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THYROID DISORDER DETECTION AND REVIEW OF EXISTING THYROID SEGMENTATION TECHNIQUES

Ms. V A Kulkarni[1], Dr. A R Karwankar[2]

[1]*Dept of Electronics and Telecom, MGM's JNEC,Aurangabad, Maharashtra.(India)*

[2]*Dept.of Electronics and Telecom, Govt Engg College,Aurangabad, Maharashtra.(India)*

ABSTRACT

Thyroid disease is a very common endocrine disorder worldwide. As thyroid functioning directly affects most of our organisms,fast and accurate recognition of thyroid diseases are of great importance.Four types of thyroid diseases are of main interest:Hypothyroidism, Hyperthyroidism. Hashimoto's thyroiditis,(autoimmune thyroiditis), and thyroid cancer.

Out of various different diagnostic tools available, a thyroid ultrasound examination gives a precise method for detection. Aim of this paper is to study various thyroid disorders and review different existing approaches/ techniques used in thyroid segmentation.Different stages required in thyroid disorder detection are introduced. As segmentation is one of the crucial methods for successful automated analysis and implementation, focus of this paper is on studying various existing segmentation techniques like,thresholding ,edge detection,region based, active contour, morphologyetc. Applying graph cut, neural networks, fuzzy principles are investigated. Also, problems faced in segmentation are discussed in brief.

Keywords: Automated analysis, Diagnostic tools, Thyroid disease, thyroid segmentation techniques, Ultrasound.

I.INTRODUCTION

The thyroid is one of the largest endocrine glands in the body. The thyroid gland produces two active hormones, levothyroxine (T4) and triiodothyroine (T3) which are important in the production of proteins, in the regulation of the body temperature, and in overall energy production and regulation. As thyroid hormones are responsible for large part of body's metabolisms, its performance directly affects most of our organisms.More than one third of women, relatively few men and children are found with thyroid disorder.According to various studies conducted, it is estimated that in India alone, about 42 million people suffer from thyroid disease [1].

Therefore, fast and accurate recognition of thyroid diseases are of great importance.

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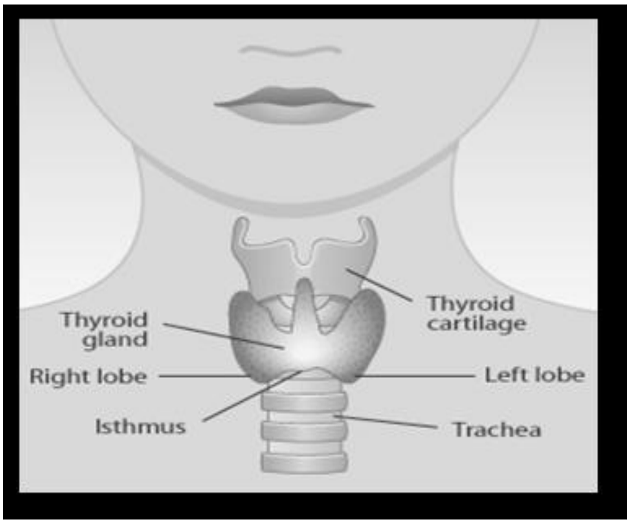

Fig.1 Thyroid gland location

There are four types of common thyroid disorders:

i) Hypothyroidism (Production of too little thyroid hormone)

Common causes are poor thyroid surgery, exposure to ionizing radiation, chronic inflammation of the thyroid (autoimmune thyroiditis), iodine deficiency, lack of thyroid hormone making enzymes etc. One of the most common causes is untreated Hashimoto's disease.

ii) Hyperthyroidism (production of too much thyroid hormone)

Common causes are inflammation of the thyroid, various kinds of medications, lack of control of thyroid hormone production. One of the most common causes is Graves' disease. In Graves' disease more thyroid hormone is prepared.

iii) Hashimoto's thyroiditis,(autoimmune thyroiditis)

It caused by an autoimmune process that causes inflammation of the thyroid gland. It is caused by a malfunction in body's immune system. Instead of protecting the thyroid tissue, immune cells attack it.

iv) Thyroid cancer:

Causes of thyroid cancer are not yet known but few factors that may cause it are radiation exposure, atomic explosions or accidents, low levels of iodine, Benign thyroid disease-which include nodules (adenomas), an enlarged thyroid (goiter),inflammation of the thyroid (thyroiditis) etc.

