Computer Aided Screening Method for Diabetes using Thermogram

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Abstract - *Diabetes is a chronic disease occurring due to insufficient production of insulin by the pancreas or the body's ineffective usage of the insulin produced. The former leads to Type 1 diabetes whereas the latter leads to Type 2. diabetes is estimated to have affected 422 million people globally and 69.2 million people in India annually. Diabetes if left untreated can cause serious health complications such as peripheral nerve dysfunction, diabetic retinopathy, diabetic foot and also doubles the risk of early death, thus making early diagnosis very essential for better disease management, thus improving the quality of life of the patient.*

*   This papers aims at proposing a non invasive method to diagnose diabetes which is based on the thermoregulation of the peroneal blood vessel. The thermograms of the peroneal vessel after a cold stress are obtained and the mean pixel intensities are found and analyzed. The results found show the feasibility diabetic screening using this method.*

Keywords: *Screening-CAD-Diabetes-Thermal images-Mean pixel intensity*

I   INTRODUCTION

Diabetes, a metabolism disorder which is a long-term condition that causes high blood sugar levels, either because insulin production is inadequate type1 diabetes, or because the body's cells do not respond properly to insulin type2 diabetes, or both. Pregnant women may also develop diabetes, called gestational diabetes. Prediabetes is a stage where blood sugar is higher than normal but not high enough to be called diabetes. Prediabetes increases the risk of getting type 2 diabetes. Diabetes is recognized as the world's fastest growing chronic condition. The number of people with type 2 diabetes is growing in each country. Statistics show that 8.8% of the global adult population has been diagnosed with diabetes as of 2015 and is expected to rise to up to 10.4% by 2040. A predictable count of 422 million people are living with diabetes while the death of 1.5 million people is accredited to it annually.

II   REVIEW OF LITERATURE

Diabetes is fast gaining the status of a potential epidemic in India with 69.2 million people currently diagnosed with the disease. Apart from the currently existing invasive glucose meter method, research on blood glucose monitoring in recent times has been improved by the proposal of non-invasive methods based on voltage intensity [1] and scattering of light [2]. A non-invasive method for monitoring of human blood biochemistry based on spatially localized NIR diffuse scattering spectroscopy and metabolic heat measurements for glucose measurement has also been developed [3].

Considering why diabetes needs to be managed or rather monitored on a routine basis, if left uncared for, it can cause serious problems, results of which may be life-threatening. Diabetes

leads to peripheral nerve dysfunction which leads to the loss of sensitivity of nerves with respect to functions like clotting and healing. In such cases, on exposure of the wound to external conditions, for example in the foot region, healing will not take place and hence the affected region gets infected. This infection may cause the foot to rot which gradually progresses to gangrene. Diabetes is fast gaining the status of a potential epidemic in India with 69.2 million people currently diagnosed with the disease. [4]. Higher blood glucose levels also caused an additional 2.2 million deaths, by increasing the risks of cardiovascular and other diseases. One of the only practical and feasible way of management of diabetes is by constant monitoring of the condition. Apart from the currently existing invasive glucose meter method, study on blood glucose monitoring in recent times has been improved by the proposal of non-invasive methods based on voltage intensity [5]. Based on cold stress provocation experiments using a cold patch and IR camera to obtain linear and non-linear thermoregulation properties of the foot the non-linear thermoregulation parameters were compared to Newton's simple coding model to detect diabetic peripheral neuropathy[6] .

To prevent painful process of repetitively finger pricking of blood sample for blood glucose monitoring that creates the risk of infection in diabetes patient a simple compact and cost-effective non- invasive device using visible red laser light of wavelength 650 nm for blood glucose monitoring (RL-BGM) [7].Patients with diabetes mellitus who could do blood sampling many times of their serious condition a development tools of non-invasive measuring glucose levels in the blood is needed[8].
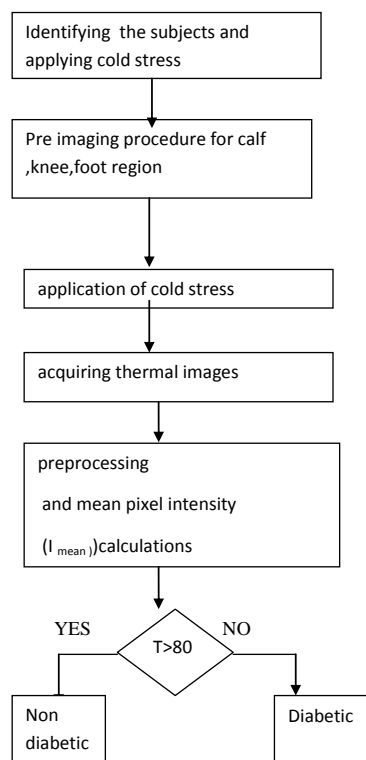
III   METHODOLOGY

Figure 1: Flow diagram of proposed method

Four patients were taken for cold stress experimentation. Prior to experimentation informed consent is obtained from subjects.

COLD STRESS EXPERIMENT

A cold stress using a cold pack at 0°C was applied to the calf, knee, foot of the patients; the pack was kept for duration of 45 seconds after which it was removed. The thermograms of the calf, knee, foot were taken using a thermal imager, one minute after removal of the cold pack. This procedure is repeated for the other subjects also.

