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Thyroid Nodule Detection using Artificial Neural Network

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***Abstract*— Thyroid gland is one of the largest endocrine gland and is located below the skin and muscles at front of neck. It has an important role in maintaining the metabolism of body. Modalities like Ultrasonography, Computer Tomography (CT),Magnetic Resonance Imaging(MRI) and Computer Aided Diagnosis(CAD) are used for identification and classification of abnormalities in thyroid gland. This paper proposes a computer based system for classifying nodules in thyroid as benign or malignant in ultrasound images depending upon the extracted features. The information related to texture is calculated from both Region of Interest (ROI) blocks. Enhancement is done to improve the image followed by segmentation using Active contour without edge(ACWE).With help of this extracted features, the Multi-layer perceptron(MLP) classifies the nodule as malignant or benign. The classification results obtained the height of accuracy, sensitivity, specificity , predicted positive value and predicted negative value at 93.84%, 97.82%, 84.21%, 93.75% and 94.11% respectively. These results suggests that proposed scheme accomplished the classification of ultrasound thyroid nodules as benign or malignant.**

Keywords*— *Ultrasound images, Artificial Neural Network, Feature extraction, Thyroid segmentation, Active contour model, Image enhancement.

I. INTRODUCTION

The thyroid cancer has been rapidly increasing. Nowadays, with the awareness of people regarding their health and with the use of advanced ultrasound equipment, a larger number of thyroid lump are diagnosed in routine checkup. Reiners et al. [11] performed a study which showed that, 33% of total populations among the age of 18 and 65 have thyroid nodules. National cancer institute conducted a survey which stated that from 100,000 people 14.2% are affected by thyroid cancer every year. Thyroid is butterfly shaped organ with cone like lobes and located in the lower part of the neck below the Adam apple. Thyroid is responsible for functions like metabolism, growth and development of the human body. It releases thyroid hormones into blood stream which helps in functioning of body.

Ultrasound images contains noise like grain noise, speckle etc. These noises have to be removed else it may provide inappropriate results. To remove this noises from Ultrasound images researchers have implemented variety of algorithms. With the advancement in field of computer vision, computer based system has become a helping hand for doctors in detection of thyroid nodules. A large number of methods are suggested for diagnosing and categorizing of thyroid lumps in Ultrasound images using variety of neural networks. For example, Chi et al. [2] has used a fine-tuned GoogLeNet to select features and classification is done by Cost-Sensitive Random method .Liu et al. [3] has used ImageNet pre-trained ConvNets to determine features from ROI and merge the extracted features with hand crafted features. The classification is done by SVM. Ali Abbasian et al. [7] proposed a wavelet texture features for classification of thyroid nodules. Keramidas et.al,developed a method in which fuzzification of the local binary pattern is done for extraction of textural features [13].

II. METHODOLOGY

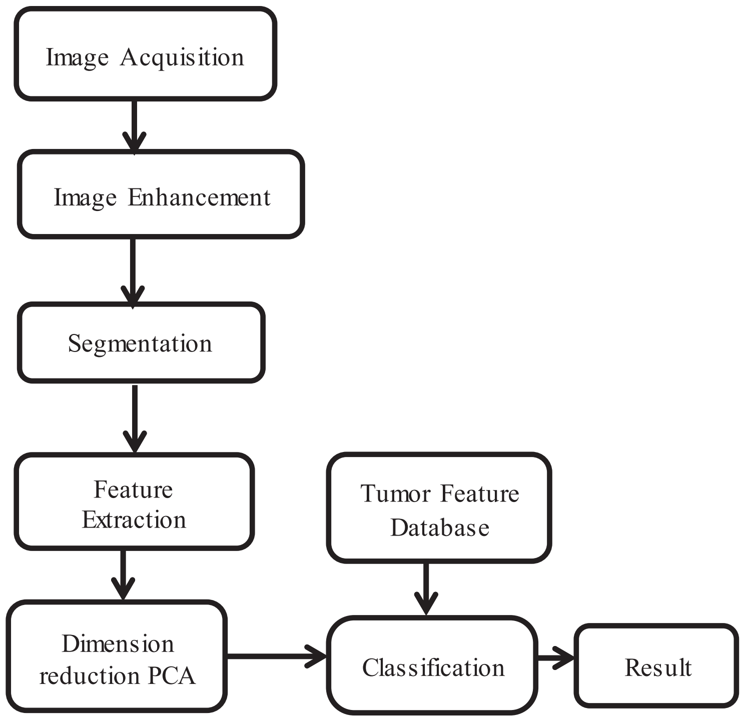

Fig.1 Block schematic of proposed work.

