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Acoustic Analysis of voice samples to differentiate Healthy and Asthmatic persons

Khushboo Batra[1], Swati Bhasin[2], Amandeep Singh[3]

[1] M.Tech Scholar, Geeta Institute of Management and Technology, Kurukshetra, (Haryana)
khushboo.batra91@gmail.com

[2]Assistant professor, Geeta Institute of Management and Technology, Kurukshetra, (Haryana)
missbhasin@gmail.com

[3]Assistant professor,Jai Parkash Mukand Lal Innovative Engineering and Technology Institute, Radaur, Yamuna nagar (Harayana)
amanshergill33@gmail.com

Abstract: ***Voice analysis for disease detection is a very important research topic in bio medical engineering. This process is non invasive and reliable. In this paper , For comparison of asthma and healthy persons speech records of five vowels /a/, /i/, /e/, /o/, /u/ have been used. Some acoustic voice parameters jitter, shimmer, harmonic to noise ratio (HNR), noise to harmonic ratio (NHR) & mean autocoorelation were extracted using PRAAT software. These parameters were then used to classify and compare the asthmatic patients and healthy persons. In other words, these features represents the particular voice and may be used for the comparison of healthy persons from unhealthy persons. This result suggests that the feasibility of the detection of asthma disease through analyzing the various acoustic parameters of voice.***

Keywords: Jitter, Noise to Harmonic ratio (NHR), Harmonic to Noise ratio (HNR), Acoustic analysis.

1. Introduction

Speech is nothing but it is a sequence of sounds which is generated from the speech production system under the influence of specific language knowledge[1]. Speech is produced by vocal folds. It involves the interaction of various body parts. The essential body part for speech production is larynx but speech production is not limited to larynx only, this includes various components like abdominal, ribcage, lungs, pharynx, oral cavity and nose and each performs its own function in speech production[2]. With the help of speech we will extract various information about the speaker, gender, language, emotions health[1]. Nowadays speech analysis of the voice of any patient is a very valuable technique for the detection of speech pathology because voice disorder can be perceptible by the analysis of some acoustic signal parameters[3]. Through acoustic analysis, factors that affect the production mechanism of human voice leads to the non-invasive diagnosis of diseases[7]. It was proved from health science point of view that the condition of human health and pathological status affect the human voice. If the vocal folds become inflamed then few structural abrasion developed on them so that they become not functioning effectively[6]. So, the person's voice suffering from any disease different from the healthy person in some extent[1]. As the various diseases like Parkinson, dysphonia, dystharia & respiratory tract infection lay their impression on voice of a person. So, various diseases can be detected with the help of speech signal processing of voice[2]. Using the speech signal processing we can extract a set of voice parameters with the help of these parameters it is possible to detect the pathologies of the vocal cords[3]. The measurements of these voice parameters is to be useful in describing the characterstics of vocal folds. In this paper asthma disease is detected with acoustic voice parameters. Asthma is a chronic inflammatory disorder of the airways associated with increased airway hyper-responsiveness, recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night/early morning[4]. