

# Approaches of Detecting and Analyzing the Thyroid Disease : *A Review*

Ms. Namrata V. Kanase  
Dept. of Electronics Engineering  
MIT Academy of Engineering  
Alandi, Pune, India.  
nvkanase@mitaoe.ac.in

Mr. Satyajit A. Pangaonkar  
Dept. of Electronics Engineering  
MIT Academy of Engineering  
Alandi, Pune, India.  
sapangaonkar@entc.maepune.ac.in

Mr. Ashish R. Panat  
Dept. of Electronics & Comm.  
Engineering  
MITADT University  
Rajbaug, Pune, India.  
ashish.panat@mituniversity.edu.in

**Abstract**—Speech signal processing is one of the most interesting areas to work with. Speech signal consists of scads of information like gender categorization, various voice features, emotion characteristics etc. Every speaker and speech has its own special signal characteristics. This review is a proposed approach which is an analysis of various methods for detecting the thyroid diseases. Basically, thyroid is butterfly-shaped gland present in the lower anterior of the neck. This controls the metabolism of the body. Different methods used for detecting thyroid disease differentiating into two ways i.e. Biomedical Analysis and Signal Processing. In this review, diverse bio-medical methods like voice self-perceptual assessment, statistical analysis, complication analysis and surgical analysis has been explained.. In signal processing method, CAD (Computer Aided Diagnosis) and Acoustic Voice Analysis approaches are found. The main approach of this review is to illustrate the various methods and approaches available to detect thyroid disorders.

**Keywords**—Hypothyroidism, Hyperthyroidism, Acoustic Voice Analysis, Thyroid Stimulating Hormone, Thyroid Function Test.

## I. INTRODUCTION

Thyroid is butterfly-shaped gland present in the lower anterior of the neck. The role of gland is to create thyroid hormone. Thyroid gland is one of the largest endocrine glands in the body. Weight of thyroid gland is about 30g [5]. Thyroxine and triiodothyronine are two active thyroid hormones. That effect on protein production, body temperature regulation, energy production and energy regulation of the human body [8]. If the thyroid gland does not work properly, then the disease related to the thyroid occurs. Thyroid disease is the second largest disease in the endocrine field. Basically, thyroid disease is divided into two groups, i.e. Hypothyroidism, and Hyperthyroidism. In Hypothyroidism, the thyroid gland does not produce the required amount of hormone to the body. So it slows down the working of the body. Due to hypothyroidism condition, many thyroid gland related problems occur. In Hyperthyroidism, the thyroid gland produces too much thyroid hormone. This is not necessary for the body, because of that excess creation of hormone makes many disorders of the thyroid gland. There are many tests are available to check disorders related to the thyroid. In practical clinical practice, many approaches can be used to diagnose thyroid diseases. Such as clinical evaluation, blood

examination, thyroid hormone (TSH) detection, imaging examination, tissue biopsy and self-perception assessment by a speech pathologist [8].

In this review, different methods of detecting and analyzing thyroid diseases are studied. The methods of detecting thyroid disease are differentiated in two ways. One is a bio-medical method and acoustic voice analysis. In bio-medical analysis method, various tests are carried out like blood examinations, TSH (Thyroid Stimulating Hormone), TFT (Thyroid Function Test), tissue biopsy, etc. According to the above test, the doctor is diagnosing the level of disease patient has, like Hypothyroidism, Hyperthyroidism or thyroid cancer. Acoustic Voice Analysis (AVA) can give important objective data on voice disturbances, especially those with organic and functional origins [8]. Consequently, it will obtain the features of voice changes in thyroid patients and what are the impacts on voice characteristics. And the main aim of this method is to check which features of voice is affected due to thyroid. For calculating the result of this method uses various techniques of speech signal processing. Speech signal processing technique uses for this method is feature extraction, feature reduction, classification, decision space and performance evaluation methods etc.

In this paper, section II deals with related work carried out for diagnosing thyroid diseases and numerous material and methods used. In section III and IV, discussion further navigates to various methods used for detecting and analysis of thyroid disease in biomedical and signal processing aspect. The glossary represents the summarized quote.

