Review: Thyroid Segmentation and Volume Estimation Using Image Processing

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Abstract - *Thyroid is one of the endocrine gland which is small butterfly in shape. It located in the front of the neck just below the Adams apple and produces hormones that help the body to control the metabolism. There are different types of thyroid disorders which include Hypothyroidism, Hyperthyroidism, goiter, and thyroid nodules (benign/malignant). To detect and classify abnormalities of the thyroid gland, ultrasound imaging is most commonly used. The objective of this overview is to provide complete information about the estimation of the volume of the thyroid gland directly from US images. This overview focused on the evaluation of the thyroid volume. The use feed forward back propagation neutral network is used to classify blocks of the thyroid gland. The integral region which is further acquired by applying a specific region growing method to potential points. The parameters for evaluating the thyroid volume is estimation using a combination of KNN classifier with variance based match point calculation.*

Key Words: **Feed Forward Back Propagation Neural Network; Thyroid Segmentation; Region Growing; KNN Classifier.**

1.INTRODUCTION

The function of thyroid gland is to make and store hormones which help to regulate the blood pressure, body temperature, heart rate, and the rate at which food is converted into energy. Thyroid hormones are very essential for the function of all cell in the body. The hormones secreted from thyroid gland help in regulating growth and the rate of chemical reactions (metabolism) in the body. The thyroid gland is located in the Adam's apple in the lower part of the neck, wrapped around the trachea (windpipe). It looks like a butterfly shape which has two wings (lobes) attached to one another by a middle part called the isthmus. There are different types of thyroid disorders which include Hyperthyroidism, Hypothyroidism, goiter, and thyroid nodules (benign/malignant). In the neck the thyroid cancer is painless mass. It is very unusual for the thyroid cancers to present with symptoms. Therefore, by its volume physicians often diagnose abnormal symptoms of the thyroid gland.

Figure 1. shows the position of the thyroid gland as well as right and left lobe for a human being. It involves three measurements of the thyroid, which are the width, depth and length. The normal thyroid gland is of 2cm or less in width and depth and 4.5 – 5.5 cm in length. Longitudinal and transverse scans are performed allowing the measurements of the depth (d), the width (w) and the length (l) of each lobe. The lobe volume is calculated by the formula:

$$V \text{ (ml)} = 0.479 \times d \times w \times 1 \text{ (cm)}$$

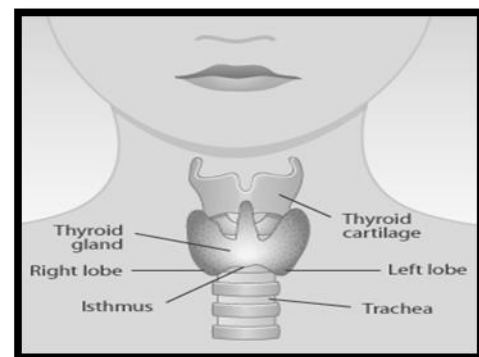The thyroid volume is the sum of the two lobe volumes.

Fig -1: Position of thyroid gland

In various medical images such as Computer tomography (CT), Magnetic resonance images (MRI), X-rays, ultrasound, etc., plays an important role in identifying different types of diseases. Among these several diagnostic modalities, ultrasound image is one of the most popular. There are several favorable properties for ultrasound image. It is inexpensive and easy to use. It is not inferior to CT or MRI images in terms of diagnostic value. It can follow anatomical deformations in real time during treatment and biopsy and it is non-invasive and does not require ionizing radiation. However, US images contains echo perturbations and speckle noises which can make diagnosis difficult.US images have not clear visualization than CT and MRI images, Ultrasound images are often adopted due to their cost portability and effectiveness. US images provide a timely approach to acquire thyroid gland image, it is useful for

dispensary in mobile medical services or in remote districts. In last years the processing techniques of US images are continuously developed. Several segmentation methods are use for anatomical objects from US images have been developing in the thyroid nodule and tumors in the breast.
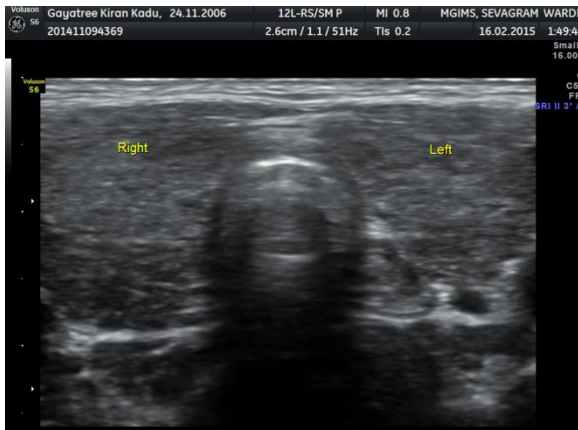

