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SEGMENTATION APPROACH AND ANALYSIS OF THERMAL IMAGES FOR DIAGNOSING SINUSITIS

*[1]K.A.Sunitha ,[2]M.Menaka, [3]P.K.Purushothaman, [4]Srinidhi Giri, [5]M.A.Pramod

***ABSTRACT**--This paper aims to detect the presence and analysing the type of paranasal sinusitis by using thermal imaging. This is done by analysing the four different sinusitis tissues in the face: the maxillary sinus tissues, the ethmoidal sinus tissues, the sphenoidal sinus tissues and the frontal sinus tissues. The optimal selection of the segmentation is important in the development process of a preliminary screening technique to detect the presence of accumulated sinus fluid in these four regions, which give rise to a significant temperature difference. This temperature difference is a sign of anomaly, indicating the presence of paranasal sinusitis. The thermal camera used is the FLIR One Pro model, and the thermal image taken is then subjected to segmentation techniques in MATLAB software. The segmentation technique used in this paper is multilevel threshold segmentation. This analysis provides insight on the relationship of sinusitis location in the face along with its type and severity. These thermal images can be used in regular check-ups to diagnose the variations in the subject's condition over a period of consistent medication suitable for PNS and it can be stored in a report format in a database for easy access of both- the subject and the medical practitioner. The analysis of results are carried out by a GUI developed in which the thermal image is given as input, and the proposed GUI automatically detects the region of interest and gives the diseased region as output.*

***KEYWORDS**--PNS- Paranasal sinusitis, Preliminary screening, Temperature difference, FLIR- Forward Looking Infrared, Thermal camera, Segmentation, MATLAB- Matrix Laboratory, Diagnose, Database.GUI- Graphical User Interface.*

I. INTRODUCTION

Paranasal sinuses are collection of four pairs of air filled void spaces in the face. Sinusitis is an inflammation of the mucous membrane of one or several of the sinus cavities of the face.(M. Wagenmann et al.,1992).An estimated 134 million Indians suffer from chronic sinusitis, the symptoms of which include debilitating headaches, fever, nasal congestion and obstruction (PratibhaMasand:Times of India, 2012). The existing diagnostic techniques are: Nasal endoscopy, which is an invasive method and may cause pain and irritation (K.W. Rosbe et al.,1998) and other imaging techniques X-ray, CT scan and MRI are all non-invasive method and are the best techniques for

[1] Associate Professor,Department of Electronics and Instrumentation Engineering, Associate professor, SRMIST, Chennai,sunithak@srmist.edu.in,+919600086770

[2] Department of Atomic Energy,SQRMG, Indira Gandhi Centre for Atomic Research, Kalpakkam

[3] Department of ENT, SRM Medical College Hospital and Research Centre, Head of the Department

[4] Student,Department of Electronics and Instrumentation Engineering, UG Student, SRMIST

[5] Student,Department of Electronics and Instrumentation Engineering, UG Student, SRMIST

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accurate diagnosis (H.B. Eggesbø, 2006) but are costly and the exposure of the subjects to the radiation emitted by them remains an issue of concern. Since Thermal imaging is non-invasive and non-ionising in nature (Walter Wild et al., 2003), which is useful to map the thermal differences on the skin's surface (B.B. Lahiri et al.,2012).

Therefore, by using thermal imaging, a preliminary screening tool (Kenya Fujita et al.,2013) which is radiation-free and cost efficient that can be used in a clinical setup (John HE et al., 2016) is necessary for detecting the presence of sinusitis.

II. MATERIALS & METHOD

Methodology

The IR image is obtained from a thermal imaging FLIR camera. The image is provided as an input to MATLAB. Segmentation is done on the image using MATLAB. The thermal images are classified based on the demarcated regions into different types of sinusitis. A report can be generated based on the dataset of subjects with different types of sinusitis. The block diagram of the method is shown in Figure 1.

