Analysis of Foot Ulcer Level Using Non-Invasive Technique Based on Image Segmentation for Type 2 Diabetic Patients

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Abstract - Medical imaging is that the technique and method of making visual representations of the inside of a body for clinical analysis and medical intervention, furthermore as visual illustration of the performance of some organs or tissues (physiology). In computer vision, image segmentation is the method of partitioning a digital image into its constituent parts with identical pixel values. The goal of segmentation is to modify the illustration of a picture into one thing that is a lot of purposeful and easier to investigate. A foot ulceration is associate degree open sore on the foot. Foot ulceration may be a shallow red crater that involves solely the surface skin. Foot ulceration can also be terribly deep. There are many issues with current practices for treating diabetic foot ulcers. First, patients should move to their wound clinic on a daily basis to own their wounds checked by their clinicians. Second, a clinician’s wound assessment method is predicated on visual examination. Technology using image analysis techniques may be a potential resolution to each these issues. The wound image is captured by the camera on the smart phone with the help of a picture capture box. In the Image pre-processing step, the electronic image is first down-sampled into high-resolution image. Second, the pictures are sleeked to get rid of noise (which is assumed primarily to be Gaussian noise made by image acquisition process) by mistreatment the Gaussian blur methodology whose variance with 0.5 was through empirical observation judged to be optimum supported multiple experiments. The foot outline is decided by using Sobel edge detection methodology. Then, Region of interest is developed by keeping the foot as foreground and rest as background. Color segmentation is performed by partitioning pixels into totally different clusters supported color similarity and abstraction relation. The RYB image is transformed to HSV and color thresholding is performed to find the outer area.

Keywords - Physiology, computer vision, Foot ulceration, Gaussian noise, Sobel edge detection, Color segmentation, RYB image.

1. Introduction

Diabetics in chronic stage is a womb-to-tomb condition which affects human body's normal function to use the energy found in food. There are three major varieties of polygenic disease: sort one diabetes, sort a pair of polygenic disease, and physiological state polygenic disease. Diabetes may be a chronic condition related to abnormally high levels of sugar (glucose) within the blood. Every type of diabetes has one thing in common [1]. Normally, human body separates the sugars and carbohydrates and the separated sugar is called as glucose. However, the cells would like hypoglycemic agent, an endocrine so as to require within the glucose and use it for energy. With diabetes, either the body does not build enough hypoglycemic agents; it cannot use the hypoglycemic agent it will turn out, or a mix of each. Hypoglycemic agent created by the exocrine gland lowers blood sugar [2]. Absence of short production of hypoglycemic agent, or associate inability of the body to properly use hypoglycemic agent causes polygenic disease. Since the cells cannot absorb the glucose, it builds up in our blood.

High levels of blood sugar will harm the little blood vessels in your kidneys, heart, eyes, or system. That is why diabetes specially if left untreated will eventually cause heart condition, stroke, uropathy, blindness, and nerve harm to nerves within the feet. Different types of polygenic disease are type-1 and type-2. Former names for these conditions were insulin-dependent and adult-onset diabetes, or juvenile onset and adult-onset polygenic disease [3]. The main complications of polygenic disease are acute and chronic. The different types of complications that may occur due to diabetes are listed as follows, 1) Acute complications: hazardingly elevated glucose (hyperglycemia) or abnormally low glucose (hypoglycemia) because of polygenic disease medications and 2) Chronic complications: blocks in the blood vessels (both tiny and large) that may harm the feet, eyes, kidneys, nerves, and heart [4,5].

2. Problem Statement

There are numerous issues with current practices for treating diabetic foot ulcers. To begin with, patients should visit their injury center consistently to have their injuries checked by their clinicians. This might want for regular clinical examination and exclusively badly arranged and time
exceptional for patients and clinicians, anyway jointly speaks to a significant medical care an incentive because of patients could require unique transportation, e.g., ambulances. Second, a clinician's injury evaluation technique is predicated on visual examination [6]. The clinician depicts the injury by its actual measurements and the shade of its tissues, giving essential signs of the injury sort and the phase of mending. On account of the visual evaluation doesn't turn out target estimations and quantitative boundaries of the mending standing, interest an injury's recuperating strategy across successive visits might be a problematic undertaking for every clinicians and patients. Innovation utilizing picture examination procedures might be a possible response to each these issues. Numerous attempts are made to utilize picture measure procedures for such assignments, along with the proportion of room, or rather utilizing a Volume Instrument System (MAVIS) [7,8].

