

Early Detection of Ulcer using the Non Invasive Thermography Technique on the Foot Images

Monali D. Rathod

Dept of Computer science and
IT, Dr. Babasaheb Ambedkar
Marathwada University,
Aurangabad
MS (India)

Ramesh R. Manza

Dept of Computer Science and
IT, Dr. Babasaheb Ambedkar
Marathwada University,
Aurangabad
MS (India)

Deepali D. Rathod

Dept of Computer Science and
IT, Dr. Babasaheb Ambedkar
Marathwada University,
Aurangabad
MS (India)

ABSTRACT

Day by day the numbers of diabetic patients are increasing rapidly. In diabetes ulcer is a major complication and once the ulcer is occurring then it does not cure easily. Ulcer can be prevented if it is detected in early stage. For detection of diabetes there are many pathological techniques are available, but all they are invasive techniques and many people have panic of that so they avoid for regular diabetes checkup. Thermography is used for detection of ulcer area and this technique is totally non-invasive technique. Thermography is working on heat which is naturally emitted from the human body. High temperature under the foot is a symptom of diabetic neuropathy, and if this symptom is detected using a thermal technique then detection of ulcer in early stage is possible.

Keywords

Diabetes, neuropathy, temperature, wound area, masking

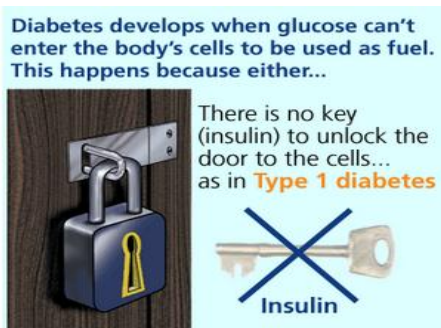
1. INTRODUCTION

Diabetes is also known as diabetes mellitus. It describes a group of metabolic diseases. Diabetes occurs due to the high blood sugar, either because an insufficiency of insulin production, or because the body's cells do not respond properly to insulin, or both [1]

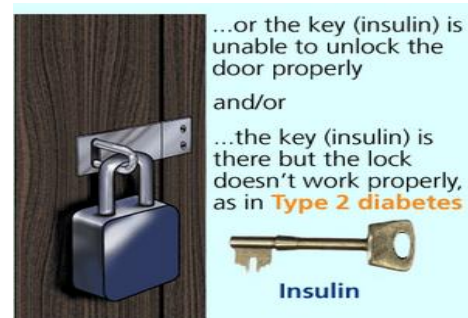
There are mainly two types of diabetes:

Type 1 diabetes-In this case body does not produce insulin.

Type 2 diabetes – In this case body does not produce enough insulin for proper function, or the cells in the body do not react to insulin that time type 2 diabetes accrued.



(A) Type I Diabetes



(B) Type II Diabetes

Fig 1. (A) Type 1 diabetes and (B) type 2 diabetes

Figure 1 referred from the reference number [2] Day by day the patient with type 2 diabetes is rising rapidly worldwide. If diabetes is not recognized in early stage then it can be converted into the ulcer. Uncontrolled diabetes can affect the eyes, kidneys, heart, nerves, and feet. In that foot complications are one of the most common problems. Due to the foot complications near about 50% diabetic patients are admitted in the hospitals. There are main two causes of diabetic complications that are decreased blood supply and loss of sensation in the feet and these are the symptoms of diabetic neuropathy [3, 4]. Nerves are damaged due to the diabetic is called a diabetic neuropathy and diabetic neuropathy is a major problem in diabetes [5]. The term neuropathy is short for peripheral neuropathy, meaning nerve damage in the peripheral nervous system. In peripheral neuropathy only nerves outside of the brain and spinal cord are involved, it does not affect the central nervous system [6]. In peripheral neuropathy feet and legs are often affected first and followed hands and arms [7]. The early natural warning system of ulceration is, it increases the temperature of any particular area continuously 6-7 days and if these high temperature areas detect during those 6-7 days then detection of ulcer in early stage is possible. Using the thermography we can detect this high temperature area because thermography works in the heat. This technique is totally non invasive technique. In medical procedure non-invasive means without cutting a skin or without touching the internal body of a human. Thermography works on infrared radiation [8]. It captures the natural thermal radiation which is generated by an object at a temperature above absolute zero [9]. Thermography gives valuable information of human body surface on the temperature differences of different parts [10].