A. *Image Acquisition:*

The database consist of ultrasound thyroid images of mixed types like some with cancerous nodules some with non-cancerous nodules. Total 65 ultrasound images are used out of which 46 are cancerous (malignant) and 19 are non-cancerous (benign).The thyroid images are provided by internet (wiki.cancerimagingarchive.net).The format of image used is JPG.

B. Image Enhancement:

The enhancement provides improved brightness and contrast of image. Techniques like median filtering, Histogram equalization, Global histogram equalization (GHE), Bi-histogram equalization (BBHE), Brightness preserving Dynamic fuzzy histogram equalization (BPDHE) and many other are available. Among these BPDHE is used in this proposed work, because it preserves brightness and provides good contrast enhancement. The image histogram is manipulated in such a way that the redistribution of gray level values in valley portion takes place between two consecutive peaks and there is no remapping of histogram. It is implemented by following steps:

1. Fuzzy histogram creation.

2. Histogram partition.

3. Dynamic histogram equalization of partitions.

4. Normalization of image brightness.

Figure 2 illustrates test image, enhanced image and tumour image.

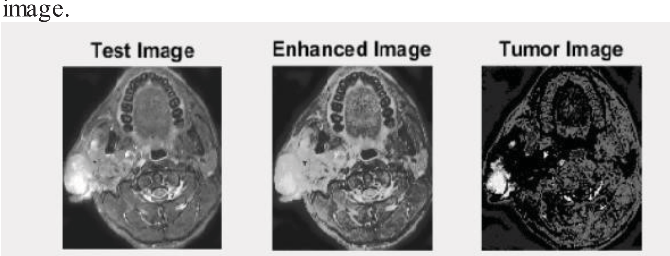

Fig.2 Enhanced Thyroid ultrasound image.

C. Segmentation:

In this proposed work, Snake active contour model is used which works by detecting item in an image by defining beginning curve then it goes on evolving till it reaches and ends on the boundary of the item with following steps:

1. The image and σ values for the Gaussian smoothing are chosen.
2. The beginning position of the snake is selected by just a click on the image and select control parameters which are then inserted (Spline based) into a curve.
3. The different control criterion for snake is specified by user. These include

i) α (alpha) : It defines the flexibility of the snake.
ii) β (beta) : It defines the severity in the curve by joining with the second derivative term.
iii) γ (gamma) : It determines the step size.
iv) κ (kappa) : It is the scaling factor for the energy term.
v) W (Eline) : It relates balancing factor for intensity based potential term.
vi) W (Eedge) : It specifies evaluating factor for edge based potential term.
vii) W (Eterm): It relates the evaluating factor for terminating the potential term.

4. Lastly, user specifies number of times the process should be repeated.

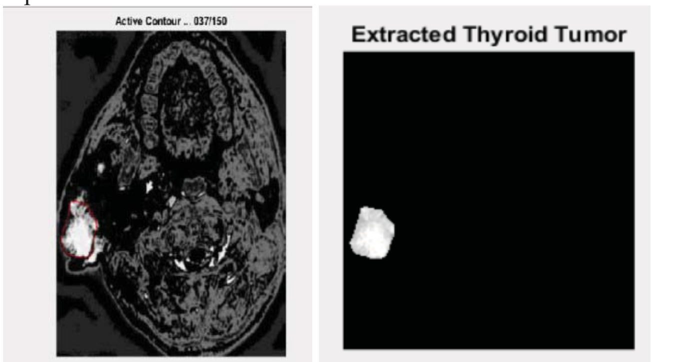

Fig.3 Segmented thyroid nodule.

D. Feature Extraction:

Feature extraction is done by extracting some appropriate values from large input data. Classification system is trained using the extracted features. The extracted features must be appropriate to get the accurate and desired output. The feature extraction from the captured images can be carried out different available techniques. Various algorithms and techniques are used by this stage to detect and isolate different portions or shapes of image. These features are defined as follows:

Statistical features: The features of the selected ROI are calculated as a feature vector, these include *Mean, standard deviation, Variance, Energy and GLCM (Gray Level Co-occurrence Matrix) features.*

Texture Features: Gabor filters are used to extract texture features which include contrast, homogeneity, energy, correlation.

