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Foot Ulcer Detection Using Super-pixel and Faster Regional Convolutional Neural Network(R-CNN)

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ABSTRACT:The main objective of the project is to provide properly diagnosed results of ulcer conditions. The entire project is coded in MATLAB software to achieve the desired goal. The GUI is created to present a framework for the project. The images are collected and formed as a separate group according to their characters. These images contain the collection of ulcer images, non-ulcer images, and pre-ulcerative images. The image is selected as the input images and subjected to preprocessing. If we want to segment, the image should be preprocessed. This preprocessed image is programmed to extract the features using Gabor filter bank theory and the required features help to segment the ulcer area. For segmentation, the superpixel algorithm is applied to the input image. Then the classification is done by applying the Region based Recurrent Neural Network (R-CNN) algorithm to classify the input as either ulcer image or non-ulcer image. After processing, this classification is achieved and has high accuracy. The R-CNN is used to attain the original image without losing its originality.

KEYWORDS: Diabetic Foot Ulcer, Super-pixel algorithm, Regional Convolutional Neural Network(R-CNN).

I. INTRODUCTION

Too many researches are done on foot ulcer identification. Based on the complexity of the problem, towards the disease. Foot Ulcer is the most frequent Ulcer in Human worldwide. The disease is curable if detected early enough. Primary prevention seems impossible since the causes of this disease are still remaining unknown. The development of Foot carcinoma has been associated with several well-recognized epidemiological risk factors such as early menarche and late menopause, family history, dietary, environmental factor and genetic factors. Our objective in improving the existing method and thereby achieving a method for identification of foot ulcer.

[1].Diabetic Foot Ulcer (DFU) is one of the major causes of death among humans. The cells with similar functions grow side by side to form a common tissue, such as brain tissue or muscle tissue, or bone tissue. As these normal cells proliferate into the tissues, they begin to crowd and bump into each other and a phenomenon that researchers call cell recognition occurs, and a message is sent to the individual cells in the tissue to stop proliferating. Ulcer cells do not recognize this phenomenon, and they continue to grow and multiply and cause the tissue to expand into a larger mass called a Foot Ulcer.

[2].Small clusters of microcalcifications appearing as a collection of white spots on Thermal Images show an early warning of Foot Ulcer. Microcalcifications are tiny bits of calcium molecules that may be shown in clusters or in patterns (like circles) and are associated with extra cell activity in Foot tissue. Usually, the extra cell growth is not Ulcerous, but sometimes tight clusters of microcalcifications can indicate early Foot Ulcer. Scattered microcalcifications are usually a sign of benign Foot tissue. The main causes of foot ulcers are Swelling, Redness, Open lesions, Cracks, Sores, Pus, Odor and Pain in ankle.

[3].The most effective method for early detection and screening of Diabetic Foot Ulcers is Ultrasound mammography. Ultrasound Mammography is commonly used in clinical areas for diagnostic and screening purposes of Diabetic Foot Ulcer(DFU). Reading mammography results is a demanding job for radiologists, and cannot provide consistent results from time. Hence several computer-aided diagnosis (CAD) schemes have been developed to improve the detection of primary signatures of this Diabetic Foot Ulcer disease. Digital images of mammography are displayed on a computer monitor and can be viewed that are either

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the lightened images or darkened images of the ulcer-prone areas in the foot before they are printed on film. Image processing techniques are widely used in various medical fields for earlier detection and treatment stages of diabetic foot ulcer, where the time is very important to find the abnormality issues in target images, especially in various ulcers such as Foot Ulcer, lung Ulcer, etc.

[4].A foot ulcer is a sore or wound that occurs in a person who suffers from an increased level of diabetes. There are many detection techniques are implemented to diagnose diabetic foot ulcers. But the most commonly used method is the thermal imaging technique. As per the acquisition protocol, the foot is well cleaned and background is covered with a black cloth and then the image has been taken using the thermal camera.

[5].This paper represents the Foot ulcer development when the person is having diabetes. If the level of sugar level increases it causes many problems and affects the eyes, kidneys, foot, and nervous system. Due to this condition, the ulcer will form in the foot for diabetic patients. It must be diagnosed periodically for the control of the development of ulcers in the foot. When the sugar level is maintained at a normal range the ulcer should be controlled. If it is left untreated, the ulcer will spread in the foot causes nerve damage, and lead to loss of the foot. To avoid this condition the ulcer must be diagnosed frequently to know the seriousness and condition of the ulcer. This proposed project will give the ulcer condition as a percentage of affected and the stage of ulcer in foot and the segmented ulcer regions.