Thyroid related cancer is a serious disease which can lead to death. Their early diagnosis is very important.

1.1 Imaging techniques

To determine thyroid disorder, differentinvasive and non-invasive techniques are used.Invasivetechniques include Thyroid Function Tests (TFTs), biopsies. These are traumatic methods. Some ofnon-invasive techniques are: (1) USG (Ultra sonography), (2) Scinitigraphy, (3) X-Rays, (4) MRI (Magnetic Resonance Imaging), (5) CT (Computed Tomography), (6) OCT (Optical Coherence Tomography) etc.

A thyroid ultrasonography, used to detect and classify abnormalities of the thyroid gland, is the popular choice for diagnosis and managing thyroid disorder, because of sensitivity and convenience.

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According to S.Feld[2], about 50% of people detected with solitary nodules by experienced doctors have been found with additional nodules when examined further by ultrasonography.The other imaging methods are more costly than US, less efficient in detecting small lesions, and are best used selectively when US is inadequate for a clinical problem.

The increased use of thyroid ultrasound imaging by radiologists, endocrinologists, and surgeons has helped discover large number of asymptomatic thyroid nodules as well as diagnosis of thyroid cancer. Due to high prevalence of nodules, and less frequency of symptomatic cancer, there is uncertainty and conflict about which nodules may be cancerous, in need of biopsy [3]. Major problem in the medical field is the correct diagnosis and detection of disease before advising any treatment.Thyroid ultrasound imaging can help identify patients who have a low risk of cancer where biopsy can be avoided.

Various new methods, such as thermal imaging, Image processing techniques, fuzzy classifiers, artificial immune recognition system, neural networks, neuro fuzzy, genetic algorithm etc, have been used to diagnose thyroid disease

This paper is further arranged as following:section II describes in brief proposed methods and tools, followed by segmentation introduction.Further sections cover the survey of different segmentation algorithms. At the end is conclusion.

II. PROPOSED METHODS AND TOOLS

Ultrasound (US) images contain speckle noise and echo perturbations, which makes diagnosis harder. Additionally, image interpretation is subjective.

Image processing algorithms consists of following steps such as image preprocessing, segmentation, feature extraction, feature selection and classification. This needs thyroid database, better and effective segmentation, classification methods.Use of Matlab software and alternatives like labview will also explored in future.

Different steps used in image processing algorithm are: (Fig 2)

- **Image database**:First, thyroid US image is taken and stored in proper format. It consists of both normal and abnormal images stored in the database
- **Image Preprocessing:** Imagepreprocessing step will acquire the low contrast image with noise. It enhances certain image features significant for further processingand detection, suppressing the undesired distortions. It includes removal of noise using filters to enhance the image. This is shown in Fig no.3.
- **Image segmentation:** Different approachesare used for partitioning an image into multiple segment or set of pixels to locate object and boundaries. It is based on each of the pixel is similar in some characteristic like color, texture etc. with its neighbor pixel.
- **Extraction and Image classification:** The feature extraction is used to maximize the discriminating performance of the feature group. Classification of thyroid nodule is done in order to eliminate operator dependency and to improve the diagnostic accuracy. Different advanced techniques in image classification are Artificial Neural Networks (ANN), Genetic Algorithms (GA), Support Vector Machines (SVM),Fuzzy measures, Fuzzy support Vector Machines (FSVM)

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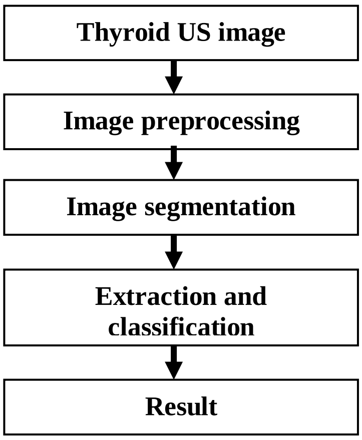

