ISSN 2250-3153

Thyroid Disease Diagnosis using Image Processing:A Survey

Ms.Wrushali Mendre*, Dr.R.D.Raut**

* Department of Electronics & Telecommunication
Smt.Kashibai Navale College of Engineering
Pune, India
** Department of Applied Science
SGB Amravati University
Amravati, India

Abstract- An overview is presented of the medical image processing literature on thyroid disease diagnosis. The aim of the survey is to introduce for those new to the field, an overview for those working in the field, and a reference for those searching for literature on a specific application. Thyroid disease is extremely common and of concern because of the risk of malignancies and hyper function. Thyroid nodules may become malignant if not diagnosed at right time. During last few years, various image processing algorithms have been proposed for efficient and effective computer aided detection of thyroid nodules. Algorithms work on USG, SPECT images and planar scintigraphy. An overview of algorithms in each step (preprocessing step, segmentation step, feature extraction step, feature selection step, classification step) for thyroid disease diagnosis is given. Fuzzy cognitive map based decision support system and other recently proposed methods are presented. An overview of texture representation via noise resistant image features is given as well.

Index Terms- Ultra-sonography (USG) images,Multilayer Perceptron (MLP),Radial Basis Function(RBF), Conic Section Function Neural Network (CSFNN), Adaptive Neuro Fuzzy inference system (ANFIS), Thyroid Diseaes,Neural Networks,Artificial Neural Networks (ANN).

I. INTRODUCTION

Thyroid hormone produced by the thyroid gland helps regulate the body's metabolism. The thyroid data are obtained from the measurements of the thyroid gland. The thyroid makes two active thyroid hormones, levothyroxine (abbreviated T4) and triiodothyronine (abbreviated T3). These hormones are important in the manufacture of proteins, in the regulation of body temperature, and in overall energy production and regulation [22].

In general, thyroid disease can be divided into two broad groups of disorders: those which primarily affect the function of the thyroid and those which involve neoplasms, or tumors of the thyroid. Both types of disorders are relatively common in the general population. Most thyroid problems can be treated successfully. Abnormalities of thyroid function are usually related to production of too little thyroid hormone (hypo-.thyroidism) or production of too much thyroid hormone (hyperthyroidism). Hypothyroidism, or an under active thyroid, has many causes. Some of the causes are prior thyroid surgery, exposure to ionizing radiation, chronic inflammation of the thyroid (autoimmune thyroiditis),iodine deficiency, lack of enzymes to make thyroid hormone, and various kinds of medication [15,22].

Hyperthyroidism, or an overactive thyroid, may also be caused by inflammation of the thyroid, various kinds of medications, and lack of control of thyroid hormone production. One of the most common causes is Graves' disease. Graves' disease happens when the body makes proteins that constantly tell the thyroid to make more thyroid hormone [22].

Proper interpretation of the thyroid data besides clinical examination and complementary investigation is an important issue on the diagnosis of thyroid disease. Various image processing techniques have been used to fit patients into a well defined status.

Most image processing algorithms consist of a few typical steps viz. image preprocessing, segmentation, feature extraction, feature selection and classification. The first step in image processing is the preprocessing step. It has to be done on digitized images to reduce the noise and improve the quality of the image. The segmentation step aims to find suspicious regions of interest (ROIs) containing abnormalities. In the feature extraction step the features are calculated from the characteristics of the region of interest. Critical issue in algorithm design is the feature selection step where the best set of features is selected. Feature selection is defined as selecting a smaller feature subset that leads to the largest value of some classifier performance function. Finally, on the basis of selected features the classification is done.

Further sections cover the survey of image processing algorithms for thyroid disease diagnosis.

II. OVERVIEW OF ALGORITHMS

Thyroid nodules are abnormal lumps growing within the thyroid gland which may represent various different conditions including cancer [6]. Various thyroid nodule detection algorithms are proposed in past. Following subsection describes the same.

A. Thyroid Nodule Detection Algorithms

Chang et al. [2] adopted seven feature extraction techniques viz.co-occurrence matrix, gray level run-length matrix, laws texture energy measures, neighboring gray level dependence matrix, wavelet features and Fourier feature based on local

ISSN 2250-3153

Fourier coefficients.78 textural features were extracted and six of them were selected and classification was done using five binary SVM [2]. Method proposed by authors [2] successfully identifies six kinds of thyroid nodules but requires more time than sequential floating forward selection [23].