Figure 2: Ultrasound Image of Thyroid gland

The thyroid volume is estimated according to the area of segmented thyroid region, the thickness, and the depth of thyroid. Proposed a method for volume estimation which uses Back Propagation neural network and cooperates with KNN classifier with variance based match point calculation algorithm to estimate the thyroid volume from US images.

2. RELATED WORK

There had been various attempts towards the subjective techniques for diagnosis of thyroid gland nodule. Some of the earlier research for thyroid nodule diagnosis is described. In [1], the radial basis function (RBF) neural network is used to classify blocks of the thyroid gland. The integral region is further acquired by applying a specific region growing method and with the help of that image the thyroid volume was estimated.

Nikita Singh et al. [5] proposed classification using KNN,SVM and Bayesian and also provide a lot of information about segmentation and classification methods that are very important for medical image processing. They provided features of malignant nodules in thyroid gland and a comparative study was done. The results showed that SVM gives much better accuracy than KNN and Bayesian classifiers.

Nasrul Humaimi Mahmood and Akmal [8] had presented a simple guide of determine the thyroid lobes in the thyroid ultrasound image using a MATLAB. The image was done contrast enhancement to suppress speckle noise. The enhancement image was used for further processing of segmentation the thyroid region by local region-based active contour. The thyroid region is segmented into two parts, which are right and left with the active contour method separately. Thyroid ultrasound image of transverse view was used in this study. Therefore, the measurements only involve the width, depth and area of the thyroid region. The result of thyroid measurement was successfully calculated in pixel unit. The proposed method is benefited to enhance the image and segmentation the thyroid lobe.

3. THYROID SEGMENTATION AND VOLUME ESTIMATION APPROACH

Ultrasound images of thyroid gland are selected for experimental work. These ultrasound images contain some of abnormal images having benign thyroid nodule (non cancerous) and malignant thyroid nodule (cancerous). The total 80 thyroids ultrasound images were used which contains total 42 cancerous and 38 non-cancerous nodules was selected in database. These thyroid images are available in image gallery of Wilmington Endocrinology PA on website. The image size of 546 × 410, with 24 bit depth size, format of images are JPEG and true color image. The Matlab R2013a software utilizing image processing toolbox is used for experimental work. Details of these processes are described as follows:

3.1 Image Enhancement and Locating a Suspicious Thyroid Region :

In thyroid US images, low visual quality affects the segmentation and the volume estimation results. A preprocessing step is required to enhance the US image and to locate suspicious thyroid region. The preprocessing step includes 1) locating suspicious thyroid region, 2) performing an adaptive weighted median filter to reduce speckles, 3) applying a morphological operation to enhance the filtering result, 4) compensating different US images according to intensity template of thyroid region.

1) Locating Probable Thyroid Region:

In a thyroid US image, the thyroid gland is always in the middle, below the bright part and above the dark part of the image. Two reference values ($R1$ and $R2$) are defined to locate the probable thyroid region. $R1$ is the row index with the largest average intensity in the horizontal projection of the US image. $R2$ is the first row index with an average intensity of zero from the top to bottom in the horizontal projection of the US image. The probable thyroid region is located between the $R1^{th}$ row and the $R2^{th}$ row of the US thyroid image. An example of locating a probable thyroid region in an US thyroid image is shown in Fig. 3.
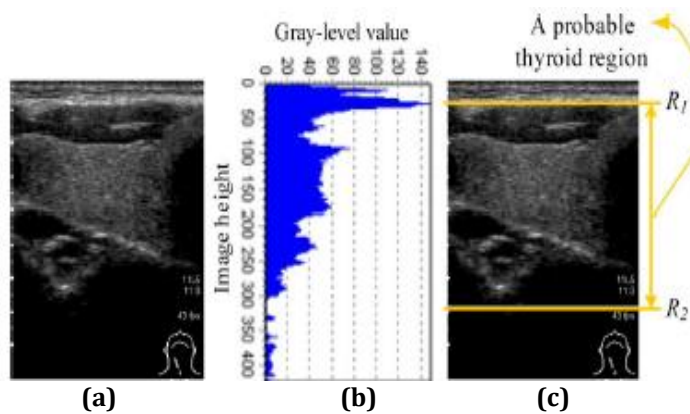
Fig 3: a) Original US image **b)** Horizontal projection of the US image **c)** Result of locating a probable thyroid region.