II. LITERATURE SURVEY

Many models are brought by the scientist to find out the foot ulcer occurrence in human. There are different kinds of diagnosing techniques such as CT, MRI, and PET scans are done for the identification of ulcers. Among that Infrared thermography detection is the best method for interpreting the pathophysiologic information on metabolic, thermal, and vascular conditions of the human body. This method of scanning is non-invasive, non-destructive, and does not require any physical contact with the person who subjected under-diagnosis.The most effective method for early detection and screening of Foot Ulcers is Ultrasound mammography. Ultrasound Mammography is commonly used in clinical practice for diagnostic and screening purposes.

Studies and clinical observations prove that IR thermography detection of the diseases in the early ulcer phase and provides the information for suitable therapeutic treatment. It is explained that the accuracy of foot ulcer diagnosis in IR imaging depends on the segmentation of Region of Interest (ROI). Image segmentation algorithm methods

automatically detect the region of interest in IR input images and the results are extracted to measure the outputs by compared with other methods. To test and verify each ulcer images segmentation techniques, a graphical user interface is designed. In the first method is, the thermal images of feet are taken. In the second step, the image is performed with pre-processing steps like conversion of RGB image into a grayscale image and plotting the gray image in [0, 1], histogram and represents in the gray level values.

In order to assess the risk occurrence of ulcer cases, the SVM classifier is used in two terms as low risk and high risk. The image segmentation techniques in the related work are thresholding algorithms used as global thresholding and multiple thresholding. The edge-based segmentation methods are used as Sobel, canny, and Robert operators used for the gradient edge-based methods. Region-based segmentation is applied as region growing and region splitting and merging, watershed segmentation is used as continuous for boundaries and the last method is clustering-based method is used as hard and soft clustering.

Foot ulcers can lead to infections such as gangrene, amputation, and even death if necessary care is not provided. On the other side, once DFU has developed, there is an increased risk of ulcer development that may ultimately lead to amputation. Overall, the reports stated that the rate of lower limb amputation in patients with Diabetic Mellitus is 15 times higher than in patients without diabetes. It is estimated that approximately 50-70% of all lower-limb amputations are due to Diabetic Foot Ulcer.

One of the methods of detecting the DFU is related to the diabetic foot is with the angiosome extraction concept. It may be possible to identify, if the blood supply of a particular angiosome is compromised, and if it is detected, the patient can pay more attention to prevent the formation of diabetic foot ulcers.

The image processing techniques used for the detection of the wound are also done in the CS algorithm. It performs the study of its search mechanisms to discover how it is efficient in detecting tumors and compares the results with the PSO.

The Graphical user interface (GUI) is designed for segmentation step is handled with thresholding algorithm in two ways such as global and multiple thresholding. The overall output is executed as a temperature extraction to compare

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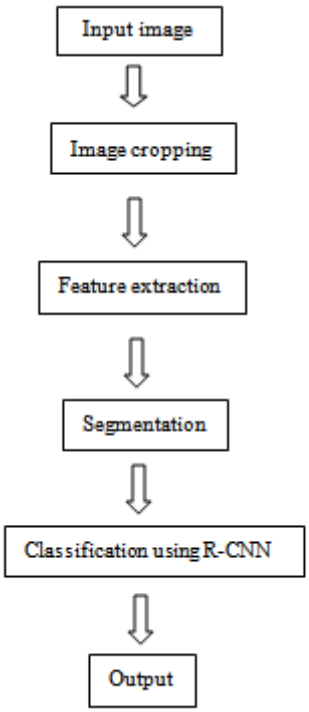
with the average temperature reading and execute the output based on the level of comparison.

III. METHODOLOGY

The working of the proposed method consists of acquiring the image, preprocessing, color segmentation, feature extraction of the image, and then classification using the R-CNN algorithm. The work has been split into the training phase and the testing phase. In the training phase, the tool is trained using a recurrent neural network algorithm to classify the ulcer stages. The background work has several steps to the acquisition of images and further processing. The overall process is to give the input image and the result shows the segmented region and the percentage of ulcers affected in the foot.



DATASET:

The dataset contains the collection of foot ulcer images. These images are gathered from online databases. The images are classified as ulcer images, non-ulcer images, and pre ulcer images. Those images are grouped accordingly to these categories. Every image is ordered and grouped into separate folders. This folder has high contrast images as well as low contrast images taken from an IR cameras.

