Diagnosis of Thyroid Disorder using Infrared Thermography

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Abstract **– The thyroid disorder has become a major disorder in the recent decades. It plays a major role in the metabolic rates of our body, either it can get lower or higher. The pituitary gland is the centre for the secretion of thyroid hormone. So if any fluctuation occurs in this particular gland the hormone changes can arise and that will result to many sorts of abnormalities in our body. The general procedure used for the detection of thyroid is through invasive blood test. The aim of this study is to compare the existing biomarker with the imaging modality for the early stage diagnosis of thyroid disorder. A total of 63 subjects participated in this study. Various biochemicals, physical and physiological parameters were obtained. Thermal images from head to toe were obtained for all the subjects. Further, the images were processed using MATLAB Tool and ANN classifier. Among the study population, 37 were control and 26 were thyroid affected based on biochemical results. The classifier provided an accuracy of 98.4%, sensitivity of 100% and specificity of 96.3%. Thus, thermography with the help of image processing can be used as screening tool for early diagnosis of thyroid disorder**.

Keywords- Infrared thermography, Thyroid disorder, Matlab, Segmentation, ANN classifier.

I. INTRODUCTION

The Thyroid is a small gland situated at basal anterior region of our neck that makes thyroid hormone. This hormone is the vital factor of our whole bodies' energy level. It is been estimated that 42 million people suffer from thyroid disorder in India [1]. If there is any fluctuation in the thyroid hormone that can cause a number of complications to our body ranging from tiredness to mental retardation [2].

There are two types of thyroid such as hypothyroidism (Hashimotosthyroiditis) and hyperthyroidism (Grave's disease). An underactive thyroid hormone leads to hypothyroidism and an overactive thyroid hormone leads to hyperthyroidism. A symptom of hyperthyroidism is that the metabolic rate of the individual increases. The individual may start losing weight even though he/she tries hard to increase the appetite. In this condition people will have more chances of being fatigue and stressed out, also have frequent bouts of palpitation, feeling anxious and getting irritated. When these symptoms remain unchecked for a long time could lead to traumatic conditions and for the case of hypothyroidism the body's metabolism rate decrease which leads to gaining of weight. The individual may feel tired, weak, and insomnic. The immune system may also suffer and more, intolerant to cold. Dry skin, breakage of nail, hair bound to fall, constipation, puffiness of eye, irregularities in the menstrual cycles can lead to infertility when a woman is pregnant [3].

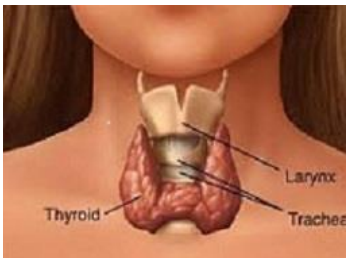

Fig. 1. Thyroid anatomy

The thyroid gland is the centre for increased blood flow, hence it is the centre of heat production that can be sensed by thermal camera. The temperature can be sensed using FLIR-A305s. The thermal image of neck was taken for 63 subjects has been chosen and hence classified as normal or abnormal based on their biochemical criterion. Section II provides different testing modalities, Section III gives thermographic camera setting.

Section IV provides block diagram of system. Section V provides image processing includes image filtering, image enhancement and image segmentation. Section VI provides different feature extraction technique. Section VII display the classification, results, conclusion and discussions.

II. DIFFERENT TESTING MODALITIES

1. Thyroid Function Test (TFT): It is the standard test used to determine the level of thyroid hormone, but it is painful method to determine thyroid disorder. Normal ranges are triiodothyronine (T3)

(80 to 200ng/dl) , tetraiodothyronine (T4) (4.5 to 11.2µg/dl) ,

Thyroid Stimulating Hormone (TSH) (0.5 to 6µU/ml).

2. Ultrasound: It is a non invasive and harmless technique, but is insignificant for the detection of some cancer lumps.

3. CT scan: This technique cannot give a clear cut idea of detecting small nodules, but able to detect larger nodules

4. Biopsy: It is examined through a fine needle aspiration or through surgery. This is also a painful methodology.

5. Radioactive Iodine and Uptake (RAIU) test: This test is more risky for the pregnant and nursing women, since the radioactive material could travel across the womb to baby's blood causing defects to the foetus [4].