Once the features are determined then using PCA its dimensions are reduced. The features database of all the images is created for classification purpose.

E. Classification:

Classification is a process to determine or identify a category of an object. An algorithm is needed to recognise the correct class. The classifier performance is evaluated by using testing dataset.

ANN is a self-learning system and widely used for pattern recognition and classification. It is a parallel distributed processor with natural tendency of storing data. Multi-layer perceptron (MLP) by using back-propagation algorithm is used in this proposed work. First feature database of all the known images is built in training phase. These features are uses to train the Neural Network. The features of the testing image are used to classify using trained NN to predict whether the tumour is malignant or benign.

The efficiency of the introduced scheme is resolved by five statistical parameters, i.e. accuracy, sensitivity, specificity, predicted positive value (PPV) and predicted negative value (NPV). These parameters are figured out depending upon on the number of true positive (TP), true negative (TN), false positive (FP) and false negative (FN). They are mathematically defined as:

Parameters	Equation
Accuracy	(TP+TN)/N
Sensitivity	TP/(TP+FN)
Specificity	TN/(TN+FP)
PPV	TP/(TP+FP)
NPV	TN/(TN+FN)

Table 1: Equation of Parameters.

III. EXPERIMENTAL RESULTS:

The extracted features are given to classifier to regulate whether the tumour is benign (non-cancerous) or malignant (cancerous). The following tables show calculated features of benign thyroid nodule and malignant thyroid nodule:

US Image	Benign Measurement indices						
	Eccentricity	Equiv di-ameter	Contrast	Correlation	Energy	Homogeneity	Entropy
Case 1	0.645872	20.897875	38591.46	-0.020469	0.00342	0.017789	1.2459
Case 2	0.551873	34.852124	2777.392	0.251199	0.00133	0.020100	2.1290
Case 3	0.549843	35.143169	4957.300	-0.469141	0.00157	0.051588	3.9580
Case 4	0.688864	14.138550	2607.224	0.325869	0.00843	0.019423	1.2015
Case 5	0.467051	30.487126	8514.731	-0.16466	0.00142	0.038273	1.2210
Case 6	0.680451	31.634890	22505.68	-0.086255	0.00155	0.023186	1.5846
Case 7	0.705012	22.539356	11013.95	-0.127240	0.00281	0.030979	2.8703

Table 2: Extracted Feature values of Benign Thyroid Images.

US Image	Malignant Measurement indices						
	Eccentricity	Equivdi-ameter	Contrast	Correlation	Energy	Homogeneity	Entropy
Case 1	0.698329	60.71262	34330.231	-0.005944	0.005944	0.024048	10.6523
Case 2	0.579216	33.73834	151.86771	-0.110030	0.001324	0.168192	8.9852
Case 3	0.633049	72.14570	4514.9056	-0.006322	0.000264	0.043172	21.377
Case 4	0.556622	44.1079	6571.6312	-0.2190	0.00068	0.013044	4.60528
Case 5	0.508602	60.9846	530.599	0.058653	0.000356	0.107561	3.6974
Case 6	0.527402	48.3494	662.182	-0.096124	0.000565	0.10452	3.37408
Case 7	0.665317	41.71952	53778.431	-0.01892	0.000750	0.007028	5.9336

Table 3: Extracted Feature values of Malignant Thyroid Images.

The ultrasound database used in this proposed work consists of total 65 images out of which 46 are malignant and 19 are benign. The extracted features of nodule within the ultrasound images were applied as classification criteria. The implemented method in this proposed system is used using

Matlab tool and snapshot of GUI are shown below. The performance of system is evaluated using the equations in table 1.

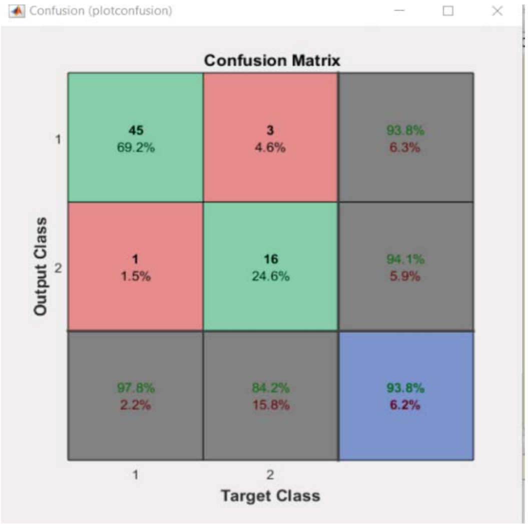

Fig.4 Confusion Matrix

From above confusion matrix,

True Positive (TP) =45,

True Negative (TN) =16,

False Positive (FP) =3,

False Negative (FN) =1

Accuracy= (TP+TN)/N

= (45+16)/65

= 0.9384

= 93.84%

Thus overall accuracy of system is 93.84%.

