DIAGNOSIS OF DIABETES TYPE II USING THERMAL IMAGE PROCESSING

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ABSTRACT

Diabetes is one of the major problems worldwide. It is a metabolic disorder caused due to the improper management of blood glucose level. There are several methods to detect diabetes which are invasive. Thermal imaging is a non- invasive technique used to detect diabetes. Here thermal images are acquired using IR camera and diagnosed the disease based on the temperature differences of the ROI. Thermography can be used as a prognostic tool for the diabetes. The images were taken using FLIR E6 thermal imager. Image processing and analysis was done using MATLAB.

INTRODUCTION

Diabetes mellitus (DM) is a chronic disease characterized by hyperglycemia which is due to disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both. Hyperglycemia of diabetes causes long-term dysfunction and failure of different organs such as eyes, kidneys, foot, nerves, heart and blood vessels. There is a global predominance of the disease powered and unhygienic environment.

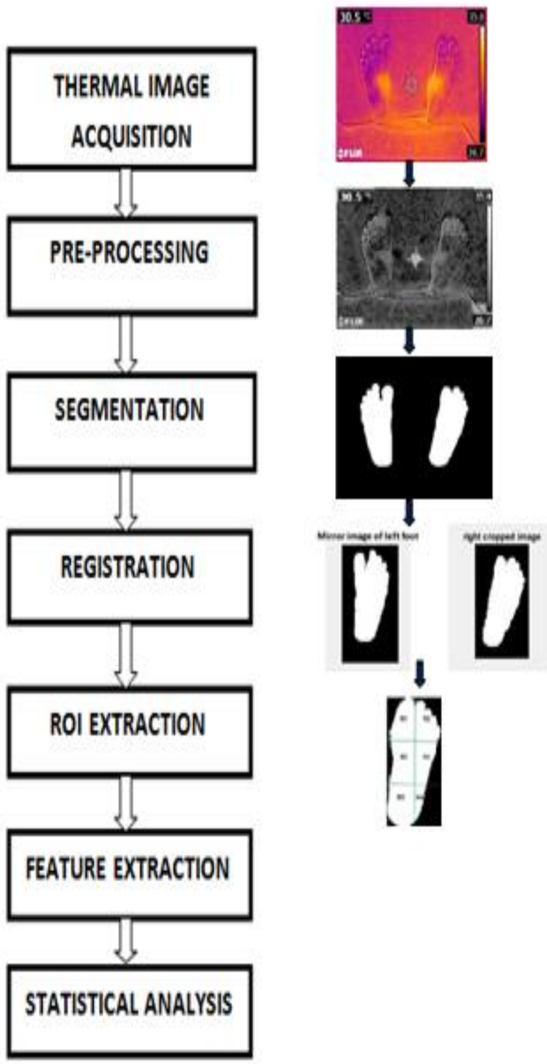
The current healthcare practice for temperature assessment is manual palpation of foot temperature. However, the increase in temperature is usually too subtle to be detected manually. This situation demands an innovative technique for regular assessment of foot which is easy, safe and comfortable for the patients and is cost-effective. Mapping of the foot temperature with a thermometer is rather time consuming, and the invention of a thermographic instrument for thermal imaging of the entire foot has therefore been an attractive option.

Since an increase in body temperature has always been considered as a reaction to an underlying inflammation, we could use this as an indicator of any abnormality. This is possible with the use of infrared thermography which is a non-invasive and non-contact method of capturing the surface temperature distribution as an image.

Temperature is a vital and useful indicator of various diseases; there is a resurgence of interest in the application of infrared (IR) imaging in medicine with improvements in camera technology, which captures the natural thermal radiation emitted by any object above absolute zero.IR imaging allows the representation of the body surface thermal distribution. It depends on the heat exchange processes between skin tissue, and inner tissues.

In this project thermal images are acquired using thermal camera. Thermography is completely safe and uses no radiation. First stage is to pre-process the given thermal image by resizing and converting the colour image into gray-scale image. In the next stage, segmentation has been performed to detect the abnormal region. From the segmented region, statistical features have been extracted for performing the classification.

