Machine Learning Thyroid Nodules Classification

Sruthy B.S, S.Muruganantham

Abstract*: An overview is presented of thyroid medical image processing literature on thyroid cancer diagnosis.The main aim of this survey is to introduce for those new to this feild,and a reference for those who searching for specific literature survey on application.Thyroid cancer is now commonly seen one and main concern in nowdays due to the risk of malignancies and hyper function.The nodules becomes more malignant if it is not diagnosied at right time.computer aided detection of thyroid nodules and various image processing techniques and methods are used for effective and efficient classification of thyroid nodules. Diagnostic imaging is an important tool in medical science due to the continuous observations of the expert and uncertaninty in medical knowledge. A thyroid ultrasound is a more commonly used imaging study used to detect and classify abnormalities of the thyroid gland clearly and correctly. Computerized system is a valuable and beneficial means for feature extraction and classification of thyroid nodule in order to eliminate false diagnosis and to improve the diagnostic accuracy. The main aim of this paper is to review existing methods and techniques to the automatic classification of nodules in thyroid ultrasound images, highlighting the main differences between the used strategies and also for the diagnosis of Nodules in thyroid ultrasound images with their performance measures.

IndexTerms:Nodules,Thyroid,Ultrasound,Classification,cancerdiagnosis,,image processing.

I. INTRODUCTION

Thyroid is a small gland located at the region of our neck. This gland makes thyroid hormone that travels in blood to all parts of body. The thyroid hormone controls body's metabolism. It also releases hormones that direct many functions in our body. Thyroid cancer that develops from the tissues of thyroid Gland.

It is a disease in which cells grow abnormally and have to spread to other parts of the body. The first symptom of thyroid cancer is a nodule in thyroid region of the neck.65% of adults has same nodules in their thyroids but typically fewer than 10% of these nodules are found to be cancerous. Computer aided diagnosis (CAD) help radiologists and doctors to identify the cancerous region easily and diagnosis also done properly. Many researches have been carried out in thyroid medical images and misleading diagnosis prevented disease affects more women than men. Computer Aided Diagnostic (CAD)systems have brought substantial change and traditional diagnostic systems are converted into computer based diagnostic systems such as DSS (decision support systems) for diabetes, retinopathy, cardiac, thyroid and so on. In the last three decades, thyroid cancer continuously increased, thyroid cancer is the fifth most common cancer in women recent year. With the increasing number of patients with thyroid disease, the volume of imaging and clinical data is increasing dramatically meanwhile .manual examination of the patients data is therefore time and labor intensive and examiner dependent and variant. Computer aided diagnosis systems are developed to assist clinical professionals in effective and efficient thyroid disease diagnosis, treatment and management procedures.

A careful examination is required to be directed to estimate the structural and functional states of the gland because despite of initial structural changes thyroid glands. Due to this misleading nature of normal values with minor differences creates lots of difficulties for physicians during the diagnostic phase that either thyroid disease is going to be developed at structural level or not. Thus a patient would be saved from misdiagnosis by making the proper assessment of the gland as it is one of major problems in healthcare industry. In these circumstances proper diagnoses of thyroid disease types are of great importance, since some of these types are very prone to be converted into cancer. Thyroid cancer can spread directly via lymphatic or via blood. It may affect to surrounding tissues.

The thyroid cancer can be classified according to their histopathological characteristics

Papillary Thyroid cancerSeen in young females occur due to familial adenomatous polyposis.

Follicular Thyroid cancerSeen in people with Cowden syndrome.

Medullary Thyroid Cancer of Para follicular cells.Anaplastic Thyroid cancer

Anaplastic Thyroid cancer Not responsive to treatment cause pressure symptoms

A. Simple Diagnostic Methods

1) Physical Examination-Checking the general body conditions of the patient.

2) Temperature test for measuring Thyroid Function-Due to excessing of temperature based upon the continuous updating of 4 to 5 days.

B.Pathological Diagnostic Methods

Revised Manuscript Received on December 22, 2018.

Sruthy B.Research Scholar in Computer Science(18223152162026)–S,T.HinduCollege,Nagercoil,AffliatedtoManonmaniumSundaranarUniversity, Tirunelveli-627412.