Savelonas et al. [4, 6] in 2005 proposed the variable background active contour model for detection of thyroid nodules in USG images which has provided better accuracy compared to active contour without edges model [24]. The proposed model [4, 6] can be applied without preprocessing due to its edge independency.

Isa et al. [9] had experimented for several activation functions such as Sigmoid, Hyperbolic tangent, Neuronal, Logarithmic and sine activation function for MLP neural network and determined the most suitable function to classify the thyroid diseases as hypothyroid or hyperthyroid. Hyperbolic tangent function had shown the capability of achieving the highest accuracy of an MLP performance [9].

Senol et al. [12] had investigated a new hybrid structure in which neural networks and fuzzy logic are combined to diagnose thyroid diseases. Datasets were taken from UCI machine learning repository [25].Fuzzy CSFNN, Fuzzy-MLP and Fuzzy-RBF structures were constituted and their performances had been compared [12]. Proposed hybrid schemes [12] have better performances than ANFIS and non-hybrid schemes. The same method had also been experimented for breast cancer diagnosis.

Anupam Shukla et al. [15], in 2009, had presented the diagnosis of thyroid disorders using Artificial Neural Networks (ANN).Feed forward neural network had been trained using Back propagation algorithm (BPA), RBF neural network and Learning Vector Quantization (LVQ) neural network. Authors had concluded that LVQ network have the best accuracy which is 98% because it doesn’t have a problem of getting trapped in local minima like BP network and doesn’t require a very good coverage of input space , as required by Radial Basis functions used in RBF networks. But RBF NN has the least training time when trained on the thyroid gland data [15].The dataset for this research work had been collected from UCI repository of machine learning database [26].

Saiti et al. [17], in 2009, had proposed SVM and Probabilistic Neural Network (PNN) as classifier. Genetic Algorithms (GAs) had been used for selection of good subsets of features for improving the diagnosis rate. The classification accuracies obtained by this method is better, but SVM has performed better than PNN [17].UCI machine learning database for thyroid gland had been used in this research [25].

Rouhani et al. [19] compared several ANN architectures for diagnosing thyroid disease. The performance of five different networks which include RBF, Generalized Regression Neural Network (GRNN), PNN, LVQ and SVM had been compared. It is found that PNN and RBF outperform other networks. The overall accuracy of 96% is obtained [19].

Eystratios et al. [10] proposed USG image analysis technique for the boundary detection of thyroid nodule. Initially The Region of Interest (ROI) had been selected and the Thyroid Boundary Detection Algorithm (TBD) algorithm had been applied. K-Nearest Neighbor (k-NN) algorithm had been chosen as a powerful and robust non-parametric classification method. The algorithm could work successfully on longitudinal USG images only.

B. *Graves’ disease diagnosis algorithms*

Chang et al. [20], in their investigation devised a novel algorithm for automatic diagnosis of Graves’ disease in USG images. In this method, automatic segmentation of thyroid USG image had been done. Compensation is used to enhance the image. Haar wavelet, homogeneity, blocks difference of inverse probability and normalized multi-scale intensity difference features are extracted. Block classification using RBFNN had been applied to classify the block as thyroid region and non-thyroid region. Segmented thyroid is further inspected for Graves’ disease using artifact compensation and mid-point filtering. Blood test results take weeks to obtain inspection results. Comparatively the proposed approach makes the inspection fast and immediately [20].

Huang et al. [18] had proposed, fully automatic computer-aided thyroid volume measurement method based on planar scintigraphy to avoid the dependence on USG.Thyroid volume is important parameter to plan the dosage in Grave’s disease. The noise is high in scintigraphy as compared to USG images. Hence convolution mask with a standard deviation of 1.5 for calculating the net expansion force is used. Finally the thyroid volume is calculated after adaptive segmentation. The experiments were performed on an image database from the Department of Medicine, Chang Gung Memorial Hospital, Keelong, Taiwan [18].

