

Parallel Implementation of Wound Image Analysis System for Diabetic Patient

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ABSTRACT: Proper wound healing can be assessed by monitoring the wound surface area. There are various methods of wound area measurement, which differ in terms of the cost of the devices and their accuracy. Using smartphones to remotely monitor incisional wounds via digital photos as well as collect postoperative symptom information has the potential to improve patient outcomes and transitional care. Currently, clinicians and nurses mainly base their wound assessment on visual examination of wound size and healing status, while the patients themselves seldom have an opportunity to play an active role. Hence, a more quantitative and cost-effective examination method that enables the patients and their caregivers to take a more active role in daily wound care potentially can accelerate wound healing, save travel cost and reduce healthcare expenses. Considering the prevalence of smartphones with a high-resolution digital camera, assessing wounds by analyzing images of chronic foot ulcers is an attractive option. In this paper, the system proposes a novel wound image analysis system for analyze the image. Diabetic foot ulcers represent a significant health issue, and daily wound care is necessary for wound healing to occur. The goal of this research is to create a smart phone based wound image analysis system for people with diabetes to track the healing process of chronic ulcers and wounds.

KEYWORDS: Android based samartphone, Mean Shift, Sample images of foot ulcers, wound analysis, Region Adjacency graph

I. INTRODUCTION

Diabetic foot ulcer represents constitute a significant healthissue affecting millions of individuals around the world. Foot ulcers are very painful and very slow to heal. Cost of treating diabetic foot ulcers is high. Many problems will occur while treating diabetic foot ulcers. First, patients must go to their wound clinic on regular basis to check their wounds. This type treatment is inconvenient time and cost consuming for patient. Wound assessment process is based on the visual examination of wound. This visual examination does not produce exact measurement and quantifiable of healing status.

Image analysis technique gives the solution to above problem. Different techniques are used for wound image analysis system. Measurement of wound area is done by MAVIS (Measurement of Area using a Volume Instrument System) and MEDPHOS (Medical Digital Photogrammetric System). The main disadvantages of these systems are high cost, complex to use and lack of tissue classification.

Image segmentation and supervised machine learning algorithm is applied to produce good results in wound boundary determination and wound analysis. SVM (Support Vector Machine) based wound classification method produced by a French research group. Even though the SVM produce good results it is not flexible for users. Supervised learning algorithm requires a large number of training image

samples and experienced clinical input, which is difficult and costly.

Our solution provides image analysis algorithm that run on a smartphone, and thus provide a low cost and easy to use device for self management of diabetic foot ulcer patients. Patients can play an active role in their own care. Now a days all smartphones are containing high resolution camera. Monitoring of diabetic foot ulcers can be done by

Parallel Implementation of Wound Image Analysis System for Diabetic Patient

using smartphone. To convert an ordinary smartphone into a practical device for self management of diabetic wound we need to do two tasks: 1) Develop a simple method for patient to capture an image of their foot ulcers; 2) Design highly efficient and accurate algorithm for real time wound analysis that is able to operate within the computational constraints of smartphone.

Accurate and computationally efficient algorithm implemented by mean-shift algorithm. In this wound boundary determination followed by color segmentation is done within the wound area for assessing the healing status.

In existing system wound boundary determination was done with the particular implementation of level set algorithm specifically distanced level set evolution algorithm. The main disadvantages of this level set evolution algorithm is computationally too intensive, it computationally depends on the initial curve and false edges may interfere with the evolution when skin color is not uniform.

To address this problem level set evolution algorithm is replaced by mean-shift segmentation algorithm. This also creates the additional problem called over segmentation which can be solved by the Region Adjacency Graph (RAG)

II. WOUND ANALYSIS METHOD

2.1 Wound Image Analysis System Overview

Our quantitative wound assessment system consist of several functional modules including wound image capture. Wound image storage, wound image processing, wound boundary determination, wound analysis by color segmentation and wound trend analysis based on a time sequence of wound image for a given patient. All the processing steps are carried out by the computational resources of the smartphone. Wound image is captured. The JPEG file path of this image added into a database. This image cannot be process directly with our image processing algorithms, therefore needs to be decompressed into a 24-bit bitmap file format.

In the image processing step, we first downsample the high resolution image. We downsample the original image by factor4 in both horizontal and vertical direction. Then we smooth the image to remove noise by using Gaussian blur method whose standard deviation 0.5 was empirically judged to be optimal based on multiple experiments.