3. Proposed Work and Methodology

Purpose of Edge Detection

Edges are unit places within the image with sturdy intensity distinction. Edge detection is one of the most utilized image processing algorithms in the preprocessing stages, as it helps in finding boundaries of objects. Figure 1a shows the original image with different segments. Figure 1b shows the segmented image with outlines of every shape in the original image using edge detection technique.

Sobel Edge Detector

Edges in each horizontal and vertical direction then mix the knowledge into one metric. The Sobel operator performs a 2-D spatial gradient on a picture then emphasizes regions of high spatial frequency that correspond to edges. Usually, it's wont to realize the approximate absolute gradient magnitude at every purpose in associate degree input gray scale image. In theory a minimum of, the operator consists of a try of 3×3 convolution kernels. One kernel is just the opposite turned by 90°.

RyB Wound Classification Model

The RyB (red- yellow-black) wound classification model, projected in 1988 by Arnvist, Hellgren and Vincent could be a consistent, easy assessment model to judge wounds. It classifies wound tissues inside a wound as red, yellow, black or mixed tissues, that represent the various phases on the time of the wound healing method. In particular, red tissues show the inflammatory (reaction) section, proliferation (regeneration), or maturation (remodeling) phase; yellow tissues imply infection or tissue containing slough that looks like it is unable to heal; and black tissues indicate death tissue state, that isn't able to heal either [13]. A search table is best owed for the convenience of patients supported the RyB wound analysis model, our wound analysis task is to classify all the pixels inside the wound boundary into the RyB color classes and cluster them. Therefore, classical cluster strategies are often applied to resolve this task [14].

Image Capturing Box

The image capture box was designed as a compact, rugged and cheap device that: (i) permits patients to capture a picture since the bulk of patients’ wounds occur on the soles of their feet, (ii) permits patients to rest their feet well, while not requiring sportfishing of the foot or the smartphone camera, as patients is also overweight and have reduced quality, and (iii) accommodates image viewing and capture of left foot sole further as right foot sole. during this case, the patients will rest their foot well. Once victimization the box, the patients ought to make sure that the wound is totally settled inside the gap [15].
Making GUI
Graphical User Interface (GUI) was introduced in reaction to the perceived steep learning curve of command-line interfaces (CLIs) that need commands to be written on the keyboard. GUIs offer point-and-click management of computer code applications, eliminating the necessity to find out a language or kind commands so as to run the appliances [16]. MATLAB apps square measure self-contained MATLAB programs with GUI front ends that automatize a task or calculation. The GUI usually contains controls reminiscent of menus, toolbars, buttons, and sliders.

4. Experimental Setup
Image capture box connected to laptop to capture the image.

Fig. 2: Experimental Setup for the system
With reference to the box, the patients can understand that, the location of wound is completely inside the opening. A sample foot image placed on Image Capture box is shown on Figure 2.

5. Image Processing Section
The image is captured with the help of capture box and stored in the system. The stored image can be taken for processing using MATLAB command [17]. A dialog box is opened and image is selected as shown in Figure 3. The destination folder is specified in the path. Capture image button is created in GUI and a click on the button helps to obtain the captured image.

Fig. 3: Experimental Setup for the system
To examine the morphological structure of an image such as area, Region of interest is needed [18]. Here, the wound located on the foot is the area to be concentrated. Hence, the foot portion containing the wound is taken as foreground and remaining as background [19]. This is done by calculating the region properties of an image and bounding box is used to crop the image. The ROI extraction step in GUI is shown in Figure 4.

