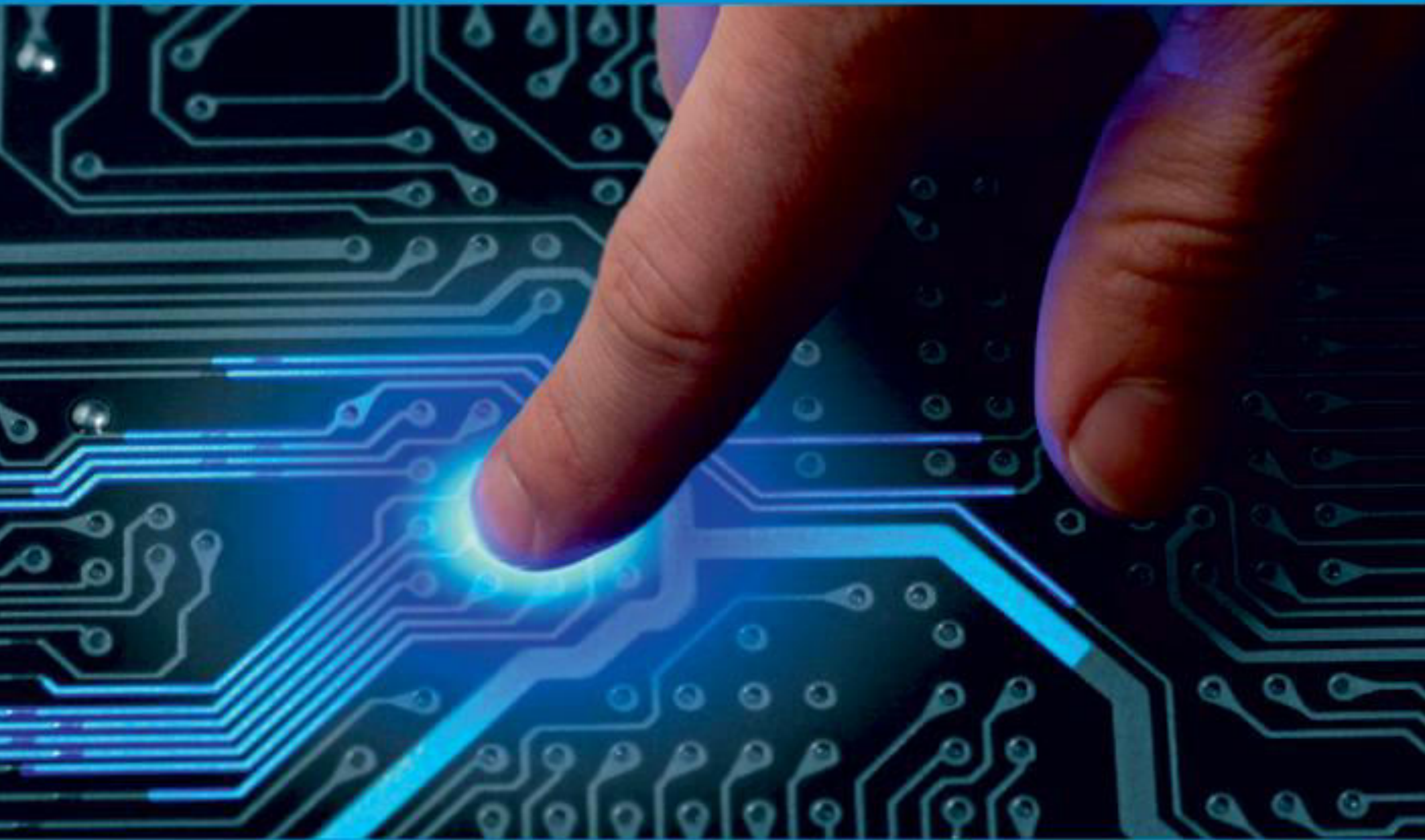

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Low-cost Wireless Footwear for Monitoring Diabetic Foot Patients

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ABSTRACT: The primary objective of this project is to mitigate the occurrence of foot ulcers in patients with diabetes. With approximately 537 million people globally living with diabetes, such individuals are susceptible to developing foot ulcers as a result of diabetic neuropathy. Foot complications are a prevalent issue among individuals with diabetes and are major contributors to medical expenses. In fact, 50% of all inpatient admissions related to diabetes arise due to foot complications. This project seeks to tackle the problem of foot ulcers through the early detection of such ulcers via the use of smart sensors and machine learning integrated into the footwear. This technology detects high-pressure areas on the foot and alerts the patient in real-time to reduce pressure on the affected areas. By promptly identifying and treating such areas, the occurrence of foot ulcers can be prevented, thereby reducing the need for foot amputations.