1.1 Stages of Diabetic Ulcer

Diabetic Ulcer has mainly three stages,

- 1) Inflammatory stage
 - 2) Proliferative phase
 - 3) Maturation stage
1. **Inflammatory Stage:** It is an early stage of an ulcer.
 2. **Proliferative phase:** It is a secondary stage of the ulcer. In that new capillaries are form.
 3. **Maturation stage:** Lastly stage is the maturation stage, in which collagen tissue is remodeled and size of the ulcer is increased [11].

2. DATABASE

The database which is used in this work that collected from DITI Chennai, the details of this database shown in following tables,

Table 1. Details of database

Total Images	Age Interval	Diabetic subject	Normal Subject
7	45-70	5	2

Table 2. Details of images

Property	Value
Dimensions	320*240
Types of files	.tif

3. METHODOLOGY

The following steps are followed for this experiment,

- 1) Original Image

All images are thermal Infrared. Sizes of images are 320*240. Images are saved as .tif format

- 2) Channel Separation

In channel separation process, it read the RGB channels separately. In RGB channel separation, R value for the red channel, G value for the green channel and B value for the blue channel. For blue channel Blue put into the place of green & blue value for each pixel & then get the blue channel separated image. This theory is applied respectively, for red & green channel [12]

Hear Red Channel is used for the process,

$$r = \frac{R}{(R + G + B)} \quad (1)$$

Where r= is a Red channel, R=Red, G=Green, B=Blue [13], [14].

- 3) Histogram

Histogram shows the frequency of pixel intensity values. In an image histogram, the x axis shows the intensity of gray level and the y axis shows the frequency of these intensities. The Histogram of images mainly used for showing the brightness

of image. The Histogram is not only used for showing the brightness of the image but also its use for adjusting the contrast of an image [15].

A histogram for a grayscale image with intensity values in a range

$$I(U, V) \in [0, K - 1] \quad (2)$$

Would contain exactly K entries

$h(i)$ = number of pixels with intensity I for all $0 < i < K$

$$h(i) = \text{card}\{(u, v) \mid I(u, v) = i\} \quad (3)$$

Where,

Card=size of pixel

[16].

- 4) Apply threshold on histogram

For automatic segmentation of the image thresholding is used. For segmenting the high intensity area automatically from the image histogram thresholding is used. In histogram high intensity shows the objects and low intensity shows the background.

If $f(x, y) < T1$
then $f(x, y) = 255$
else if $T1 \leq f(x, y) < T2$
then $f(x, y) = 128$
else $f(x, y) = 0$

[17][18]

- 5) Remove Noise

For making the images clear noise removal is necessary. Noise is nothing but an unwanted data in an image. For removing a noise from the images morphological opening operation is used. By applying morphological opening operation all the small objects are removed from images.

- 6) Masking

When executing operations on the image, the mask is used to restrict the result to the pixels that are 1(selected, active, and white) in the mask. In this way the operation restricted to some parts of the image [19].

Syntax of Red, Green, Blue color masking

Red object mask:

`maskedrgbImage(:, :, 1) = rgbImage(:, :, 1)`

Green Object Mask:

`maskedrgbImage(:, :, 2) = rgbImage(:, :, 2)`

Blue Object Mask:

`maskedrgbImage(:, :, 3) = rgbImage(:, :, 3)` [14]

