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Foot Injury Detection Using K-Means Clustering and Mean Shift Segmentation Algorithm

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Abstract- **Diabetic foot ulcer is a major complication of diabetes mellitus and probably the major component of the diabetic foot. Its significant transcendence is related to a higher incidence and amputation percentage as well as deaths. In present days, clinicians and nurses mainly base of their wound assessment on visual examination of wound size, healing status, and colour of wound. This paper aims to become the first link to optimize the diabetic's foot evaluation through the introduction of Digital Image processing techniques. In this paper we proposed easy method of wound image analysis system implemented on the MATLAB using Mean Shift Segmentation Algorithm. Patient wound image is processing under different steps such as pre-processing, RGB to Gray conversion, Segmentation, K-means clustering algorithm, boundary line detection, healing status. Healing status is depending on blue, yellow, green colour evolution model. Wound image is collected in DHANABAKKIYAM diabetic centre, Tiruvannamalai. We proved the implementation of this algorithm to a series of trial images to show the efficient and high accurate result of wound healing status.**

Key words - Diabetic, wound assessment, K-means clustering and mean shift algorithm, MATLAB.

I INTRODUCTION

Today, there are more than 65 million people affected by diabetes in India, and that number only seems to be rising, in rural and urban areas alike. The diabetic foot is one of the most frequent and devastating complications. According to Diabetes, DEAKIN university survey, there were an estimated 40 million persons with diabetes in India in 2007 and this number will be rise to almost 75 million people by 2025. The countries with the largest number of diabetic people will be India, China and USA by 2030. It is estimated that every fifth person with diabetes will be an Indian. Due to these sheer numbers, the economic burden due to diabetes in India is amongst the highest in the world. There are so many problems with recent treatment for diabetic foot ulcer. In existing methods were all using region of interest of the foot ulcer skin. Initially, patients should go to hospital on a common basis for check the wound by clinicians. Because of this so many disturbances occurred such as inconvenient, cost and time consuming for clinicians and patients. Second, wound assessment process is processed under Visual Examination. The description of wound analysis gives by physical dimension and tissue colour, it will provide healing status. Steps of wound analysis system is shown in figure 3 and explained in further steps.

Image processing technique is a potential solution and it made different tasks such as measurement of affected area, unaffected area and total area of wound.

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Figure 1: Diabetic foot ulcer

Image segmentation is the better tool for determining wound boundary and classifies wound tissue. To classify the wound type Neural Networks are used. This will give the better result.

II METHOD OF WOUND ANALYSIS

OVERVIEW OF WOUND IMAGE ANALYSIS SYSTEM

The five main steps on implementation those are all written and executed in MATLAB R2013a successfully. Image collection is the first step.

The acquired images are resized to reduce the total memory usage. The second step involves a few pre-processing steps to make the results less sensitive to noise such as smoothing like image enhancement techniques. After pre-processing, wound image segmentation is performed. Using K-means and Mean shift segmentation algorithm for separate affected part with effective and high resolution. Finally, boundary line detected and healing status provided.

A. Image Capture Protocol

The images used for this paper were taken at DHANABAKKIYAM diabetic centre, located at Tiruvannamalai. Image Acquisition Toolbox enables to acquire images and video from cameras. We can acquire image by using web camera or high definition camera. For the trials and the algorithm design, fifteen photographs were taken to a patient's foot from 6 different. For some angles, the photographs were taken more than once using the camera's flash and without it.

Figure 2: Colour input image

B. Image Pre Processing

This first stage is divided into three main processes: redimension, space colour conversion, filter, and region of interest delimitation. Image pre-processing technique is applied to enhance data in images proceeding to computational processing. The pre-processing step applies gray scale conversion and possible image enhancement techniques to obtain the required visual quality of the web camera images. The original image size is 3264x2448.Here it was used the Gabor filter to remove the noise for smooth the image. The Gabor standard deviation ∂=0.5 and Gabor noise is produced by the image acquisition process. The conversion of space colour and filter processes might take longer depending on the photograph's size. It is a widely used effect in graphics software, typically to reduce image noise. Scaling is done to modify the visual look of an image, to change the quantity of information stored in a picture representation, or as a low-level pre-processor in multi-stage image processing chain which operates on features of a particular scale. First, considering the previous information, the image is resized to 640 x 480 pixels. The second step of the process corresponds to the RGB – HSV space conversion. Out of this transformation there are three components left H, S, and V.

