ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

Wound Assessment for Diabetic Patients using MatLab Application in Smartphones

Geetha C [1], Sathish Kumar [2]

[1]Department of Electrical and Electronics Engineering, Maharaja Institute of Technology,Coimbatore
[2]Assistant Professor and Head, Department of Electrical and Electronics Engineering, Maharaja Institute of Technology,Coimbatore

***Abstract*— *DFU* (Diabetic foot ulcer) have become an increasingly significant public health concern within both the developed and developing countries. This paper presents the healing stages of wounds caused due to diabetic foot ulcers and its assessment for patients with diabetic. Currently, the wound assessment is based on visual examination of wound size and healing status, while the patients themselves have an opportunity to play an active role. Hence, a more quantitative and cost-effective examination method that enables the patients to take a more active role in daily wound care potentially can accelerate wound healing, will keep the patient aware of their wound severity so that the pateint can have timely treatment as adviced by the clinicians before it reaches the severe stage and it aslo saves the time and travel cost and reduces healthcare expenses. Considering the prevalence of smartphones and various useful mobile applications, assessing wounds by analysing images of chronic foot ulcers using the Matlab mobile pplication is an attractive option. In this paper, we propose the wound image analysis using the MatLab application in the Android smartphone. The wound image is captured by the camera on the smartphone and the image is processed using the matlab. After that, the wound segmentation process is followed by applying the accelerated mean shift algorithm. Specifically, the outline of the foot is determined based on skin color, and the wound boundary using a simple connected region detection method. Within the wound boundary, the healing status is next assessed based on Color-Based Segmentation Using the L*a*b* Color Space in Matlab. Simulated results shows the wound analysis and healing stage result of the patients with diabetic foot ulcer.**

***Index Terms*— Patients with diabetes, Wound Analysis, Mean shift algorithm, Matlab smartphone application ,Diabetic Foot Ulcer(DFU)**

I. I NTRODUCTION

Diabetic foot ulcers (DFU) is one of the common and serious complications in diabetic patients. Diabetic foot ulcer is not only a patient problem but also a major health care concern throughout the world. Diabetic foot ulcer is one of the common and serious complications in diabetic patients.Foot ulcers are painful,susceptible to infection and very slow to heal.Early recognition and timely treatment of the wound severity of the diabetic patients is very essential and will help to keep the wound in control before it developes into a foot ulcer because diabetes-related wounds are the primary cause of non-traumatic lower limb amputations.

Treatment of infection in diabetic ulcer is difficult and expensive. Patients usually need to take long-term medications or become hospitalized for an extended period of time. It is estimated that usually 15-25% of diabetic patients develop DFU during their life-time.[1]

If an ulcer develops unfortunately, the treatment is challenging and need long duration as the ulcer usually appears in the same extremity or the extremity of the opposite side; at least a quarter of these ulcers do not heal.There are several problems with current practices for treating diabetic foot ulcers. A Teamwork of orthopedic surgeon, endocrinologist, infectious disease physician and a trained nurse in dressing is necessary to care for the wound. It is also advisable to add a podiatrist to the team if one is available.

As a solution the technology employing image analysis techniques using the Matlab simulation is a potential solution for these problems.To better determine the wound boundary and classify wound tissues, the image segmentation and algorithm for wound analysis can be applied.

Hence as a solution image analysis algorithm can be designed and run using the Matlab mobile appliation on a smartphone, and thus provide a handy,low cost and easy-to-use method for self-management of foot ulcers for patients with type 2 diabetes. And the smartphones are the widely used commodity nowadays which contains a high-resolution camera is very appropriate for image capture and image processing provided that the processing algorithms are designed both simple and accurate for the patients to use it as easier as possible with no complications.

To perform wound assesment using the matlab mobile Application in a smartphone for self-management.The diabetic patients need to perform few steps like, firstly to capture an image of their wound. Then secondly,to run the highly efficient and accurate algorithm designed for wound analysis which has the ability to operate within the computational constraints. And finally to browse the image captured and stored in their smartphones for image processing and to get the simulated output of the wound healing stages.[2]

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

In present work which is the "Smartphone Based Wound Assessment System for Patients with Diabetes"the wound assessment is done using as specific hardware – Image capture box and even before this method the boundary determination was done with a particular implementation of the level set algorithm, specifically the *distance regularized level set evolution* (DRLSE) method [3].