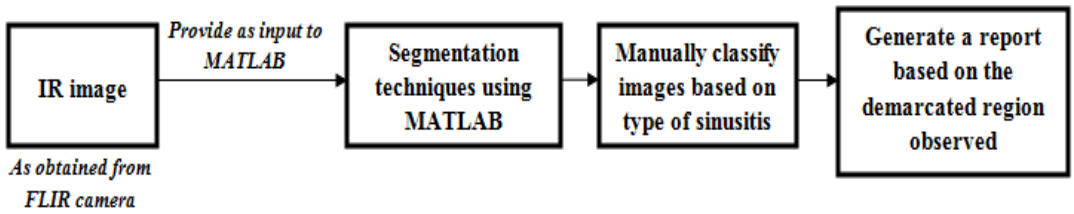

Figure 1: Block diagram of the developed screening system

Tools and Equipment's

This study has been performed using the FLIR One Prothermal camera to acquire the thermographic images of the subjects. It covers a temperature range of -20℃ to +400℃, with a thermal sensitivity <0.15℃ (150mk) and an accuracy of about ±3℃. It can capture 55° x 43° field of view with 160 x 120 (19200) pixels resolution at 8.7 Hz frame rate. In addition to that MATLAB software has been used to perform the segmentation on the acquired thermal image in order to get the required region of interest.

Using the same MATLAB software a basic GUI has been developed in which the thermal image is given as input, the proposed GUI automatically detects the region of interest and gives the diseased region as output as shown in Figure 2.

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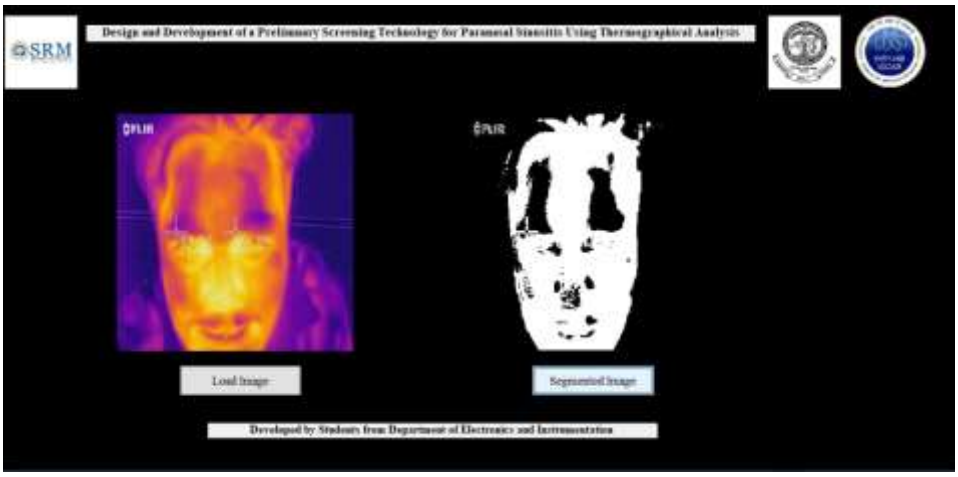

Figure 2: The developed GUI for the thermographic Analysis

III. Analysis Using Segmenting Techniques

Watershed segmentation

From figure 3a and 3b, it is seen that in watershed segmentation, the demarcated area is not very clear. The region of interest displays a temperature variation of 1.4 degree Celsius (36.2-34.8 degrees). This marks it as the region of interest- the region which denotes the area of sinusitis.

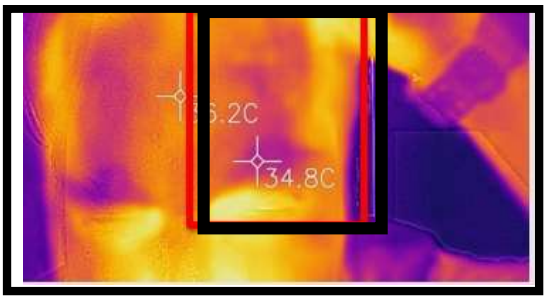

Figure 3a: Thermal image

Figure 3b: Segmented image

Edge based segmentation

From figure 4a to 4f, it is seen that using edge detection, it does not efficiently segment the expected region of interest. Only the edges or outline of the face can be inferred from the segmented image.

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Figure 4a: Thermal image

Figure 4b: Segmented image using Sobel method

Figure 4c: Segmented image using Roberts method

Figure 4d: Segmented image using Prewitt method

Figure 4e: Segmented image using Log method

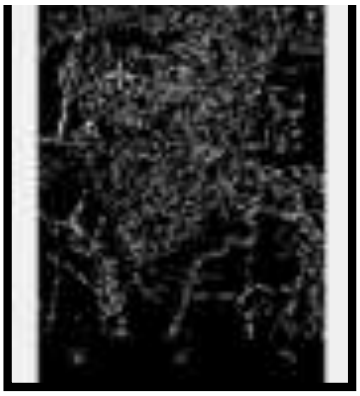

Figure 4f: Segmented image using Canny method

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Thresholding segmentation

From figure 5a and 5b, it is seen that in threshold segmentation, the demarcated area is very clear. The region of interest displays a temperature variation of 1.2 degree Celsius (34.9-33.7 degrees). This marks it as the region of interest- the region which denotes the area of sinusitis.

