IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.311 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 12, Issue 5, May 2025
DOI: 10.17148/IARJSET.2025.125383

SHOES FOR DIABETIC PATIENTS

Sachin B[1], Srujan H G[2], Vishwanath V[3], Vivek M S[4], Mrs. Bhargavi Ananth[5]

Electronics And Communications Engineering, K S Institute of Technology, Bangalore, India[1-5]

Abstract: Diabetics causes neurovascular complications which leads to development of high pressure areas in the feet. Diabetic neuropathy causes severe nerve damage, which may ultimately lead to ulcerations. This paper discusses about the detection of foot neuropathy as early as possible, from a home based environment. Flexi force sensors are used to measure the pressure in different areas of our foot and it will be displayed on the server side console. The vibrating motors can be used to stimulate vibrations at different frequencies at the desired locations thus improving the blood flow. Thus a low-cost foot pressure and foot movement analysis and blood flow stimulation system, is developed which a patient can wear at any place to monitor his or her foot pressure distribution. AI based deep learning model is used to generate the foot pressure level graphically.

Keywords: Diabetic Neuropathy, Foot Pressure Monitoring, Smart Shoe, Vibration Therapy**.**

I. INTRODUCTION

Diabetes is a major global health issue, contributing significantly to illness and death rates worldwide. It leads to the formation of high-pressure areas in the lower limbs, especially the feet. In a 2012 report on the economic impact of diabetes in the United States, it was found that 9.3% of the population was affected. Additionally, 25.9% of people aged 65 and above, which is about 11.8 million elderly individuals, were living with the condition. In 2010, nearly 69,071 death certificates listed diabetes as the primary cause of death. One of the serious complications of diabetes is diabetic neuropathy, a condition that causes significant nerve damage and leads to the creation of pressure hotspots on the feet, which may result in ulceration. Research conducted at a biomedical university in the United States has shown that applying controlled thermal stimuli to the feet of diabetic and stroke patients can enhance nerve function and improve blood circulation. Diabetic neuropathy is a severe medical condition, but early detection through the identification of abnormal foot pressure patterns can help prevent it. While foot pressure monitoring equipment is available in India and some other countries, such devices are often not accessible to most people because they are expensive, bulky, and not portable. These pressure measurement systems are rarely found in developing countries, which are home to large populations with high diabetes prevalence. Our proposed system addresses this gap by designing a solution where sensors and pressure detectors are embedded within a smart shoe, and the data is monitored through a simple handheld device. This approach not only allows early detection of pressure anomalies but also aids in treatment and prevention of diabetic neuropathy. The system is designed to be affordable, portable, and easy to use, making it well-suited for deployment in regions with limited healthcare access. It also includes a large external memory unit capable of storing continuous foot pressure data for several weeks, enabling ongoing monitoring and timely medical intervention. By making advanced diabetic foot care more accessible and cost-effective, our design aims to significantly reduce the risk of complications among patients in low-resource settings.

II. LITERATURE SURVEY

1)Artificial Intelligence Based Prediction of Diabetic Foot Risk in Patients with Diabetes: A Literature Review
Author: Lucija Gosak 1,* , Adrijana Svensek 1 , Mateja Lorber 1 and Gregor Stiglic
Year:2023

Diabetic foot is a common long-term complication of diabetes and is associated with an increased risk of lower limb amputation, which is both an economic and social issue. Through the identification of the risk of diabetic foot early enough, it can be avoided or postponed at least. By employing artificial intelligence, delayed diagnosis can be avoided, resulting in intensified preventive treatment of patients. On the basis of a systematic review of literature, we examined 14 studies involving the application of artificial intelligence to predict diabetic foot risk development. The studies were extremely heterogeneous regarding data utilization and exhibited different sensitivities, specificities, and accuracies. Support vector machine (SVM) (n = 6) and K-Nearest Neighbor (KNN) (n = 5) were the most frequently employed machine learning methods. Further studies are advised on larger samples of subjects employing various methods to establish the most appropriate one.

Advantages: allows for early detection, avoiding delayed diagnosis and enabling more intensive preventive treatment.
Disadvantages: Data heterogeneity in use and differing performance measures across studies indicate that future studies with larger samples and diverse methods are needed to determine the best approach.