## II. RELATED WORK

### A. Block Diagram

The figure below shows the different stages involved in the process of detecting the thyroid diseases detection. The stages include feature extraction, Feature reduction, classification, decision space and performance evaluation. Each stage has its own operation to detect the thyroid disease. This diagram gives idea about which stages are required to complete the task of thyroid disease detection.

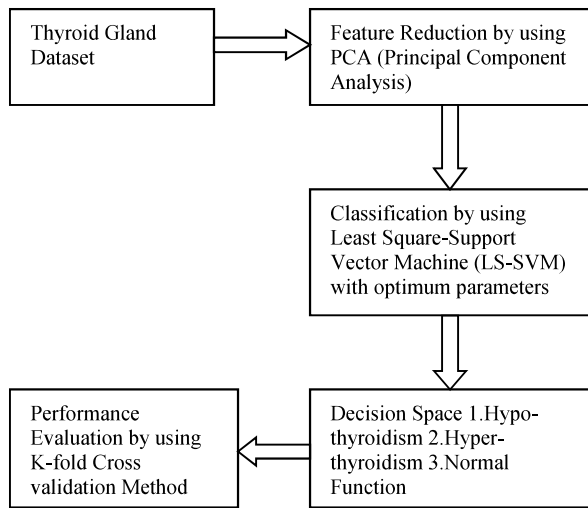


Figure 1: Block Diagram of Thyroid Disease Detection System [10]

### B. Methodology of the existing techniques:

The present techniques involves basic steps like feature extraction and classification [10]. Further section explains this in short:

#### • Feature Extraction

Esin Dogantekin et al. [10] have proposed in this work is a PCA (Principle Component Analysis), used for the feature reduction. Here are featured reduction is the statistical process for minimizing the random variables under analysis for finding a set of principle variables. PCA is a widely used technique for obtaining features in data for high dimensions. PCA is used for dimension reduction of high dimension feature vector [10]. For calculating the feature vector dimension following equation is used.

$$C = (1/L) \sum_{k=1}^L (X_k - m)^T (X_k - m) \quad (1)$$

$X_k \in M$ ,  $M = t$ - dimensional data set  
 $m$  = mean of samples  
 $L$  = No. of samples

Ahmed Taher Azar et al. [11] have discussed LDA (Linear Discriminant Analysis) as a feature selection method for a thyroid disorder. This gives higher accuracy of the system. LDA is a statistical method for extracting one or more feature vector from an event.

Azlee Zabidi et al.[13] have proposed about MFCC is best for voice recognition. The co-efficient constitute a good representation of the dominant features in acoustic information for selected window time [13]. The MFCC can be easily distinguished between healthy and unhealthy subjects by considering their features. The mathematical equation of MFCC is,

$$C(n) = \text{DCT}(\log(|\text{FFT}(S(n))|)) \quad (2)$$

For finding MFCC feature they look hamming window signal by using below equation,

$$W(n,a) = (1-a) - a \cos(2\pi n/(n-1)) \quad (3)$$

Where  $0 \leq n \leq N-1$

Then DCT of signal will be,

$$C_i = \sum m_j \cos[ij/M(j-0.5)] \quad (4)$$

$$m_j = \log_e(Y_j)$$

$$i = 0, 1, 2, 3, \dots, N; N < M$$

After filter bank equation, mel scale equation can be written as,

$$\text{Mel} = 2595 * \log(1 + \text{freq}/700) \quad (5)$$

#### • Classification

Shaik Razia et al. [14] have proposed a method, is SVM in their work for classification technique and regression issue is studied. SVM provides very good outputs or results due to its supreme decision making. SVM classifier is a binary classifier. Shaik Razia et al. [14] have got 96.04% accuracy by using SVM

Esin Dogantekin et al. [10] have used SVM for obtaining optimum hyperplane, this differentiates various classes. In this work, the following equation is used for calculating the accuracy of SVM.

$$Y(x) = \text{sign}[\sum_{i=1}^L \alpha_i Y_i \psi(x, x_i) + b] \quad (6)$$

Where  $\psi$  = kernel function

$\alpha_i$  = lagrange multiplier

$b$  = real constant

$x_i$  = support vectors

If the data is separable,

$$Y_i [W^T \phi(x_i) + b] \geq 1, i = 1, \dots, L \quad (7)$$

If data is non separable, it is used a slack variable  $\xi_i$

$$y_i [W^T \phi(x_k) + b] \geq 1 - \xi_i, \xi_i \geq 0$$

$$i = 1, \dots, L.$$

The SVM solve the optimization problem by using following equation.