- 7) Extract wounded (Infected) area

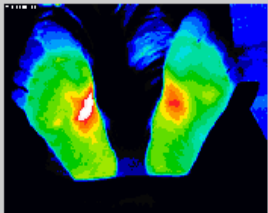



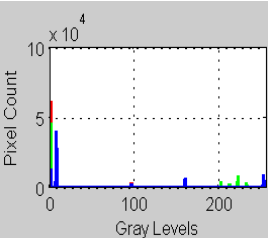
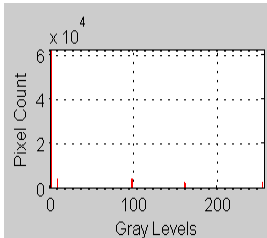
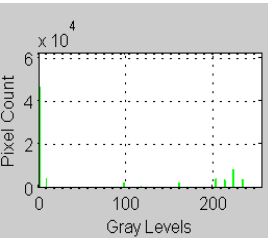
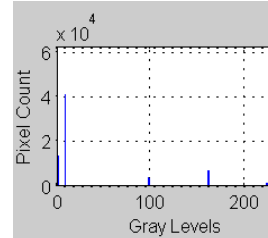
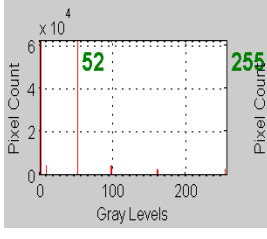
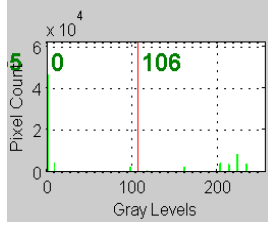
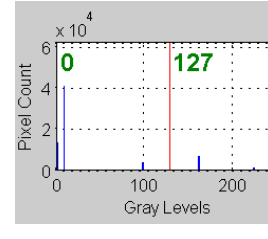



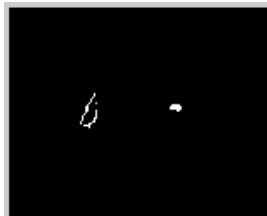


After the applying making on the RGB channels it extract only the red object from the image. This red object is nothing but an infected or wounded area, because in thermography red colors shows the high temperature area and in diabetes, high temperature areas are nothing but an infected or wounded area.

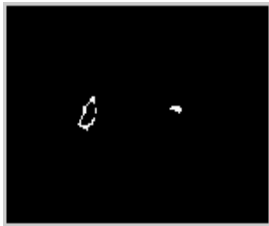
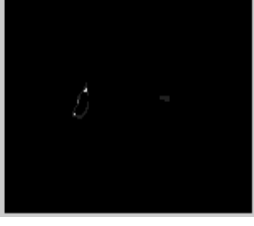

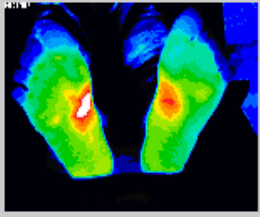
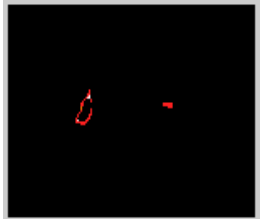
8) Statistical analysis
After extracting the wounded area, next step is, to calculate the size of that wounded area for knowing the

type of the wound area and also calculate the values of RGB pixels in that area. Table 3 shows the output of this experiment.

4. OUTPUTS

Table 3: Some output images

Individual Color Band			
Original Color Image	Red Band	Green Band	Blue Band
			
Histogram			
Histogram of all Bands	Histogram of Red Band	Histogram of Green Band	Histogram of Blue Band
			
Apply color threshold range and dispaly them over the Histogram			
	Histogram of Red Band	Histogram of Green Band	Histogram of Blue Band
			
Apply each color band threshold range to the color band			
	Is Red Mask	Is Not Blue Mask	Is Not Green Mask
			
Eliminate smaller region			
	Remove Smaller Objects	Border smoothed	Regions filled
			
Apply This mask to the Original Image			

	Mask Red Image	Mask Green Image	Mask Blue Image
			
Original Image	Mask original Image showing only the red object		
			

Once the wounded areas are detected, then the second step will be to detect in which stage this ulceration are. By calculating the size of wound area and calculating the numbers of wound areas the stage of ulcer can be detected. Some samples of images are explained below,