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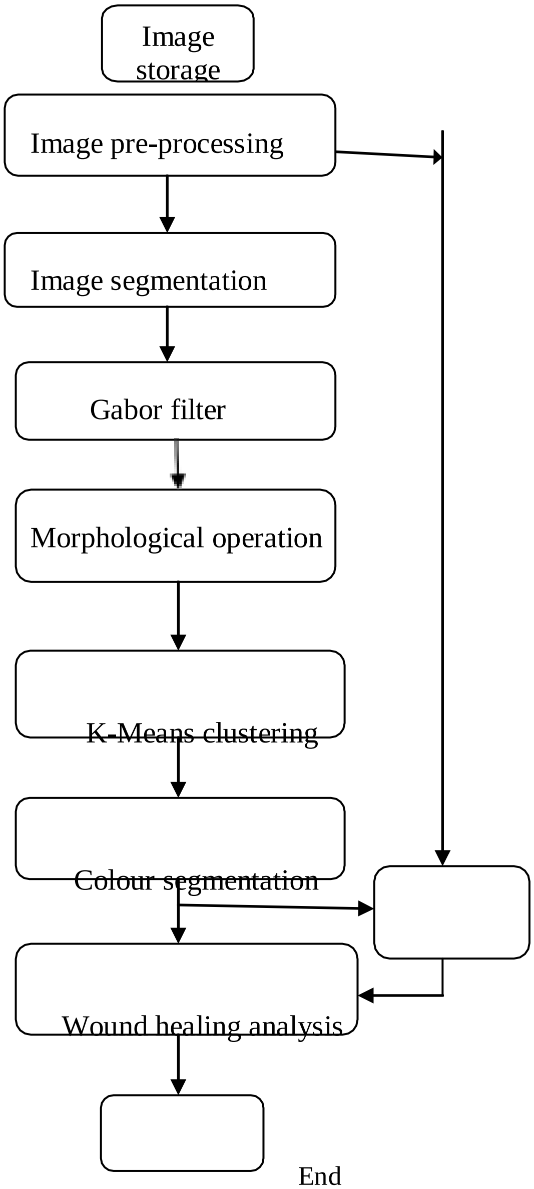

Figure 3: Wound image analysis system

C. Image Segmentation

Segmentation is the process of sub divide the original image into pixel group with homogeneous colour values. Segmentation is also useful for registration and structure analysis, such as counting the volume of a tumour. Robust and accurate medical image segmentation is challenging due to low image quality, tissue intensity in-homogeneity and other image artifacts. Foot Outline Detection is used to find the highly connected components in the segmented image. This are done under the condition of colour of the component is similar to the default standards skin colour.

This information provided in the standard CIE for both light and dark skin colour threshold. Which means that algorithm is based on the skin colour. Here we used a luminance and chrominance of colour of the skin. Wound boundary determination is depending on the foot outline detection result. In the foot outline detection binary image is processed and white area marked as inner area of wound image and black area marked as outer area of wound.

D. Morphological Operation

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. Morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image

K-Means Clustering

K-means clustering is a method of vector quantization, originally from signal processing, that is popular for cluster analysis in data mining. K-means clustering aims to partition *n* observations into *k* clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. This results in a partitioning of the data space into Voronoi cells. The algorithm has a loose relationship to the K-nearest neighbour classifier, a popular machine learning technique for classification that is often confused with K-means because of the K in the name. One can apply the nearest neighbour classifier on the cluster centers obtained by K-means to classify new data into the existing clusters. This is known as nearest centroid classifier or Rocchio algorithm.

F. Mean Shift Segmentation Algorithm.

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Here I have applied mean shift segmentation algorithm for a colour image for a better accuracy or resolution. Mean shift filtering and region merge methods are used. The quality of the segmentation is controlled by spatial and colour range resolution .By changing the resolution parameters segmentation algorithm can be adjustable to different degree of skin colour smoothness. For the parallel implementation mean shift filtering algorithm is used. The mean shift algorithm is a nonparametric clustering technique which does not require prior knowledge of the number of clusters, and does not constrain the shape of the clusters. Mean shift algorithm is analysing the image features space such as colour space, spatial space or combination of two spaces. Given n data points xi, i = 1, ..., n on a d-dimensional space Rd, the multivariate kernel density estimate obtained with kernel K(x) and window radius h is shown in below.