Fig. 1. Image capture box illustration; (a) actual product of the image capture box[4]

In order to reduce the hardware cost and make it handy for the patients an advanced and simple method of self-assesment is required.

Fig. 2.The mechanical structure of the image capture box. (a)From the back. (b) From the front. (c) Internal structure from the front.[4]

To address these problems, we replaced the level set algorithms with the efficient mean shift segmentation algorithm [5]. While it addresses the above problems, it also creates additional challenges, such as over-segmentation, which we solved using the *region adjacency graph* (RAG) based region merge algorithm [6]. In this paper, we present the entire process of recording and analyzing a wound image, using algorithms that are executable on a smartphone, and provide evidence of the efficiency and accuracy of these algorithms for analyzing diabetic foot ulcers.

This paper is organized as follows: Section II-A provides an overview of the structure of the wound image analysis software system. Section II-B briefly introduces the mean shift algorithm used in our system and related region merge methods. Section II-C introduces the wound analysis method based on the image segmentation results including foot outline detection, wound boundary determination, color segmentation within the wound and healing status evaluation. In Section III, the GPU optimization method of the mean shift segmentation algorithm is discussed. Section IV presents the image capture box designed for patients with diabetic foot ulcers to easily use the smartphone to take an image of the bottom of their foot. Experimental results are presented and analyzed in Section V. Finally, Section VI provides an overall assessment of the wound image analysis system. A preliminary version of this work has been reported.

II. MatLab Application in Smartphones.

MATLAB Mobile application is a lightweight desktop on your Android device that connects to a MATLAB session running on MathWorks Cloud or on your computer. From the convenience of your Android device,you can run scripts, create figures, and view results.The Matlab mobile application is shown as in Figure below.

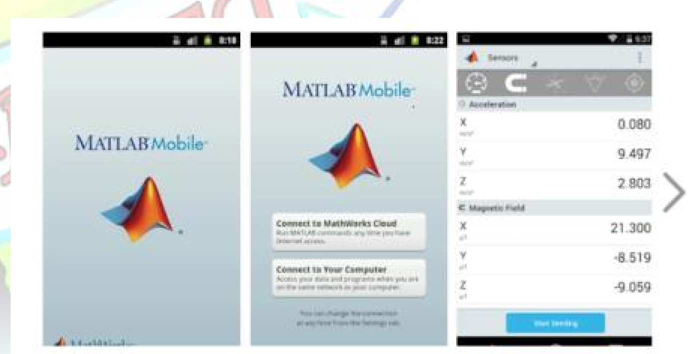


Fig. 3. Matlab mobile application

The features of the Matlab mobile application are as follows;

* Command-line access to MATLAB
* Access to MATLAB workspace
* Ability to view MATLAB figures on your Android device
* Record of commands typed on the device in your command history
* MathWorks Cloud connectivity and storage
* Windows, Mac, and Linux connectivity
* Acquire data from device sensors

The MATLAB is the leading technical computing software for algorithm development, data visualization, data analysis, and numeric computation. Christo Ananth et al. [7] proposed a system in which OWT extracts wavelet features which give a good separation of different patterns. Moreover the proposed algorithm uses morphological operators for effective segmentation. From the qualitative and quantitative results, it is concluded that our proposed method has improved segmentation quality and it is reliable, fast and can be used with reduced computational complexity than direct applications of Histogram Clustering. The main advantage of this method is the use of single parameter and also very faster. While comparing with five color spaces, segmentation scheme produces results noticeably better in RGB color space compared to all other color spaces. And the image captured can be browsed an located using the matlab application for wound analysis and simulation process. The flow chart is shown as in Figure below.

