Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.12.029

Portable Device to Predict Diabetic Foot Ulcer

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Submitted: 16 March 2023; Accepted: 19 April 2023; Published: 13 May 2023

ABSTRACT

Diabetes mellitus is a common condition in people where the blood glucose level is higher than the recommended level. It occurs either due to the improper secretion of insulin by the pancreas or when the body doesn't use the insulin effectively. The count of the number of people being affected by diabetes has been increasing drastically over the past few decades. About 60% of patients with diabetics will sustain from nerve damage, in which 5% of the patients suffer from diabetic foot ulcer and 1% of patient end up with amputation. Hence, with the early prediction of foot ulcers among diabetics, we can cure foot ulcers in the early stages of infection. An attempt is made to design a device that will be able to predict diabetic foot ulcers in patients with the help of various sensors. The device measures temperature (MLX90614), gait/pressure (piezoelectric sensor), and oxygen level (MAX30100) sensors. It is done by placing the sensors in predefined locations. The output of sensors is processed using Arduino Nano. The device captures vital biomarkers using the sensors described in the methodology. The processed values are compared with the standard values. The results obtained from the comparisons can be used to differentiate between the normal and abnormal feet of the patients.Hence, the proposed screening tool is used to predict the diabetic foot ulcer before their onset and can be used as a preliminary screening device.

Keywords: *Diabetic foot ulcer (DFU), Arduino Nano, Machine Learning, Sensors*

INTRODUCTION

Diabetes Mellitus (DM) also known as diabetes, is developed due to the improper secretion of insulin caused by Hyperglycemia that leads to life threatening complications such as Heart disease, Kidney failure, Cardio vascular diseases. The major complication of Diabetes is Diabetic Foot Ulcer(DFU) which occurs due to the prolonged Diabetes that end up with amputation. According to the global report, the people suffering from Diabetes in 2014 was about 422 million whereas in 1980 it wasonly about 108 million people.

Among the adults, the global prevalence has gone up from 4.7% in 1980 to 8.5% in 2014. By the end of 2035 it was estimated that over 600 million people will be suffering from DM. The significance is that only 20% of the people from developed countries will be suffering from DM whereas the rest of the people will be from developing countries because of the poor awareness and knowledge about the DFU, lack of healthcare facilities. The chances of diabetic patients from developing DFU is about 15%-25%.Every year, more than 1 million patients tends to lose their foot due to the lack of proper

treatment at proper time. A Diabetic patient with a ‘high risk’ foot needs periodic check-ups of doctors, continuous expensive medication, and hygienic personal care to avoid further consequences as discussed earlier. Hence, it causes a great financial burden on the patients and their families, especially in developing countries where the cost of treating this disease can be equivalent to 5.7 years of annual income. In current medical practices, there are various techniques toevaluate DFU comprises of early diagnosis, keeping continuous track on the development of the wound , and a number of lengthy actions taken in the treatment and management of DFU for each particular case: 1) the medical history of the patient is evaluated; 2) a wound or the ulcer is continuously examined by the specialist 3) additional tests like CT scans, MRI, X-Ray may be useful to detect the develop treatment for the ulcer.

