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IDENTIFICATION AND ANALYSIS OF FOOT ULCERATION USING LOAD CELL TECHNIQUE

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Abstract - *Diabetes Mellitus is one of the most serious non communicable diseases. It may cause severe health issue such as amputation. This paper presents the foot pressure analysis using load cell sensors which are inserted inside the mat. The accuracy and precision can be achieved by employing machine learning technique and applying support vector machine classifier of more than 94.6% and 95.2% respectively. Many other techniques include a thin sheet pressure pad, to capture the plantar pressure of the foot. Additionally, the 3D trajectories of the center of pressure (COP) can be obtained with the average recognition rate of 94%. Foot pressure analysis is a helpful tool to detect the abnormal high pressure point area and predict future risk of ulceration. On comparing all these techniques, the results which are produced using load cell will be more effective.*

Key Words: **Keywords: COP, Plantar surface, SCU, MCU, machine learning, risk factors.**

1. INTRODUCTION

A load cell is a transducer that measures force, and outputs this force as an electrical signal. By using load cell we can identify the location of foot ulcer in diabetic patients. The long term sequel leads to diabetic foot ulcer that may include motor neuropathy to clawing of toes and metatarsal heads. Mainly motor neuropathy involves the enter pathogenic factor results in high foot pressure. This neuropathy may cause the deformity and decreased joint mobility. Depending on this high foot pressures in the metatarsal head and loss of toe function mainly great toe. Onsorimotor neuropathy is responsible for anhydrosis and denervation of foot. Due to this it may lead to atrophic skin, callous formation and fissure. This make the increased blood stagnation and swelling in foot predisposes. Due to high pressure, tissue breakdown occur and growth of ulceration takes place. Mainly the infection is due to both the peripheral vascular disease and neuropathy. Most people are affected by amputation. Jeremy rich says that in forefoot the pressure is at peak and in rare foot it is not to that peak. The prediction may lead to about 36 months.

The increased level of glucose in the blood is hyperglycemia which has many serious complications that leads to an alteration in the distribution of the plantar pressure. These complications lead to the ulceration and causes amputation. This proposed method includes the prevention of DFU and also helps in the identification of the risk factors and predictive factors of DFU. The high pressure or moderate pressure foot regions can be identified with the help of plantar pressure measurements.

The elevation in plantar pressure or pain would not be felt by the people who are having sensory neuropathy or loss of protective sensation. In order to classify diabetic patients into normal diabetic type 2 and diabetic with neuropathy, many automated methods using static plantar pressure measurement such as neural network, Classifies discrete wavelet transform and principal component analysis .With the help of wireless foot pressure insoles, dynamic pressure managements are noted. FWHM, maximum gradient and minimum gradient, peak plantar pressure, pressure time integral features are introduced. Support vector machine helps in the classification between different groups accurately by using machine learning and data mining techniques.

This data can help to prevent from chronic foot pain and foot injury. The characteristic of foot differs from person to person due to a range of factors such as variations in walking speed, body weight, age, etc.

The plantar surface is divided into eight anatomical regions as shown in fig 4. It has been reported that during normal stance, each foot carries about half of the body weight at the heel, forefoot and big toe whereas lowest plantar load is located under the midmost foot[15]. In this

project, low cost system was developed for static and dynamic precise plantar measurement. It includes system calibration and testing, for the precise measurement.

2. METHODOLOGY:

The system comprises of Node MCU, SCU. The Node MCU is an open source software IOT platform. It includes firmware which runs on ESP8266 Wi-Fi soc from Espressif Systems, and hardware which is based on the ESP-12 module.[11]. This node MCU has wired pin mapping. A Signal Conditioning Unit is a device that converts one type of electronic signal into another type of signal. Its primary use is to convert a signal that may be difficult to read by conventional instrumentation into a more easily readable format.