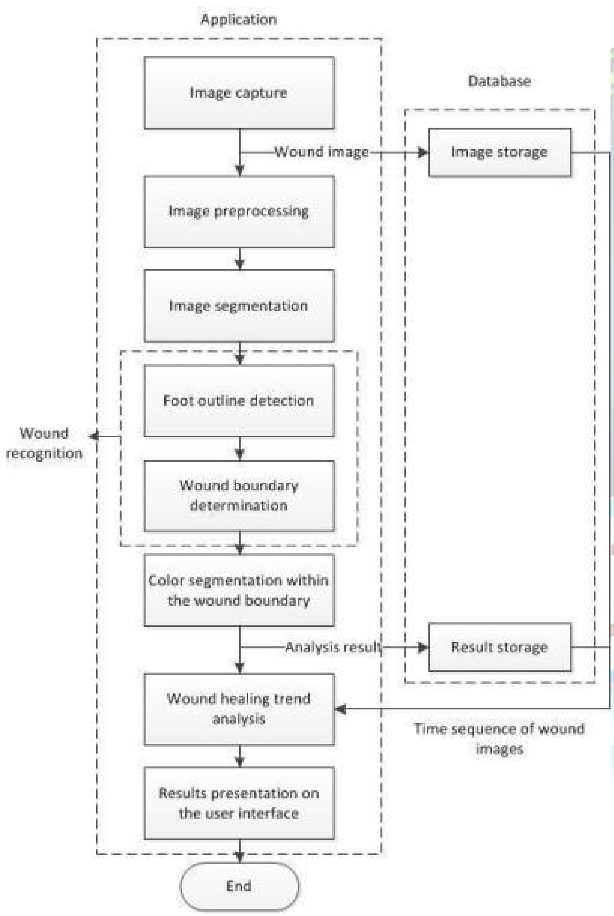


Fig .4. Wound image analysis flow chart

III.Matlab Wound Analysis processes.

A.Preprocessing and Downsampling

Image preprocessing is an early stage activity in image processing that is used to prepare an input image for analysis to increase its usefulness. In the **Image preprocessing** step, we first down-sample the high resolution bitmap image to speed up the subsequent image analysis and to eliminate excessive details that may complicate wound image segmentation.It includes image enhancement, restoration, and registration. Image enhancement accepts a digital image as input and produces an enhanced image as an output; in this context, enhanced means better in some respects. This includes improving the contrast, removing geometric distortion, smoothing the edges, or altering the image to facilitate the interpretation of its information content.In image restoration, the degradation is removed from the image to produce a picture that resembles the original undegraded picture. In image registration, the effects of sensor movements are removed from the image or to combine different pictures received by different sensors of the same field.

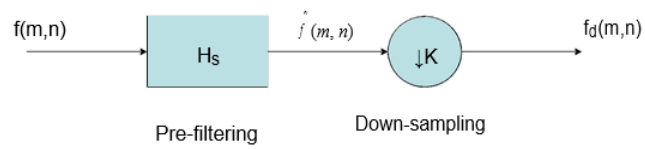


Fig . 5. Factor of K down sampling

For factor of K down sampling, the prefilter should be low pass filter with cutoff at fs/(2K), if fs is the original sampling frequency.In terms of digital frequency, the cutoff should be 1/(2K)

B. Image Smoothing Operations

Image Smoothing is used to reduce noise and/or to prepare images for further processing such as segmentation. We distinguish between linear and non- linear algorithms where the former are amenable to analysis in the Fourier domain and the latter are not. We also distinguish between implementations based on a rectangular support for the filter and implementations based on a circular support for the filter.

One of the most common algorithms is the moving average, often used to try to capture important trends in repeated statistical surveys. In image processing and computer vision, smoothing ideas are used in scale space representations. The simplest smoothing algorithm is the rectangular or unweighted sliding-average smooth. This method replaces each point in the signal with the average of m adjacent points, where "m" is a positive integer called the smooth width. Usually m is an odd number. The triangular smooth is like the rectangular smooth except that it implements a weighted smoothing function.

C. Image Segmentation

Image segmentation is the front-stage processing of image compression. There are three advantages in image segmentation. The first is the speed. The second is good shape connectivity of its segmenting result.When segmenting an image, we do not want the result of segmenting shape to be fragmentary. If the result of segmenting shape is fragmentary, we need take many resources to record the boundaries of the over-segment results. It is not we want to get the results. The third is good shape matching. Consequently, it will be reliable.

Image segmentation can be classified three categories traditionally including Threshold Technique, Region-Based Image Segmentation, and Edge-Based Image Segmentation.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

D.CIE LAB Color Space

CIE XYZ is an absolute color space (not device dependent). Each visible color has non-negative coordinates X,Y,Z.CIELab is a nonlinear transformation of XYZ into coordinates L*, a*,b*.The CIELab color space was intended for equal perceptual differences for equal chan-ges in the coordinates L*,a* and b*. Color differences deltaE are defined as Euclidian distances in CIELab.It uses new coordinates L*,a* and b* by functions.