These FIR images of that two diabetic patients and two healthy individuals were analyzed. These images were then converted from RGB to grey and the regions of interest (ROI) was selected. Median filtering and contrast stretching were carried out towards pre-processing for noise removal and image enhancement.

Median filtering is a non linear filter which replaces the value of a pixel by the median intensity levels in the neighborhood of pixels as,

$$\hat{f}(x,y) = \underset{(s,t) \in S_{xy}}{\mathrm{median}} \{g(s,t)\}$$

[9]

Contrast stretching is process that changes the range of intensity levels in an image so that its expands the full intensity range of recording medium or display device.[br]

$$P_{out} = (P_{in} - c)\left(\frac{b-a}{d-c}\right) + a$$

where a,b are upper and lower limit of original image and c,d are modified lower and higher limit values.

For the selected regions of interest, the mean pixel intensity values for both diabetic and healthy subjects were calculated and tabulated. The threshold value is fixed by calculating average of mean pixel intensity value of diabetic and healthy subjects. A decision rule is framed based threshold value for identifying healthy and diabetic subjects.

Decision rule:
T >80 non diabetic
T <80 diabetic,
Where T is the threshold.
Calculations:

$(I_{mean})_1 = (57+60+44+62+45+66)/6 = 56$

$(I_{mean})_2 = (101+127+87+100+120+90)/6 = 104.16$

$$\text{threshold value} = \frac{((I_{mean})_1 + (I_{mean})_2)}{2}$$

$$= \frac{(56+104.16)}{2} = 80$$

$(I_{mean})_1$ is the mean pixel intensity value of diabetics ,$(I_{mean})_2$ is the mean pixel intensity value of healthy persons.
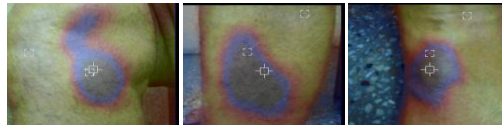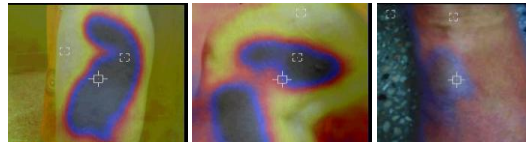
IV   RESULTS

Figure 1: Normal 1

Figure 2: Normal2

Figure 3: Patient1

Figure 4: Patient2

Thermal Imager Specifications-

HTC Brand: VT-100 Thermal Imaging Camera

   -IR SOLUTION 60x60 (3600 PIXELS)

   - FIELD OF VIEW 20 X 20º

   - THERMAL SENSITIVITY 0.15 ºC / 0.27 ºF

   - TEMPERATURE RANGE -20 TO 300 ºC / -4 TO 572ºF

   - ACCURACY ±2% OR READING ±2 ºC / 3.6 ºF

   - POWER SUPPLY 4 AA BATTERIES

Table 1 Mean Pixel Intensity Values

S. No.	Regions	Mean pixel intensity value (Healthy)	Mean pixel intensity value (diabetic)
1	Calf	101	57
	knee	127	44
	foot	87	62
2	Calf	100	60
	knee	120	45
	foot	90	66
AVG		104.16	56

Figure 2,3,4 are images of healthy and diabetic subjects.Table1 shows the mean pixel intensity values of healthy and diabetic subjects.

V   DISCUSSION

Four people, 2 healthy and 2 diabetics are taken for experimentation. Table 1 shows the mean pixel intensity values of healthy and diabetic of four images. The mean pixel intensity values and mean of each image is averaged and represented by $(I_{mean})_1$, $(I_{mean})_2$ for healthy and diabetic group respectively.

A decision rule is framed based on the mean value of healthy and diabetic subjects i.e if the threshold value is greater than 80 the subject is identified as healthy. If the threshold value is lesser than 80 the subject is identified as diabetic (Table1).

Since the temperature of the healthy person's feet is well regulated by the healthy blood vessel supplying these feet undergo smooth contractions and expansions towards thermoregulation against the cold stress they would be warmed up to the original temperature smoothly; whereas the diabetic feet would be supplied of the impaired blood vessels whose walls become hardened due to disease progression and lose their elasticity. Moreover, the diabetic person's nerve would also be impaired due to the disease.

Endothelial dysfunction is observed in diabetes mellitus patients which manifests in impaired vasodilation, decreased NO, increased endothelin-1, Increased arterial stiffness [10].

All these would lead to poor thermoregulation of the diabetic person's feet. Hence the skin texture of the feet would change and that would manifest in the FIR image. This has resulted in the difference in the mean pixel intensity of the healthy subject and diabetic group.

VI   CONCLUSION

Four patients foot, knee, calf region images of diabetic and healthy people were analyzed. Mean pixel intensity values are calculated. The thermoregulatory response of the person's feet ,knee, calf for cold stress was considered. The values of the mean pixel intensity and mean of the diabetic persons were found to be significantly lesser than that of the FIR images of the healthy individuals, this is due to the blood vessels impairment caused by the diseases.

VII   ACKNOWLEDGEMENT

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