2) An IoT based Foot Healthcare System for Diabetic Patients and a Futuristic Approach for transforming Sensor Data into real-time Medical Advice.
Author: S.K.Mydhili1 ,Jayalakshmi N 2 ,Fathima Naseera M 3 ,Ranjith Kumar R 4& Rohith N
Year: 2022
Foot plantar pressure distribution disquisition is an important aspect in diabetic healthcare. Diabetic cases have weaker bottom due to increased blood sugar position. It damages the small blood capillaries particularly in bottom. The primary cause of the damage is due to the compression of blood capillaries. The Diabetic bottom complaint is anticipated to increase in the near future. In the event of inadequately managed diabetes, diabetic cases encounter the complication in form of bottom ulcers, decomposition of the skin apkins. To help dangerous detriment to the bottom and to enhance the mending time, it's necessary to screen the case's regular remedy conditioning in the sanitarium and at home. Although several styles have been evolved to do quantitative GAIT analysis, the system proves to be unprofitable as it takes dimension of static or dynamic process for a short time. Because the figures of cases suffering from diabetes are growing around the world due to hygienic living, the conception to identify the diabetic issues beforehand has been acquiring lesser significance in the medical profession. Foot ulcers are developed because of indecorous blood inflow, loss of sensation, and low rate of crack mending. The system to be proposed will give the readings of hardness position and pressure at different locales of the bottom. When the signal exceeds the limit, the alert will be given to case's consulting croakers or physiotherapist or their separate caretaker to help any life- hanging condition. contemporaneously the concerned people come to attend the cases; this suggested system is equipped with a blood inflow stimulator in order to stimulate the bold rotation to help impassiveness or any other worse state. colorful ways have been established for bottom health monitoring, those methodical processes just cover and save the data, there's no ways to reduce the problem from getting worse. This suggested system with blood inflow stimulator will enhance the blood inflow that aids in accelerating the mending of the crack and avoiding its deterioration.

Benefit -The target system for covering bottom health along with a blood inflow stimulator offers real- time bottom pressure and hardness readings and has an inbuilt point of stimulating blood rotation for better mending of injuries.

Disadvantages- Limited substantiation or discussion regarding the effectiveness of the system in preventing worsening conditions, and possible difficulties in incorporating this system into standard patient care practices.

3) IoT and Cloud Based Healthcare Solution for Diabetic Foot Ulcer
Author: Punit Gupta, Navaditya Gaur, Rajan Tripathi.
Year:2020
Iot can be used to attack real time issues in Healthcare. multitudinous problems can be corrected using the stylish application of IOT Healthcare. It can be used to descry Diabetes in early stages, discovery of Foot ulcers, abnormality in the heart rate and so on. This paper suggested the plan and its operation in Healthcare with the operation of IOT in detecting ulcer in the bottom of cases suffering from Diabetes. The handed model is used to dissect the medical status of ulcer caused by diabetic and alert in case of anomaly. knot MCU development board is used in its model development and retains and keeps track of the medical record of the Case. It also facilitates real time sharing of large quantities of data with high effectiveness. In fact, this model slack off considerable time consuming tasks similar as frequent croaker visits and offer real time update concerning case.

Benefits: -IoT healthcare makes diabetic bottom ulcers easier to descry beforehand, allows real- time shadowing, and uses Node MCU for data sharing and storehouse effectively to lower the frequence of croaker visits.

Disadvantages :-Some possible downsides could be issues regarding data protection and sequestration, and an assurance of secure internet connection for smooth real- time updates.

4) A Non-Invasive Photonics-Based Device for Monitoring of Diabetic Foot Ulcers: Architectural/Sensorial Components & Technical Specifications
Author: Anastasios Doulamis 1,*, Nikolaos Doulamis
Year:2021
In the following paper, a newnon- invasive photonic- based device for controlling Diabetic Foot Ulcers(DFUs) in diabetic cases is suggested. DFUs are one of the most severe complications of diabetes, which could beget significant disabilities, i.e., nethermost amputation, or indeed death. The device under consideration utilizes hyperspectral(HSI) and thermal