E. Mean Shift and K- mean Clustering

Numerous nonparametric clustering methods can be classified into two large classes: hierarchical clustering and density estimation. Hierarchical clustering techniques either aggregate or divide the data based on some proximity measure. They tend to be computationally expensive and not straightforward. Differently the density estimation is regarded as the empirical probability density function (p.d.f) of the represented parameter.

The mean shift can be classified into density estimation. The mean shift adequately analyse feature space to cluster them and can provide reliable solutions for many vision tasks.

The K-means algorithm is most well-known in the partitional clustering.

K-means algorithm:

1. Decide the numbers of the cluster and choose randomly data points (pixels or image) in the whole image as the centroids in clusters.
2. Find out nearest centroid of every single data point (pixel or image) and classify the data point into that cluster the centroid located. After doing step 2, all data points are classified in some cluster.
3. Calculate the centroid of every cluster.
4. Repeat step 2 and step 3 until it is not changed.

Using the K-means algorithm, it has an advantage of less computing time. In other words, the partitional clustering is faster than the hierarchical clustering.

2.3. Wound Boundary Determination and Analysis Algorithms

Because the mean shift algorithm only manages to segment the original image into homogeneous regions with similar color features, an object recognition method is needed to interpret the segmentation result into a meaningful wound boundary determination that can be easily understood by the users of the wound analysis system. As noted in [8], a standard recognition method relies on known model information to develop a hypothesis, based on which a decision is made whether a region should be regarded as a candidate object, i.e., a wound. A verification step is also needed for further confirmation. Because our wound determination algorithm is designed for real time implementation on the smartphones with limited computational resources, we simplify the object recognition process while ensuring that recognition accuracy is acceptable.

IV Matlab Simulation Output

The Mat lab simulated output of the analysed wound and their stages are shown below.The simulated output is obtained by processing the captured real wounded area and the image is been analysed and the different stages of the severity is been displayed.There are different stages of simulated results they are i)Input and down sampled results; ii)Image smoothing results; iii) RGB to LAB color space result; iv)CIE L*A*B Color Space; v)Segmentated Result; vi) Largest connected componenet; vii)Foot cutline detection; viii)Color Segmentation; ix) k-Mean Result; x)Meanshift cluster result and final severity result if its intermediate, severe or healing stage.

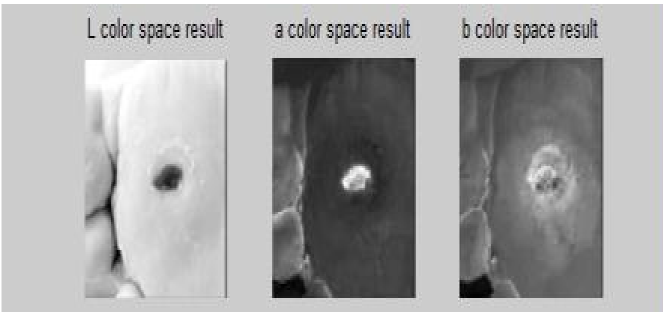
A.Severe Stage

The simulated results of the severe stage wound are shown below;