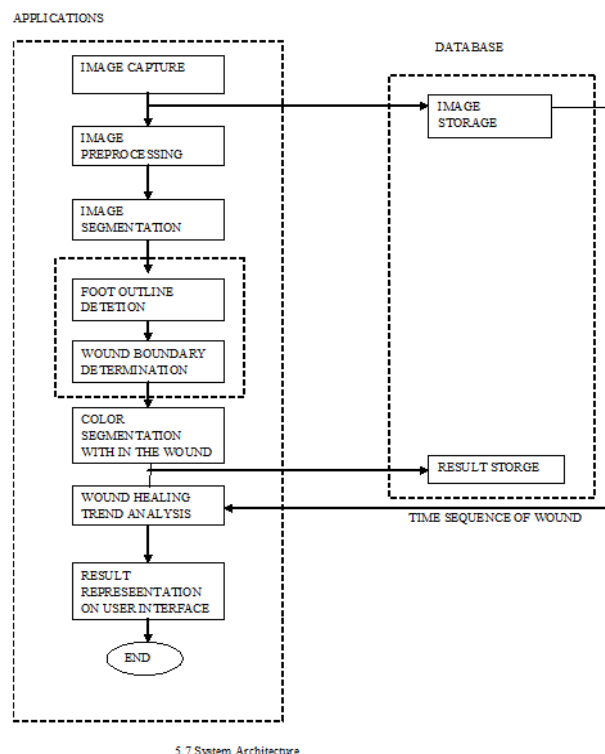


Fig 1. Wound image analysis system

Image segmentation operation is to divide the original image into pixel groups with homogeneous color values. Foot outline detection is performed by finding the largest connected component in the segmented image under the condition that the color of this component is similar enough to a preset standard skin color. Based on the standard color checkers provided in both the light and dark skin color thresholds.

Parallel Implementation of Wound Image Analysis System for Diabetic Patient

Wound boundary determination based on the foot outline detection result. If the foot detection result is regarded as a binary image with the foot area marked as “white” and rest part marked as “black”, it is easy to locate the wound boundary within the foot region boundary by detecting the largest connected “black” within the “white” part. Wound boundary has been successfully determined and the wound area calculated.

Healing state of the wound by performing color segmentation with the goal of categorizing each pixel in the wound boundary into certain classes labeled as granulation, slough and necrosis. The wound healing trend analysis is performed by comparing the wound feature vectors between the current wound record and standard time interval earlier. Alternatively, a long term healing trend is obtained by comparing the feature vectors between the current wound and the base record.

2.2 Mean-shift-Based segmentation algorithm

We chose mean-shift algorithm over other segmentation method such as level set and graph cut based algorithm for several reasons. First mean-shift algorithm takes into consideration the spatial continuity inside the image by expanding the original 3-D color range space to image 5-D space, including two spatial components, since direct classification on the pixels proved to be inefficient. Mean shift filtering algorithm is suitable for parallel implementation since the basic processing unit is the pixel. In this case, the high computational efficiency of CPU can be exploited.

The mean-shift algorithm belongs to density estimation based non parametric clustering method. This type of algorithms adequately analyzes the image feature space (color space, spatial space or the combination of two spaces to cluster) to cluster and can provide a reliable solution for many vision tasks. In general the mean-shift algorithm models the feature vectors associated with each pixel (e.g. color and position in the image grid).