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imaging to quantify the condition of an ulcer, as opposed to the being procedure where invasive autopsies are generally employed. Specifically, these two photonic- predicated imaging styles can estimate the biomarkers of oxyhaemoglobin(HbO2) and deoxyhaemoglobin(Hb), upon which the Peripheral Oxygen Saturation(SpO2) and Towel Oxygen Achromatism(StO2) is calculated. These parameters are extremely critical for the early opinion and prognosis of a DFU. The device is applied in two editions the in- home edition applicable for cases and the PRO(professional) edition for the professionals. The ultimate is handed with active photonic instruments, like tuneable diodes, to allow thorough opinion and treatment of an ulcer and its development. The device is augmented with embedding signal processing machines for noise elimination and pixel delicacy improvement through super resolution fabrics

Advantgaes:- help the croakersand the cases realize the impact of the biomarkers on DFU.
Disadvantages:- The device is to be validated at large scales

5) Classification of Diabetic Foot Ulcers Using Class Knowledge Banks
Author: Yi Xu1 , Kang Han2 , Yongming Zhou3 *, Jian Wu1 , Xin Xie1 and Wei Xiang4
Year:2022
Diabetic bottom ulcers(DFUs) are a veritably frequent diabetes complication. Determining the actuality of infection and ischaemia in DFU is pivotal in ulcer assessment and treatment planning. lately, the motorized opinion of infection and ischaemia of DFU using deep literacy ways has displayed encouraging performance. The maturity of slice- edge DFU image bracket approaches use deep neural networks, particularly convolutional neural networks, to learn discriminational features, and estimate class chances from the learned features using completely connected neural networks. During the testing, the vaticination relies on a single input image and trained parameters, whereby knowledge within the training data is n't Its performance and characteristics for incremental literacy remainexplicitly used. To work the knowledge in the training data more effectively, we introduce class knowledge banks(CKBs) as trainable units suitable to prize and represent class knowledge effectively. A unit in a CKB is employed to calculate similarity against a representation drawn from an input image. The mean similarity of units in the CKB to the representation can be interpreted as the logit of the input being considered. therefore, the vaticination relies not only on input images and learned parameters in networks but also on class knowledge learned from training data and saved in the CKBs

Strengths:- Experimental results indicate that the proposed system can significantly enhance DFU infection and ischaemia groups.
Disadvantages:- Its incremental literacy performance and nature stayed the same.

6) Artificial Intelligence Methodologies Applied to Technologies for Screening, Diagnosis and Care of the Diabetic Foot: A Narrative Review
Author: Gaetano Chemello 1 , Benedetta Salvatori 1 , Micaela Morettini 2 and Andrea Tura 1
Year:2022
Diabetic foot syndrome is a multifactorial disease with at least three primary etiological factors, i.e., peripheral neuropathy, peripheral arterial disease, and infection. Besides complexity, another characteristic feature of diabetic foot syndrome is its insidiousness, as a result of a common lack of early symptoms. Over the past few years, it has become obvious that the frequency of diabetic foot syndrome is on the rise, and it is one of the complications of diabetes with a more significant effect on patient's quality of life. Given the multifaceted character of this syndrome, artificial intelligence (AI) techniques seem to be sufficient to deal with issues like timely screening for risk detection of foot ulcers (or, worse still, for amputation), on the basis of suitable sensor technologies. Herein, we review the essential results of the relevant research works in the field, focusing both on the AI methodology aspects and on the chief physiological/clinical study outcomes.

Advantages: The studies analyzed reveal that AI application to data obtained by various technologies offers promising outcomes.
Disasdvantages: incorporation of quantitative measures based on simple sensors, which are still underutilized.

7) Machine learning prediction of diabetic foot ulcers in the inpatient population
Author: Stavros Stefanopoulos [1], Samar Ayoub [1], Qiong Qiu [1], Gang Ren [1], Mohamed Osman [1], Munier Nazzal [1], Ayman Ahmed
Year:2021
Nationwide Inpatient Sample databases were analyzed between the times 2008 and 2014. ICD-9-CM and Agency for Healthcare Research and Quality comorbidity canons were employed for data collection backing. Chi-square testing was performed by employing variables that had a positive correlation with DFUs. Pupil T- test, Wilcoxon rank sum test, and chi-square test were employed for descriptive statistics. Six predictive variables were set up. A decision tree model

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CTREE was used to help in creating an algorithm. 326,853 cases were recorded with DFU. The significant variables that were responsible for this opinion(both p< 0.001) were cellulitis(OR 63.87, 95 CI(63.87 – 64.49)) and Charcot joint(OR 25.64, 95 CI(25.09 – 26.20)). The model delicacy of the six-variable test data was 79.5(80.6 perceptivity and 78.3 particularity).