KEYWORDS: Diabetes, Foot ulcers, Diabetic neuropathy, machine learning.

I. INTRODUCTION

Globally15% of the diabetic patients suffer from foot ulcers. If these foot ulcers are not taken care of, they lead to foot amputations in severe cases. Foot ulcers are caused due to uneven plantar pressure in feet. Prolonged period with high plantar pressure at a spot lead to formation of ulcers. This project is a smart footwear that aids diabetic patients to detect pressure at different parts of their feet. It detects high plantar pressure in the insole and warns the patient. The patient then takes preventive care such as scrapping of sole in the footwear to prevent formation of an ulcer.

I. SOFTWARE AND HARDWARE COMPONENTS

Software:

A. **Flexi-force sensor:** F Flexi-force sensors are specialized pressure sensors capable of detecting and measuring the magnitude of force applied to them through bending or flexing. They are constructed from a thin conductive material film that adjusts its resistance proportionally to the amount of force applied. These sensors have broad applications, including robotics, medical devices, and consumer electronics, due to their high level of versatility.

B. **Arduino Uno:** The Arduino Uno is a microcontroller board that is widely used for building open-source electronics projects. It features various inputs and outputs that allow for the interface with other hardware components, including sensors and actuators. Based on the ATmega328P microcontroller, the Arduino Uno can be easily programmed with the help of the Arduino software.

C. **ESP 32:** The ESP32 is a flexible and robust microcontroller suitable for various applications. It boasts dual-core processors, Wi-Fi, Bluetooth, and multiple communication interfaces, as well as an extensive set of peripheral features such as timers, PWM, and analog-to-digital converters. Additionally, the ESP32 is highly energy-efficient, with advanced power management capabilities and multiple low-power modes, which make it well-suited for battery-powered applications.

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D. DC Motor: A DC motor is an electrical device that transforms electrical energy into mechanical energy through the use of a magnetic field, resulting in rotational motion. They are utilized in a wide range of applications, including robotics, automation, and electric vehicles.

Hardware:

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II. SYSTEM ARCHITECTURE

A system architecture diagram is a graphic illustration that depicts the components and connections of a system. It provides a structural overview of the system and illustrates how the individual components interact with one another to attain specific objectives. The diagram usually consists of blocks that represent the system's components, and lines or arrows that signify the connections between these components.