III. THERMOGRAPHIC CAMERA SETTINGS

Thermal camera can be utilized to capture heat distribution over a surface [5]. In the recent decades thermal imaging has been utilized for many purposes, such as, testing of materials, assessment of modern procedures and medicinal conclusions [6]. The infrared energy coming from an object is focussed onto an infrared detector. The detector will send the information to the sensor for image processing. A study population of 63 subjects were considered out of which (n=26) where having abnormality, (n=37) where normal subjects. The subjects were asked to fill the consent form for the participation along with questionnaire to be filled such as age, gender, family history etc. The subjects were reconciled to a dark room with a room temperature of 22˚C. They were asked to sit under the air conditioned room for 10-15 minutes preceding the examination was carried out. They were instructed to remove all metallic jewellery and the regions of interest were made clear with no disturbance by hair.

The experiment was carried out at Sri Soorya hospital for diabetics and thyrocare, at Maraimalainagar, Chennai, India. The instrument used for data acquisition was the FLIR-A305s. In fig.2 left side image shows thermal image of normal person and right side image shows thermal image of thyroid disorder person.

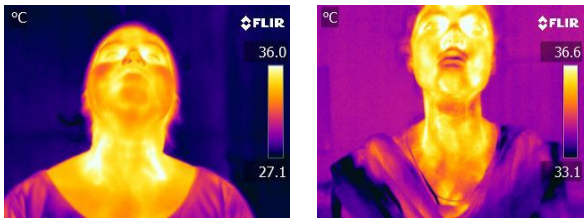

Fig.2 Thermal image of normal person and person affected with thyroid disorder

IV. BLOCK DIAGRAM OF SYSTEM

The thermal images of neck of thyroid patients by using thermal camera FLIR A-305s. The images were taken in iron palette mode. The images were resized, then filtering of image has been done. Different types of filters like median filter, Gaussian filter, adaptive weighted filter, wiener filter, Unsharp filter, adaptive wiener filter etc. Then morphological operators are used. Then enhanced those images using contrast stretching and histogram equalization. Then image segmentation techniques such as adaptive thresholding, line, point and edge detection, region based segmentation and watershed transform. Then feature extracted the image and finally classification of the image has been done.

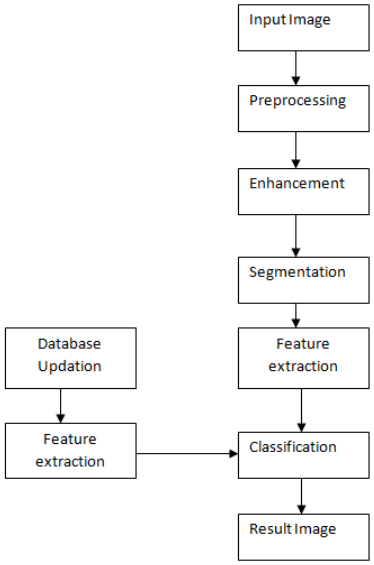

Fig.3 Flowchart

V. IMAGE PRE-PROCESSING

The major steps in the image processing are image-preprocessing, feature extraction and classifying. The first step in image pre-processing is image resizing, conversion of RGB image into Gray scale image followed by filtering technique to remove the unwanted noise.

a. Image Filtering

Adaptive median filter and weighted median filter were utilized, where adaptive median filter is more effective.

- *Adaptive Median Filtering*

Noise removal is one of the use of Non-linear filter, Signals regularly get corrupted while transmission or processing; and a continuous objective in filter configuration is the reconstruction of the original signal generally called as 'noise removal' [7].

In median filter, the pixel value of a point p is replaced by the median of pixel value of 8- neighbourhood of a point 'p'. Therefore, we can generate the median filter by the following function:

$$G(p) = \text{median } f(p), \text{where } p \in N8\ (p)\}. \quad (1)$$

- The median value will replace the central pixel according to brightness of the neighbouring pixels.

Median filtering removes salt-and-pepper noise and most other small artefacts that successfully supply a couple of perfect picture values with noise estimations of any kind.

Weighted median filter is an augmentation of the median filter. It presents the idea of weight coefficient into the median filter. Weighted median filters are utilized to diminish incautious noise and to save sharp edges in image signal proficiently [8].

The proposed method is Adaptive Weighted Median (AWM) filter. The adaptive method is evaluated to verify whether it is a noisy pixel of an image or not. If it is a noise, it will be replaced by the weighted median value otherwise the pixel estimation of the filtered image is similar to that of original image. This can maintain a strategic distance from pointless loss of detail. Figure 3 gives the result of gray scale of image in the left side and the filtered image on the right side.

Fig.3 Represents gray scale image and the filtered image.

b. Morphological Operations

Morphological Operations is an expansive arrangement of picture preparing operations that process images according to shapes. It has numerous applications like surface investigation, noise prevention, boundary extraction and so forth [9]. Morphological image handling takes after the objective of disposing of every one of these deformities and keeping up structure of image. Since the pixel resolution is of 640×480 pixels, it gives betterment of images. This will be related to pixel quality rather than numerical qualities hence they are centered around on parallel images, likewise it can connect with grayscale images with the final goal that their light exchange capacities are not clear and their absolute pixel qualities are not chosen [10].