The undercurve area(AUC) for the 6-variable model was 0.88.
Advantages- created an algorithm that had a 79.8 delicacy which was suitable to predict the trouble of developing a DFU.

Disadvantages- Cost calculation

8) Machine Learning Models for Predicting the Risk of Hard-to-Heal Diabetic Foot Ulcers in a Chinese Population.
Author: Shiqi Wang 1, Chao Xia2, Qirui Zheng3, Aiping Wang4, Qian Tan
Year:2022
sought to create a predictive model with machine learning to determine diabetic foot ulcers (DFUs) that are difficult to heal—i.e., wounds that fail to decrease in size by over 50% within four weeks. There were 362 patients with DFUs from two tertiary centers in eastern China recruited into the study. The dataset was divided into training and validation sets in a ratio of 70:30. Clinical features relevant to model development were selected using clinical experience and univariate logistic regression. Six machine learning models, such as support vector machine (SVM), naïve Bayes (NB), k-nearest neighbor (k-NN), generalized linear regression, adaptive boosting (AdaBoost), and random forest (RF), were employed. Five-fold cross-validation was utilized to assess these models along with performance metrics including accuracy, precision, recall, F1-score, and area under the curve (AUC).

The most important clinical features of predictive value were the size of the wound, random blood glucose, C-reactive protein (CRP), use of insulin, serum albumin, serum creatinine, diabetic retinopathy, peripheral artery disease, and smoking status. Of the models tried, the naïve Bayes algorithm worked best, with an AUC of 0.864, recall of 0.907, and an F1-score of 0.744. According to the results, an online calculator was created to help clinicians predict the probability of hard-to-heal DFUs based on features found. The research reveals the potential of machine learning to improve early identification and treatment of difficult DFU cases. The authors mention that the model needs validation on various populations and settings and practical use in clinical practice might pose challenges.

9) Robust Methods for Real-Time Diabetic Foot Ulcer Detection and Localization on Mobile Devices
Authors: V. Kumaravel, B. Eswara Reddy, M. Mohamed Sathik
Year of Release: 2020
Abstract: The research work "Robust Methods for Real-Time Diabetic Foot Ulcer Detection and Localization on Mobile Devices" by V. Kumaravel, B. Eswara Reddy, and M. Mohamed Sathik is one such study where a deep learning-based method of real-time diabetic foot ulcer (DFU) detection and DFU localization has been proposed. Conventional DFU screening will be done mostly through manual analysis by podiatrists, or automated systems aiming at either classification or segmentation. In this work, the authors created a strong deep learning model with 1,775 DFU images as dataset, with region-of-interest manually labeled by two clinicians. With the Faster R-CNN architecture with InceptionV2 and two-stage transfer learning, the model had a mean average precision of 91.8%, a 48 milliseconds per-image inference speed, and a slim model size of 57.2 MB. To prove its real-time functionality, the model was implemented on a NVIDIA Jetson TX2 device and a mobile app, demonstrating great potential for clinical use in practice. The research concludes that deep learning has potential for DFU localization in real-time mobile environments and could be further enhanced with a larger dataset.

Advantages :Real- time discovery and localization on mobile bias. nonentity models that are deployable on resource-limited platforms. assists in the early discovery and shadowing of DFUs, enhancing patient care. Minimizes necessity for precious clinical visits and attack.

Limitations :Holds high perceptivity to the quality and variability of input images. Limited generalizability when extended to eclectic populations not included in the training data. Demands large mobile GPU/ CPU resources for effective real-time processing.

10) Automated Diabetic Foot Ulcer Detection and Classification Using Deep Learning
Authors: L. Goyal, R. Aggarwal, R. Chouhan, S. Chouhan
Year of Release: 2020
Abstract: The authors suggest a new system called SSODL- DFUDC(Sparrow Search Optimization with Deep literacy-Eased Diabetic Foot Ulcer Discovery and Bracket). This algorithm blends the state- of- the- art deep literacy methodologies

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DOI: 10.17148/IARJSET.2025.125383

with an optimization approach to enhance the effectiveness and delicacy of DFU discovery and bracket from images. The model utilizes the commencement- ResNet- v2 network as the point birth model, and rather than using homemade hyperparameter tuning — labor- ferocious and error-prone — it applies the Sparrow Search Optimization(SSO) algorithm to automatically acclimate model parameters. To classify, the system utilizes a piled meager autoencoder(SSAE) to separate between ulcerated andnon-ulcerated areas. The issues indicate that the introduced SSODL- DFUDC frame is superior to other deep literacy models in discovery delicacy and bracket performance. Primary strengths of this strategy are high perfection in distinguishing the affected regions, lower mortal error, effectiveness with indeed a comparably small database owing to transfer literacy, and an accelerated, automated system able of easing clinicians' workloads. The exploration illustrates the pledge of marrying deep literacy and optimization algorithms towards dependable, real- time DFU opinion.