a.Input and Down Sampled Results

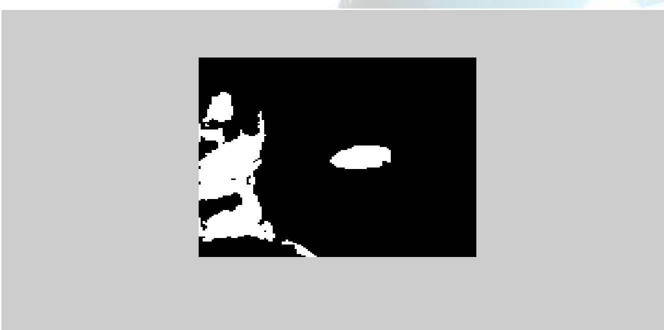
b.Image Smoothing Results

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016



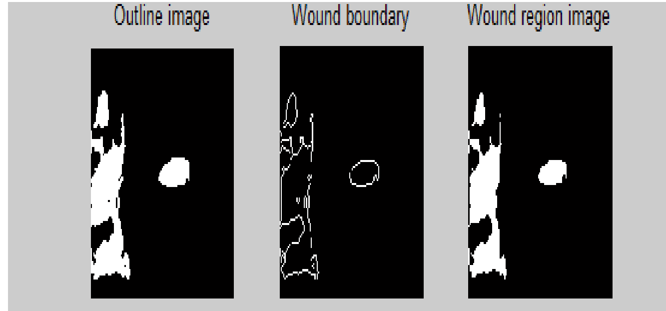
c.RGB to LAB Color Space Result

d.CIE L*A*B Color Space



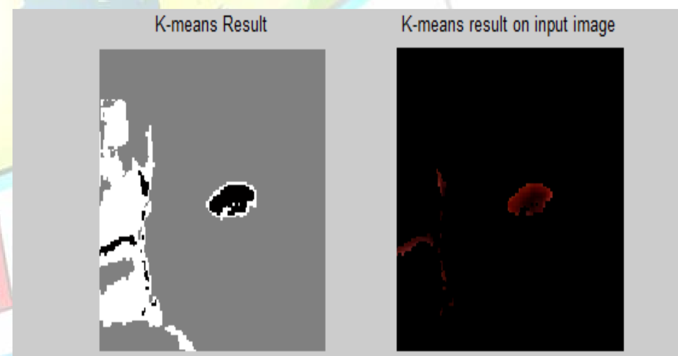
e.Segmented Result

f.Largest connected component



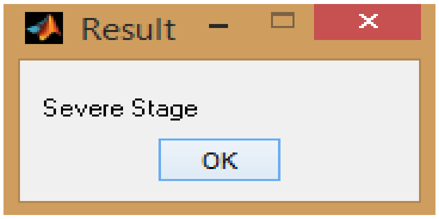
g.Foot cutline detection

h.Color Segmentation



i.k-Mean Result

j.Mean shift Cluster Result



k.Final Simulated Output (Severe Stage)

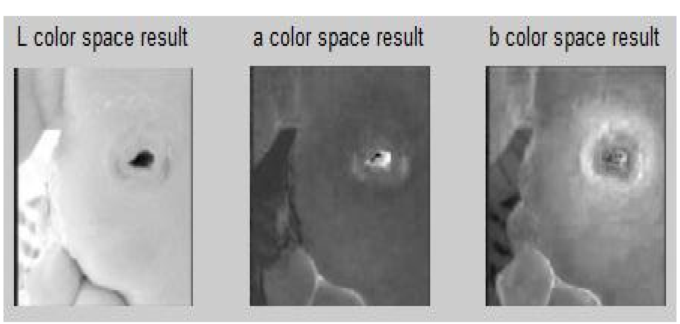
Fig. 6. Simulated Output – Severe Stage

B.Intermediate Stage

The simulated results of the Intermediate stage wound are shown below;