$$f_{h,K}(x) = \frac{c_{k,d}}{nh^d} \sum_{i=1}^{n} k\left(\left\| \frac{x - x_i}{h} \right\|^2\right) \quad (1)$$

Where bandwidth parameter h performing h>0 and *ck*, *d* is constant. The kernel function defined as k(x) for x≥0 and ‖.‖ it is represents a vector form. Local maxima is *yk*, input data *xi*, mean shift algorithm computes the density estimate f(x) at *yk* using gradient descent method. The gradient f(x) is written as,

$$\nabla f(x) = \frac{2c_{k,d}}{nh^{d+2}} \left[\sum_{i=1}^{n} g\left(\left\| \frac{x - x_i}{h} \right\|^2\right)\right] \cdot m(x) \quad (2)$$

$$m(x) = \frac{\sum_{i=1}^{n} x_i g\left(\left\| \frac{x - x_i}{h} \right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\| \frac{x - x_i}{h} \right\|^2\right)} - x \quad (3)$$

Where $g(r) = -k'(r)$ and n is the number of neighbours. where where *hs* and *hr are bandwidth values for special and range domain.*

$$y_{k+1} = y_k + m(y_k) \quad (4)$$

$$K_{hs,hr}(x) = \frac{C}{h_s^2 h_r^3} k\left(\left\| \frac{x^s}{h_s} \right\|^2\right) k\left(\left\| \frac{x^r}{h_r} \right\|^2\right) \quad (5)$$

G. Boundary Determination of Wound and Algorithms

The mean shift algorithm is mainly used for the colour images to segment the original image into homogeneous regions with same colour features. Because this boundary determination can be easily understood by the users or clinicians. The foot wound image contains some irrelevant background information and sole of the foot is same colour feature the large connected component detection is performed on the segmented wound image. The colour features is extracted in the mean shift segmentation algorithm of this component is compared with the normal skin colour features by calculating the Euclidean distance between the colour vector for the original image and standard skin colour vector from colour checker. If the distance is smaller than threshold value I can claim the foot area .after determining foot area, the binary image with pixel that are part of the foot labelled "1" as white and remaining part is "0" as black .In 1988 Arnqvist, Hellgren and Vincent is found the RYB wound classification model, this model evaluate wound and it classify the wound tissues within the wound as red, yellow, black. here I used the CIE standard, in this standard we have take the luminance of red and blue.

III RESULT AND DISCUSSIONS

Besides its functionality, the system has to be as neat and esthetic as possible. Within this context, and by taking advantage of the MATLAB's GUI environment, the graphic interface is developed to improve the user's experience, and to present the results in a neat and elegant format.

The interface originally shows just one button to load the image to be processed. After loading it, and on the bottom part a text box will

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appear for the numbers of regions of interests to be typed in. An image will be temporarily displayed where the regions will be delimitated with the mouse pointer. In the end, the figure will automatically close and the algorithm will continue until the results are shown.

Figure 4: Down sampling image

Figure 5: Gray scale image

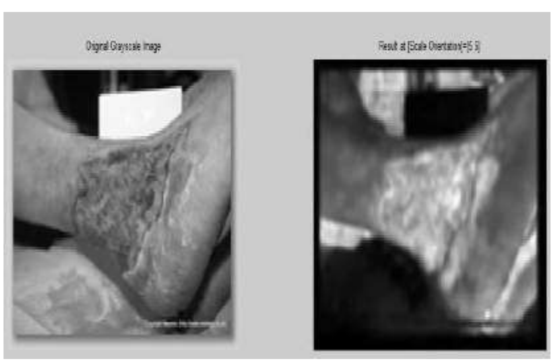

Figure 6: Filtered image

The results will be presented in an image similar to the original but with the centroids and the contours drawn in it. The image will be shown in a new figure to verify and check the process or save it. In the event that the wounds' detection was not correct the side bar will display to allow the algorithm's sensitivity adjustment. It is important to clarify that the sensitivity actually corresponds to the height threshold used for the segmentation stage.

