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# Thermal Imaging Based Diabetes Screening using Medical Image Processing Techniques

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***Abstract:-*** **Medical Image processing techniques are being deployed in various medical applications to achieve particular tasks or to find a way around some difficulties in old technologies. Various new technologies and techniques are being tried to extend the reach and reliability of health care services. Thermal imaging is one of the ways amongst them. In this paper a thermal imaging system has been reported to acquire and analyze "Infrared Images" for prognosis of diabetic patients. The measurements in the medical fields are complex as "they deal with a terribly complex object— the patient —and are performed and managed by another terribly complex instrument — the physician". Computational models and physicians' perception validate the imaging tasks and the concepts may directly be used in biomedical measurements. The "Thermal Imaging Screening System" is used to perform a planned Infrared image acquisition from 85 numbers of subjects in a diabetic camp in India. The computational model has been developed based on the clinical inputs from physician to validate the developed Medical Imaging system.**

***Keywords:-*** ***Medical Imaging, Thermal Imaging, Image Processing, Diabetes screening.***



## I. INTRODUCTION

In this research infrared camera is used as an important device for the diabetic measurement software system. The system consists of thermal image capturing, image analysis, extraction of statistical feature as output and sending the data for Machine learning. The critical role of the physician in biomedical imaging is the focus of medical imaging research where diagnosis and prognosis are human decisions based on their perceptual input. To compare diagnostic performance of this new imaging technology with conventional methods we have examined the performance of human observers making judgements about patients. We have developed a model validated for clinical tasks that allow results from one clinical trial to predict the results of others involving a different task or imaging system. A study was made to understand how clinicians extract diagnostic information from images so that we can identify and eliminate causes of errors. The imaging system was carefully designed for diabetes screening keeping in view of their costs across the healthcare enterprise.

The thermal images are captured at a proper focusing distance from the various body regions namely face, neck, hand, and leg regions and the images are captured using the LabVIEW system design software. The captured IR image is analyzed by the Digital Image Processing module developed using the software. A system has been developed for automatic capturing of ambient temperature during the acquisition of IR image. The database is maintained for future references.

The infrared camera or any other thermal imager detects changes in skin temperature of the subject by continuously monitoring the modulation (i.e., increase or decrease) of skin temperature. In this research, 'Infrared Camera based temperature profiles have been acquired from face and ear, buccal cavity etc. during a Diabetic Camp on the subjects. The IR camera (FLIR SC325) used is manufactured by FLIR Systems, Inc., USA. The analysis report generated from above experiments with selection of the region of interest as ear and interior buccal cavity is a novel approach. It has hinted significant difference in temperature profile for diabetic and non-diabetic subjects.

## II. RESEARCH PERSPECTIVES

Different research groups have worked on the selection of region of interest for IR Image capturing in their earlier studies. Amongst them Sodi A et al. compared ocular surface temperature (OST) in patients with non proliferative diabetic retinopathy (NPDR)[8], Roback K, Johansson M checked the feasibility of a thermo graphic method for early detection of foot disorders in diabetic patients[6], Nishide K et al worked to identify latent inflammation within the foot callus using thermography and ultrasonography, Minamishima C et al performed treadmill walking stress test and thermography, for clarifying the feature of the pattern typical of diabetic autonomic neuropathy for toes[4], Fujiwara Y, Inukai T , Armstrong DG used thermo graphic measurement of skin temperature for type 2 diabetes[2], Fushimi Het al worked on abnormal vaso reactions for hands[3], S. Sivanandam et al worked on different body regions like face , fore head, hand, foot, neck earlier[7]. Based on the recommendations of technical sessions of some biomedical experts, doctors, engineers and preliminary results of collected IR data the imaging strategy was set in present experimental study. To get the consistent temperature reading of a subject the nearest value of the core temperature of the subject is searched. The ear lobe, inner canther points, inner posterior buccal cavity and palm are identified as the interested regions. The images of each interested regions of the diabetic subjects are taken and analyzed by cross sectional design method. The results are compared with the normal (Non-Diabetic) subjects.