LITERATURE SURVEY

A diabetic foot ulcer is a life-threatening problem. Due to improper diagnosis and treatment of DFU, more than 1 million diabetic people every year lose a portion of their leg. So for early prevention, we have prepared a prototype to predict the diabetic foot ulcer. The foot plantar pressure sensor model is proposed to study the pressure distribution to the foot with more accuracy and authenticity [1]. The LM35 temperature sensors are used for comparison between normal and diabetic mellitus [2]. The normal pulse rate ranges from sixty to a hundred bits per minute. The pulse value is measured in theprimary artery in the foot called the dorsal pedal artery [3]. The concept of microclimate, which describes the nature of the foot, is introduced, and the systematic review aims to assess the evidence about risk predictors of DFU in relation to a pre-specified definition of microclimate [4]. Deep learning approaches can be used to detect diabetic foot ulcers (DFUs), which are the major complications of diabetes that can lead to serious health problems. Early detection and treatment of DFUs are crucial in preventing their progression. By using the algorithms of deep learning , it will be possible to increase the accuracy and speed of DFU detection, allowing for earlier diagnosis and treatment [5].The study explores uses convolution neural network (CNN) for the automated detection of the infection fromthe images of diabetic foot ulcers. The goal is to improve the accuracy and efficiency of detecting infected ulcers, which is important in preventing further complications. The CNN model was trained on a dataset of images labeled as infected or non-infected and achieved high accuracy in identifying infections. The results suggest that the CNN model has the potential for clinical use in assisting healthcare professionals with the early detection and treatment of infected diabetic foot ulcers [6].The study explores use of a convolutional neural network (CNN) for the automated detection of infection in images of diabetic foot ulcers. The goal is to improve the accuracy and efficiency of detecting infected ulcers, which is important in preventing further complications. The CNN model was trained on a dataset of images labeled as infected or non-infected and achieved high accuracy in identifying infections. The results suggest that the CNN model has the potential for clinical use in assisting healthcare professionals with the early detection and treatment of infected diabetic foot ulcers [7]. The article provides a review of the use of infrared thermography (IRT) for computer-aided diagnosis of diabetic foot. It discusses the advantages and limitations of IRT as a non-invasive imaging technique and highlights various computer-based algorithms for analyzing IRT images. The article concludes that IRT has great potential for early detection and diagnosis of foot complications in diabetic patients, and its combination with computer-aided diagnosis techniques can lead to improved accuracy and efficiency in diagnosis and treatment [8].The paper evaluates the performance of deep learning models in detecting diabetic foot ulcers (DFUs) from images. The study presents a comprehensive evaluation of the models using a dataset of DFU images and compares their performance in terms of accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve (AUC-ROC). The results showed that the deep learning models achieved high accuracy and AUC-ROC values for detecting DFUs, with the best-performing model achieving an accuracy of

J Popul Ther Clin Pharmacol Vol 30(12):e249–e255; 13 May 2023.

92.7%. Early detection and treatment ofDFUs are crucial for preventing complications, and by using thedeep learning models can aid in this process[9].Diabetic foot ulcer is the life threatening complication of diabetes that can lead to infection and amputation. This method aims to provide an early warning system for healthcare professionals to intervene and prevent the patient from developing the foot ulcer. By using dynamic pressure measurements, changes in foot pressure can be detected and monitored, which can help identify patients who are vulnerable of developing the foot ulcers[10].

In this work, there is a usage of pressure, temperature, and pulse values which is collected via various sensors such as a piezoelectric sensor, lm35, and pulse sensor. The values from the sensors are stored in the cloud. Then attempt to make a classification based on the data stored in the cloud. Here empirically Random forest algorithm is used, then the classified results are transferred to the web app. That is it will be easy to access to the users.

METHODOLOGY

To make earlier prediction values from the foot is needed, to do so Necessary sensors are placed in the required place through that biomedical signal is obtained such as foot pressure, foot temperature, and foot pulse value then required values are stored in Arduino nano. Lm35 is used to get the temperature value, the piezoelectric sensor is used to get the pressure value which is placed in the four predetermined points, Pulse sensor is used to get the required pulse for the classification. The values are sent to the cloud via the wifi module, and through the cloud, an API key is generated to fetch real-time dynamic data through that machine learning model is trained and classification is done. The results are displayed to the user via the web app.

Block Diagram

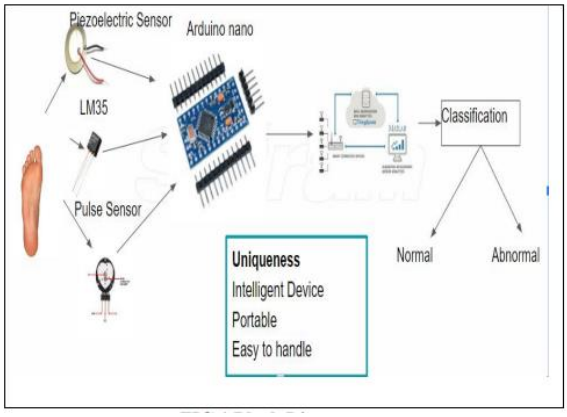

FIG 1: Block Diagram

Based on the study, the vital parameters from the foot are measured such as Temperature, Pulse, and pressure through various sensors such as lm235, piezoelectric sensor, flexi force sensor. Then the data is sent to the cloud via the wifi module.