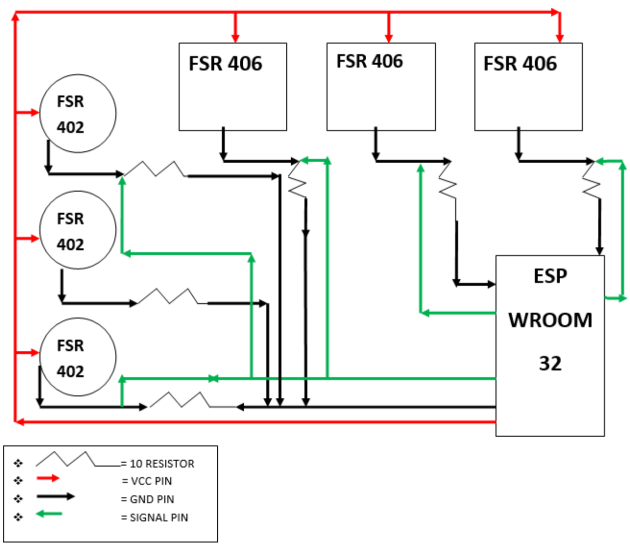

Fig 1: Circuit diagram offl exi-for cesensors and ESP32

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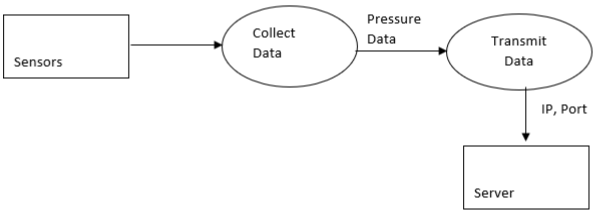
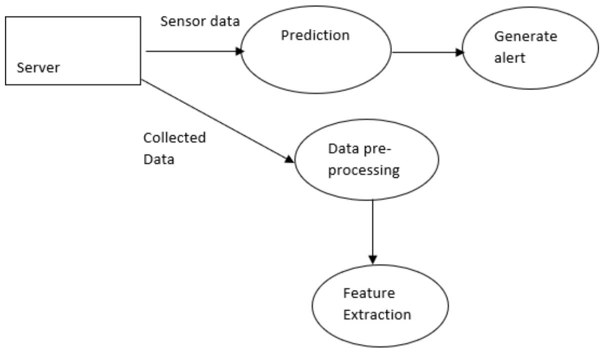
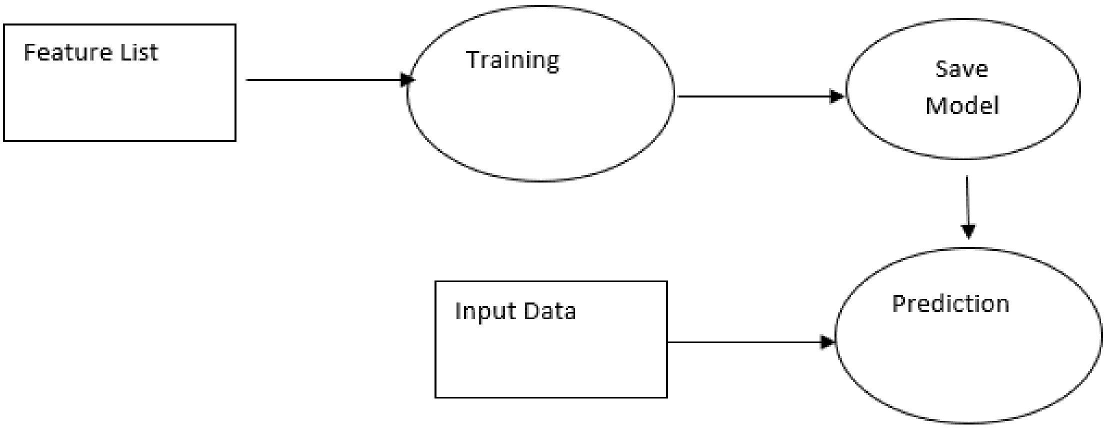
III. METHODOLOGY

The footwear was developed using a combination of hardware and software components. The hardware includes an ESP32 module that is used to transmit data to the server. The footwear is equipped with Flexi force sensors that collect pressure applied and transmit it. An Arduino Uno is used toprocess the data from sensors and use ESP32. The system alsoincludesaDCmotorthatactivateswhenhighpressureisobservedonthepatient'sfoodforalonginterval.Thesoftwareincludesalgorithmstoprocessthepressuredataandtranslateitintoseverity.







IV. WORKING PRINCIPLE

The main focus of this project is to design footwear that continuously monitors plantar pressure of the foot of a diabetic patient. The working principle of the footwear designed for diabetic patients is to prevent foot ulceration caused by prolonged high plantar pressure. The key element of this project is the use of six flexi force sensors that measure the pressure and force applied by the patient's foot while walking

The sensor data is processed by an Arduino Uno microcontroller that triggers a relief mechanism to address the issue of reduced blood circulation in the patient's feet. The relief mechanism may include a DC motor that creates a massaging effect, or other forms of support and cushioning, to improve blood circulation in the patient's foot and prevent foot ulceration.

The sensor data is also transmitted wirelessly to a server using an ESP32 module. The data is analyzed and presented in a user- friendly diagram on the patient's mobile app. The colors used in the diagram correspond to different levels of plantar pressure, enabling the patient to monitor their foot health and adjust their activity accordingly.

The footwear is designed to provide a proactive solution that addresses foot ulceration caused by prolonged high plantar pressure in diabetic patients. The use of flexi force sensors, coupled with the relief mechanism triggered by the

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Arduino Uno microcontroller, and the wireless transmission of data to a server, make this an effective and comprehensive solution for foot health management.

V. ALGORITHMS AND EQUATIONS

A. The Random Forest Algorithm:

The Random Forest Algorithm is a powerful technique in machine learning that brings together multiple decision trees to solve prediction and classification problems. It stands out for its flexibility and ability to handle intricate datasets. The name "Random Forest" comes from the concept of constructing a collection or "forest" of decision trees. Each tree is constructed individually, using a random subset of the available features and training samples. By leveraging this ensemble of trees, the Random Forest Algorithm provides reliable predictions. It combines the outcomes of the individual trees to make a final decision, whether it's assigning a class label or estimating a numerical value. This ensemble approach contributes to the algorithm's resilience against overfitting and enhances its generalization capabilities. Random Forest algorithm doesn't have a single equation, it relies on various mathematical computations within each decision tree, such as determining optimal splits, calculating impurity measures, and aggregating predictions.