Fig. 4: Image capturing step in GUI

Fig. 5: ROI Extraction step in GUI

Fig. 6: Color segmentation step in GUI
In order to quantize the image, segmentation is necessary. The result of image segmentation contains a group of various segments that cover the entire image [20]. Color Segmentation button helps to view the result of segmented region of interest.
and it is taken for next process. The GUI step of color segmentation is shown in Figure 5.

Using color thresholder application, the wound area is figured out by color adjustment [21]. It creates an auto generated function and this function is created for three stages of wound in default. Using region properties, the wound portion is represented in black and white as shown in Figure 6.

From the determined wound boundary in previous step, the boundary is mapped with the original image and the area is calculated using the region properties of segmented image and it is depicted in Figure 7.

![Wound Boundary Determination Step in GUI](image)

**Fig.7: Wound Boundary Determination Step in GUI**

![Wound ROI determination step in GUI](image)

**Fig.8: Wound ROI determination step in GUI**

### 6. Results for Different Input Images

The image is captured with the help of capture box and stored in the system. Capture image button is created in GUI and a click on the button helps to obtain the captured image. By calculating the region properties of an image and bounding box is used to crop the image to obtain the region of interest. By calculating the region properties of an image and bounding box is used to crop the image. Using color thresholder application and region properties, the wound portion is represented in black and white. The boundary is mapped with the original image and the area is calculated using the region properties of segmented image. Here the wound is in proliferation phase with wound area 20137. It is shown in Figure 8.

![Simulation results of a wound in proliferation phase in GUI](image)

**Fig.9: Simulation results of a wound in proliferation phase in GUI**

![Simulation results of an image in Inflammatory phase in GUI](image)

**Fig.10: Simulation results of an image in Inflammatory phase in GUI**

The image is captured with the help of capture box and stored in the system. Capture image button is created in GUI and a click on the button helps to obtain the captured image. By calculating the region properties of an image and bounding box is used to crop the image to obtain the region of interest. By calculating the region properties of an image and bounding box is used to crop the image. Using color thresholder application and region properties, the wound portion is represented in black and white. The boundary is mapped with the original image and the area is calculated using the region properties of segmented image. Here the wound is in inflammatory phase with wound area 10829. It is shown in Figure 9 and Figure 10.

A Database is created for individual patients to store their results of the analysis. The patients are differentiated by their ID. Patient's ID is entered and it automatically displays the details of the patient such as name and contact. By using capture image button, the prestored image is taken. Load DB helps to do the image process such as segmentation and finding region of interest. Add to Database loads the result image into the database and area is displayed. The difference in area from previous result and wound phase is also displayed as shown in Figure 11.
Intelligence can be adopted in future to make the system as a self-adoptive one. The running time of the algorithm takes only 15 seconds. The noise generated during the image acquisition can be removed by using Gaussian filter. The designed system can be used as home-based self-testing system which will minimize the repeated visiting of clinic for testing. Recent technologies such as Machine Learning and Artificial Intelligence can be adopted in future to make the system as a self-adoptive one.

### 7. Conclusion and future scope for work

This paper describes the design and implementation of a system to analyze the human wound image for patients who were affected by type 2 diabetes due to foot ulcers. From the experimental results, it is evident that, the proposed method increases accuracy as well as efficiency. The boundary of the wounded portion is detected by using proper parameter selection and setting. The running time of the algorithm takes only 15 seconds. The noise generated during the image acquisition can be removed by using Gaussian filter. The designed system can be used as home-based self-testing system which will minimize the repeated visiting of clinic for testing. Recent technologies such as Machine Learning and Artificial Intelligence can be adopted in future to make the system as a self-adoptive one.

### References


[7]. Y.Y.Yao, and J.T.Yao, “Granular computing as a basis for consistent classification problems”, *Communications of Institute of Information and Computing Machinery (special issue of PAKDD’02 Workshop on Toward the Foundation of Data Mining)*, vol. 5, No.2, pp.101-106, 2012


[17]. V. Ramu Reddy, Aniran Dutta, Choudhury Parijat Deshpande, Srinivasan Jayaraman, Naveen Kumar, Thokala Venkatesh and Kaliperumal, "DMSense: A non-invasive Diabetes Mellitus Classification System using Photoplethysmogram signal" *IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops) 2017*