From the cloud data is sourced in the rest API. By using the rest API the data is sourced in variables through which machine learning prediction is done.

PROPOSED SYSTEM

Diabetic Mellitus (DM) also known as diabetes, is developed due to the improper secretion of insulin caused by Hyperglycemia that leads to life threatening complications such as Heart disease, Kidney failure, Cardio vascular diseaseslower limb amputation- often preceded by diabetic foot ulcer- are all possible outcomes of DFU.

In this project, the vital parameters of the foot is taken and processed to obtain the prediction. The vital parameters such as temperature, pressure and pulse are taken. The raw data is processed in Arduino NANO, there is a usage of WIFI module

which will transfer the data to the cloud(ThingSpeak) for every fifteen seconds the data will be updated in the cloud. The readings has been taken for first ten entries due to high resistance of the components first two values are omitted. There is a REST API created in the cloud, which further used in machine learning model.

J Popul Ther Clin Pharmacol Vol 30(12):e249–e255; 13 May 2023.

The mean values are taken and further used in machine learning model. We used a Random Forest algorithm to classification of the diabetic foot ulcer. Based on the cloud data prediction is done.

The web application has been created with use of FLASK . Based on the machine learning output. The report will be shown as a UI format.

A diabetic foot ulcer is a prevalent disease worldwide. An attempt is made to predict DFU at an early stage. The vital parameters are extracted from the foot and the experimental setup is shown in Fig

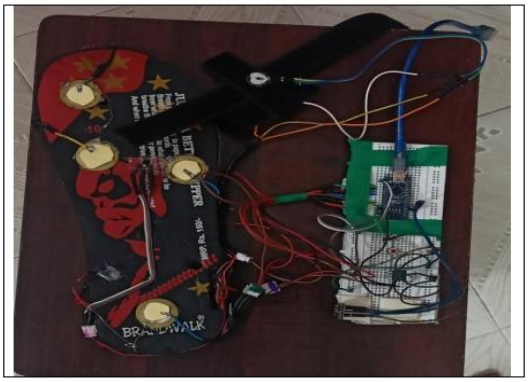

FIG 2: Experimental setup

RESULTS AND DISCUSIONS

The values of vital parameter are obtained in the cloud(ThingsSpeak). There has been a classification done based on the data in the cloud. The machine learning model is trained with Random forest algorithm with provided classification such as Positive for abnormal subjects and Negative for normal subjects.

The report will be shown to the users via web application.

Based on the observation done a table is made as below

Parameters	Normal Range	Abnormal Range
Pulse Rate	Less Than 65 And Greater Than95(Bpm)	Less Than 65 And Greater Than 95(Bpm)
Temperature	Less Than 36 And Greater Than 25	Less Than 25 And Greater Than 36

Piezoelectric Sensor

The piezoelectric sensor is placed in the four main points such as Big Toe, Mid-point 1, Mid-point2, and Hallux, and the values were fetched and fed to Arduino NANO. Then with the help of the Wi-Fi module data is transferred to the cloud called thingSpeaks through which a Machine learning prediction is made. Piezoelectric sensors will get the pressure values, and based on this gate analysis is done.

For four specific points, the sensor is placed and data is acquired in the cloud, The graphs are shown below for the classification first three entries those values are ignored since they are garbage values, then the remaining values are taken for classification

Big toe

This is one of the important points in the foot where the pressure analysis is done based on it the graph is plotted below

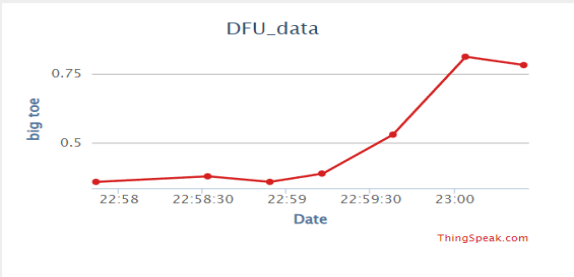

FIG 3: Variation of pressure in Big toe

Mid-point 1

This is one of the important points in the foot where the pressure analysis is done based on it, the graph is plotted below

