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Detection of Diabetes on the Basis of Color Differentiation using Thermography Infrared Imaging Technique on Plantar Foot

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)

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

***Abstract*—Diabetes is a major public health problem that is increasing significantly. According to Times of India, in India confirmed diabetes patients are 67 million, with another 30 million in pre-diabetes group. By 2030, India will have the largest number of diabetic patients in the world. For detection of diabetes there are many pathological techniques available, but all they are invasive techniques (Invasive means relating a technique in which the body is entered by puncture or incision) and many people have panic of that so they avoid for regular diabetes checkup, because of this reason there are chances to increase the diabetic level. Using a thermography it is possible to detect diabetes in early stage. Thermography is totally non-invasive technique (non-invasive means relating to a technique that does not involving puncturing the skin or entering a body cavity). For thermography thermal camera used and thermal camera works on the heat which is naturally emitted by the object. Thermographic images show the out in different colors and with the help of those color differentiation detection of diabetic is possible.**

***Keywords*—Thermography,Noninvesive,Dibeties,Teamprature, Colorize, planar skin teamprature**

I. INTRODUCTION

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]. The body has an unbalance of insulin that time diabetes occurred. Due to the unbalance and irregular supply of insulin some changes are occurred in our body, and using a thermographic technique these changes are find out. In diabetes, temperature of the foot is increases and if this temperature is calculated in early stage then detection of diabetics is become easy [2][3]. Calculating this temperature is possible with thermography technique, it is a noninvasive imaging technique that works on the calculating temperature of organs and tissues. Showing the temperature data is known as a thermogram. Thermography has been use as a diagnostic tool, for treatment arranging and to assess the impacts of treatment [4].

Thermography uses infrared cameras to measure the heat which is naturally transmitted by objects, which are changed over to temperature. To measure the exact temperature of the object, the object must be closed in a constant room temperature [5]. Infrared images are regularly colorized, in thermal Infrared image, high temperature area show in the yellow, red and white color and cold areas shows in the blue and green color. With the help of colorization in thermal infrared images according to color representation, we can easily detect the warm and cold areas [6].

In thermometry, temperature of the plantar skin has been one of the important parameters for assessing risks of diabetic. Plantar thermographic patterns show different trends between normal controls and diabetics [7]. Calculating the temperature of skin and get the information can be investigated by this technique. Changing the temperature of the skin is dependent on blood circulation. In ischemic conditions, where blood perfusion may be reduced, especially at the periphery of the human body and limbs (hands and feet), reduced temperature may be found. This requires a period of stabilization [8].

Thermography infrared imaging totally depends on the colors. When any part of our body has some medical issues or has some complication then thermography shows that part in a different color as compared to its surrounding. According to the color differentiation of thermography we will try to detect diabetes. Following figure shows the difference between Normal Image and Thermal Infrared image.

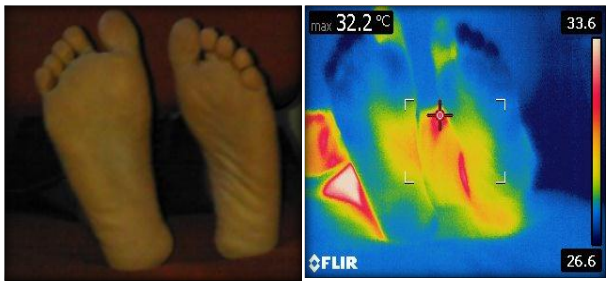

Fig. 1: Original Image and Thermal Infrared Image

International Journal of Engineering Research & Technology (IJERT)
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With Normal Image (Visible image) we cannot easily detect that in which area the temperature is high, but in thermal infrared image we can easily detect which area has a high temperature area. Infrared images are regularly colorized, in thermal Infrared image, high temperature area show in the yellow, red and white color and cold areas shows in the blue and green color. So in thermal infrared images according to color representation, we can easily detect the warm and cold areas.

II. DATABASE COLLECTION METHOD

This experimental study was based on a convenience sample. The sample consisted in 12 volunteers of two groups.

1) Group of Diabetic volunteers with their pathology reports.
2) Group of Non-diabetic volunteers with their pathology reports.

These Samples are collected in the Mulay Metropolis Pathology Lab, Aurangabad with the help of Mr. Annarao. Pathology report shows the Glucose level after fasting and post meal. Fasting glucose report means before taking any food and drink and Post meal means one or two hours after the food or drink. Following table I show the exact glucose range of fasting and post meal for deciding the subject is diabetic or not.