## III. EXPERIMENTAL PROCEDURE

The imaging is done at hospital environment during the month of September- October in Southern Indian region where there were some variations in the ambient temperature during data collection. An Arduino-Uno microcontroller with LM-35 temperature sensor based integrated data acquisition system was developed to record the ambient temperature at the moment of image capturing to normalize the effect of body temperature change due to the environmental changes. Fig 1 Shows 'Infrared Image Capture' module developed in virtual instrumentation software and Fig 2 shows the 'Infrared Image Capture with ambient temperature recording' module in "Capture" control. Fig.3. shows the integrated Data Acquisition System for measuring ambient temperature during IR data collection

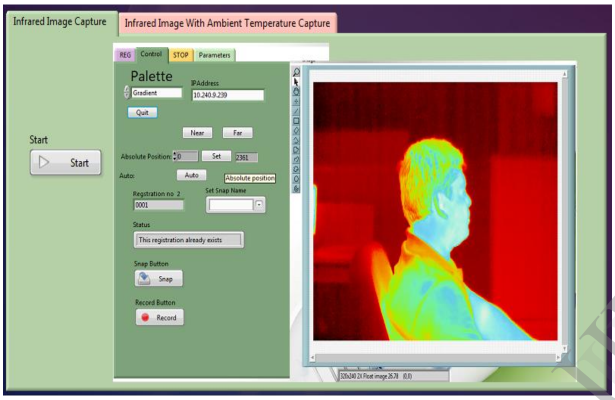


Fig.1. 'Infrared Image Capture' module developed using virtual instrumentation software

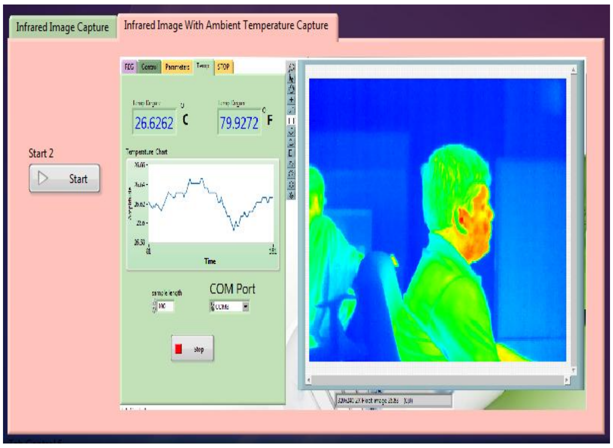


Fig.2. 'Infrared Image Capture with ambient temperature recording' module in "Capture" control

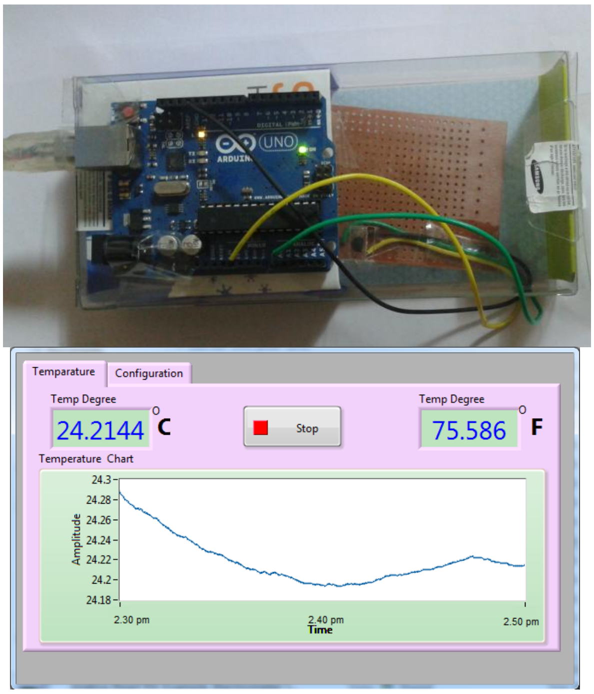


Fig.3. Integration of data acquisition module for ambient temperature along with IR data acquisition system

In a temperature controlled room, the selected body regions to be imaged were disrobed, made free of metallic ornaments and other objects to get naturalized with the room temperature at about 25.5o C for 15 min, where the temperature, humidity, and air circulation was kept under control [8]. This allowed capturing the skin temperature variations in the range of 0.05 o C -0.1oC from the affected region to the surrounding body region or the contra lateral region of the body. Therefore ensures that the naturally emitted thermal radiation from the human body is neither absorbed nor scattered by any of the objects [1].

