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A Survey on Thyroid Ultrasound Image Analysis

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***Abstract*—**Ultrasound imaging plays a prominent role in the diagnosis of thyroid gland.Imaging helps to detect and classify the abnormalities of thyroid gland.This survey focuses on thyroid ultrasound image features that are important for diagnosis.Various researchers have developed different techniques to detect and classify the thyroid nodules.A brief survey of various techniques developed for the analysis of thyroid ultrasound images is carried out in this paper.

Keywords:*Nodule, US (Ultrasound),Segmentation, ROI(Region Of Interest),SVM(Support Vector Machine),NN(Neural Network).*

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I. INTRODUCTION

The largest gland in the neck region is the thyroid gland as shown in Fig.1. It is located in the anterior (front) neck below theskin and muscle layers. The thyroid gland resembles the shape of a butterfly with two wings. These are shown by theleft and right thyroid lobes which envelope around the trachea.The only function of the thyroid is to make thyroid hormone.

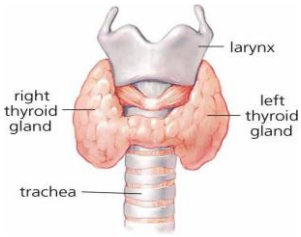

Fig 1: Thyroid gland
Courtesy: thyroid.org

The disorders related to thyroid gland are hyperthyroidism,hypothyroidism, and thyroid nodules. Nodules arecommonly benign neoplasms, but may be cancerous. Thyroid nodules are a common clinical problem anddifferentiated thyroid cancer is becoming increasingly prevalent.Thyroid cancer is seen in 5%-15% of patients depending on factors like age, sex, exposure to radiation, hereditary and others. Thyroid nodules are abnormal growth(lumps).It effects almost all tissues of the body where it enhances cellular activity. The metabolism of the body is regulated by the thyroid gland. The incidence of thyroid cancer is increasing.There are four major histopathologic types of thyroid cancer:Papillary carcinoma, Follicular carcinoma ,Medullary carcinoma and Anaplastic carcinoma.

II. THYROID ULTRASOUND

The thyroid gland and its surrounding structures are imaged using sound waves. High-resolution ultrasound (US) is the most sensitive imaging test available for the examination of the thyroid gland, to detect thyroid lesions, to accurately calculate their dimensions, to identify the internal structure and vascularization and to evaluate diffuse changes in the thyroid parenchyma. Thyroid US helps to confirm the presence of thyroid nodule.The appearance of the nodule in US images helps the healthcare expert to determine if a fine-needle aspiration biopsy is required to further evaluate the nodule.If the ultrasound appearance of the thyroid nodule is suspicious for thyroid cancer, the next step in diagnosis is a fine-needle aspiration of the nodule (FNA).

A. Role of thyroid ultrasound

The role of thyroid US [16] is to detect the presence of thyroid and cervical masses.To distinguishbetween possible benign and probably malignant masses, depending on their ultrasonic appearance. Toguidethe performance of FNA biopsy and percutaneous treatment.

B. Nodule Classification

Based on the ATA guidelines[15] the thyroid nodules can be classified into five classesnormal, benign, indeterminate, suspicious and malignant. The classification is based on the features observed in ultrasound images.

Normal: The ultrasound images donot depict any nodules

Benign: The ultrasound images depict these features.

- Hyperechoic or isoechoic with a halo
- Cystic change with ring down artefact(colloid)
- Microcystic or spongiform appearance
- Peripheral egg shell calcifications and vascularity.

Indeterminate: The ultrasound images exhibit these features

- Solid homogeneous markedly hyperechoic nodule with halo
- Hypoechoic with equivocal echogenic foci or cystic change
- Mixed or central vascularity

Suspicious: These are the features seen in ultrasound images

- Solid hypoechoic(compared with thyroid)
- Solid very hypoechoic(compared with strap muscles)
- Hypoechoic with disrupted peripheral calcification
- Lobulated outline

Malignant: These are the prominent features

- Solid hypoechoic with a lobulated or irregular outline and microcalcification(papillary carcinoma)
- Solid hypoechoic with a lobulated or irregular outline and globular calcification(medullary carcinoma)
- Intranodular vascularity
- Taller than wide axially(AP>TR)
- Characteristicassociated lymphadenopathy

III. METHODOLOGY

The prominent processes implemented in image processing are depicted in the figure 3.

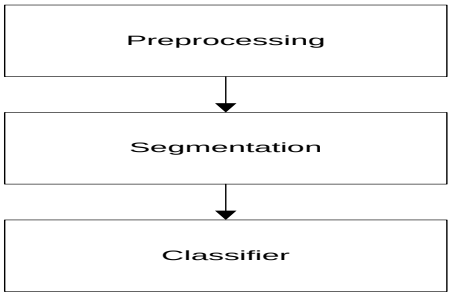

Fig. 3: Methodology

A. *Preprocessing*

Pre-processing in image processing are the various operations used for improving the quality of the image. It suppresses unwanted distortions or enhances some image features significant for further processing.The main distortion seen in thyroid ultrasound images is : Speckle noise.Speckle noise is the granular noise inherently present in the images and degrades the quality of the image.

