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Article Title: Machine Learning Based Detection of Foot Ulcer and Diabetic Foot Using IoT

Machine Learning Based Detection of Foot Ulcer and Diabetic Foot Using IoT

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ABSTRACT

Millions of individuals worldwide suffer from diabetes mellitus, a chronic metabolic condition. Diabetes can cause foot ulcers, which are one of the most dangerous side effects. If left untreated, these ulcers might result in amputation. Both healthy and ulcerated feet from diabetes patients make up the sizable dataset used to train the machine learning models. Based on the sensor data gathered from the setup, the trained models are then used to make real-time predictions about the risk of ulcer formation. This study offers a novel method for detecting diabetic foot ulcers through the use of machine learning (ML) and the internet of things (IoT). This paper introduces a new, noninvasive, and reasonably priced method for detecting diabetic foot ulcers and diabetes using NodeMCU, MPU6050, Flex, MAX30100, and DHT11 sensors, as well as piezoelectric crystal sensors. The technology offers a tool for early disease detection, allowing for prompt intervention and the avoidance of consequences. This system offers a potential approach to health diagnosis and management by utilizing technology and machine learning, which enhances quality of life and lowers healthcare expenses.

Keywords: Machine learning, KNN Algorithm, IoT

1 Introduction

Millions of individuals worldwide suffer with diabetes, a chronic illness. If neglected, diabetic foot and foot ulcers are dangerous side effects of diabetes that can result in amputation In order to lower the risk of these problems, early detection and prevention are essential. According to IDF (2022), there are 537 million diabetics worldwide, and 25% of them get Foot Ulcers. Amputation rates are still high (50–70% of non- traumatic amputations) despite advancements in wound care hyperbaric oxygen therapy, and bioengineered skin substitute. To enhance results, ongoing research focuses on gene therapy, stem cell therapy, and personalized medicine. With an estimated prevalence of 3.6% to 10.4% among diabetics, diabetic foot ulcers

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are a major problem in India. By creating a small, noninvasive, and affordable tool that provides an easy-to use approach for real time foot ulcer assessment, this study aims to close this gap. The K-Nearest Neighbors (KNN) algorithm, a popular machine learning method renowned for its ease of use and efficiency in classification tasks, forms the basis of this system. The KNN algorithm classifies foot strength into predetermined levels by evaluating sensor data, allowing users to evaluate their foot ulcer in real time.

2 Literature Survey

S Brindha et at (2024) have described that diabetes, a chronic disease affecting millions worldwide, often leads to neuropathy, causing insensitivity in the feet. This condition increases the risk of Diabetic Foot Ulcers (DFUs), which if left unnoticed, may result in the need for amputation. To address this critical issue, we propose a novel diagnostic approach utilizing a prototype scanner equipped with a thermal camera. The thermal camera captures images of the plantar region, presenting a distinct rainbow color pattern. High temperatures are represented by the color red, indicating potential infection, while green signifies moderate or normal temperatures. Cooler regions are represented by blue or purple hues. Leveraging deep learning, our model is trained on the pixel values extracted from these thermal images. This comprehensive dataset enables the accurate detection of DFUs by analyzing temperature variations in the plantar region. By utilizing this innovative scanner, healthcare professionals can swiftly and non-invasively identify potential ulcers. This research presents a promising avenue for improving the management of diabetic complications and enhancing patient outcomes.

Gopidil Rithika Reddy et al (2023) have narrated Osteoporosis is a prevalent Foot disease that can be crippling and is distinguished by a loss of Foot strength and density. Fractures and other osteoporosis problems can be prevented by an early diagnosis of the condition. In this context, Foot image analysis using X-rays and CT scans is a promising approach for detecting osteoporosis at an early stage. This research paper presents a method for the early osteoporosis identification by Foot image analysis. The proposed method combines traditional image processing techniques with Convolutional Neural Networks (CNN). A diverse dataset of Foot images is collected and preprocessed. Conventional image processing techniques are used for feature extraction, while a CNN model is developed and trained for classification. The experimental results demonstrate high accuracy, sensitivity and specificity in detecting osteoporosis. The proposed method is non-invasive, cost-effective, and scalable, which makes it a valuable tool for enhancing osteoporosis diagnosis and patient treatment. Studies in traumatology and orthopedics have demonstrated the utility and potential of DL in the radiograph-based diagnosis of fractures and illnesses. In this paper, different classification techniques have been compared to classify the Foot. This research paper presents a method for the early osteoporosis identification by Foot image analysis.