TABLE I. DETAILS OF DATABASE

Diabetic/ Non diabetic	Glucose Range	
	Fasting	Post meal
Diabetic	70-110 mg%	Up to 140%
Non-diabetic	Above 110mg%	Above 140 mg%

All samples were collected by men and women age between 25 to 60 years. Total 12 volunteers are there, from every volunteer we capture 3 images of their feet, and accordingly there are total 36 images of Diabetic Feet and Normal Feet. Following table II shows the details of the database,

TABLE II. DETAILS OF DATABASE

Total Number of Voluntaries	Interval of Age (years)	Number if Healthy Subjects	Number Of Diabetic Subjects
Men-7 Women-5 Total- 12	25-60	8	4

Following table III describes the details of the camera, which are used for collecting database,

TABLE III. DETAILS OF CAMERA

Property	Value
Camera Marker	FLIR Systems AB
Camera Model	FLIR E8
Focal Length	6mm
Subject Distance	1 m

The following Table IV describes the details of the images, which are used in this work,

TABLE IV. Details of first database images

Property	Value
Dimensions	320 × 240
Type of file	.jpg file
Resolution unit	2
Color representation	Rgb

There are two ways of capturing the images,

1) The subject lay down in relax position without doing any physical activity.
2) The subjects seated in relax position without doing any physical activity.

These images are captured after the subject seated/lay down in relax position minimum 5 minutes

III. WORKGLOW AND METHODOLOGY

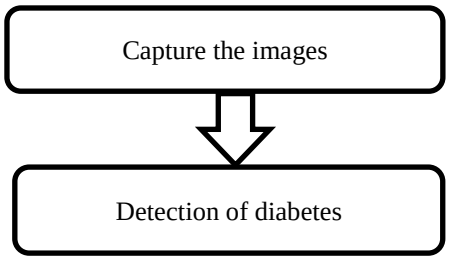

Fig. 2: Workflow for detection of diabetes on the basis of color differentiation using thermogram technique

1. Capture the images

Capture the images with the help of thermal infrared cameras. All images are in the form of infrared and .jpg format.

2. Detection of Diabetes

Captured images are in the form of infrared and infrared base on the colorization. On the basis of this color differentiation, detect the images are diabetic or not.

IV. OUTPUT

Following table V, shows the some examples of diabetic and non-diabetic thermal infrared images. Also, it shows the Gender, age of that subject, the subject is diabetic or non diabetic and the pathological report. In pathological report it shows the glucose level (Fasting and post meal).

International Journal of Engineering Research & Technology (IJERT)
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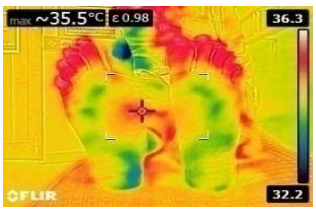
Vol. 5 Issue 08, August-2016

TABLE V. Details of first database images

Sr.no	Original Thermal Image	Gender	Age	Diabetic/Normal	Glucose Level
1		Male	49	Normal	-
2		Female	31	Diabetic	Fasting-172 Postmeal-87
3		Male	27	Normal	-
4		Male	46	Diabetic	-
5		Male	38	Diabetic	Fasting-97 Postmeal-142

In the above table, Image number- 2, 4 and 5 are the images of diabetic subjects. When observe those three images, in these images most of the parts are shown in the dark blue color as compare to Image 1 and Image 3, because these subjects have the high glucose level as compare to other two, and this difference can be found by using the thermography technique.

As seen earlier, when temperature of foot is high as compared to others, at that time it is clear that these persons is suffering from the diabetic. In thermography technique high temperature areas are always shown in the red color, but in these images, diabetic images shown in blue colors. This is because according to literature, at the time of data collection subject should be seated in relax position for 20-25 minutes but these images are captured after the subject seated in relax position near about 5 minutes. Because of this less time relaxation the pressure of the leg cannot be release and in thermography when any area have pressure at that time color will be change.

For calculating the exact value of RGB channels, following steps are apply

1) Take a RGB image :

Captured images are in the form of thermal infrared. These images are capture through a FLIR thermal camera. Sizes of the original images are 320 × 240 pixels. All images are in the form of RGB color and save as jpg format.