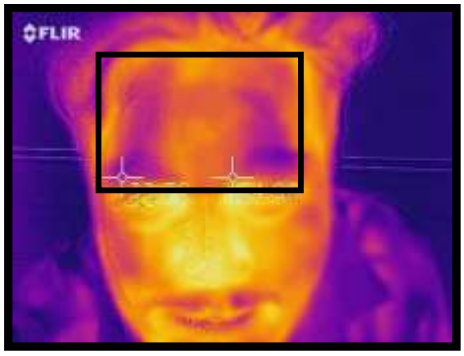

Figure 5a: Thermal **image**

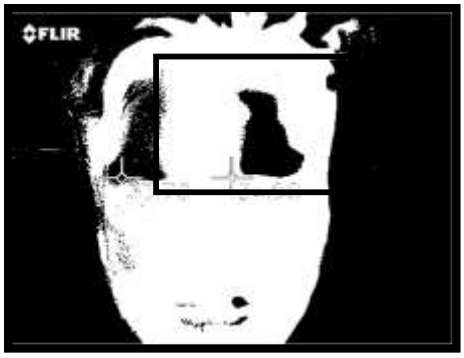

Figure 5b: Segmented image

Optimal Segmentation Technique

Watershed segmentation, Edge detection segmentation and Threshold segmentation were the segmentations techniques used to the analysis of the thermal images, as a way of partitioning an image into a foreground and background.

Watershed segmentation, the result displays a lot of noise in the binary region. Edge detection segmentation,Edge detection is capable of only detecting the edges of the object, and not for a cluster of pixels within an image. Under Threshold segmentation, Multi-level Thresholding is the optimal option for segmenting the thermal image because of its lack of noise and clear demarcation in the region interest.

IV. RESULTS

From the given thermal images and its respective segmented image we could clearly infer the region of interest and the accumulation of fluid in the nasal (Figure 6a and 6b), forehead (Figure 7a and 7b) and cheek (Figure 8a and 8b) regions for the volunteers with sinusitis. Whereas, there is no demarcation found in the region of interest for the volunteer with no sinusitis (Figure 9a and 9b). The segmentation technique used here is Multi-level thresholding to segment the thermal images with the threshold limits ranging from 130-250.

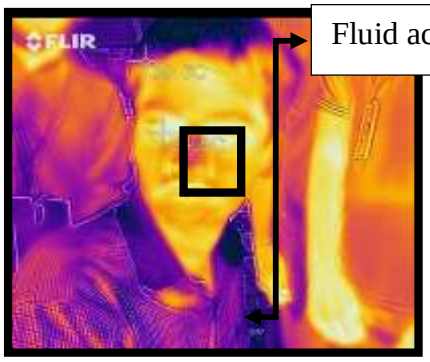

Figure 6a: Thermal image of nasal region

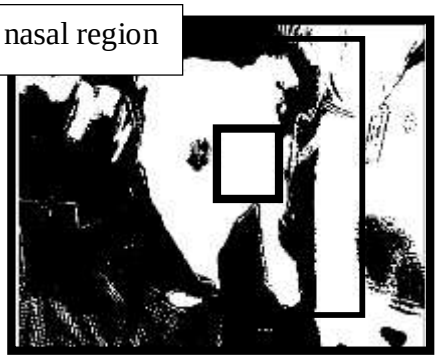

Figure 6b: Segmented image of nasal regi

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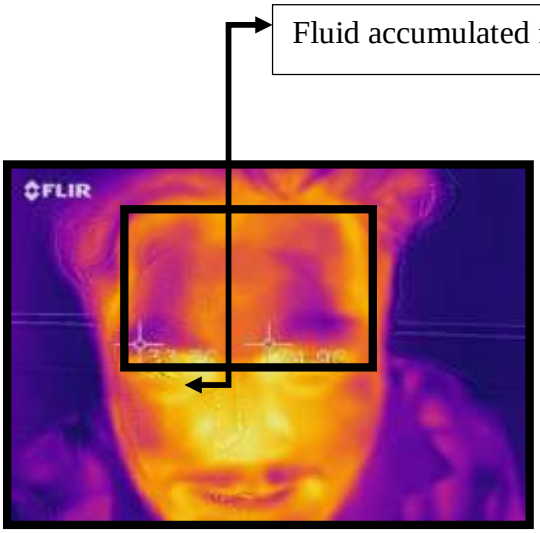