PROPOSED METHODOLOGY



1.IMAGE ACQUISITION

The subjects were placed in a room with temperature 22˚C ± 3˚C for 15 minutes.Thermal images were taken by using thermal camera. All lights in the room were switched off so that the heat radiated from the lights does not influence the temperature readings. All windows and doors were kept closed so that the temperatures stabilized inside the room and there is no variation throughout the imaging process.

2. PRE-PROCESSING

The aim of pre-processing is to convert the given thermal image into gray-scale image. Histogram analysis is done to convert image into grey levels on x-axis varying from 0 to 255. Next thresholding is done to convert an intensity image to a binary image. Here the object can be extracted from the background by a simple operation that compares image values with a threshold value T. The threshold image g(x,y) is

$$g(x,y)=\begin{cases} 1 \text{ if } (x,y) > T \\ 0 \text{ if } (x,y) \leq T \end{cases}$$

The result of thresholding is a binary image, where pixels with intensity value of 1 correspond to objects, whereas pixel with value 0 correspond to background. It works well on images that contain object with uniform intensity values on a contrasting background.

3.SEGMENTATION

The dorsal and lateral surfaces of the foot have to be extracted for their temperature variations because in thermal imaging temperature variations play an important role in the detection of diabetes foot.

The thermal images are segmented using the Image Segmenter application. Image Segmenter is an application in Image Processing and Computer Vision toolbox which can be found under the APPS tab of Matlab R2018a. The ground truth segmentation is obtained using the free hand tool of the Image Segmenter. We chose Chan and Vese segmentation method to segment our image, which is shown in the figure 1. It has an energy function based on gray level of pixels inside and outside the contour.

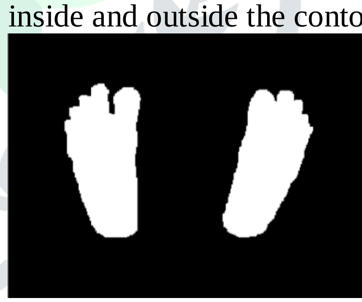


Figure 1.segmented foot using Image segmenter application.

4.REGISTRATION

For the application of thermal image foot registration, the rigid registration was chosen. It was observed that, in case of acquisition problems in the malleolus region or in the toes region, results were better using rigid registration. Mirror image of left foot (in the following description, this step will be included in the pre-processing task) is taken but the right foot is kept as such. Registration of the two segmented feet is done. Here automatic registration is used to register the image. It is an iterative process. It requires that we specify a pair of images, a metrican optimiser and a transformation type. The metric defines the image similarity metric for evaluating the accuracy of the registration. It shows the similarity in the image by returning a scalar value.

5.ROI EXTRACTION

A region of interest (ROI) is a portion of an image that we want to filter. We can define an ROI by creating a binary mask, which is a binary image that is the same size as the image you want to process with pixels that define the ROI set to 1 and all other pixels set to 0.We can define more than one ROI in an image.

Six regions of interest are found to be effective in analyzing a foot for diabetic complications. They are the hallux or the bigger toe, other toes region, arch, lateral foot region in the middle and the heel – inner and outer regions explained by Hernandez-Contreras, D.

Bounding box of the segmented left foot and the six regions of interest are extracted from the bounding box.

6.FEATURE EXTRACTION

GLCM points to Gray level Co-occurrence matrix. There are various features in GLCM. The various features are entropy, energy, area, contrast, correlation, homogenity, mean, standard deviation. Normal and diabetic subjects possess variation in these features. The variation in these features is used to plot the graph and classify them accordingly.

7.STATISTICAL ANALYSIS

The statistical feature of the mean temperature difference between the left and the right foot of the 3 diabetic and 3 healthy subjects are analyzed. It can be seen that the mean temperature difference is very minimal in the case of healthy subjects as the temperature distribution in the both the foot is symmetrical. There is a slight increase in the mean temperature difference of diabetic subjects as there is an inflammation or some diabetic foot complication present. This does not give any idea to the consulting physician regarding the location of the problem. Hence splitting the plantar foot region into different regions provides meaningful analysis. This further leads to identifying specific thermal patterns in these regions useful for the detection of any foot complication and their specific location. The correlation coefficient ‘r’ is calculated as follows

$$r=\frac{\sum m \sum n (A_{mn}-A')(B_{mn}-B')}{\sqrt{(\sum m \sum n (A_{mn}-A')^2)(\sum m \sum n (B_{mn}-B')^2)}}$$

where $\bar{A}$ = mean(A) and $\bar{B}$ =mean(B) m and n are the size of the region given as m×n pixels.