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PREPROCESSING:

The aim of the project is to segment the ulcer-detected area using a superpixel algorithm. Before going to segment, the image must be preprocessed for clear segmentation. The first step of preprocessing starts after getting an input image.

(i) **Original image to grayscale image**: The raw RGB image is processed by the code of converting the RGB to a grayscale image. Thus the original image is transformed into grayscale in this process. The need of converting the original image to a grayscale image is, it has more shades of color which are helpful for the identification of ulcer areas.

(ii) **Grayscale to digital:** The second step of the preprocessing of the image is the conversion of the grayscale image to a digital image. The need for converting digital images is to count the pixels in the image. This will result as m*n matrix format contains pixel value. The digitalization of images helps to attain more accurate segmentation results.

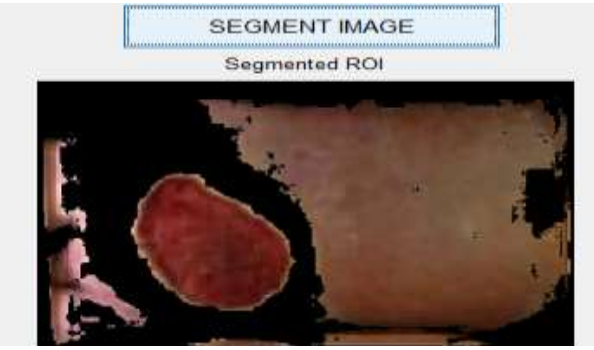
FEATURE EXTRACTION:

To extract the wound features, Hue and saturation concept is used. The characteristic of the ulcer is extracted by applying the hue and saturation concept. This helps to find the percentage of ulcers affected in the foot region and also to segment the ulcer areas in a clear view.

The Gabor filter bank is used to extract the secondary features in the image. The basic acquired features for segmentation are extracted by applying the Gabor filter. This will order the ulcer characteristics and non-ulcer characters during the stage of training the software. The ordered features are used while testing each image and compares those characters with the trained characters for the identification of ulcers.

IV. SEGMENTATION

The segmentation of the foot ulcer is the main part of this project. Segmentation will be done after the preprocessing stage. The preprocessed image is helpful to cut the image for the required region. Superpixel algorithm is employed for the segmentation of the ulcer areas. This algorithm is most effective and reduces the noise in the segmented image. It contains superpixels carrying more information from the original image and there is less loss of originality. It takes the entire region of the image as a regionof interest and segments according to features extracted in the feature extraction method. The K-means clustering algorithm first helps to transform into three clusters of images carrying differently segmented regions. From that clusters, one is selected and given as the input for the segmentation of ulcer areas. The output of this part is the segmented region of ulcer areas in the image. It shows the clear color segmented view of the ulcer areas in the GUI prompt.



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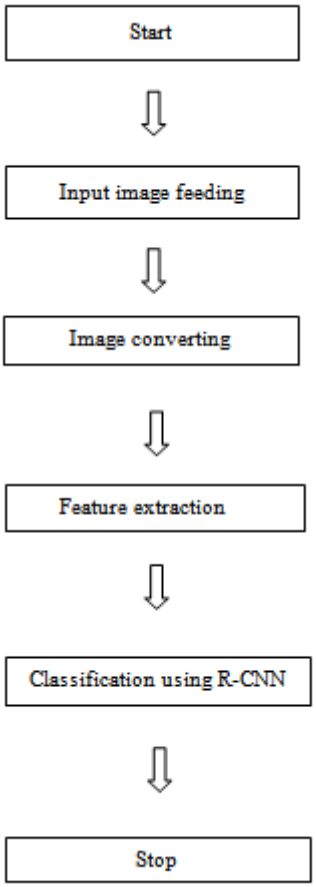
CLASSIFICATION:

After the features are extracted, a suitable classifier must be chosen for the classification of the foot ulcer disease. The pre-diagnosed image is diagnosed by applying the Superpixel algorithm and the use of R-CNN classifiers to classify the disease stages along with the affected region and the percentage affected. The work has been split into the training phase and the testing phase.

Region based Recurrent Neural Network (R-CNN) is a sophisticated classifier which will help for high efficiency results. The Densenet-201 architecture help to find the comparative results with the extracted features in nine layers of search. The **Global average pooling(GAP)** is a pooling concept tostable the translations and deformations during the process of checking the input image with the trained features.