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3 Proposed Methodology by KNN Algorithm

Creating a small, non-invasive, and affordable tool that provides an easy- approach for real-time foot ulcer assessment, this study aims to close this gap. The Nearest Neighbours (KNN) algorithm, a popular machine learning method renowned for its ease of use and efficiency in classification tasks, forms the basis of this system. The KNN algorithm classifies foot strength into predetermined levels by evaluating sensor data, allowing users to evaluate their foot ulcer in real time. The procedure usually starts with the collection of foot data utilizing imaging methods that offer precise structural information, like MRIs, X-rays, or 3D scanning. To improve image quality, preprocessing techniques like noise reduction and normalization are used after the data is gathered. Then, regions of interest like the arch or toes—that are essential for spotting anomalies are separated using segmentation algorithms. Convolutional Neural Networks (CNNs), in particular, are sophisticated machine learning models that employ vast datasets to identify patterns in order to diagnose abnormalities. In certain situations, wearable sensor pressure mapping is also used to identify functional problems like overpronation. Following segmentation, the system examines the anomalies found and offers diagnostic information, suggesting possible therapies like orthotics or surgery.

New developments in machine learning (ML) and the Internet of Things (IoT) present encouraging options for early detection and real time monitoring of diabetic foot disorders. IoT enabled gadgets, like smart insoles, can gather information on pressure distribution, foot temperature, and other markers that point to possible problems. The foot can then be classified as healthy, at risk of ulcers, or already impacted by a foot ulcer by utilizing machine learning methods, such as the K-Nearest Neighbors (KNN) algorithm. The system can learn to recognize patterns in temperature and pressure fluctuations and differentiate between normal and abnormal foot states by using labeled datasets to train the KNN model. CNN is divided into two stages. First, use feedforward to group photos together. The backpropagation technique should then be applied. Right now, the cropping and wrapping. CNN is divided into two stages. First, use feedforward to group photos together. The backpropagation technique should then be applied. Before classifying, the wrapping and cropping systems are now used to highlight the categorized object. Backpropagation and feed forward techniques can then be used for training. The Fully connected layer and feature extraction layer are the two most crucial components that make up CNN's structure. The 164-layer CNN architecture known as Inspection ResNetV2 was first trained using the Image Net datasets. The model is more robust for a wide variety of image formats and has learned feature representation.

4 Block Diagram for Detection of Foot Ulcer, Diabetic Foot

This block diagram illustrates a system that uses a NodeMCU microcontroller for data processing, acquisition, and display. A voltage regulator stabilizes the energy that comes from the power supply after it has been transformed from AC to DC by an ACDC converter. By interacting with different sensors and modules, the NodeMCU serves as the main controller.

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The MPU6050 is a motion sensor that measures direction and movement by fusing a gyroscope, accelerometer.

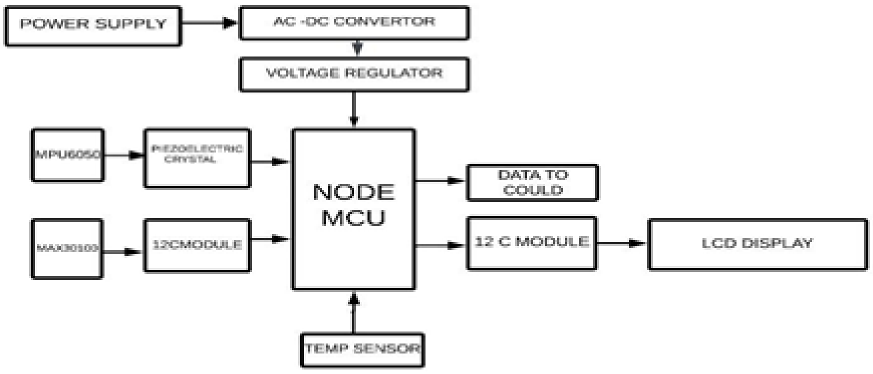

Figure 1: *Block Diagram*

The NodeMCU processes the electrical impulses produced by a piezoelectric crystal under mechanical stress. An I2C module connects the microcontroller to the MAX30100, a pulse oximeter rate sensor, to collect data. A temperature sensor keeps track of the body's or the environment's temperature. Data is concurrently shown locally on an LCD screen connected by another I2C module and transmitted to the cloud for analysis or storage. This adaptable system has several sensors for data management and real-time monitoring. processed by the NodeMCU. The MAX30100, a pulse oximeter and heart-rate sensor, interfaces with the microcontroller via an I2C module.