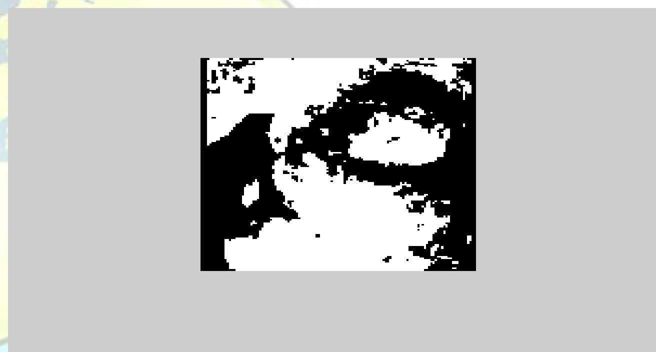
a.Input and Down Sampled Results

b.Image Smoothing Results

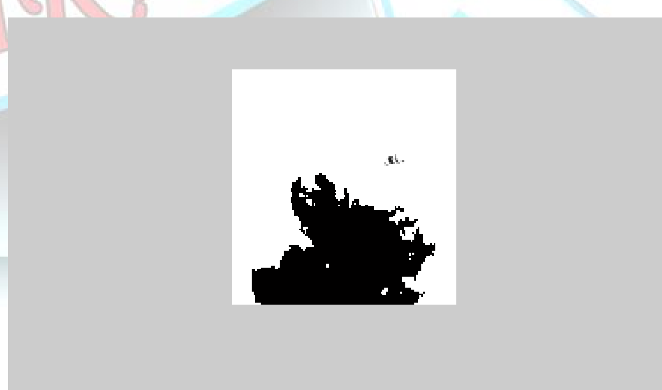


c.RGB to LAB Color Space Result

d.CIE L*A*B Color Space

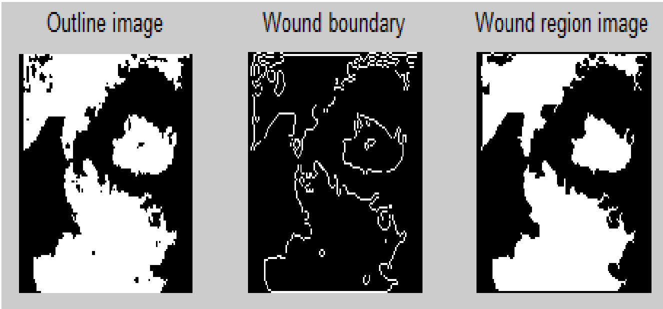


e.Segmented Result

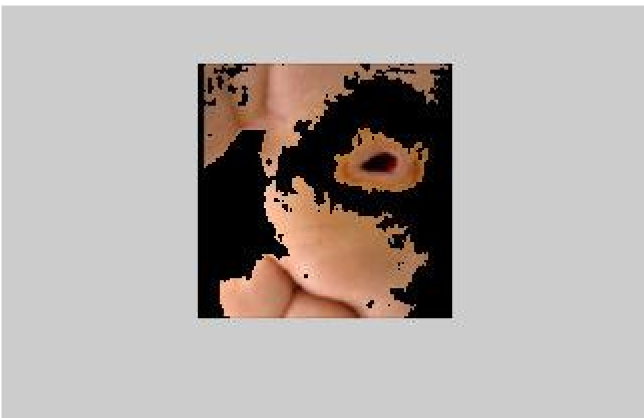


f.Largest connected component

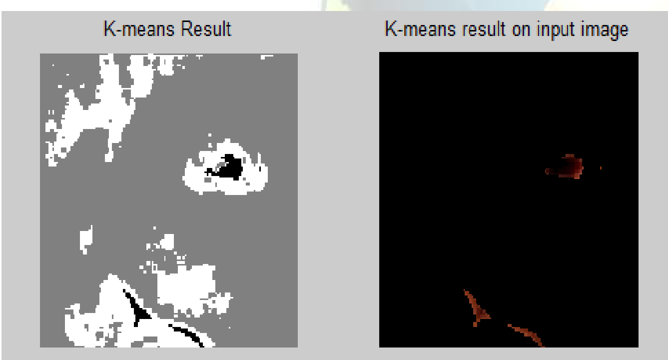
ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016



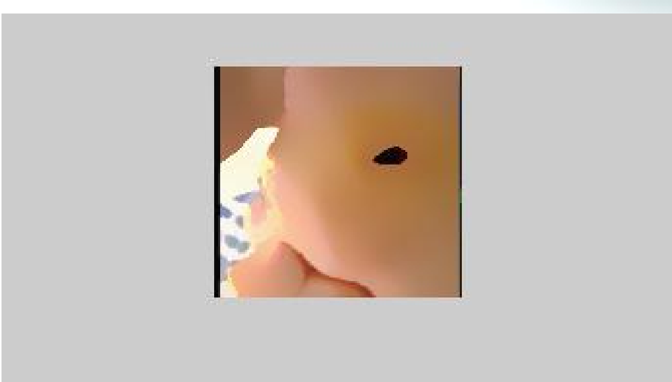
g.Foot cutline detection



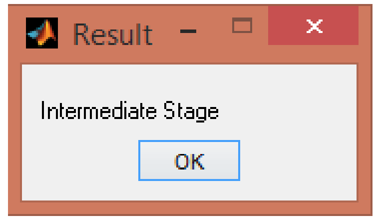
h.Color Segmentation



i.k-Mean Result



j.Meanshift Cluster Result



k.Final Simulated Output (Intermediate Stage)