RESULTS AND DISCUSSION

Correlation coefficients between the left and right counterpart is > 0.8 in the case of healthy subjects and it is less in the range of 0.4 to 0.7 in most of the diabetic subjects.

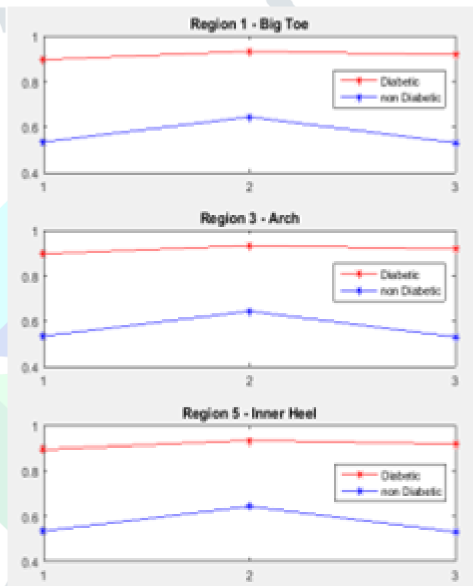


Figure 2: Correlation coefficient graph for various subjects in regions R1, R3 and R5 respectively.

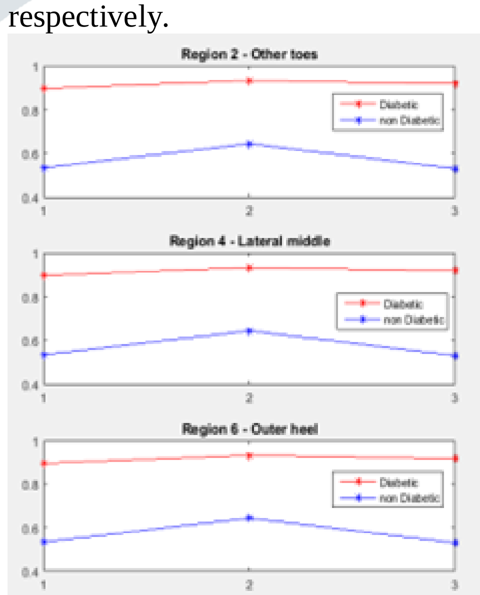


Figure 3: Correlation coefficient graph for various subjects in region R2, R4 and R6 respectively.

Based on the features extracted the correlation coefficient for various subjects were found and the corresponding results were plotted in a graph for various regions as shown in Figure 2 and Figure 3. Compared to mean temperature calculation, correlation coefficient calculation is found to be accurate.

Plantar foot temperature varies in diabetic foot due to thermoregulation problems related to neuropathy and/or ischemia, and also in case of inflammation. No typical form exists as in normal persons but several shapes can be observed. In both cases (controls and cases), the possible variations of the plantar foot temperature are usually lower than 4°C. There is a wider variation in diabetic patients compared to healthy subjects.

CONCLUSION

In this research paper, we have implemented segmentation using the Image Segmenter application. The obtained correlation values between the corresponding regions in both the foot is higher in healthy subjects compared to diabetic subjects. The thermal pattern in the regions 1, 2 and 3 are the most important of all the regions which is typical for all diabetic foot complications. Hence care should be taken to analyze these regions. There is a difference in the temperature distribution across different regions of both subjects due to impaired metabolism and presence of inflammation causing an increase in temperature as shown by Adam, et al. This states that thermal imaging can be used to build a computer aided diagnosis system to detect the presence of an abnormality or infection in diabetic subjects.

ACKNOWLEDGMENT

The work reported in this paper is supported by the Kamaraj College of Engineering & Technology. We are very grateful to the EEE department of our college for providing us valuable thermal camera.

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