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Morphological Feature Extraction of Thermal Images for Thyroid Detection

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Abstract **– Nowadays thyroid gland disorder is very common disease. More than one third of all women may be found to have at least one thyroid nodule disorder during their lifetime.**

Thyroid detection test is usually done by invasive and non-invasive methods. Invasive methods are traumatic methods and non-invasive methods like ultrasound and x-rays should not be used many time. Thyroid function tests (TFTs) is a collective term for blood tests used to check the function of the thyroid. This is invasive method to detect thyroid gland disease. TFTs may be requested if a patient is thought to suffer from hyperthyroidism or hypothyroidism. This paper gives the state of the art of image processing techniques to detect the thyroid gland disease non- traumatically using Thermograph. Thermal Imaging is a technology that creates analyzes images by detecting the heat radiating from an object. We have proposed a system to detect the thyroid gland disease using thermograph. A hyperactive thyroid gland is a center of increased blood flow and chemical activity, so it a center of heat production that can be detected by thermal sensing. Temperature can be sensed using thermal camera FLIR-E30 with thermal sensitivity of 0.1°C with temperature range -20°C to +120°C

Keywords **– Thermography, Thermal Imaging, Thyroid Gland.**

I. Introduction

The thyroid is a small, butterfly-shaped gland located in the front of the neck below the larynx, or voice box as shown in figure 1. The thyroid g land makes two thyroid hormones, triiodothyronine (T3) and thyroxine (T4), which circulates in the blood- stream and act on virtually every tissue and cell in the body. Thyroid hormone production in the thyroid is regulated by another hormone called thyroid-stimulating hormone (TSH). TSH is made by the pituitary gland, which is located in the brain.

There are two types of thyroid Hypothyroid and Hyperthyroid. Hypothyroidism occurs when thyroid gland does not produce enough amounts of thyroid hormones, hypothyroidism is a condition characterized by abnormally low thyroid hormone production. And Symptoms of hypothyroid are Fatigue, Increased sensitivity to cold, Constipation, Dry skin, weight gain, Puffy face, Hoarseness, Muscle weakness etc. The mean skin temperature of [2]. °C gland Hyperthyroidism occurs when thyroid produce too much amount of thyroid hormones. The most common underlying cause of hyperthyroidism is Graves's disease. And Symptoms of hyperthyroid are Palpitations, Heat intolerance, Nervousness, Insomnia, Breathlessness, Increased bowel movements etc. The mean skin temperature of hyperthyroidism is 36.63±0.56 °C [2].

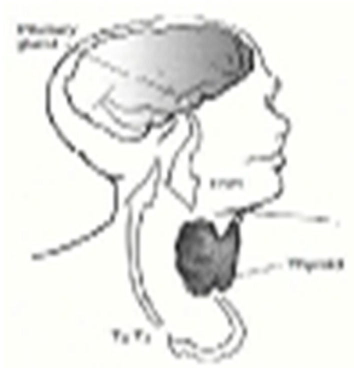

Fig 1. Thyroid anatomy

A hyperactive thyroid gland is a center of increased blood flow and chemical activity, so it a center of heat production that can be detected by thermal sensing [1]. Basically the emissivity of human skin is high therefore the measurement of IR radiation emitted by skin can be directly converted to temperature. Temperature can be sensed using thermal camera FLIR-E30. The colored images of neck of 20-30 thyroid patients and normal persons can be compared to classify the thyroid disorder in hyperactive, hypoactive or normal range. Section II provides Different Testing Methods of detecting thyroid. Section III gives block diagram of system. Section IV provides Thermographic Camera System. Section V provides image preprocessing includes image filtering, image enhancement and image segmentation. Section VI provides different feature extraction techniques. Section VII gives results of feature extraction.

II. Different Testing Methods

For thyroid detection different testing methods are: 1.Blood test: Blood testing is now commonly available to determine the levels of thyroid hormones but it is traumatic method to determine the thyroid disorder. 2.Radio Active Iodine & Uptake (RAIU) Test: Pregnant and nursing women should not undergo this test, because the radioactive material can travel across the placenta to

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the baby's bloodstream or be transmitted to the baby via breast milk, 3.Biopsy: It is a traumatic method in biopsy obtaining a thyroid tissue sample for microscopic examination by fine needle aspiration or by surgery, 4.Ultrasound: ultrasound scanning is noninvasive and is usually painless but many cancers are not visible on ultrasound, 5. CT Scan: A CT scan can't detect smaller nodules but may help to detect larger nodules, 6.MRI Scan: MRI has quite some limitations that make it inappropriate as a first-line imaging modality, 7.Thermography (Thermal imaging): Thermography is best technique to detect thyroid gland disease. Thermography is a technology that creates and analyzes images by detecting the heat radiating from an object. Temperature can be sensed using thermo camera. It is non-invasive, non-traumatic method to detect thyroid disorder.