Training Phase: In the training phase, the MATLAB tool is trained with a recurrent neural network algorithm. The initial step has image feeding as ulcer image non-ulcer image and partially affected ulcer image. Then coded for cropping the image for the same histogram level and converting it into the grey shaded image. the converted grey image is subjected to convert a digital image for calculating the pixel count and form as a matrix. The digital image is coded for the feature extraction for the segmentation of the region affected by the foot ulcer caused by diabetes. The extracted features from the original image are mean, standard deviation, variance, contrast, homogeneity, etc., Then the superpixel algorithm is applied over the images and the features extracted to divide the digitally converted image into three cluster regions. The entire process has been trained with Region-based Convolutional Neural Network(R-CNN) to classify the stages of ulcer in the detection process. The entire process is modeled as a GUI concept for framework and trained with many ulcers and non-ulcer images.

Testing phase: In a testing phase, the captured foot image of the person is loaded for testing of foot ulcer. The image is loaded for further processing. Initially, the image is cropped and converted into a

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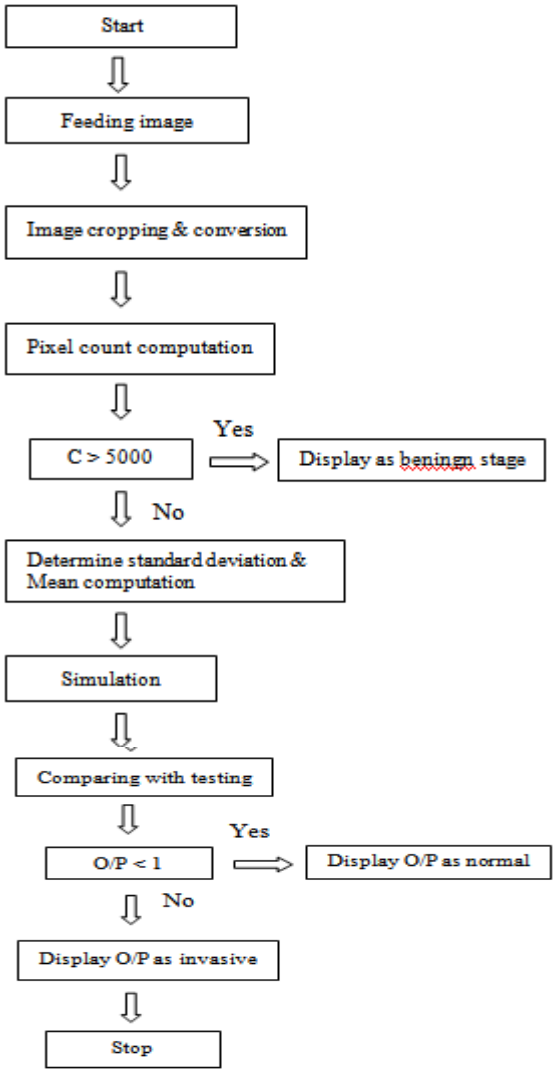
digital image. The converted image is processed in the Matlab tool and extract the feature of the input image and segment into clusters. The segmented cluster of images is uploaded to classifying the stage of ulcer formed and with the percentage with segmented ulcer region.



V. CONCLUSION

Thus the segmentation of foot ulcers is achieved using the superpixel algorithm with the help of features extracted. This concept is discussed about the methods of detecting foot ulcers in 3-D segmentation. It is helpful for early diagnosis of foot ulcers and can be able to find ulcers at their initial stages. Embedding these types of ulcer detection processes and applications can make the work of analyzing and detecting not only Foot ulcers but also other Ulcers can be made possible. So, this process is implemented in the form of a GUI concept in MATLAB application so that we can give any Thermal image and it provides the pre-diagnosis results for Ulcer detection. The pre-diagnosed image is diagnosed by applying the Superpixel algorithm and the use of Region-based Recurrent Neural Network (R-CNN) classifiers to classify the disease stages along with the affected region and the percentage affected. In the future, this will be modified into mobile applications like sugar and blood pressure monitoring so that each and everyone will know about their foot ulcer in their hands and prevent severe conditions. The aim of this project is to provide stress-free diagnosis and help to reduce the annual medical cost of diabetic patients. The accuracy is increased by training the tool using Region-based Recurrent Neural networks

to classify the stages of the disease and the percentage of ulcers formed in the foot.

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