Dr.S.muruganantham,Research Scholar in Computer Science(18223152162026),S,T.HinduCollege,Nagercoil.AffliatedtoManonmaniumSundaranarUniversity, Tirunelveli-627412.

1) Thyroid Function Test-Used blood test.It is a painful process.

2) Ultrasound guided fine needle fine aspiration biopsy-It is an accurate method. Needle is inserted in affected parts of body with help of ultrasound.

3) Immunofluorescences detection method.It visualized based on ultraviolet rays or fluorescence.

4) Test by Radio immunoassay detection method.Based upon the blood sample

C. Diagnosis by Imaging Methods

1)Radioiodine Scan

Radioactive material radioiodine is given before test get through injection, liquid or tablet gamma rays releases. Scanner detects this type of energy.

2) Ultrasonography

Transducers produce high frequency signal, applied to neck the transducer collects the sounds and bounce back to computer uses these sound waves to create an image. They show the structure and movement of body's internal organ as well as blood flowing through blood vessels and give idea about the shape and size and location about thyroid glands.

3) Positron Emission Tomography (PET scan)

PET detects gamma rays from tracer and they are displayed on monitor.

4) D.X-rays

Image recorded on a film called radiograph, produced images light or dark depending upon the absorption rates of different tissues.

5) E.CT Scan

X-ray computerized tomography makes use of computer processed combinations of many x-rays images and produces cross tomography.

6) Fluroscopy

Used to see the internal structure and function of a patient. It uses continues x rays to obtain real time moving images.

7)MRI(Magnetic Resonance Imaging)

The powerful scanner magnets can pull the needle of compass towards the protons in body. Short radio waves are sent to certain areas of body knocks the protons out of alignment. It also help to distinguish various types of tissue in body, the signals from millions of protons in the body are combined to create detailed image inside the body.Thyroid happens when cancer cells form from tissues of thyroid gland. The thyroid cancer have thyroid nodule that does not cause any symptoms. Surgery to take out whole thyroid gland or safely removed. If cancer is small surgery can cure thyroid cancer.

II. LITERATURE SURVEY

Chaunet al.[1] According to this research, thyroid modules were categorized as enlarged follicles. Support Vector Machine (SVM) based thyroid classification method was proposed. The feautures(the enlarged follicles, follicular cells with follicules,the papillary cells with follicles, the follicular cells with fibrosis, the papillary cells with fibrosis) was extracted from each ROI's which was identified by the radiologist and by biopsy then applied SVM feautures selection and obtain more discriminative feature set of different categorizes of thyroid nodules. SVM was trained by shifted features of corresponding category. Based upon the classification approach successfully identifies six kinds of thyroid nodules.Roberto et al. [2]had examined three steps were used to reconstruct the intra-nodular vasculature, by using 3-D contrast enhanced ultrasound. The image is first preprocessed and then performed morphological opening. It was based on processing of volumes based on thresholding and 3-D representation. Contrast enhanced Ultrasound Imaging (CEUI) has introduced to improve the diagnosis.CEUI distribute the micro bubbles into lessions to differentiate between benign and malignant nodules are identified by increased intranodularvasculature.Konstantin et al. [3] introduced a classification scheme for medical application to validate Fine Needle Aspiration (FNA) examination. Artificial Immune System (AIS) is used to identify thyroid malignancy diagnosis.BoxCells is an proposed algorithm applied on FNA. Feature selection is performed to reduce dimensionally of input FNA and classification done using AIS based classifier.Rajendra et al. [4] had presented a Computer Aided Diagnosis (CAD) based technique for automatic classification of benign and malignant thyroid lesions in 3D contrast-enhanced ultrasound images. Discrete Wavelet Transform (DWT) and texture based features were