Fig no.2: **Flowchart of steps used inthyroid disorder detection of USimages**

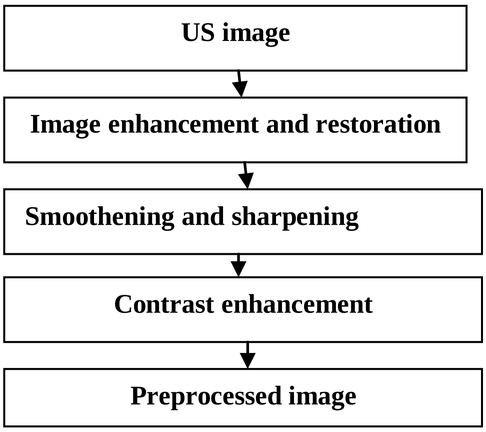

Fig no.3: **Preprocessing steps used inthyroid disorder detection of USimages**

III. REVIEW OF RELATED WORK

3.1 Introduction to segmentation

3.1.1 Definition

Segmentation is the process of partitioning an image into non-intersecting regions such that each region is homogeneous and the union of no two adjacent regions is homogeneous. It is defined as:

"Let F be the set of all pixels and P() be a uniformity (homogeneity) predicate defined on groups of connected pixels, then segmentation is a partitioning of the set F into a set of connected subsets or regions (S1, S2, · · · , Sn) such that$\bigcup_{i=1}^{n} S_i = F$with **Si** ∩ **Sj** =∅ when i ≠j.

Theuniformity predicate P (Si) is true for all regions Si and **P (Si** ∪ **Sj)** is falsewhen Si is adjacent to Sj".This definition can be applied to all images.[4]

3.1.2 Traditional Segmentation Approaches

For intensity images, important types oftraditionalsegmentation approaches are: (1) threshold technique, (2) edge detecting algorithms, (3) region-based techniques, (4)Active contour based techniques, (5) Morphological techniques etc.

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In threshold techniques, decisions are based on local pixel information. In this technique, intensity levels of background and the object are fairly different. This technique is not suitable for blurred region boundaries.

Edge based methods are mainly based on abrupt changes in intensity. First-order or second-order derivatives can be used to detect edges. However it may result in broken boundary lines.

In region-based method the image is partitioned into connected regions by grouping neighboring pixels of similar intensity levels. Adjacent regions are then merged based on some criterion. Region based techniques are difficult to process the low contrast image. Fragmentation, over merging may occur.

In, Active contour model some initial boundary shape is represented as spline which is repeatedly changed by operations (expand and contract) depending on some energy function.

The morphological segmentation algorithm of watershed transform often results in over segmentation, if used directly on an original image.

For thyroid disorder detection, location, size (area), volume parameters are etc. are to be considered for segmentation. Segmentation accuracy determines the success of automated analysis procedures. Thus different approaches to provide accurate and efficient segmentation are essential for study. Hence various approaches used for segmentation are mentioned in the literature review. Segmentation techniques depend on the specific application, imaging modality, and other factors and vary with applications [5]. Thus, the segmentation technique used for lungs will be different from that of the liver or of thyroid etc.

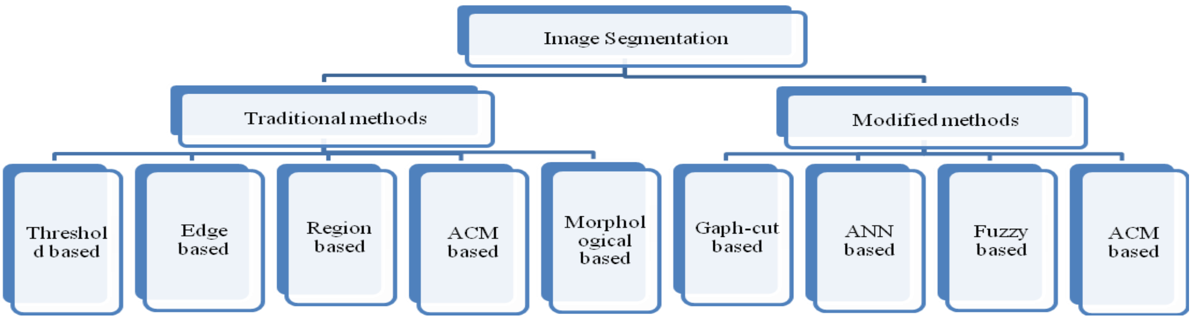

Fig no.4- Different segmentation techniques

3.2 Problems in segmentation

1. The speckle noise is inherently present in ultrasound thyroid image,which deteriorates the image quality.

2. The images obtained have poor contrast and the intensity is not uniform, it is fluctuating, deteriorating image resolution.