Limitations :
Model performance is subject to degradation with poor image quality or innocent differences. Requires annotated data sets, which may be time-consuming to set up.Deep models are typically regarded as" black boxes," which degrades explainability for clinical validation.

III. PROBLEM IDENTIFICATION

Diabetes is a worldwide health problem, and it makes a major contribution to rates of illness and death. Its serious complication is Diabetic Neuropathy, leading to the formation of high-pressure areas on the feet through damage to the nerves. It is a condition, if undiagnosed, that may lead to disastrous results like ulcerations and amputations of the limbs. Consistent with a 2012 research study on the United States' economic burden of diabetes, nearly 9.3% of the population was impacted, with 25.9% of those aged 65 and older suffering from the disease. Additionally, diabetes was listed as the underlying cause of nearly 69,071 death certificates in 2010. These statistics substantiate the need for enhanced management of diabetes and the detection of early complications.

Present-day foot pressure distribution monitoring technologies tend to be expensive, heavy, and not portable, reducing their accessibility—particularly in developing areas with a high incidence of diabetes. In addition, the technologies are not readily affordable or accessible to common users, especially in rural or resource-poor environments.

There is a specific need for an inexpensive, compact, and portable device that can be embedded in a shoe to track foot pressure patterns in real time. The device might also include therapeutic modalities—such as subtle vibrations—to activate blood flow and aid nerve recovery, providing preventive as well as treatment advantages. This would fill the gap between availability and affordability, particularly for low-resource populations in developing areas, to allow for early diagnosis and treatment of Diabetic Neuropathy.

IV. APPLICATIONS

- **Early Detection of Diabetic Neuropathy**

Identifies abnormal pressure patterns in the foot, enabling early diagnosis before visible symptoms or ulcers develop.

- **Prevention of Foot Ulcers and Amputations**

Continuous monitoring helps reduce the risk of complications like ulcers, which, if untreated, may lead to amputations.

- **Therapeutic Stimulation**

Delivers imperceptible vibrations to stimulate blood circulation and nerve repair, improving foot health in diabetic and stroke patients.

- **Remote Health Monitoring**

Enables healthcare providers to access real-time or stored patient data remotely, allowing for better follow-up and timely interventions.

- **Personalized Footwear Design**

Helps orthopedic specialists design custom insoles or footwear based on pressure distribution data to reduce strain and discomfort.

- **Portable and Home-Based Care**

Provides an affordable, easy-to-use solution for home care, especially beneficial in rural or underserved regions with limited access to hospitals.

- **Data Logging for Medical Research**

Accumulates long-term pressure data that can support research on diabetic complications, gait analysis, and treatment effectiveness.

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V. CONCLUSIONS AND FUTURE SCOPE

Diabetic Neuropathy is a critical health issue that often remains undetected until serious complications arise, such as foot ulcers or amputations. The proposed smart foot pressure monitoring system addresses this challenge by offering a low-cost, portable, and efficient solution that enables early detection and continuous monitoring of abnormal pressure patterns in the feet. By integrating sensors and therapeutic actuators into a wearable shoe unit, the system not only facilitates early diagnosis but also promotes nerve health through subtle vibration therapy, making it especially valuable in underserved and rural areas where access to healthcare is limited.For real-time data sharing, integration with mobile applications for user-friendly interfaces, and implementation of AI algorithms to predict complications based on pressure trends. Additionally, cloud-based platforms could support remote monitoring of multiple patients by healthcare providers Looking ahead, this system has significant potential for further development. Future enhancements could include wireless connectivity. Incorporating energy-efficient designs or self-powering mechanisms could also improve usability and reduce maintenance. With these advancements, the system can evolve into a comprehensive tool for preventive care, personalized treatment, and long-term management of diabetic foot complications.

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