III. Block Diagram of System

Fig.2. shows the block diagram of the system. First we take the colored images of neck of thyroid patients by using thermo camera FLIR E-30 then filtering of that images by using different types of filters like, Median filter, Gaussian filter, Unsharp filter, Wiener filter, Adaptive wiener filter etc. Then enhance those images using different by enhancement techniques like, Contrast-limited equalization, Histogram equalization, Decorrelation stretch etc. Then segmentation of the images by using image segmentation techniques, Point, Line and Edge detection, Thresholding, Region based segmentation, Segmentation using the watershed transform. Then Feature Extraction (Morphological, Wavelet Transform, Clustering) and classification of those images.

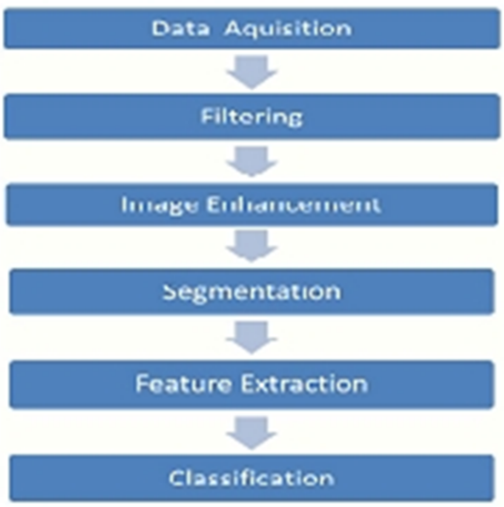

Fig.2. Block diagram of system

IV. Thermographic Camera System

Infrared energy coming from an object is focused by the optics onto an infrared detector. The detector sends the information to sensor electronic for image processing. The electronics translate the data coming from the detector into an image that can be viewed in the viewfinder or on a standard video monitor or LCD screen [6].

The FLIR E30 is easy to use out of the box and offers a temperature range of -20 to 250°C (-4 to 482°F) with an accuracy of ±2% and a thermal sensitivity of < 0.10°C. The 160 x 120 pixel resolution provides impressive infrared image quality while a laser pointer aids aiming. The manual focus lens provides a 25° x 19° field of view [6]. In Fig.3 Right figure shows thermal image of normal person left image shows thermal image of person having thyroid disorder obtained from IR camera FLIR E-30.

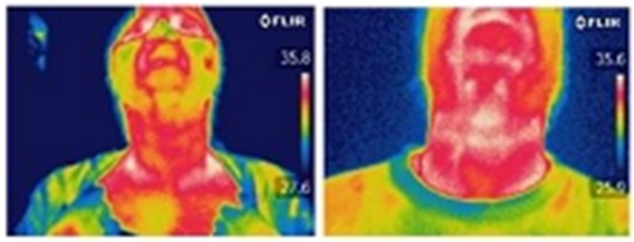

Fig.3 Thermal image of normal person and person having thyroid disorder

V. Image Pre-Processing

Overall, there are three main processes used throughout; Pre-processing, feature extraction and finally the classification process. The first step of pre-processing is conversion of RGB image to Gray scale image followed by filtering and resizing of image to remove undesired body part.

1. Image Filtering

For filtering of images wiener filter and median filter is used. Result of median filter is good than the wiener filter.

• *Median Filter*

Median filtering is a nonlinear method used to remove noise from images [5]. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing salt and pepper type noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value. The input pixel is replaced by the median of the pixels contained in a window around the pixel.

$$V(m,n) = \text{median}(y(m-k,n-l)\ ,\ (k,l) \in W)$$

Where, W is suitably chosen window. The algorithm for median filtering requires arranging the pixel values in the window in increasing or decreasing order and picking the middle value. Generally the window size is chosen so that Nw is odd. If Nw is even, then the median is taken as the

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average of the two values in the middle. Typical windows are 3x3, 5x5, 7x7, or the 5 point window considered for special averaging [5]. Fig.4 left image shows Gray image and right image shows result of median filter. Fig.4 left image shows gray image and right image shows result of median filter.

Median filter has following properties:

1. It is nonlinear filter, thus for two sequences X(m) and Y(m)

Median(X(m)+Y(m))≠median X(m)+median Y(m)

2. It is useful for removing isolated lines or pixels while preserving special resolutions.

3. Its performance is poor when the number of noise pixels in the window is greater than or half the number of pixels in window.

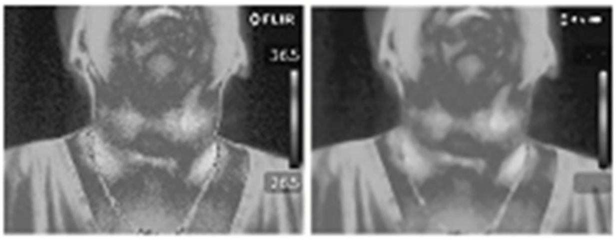

Fig.4. Original Gray image and median filtered image.