extracted from the thyroid images. The resulting feature vectors were used to train and test three different classifiers: K-Nearest Neighbor (K-NN), Probabilistic Neural Network (PNN), and Decision Tree (DeTr) using ten-fold cross validation techniqueGopinath et al.[5] had proposed Computer aided diagnostic system for diagnosis of thyroid cancer pattern in Fine Needle Aspiration Cytology(FNAC).Samples are tested based on region based morphology. Texture features are derived using Gabor Filter bank at various wave length and angles. The SVM uses machine learning algorithm to identify the benign and malignancy of cancer.SVM classifier was used forclassification which is used to perform nonlinear classification using kernel trick and map their inputs to high dimensions. It is proved that SVM classifier with trained feautures gives high performance than K-NN classifier for automated diagnosis.Maria et al.[6], had examined high frequency quantitative spectral and envelope based parameters are used to differentiate cancerous thyroids from normal/benign thyroids in a rodent model. The two dimensional feature spaces was allowed to perform

classification. The performance was achieved by using effective acoustic concentration parameters and this parameter observed to increase from normal/benign thyroid to cancerous thyroids. This research used nonlinear classification approach and quantitative ultra sound analysis to differentiate the different types of malignant Jianruri et al.[7] had proposed the thyroid B-mode ultrasound image and elastogram are viewed as a bag. Computer Aided Diagnosis system used to improve thyroid cancer detection and classification. First the B-mode vector image is constructed. The features are clustered and ROI was projected to concept space, next the elastogram feature vector is constructed first, the B-mode image feature vector is constructed. The hue component is extracted and processed. The statistical texture features are extracted from elastogram. Finally traditional supervised method employed to classify the bags. A Multiple Instance Method (MIL) is presented to classify the thyroid nodules.Hanunget al.[8] had suggested a study to extract the nodules of thyroid. From the US image ROI is determined and preprocessed using median filter and morphological methods are used to change the structure of object. Histogram equalization is used to assign uniform intensity in image. Feature extraction done by means Gray Level Co-Occurrence Matrix (GLCM) and Gray Level Run Length Matrix(GLRLM).Cfs (Correlation Based Feature Selection) subset evaluation is done for feature selection. Classification is done by means of Multilayer perceptron it classify images in to two categories of cystic and solid. Handgun et al.[9], used to construct classifier models using machine learning algorithms to evaluate diagnostic performance for differentiating malignant from thyroid nodules. Ultrasound images and nodules were graded according to five –tier sonographic scoring system. Observation obtained using fivefold cross validation. Bayes classifier was used and output was queried using Bayesian network which 0will then directed the output queried using Bayesian network which will directed the output to input again an SVM classifier was trained with learning algorithms from optimization theory .Radial Basis

Function-Neural Network (RBF-NN) method was used a clustering method to obtain the center of RBF.Performance was compared using ROC curve analysis Liu et al.[10] had proposed Ultrasonography is a valuable diagnosis method for

thyroid nodules. Proposed feautures extraction method for ultrasound image based on CNN(Convolutional Neural Network).CNN is trained with natural dataset and transferred to US image to generate semantic deep feautures and handle small problems then combined deep features with conventional feautures such as Histogram of oriented gradient and Local Binary pattern to form hybrid feature space. Finally the last positive sample first majority and feature selected based strategy are employed for hybrid classification. In this work VGG-F model trained from IMAGENET is used to extract feautures and for complete classificationYezhu et al.[11], explored the problem of thyroid nodule classification. The overall process includes preprocessing of ultrasound images, image augmentation and classification by transfer learning. The preprocessing step focuses on extraction of ROI for data augmentation. Used two different means, the traditional method that augments data by direct original images and convolutional method that uses 3layer convolutional network to generate new images. For final classification a pertained residual net is adopted for transfer learning and three sets of experiment are conducted based on different datasets and performance was evaluated. Final results have shown the effectiveness of convolutional network in generating new thyroid ultrasound imagesXueyan et al.[12] had proposed deep learning feature extraction and machine learning classifier to predict the benignity of thyroid nodules. Uses convolutional auto encoders to extract useful features from US images of thyroid nodules then to add more spatial pattern features use computer vision techniques also uses local binary patterns and histogram of oriented gradients to capture the appearance and shape the object. Thyroid Imaging Reporting and Data Systems (TIRADS) as described by attained radiologist. Finally all the features mentioned above were used to train on classifier. Support Vector classifier used to reduce the goal of false negative rate. From this research it is useful for clinical practice to reduce unnecessary benign biopsies. Zulfanahri et al.[13]had suggested Ultrasound image is one of the modalities that are widely used to examine the abnormality of thyroid gland, since it is low cost and safety. This research proposes a scheme for classifying thyroid nodule based on shape feature analysis in to two classes is round to oval and irregular classes. Image is preprocessed using Adaptive Median and SRB filtering. Segmentation was done through Active contour and morphology operation. Feature extraction uses Zernike and Invariant moments are used for shape recognizing. Feature selection is done through Correlation Based Feature Selection (CFS)used subset evaluation and results are classified using SVM classifier. Muhammad et al.[14],had presented a computer aided diagnosis system for classifying thyroid nodules in ultrasound images. The image is pre-processed to remove annotations and sample augmentation was done. Then the image was classified based upon fine tuning an existing deep convolutional neural network ie is Google Net. Automated benign & malignant thyroid lesion characterization and classification in 3D contrast-enhanced ultrasound.Jianninget al.[15],had proposed, image enhancement in US obtained by spatial linear filter morphological opening by diamond structure element and the image is divide by filtered image and opened image and transform image into gray scale. Then the image is segmented by thresholding then the feautures extraction is done by using hill climbing algorithm. Classification done by using Support vector machinesAmir et al.[16] had suggested that online learning method is used continuously. All the features are normalized and unnecessary features are removed using feautures rejection method. Two decision trees are trained for classification.one is simple decision tree based classifier other is cost aware version of first. Provides better results than individual classifiers. Classification updated using weighed majority system.Farihah et al.[17],had evaluated the reliability of Ultra sound classification