B. Decision Tree Algorithm:

Data preparation: To train the Decision Tree, we need a labeled dataset with features and corresponding target variables. This dataset is divided into a training set for building the tree and a separate test set for evaluating its performance.

Tree construction: The algorithm begins by selecting the most informative feature from the dataset. It determines the feature's importance based on metrics like Gini impurity or information gain. This feature is then used as the root node of the tree.

Splitting nodes: The selected feature is utilized to split the data into subsets at each internal node. Each subset corresponds to a specific outcome or branch based on the feature's values. This process continues recursively, creating additional internal nodes and branches until a stopping criterion is met, such as reaching a maximum tree depth or having a minimum number of instances per leaf.

C. Support Vector Classifier:

SVC is a popular machine learning algorithm that is commonly used for binary classification tasks. The goal of SVC is to find a hyperplane that separates the positive and negative instances in a given dataset in a way that maximizes the margin, or the distance between the hyperplane and the closest data points. This hyperplane is constructed in a high- dimensional space, where each dimension represents a feature of the data.

The equation of a Support Vector Classifier (SVC) depends on the specific formulation and the choice of kernel function.
Here, is the equation for the linear SVC, which is one of the commonly used variants.

VI. BENEFITS

- Prevention of foot ulceration: One of the primarybenefits of this project is its ability to prevent footulceration caused by prolonged high plantar pressure.The use of six flexi force sensors, coupled with arelief mechanism, helps reduce the likelihood of footulcersindiabetic patients.

- Improved foot health: By providing real-timemonitoring and analysis of plantar pressure, thefootwear can help diabetic patients maintain betterfoothealth.TheuseofaDCmotorformassaging canalso enhance blood circulation, reducing the risk ofcomplications associated with poor blood flow in thefeet.

- Remote monitoring: The wireless transmission ofsensor data to a server enables healthcareprofessionals to remotely monitor the patient's foothealth.Thiscanbeparticularly usefulincaseswherethe patient may have difficulty visiting a medicalfacility regularly.

- User-friendly mobile app: The mobile app used inconjunction with the footwear provides an easy-to-use

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interface for patients to monitor their foot health.The diagram, with different colors representingdifferentpressurevalues,makesiteasyforpatientstounderstand theirfoothealthstatus.

- Early detection of foot problems: By continuouslymonitoring plantar pressure, the footwear can detectearlysignsoffootproblems,enablingpatientsto takeaction before theconditionworsens.

- Cost-effective solution: This project offers a cost-effective solutionfordiabeticpatientsto monitorandmanage their foot health. Compared to traditionalmedical interventions, this footwear is less invasiveand less expensive, making it a viable option formany patients.

VII. RESULTS AND CONCLUSION

The development of the footwear for detecting plantar pressure in diabetic patients is a significant breakthrough in the healthcare industry. This project has several notable results that can improve the quality of life for diabetic patients. One of the most important results is the reduced incidence of foot ulcers. Foot ulcers are a common complication of diabetes that can lead to serious health problems such as infections, amputations, and even death. The continuous monitoring of plantar pressure in the footwear can help identify high-pressure areas that can lead to ulcers. Early detection and prevention of these high-pressure areas can reduce the risk of foot ulcers in diabetic patients, leading to better overall foot health.

Another important result of this project is the increased patient awareness of their foot health. The use of the mobile app to display real-time pressure data can educate patients on the factors that contribute to foot ulcers, leading to earlier detection and prevention. Patients can take an active role in managing their foot health, leading to improved self-management and potentially reducing the need for medical intervention. The mobile app can also help patients understand the impact of lifestyle choices such as footwear, walking habits, and exercise on their foot health. By increasing patient awareness of their foot health, this project can lead to better overall health outcomes for diabetic patients.

The use of the footwear and mobile app can also improve the quality of life for diabetic patients. Better overall foot health can reduce the risk of more serious health problems such as heart disease, stroke, and kidney disease. The empowerment of patients to take an active role in managing their foot health can lead to improved self-confidence and independence. The footwear can also help diabetic patients remain active and mobile, improving their quality of life. The project can lead to significant cost savings for patients and the healthcare system by reducing the need for medical intervention and hospitalization. Overall, the development of the footwear for detecting plantar pressure in diabetic patients can lead to better overall health outcomes and a higher quality of life for diabetic patients.

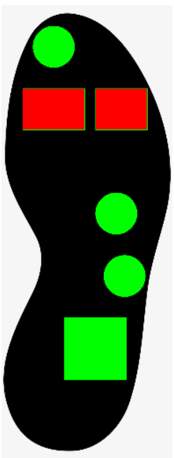

Fig 2:Androidappoutput

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