2. Image enhancement

Image enhancement refers to accentuation, or sharpening, of image feature such as edge boundaries or contrast to make a graphic display more useful for display and analysis [5]. The enhancement process increases the dynamic range of chosen feature so that they can be detected easily. Image enhancement includes gray level and contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation magnification, psudocoloring, and so on [4]. Image enhancement remains a very important topic because of its usefulness in virtually all images processing application. There are many Techniques for enhancement like contrast limited adaptive histogram equalization, histogram equalization, décorrelation among that Histogram Equalization is used in this work. Fig.5 left image shows result of median filter and right image shows result of histogram equalization.

Fig.5. Median filtered image and histogram equalized image.

3. Image Segmentation

Image is binarized by using Otsu Thresholding method. Thresholding is used to extract an object from its background by assigning an intensity value T (threshold) for each pixel is either classified as an object point or a background point.

In general, T= T[x, y, p(x, y), f(x, y)]

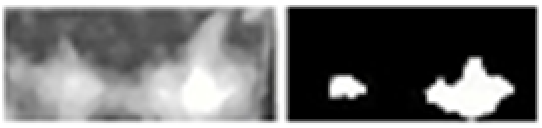

Fig.6. ROI and Otsu's Thresholded image.

Otsu's Thresholding chooses the Threshold to minimize the interclass variance of the thresholded black and white pixels. In Fig.6 left image shows ROI and right image shows result of Otsu's Thresholding.

The within interclass variance is defined as,

$$\sigma^2_{within}(T) = \omega_B(T)\,\sigma^2_B(T) + \omega_o(T)\,\sigma^2_o(T)$$

Where

$$\omega_B(T) = \sum_{i=0}^{L-1} p(i)$$

[o, L-1] the range of intensity levels

$$\omega_o(T) = \sum_{i=T}^{L-1} p(i)$$

σ_B^2 (T) = the variance of pixels in the background (below threshold)

σ_o^2 (T) = the variance of pixels in the foreground (above threshold)

Otsu's method is used to automatically perform reduction of gray level image. The algorithm assumes that the images to be thresholded contains two classes of pixel or bimodal histogram then calculate the optimum threshold separating those two classes so that their combined spread is minimal. Here the optimal threshold is taken to be 0.85 for all images (Normal/ Abnormal).

VI. Feature Extraction

The most important task is feature extraction. For feature extraction estimate the area of object in binary image. Input image can be numeric or logical. For numeric input, any nonzero pixels are considered to be on.

1. Area:

Area is the pixel information present in binary image. Area is defined as:

Area = A= $\sum_i \sum_j$ (Ai, j Xroi [A], Yroi [A])

Where,

Xroi [A] = i and Yroi [A] = j vector contains ROI X & Y position respectively.

2. Mean:

The mean, m of the pixel values in the defined window, estimates the value in the image in which central clustering occurs. The mean can be calculated using the formula:

$$\mu = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} p(i,j)$$

Where,
p(i,j) is the pixel value at point (i,j) of an image of size MxN.

3. Standard Deviation:

The Standard Deviation, σ is the estimate of the mean square deviation of grey pixel value p (i, j) from its mean value. Standard deviation describes the dispersion within a local region. It is deter-mined using the formula:

$$\sigma = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(p(i,j)-\mu\right)^2}$$

Where,
p(i, j) is the pixel value at point (i,j), μ and σ are the mean and standard deviation respectively.

4. Variance:

Variance is the square root of standard deviation. The formula for finding Variance is:

$$V = \sqrt{\sigma}$$

Where, σ is the Standard Deviation.

VII. Results

The different parameters of thyroid like, area, Mean, Variance, Std. deviation, kurtosis, Skewness, Entropy of the different patients of Hypothyroid, Hyperthyroid and normal persons is shown the table also the results of persons according to the doctor, their types and results according to our analysis. For our analysis we take the area below 50 is normal and above that value is thyroid patients, Variance below 5.3 are normal and above that value is abnormal patients, Std. deviation below 35 are normal persons and above 35 are abnormal persons:

No.	Img no.	Area	Mean	Standard Deviation	Variance	Thyroid according to doctor Yes/no	Thyroid according to our analysis Yes/no
1	527	145	167.8	44.94	6.7	Yes	Yes
2	437	570	142.2	43.29	6.5	Yes	Yes
3	789	819	147.7	51.74	7.2	Yes	Yes
4	625	545	188.9	30.37	5.5	Yes	Yes
5	897	143	170.6	44.85	6.69	Yes	Yes
6	909	244	140.9	42.36	6.51	Yes	Yes
7	673	896	174.6	44.29	6.65	Yes	Yes
8	677	181	159.2	29.32	5.3	Yes	Yes
10	861	15	133.3	34.39	5.86	Yes	No
9	285	0	159.6	20.12	4.48	No	No
11	125	0	114.6	27.95	5.2	No	No
12	277	39	166.3	21.58	4.6	No	No
13	359	0	148.4	20.56	4.53	No	No
14	133	0	126.4	30.1	6	No	No

VIII. Conclusion

Thermography could be the best technique to detect thyroid gland disease. Thermography is a technology that creates and analyzes images by detecting the heat radiating from an object. Thermography can be used to detect thyroid gland disease as it is non-contact, non-invasive, non- traumatic and simple method of mapping the body skin temperatures.

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