If a person stands on the frame, the resistors that are present inside the load cell bends and the voltage drop is calculated.This values are passed onto the SCU which will convert the value into electrical signal and then transmit the signal to the node MCU. This node MCU is inbuilt with Arduino and Wi-Fi module. Raspberry pi gets the information from node MCU through Wi-Fi and then display this information in LCD or laptop.

The maximum of 84 subjects were recruited for this study[6]. The dynamic pressure distribution is recorded using med logic foot pressure measuring system for both feet. The frequency of 300Hz and 240 sensors are fitted into each wireless insole.

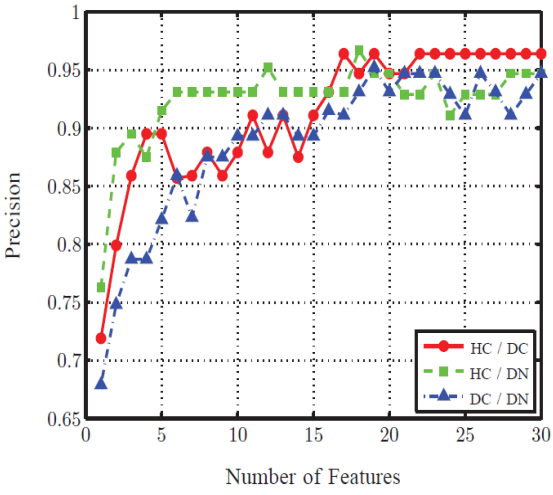

Fig-1: Precision

The subjects were asked to walk with this insole in order to record the dynamic measurements. The foot regions are divided into 11 sub regions in order to provide higher resolution.

The recorded measurements were computed in MATLAB version 1220149 and for each of 11 regions; the average dynamic pressure was calculated fig 1.The classification and feature selection can be done using WEKA data mining software.[5] In order to minimize generalization error and maximize the classification accuracy, the parameter combination is necessary which can be determined using this criterion.

Fig 1 There are three different criteria involved here they are sample size, Inclusion criteria and Exclusion criteria. After these assessment some parameter are involved.

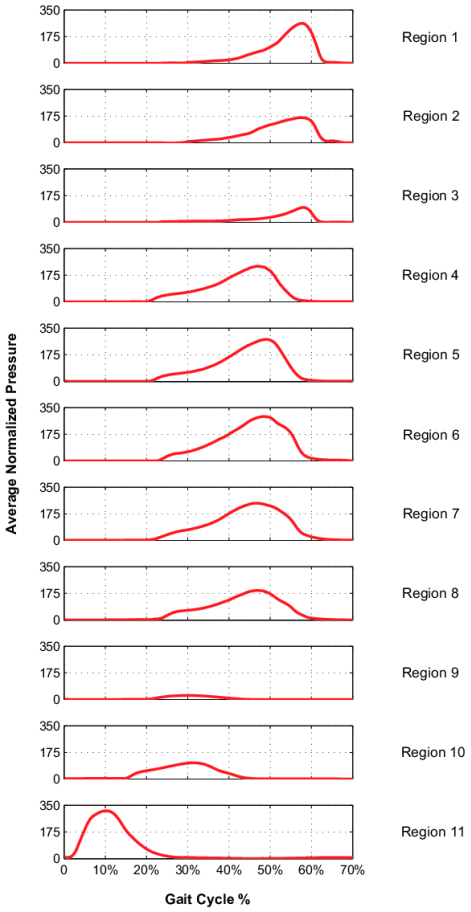

Fig-2: Different regions of foot

1) Demographic parameter: This may involve sex, age and the entire duration of diabetes mellitus from the starting date of diagnosis.

2) Neuropathy diagnosis: It is done by the use of neuropathy symptom. The reflexes of patellar and Achilles tendon are determined. Some score are given for each symptom and night exacerbation.

3) Vascular examination: The calculation is done in the ankle brachial and ankle region with the help of Doppler.

4) Integumentary examination: This includes automatic changes of peripheral neuropathy, loss of hair over dorsum of foot, tibia and nail changes and inters digital infection.