The two most basic morphological operations are erosion and dilation. In erosion, each object pixel that is touching a background pixel is changed into a background pixel. In dilation, every background pixel that is touching an object pixel is changed into an object pixel. Erosion makes the object smaller, and can break a solitary object into different objects. Dilation makes the objects bigger, and can consolidate numerous items into one.

$$G[x, y]=\text{AND}[W\{f(x, y)\}]=\text{erode}(f, W) \quad (2)$$

$$G[x, y] =\text{OR}\ [W\ \{f(x, y)\}]=\text{dilate}(f, W) \quad (3)$$

W {f(x, y)}-Neighbourhood window operator

Opening

Opening operation is an erosion took after by a dilation. Stray frontal area structures that are smaller than the H structure component will vanish. Bigger structures will remain.

Closing

Closing operation is an enlargement took after by disintegration. Holes in the frontal area that are smaller than H will be filled. These systems are helpful for taking care of noisy images where a few pixels have the wrong parallel esteem.

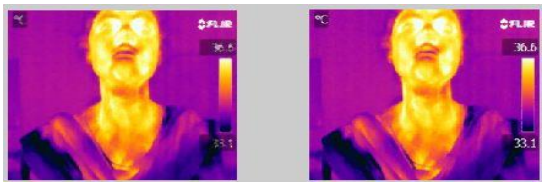

Fig.4 Depicts the morphological opening and closing

The above morphological operations are performed to smooth the image.

c. Image Enhancement

Resolution, noise level, contrast are the major problems in medical images. It is basic to improve images by changing the intensity level of pixels. Most programming software for image preparation have a few alternatives for changing the presence of an image by changing the pixels through a solitary capacity that an information input value into new output value [11]. Thus image enhancement is done to improve the quality of image using contrast stretching and histogram equalization. The above mentioned modalities leads to a better clarity for the thermal images which provide better accuracy.

d. Image Segmentation

Image segmentation is used for dividing a digital image to multiple & meaningful segments. This process converts a gray level image to binary/black & white image. This conversion takes into account a threshold values or threshold level. The two segmentation techniques used are:

- Adaptive threshold segmentation
- Region of Interest segmentation

Of which Region of Interest segmentation is used. The below figure will show the segmented thyroid portion of the neck.

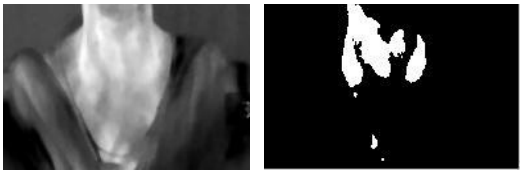

Fig.5 Represents gray scaled image and the segmented image

VI.FEATURE EXTRACTION

This was completed with the assistence of gabor feature extraction (mean, standard deviation, entropy, correlation, energy, contrast, homogenity, variance, covariance) at 45˚orientation. This gabor features will work according to the textures of each images. Here Textural properties in the image can be utilized to gather distinctive datas such as micropatterns of edges,lines,spots and level regions in a well defined manner. Hence gabor channels has been used here, which can be tuned with various introductions and scales to give intense insights which could be extremely valuable for the thyroid gland detection. The general capacity g(x,y) of 2D (for image) gabor channel family can be spoken to as a Gaussian kernal modulated by an oriented complex sinusoidal wave is depicted by

$$g(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{[\frac{1}{2}(\frac{x^{-2}}{\sigma_{\tilde{x}}^2}+\frac{y^{-2}}{\sigma_{\tilde{y}}^2})]} * e^{(2\pi jW\tilde{x})} \quad (4)$$

$$\tilde{x} = x.cos\theta + y.sin\theta \text{ and } \tilde{y} = -x.sin\theta + y.cos\theta \quad (5)$$

Where σ_x and σ_y are the scaling parameters of the channel and portray the area of a pixel where weighted summation happens. W is the focal recurrence of the complex sinusoidal and $\theta \in [0,\pi)$ is the introduction of the typical to the parallel stripes of the Gabor capacity [12].

VII.CLASSIFICATION

Back propagation neural network is intended to take care of any issues by attempting to emulate the structure and the capacity of our apprehensive system. Neural system depends on recreated neurons which which are combined in an assortment of approaches to shape networks.Neural network will works like human brain. It acquires knowledge through learning and it is stored within the interconnection strengths known as synaptic weight.