The IR image capturing was a time consuming task; it took time to normalize body temperature about 15 to 20 minutes when a person is coming from outside, so a resting time of 15 minutes is to be allowed. The data collection was performed in two sessions in a day: A gap of two hours is kept between fasting blood sample and PP blood sample collection as per medical practices. In this manner a data collection plan has been prepared to maximize the number of subjects per day which was around 12 to 13 people. The images were collected in two segments, during fasting and PP blood collection. Clinical reports revealed that among 85 subjects' 49 are diabetic (D) subjects and 36 are non-diabetic (ND) subjects. The postures were observed for analysis in different manner from the IR images. The temperature profiles of diabetic patients were lower than the normal patients. These profiles were extracted using VI based Image analysis method using thresholding, Particle area calculation of "Region of Interest" (ROI) and histogram analysis methods. Image processing was done on the ear images. "Image Segmentation" is used to divide an image into its constituent sub regions or objects [5]

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## IV. ANALYSIS AND VI TECHNIQUES

The attributes of the particles and light distribution are different, so the particles are segmented by thresholding. A threshold image g (x, y) is defined as

$$g(x,y)=\begin{cases}255 & \text{if} \quad f(x,y) > T \\ 0 & \text{if} \quad f(x,y) \leq T\end{cases} \quad \ldots\ldots\ (1)$$

Where, T is the range of the threshold value, f(x, y) is the intensity value of corresponding image pixel. Here, the changing temperature of the ear has the range of T, which are scanned in the images by the algorithms and extracted values are stored for further use. For example, the intensity values for extracting the interested temperature range, thresholding values are taken in a range of 105 to 108 here as the upper value, otherwise zero. The patients may require moving their position and postures for relaxation during image capturing process. So here the "Region of Interest" was to be tracked which was done by the Virtual Instrumentation Software. Here geometrical shape based object tracing procedure was followed. The overall experimental process is shown in the flowchart in Fig4.

Fig.5 shows the image analysis algorithm of the image of a body part.

The IR images were saved by snaps. The main difference between snaps of different subjects is the positional change of corresponding subject's body part along with the change in temperature value. The 16 bit raw IR images are converted to 8 bit grayscale image. A particular area (ear or buccal cavity) as ROI was selected from the first image and cropped. It was then saved as a template. Edge based geometric shape features were extracted using generalized "Hough Transform" algorithm and they were trained as Geometric Shape pattern. Such geometric shape features were searched within the region of IR image received during data collection. The coordinate values of the matched (between ranges 80 -100 %) ROI from the IR images were used to crop the desired positioned and oriented image from the original IR image. This image is analyzed by using thresholding, particle area calculation and histogram analysis methods. The extracted features from this analysis are Mean temperature, Minimum temperature, Maximum temperature, Standard Deviation and total area of searched temperature region. The changes of these parameters were plotted frame by frame.