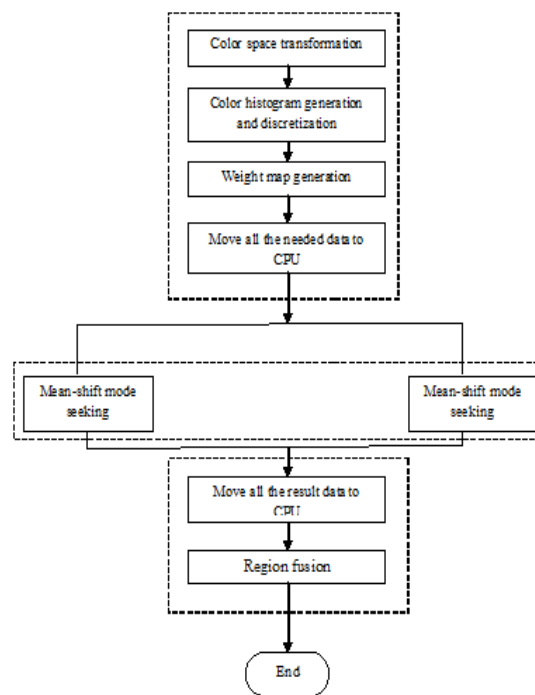


Fig 2. Implementation Flow of Mean-shift algorithm

III. ANALYSIS PROCESS

3.1 Image Processing

In this module, the system first downsample the high-resolution bitmap image to speed up the subsequent image analysis and to eliminate excessive details that may complicate wound image segmentation. In this case, the system downsample the original image by a factor 4 in both the horizontal and vertical directions to pixel dimensions, which has proven to provide a good balance between the wound resolution and the processing efficiency. In practice, we use the standard API for image resize on the Android smartphone platform to ensure high efficiency. Second, we smooth the images to remove noise by using the Gaussian blur method was empirically judged to be optimal based on multiple experiments.

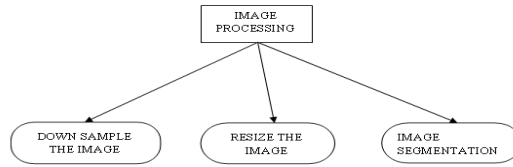


Fig 3. Image Preprocessing

3.2 Image Segmentation

To determine the boundary of the wound area, the system first determines an outline of the foot within the image. Hence the initial Image segmentation operation is to divide the original image into pixel groups with homogeneous color values. Image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

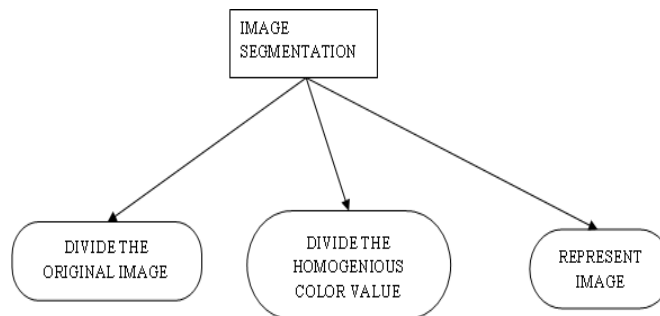


Fig 4. Image Segmentation

3.3 Foot Outline Detection

The Foot outline detection is performed by finding the largest connected component in the segmented image under the condition that the color of this component is similar enough to a preset standard skin color. Based on the standard color checkers provided, both the light and dark skin color thresholds in CIE LAB space are incorporated into the system, which means that our algorithm is expected to work for most skin colors.

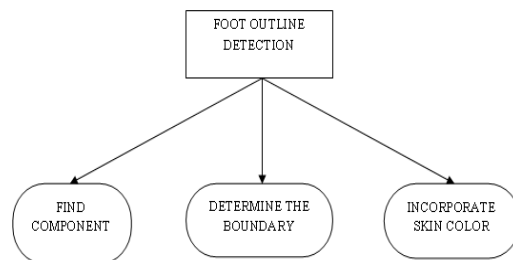


Fig 5. Foot out line detection

3.4 Wound Boundary Determination

Wound boundary determination method is based on three assumptions. First, the foot image contains little irrelevant background information. In reality, it is not a critical problem as we assume that the patients and/or caregivers will observe the foot image with the wound on the smartphone screen before the image is captured to ensure that the wound is clearly visible. Second, we assume that the healthy skin on the sole of the foot is a nearly uniform color feature. Finally, we assume that the foot ulcer is not located at the edge of the foot outline. In this wound boundary determination algorithm, each row in the binary image matrix is regarded as the basic scanning unit.

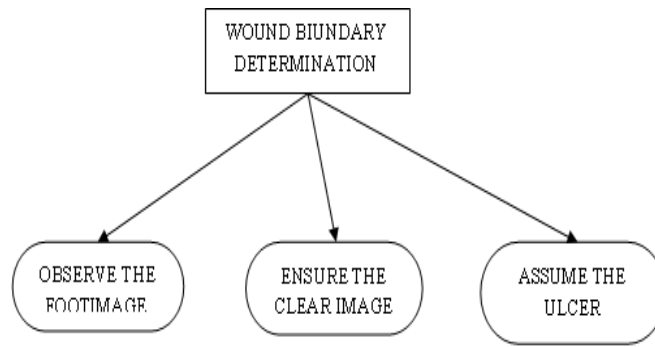


Fig 6. Wound Boundary Determination

3.4 Color Segmentation

When the wound boundary has been successfully determined and the wound area calculated, we next evaluate the healing state of the wound by performing Color segmentation, with the goal of categorizing each pixel in the wound boundary into certain classes labeled as granulation, slough and necrosis. The classical self-organized clustering method called K-mean with high computational efficiency is used. After the color segmentation, a feature vector including the wound area size and dimensions for different types of wound tissues is formed to describe the wound quantitatively. This feature vector, along with both the original and analyzed images, is saved in the result database.

