Diagnosis of thyroid disorder using infrared thermography

Conference Paper · April 2017

DOI: 10.1109/ICECA.2017.8203718

CITATIONS
2

READS
1,612

2 authors, including:

Sivanandam S
SAVEETHA ENGINEERING COLLEGE
9 PUBLICATIONS **101** CITATIONS

SEE PROFILE

International Journal of Pure and Applied Mathematics
Volume 119 No. 7 2018, 1085-1092
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

DIAGNOSIS OF HYPOTHYROIDISM USING INFRARED THERMOGRAPHY

Lekshmy Ashok[1], S.Sivanandam[2]
[1]M-Tech Final year, [2]Assistant professor
[1,2]Department of Biomedical Engineering , SRM University, Kattankulathur, Chennai-603203, India.

ABSTRACT

The thyroid disorder has become a major disorder in the recent decades. It plays a major role in the metabolic activities 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 distortion occurs in this particular gland the hormone changes could arise and that will lead to many sorts of abnormalities in our body. The general procedure used for the detection of thyroid is through invasive blood test. The scope of this study is to compare the existing biomarker with the imaging modality for the early stage diagnosis of hypothyroidism. A total of 63 subjects participated in this study. Various biochemical, 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, FLIR Analysis Tool, ANN and SVM classifier. Among the study population, 37 were control and 26 were hypothyroidic based on biochemical results. Among the classifiers ANN provides a better result than SVM classifier. Even the FLIR analysis tool showed a good separation among normal and affected subjects. Thus, thermography adjunct with image processing could be used as screening tool for early diagnosis of hypothyroidism.

Keywords— Infrared thermography; hypothyroidism; Matlab; Segmentation; ANN classifier; SVM classifier; FLIR Analysis tool.

INTRODUCTION

The Thyroid is a small organ located at basal anterior region of our neck that makes thyroid hormone. This hormone is the key variable of our entire bodies' vitality level. It is been assessed that 42 million individuals experience the ill effects of thyroid issue in India [1]. On the off chance that there is any vacillation in the thyroid hormone that can lead to various inconveniences to our body extending from tiredness to mental retardation [2]. There are two sorts of thyroid, they are hypothyroidism (Hashimotosthyroiditis) and hyperthyroidism (Grave's ailment). An underactive thyroid hormone prompts hypothyroidism and an overactive thyroid hormone prompts hyperthyroidism. An indication of hyperthyroidism is that the metabolic rate of the individual increments. The individual may begin shedding pounds despite the fact that he/she tries hard to expand the hunger. In this condition individuals will have more odds of being weakness and worried, likewise have visit episodes of palpitation, feeling on edge and getting aggravated. At the point when these symptoms stay unchecked for quite a while could prompt traumatic conditions and for the instance of hypothyroidism the body's digestion rate diminish which prompts putting on of weight. The individual may feel drained, frail, and insomnic. The immune system may likewise endure and more averse to cold. Dry skin, breakage of nail, hair bound to fall, obstruction, puffiness of eye, anomalies in the menstrual cycles can prompt barrenness when a lady is pregnant [3].In this hypothesis mainly focus on hypothyroidic subjects. Since the body is expecting a specific measure of thyroid hormone the pituitary will make extra thyroid empowering hormone (TSH) trying to allure the thyroid to deliver more hormone. This steady barrage with large amounts of TSH may make the thyroid organ end up plainly extended and frame a goiter (named a "compensatory goiter"). If left untreated, the side effects of hypothyroidism will generally advance. Rare complications could bring about extreme life-threatening despondency, heart disappointment, or coma state[4]. The anatomical structure of thyroid portion has been given as Fig.1. The temperature can be detected utilizing FLIR-A305s. The thermal images of neck were taken for 63 subjects and has been categorized as normal and abnormal in the view of their biochemical test. Section B provides different testing modalities, Section C gives thermographic camera setting. Section D provides block diagram of the system. Section E provides image processing includes image filtering, image enhancement , image segmentation and different feature extraction technique. Finally the Sections F,G,H displays the classification, results, conclusion and discussions.

2nd International Conference on Recent Trends in Engineering and Technology

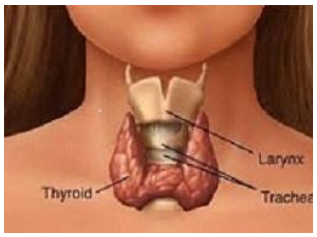

Fig. 1 Anatomy of thyroid gland

B. Different Testing Modalities

1) Thyroid Function Test (TFT): It is the standard test used to decide the level of thyroid hormone, yet it is difficult strategy to decide thyroid issue. Typical extents 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 intrusive and safe method, however is inconsequential for the discovery of some tumor bumps.
3) CT scan: This strategy can't give an obvious thought of identifying little nodules, however ready to recognize bigger nodules.
4) Biopsy: It is analyzed through a fine needle desire or through surgery. This is additionally an excruciating approach.
5) Radioactive Iodine and Uptake (RAIU) test: This test is more dangerous for the pregnant and nursing ladies, since the radioactive material could head out over the womb to infant's blood making defects to the foetus [5].