$$\text{Min}_{w,b,e} J_{LS}(w, b, e) = (1/2)W^T W + C \sum_{i=1}^L 1 - \xi_i \quad (8)$$

Liyong Ma et al. [8] have discussed a very important part of speech signal processing, i.e neural networks. Various neural networks are used in speech processing for classification purpose. Also, like SVM, CNN (Convolution Neural Network) method is encouraged for selectivity, immutability. CNN has the potential to find features automatically.

#### • Acoustic Voice Analysis (AVA)

Here the acoustic voice analysis is used for detecting the thyroid disease, which gives the difference in between the normal and thyroid patient's voice. Acoustic Voice Analysis can give important objective data on voice disturbances, especially those with organic and functional changes [9]. Therefore, this method is used for calculating the various voice parameters, which are affected due to thyroid disease. And also obtain the changes in voice. The

voice changes happen due to various reasons like vibrating vocal folds, due to cough, due to voice disorders, etc. in an acoustic voice analysis method checks the various voice parameters like jitter, shimmer, fundamental frequency, harmonic to noise ratio and many more parameters are changes in thyroid patients.

### III. METHODS IN BIO-MEDICAL ANALYSIS

#### A. Voice Self-Perceptual Assessment

This method is used for checking the changes are happening in thyroid patients. It can be assessed by using GRBAS (Grades in Roughness, Hoarseness, Breathing, Asthenic, and Strain). Speech therapist has used this method for diagnosing the level of disease. Self-perceptual assessment is carried out on voice quality by asking questionnaires such as voice impairment scale, voice handicap index (VHI), voice disorder index or voice symptom scale [1]. In all above method most commonly used method by a speech therapist is VHI (Voice Handicap Index). Because of its reproducibility and simplicity [1]. In VHI obtain data into three subscales i.e. emotional, physical and functional. According to this scale, VHI decides most and less impaired voice. This method validates into 11 languages. This method is working on a competitive study of voice like preoperative and postoperative voice samples. Preoperative samples are collected before the surgery. And postoperative samples are collected after 4 to 6 weeks after surgery.

Table I: Tests required for self-perceptual voice analysis

Test	Scale
Questionnaires	Range
1. VHI (Voice Handicap Index)	0 1 2 3 4
2. Voice impairment scale	0 1 2 3 4
3. Voice Disorder Index	0 1 2 3 4
4. GRABS Scale	0 1 2 3 4

0 = Never, 1 = Almost Never (Occasionally), 2 = Sometimes, 3 = Almost Always, 4 = Always.

#### B. Statistical Analysis

In statistical Analysis method, data can be expressed in mean  $\pm$  standard deviation for analysis. The difference between mean values for quantitative variables was evaluated using a t-test, chi-square and Mann Whitney tests were used for analysis of nominal and ordinal variables [4]. In the statistical analysis method, SPSS software is commonly used for 0.05 P value. Eun Ju Ha et al. [6] have discussed which factors are required for statistical analysis. These factors are age, sex, location, US diagnosis, etc.

#### C. Complication Analysis

Eun Ju Ha et al. [6] have proposed technique is complication analysis is also considering various parameters regarding the voice. And the parameters are time to detect, Nodule size, location, US diagnosis, time to recovery. The complication analysis is divided into two parts, i.e. major complication and minor. In a major complication analysis, includes the major occurrence of disability and life-threatening incident so it requires extra care, proper medication, proper diet and all. In major complication also includes permanent damages of body parts like vocal fold, voice, thyroid nodule, etc. In minor complication analysis, includes not any side effect on the body. It might be temporary damage to voice, and temporary damage to body parts; in the same condition does not require medication, prescription, etc.