RESULTS

Features such as mean, standard deviation, entropy, correlation, energy, contrast, homogenity, variance, covariance were extracted. The classification result depicted an accuracy of 98.4%, sensitivity of 100% and specificity of 96.3% as shown in figure 6(b). The figure 6 (a)shows the acccuracy range of normal and abnormal subjects wherein the value is 0.0079 at epoch 200. The confusion matrix will work with the help of TP(TruePositive), TN(True Negative), FP(FalsePositive), FN(FalseNegative). Here the accuracy decreases because the prediction of 1.6% of FP occurs. In case of specificity there is a higher value of TN compared to TP the specificity value decreases compared to accuracy and sensitivity.

Since the thyroid function test has been confirmed for normal and abnormal subjects the sensitivity was high.If we go for more number of subjects the other parameters may also can increase effectively.

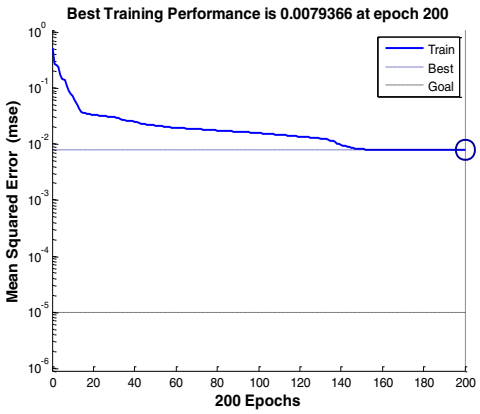

Fig.6 (a) Depicts the graph of trained data set

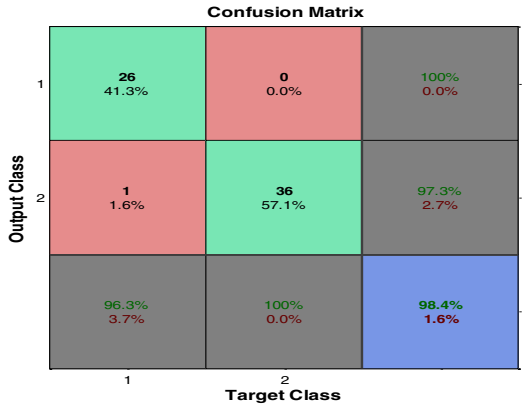

Fig.6 (b) Represents the confusion matrix

CONCLUSION AND DISCUSSION

As high sensitivity is achieved, this method could diagnose thyroid subjects among normal. The features could be classified using other networks for higher efficiency. Apart from the concentrated region features could also be extracted from palm regions and it could be classified using neural network for efficiency.

REFERENCES

[1] Unnikrishnan, Ambika Gopalakrishnan, and Usha V. Menon. "Thyroid disorders in India: An epidemiological perspective." *Indian journal of endocrinology and metabolism* 15.6 (2011): 78.

[2] Iodine intake as a risk factor for thyroid cancer:a comprehensive review of animals and human studies,thyroidresearchjournal.biomedicalcentral.com.

[3] E,UtigerRD.Werner and Ingbar's The thyroid:A Fundamental and Clinical Text.9th ed,Philadelphia:Lippincott Williams & Wilkins(LWW),2005.

[4] Mrs.Pallavi Mahajan;Prof.Mrs.Swathi Madhe;-Morphological Feature Extraction of thermal images for thyroid detection;IJECCE vol5,Issue(4)july,Technovision-2014,ISSN 2249-071X.

[5] Study of changes in surface temperature of facial region due to mobile phone radiationC. R. Parvathy; Meghna Hukeri; Santhoshi NKrishnan; Anburajan Mariamicheal; Oinam Robita Chanu2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS).

[6] M. Anbar, "Quantitative and dynamic telethermometry-A fresh look at a critical thermology," IEEE Eng. Med. BioI., vol. 14, pp. 15-16, Jan. IFeb. 1995. [9]A. W. Guy, "Analyses of electromagnetic fields induced in biological.

[7] Gopinath, M. P., and S. Prabu. "classification of thyroid abnormalities on thermal image: a study and approach."

[8] Anil k. Jain, "Fundamentals of Digital Image Processing", Eastern Edition 2002.

[9] Serra, Jean. Image analysis and mathematical morphology*, v. 1*. Academic press, 1982.

[10] Comer, Mary L., and Edward J. Delp. "Morphological operations for color image processing." image 1.2 (1999): 12-15.

[11] Rafeal c. Gonzalez, Richard E. Woods, Steven E. Eddins, "Digital Image Processing Using MATLAB", Second Edition 2012.

[12] Khan, Salabat, et al. "A comparison of different Gabor feature extraction approaches for mass classification in mammography." Multimedia Tools and Applications 76.1 (2017): 33-57.