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Detection of Tumors in Ultra Sound Thyroid Images using Random Forest Classification Method

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Abstract: ***The thyroid gland is important for balancing the hormones in our body for our daily routine activity. This paper detects the tumor regions in ultrasound thyroid image using feature extractions based Random Forest (RF) classification approach. In this paper, Curvelet transform is used to transform the pixels associated with spatial into the pixels associated with frequency. In this paper, Random Forest (RF) classification algorithm is used for the classification of the computed features from the thyroid image.***

Keywords: Thyroid, gland, tumor, Curvelet, classifications.

I. INTRODUCTION

The thyroid gland is important for balancing the hormones in our body for our daily routine activity [6]. The tumors are formed in this thyroid gland due to the hormones imbalance and genetic disorder. The tumors in this thyroid gland are also affects the parathyroid functionalities which is also essential for our body hormones generations [7, 8]. Hence, the detection and segmentation of this tumor region in thyroid gland is important. In this paper, the tumor regions in thyroid gland are detected using feature extractions based random forest classification method. The thyroid gland is shown in Fig.1.

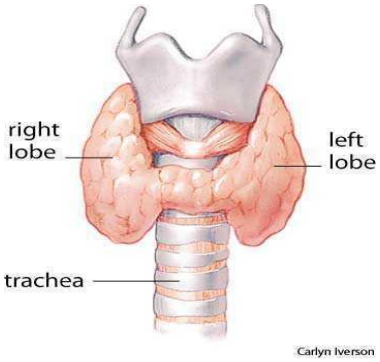

Fig. 1. Thyroid gland

Tsantis et al. (2005) developed a method for detecting and segmenting the tumor regions in thyroid image. The authors used ultra sound imaging technique to capture the thyroid image and the tumor regions in this thyroid image were detected and segmented using support vector machine classification algorithm.

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The authors tested their proposed work on several thyroid ultra sound images for robustness verifications. Iranmanesh et al. (2013) analyzed and stated various thyroid node detection problems in details. The authors explained various screening methods for the detection of cancer or tumor regions in thyroid image using clinical approaches.

Jukkola et al. (2004) used prognostic factors for detecting the cancer regions in thyroid images. The authors analyzed various impact factors for detecting the cancer regions in thyroid images. The linear and non-linear regression approaches were analyzed in this paper for developing an methodology to detect the thyroid cancers. Mazzaferri et al. (2001) detected follicular thyroid cancer using various regression based systematic approaches. The authors tested their proposed method on various testing protocols in order to validate the simulation and clinical results.

II. PROPOSED METHOD

This paper detects the tumor regions in ultrasound thyroid image using feature extractions based Random Forest (RF) classification approach. The process of entire tumor detection is illustrated in Figure 2.

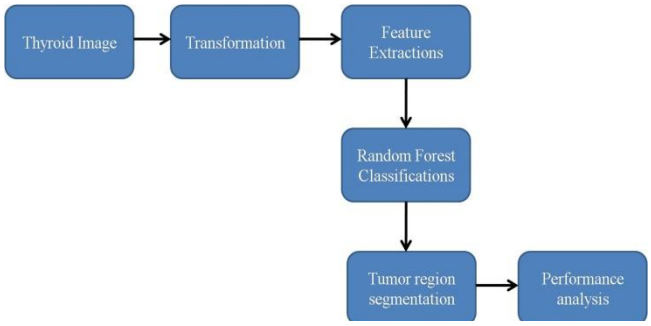

Fig. 2. Thyroid tumor region detection work flow

Transformation

In this paper, Curvelet transform is used to transform the pixels associated with spatial into the pixels associated with frequency. This transform is derived from wavelet transform through the modifications of their internal kernels. Its main property is its non-adaptability with its features which produces high degree of correlation between each pixel and its surrounding pixels. The edge pixels are preserved in this transform during the process of transforming the pixels from one mode to another mode. The accuracy of this pixel transformation is based on the window used in this transform. These windows are called as radial and angular window.

The following equations are the kernels of these window used in this transformation.

$$\sum_{j=0}^{\infty} w^2 * (2^{-j} * r) \quad (1)$$

Where as, w is the real valued window and r is the radial function.

$$\sum_{i=0}^{\infty} v^2 * (t - 2\pi l) \quad (2)$$

Whereas, v is the real argument and l is the length of window, with respect to time function 't'.

The frequency contents are linearly distributed over the transformed image using this Curvelet transform. The radial and angular windows are placed over the thyroid image and the pixels in the thyroid image are multiplied by the kernels of these windows which produces the linear coefficients. These transformed coefficients are stored in an array which is called as array vector.

Feature Extractions

Features are the important parameters for differentiating the normal regions in thyroid images from the abnormal regions in thyroid images. These features are used to differentiate the well known regions from the other unknown regions in ultrasonic thyroid images. The features which are used in this paper are directly computed from the coefficients of Curvelet transform. The following features are extracted from the array vector and they are explained in the following equations as described below.

$$Mean\ Square\ Vector = \sum_{i,j=1}^{M} A(i,j)^2 \quad (3)$$

Where, M is the size of the array vector and A(i,j) is the element in array vector.

$$Vector\ feature = \frac{\sum A(i,j)}{N} \quad (4)$$

$$Index\ feature = \frac{1}{M*N} \sum A(i,j) \quad (5)$$

$$Vector\ correlation\ feature = \frac{\sum A(i,j)^2}{\sum A(i)^2} \quad (6)$$

$$Index\ correlation\ feature = \frac{\sum A(i,j)^2}{\sum A(j)^2} \quad (7)$$

Table-I: Features values from array vector for normal and tumor affected thyroid image

Features	Normal thyroid image	Tumor affected thyroid image
Mean square vector	$1.5*10^2$	$1.5*10^6$
Vector feature	0.768	3.921
Index feature	1.858	-0.968
Vector correlation feature	$1.8*10^5$	$1.8*10^{-2}$
Index correlation feature	$3.8*10^4$	$3.8*10^2$

Table 1 shows the features values from array vector for normal and tumor affected thyroid image.