Example 1: Image of Non diabetic subject

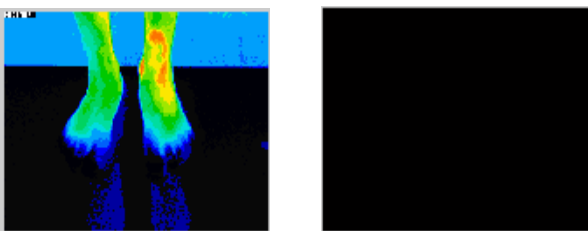


Figure 2: (A) Original Image (B) After processing

The above figure 2 shows the thermal image of normal (non diabetic) subject. Fig 2 (A) shows the some red portion after processing there is no any red area is found in fig 2 (B). It means that this red portion is not because of diabetic ulcer, this area shows red color due to the some other reasons like any external injury. When calculate the mean value of that red pixel area which is shown in fig 2(A) it is very less as compared to the mean value of diabetic infected areas. According to these mean value it is clear that this areas are not infected due to the diabetes.

Example 2: Proliferative phase

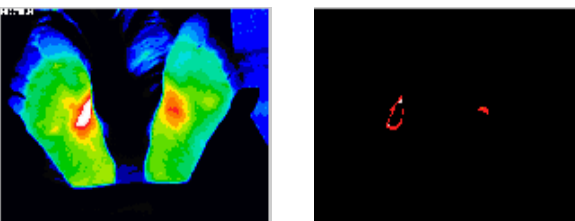


Figure 3: (A) Original Image (B) After processing

Figure 3 (a) show the thermal image of plantar foot. Above image is off 69 years old person. Figure 3 (b) shows the

extracted red object and this extracted red objects are nothing but an ulcer areas. The following table shows the mean value of RGB channels of Example 2.

Table 4: Outputs of example 2

Sr. no	Area in pixel	Mean R	Mean G	Mean B
1	191	251.02	50.71	49.5
2	80	251	35.15	30.8

Table 4 shows the number of extracted wound areas, pixels count of that extracted wound area and show the pixel values of Red green blue of that extracted wound area. According to table and fig(3) there are two wound areas are extracted, one from left foot and one from the right foot. Pixel count of first extracted wound area is 191 pixels and pixel count of second extracted wound area is 80 pixel. According to the pixel count of that wound areas, it is clear that this is a Proliferative phase means it is an initial stage.

Example 3: Maturation stage

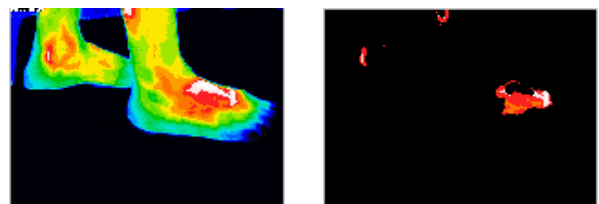


Figure 4: (A) Original Image (B) After processing

Table 5: Outputs of example 3

Sr. no	Area in pixel	Mean R	Mean G	Mean B
1	1388	251.08	79.22	58.41
2	145	251	79.03	76.63
3	102	251	51.42	43.46

According to table 5 and fig 4 there are three wound areas are extracted one from the left foot and two from the right foot. Pixel count of first extracted wound area is 1388 pixels and

pixel count of second extracted wound area is 145 pixels and pixel counts of third wound area is 102 pixels. According to the pixel count of that wound area, it is clear that this is a Maturation stage.

Outputs of all 7 images

Table 6: Outputs of all 7 images

Area in pixel	Mean R	Mean G	Mean B
170	251	125.37	0.19
119	251	140.93	0
187	251	132.33	0
1653	251	84.95	12.4
146	251	71.91	18.68
145	251	79.03	76.63
102	251	51.42	43.46
1388	251.08	79.22	58.41
614	251.09	64.43	51.96
63	251.19	110.11	104.59
87	251	66.31	66.31
191	251.02	50.71	49.5
80	251	35.15	30.8
222	101.83	0	152.17
83	253.98	3.04	3.04
642	253.84	17.25	17.25
2213	252.67	65.69	31.66
3663	252.22	115.55	99.21
514	252.2	74.14	12.35

The above table shows the output of all wound areas which are extracted from the thermal images of diabetic subjects