Figure 7a: Thermal image of forehead region

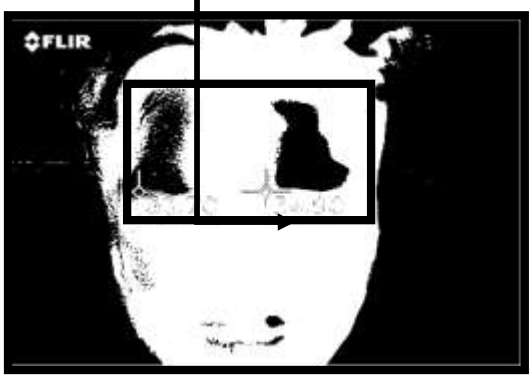

Figure 7b: Segmented image of forehead region

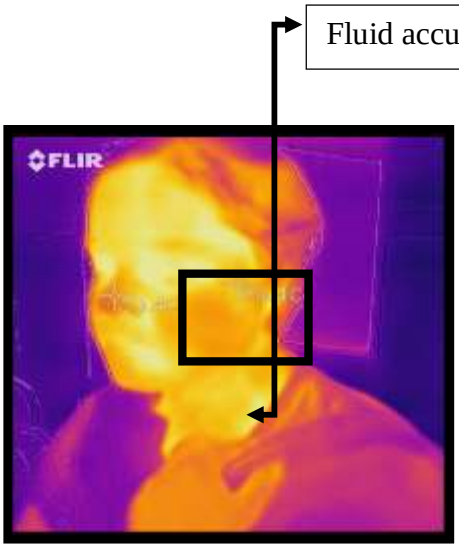

Figure 8a: Thermal image of cheek region

Figure 8b: Segmented image of cheek region

Figure 9a: Thermal image of healthy subject

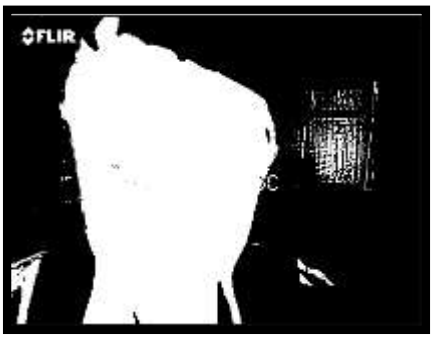

Figure 9b: Segmented image of healthy subject

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V. CONCLUSION

In the course of this paper, a method for preliminary screening test for the detection and identification of PNS using thermographical analysis is established. This study focuses on segmenting the demarcated region of interest in different test and control subjects to analyse the degree of variance and generate a report which gives insight to the type of sinusitis: ethmoidal, sphenoidal, frontal and maxillary. This study has a target audience of small scale clinical setups where this procedure can be carried out for preliminary diagnosis of PNS.The generated report can be stored in a database for reference of the subject and evaluation by the medical practitioner (Table 1). This reference can be used as a standard to analyse the progress of the intensity of sinusitis over the period of treatment and medication of the subject.

Table 1: Dataset Table

Volunteer ID	**Result from thermal imaging**	**Validation from existing diagnostic tools (CT/X Ray)**	**Temperature Difference**	**Proof of validation**
V_ID 001	No demarcation	_	0.4℃	Proved
V_ID 002	No demarcation	_	0.1℃	Proved
V_ID 003	Demarcation in frontal/ sphenoidalregion	YES (CT Scan)	1.2℃	Proved
V_ID 004	Demarcation in ethmoidal region	NIL	2.5℃	_
V_ID 005	Demarcation in ethmoidal region	NIL	0.6℃	_
V_ID 006	No demarcation	_	0.3℃	Proved
V_ID 007	Demarcation in ethmoidal region	NIL	0.8℃	_
V_ID 008	Demarcation in ethmoidal region	NIL	1.3℃	_
V_ID 009	No demarcation	_	0.4℃	Proved
V_ID 010	Demarcation in maxillary andethmoidal region	YES (X-ray)	1.0℃	Proved
V_ID 011	No demarcation	_	0.3℃	Proved

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