system in predicting thyroid malignancy by using pathology diagnosis as reference standard and also uses US guided Fine Needle Aspiration Cytology (FNAC) based upon British Thyroid Association (BTA) .Correlation of ultrasound classification with pathology results was accessed. Conservation method is used to calculate the sensitivity.Dandanetal.[18] , had proposed the method of classification of diffuses thyroid disease based on ultrasound images. Diffuse thyroid disease had a bad impact as HASHIMOTO disease and GRAVES disease are the two most common thyroid diffuse disease .uses Wavelet Multi-Sub Bands Co-Occurrence Matrix (WMCM) based new texture features can be evaluated. Fibrous variant texture is important feautures in which bright parts are identified as HT disease image and normal as Grave disease.GLCM(Gray Level Co-occurrence) and GLRL(Gray Level Run Length Matrix) are used for expand the feature space.ROI is extracted and preprocessed for Normal and Grave disease ROI should be uniform. For HT there seen a fibrous variant. Minimal Redundancy Maximum Relevance (MRMR) algorithm is used to achieve feature selection. Two level classifications were adopted using KNN classifier and SVM classifier. The classifiers distinguished image of thyroid with diffuses from images of normal thyroid tissue. Images of thyroid with Graves disease and HT disease were separated from each other.Zhang et al [19]had presented the uses novel multichannel feautures association and fusion learning(FAFL)for thyroid tissue classification from multi-modality MRI images. It has three layers 1.Two layer convolutional neural network for produce 3 multi-channel CNN tensors.2.Multi feautures association layer used to fuse the three layer CNN tensor to generate new feature association tensor.3.used to connect the multichannel CNN tensors for classification.FAFL takes one input image and produce 3 modalities .CNN Which gives classification of input image based on accuracy, specificity and sensitivity. Uses deep learning modal support vector machine for classification.Jianxion et al.[20],had proposed the semi supervised method based on weakly labeled data to automatically classify US images into thyroid nodules.US images as a bag and corresponding pathology report result as bag label. First generate bag instances then they are preprocessed applied proposal extraction method and

classification done through VGG-16 to obtain ROI. Non maximum suppression algorithm was used to merge and regenerate nodule of ROI'S to get final nodule. Finally uses CNN based nodule classification with EM algorithm on weakly labeled training data. At last image is applied to trained nodule classification model to obtain benign or malignant classification result.

III. CLASSIFICATION

The regions classified as lessions and non-lessions or benign or malignant based upon the features that we selected using various classification methods. The Thyroid Imaging Reporting and Data System(TIRADS) are standardized US based characterization and support reporting data system of thyroid classification for Clinical managements.