3. Other parts like muscles present in an image may be misinterpreted as a nodule due to its similarity to image of interest.

4. Boundary of image is dependent on the way image is taken.[6]

3.3. Literature review on segmentation techniques.

A graph-cut is a grouping technique in which the degree of dissimilarity between two groups is computed as the total weight of edges removed. In grouping, a weighted graph is split into disjoint sets (groups).This technique can

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optimally bi-partition the graph and achieve good segmentation. The normalized cut criterion measures both the total dissimilarity between the different groups as well as the total similarity within the groups. Even though it has great advantage, its limitations are requirement of large memory as calculations involved are huge. It is easy to generate the over segmentation or under segmentation, which leads to inaccuracy in thesegmentation [7].

Zhao[8] has used anisotropic diffusion model with the improved normalized cutfor removal of speckle noise while preserving the important edges and local details. A novel normalized cut segmentation method based on fractional derivatives was used, which enhanced images by adjusting the fractional derivatives parameters, marking the outline of images and accurately calculating the weight matrix. It segmented the areas of thyroid tumor through the discrete eigenvectors.This reduced the amount of computation in constructing the weight matrix and improves the accuracy of the final segmentation results. Establishment of parameters of anisotropic diffusion model and similarity definition is the crucial for final results. If iteration step is too small or too large, result obtained will not be accurate. There is also limitation in setting and optimizing initial parameters.

Chan, Vese[9]proposed an active contour model, without a stopping edge-function. This method is minimization of an energy based-segmentation, which is not based on the gradient of the image for the stopping process. It is based on Mumford-shah Segmentation technique and level set method, which does not require smoothing the initial image even if it is noisy. So this method works on noisy images successfully. This model can detect objects whose boundaries are not defined by gradient or with very smooth boundaries. Also, interior contours starting with only one initial curve can be automatically detected. A limitation of this model is that it assumes approximately piecewise constant intensities for object and background regions. This assumption does not hold true in thyroid US images where intensity is not uniform.

Dimitris, Savelonas, Karkanis, Maroulis[10]have also used a level set active contour model based on active contour without edges (ACWE). It uses information of variable background regions to reduce the effects of intensity inhomogeneity, which is attributed to noise, tissue texture, and calcifications. Thus, VBAC achieves more accurate segmentation and faster convergence as compared to ACWE.It works well for hypo echoic nodules.

Shawn, Allen [11]has used Localized region based active contour method for segmentation. Foreground and background are described in terms of smaller local regions and not as global region models. Local energies are optimized by considering each point separately, and moving it in order to minimize or maximize the localized energy computed . For this purpose, local neighborhoods are divided into two regions: local interior and local exterior. This model has worked well in segmenting heterogeneous images .However; it is more sensitive to initialization as compared to global region based methods.

Nasrul Humaimi Mahmood and Akmal segmented the contrast enhanced thyroid region image by local region-based active contour [12]. It was segmented into two parts, right and left with the active contour method.

Transverse view of image was used for measurements of width, depth and area of the thyroid region. The result was calculated in pixel unit. The proposed method successfully segmented the thyroid lobe.

Chuan Yu [13] has segmented thyroid gland using radial basis function (RBF) neural network. The particle swarm optimization (PSO) algorithm is then used to estimate the thyroid volume from US images. Preprocessing steps used to enhance and locate the probable thyroid region are: 1) locatingthe probable thyroid region; 2) applying an Adaptive Weighted Median Filter(AWMF) to reduce speckles; 3) applying two morphological operations to enhance the filtering result; and 4) compensating for differentUS images according to the intensity template of the

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thyroid region. Segmentation accuracy is 96.54% as compared to94.5% in AWMF+ ACM [14] and 88.2% in AWMF + watershed model [15] .This method requires too many morphological operations.

D Selavathi [16] has used Extreme learning machines (ELM) and Support Vector machines (SVM) for thyroid segmentation.ELM, which randomly chooses hidden nodes and analytically determines the output weights of Single hidden Layer Feed forward Neural Network has better performance than SVM in segmenting the thyroid gland in ultrasound images.Accuracy obtained with ELM is94.5% as compared to SVM which is 84.8%.

Another approach to segmentation is based on fuzzy logic [17].