#### D. Surgery Analysis

The surgical method is used when the life-threatening condition occurs. In the surgical method, various operations related to the thyroid gland happen. There are various disorders which require surgery like thyroidectomy, thyroid cancer, etc. During thyroidectomy surgery, thyroid gland or part of the thyroid gland is removed. Surgeons can perform thyroidectomy surgery when a patient has some problem related to hyperthyroidism or thyroid cancer.

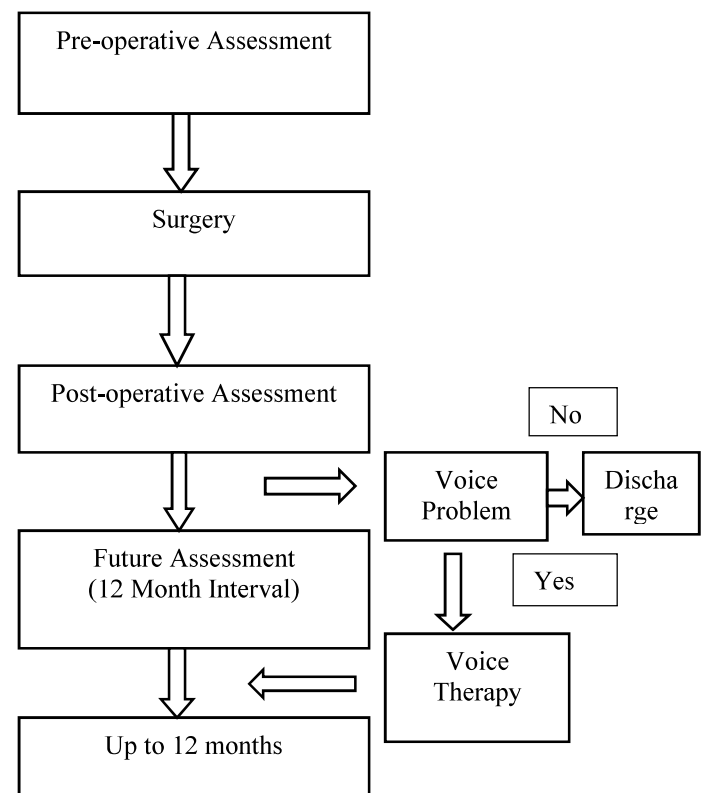


Figure 2: Surgical method for diagnosis of thyroid disease.

Table II: Comparison of various methods used for diagnose for thyroid disease

Sr No.	Methods	Pros	Cons
1	Voice self – perceptual assessment	1. Easy to use. 2. high reproducibility	1. Analysis is little bit confusing
2	Statistical Analysis	1. High Accuracy 2. Easy to use.	1. High Computation time required
3	Complication Analysis	1. Provides the level of disease.	1. Required large dataset
4	Surgical	1. Accurate results.	1.High complexity
5	CAD	1. Flexible to work with.	1. Less sensitive
6	Acoustic Voice Analysis	1. Easy to use 2. Accurate results	1. required dataset

#### IV. METHODS USED IN SIGNAL PROCESSING

##### A. Computer Aided Diagnosis (CAD)

Angel Arul Jothi J, et al. [15] have proposed about, in digital platform CAD (Computer Aided Diagnosis) is used to help the physician and pathologist to diagnose the various diseases. Pathologists have used their special hardware and software for analysis of disorder using CAD.