5. CONCLUSION

Diabetic patients have the highest risk of ulcer. Many times ulceration cannot be detected in early stage, so it may be converted in higher risk. Early symptoms of ulcer are temperature of the foot is increase before 7-8 days. If this inflammation detect within 7-8 days then it can easily prevent the ulcer. Using the thermography it can easily detect because thermography is mainly working on the heat. In diabetic ulceration temperature of some areas are increases or decrease as compared to surrounding areas, using thermography it is easy to detect the infected areas. But some time when any person had any internal injury at that time there is chances of thermal camera detect it as an infected area because, when people have any injury that time this area shows the different temperature as compared to the surrounding. To avoid this problem this work is useful.

6. REFERENCES

- [1] MNT (Medical News Today), <http://www.medicalnewstoday.com/info/diabetes/>
- [2] <https://www.diabetes.org.uk/Guide-to-diabetes/What-is-diabetes>
- [3] Subramnaiam Bagavathiappan, John Philip, Tammana Jayakumar, Baldev Raj, Pallela Narayana Someshwar Rao, Muthukrishnan Varalakshmi and Viswanathan Mohan,” Correlation between Plantar Foot Temperature and Diabetic Neuropathy: A Case Study by Using an Infrared Thermal Imaging Technique”, J Diabetes Sci Technol 2010 4: 1386, DOI:10.1177/193229681000400613
- [4] Monali D. Rathod, Ramesh R. Manza, Deepali D. Rathod,” Early Detection of Peripheral Neuropathy using Thermography: A Review”, International Journal of Computer Applications (0975 – 8887) National conference on Digital Image and Signal Processing, DISP 2015
- [5] National Diabetes Information Clearinghouse (NDIC)
- [6] www.medicalnewstoday.com_articles_147963.php
- [7] Diabetic neuropathy Symptoms - Diseases and Conditions - Mayo Clinic
- [8] Francis Ring,” Thermal Imaging Today and Its Relevance to Diabetes”, J Diabetes Sci Technol. Jul 2010; 4(4): 857–862. Published online Jul 1, 2010. Foot Technology , Part 1 of 2
- [9] Gerald Schaefer, Shao Ying Zhu, Bryan Jones,” An image retrieval approach for thermal medical images”
- [10] Ana Rita Soares Marques,” Diabetic foot thermophysiology characterization”, Thesis
- [11] Manish Bharara,Jeffrey Schoess2,David G. Armstrong,” Coming events cast their shadows before: detecting inflammation in the acute diabetic foot and the foot in remission”, diabetes/metabolism research and reviews, 2012; 28(Suppl 1) : 15–20, DOI: 10.1002/ dmrr.2231
- [12] <http://amarsinghhpcs.blogspot.in/2013/01/different-color-spaces-channel-separation.html>
- [13] Yogesh M. Rajput, Ramesh R. Manza, Manjiri B. Patwari, Neha Deshpande, “Retinal Optic Disc Detection Using Speed Up Robust Features”, National Conference on Computer & Management Science [CMS-13], April 25-26, 2013, Radhai Mahavidyalaya, Auarnagabad-431003(MS India).
- [14] Javier Medina, Carlos Pinilla,Luis Joyanes,” Implementing Fast-Haar Wavelet transform on original Ikonos images to perform image fusion: qualitative assessment”, Revista Facultad de Ingeniería Universidad de Antioquia,Print version ISSN 0120-6230
- [15] http://www.tutorialspoint.com/dip/Histograms_Introduction.htm
- [16] Prof Emmanuel Agu,” Digital Image Processing (CS/ECE 545)
- [17] Lecture 2:Histograms and Point Operations(Part 1)”, Computer ScienceDept. Worcester Polytechnic Institute (WPI)
- [18] <http://www.cse.unr.edu/~bebis/CS791E/Notes/Thresholding.pdf>
- [19] http://www.answers.com/Q/What_is_mask_in_image_processing
- [20] <http://www.mathworks.com/matlabcentral/fileexchange/26420simplecolordetection/content/SimpleColorDetection.m>