C. Thermographic Camera Setting

Thermal camera can be utilized to capture heat distribution over a surface [6]. In the recent decades thermal imaging has been utilized for many reasons, such as, testing of materials, assessment of modern procedures and medicinal conclusions [7]. The infrared rays emitting from an object is focussed onto an infrared detector. The detector will send the information for further image processing. A review population of 63 subjects participated in the study out of which (n=26) were having hypothyroidism,(n=37) was normal subjects. The subjects were asked to fill up 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 utilized for the analysis was FLIR-A305s.In Fig.2 left side picture depicts thermal image of normal person and right side image shows the thermal image of thyroid affected individual.

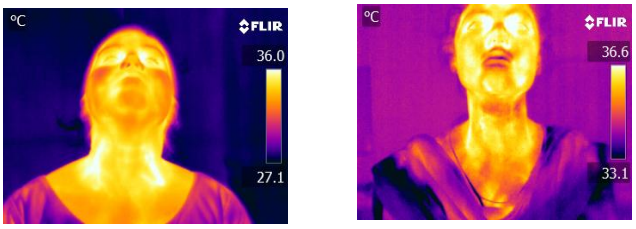

Fig. 2 Thermal images of normal subject and person with hypothyroid condition

2nd International Conference on Recent Trends in Engineering and Technology

D. BLOCK DIAGRAM OF SYSTEM

The thermal images of neck region of thyroid patients were captured 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 were 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 images and finally classified the images with the help of neural network and SVM classifiers. After that every patients images were analysed using FLIR Analysis tool for detecting the skin surface temperature around the neck. The work flow of the system is depicted below in Fig. 3.

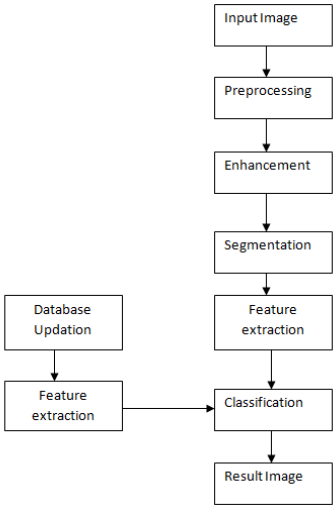

Fig. 3 Flow chart of system

E. IMAGE PRE-PROCESSING

The significant steps in the image processing are image preprocessing , feature extraction and classifying. The initial phase of image processing are image resizing, convertion of RGB component to gray scale image. Followed by the filtering technique to remove unwanted noise.

a. Image Filtering

Adaptive median filter and weighted median filter were utilized, where adaptive median filter is more effective. Since the images have a thermal sensitivity of 0.1˚C.This also plays a major role in the quality of the images results in good or noisy images[14].

- *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:

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

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 strategy is adaptive Weighted Median (AWM) filter. The adaptive technique is assessed to confirm whether it is a noisy pixel of a picture or not. If it is a noise, it will be replaced by the weighted median value, orelse the pixel estimation of the filtered image is similar to that of original image. This can keep up a vital separation from minute loss of details. Fig. 3 gives the result of gray scale image in the left side and the filtered image on the right side.

2nd International Conference on Recent Trends in Engineering and Technology

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

b. Morphological Operations

Morphological Operations is a non linear operations for 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.

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

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

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

In Fig.4 represents the usage of morphological operators such as dialation(opening) and erosion(closing).

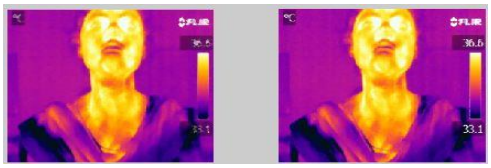

Fig. 4 depicts morphological opening and closing.

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. A threshold of 0.89 has been set to obtain the neck region alone by eliminating the other background features. The two segmentation techniques used are:

- Adaptive threshold segmentation

2nd International Conference on Recent Trends in Engineering and Technology

- Region of Interest segmentation

Of which Region of Interest segmentation is used. The below Fig. 5 will show the segmented thyroid portion of the neck.