Table 4 shows the overall classification results.

Parameter	features
TP	45
TN	16
FP	3
FN	1
Accuracy (%)	93.84
Sensitivity (%)	97.82
Specificity(%)	84.21
PPV (%)	93.75
NPV (%)	94.11

Table 4: Classification results

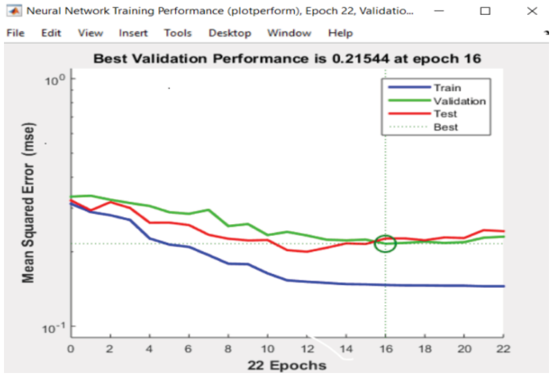

Fig. 5 Neural network training performance.

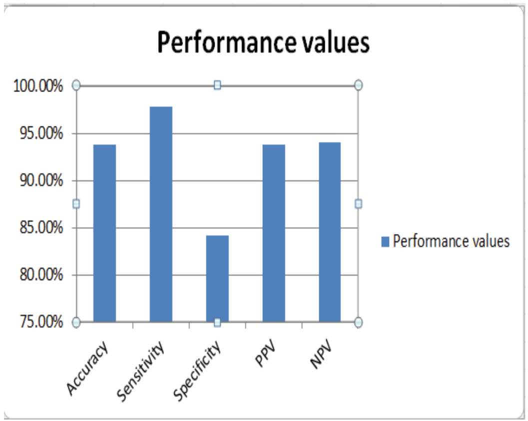

Fig.6 Performance of proposed system.

The successfully segmented and classified thyroid nodule is shown in below figure.

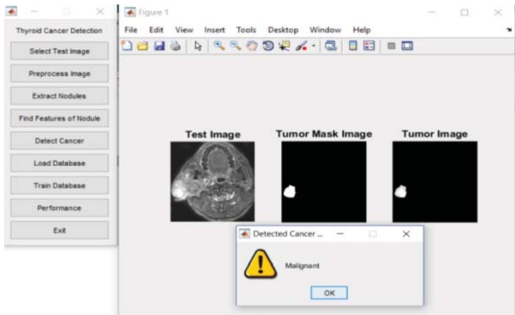

Fig.7 Malignant nodule

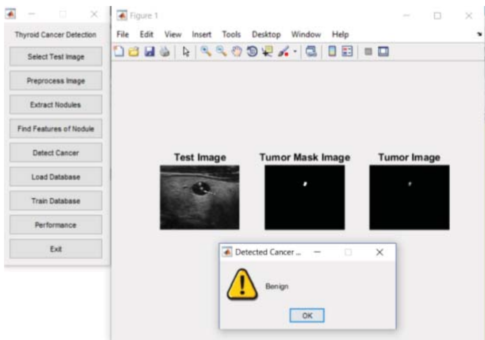

Fig.8 Benign nodule

IV. CONCLUSION

The proposed scheme consists of stages like preprocessing, segmentation, feature extraction and classification. It successfully classifies thyroid nodule from ultrasound images as malignant or benign. The result shows that performance of proposed method achieves accuracy of 93.84%, sensitivity of 97.82%, specificity of 84.21%, and predicted positive value of 93.75% and predicted negative value of 94.11%. This simulation method will assist the experts for detecting thyroid nodules as benign or malignant and expected to be a second opinion in decision making.

Moreover, it is suggested to be a part of computer based analysis of thyroid cancer in future research. Further, volume estimation of segmented thyroid nodule can be done in future work.

The ANN provides better result but are prone to trapped in local minima means they sometimes miss global picture as compared to SVM classifier.

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