A NodeMCU microcontroller, which acts as the main processing and transmission unit, receives the gathered data. The NodeMCU serves as the brain of the gadget, processing sensor input in real time and getting the data ready for analysis. The device can send the processed data to an external machine learning system for analysis because the NodeMCU manages wireless connectivity as well. In certain configurations, the gadget might transmit the information to a local server or cloud platform for additional processing. The classification result is produced instantly after the data has been processed by the machine learning model. By classifying the foot ulcer into predetermined levels like "low," "medium," or "high," the device offers immediate feedback on the condition. It is essential that the user comprehends this classification.

Because of its lightweight and portable design, users do foot ulcer tests anywhere at home, in a gym, or in a clinic without the need for complicated equipment. Wireless feature of the device makes it easy to integrate with mobile applications, allowing for remote detection and ongoing monitoring of foot health over time. People in remote locations with limited access to standard healthcare services or those in need of examinations can use it thanks to this function. The results can be displayed on a user-friendly interface, either on a connected mobile device, computer, or a dedicated display screen on the device itself. Users can view their Foot strength

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analysis in real-time, allowing for easy and immediate interpretation of the results. In more advanced implementations, the system may provide detailed insights, trends over time, or recommendations based on the classified Foot ulcer. The device is designed to be lightweight and portable, enabling users to perform Foot ulcer tests in various settings, such as at home, in gyms, or clinics, without the need for complex equipment. The device's wireless capability allows for seamless integration with mobile applications, enabling remote detecting and continuous tracking of Foot health over time. This feature makes it accessible for people who need assessments or those in remote areas with limited access to traditional healthcare services.

5 Output

"Foot Ulcer Detection System" interface is shown in the final output window, together with the patient's parameter and the diagnostic outcome. Vital indications including blood pressure, oxygen saturation (SpO2), and heart rate (BPM) are included in the interface and are crucial for tracking a patient's health.

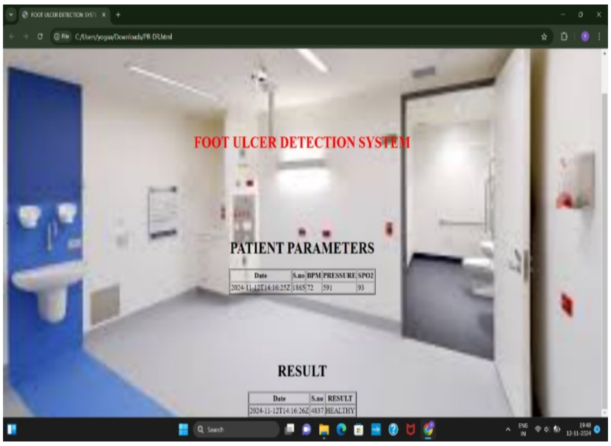

Figure 2: *Output*

The system processes those parameters and displays diagnostic results, made positive or negative for foot ulcers. The background of the interface resembles a clinical settings, enhancing its practical application in a healthcare environment.

6 Conclusion

In summary, the Foot Ulcer Detector project offers a non-invasive and user friendly way to track foot strength in real-time, marking a substantial progress in the field of foot health evaluation. This device is intended to provide precise and trustworthy data about a person's foot integrity by utilizing state of- technology like flex sensors, piezoelectric sensors, and machine learning algorithms. Because of its portability, users can do assessments in a variety of locations, including at home, in a clinical setting, or even during athletic training identify possible foot related problems early. Additionally, by integrating advanced data analytics, medical professionals may make well decisions about treatment plans and patient care, which

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ultimately improves health outcomes for people with foot diseases, fractures, and osteoporosis. Patient care and treatment programs, ultimately leading to better health outcomes for those with foot problems, fractures, and osteoporosis. In addition to giving people the ability to take charge of their foot health, the Foot Ulcer Detector offers researchers and medical professionals insightful information. This cutting-edge gadget has the potential to completely transform the way foot health is tracked by fusing affordability and effectiveness, making it a vital instrument in the continuous endeavours to improve general wellness and quality of life for people who are susceptible to foot-related conditions.

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