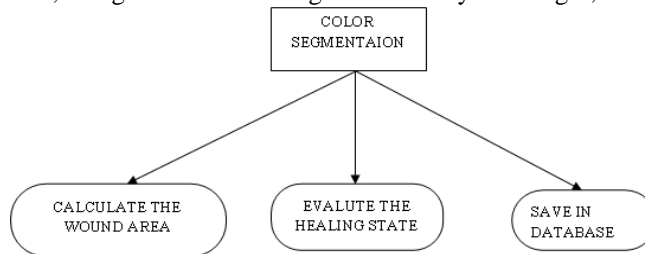


Fig 7. Color Segmentation

3.6 Result Analysis

The goal of this work has been to assess the accuracy of the wound boundary determination based on the mean-shift algorithm and the color segmentation based on the K-mean algorithm; and to perform an efficiency analysis by comparing the mean-shift algorithm to two other algorithms. To test accuracy, we applied the mean-shift-based algorithm on two categories of wound images. To test the algorithm efficiency, the mean-shift-based wound analysis algorithm was implemented on the CPU.

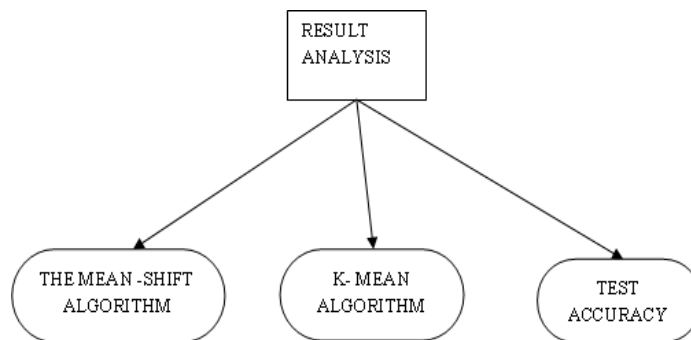


Fig 8. Result analysis

IV. EXPERIMENTAL RESULTS

4.1 Experimental results on clinical images from actual patients

The original images from actual patients shown in Fig. 9. These simulations are taken from different patients. These images are appropriately illuminated with uniform skin color and well-defined wound boundaries. Color segmentation results provided by K-means algorithm based on wound boundary determination. The wound analysis task much more complicated for the clinical image of real patients due to complicated skin color and texture of patient’s feet, various wound locations and uneven illumination over the image plane



Fig. 9 (d) Foot and Wound Outline Detection



Fig. 9 (a)