Random Forest classifications

The features from the array vector are classified into normal and abnormal pattern using classification algorithm. In this paper, Random Forest (RF) classification algorithm is used for the classification of the computed features from the thyroid image. The computed features from the array vector are split into four set of features as depicted in Fig.3. Then, correlation rank index is computed for each split feature set.

The feature with highest correlation rand index is selected and they are called as best features from each split feature set. Finally, vote is computed for each best feature value from each set. The final class is selected by finding the maximum rand index from the set of ranks.

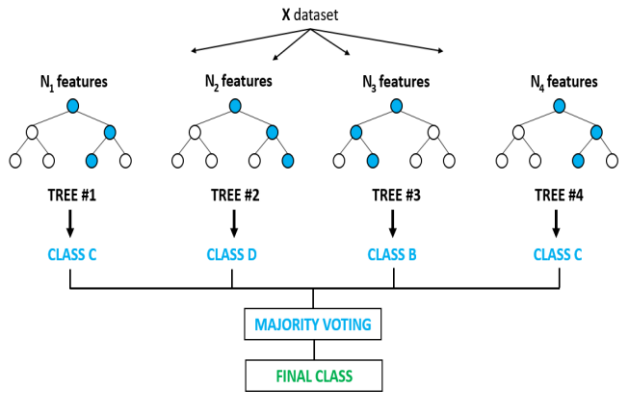

Fig. 3. Random classification approach

III.RESULTS AND DISCUSSIONS

The analysis of this proposed thyroid detection method is performed in MATLAB simulation environment and the following parameters are used in this paper for this analysis.

$$Sensitivity\ (Se) = TP/(TP + FN) \quad (8)$$

$$Specificity(Sp) = TN/(TN + FP) \quad (9)$$

$$Accuracy(Acc) = \frac{(TP+TN)}{(TP+FN+TN+FP)} \quad (10)$$

The tumor pixels are denoted by TP, the non tumor pixels are denoted by TN, the false detected tumor pixels are denoted by FP and the false detected non-tumor pixels are denoted by FN.

Table II shows the simulation report of the proposed thyroid tumor detection. This proposed work achieves 95.51% of sensitivity, 96.41% of specificity and 97.04% of accuracy.

Table-II: Simulation report of the proposed thyroid tumor detection

Thyroid Images	Sensitivity (%)	Specificity (%)	Accuracy (%)
1	91.6	95.8	98.5
2	90.7	96.1	98.9
3	98.2	98.2	97.9
4	97.8	96.9	95.8
5	96.9	93.2	97.8
6	95.9	97.9	94.9
7	96.1	95.9	96.9
8	94.2	93.8	95.7

9	97.9	97.2	96.1
10	95.8	99.1	97.9
Average	95.51	96.41	97.04

Figure 4 shows the graphical implementation of the simulation report.

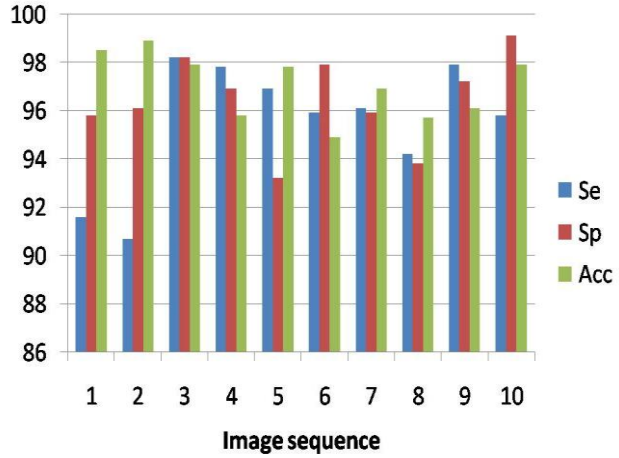

Fig. 4. Graphical implementation of the simulation report

IV.CONCLUSION

The tumors in this thyroid gland are also affects the parathyroid functionalities which is also essential for our body hormones generations. Hence, the detection and segmentation of this tumor region in thyroid gland is important. This paper detects the tumor regions in ultrasound thyroid image using feature extractions based Random Forest (RF) classification approach. In this paper, Curvelet transform is used to transform the pixels associated with spatial into the pixels associated with frequency. In this paper, Random Forest (RF) classification algorithm is used for the classification of the computed features from the thyroid image. This RF classifier produces significant simulation results for the set of thyroid images. The proposed methodology is tested on various number of ultrasonic thyroid images in order to evaluate the performance of the proposed system. The performance of this proposed framework is analyzed in terms of sensitivity, specificity and tumor region segmentation accuracy. This proposed work achieves 95.51% of sensitivity, 96.41% of specificity and 97.04% of accuracy.

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