B. *Segmentation*

Segmentation is the technique which divides the image into its constituent regions or objects. It allows to extract objects in images. It is unsupervised learning. The segmentationalgorithms are based on two basic properties, discontinuity and similarity.

C. *Classifier*

The role of a discriminant is performed by the image classifier.It discriminates one class against others. The commonly used supervised classification algorithms are support vector machine, minimum distance from mean, maximum likelihood and artificial neural networks.

IV. PREVIOUS WORK

Various detection algorithms have been developed to detect thyroid nodule using ultrasound images.

Deepika et al.[8]have developed an automatic ROI(region of interest) extraction technique for thyroid nodule from ultrasound images.The inner and outer boundaries of the thyroid nodule is calculated and the difference between these boundaries is computed. This method is evaluated using Jaccard overlap metric.

Nikhil S Narayana et.al[14] have performed automatic removal of artefacts in thyroid ultrasound images which had been induced manually. The artefacts considered are caliper marks and anatomical labels. Artefacts intensity is estimated using histogram data and it is suppressed. The image is restored using projection onto convex sets method.

Junying Chen and Haijun You[7] have differentiated the benign and malignant thyroid tumors based on the characteristics of US images. They have investigated four regions of interest : central region, 45^{o}directional region,135^{o}directional regionand 315^{o}directional region. They have used standard deviation method for classification. In this method average gray scale value and standard deviation is calculated for the ROIs. They have also performed classification based on aspect ratio .In this method ,first the thyroid edge is extracted , then axial and horizontal diameter is obtained and aspect ratio is calculated. If the ratio is large then it is malignant else it is benign. They concluded that the aspect ratio classification was better than standard deviation method.

M.Malathi [1]has performed thyroid nodule analysis using morphological segmentation.Gaussian filter is used to remove the speckle noise from the ultrasound images.Basic morphological operators like erosion and dilation is used to segment the malignant region.The perimeter,area and width of the malignant region is calculated.

Hanung adi Nugroho et al.[11] have performed segmentation of thyroid nodule by implementingactive contour bilateral filtering.Bilateral filtering softens the edges of the nodule.

Jamil Ahmed Chandio et al. [4]have proposed an intelligent system for thyroid disease visualization.A decision model is constructed using time series regression in R software and final visualization is done in Q-GIS.

Narain Ponraj et al. [10] have performed the segmentation of thyroid nodules using watershed segmentation. The gradient magnitude was used as the segmentation function.

S.Amrollahi Biyouki et al. [9] have proposed a fuzzy based expert system for diagnosing thyroid function diseases.The system works as an endocrinologist expert.

Patricio et.al [2] have differentiated malignant thyroid nodule using demographic and ultrasound images.They have implemented classification methods like

Random Forest, Logistic regression and Support Vector Machine. Logistic regression method gave the best results.

Ling-Ying Chiu et.al[13] have developed a method to perform automatic segmentation and identification of thyroid nodule. They have used radial gradient algorithm and variance reduction statistics.

Gouri S. Yende et.al[9] have performed segmentation and volume estimation of thyroid using ultrasound images. They have performed gray scale conversion as they have used color images. They have used textural features from histogram, homogeneity, Haar wavelet, Graycomatrix. Segmentation is performed by bwboundaries and boundary mask method. The classifier used is SVM. The volume is estimated by calculating the area of ROI and multiplying it with constant value 0.026458333

Priti S Dhaygude & S M Handore [3]have used level set method to perform segmentation. ANN classifier is used to classify the thyroid nodule as cancerous or noncancerous using the following features area, perimeter, AP, compactness, solidity, eccentricity, orientation.

P.Ganesh et.al[12] have eliminated speckle noise by using stick technique. The image is segmented automatically by using edge based geometric active contour model.

Hanung Adi Nugroho et. al[6] have used median filter to eliminate noise from the US images. Morphological operations are performed to obtain the object structure. To improve the overall contrast they have performed histogram equalization. They have implemented active contour without edge to perform the image segmentation .Multilayer perceptron classifier is implemented for the classification. The features used for classification are mean, standard deviation, skewness, energy, entropy,smoothness,GLCM, contrast and correlation.

V. CONCLUSION

This survey work provides knowledge about the classification of nodules and features to be extracted from the ultrasound images for diagnosis. A brief insight into different methods used for filtering and segmentation. Various researchers have developed techniques to classify thyroid nodules efficiently and it is a great aid for the doctors. From the survey we could conclude that Gaussian filter is usually used to eliminate speckle noise. Segmentation is performed by watershed, morphological, active contour method. Classifiers commonly used are ANN and SVM.

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