5) Musculoskeletal examination: The finding includes corn, callosity and fissure.

6) Radiological examination: It is done to find the prevalence of Charcot joint.

7) Foot pressure mapping: The patient is allowed to walk then multiples of images of foot are taken of plantar foot pressure [1]with basic EDMA.[14]The system captures around 100images per second.

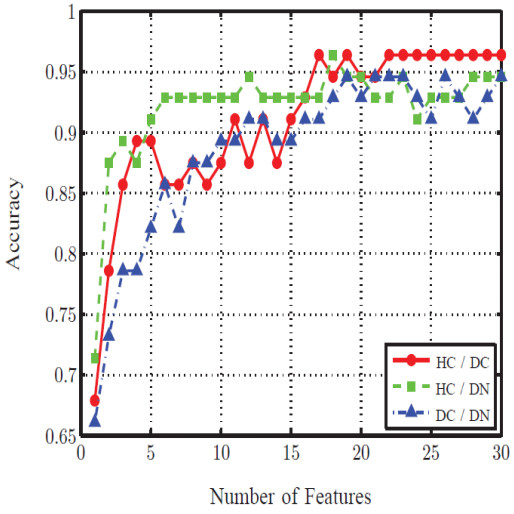

Fig-3: Accuracy

The other method involves the detection of foot ulceration by the help of the analysation of foot images. The captured colored images are converted to the gray scale image. After which the Edge detection algorithm is applied to detect the outline of the image. The erode and fill techniques are used to enhance the image and masking is done. Finally, the masked image is compared with the original image for easier analysation. Then the recorded images are sent to the mobile for the reference by developing the Application for it.

Using asymmetric analysis we can detect the foot ulcer. It involves three steps: as shown in fig 3.

1) Foot Segmentation: It involves the segmentation of right and left foot.

2) Feet Registration: The two feet is registered to associate areas of one foot with a corresponding area of other foot.

3) Detection: The temperature difference of the two foot is compared; if the associated area is larger than the threshold then one of these areas is assumed to be at risk [8].

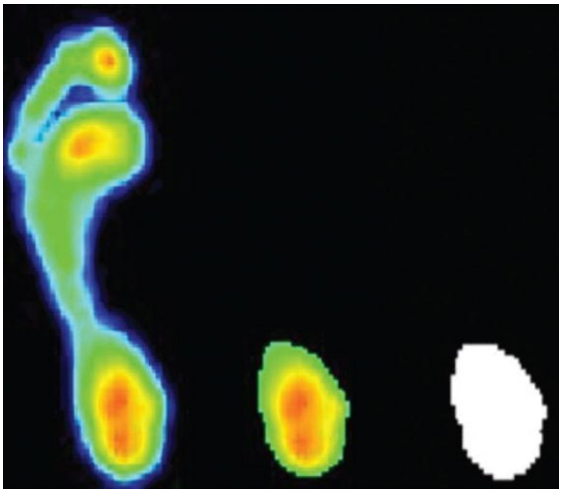

Fig -4: Temperature difference

However, a minor amputation periodically causes morphological differences between the two feet which leads to the risk of developing diabetic foot complications.

These sheet sensor pads of 150 cm by 400 cm gait mat were used. Each sheet consist of an array of 70 force sensing cells.70 rows and 10 column allows the user to measure force of every cell at once as shown.

The data of foot images have been gathered from walking samples of a person. For each person, the two images from left and right foot have been taken. The images were formed with different colors like Red, Yellow, Green and Blue which respectively shows the pressure from most

to least. The two processes such as Preprocessing and Future extraction have been done.