International Journal of Engineering Research & Technology (IJERT)
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2) Separate RGB Channels:

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

Mathematical formula for Red channel Separation

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

Where r= is a Red channel, R=Red, G=Green, B=Blue

$$g = \frac{R}{(R + G + B)} \qquad (2)$$

Where g= is a Green channel, R=Red, G=Green, B=Blue

$$b = \frac{R}{(R + G + B)} \qquad (3)$$

Where b= is a Blue channel, R=Red, G=Green, B=Blue [9][10][11][12].

3) Calculate Mean values of each channel:

Calculating mean value of each channel means calculate the average value. For calculating mean value following formula are used,

$$f(x,y) = \frac{1}{mn} \sum_{(r,c)eW} g(r,c) \qquad (4)$$

Where 'g' is the noisy image, f(x,y) is the restored image, and 'r' and 'c' are the row and column coordinates respectively, within a window 'W' of size 'm×n' where the operation takes place [13].

Following table VI shows the RGB pixel values of some non-diabetic images

TABLE VI. Calculate the mean vales of RGB channels of Non-diabetic subject

Sr. No	Image_Id	Mean value of red-channel	Mean value of green Channel	Mean value of Blue channel
1	Img_1	181.1654	188.1117	28.2161
2	Img_2	218.3526	165.9244	25.5821
3	Img_3	179.7084	181.6599	31.7854
4	Img_7	230.1513	161.8751	25.8874
5	Img_8	233.6833	148.6720	30.6198
6	Img_9	227.4423	155.2217	30.8400

Following table VII shows the RGB pixel values of some diabetic images

TABLE VII. Calculate the mean vales of RGB channels of Diabetic subject

SR. NO	IMAGE_ID	MEAN VALUE OF RED-CHANNEL	MEAN VALUE OF GREEN CHANNEL	MEAN VALUE OF BLUE CHANNEL
1	Img_4	136.1408	170.1685	66.1284
2	Img_5	97.3319	149.6931	101.3158
3	Img_6	103.8723	150.8607	94.6081
4	Img_10	193.6276	119.8930	48.3986
5	Img_11	189.9601	134.2152	45.6484
6	Img_12	186.0926	134.1030	49.3717
7	Img_27	208.7416	135.7332	40.9033
8	Img_28	226.0686	114.6572	52.1323
9	Img_29	191.7440	145.7400	42.6211

This experiment mainly focusing on the pixel values of the blue channels because, in this database high temperature areas shows in the blue color.

Blue channel's pixels range for diabetic and non-diabetic subjects show in the following table,

TABLE VIII. Blue Channels Pixels Range For Diabetic And Non-Diabetic Subjects

	Pixel value range of blue channel
Diabetic	50-110 pixels
Non Diabetic	25-35 pixels

According to table 5.4, pixels range for diabetic subject is higher than the non-diabetic subjects.

Following image shows the graphical representation of blue channels pixel range of diabetic and non-diabetes images.

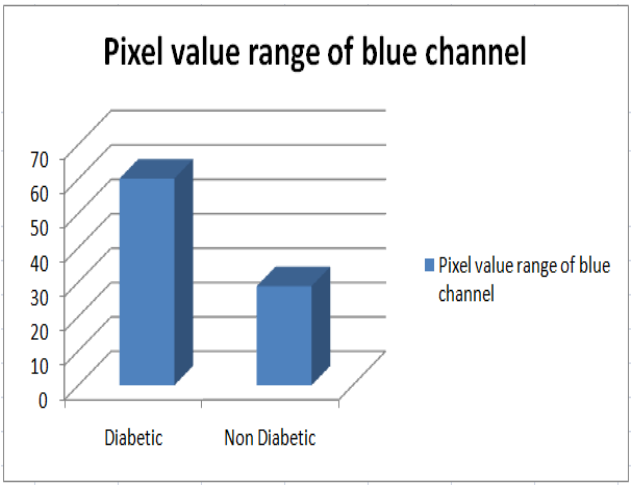

Fig. 3: graphical representation of blue channels pixel range of diabetic and non-diabetes images

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V. CONCLUSION

Diabetic foot is a major public health problem. The aim of this work is to detect the diabetes in early. The main Advantage of Thermography is, this technique is totally non-invasive so there is no need to inject the needles into the body because of that no one has a panic to this technique, it is simple to use, contactless, no any harmful radiations pass from our body because in this technique thermal cameras only receives the heat which is naturally emitted from the human body it does not reflect any rays toward the body and this technique is time consuming.

In this work detection if diabetes is done with the help of thermal infrared images. This work gives a 100% result.

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