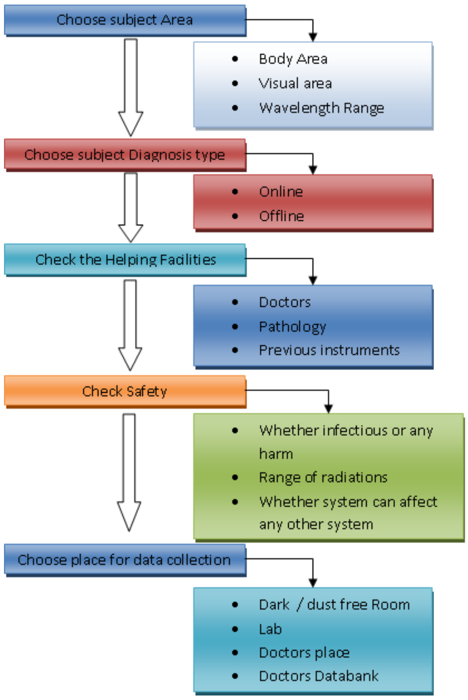


Fig.4. Flow chart for the experimental process followed

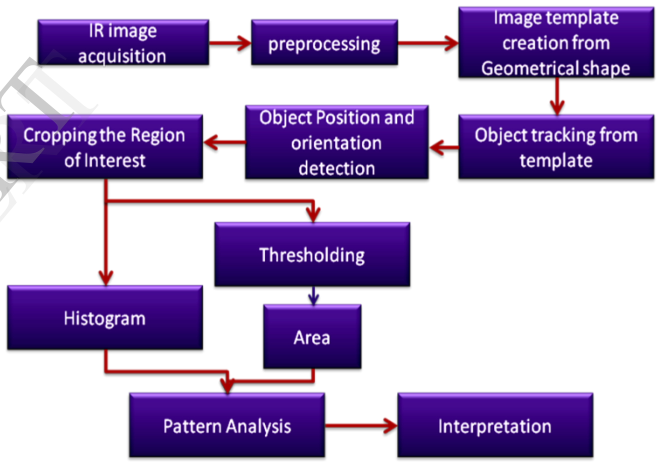


Fig.5. Flow chart of image analysis algorithm for tracking a body organ (ear)

Fig.6 represents the steps of implementing the imaging algorithm for the diabetic monitoring system. The images were taken from diabetic subjects and controlled subjects for comparison analysis. The ROI for analysis was selected manually according to expert doctor's suggestion. This selection might be a rectangle, line, point or a polygon as per requirement. The coordinate values of the selected body area were used for cropping the IR image to get the temperature value. The statistical parameters like mean temperature, minimum temperature, maximum temperature and standard deviation were calculated from the histogram analysis. The outputs were compared for diabetic and non-diabetic subjects.

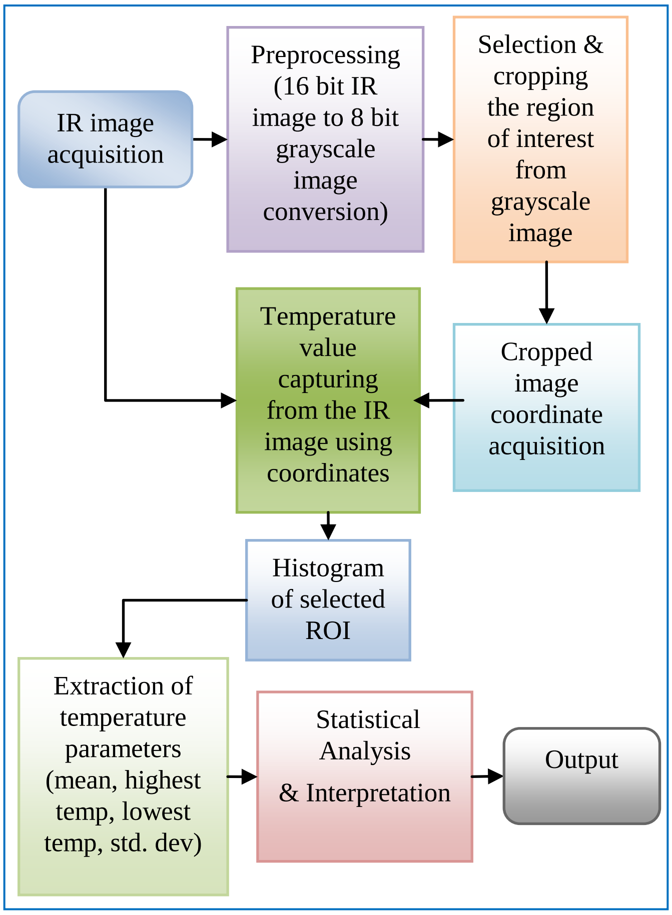


Fig.6. Flow chart of image analysis algorithm for the diabetic monitoring system

## V. RESULTS AND OBSERVATIONS

Body temperature is an effect of human energy emission from the physical organs (mainly Metabolism). The infrared camera detects changes in skin temperature of the subject by continuously monitoring the modulation of the same.