A. Categories:

1) TIRADS 1-normal thyroid gland
2) TIRADS 2-benign conditions (0% Malignancy)
3) TIRADS 3-proably benign nodules (<5% Malignancy)
4) TIRADS 4-Suspicious nodules (5-80%) Malignancy
5) TIRADS 5-Malignant nodules (>80%)
6) TIRADS 6-Included biopsy proven malignant nodules

TABLE: 1 COMPARISION USING VARIOUS CLASSIFICATION METHODS

Publication year	Reference	Methodology	Data collected	Accuracy
2008	[1]	a.co-occurrence matrix wavelet features c. Law texture energy measures	Data set obtained from available sonographic system LOQ10 700 ultrasound system approved by General Electric Healthcare,Chailes UK	99.8 %
2008	[2]	a.Morphological aperture b.Thresholding and 3D construction	Images acquired by My Lab 70 US device and approved by "Umberto I "Hospital of Torino	98%

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

2009	[3]	a.Box cells population cloning box cells c.Inflation and Deflation of Box cells	Data collected from department of pathology of medical school of athens	98%
2012	[4]	a.Discrete wavelet transform b.Neural network c.Decesion tree	Data collected from "Umberto I" hospital of Toronto	93%
2013	[5]	a.Morphological Transform b.Gabor filter	fnac image have been used from on-line image atlas papanicolaousociety of cytology approved by atlas committee	95%
2014	[6]	a.Effective acoustic concentration b.Effective scattering diameter	Data collected using single element transducer using a Olympus panametrics 5900 receiver ,strategic test corporation woubon	87%
2014	[7]	a.13 mode feature vector mode feature vector	Data base collected from department of ultrasound second Affiliated Hospital of Harbin medical	96.8 %
2016	[8]	a.Gray level co-occurance matrix b.Gray level run length matrix	Image was obtained from Sardjito hospital Yogyakarta database	89.74%
2016	[9]	a.classifier model construction	Dataset collected from Institute of Nuclear medicine	88.66%
2017	[11]	a.Residual net transfer learning	Open access provided by Universidad Nacional; decolombia,Instituto de DiagnOstiocomedico	93.75%

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

2017	[12]	a.Auto encoders b.Local Binary patterns	Cases collected at East river medical imaging using general Loqiq L9 and 69 ultrasound Machines	94%
2017	[13]	a.Active Contour b.Zernike and invariant c.Correlation based feature	US images taken from Department of Radiology Sardjito hospital ,Yogyakarta	91.52%
2017	[14]	a.Online Ensemble a.Offline Ensemble	Data is a publicly availabl e thyroid ultrasound images and from local databas e	96%
2017	[15]	a.Sample Augmentation b.GoogLeNet	Data collected from local databas e	92%
2017	[16]	a.Spatial linear filtering b.Thresholding	Dataset collected from Center of machine learning and intelligent systems, university of California	99.8%
2018	[17]	a.U classification method suggested by BTA.	US images collected from university kebangsaan Malaysia medical center	98%
2018	[18]	a.Wavelet Multi –sub-bands Co-occurance Matrix b.Gray level co-occurance matrix	Data collected fromdepartment of us of second affiliated hospital of Harbin medical university	87.83%
2018	[19]	a.Data augmentation b.Multi –feature association	Data collected using 63AC55C scanner philiphs healthcare.	80.91%

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

2018	[20]	a.ROI detection with VGG-16 b.ROI merging	Data collected from the peking union medical hospital and publicly availabe databas	80.91%