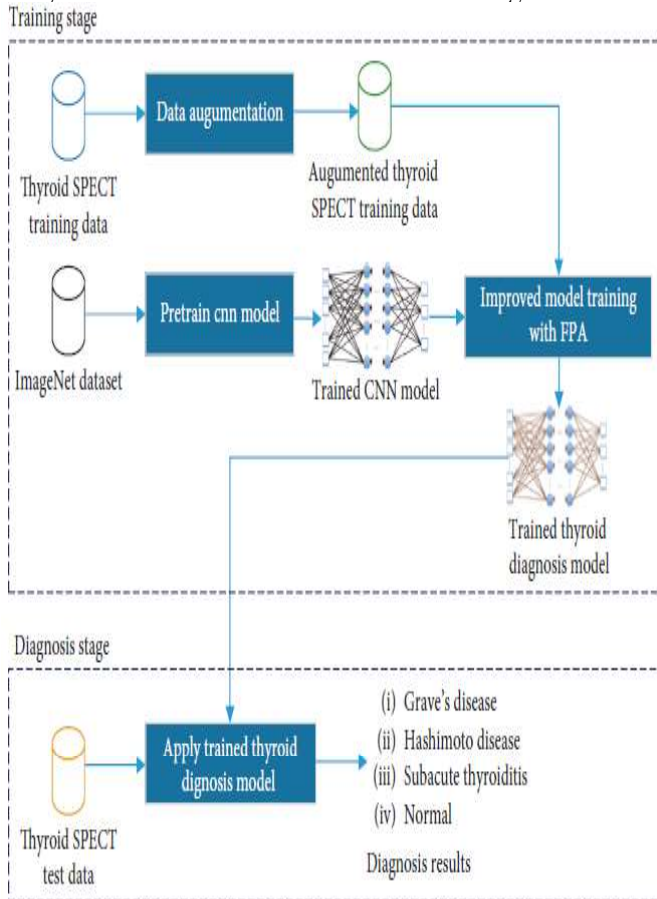


Figure 3. Block Diagram of thyroid diagnosis using SPECT images [8]

In CAD variety intelligent algorithms are used as a simple test to text reports, to complex radiology or histopathology images. The physician uses CAD for a better understanding of diseases. In this proposed system, shows the difference between normal thyroid and papillary thyroid carcinoma. By using CAD gets the exact result of disease. Liyong Ma et al. [8] have discussed how the use of CAD tool growths over a year. In that various imaging methods are developed during that period like CT, Ultrasonic, and SPECT images for getting a better accuracy of diagnosis. Lots of research is carried out in imaging technology for segmentation, feature selection, feature reduction, and volume estimation. In this proposed system, the SPECT imaging technology used for diagnosing thyroid disease. Tien Chun Chang et al. [16] have discussed the CAD system, which is objective and easy to use so it is widely used. In this system, calculates various parameters like indistinct margin, hypoechoic lesion, micro-calcification, and heterogeneity. According to the above parameters, this method is accurately diagnosing the size, location, and change in the thyroid gland.

##### B. Acoustic Voice Analysis(AVA)

Acoustic Voice Analysis (AVA) is one of the methods used for diagnosing voice disorders. The main aim of this method is checking which features of voice are changes in thyroid patients. Gururaj B Gour et al. [9] have discussed, the important objective data on voice interference, which mainly those with functional origins and organic. The reason to use this method for diagnosing the thyroid disease is the location and size of thyroid gland produce various symptoms, which are complex to understand therefore it distracts the pathologist observation in various directions. So it creates a big challenge to physicians. Sometimes a patient's symptoms can be confusing so that it leads pathologist to the inaccurate diagnosis. In the above conditions, acoustic voice analysis is very helpful. Acoustic voice analysis is carried out by taking the voice samples of the patients. Then this signal follows some steps like digitization, feature reduction or selection. After this process, the signal will analyze and stored using various software. And this software's are PRAAT, MDVP, etc. In signal analysis, investigates the various features of the

voice includes jitter (The perturbation fundamental frequency), shimmer (amplitude perturbation), voice turbulence index (VTI), harmonic to noise ratio (HNR), standard deviation (SD), fundamental frequency variation (vFo), soft phonation index (SPI), maximum phonation time and many more. This parameter provides information about vocal fold vibration. In case of thyroid diagnosis, patient parameters are compared with normal range. If it shows the difference between normal range and patients parameters then it is concluded that the vocal function of the patient is abnormal. The acoustic voice analysis is performed two times when patients underwent through surgery, i.e pre-operative and post-operative and once if it is in the control group.

## V. SUMMARY

This paper reviewed a brief description of thyroid disease and their types. The types of thyroids like hypothyroidism, hyperthyroidism, thyroid cancer, and thyroidectomy. Also the review discussed about various methodologies of diagnosis. The various methods used for detecting the thyroid disease are discussed. These methods are divided into two sections like biomedical and signal processing. The particular method for better accuracy is also been mentioned. Every method uses a different technology for getting better results. By considering these approaches further research can be smoothen. This paper assists the researchers to choose diverse methods for detecting the thyroid disease and its accurate diagnosis.

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