C. *Thyroid Texture Representation and Retrieval methods*

Keramidas et al. [1] had represented the thyroid texture via noise resistant image features. Fuzzy logic and Local Binary Pattern (FLBP) had been presented and evaluated for improving the texture features considerably, resistant to the speckle noise that is inherent in thyroid USG images. For supervised classification phase of the experimental procedure, the SVM algorithm had been adopted. FLBP approach had been compared with crisp LBP, co-occurrence matrix, and with the Radon transformation approach and demonstrated the higher classification performance of the FLBP [1].

Wang et al. [16] had introduced how the texture feature of the thyroid gland Single Photon Emission Computed Tomography (SPECT) image is gained by co-occurrence matrix. First the image preprocessing had been done. Then gray level co-occurrence matrix had been extracted from preprocessed image. Texture factors such as energy, entropy, moment of inertia, and local stationarity had been calculated from co-occurrence matrix, and then retrieval images had been carried on similarity calculation with images in database. Two effect evaluating indicators are commonly used in the image retrieval: the recall ratio and the precision ratio. The retrieval result was quite satisfactory for threshold value of 0.85 [16].

D. Thyroid Cancer Detection based on Elastography

Elastography is a noninvasive ultrasound procedure to gather information on tissue stiffness. Ding et al. [3] investigated the new computer aided diagnosis algorithm based on elastography for diagnosing the thyroid cancer. In this algorithm, statistical and texture features had been extracted first from the lesion region on the elastogram, then, important and reliable features had been selected using Minimum Redundancy Maximum Relevance (mRMR) algorithm. The selected features were given as an input to a SVM classifier to classify the thyroid nodule. The method had been compared with color score and strain ratio and found to be more accurate and robust [3].

E. Fuzzy Cognitive Map Based Decision Support System for Thyroid Disease Diagnosis

Papageorgiou et al. [14] characterized thyroid diseases with an alternative medical decision support system comprising of knowledge extraction methods and Fuzzy Cognitive Maps (FCMs) producing the FCM based decision support system for thyroid disease management. The proposed method had been compared with several other methods [27] proposed earlier and found to have better performance [14].

F. Clinical Laboratory Expert System

A.S.Varde et al. [28] developed the clinical laboratory expert system in 1991 for the diagnosis of thyroid disfunction.The system had considered both clinical findings and the results of applicable laboratory tests along with the patient's medical history. The system had been implemented using VP-Expert, version 2.02 which is commercially available software [28].

F. Microscopic Thyroid Tissue Classification

Yen-Ting Chen et al. [13] proposed the algorithm for characterizing thyroid tissue using quad tree based segmentation method from heterogeneous microscopic image. Five typical thyroid tissues had been classified. Proposed algorithm has capability of pathological classification of tissues.

III. DISCUSSION

Many algorithms have been proposed for the diagnosis of thyroid diseases using image processing. These algorithms use various kinds of images such as USG, SPECT images and planar scintigraphy. USG is one of the several diagnostic methods currently available for the evaluation of the thyroid gland It combines a unique set of virtues including real time imaging, low cost, mobility, and no side effects. However an inherent characteristic of USG is the presence of multiplicative speckle noise which tends to reduce the image resolution and contrast including the degree of uncertainty. Therefore medical diagnosis based on USG images can be greatly affected by this type of image degradation [1]. There is need of noise resistant texture descriptor for optimal results.

Thyroid nodule detection method based on elastography, considers only solid nodules, regardless the cystic and mixed nodules. Most of cystic and predominant cystic nodules are benign. Hence cystic nodules need the consideration. Besides this the automatic selection of static images and automatic delineation of lesions is required [3].

As far as thyroid nodule detection algorithms are concerned, there is a scope for experimentation to determine the optimal feature extraction and classification methods .Enhancement of the functionality of proposed algorithms is needed to deal with other USG images besides longitudinal USG images of thyroid gland. Evolvement of time efficient scheme is also needed for applications in an integrated real time system for the assessment of thyroid gland.

Algorithms based on ANN, effectively compare the performance of various kinds of NNs and choose the best one for the diagnosis. It is observed that some neural networks like RBF, MLP are found to have best classification accuracy but takes more time for training. ANN can be investigated by employing various activation functions to get higher classification accuracy [9].SVM is also found better as a classifier.

In Grave's disease, thyroid volume estimation is an important factor for the dosage plan of radioiodine therapy. Huang et al. [18] estimated the thyroid volume using planar scintigraphy. This encourages us to further develop new and more efficient approach that can also be applied to SPECT and USG images.