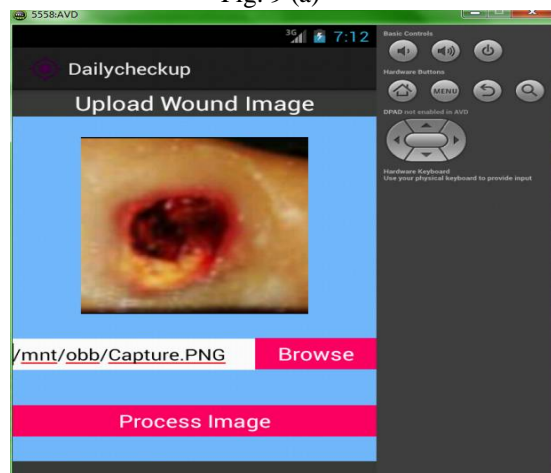


Fig. 9 (c) processing of wound image



Fig. 9 (d) Foot and Wound outline detection

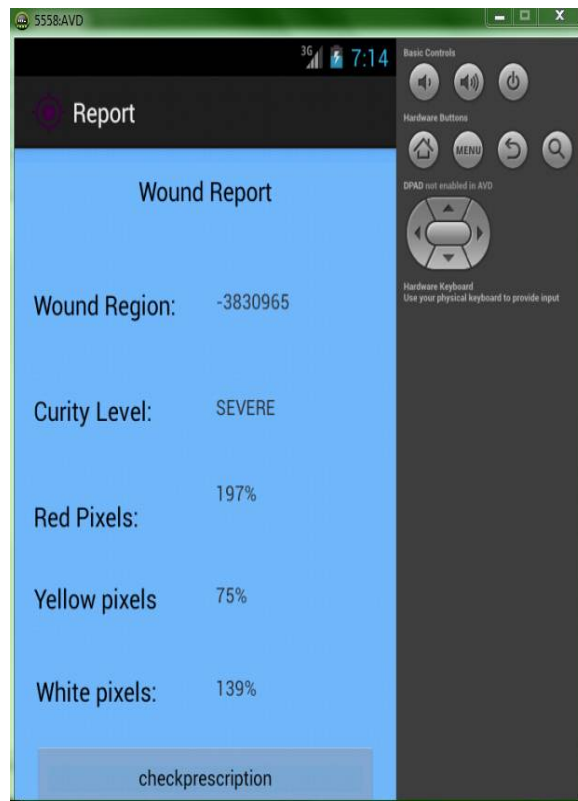


Fig. 9 (e) Wound Status

IV. CONCLUSION

In this paper, the system has proposed a novel wound image analysis system for diabetes patients. The wound analysis algorithm is implemented to analyze the wound and to provide the result. A database of chronic wound images was constituted with the help of clinical staff in several hospitals to obtain a representative set of images for different tissue types as input for the wound image-processing chain. Considering that the application is intended for the home environment, we can for each individual patient manually find an optimal parameter setting based on a single sample image taken from the patient before the practical application. Segmentation is the process of partitioning a digital image into multiple segments to simplify and/or change the representation of an image into a fashion that is more meaningful and easier to analyze. For remotely sensed images of the Earth, an example is a map that divides the image into areas labeled by distinct Earth surface covers such as water, snow, and types of natural vegetation, rock formations, crops, and otherman-created objects. Finally, the result shows that the proposed system can effectively provide the result. And it can outperform the existing system and provides the promising accuracy.

REFERENCES

1. Lei Wang, Student Member, IEEE, Peder C. Pedersen*, Senior Member, IEEE, Diane M. Strong, Bengisu Tulu, Member, IEEE, Emmanuel Agu, and Ronald Ignatz: (FEBRUARY 2015) "Smartphone-Based Wound Assessment System for Patients With Diabetes" VOL. 62, NO. 2, pp 477-488.
2. K. M. Buckley, L. K. Adelson, and J. G. Agazio (Mar. 2009), "Reducing the risks of wound consultation: Adding digital images to verbal reports," *Wound/Ostomy Continence Nurs.*, vol. 36, no. 2, pp. 163–170.
3. R. S. Rees and N. Bashshur (Dec. 2007), "The effects of tele wound management on use of service and financial outcomes," *Telemed. J. E. Health*, vol. 13, no. 6, pp. 663–674.
4. H. Wannous, Y. Lucas, and S. Treuillet (May 2010), "Combined machine learning with multi-view modeling for robust wound tissue assessment," pp. 98–104.
5. H. Wannous, Y. Lucas, S. Treuillet, and B. Albouy (Oct. 2008), "A complete 3D wound assessment tool for accurate tissue classification and measurement," in *Proc. IEEE 15th Conf. Image Process*, pp. 2928–2931.
6. H. Wannous, S. Treuillet, and Y. Lucas (Apr. 2010), "Robust tissue classification for reproducible wound assessment in telemedicine environment," *J. Electron. Imag.*, vol. 19, no. 2, pp. 100–113.
7. H. Wannous, Y. Lucas, and S. Treuillet (Aug. 2007), "Supervised tissue classification from color images for a complete wound assessment tool," in *Proc. IEEE 29th Annu. Int. Conf. Eng. Med. Biol. Soc PP*, 30–43.
8. L. Wang, P. C. Pedersen, D. Strong, B. Tulu, and E. Agu (Feb. 2013), "Wound image analysis system for diabetics," *Proc. SPIE*, vol. 8669, pp. 866924-1– 866924-14
9. C. M. Li, C. Y. Xu, and C. F. Gui (Dec. 2010), "Distance regularized level set evolution and its application to image segmentation," *IEEE Trans. Image Process.*, vol. 19, no. 12, pp. 3243–3254.
10. L. Wang, P. C. Pedersen, D. Strong, B. Tulu, and E. Agu (Oct. 2013), "Smart phone based wound assessment system for diabetic patients," presented at the 13th Diabetes Technology Meeting, San Francisco, CA, USA PP. 1000-1013.
11. J. C. Tilton, Y. Tarabalka, P. M. Montesano, and E. Gofman (Nov. 2012), "Best merge region-growing segmentation with integrated nonadjacent region object aggregation," *IEEE Trans. Geosci. Remote Sens.*, vol. 50, no. 11, pp. 4454–4467.