As it is very important to assess the diagnostic technology input from the clinical population to whom it is applied—the individuals who use it in clinical practice, we have collected the perceptual assessments from the physicians after collecting data from the subjects. To compare diagnostic performance of any new imaging technology with conventional methods we have examined the performance of human observers i.e., physicians making judgements about patients from the clinical reports and machine is learned accordingly using Artificial neural models based on feature ranking and some statistical neural network models like ANN, SVM, etc. The developed model validated for clinical tasks that allow results from one clinical trial to predict the results of others to develop an screening system for Diabetes.

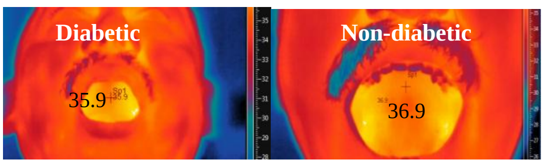


Fig.7. Thermal profile of Non-Diabetic and Diabetic patients

Observations reveal the information that the computed statistical measure of the thermal profile of diabetic patients is less than the non-diabetic patients. Fig 7 is showing the corresponding Inner posterior buccal cavity image of two subjects where first one is diabetic and the other image is of Non-diabetic patient according to their clinical test reports.

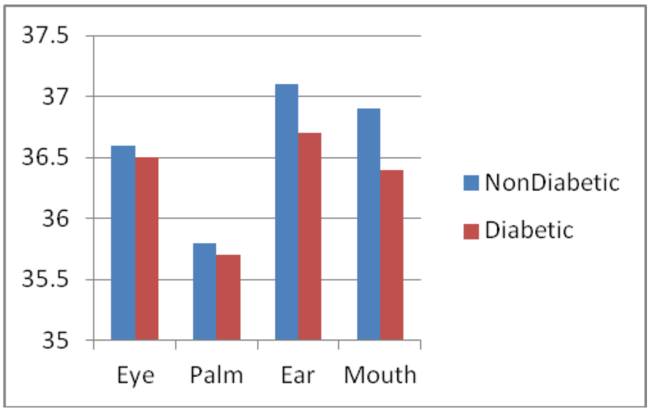


**Fig.8.Graphical representation of thermal profile of Non diabetic vs diabetic subjects**

The thermal profile distribution in the, inner canther points (Eye), palm, ear lobe and inner posterior buccal cavity(Mouth) of the diabetic and non-diabetic patients is shown in Fig.8 where the temperature difference is clearly reflected.

In thermal profile distribution of diabetic versus non-diabetic subject, the temperature difference is around 0.5 degree centigrade. This result supports the previous works on thermography for diabetic patients by taking images from different body regions which may reflect variations; this encouraged us to precede our research work for optimizing the number of body regions for better results in future. Some other image processing algorithm would be tried to improve the differentiability between diabetic and non-diabetic subjects.



## VI. CONCLUSIONS

As the practice of medicine focuses on “meaningful use” to improve the quality, safety and efficiency in the provision of healthcare, the critical role of the clinician as a decision-maker cannot be ignored. Research in medical image processing in Infrared domain for diabetes diagnosis and prognosis helps us to learn how we can advance our understanding of the mechanisms underlying the interpretation of medical images to improve patient care. If we improve our understanding of the characteristics of the medical images using physician’s perception, this can reduce diagnostic error and improve medical decision-making quality.

So far, we have reached a first level of developmental success with promising results. The fully developed system can be utilized non-invasively in hospitals and other environments requiring screening and monitoring of diabetic status.

## VII. ACKNOWLEDGMENTS

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