IV. CONCLUSION

Thyroid is among the most important organs of human body which have a high influence on the performance of other body parts. Since thyroid hormones are responsible to control the body metabolism, the performance of the thyroid gland directly influences each of the main body organs. Computer-aided detection and diagnosis algorithms have been developed to help radiologists give an accurate diagnosis and to reduce the number of wrong decisions regarding the thyroid diseases. Number of algorithms have been developed for detection of thyroid nodules, automatic diagnosis of thyroid Graves' disease and various other thyroid diseases. In this paper, algorithms that are commonly used and the ones recently developed are discussed. Over the years there has been an improvement in the detection algorithms but their performance is still not perfect. Possible reason for such a performance may be the multiplicative speckle noise and artifacts inherent in USG and other images which make the segmentation of correct regions of interest difficult. Another issue is extracting and selecting appropriate features that will give the best classification results. Furthermore, the choice of a classifier has a great influence on the final result and classifying abnormalities of thyroid nodule as benign or malignant is a difficult task even for expert radiologists. Further developments in each algorithm step are required to improve the overall performance of computer aided detection and diagnosis algorithms.

REFERENCES

[1] Eystratios G. Keramidas, Dimitris K. Iakovidis, "Thyroid Texture Representation via Noise Resistant Image Features " ,IEEE International Symposium on computer – based Medical Systems , 2008, pp 560-565

[2] Chuan-Yu Chang, Ming-Fang Tsai and Shao-Jer Chen," Classification of the Thyroid Nodules Using Support Vector Machines" International joint conference on Neural Networks 2008, pp 3093- 3098.

[3] Jianrui Ding, H.D. Cheng, Chunping Ning, "Novel Quantitative Measurement for Thyroid Cancer Detection Based on Elastography", The 4th International congress on Image and signal processing. 2011, pp- 1801-1804.

[4] D.E. Maroulis, M.A. Savelonas and S.A. Karkanis, "Computer –Aided Thyroid Nodule Detection in Ultrasound Images" 18th IEEE International Symposium on computer based medical systems(CBMS'05),2005.

[5] C.C.Leung, F.H.Y. Chan, K.Y. Lam and P.C.K. Kwok, "Thyroid Cancer Cells Boundary Location by Fuzzy Edge Detection Method" , 2000 IEEE. pp 360 – 363.

[6] M. Savelonas, D. Maroulis, D. Iakovidis and S. Karkanis, "Variable Background Active Contour Model for Automatic Detection of Thyroid Nodules in Ultrasound Images ", 2005.

[7] Gheorghe Gavriloaia and Roxana-Mariuca Gavriloaia, "Spatiotemporal Filtering for Ultrasound Images", International joint conference on biomedical engg. And informatics,2011, pp 502- 505.

[8] Felix Grimm, Xavier Fabregas and Horst Bonke, "Knowledge Based Interpretation of Thyroid Scintigrams ", 1994, pp 230 – 239.

[9] I.S.Isa,Z.Saad,S.Omar,M.K.Osman,K.A.Ahma ,"Suitable MLP Network Activation Functions for Breast Cancer and Thyroid Disease Detection" ,Second international conference on computational intelligence,modelling and simulation,2010 IEEE, pp 39 – 44.

[10] Eystratios G.Keramidas,Dimitris K.Iakovidis,Dimitris Maroulis and Stavros Karkanis "Efficient and effective image analysis scheme for thyroid nodule detection ".

[11] Sergio Okida,M.Heloisa,B.S.Canalli,Fernando M.de Azevedo and Jefferson L.B.Marques, "Expert System to Support the Diagnosis of Thyroid Nodules", 22nd Annual EMBS International Conference ,July 23-28,2000,Chicago, pp 2365- 2368.

[12] Canon SENOL,Tulay YILDIRIM, "Thyroid and Breast Cancer Disease Diagnosis using Fuzzy-Neural Network ", unpublished.

[13] Yen-Ting Chen,Chu-Ju Hou,Min-Wei Lee,Sha-Jer Chen,Yao-Chuan Tsai,Tzu-Hsuan Hsu, "The image feature analysis for microscopic thyroid tissue classification", 30th annual international IEEE EMBS Conference Vancouver,British Columbia,Canada,August 20-24,2008, pp: 4059-4062.