IV. CONCLUSIONS

Different techniques were applied by different researchers to process the Thyroid Ultrasound ,but the structures were very difficult to visible due to noise unclearness, blurred and uncertainty in Thyroid Ultrasound.To detect the abnormal structure of thyroid, perceptive ways must be found out to analysis and describe the correctness in US image. So the above mentioned techniques and methods are useful to find out the structural behavior of Thyroid US image. Therefore this research would also helpful for characterization of nodules, it is an valuable tool for follow up the diagnosing the nodules in thyroid images and lead to false diagnosis related thyroid diseases. Many physicians are confessed about the nature of various echoes due to low resolution of US.so more efficient classifiers used to improve the accuracy of performance of thyroid nodules as benign/malignant. Studies regarding different feature extraction techniques and classification techniques could be carried out clearly, hardly and correctly. The deep learning and machine learning approaches are much more widely used for the classification of thyroid nodules. This work basically provides an summary about the existing automatic tools available to develop disease diagnosis part easier and also well efficient. Different execution evaluation metrics are studied and future developments and trends are also investigated. Such techniques will help the diagnosis process by automatically detect the nodules in thyroid images and reduce the false diagnosis. The feasible feature extraction and classification methods for detecting thyroid nodules can be determined and applied to ultrasound images using various methods and techniques for application in an integrated real-time system for thyroid gland in future.

REFERENCES

1. Chuan-yu-chang, Ming-fang Tsai and shao-jer chin “Classification of thyroid nodules using Support Vector Machines”-2008
2. Robertocarraro, FilippoMolinari, MaurilioPeandra, RobertoGarberoglio”Characterization of thyroid nodules by 3-D contrast enhanced ultrasound Imaging.
3. Konstantin us k.Delibasis, George k matsopoulos, Panatelas A Asbestos “Computer Aided diagnosis of thyroid malignancy using an Artificial Immune system classification”-2009
4. U.RajendraAcharya, VinithaSree “Automated Benign and Malignant Thyroid Lessions Characterization and Classification in 3D Contrast –Enhanced Ultrasound”.
5. B.Gopinath, N.Shanthi “Support vector machine based diagnostic system for thyroid cancer using statistical texture features”-2013
6. MariaLusiaMontero,OmarZenteno,BenjaminCastaneda,MichaelOelze” Evaluation Of Classification Strategies Using Quantitative Ultrasound Markers and a Thyroid Cancer Rodent Model”.
7. Jianruri Ding, H.D Cheng, Jianhua Huang” Multiple instance learning with global and local features for thyroid ultrasound image classification”-2014
8. HANUNG Aid Nugroho, Made Rahmawaty, YuliTriyani,”Texture analysis for classification of thyroid ultrasound images”-2016
9. Handgun Wu,ZhaohongDeng,BingjieZhang,”Classifier model based on machine learning algorithms :Application to differential diagnosis of suspicious thyroid nodules via sonography”-2016
10. [TianjiaoLiu,ShuainingXie,JingYu,LijuanNiu,WeidongSum, “Classification of thyroid nodules in ultrasound images using deep model based transfer learning and hybrid features”-2017
11. Yezhu, Zhuang ,Jainfei”An image augmentation method using convolutional network for thyroid nodule classification by transfer learning”-2017
12. Xueyan Mei, Xiaomeng Dong, Timothy Deyer, Jing0yizeng”Thyroid nodule Benignity prediction by deep feature extraction”-2017
13. Zulfanahri,Hanung,AdiNugroho, Anan Nughroho,”Classification of thyroid ultrasound images based on shape features analysis”-2017
14. Muhammad Anjou0 Qureshi,Kub0ilay0 Eksioglu0,”Expert Advice Ensemble for Thyroid disease diagnosis”-2017
15. JianningChi,EktaWalia,P aulBabyn”Thyroid Nodule Classification in Ultrasound Images by Fine-Tuning Deep Convultional Neural Network”.2017
16. Amir Torah,Miandoab and TahasSamadi,SogandHabibi”Image Processing Techniques for Determining Cold Thyroid Nodules”-2017
17. FarihahAbdGhani,Nurismah,HusyairiHarunarashid,RadhikaSridharan, ”Reliability of the ultrasound classification system of thyroid nodules in predicting Malignancy”-2018
18. LiDandan,ZhangYakui,DuLinyao,ZhouXiannli,ShenYi”Texture analysis classification of diffuse thyroid disease based on ultrasound images”-2018
19. Rong Zhang.QiufangLiu,HuiCui,”Thyroid Classification Via New Multi-Channel Feature Association And Learning From Multi-Modality MRI images”.-2018
20. Jianxiongwang,shuai Li Wenfengsong,HongQin,”Learning from weakly –labelled clinical data for automatic thyroid nodule classification in ultrasound images-2018.