2) Adaptive Weighted Median Filter:

An adaptive weighted median filter (AWMF) is applied to remove inevitable speckle noise and enhance a suspicious thyroid region in the US images. AWMF performs on a fixed running mask with the weights adjusted according to the local statistics. In practical, the performance of the AWMF method depends on the filtering mask size and its parameter selections.

3) The Morphological Operation:

A 3×3 closing and opening operator is used to further removal of the redundancy enhanced by AWMF.

4) Gray-Level Compensation:

If the variance of the gray level of thyroid region in the US image is too large, the segmentation result will be affected finally. A gray-level compensation technique is applied to adjust the intensity of the suspicious thyroid region.

3.2 Feature Extraction:

Textural features contains important information which is used for analysis and the explanation of US images. the physician manually extracted $2n$ ROIs with size of $M×M$ (n thyroid ROIs and n non-thyroid ROIs) from the suspicious thyroid region.

$$Energy = \sum_{i,j} p(i,j)^2$$

$$Contrast = \sum_i \sum_j (i-j)^2 \, P(i,j)$$

$$Entropy = - \sum_i \sum_j P(i,j) \log(p(i,j))$$

$$Homogeneity = \sum_{i,j} \frac{p(i,j)}{1+|i-j|}$$

NMSID feature =

$$NMSID = \sum_{k=1}^{n} \left[\begin{array}{l} \sum_{x=0}^{M-1} \sum_{y=0}^{M-k-1} |I(x,y) - I(x,y+k)| / M(M-k) + \\ \sum_{x=0}^{M-k-1} \sum_{y=0}^{M-1} |I(x,y) - I(x+k,y)| / M(M-k) + \\ \sum_{x=0}^{M-k-1} \sum_{y=0}^{M-k-1} |I(x,y) - I(x+k,y+k)| / (M-k)^2 + \\ \sum_{x=0}^{M-k-1} \sum_{y=0}^{M-k-1} |I(x,M-y) - I(x,M-(y+k))| / (M-k)^2 \end{array} \right] / 4$$

3.3 Feed Forward Back Propagation Neural Network and Recovering:

Here, feed forward back propagation neural network classifies the block into thyroid gland and non-thyroid gland by using the scaled conjugate gradient stochastic based learning algorithm. The trained feed forward back propagation neural network classifies the block into the thyroid gland and the non-thyroid gland.. Finally, the largest connected component is extracted from the classified US image. The region of the largest connected is considered as part of the thyroid gland region. Using the aforementioned procedures, a pure region of the thyroid gland can be extracted. However, the shape of the segmented thyroid region is serrated, and thus, a refinement procedure is required to recover the complete shape of the thyroid gland.

3.4 Volume Estimation:

The thyroid volume estimation is done by using a combination of KNN classifier with variance based match point calculation. The k-nearest neighbor's algorithm (k-NN) is a method for classifying objects based on closest training examples in the feature space. KNN is a type of instance-based learning, or lazy learning where the function is only approximated locally and all computation is deferred until classification. The k-nearest neighbor algorithm is amongst the simplest of all machine learning algorithms, an object is classified by a majority vote of its neighbors, with the object being assigned to the class most common amongst its k nearest neighbors (k is a positive integer, typically small). If $k = 1$, then the object is simply assigned to the class of its nearest neighbor.

4. CONCLUSION

Nowadays, the US images are the most powerful and inexpensive tool for clinical diagnosis. However, it is time consuming to segment thyroid gland region by means of the physician eyesight and the estimation volume of thyroid gland region in CT image is very expensive, so a convenient system for thyroid segmentation and volume estimation in US images is necessary to assist physicians. The influence of the speckle noise causes the segmentation result of the thyroid gland region in US image inefficiency and inaccuracy. Therefore, our method includes image enhancement processing technologies to remove noise in the first. Simultaneously, locate the suspicious thyroid gland region from the US image. Secondly we utilize the feed forward back propagation neural network to classify the block into thyroid gland and non-thyroid gland in the US image. Thirdly, region growing is applied to recovery the accurate shape of the thyroid gland region in practice. The thyroid gland region from US image and estimated the thyroid gland volume from US images directly.

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