[14] Elpiniki I.Papageorgiou,Nikolaos I.Papandrianos,Dimitrios J.Apostolopoulos,and Pavlos J.Vassilakos, "Fuzzy cognitive map based decision support system for thyroid diagnosis management", 2008 IEEE conference on Fuzzy Systems (FUZZ 2008) ", pp.1204-1211,2008.

[15] Anupama Shukla,Prabhdeep Kaur, "Diagnosis of thyroid disorders using artificial neural networks " ,2009 IEEE International Advance computing Conference(IACC 2009)– Patiala ,India , 2009, pp 1016-1020.

[16] Xiangbin Wang,Junmin He,Zhongwei Lv, " Texture Based Retrieval of Thyroid Gland SPECT Image", 2nd International conference on Biomedical Engineering and Informatics(BMEI 2009) 2009.

[17] Fatemah Saiti,Afsaneh Alavi Naini,Mahdi Aliyari shoorehdeli,Mohammad Teshnehlab , "Thyroid disease diagnosis based on genetic algorithm using PNN and SVM", 2009 IEEE, pp 1-4

[18] Jia-Yang Huang,Ming-Fong Tsai,Kun-Ju Lin,Yung-Sheng Chen, "Automatic thyroid volume estimation in graves disease using planar scintigraphy" ,2009 IEEE ,2009.

[19] Modjtaba Rouhani,Kamran Mansouri, "Comparison of several ANN architectures on the thyroid diseases grades diagnosis " , 2009 International Association of computer science and information technology-spring conference, 2009, pp 526-528.

[20] Chuan-Yu Chang,Hsiang-Yi Liu,Chin-Hsiao Tseng,Shyang-Rong Shih, "Automatic diagnosis of thyroid graves diseases in ultrasound images", 9nd International conference on hybrid intelligent systems 2009 IEEE, 2009.

[21] Saeed Shariati,Mahdi Motavalli Haghighi, "Comparison of anfis neural network with several other anns and support vector machine for diagnosing hepatitis and thyroid diseases", 2010 IEEE, pp 596-599.

[22] Erdem Alkim, Emre Gurbuz,erdal Kilic, "A new intelligent diagnosis method to determine thyroid disorders" , 2011 IEEE 19th signal processing and communication s Applications Coference, 2011 IEEE , pp 38-41.

[23] Pudil P., Ferri F.J., Novovicova J. and Kittler J., " Floating Search Methods for Feature Selection with Nonmonotonic Criterion Functions", *Proceedings of the 12th IAPR International Conference on Pattern Recognition,* Vol. 2. 1994.

[24] T.F. Chan, L.A. Vesse, "Active Contours Without Edges", IEEE Trans. Image Processing, vol. 7, pp. 266-277, February 2001.

[25] www.ics.uci.edu/pub/ml-repos/machine-learningdatabases thyroid-disease/ accessed May 2012.

[26] UCI repository of machine learning databases, http.//archive. ics. uci. edu/ml/datasets. html accessed May 2012.

[27] Lale OZYLMAZ and Tulay YILDIRIM, "Diagnosis of Thyroid Disease using Artificial Neural Network Methods", Proceeding of the 9th International Conference on Neural Information Processing (ICONIP'02), Vol.4, pp 2033-2036.

[28] A.S.Varde,K.L.Massey and H.C.Wood, "A Clinical Laboratory Expert System for the Diagnosis of Thyroid Disfunction", Proceeding of Annual International Conference of the IEEE Engineering in Medicine and Biology Society,Vol. 13, No. 3, 1991 IEEE, pp 1288-1289.

AUTHORS

First Author – Ms.Wrushali Mendre, M.Tech (Electonics and Telecommunication Engineering), Smt.Kashibai Navale College of Engg.Pune,India. vrushalimendre@gmail.com
Second Author –Dr.R.D.Raut, PhD (Electronics), Department of Applied Science SGB Amravati University, Amravati, India Rdr24164@rediffmail.com

Correspondence Author – Ms.Wrushali Mendre, M.Tech (Electonics and Telecommunication Engineering), Smt.Kashibai Navale College of Engg.Pune,India. vrushalimendre@gmail.com Mob.No.-9923318187