Data clustering technique:In Fuzzy c-means (FCM) a dataset is grouped into n clusters with every data point in the dataset belonging to every cluster to a certain degree. FCM works efficiently as compared to Histogram clustering, Quad tree, Region growing and Random Walker methods.[19]

Liu Yucheng [20] proposed a fuzzy morphological based image segmentation algorithm. Algorithm has used morphological opening and closing operations to smoothen the image and then perform the gradient operations. Fusion approach solves the problem of over-segmentation and is efficient as compared to Watershed algorithm and Prewitt methods.Table 1 and fig.5 summarizes different segmentation techniques studied

Table no.1- Comparison of different segmentation techniques

Sr.No.	type	ACCURACY in %
1	Normalised cut(N-cut)method	92
2	Modified N-cut method	94
3	Active contour model without edge(ACWE)	80
4	ACWE-VBAC	94
5	Local region based active contour	80
6	AWMF+RBF neural network based	96.5
7	AWMF+ACM	94.2
8	AWMF+Watershed	88.2
9	ELM	94
10	SVM	88.8

ACWE-VBAC: Active contour model without edge with variable background
AWMF+RBF:Adaptive Weighted Median Filter radial basis function
AWMF+ACM: Adaptive Weighted Median Filter with active contour model
ELM: Extreme learning machines
SVM: Support Vector machines

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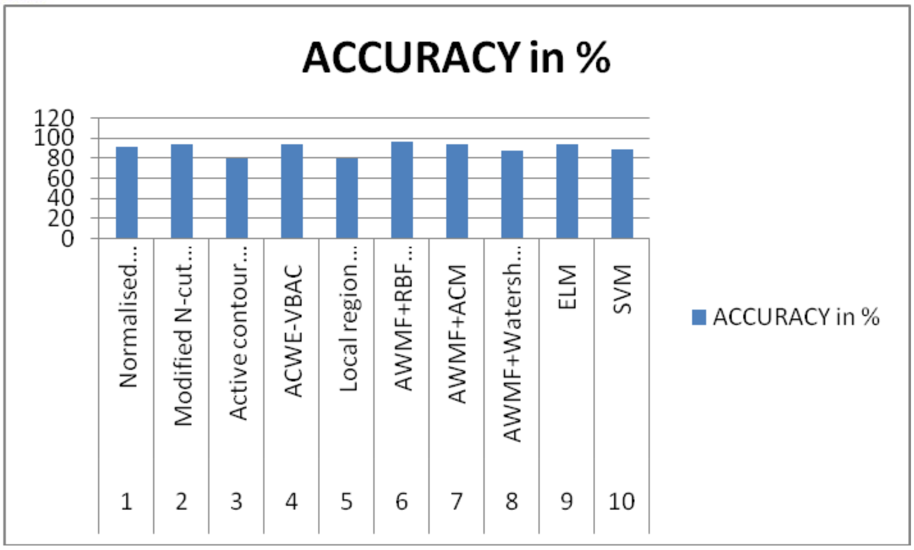

Fig.no.5: **Accuracy graph of different segmentation techniques studied**

IV. CONCLUSION

Amongst all existing modalities, thyroid ultrasonography is a popular choice. It is cheaper than the other nonintrusive modalities. It can be used efficiently to detect and classify abnormalities of the thyroid gland and help Medical personas to correctly diagnoseand manage thyroid disorder.

Out of various different steps in thyroid image processing segmentation, feature selection, extraction and classification are important and various researchers have proposed techniques for the same. This paper has focused only on literature regarding existing segmentation techniques, for further formulating the use of efficient segmentation technique in the author's research. This paper will prove beneficial to all future researchers.

Segmentation accuracy is a challenge in case of thyroid disorder detection, as the US images are vague, have low contrast and difficult to separate from background due to existing similarities. Inherent noise present, maintains the degree of uncertainty in detection. Thus critical study of segmentation techniques is a must, as it decides the accuracy of automated analysis.Before segmentation, preprocessing on image is essential.

Different segmentation approaches are suited for different applications.

Segmentation using N-cut, neural networks, fuzzy techniques have shown results with accuracy varying from approximately 84%to 95%.

[1] Segmentation using Active contour without edges (ACWE), Variable Background Active Contour (VBAC), Minimization of Region-Scalable Fitting Energy, ELM, and RBF, localized region based active contours methods have been compared and discussed with their application to Thyroid image processing.

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