Fig. 5 Represents gray scaled image and the segmented image

e. Feature Extraction

This was completed with the assistence of gabor filter assisted with GLCM feature extractions (mean, standard deviation, entropy, correlation, energy, contrast, homogenity, variance, covariance) at 45˚orientation. This gabor filter will work in accordance to the texture 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

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

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

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].The various features has been distinguished seperately for normal and thyroid patients and has found out with the significance level which is displayed in the table below.

TABLE I. Statistical Feature Significance level

Parameters	Normal(37) mean ± standard deviation	Abnormal(26) mean ± standard deviation	Significance P value (<0.05)
Mean	127.558±0.607	132.505±0.939	0.00 (s)
Standard deviation	74.719±1.089	84.58±1.3	0.00(s)
Entropy	4.902±0.506	7.542±0.502	0.00(s)
Correlation	1.136±0.828	2.357±0.498	0.000(s)
Energy	0.112±0.036	2.362±0.613	0.00(S)
Contrast	0.274±0.086	2.77±0.609	0.00(s)
Homogeneity	0.929±0.013	0.936±0.016	0.0618>(ns)
variance	2977.308±573.471	4975.385±620.137	0.00(s)
Covariance	675.311±426.609	769.402±314.189	0.3695>(ns)

(s)-significant;(ns)-non-significant.

F. CLASSIFICATION

Back propagation neural network and SVM has been incorporated for the study .The main focus of interest was with Back Propagation Neural Network. Since the data set was trained the back propagation could be more convenient in classifying the result more accurately and precisely. 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. In case of SVM there was a lot of misclassification occurred among normal and abnormal.

G. RESULT

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 Fig. 6(b). The Fig. 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. And through the FLIR Tool we could able to see a very good temperature difference between normal and abnormal subjects, in case of thyroid subjects the body temperature was much lower compared to normal say like 31˚-33˚C and for normal it was between 34˚ to 36˚.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.The comparison table for Neural Network and SVM is depicted below in Table II.

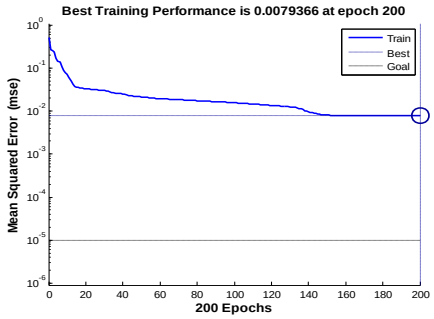

Fig.6 (a) Depicts the graph of trained data set

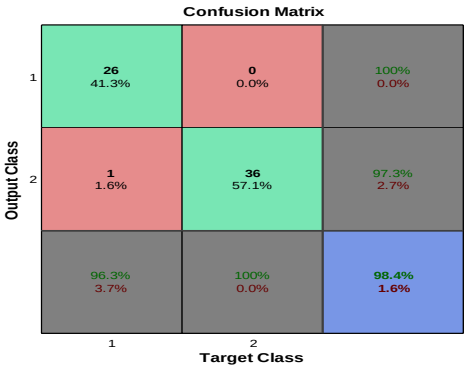

Fig. 6(b) Represents the confusion matrix

TABLE II. Comparison between ANN and SVM

Variables	ANN(%)	SVM(%)
ACCURACY	98.4	60.3175
SENSITIVITY	96.3	43.2432
SPECIFICITY	100	84.6154

H. Conclusion and Discussions

As high sensitivity is achieved through ANN, this method could be used similar like mammography in diagnosing thyroid disorder in the early stage among normal. The results conclude that our body temperature has a major impact factor for detecting various problems, hence thermal camera could capture the heat emanating from our body since it is non-traumatic, non-obliterative and time reduction method to diagnose the thyroid disorder. Apart from the concentrated region features could also be extracted from palm regions and it could be classified using neural network for efficiency.

Acknowledgement

The authors wish to sincerely thankful for the contribution from Sri Soorya Hospital for diabetics and thyrocare ,Maraimalainagar,Chennai for providing necessary research infrastructure for data collection.

REFERENCE

[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] http/www.endocrineweb.com/conditions/thyroid/hypothyroidism-too-little-thyroid-hormone

[5] 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.

[6] 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)

[7] 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.

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

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

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

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

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

[13] 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.

[14] http://infraredcameras.net.au/selecting-the-right-infrared-camera-thermal-sensitivity/

[15] G. Indrajith and K.Vijayakumar, "Automatic Mathematical and Chronological Prediction in Smartphone Keyboard" International Journal of Engineering and Computer Science ISSN: 2319-7242Volume 5 Issue 5 May 2016, Page No. 16714-16718.

[16] K. Vijayakumar and C. Arun, "Continuous Security Assessment of Applications in Cloud Environment", International Journal of Control Theory and Applications, ISSN: 0974-5645 volume No. 9(36), Sep 2016, Page No. 533-541.