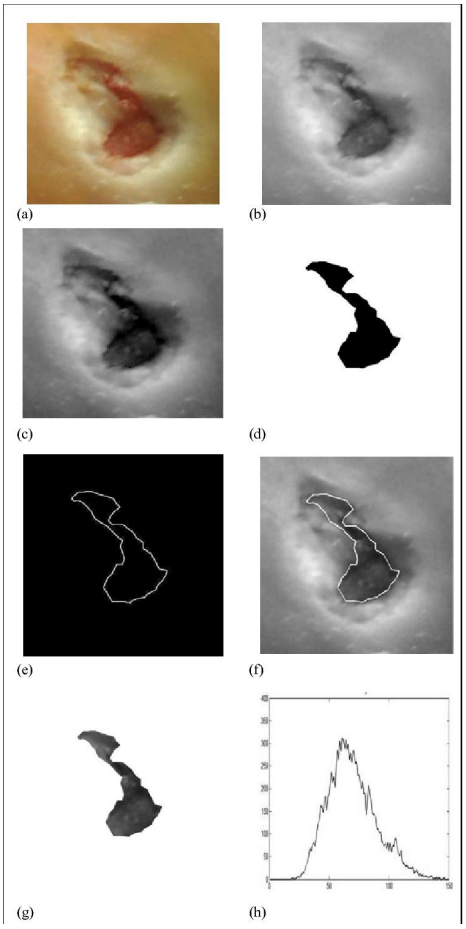

Fig-5: Location identification

In Preprocessing, the data includes the removal of false, incomplete, [10] duplicate, inconsistent or inappropriate structure whereas in Future extraction, the important information in the foot pressure images needs to be extracted fig 5.

In this, the heel area, statistical characteristics of high pressure in each image were selected as static features fig 7. The dynamic characteristics were selected as pressure changes over a step in the foot.

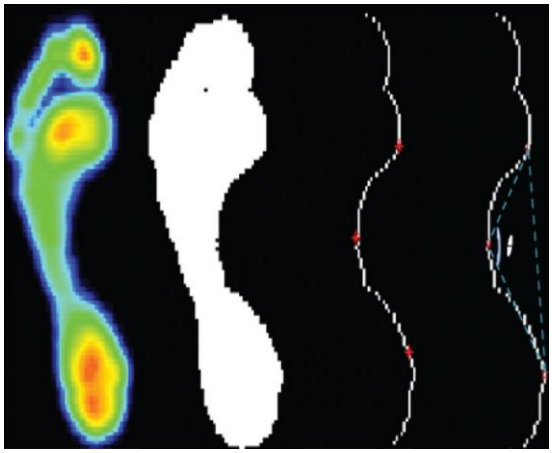

Fig -6: Extracted image

One of the frequent methods for classifying and separating image from its background is thresholding with the use of color histogram.

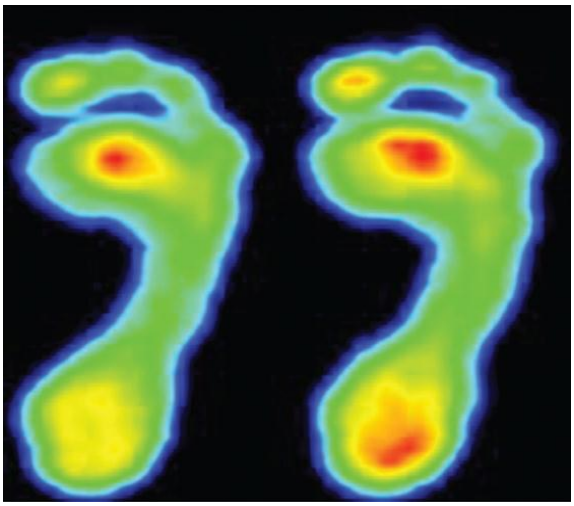

Fig-7: Depth identification

The purpose of this segmentation involves the original image. The segmentation was done twice fig 8.1. The first one was original extract object of the thermal image, where the second segmentation involves the possibility of ulcer in that foot. Here the procedure was applied with thermal image in the raw foot.

The segmentation process involved here is Histogram which results in bi-model histogram with different two peaks. This histogram shapes the optimum threshold to separate the images. It has image smoothing, analysis and observation, otsu thresholding techniques, point-to-point mean difference fig 8.