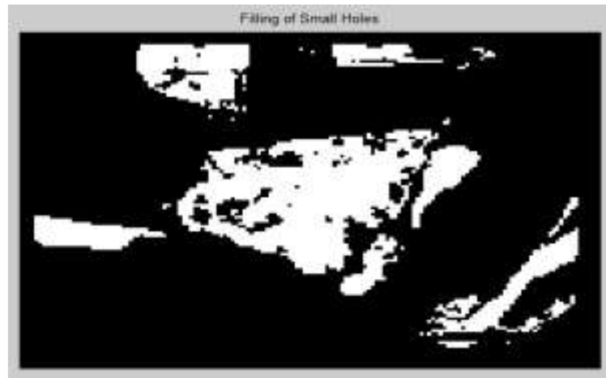

Figure 7: Filling of small holes

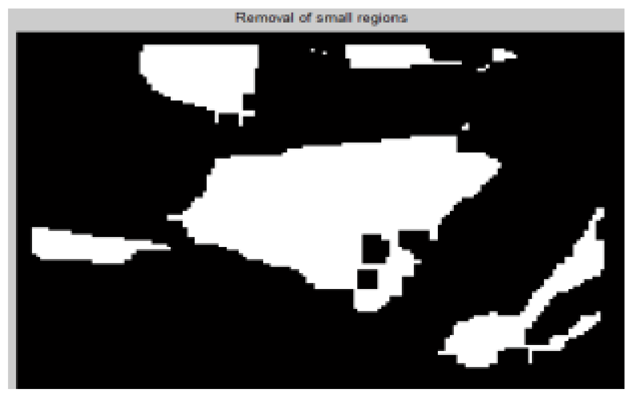

Figure 8: Removing of small regions

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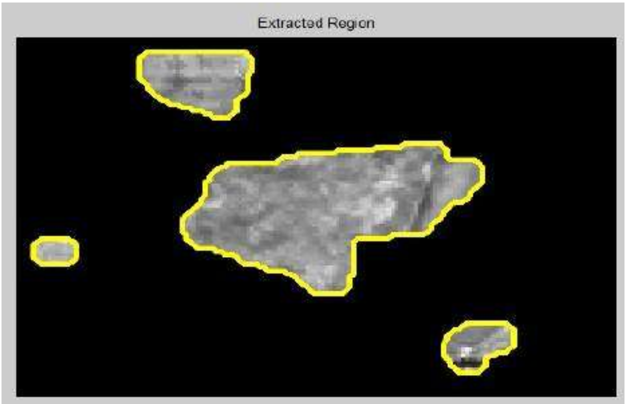

Figure 9: Extracted region

Figure 10: K-Means result

From the algorithm applied to the trial images it is observed that, in all the cases, the detection of lesions was successful with acceptable quality because of the adjustment parameter that allows the sensitivity variation until the desired result is obtained. In some of the cases the detected contour might differ from the lesions' limits as a consequence of the softening performed on the filtering stage. It shows the results for a trial image.

The lesions area depends on the lesions' detection, meaning that the higher the detection quality is the lower the error. Besides, it has to be mentioned that an error in the image is present since the background is further away from the camera than the wounds are, and the reference measures belong to that background. However, it is possible to disregard this error given the fact that all the images present it.

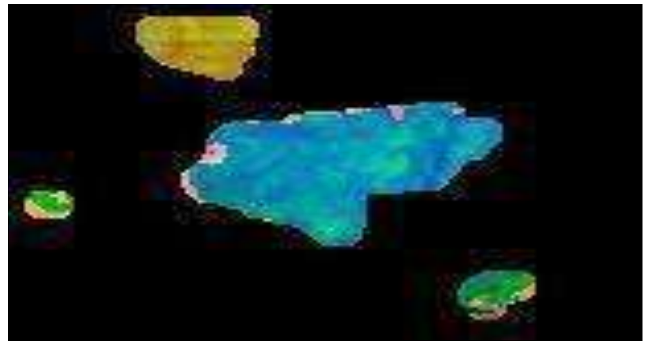

Figure 11: Mean shift segmented result

Figure 12: Final result

IV CONCLUSION

We have implemented a new wound assessment system for patients with diabetic. This system use to analyse the wound with type 1 and type 2 diabetic suffering from foot ulcers. The patient images are collected from the clinic and save in the PC or mobile. We have pre-processed, smooth and segmented the binary image. Then we have used Mean shift segmentation and K means clustering algorithm because this will give better accuracy. Back propagation Neural Network classifier is used for classifies the image then finally get the output. We can transfer the result to others by using GSM technology. This system is also used to find the healing stage of Skin cancer. This system gives high resolution, much better result and low cost system.

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