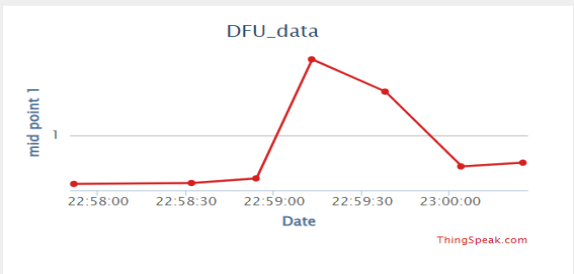

FIG 4: Variation of pressure in Mid-point 1

J Popul Ther Clin Pharmacol Vol 30(12):e249–e255; 13 May 2023.

Mid-point 2

This is one of the important points in the food where the pressure analysis is done based onthis point value graph is plotted below

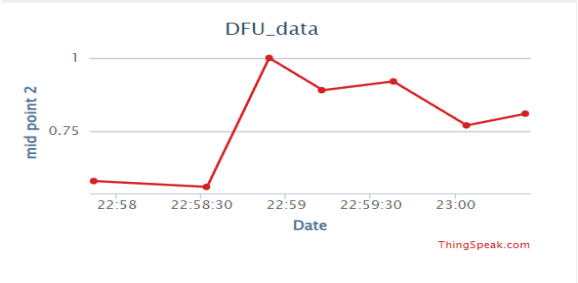

FIG 5: Variation of pressure in Mid-point 2

Hallux

This is one of the important points in the foot where the pressure analysis is done based on this value, the graph is plotted below

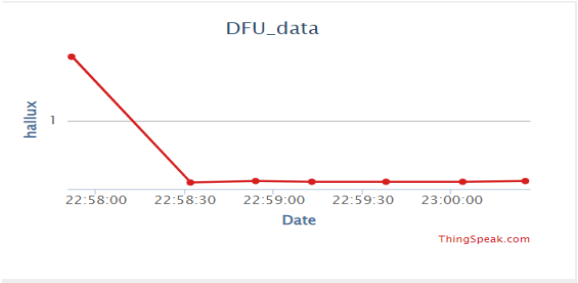

FIG 6: Variation of pressure in hallux point

Pulse Value

The Pulse value is measured and has been taken for prediction purposes The graphs are shown below for the classification first 3 entries those values is ignored, then the remaining values are taken for classification

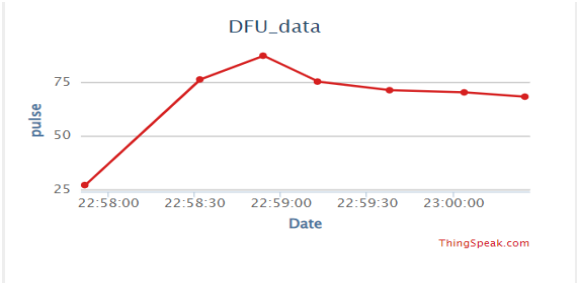

FIG 7: Variation of pulse rate in foot

Temperature

Temperature is a key parameter in diabetic foot ulcers using the Lm35 sensor at the foot through which the temperature is measured. It is one of the most important parameters for the classification if the temperature values exceed 37° C, it's classified as abnormal The graphs are shown below for the classification first 3 entries that values are ignored, then the remaining values are taken for classification

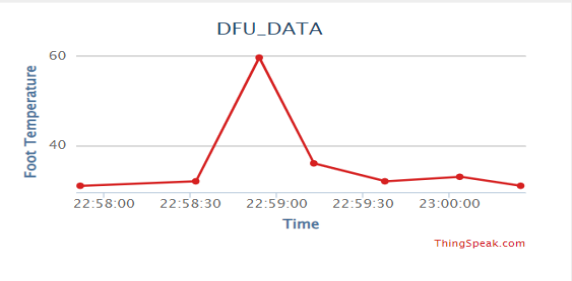

FIG 8: Variation of temperature in the foot

Cloud

There are many free cloud sources available for this purpose, we have made use of the "things speak" cloud which is open-source and free to use. As discussed earlier data is sent to the cloud (things speak) through a wifi module through which data is sent to the classification with the use of REST API. Based on the cloud data graphs are plotted. There is a high resistance value for the first three entries we can see that in the graph.