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The early diagnosis of diabetic neuropathy helps the following procedures. The patients were first excluded if any active ulcer is identified. Also the patients who were unable to walk also excluded in this process. The foot deformity is defined as any contracture that cannot be cured manually such as hallux valgus, hammer toes, claw toes.

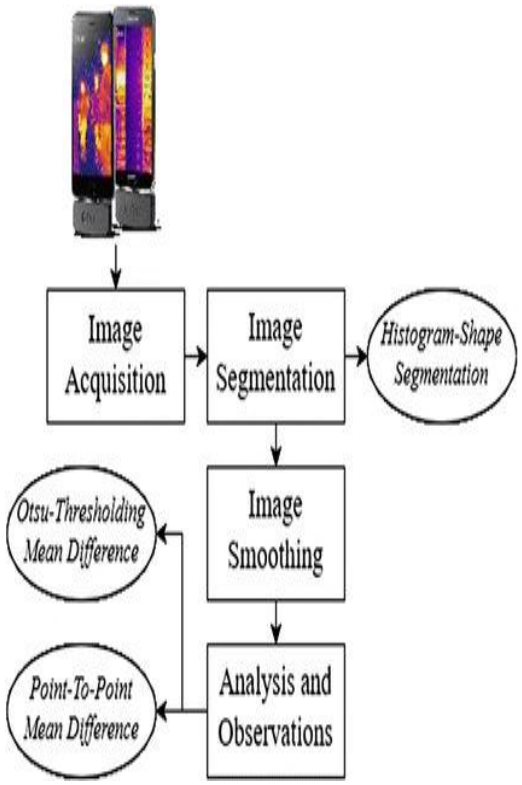

Fig- 8: Flow diagram

The patients were classified into two groups: Diagnosis made by SWM(Method 1) and fig 8.2 the diagnosis made by SFT(Method 2).

1) Follow-up data collection: The defected patients were under the same researcher were gone to periodic assessment. It includes four different types of groups.

i. Group 0 people go once in a year for a checkup.

ii. Group 1 people go for a checkup twice in a year.

iii. Group 2 people go for a checkup once in 3 months.

iv. Group 3 people go for a continuous regular checkup which is monthly once.

2) Measurement of Outcome: The evaluated images were from the main outcome. The occurrence of foot ulcer is clearly recorded. DFU is defined as wound penetration through the skin of full thickness-lesion layer. They were treated by Good wound care for complete care.

3) Statistical analysis: It is performed in the Windows version of about 19.0. Here the receiver operating character (ROC) curve will be used to diagnostic the wound accuracy level for the patients who are affected [2]. Further classifications are done by Area under the curve (AU).

The loading is practically done. Dynamic foot pressure is important for prediction of ulcer due to high foot pressure, Metatarsal heads and mid most foot area. The high pressure values with abnormal peak point are obtained. At the risk factor the foot ulceration of the measurements VPT is done. Neuropathic patient have an increase in dynamic plantar ulceration. To detect the position of plantar ulceration EMFD-SF system is used.

This study provides the three classification stages with the accuracy and precision of about 96.4% and 95.2% respectively. It is a very useful screening or predictive tool for DFU.

Efficient measurement is dynamic measurement as it provides more valuable information than static measurement. A ground reaction force is experienced by a foot when a subject is standing, this force will be equal to half of the body weight.

During walking, high pressure values are experienced by the foot and the contact area changes in location and size when GRF progress from heel to hallow. For these reasons dynamic measurement is necessary.

This study provides the best feature for classifying the patients. This dynamic measurement is more advantageous than the static measurements. In future, other classification techniques are included and their results are compared with SVM classifies.

3. CONCLUSIONS

The research set out to develop a low cost precision plantar pressure measuring system. The system developed is suitable for a range of health and industrial applications. With the help of early diagnosis and prevention of diabetic foot complications the future risk can be avoided. The accuracy of 96.4% and a precision of 96.7% can be obtained using SVM classifier.

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