Fig. 7. Simulated Output – Intermediate Stage

C.Healing Stage

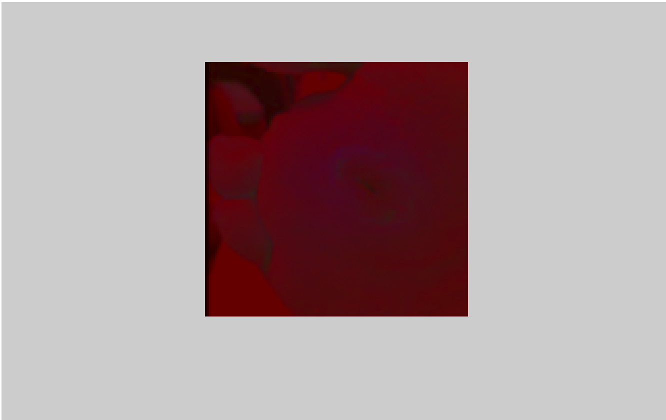
The simulated results of the Healing stage wound are shown below;

a.Input and Down Sampled Results

b.Image Smoothing Results

c.RGB to LAB Color Space Result

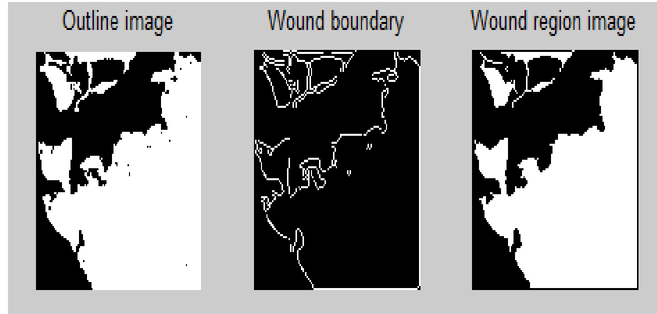
ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016