Classification

The data from the foot is collected in the cloud and exposed via REST API to make classifications. Through the API key one can get real-time data dynamically. With the help of the API key, The mean temperature and mean pulse for 10 entries are used for the classification

Web Application

To make user-friendly access to our project, we app has been created through which users can access and find their results. It will change dynamically whenever the values in the cloud change that is for every new entry it will change

J Popul Ther Clin Pharmacol Vol 30(12):e249–e255; 13 May 2023.

the results dynamically. Here flask is used to transfer the data to the Font end.

Mocked up screens are shown below

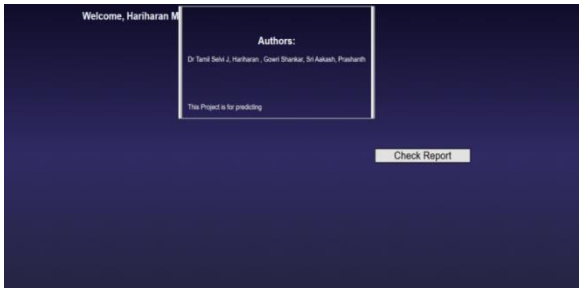

FIG 9: Home page of web app

For normal subjects

If the subject is normal then the below screen will be displayed, based on that report is provided in the screen itself

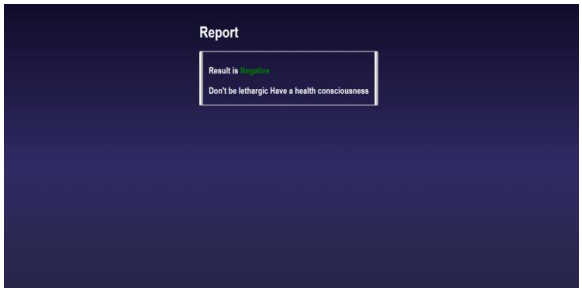

FIG 10: Report of Web app for normal subject

For abnormal subjects

If the subject is normal then the below screen will displayed , based on that report is provided in the screen itself

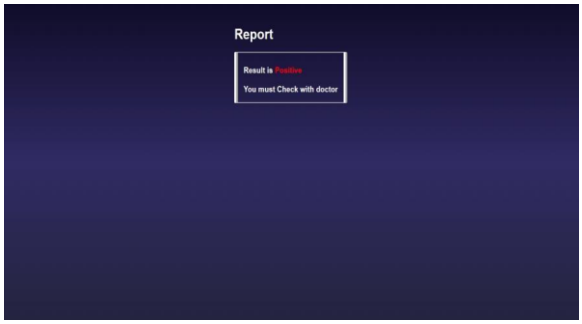

FIG 11: Report of web app for abnormal subject

CONCLUSION

A foot ulcer is the most unseen problem in today's world, however, it will be Sevier when it's unnoticed. As there is a famous saying that "Prevention is better than cure". So the prevention tool is designed. Proper measures should be taken to prevent this, to know about the starting stage of foot ulcers. People want to visit the hospital and need to do examinations in person so many are hesitating to do so. The proposed device that uses temperature, gait/pressure, and pulse level sensors to predict diabetic foot ulcers in patients is a promising tool that can help identify the onset of foot ulcers in diabetic patients at an early stage. Early detection can lead to early intervention and treatment, which can prevent the progression of foot ulcers and reduce the risk of amputation. However, further research and testing are necessary to determine the accuracy and effectiveness of the device in predicting foot ulcers in a clinical setting. Additionally, the device should be validated through clinical trials to ensure its reliability and safety before being implemented in clinical practice.. Foot ulcers in the earlier stage are predicted and measures are taken in the earlier stage. This is create a great impact in society. The mortality rate due to diabetic foot ulcer can be reduced significantly

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