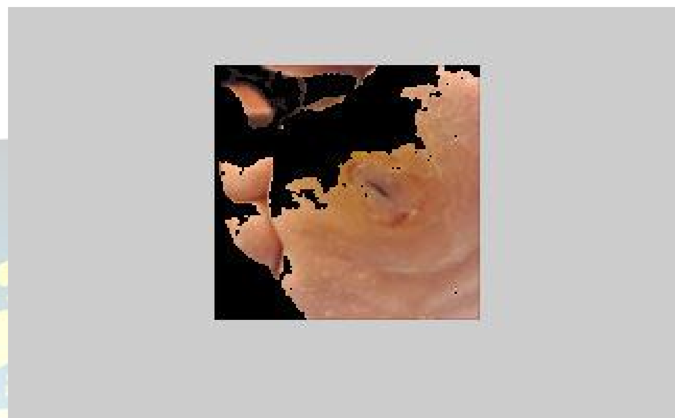
d.CIE L*A*B Color Space

e.Segmented Result

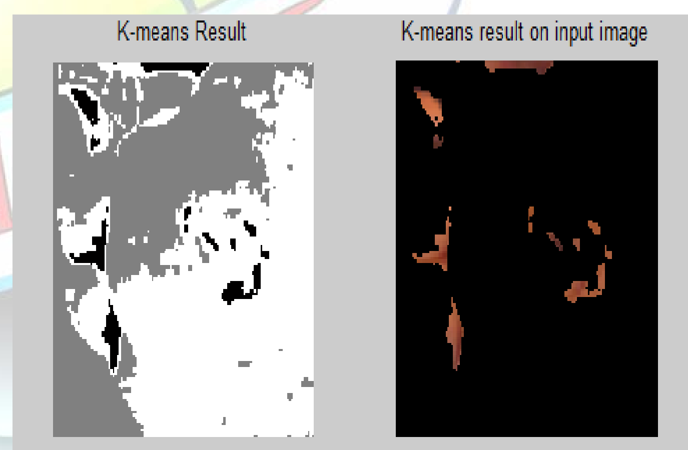
f.Largest connected component



g.Foot cutline detection

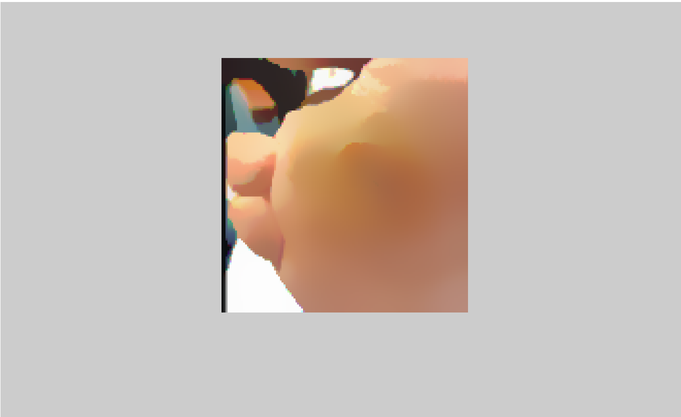


h.Color Segmentation

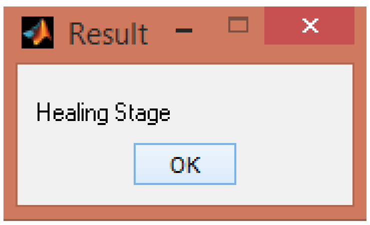


i.k-Mean Result

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016



j.Meanshift Cluster Result



k.Final Simulated Output (Healing Stage)

Fig. 7. Simulated Output – Healing Stage

V.Conclusion

DFU is a costly and debilitative disease with severe consequences in diabetic patients. It is important to carefully and completely train the preventive measures as well as foot care to all diabetic patients. We have designed a Wound self-Assessment using MatLab application in Smartphone for Diabetes Patients.The simulated output is obtained by processing the captured real wounded area and the image is been analysed and processed .The different stages of the severity are displayed as a simulated output to the patients.Early recognition and timely treatment of the wound severity of the diabetic patients is very essential and will help to keep the wound in control before it developes into a foot ulcer .Hence result of wound analysis using matlab application in smartphones shows that this method is efficient and provides accurate wound severity stage output on all wound images captured with an appropriate parameter setting. This will allow easier and more objective wound self assessment method as the patients will be aware of the wound severity wether if its of severe , intermediate or of healing stage and will help to keep the wound in control before it developes into a foot ulcer.This implementation of the wound analysis system is likely to reduce the number of visits to the clinic and reduced travel charges.The smartphones are the widely used commodity nowadays which contains a high-resolution camera which is very appropriate for image capture and image processing .The processing algorithms are designed both simple and accurate for the patients to use it as easier as possible with no complications.

REFERENCES

[1] Bijan Iraj, Fariborz Khorvash,1 Alireza Ebneshahidi, and Gholamreza Askari2" Prevention of Diabetic Foot Ulcer" Int J Prev Med.4(3): 373–376, 2013 Mar

[2] Ingrid Kruse, DPM and Steven Edelman, MD "Evaluation and Treatment of Diabetic Foot UlcersClinical Diabetes.vol. 24 no. 2 91-93, April 2006

[3] C.M. Li, C.Y. Xu, C.F. Gui, "Distance regularized level set evolution and its application to image segmentation," *IEEE Trans. Image Processing,* vol. 19, no. 12, pp. 3243-3254, Dec. 2010.

[4] L. Wang ;P. C. Pedersen ; D. M. Strong ; B. Tulu ; E. Agu ; R. Ignotz," Smartphone Based Wound Assessment System for Patients with Diabetes" IEEE Transactions on Biomedical Engineering (Volume:62 , Issue: 2) 0018-9294, Feb. 2015.

[5] D. Comaniciu, P.Meer, "Mean shift: A robust approach toward feature space analysis," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 24, no. 5, pp. 603-619, May, 2002.

[6] C.M. Christoudias, B. Georgescu, P. Meer, "Synergism in low level vision," *IEEE Proc. of 16 Inter. Conf. on Pattern Recognition*, vol. 4, pp. 150-155,

[7]Christo Ananth, A.S.Senthilkani, Praghash.K, Chakka Raja.M., Jerrin John, I.Annadurai, "Overlap Wavelet Transform for Image Segmentation", International Journal of Electronics Communication and Computer Technology (IJECCT), Volume 4, Issue 3 (May 2014), pp-656-658

[8] R. Jain, R. Kasturi, B.G. Schunck, "Machine Vision," McGraw-Hill, Inc., 1995.]]

[9] Shan M Bergin, Joel M Gurr, Bernard P Allard, Emma L Holland, Mark W Horsley, Maarten C Kamp, Peter A Lazzarini, Vanessa L Nube, Ashim K Sinha, Jason T Warnock, Jan B Alford and Paul R Wraight "Australian Diabetes Foot Network: management of diabetes-related foot ulceration — a clinical update"Med J.197 (4): 226-229,Aust 2012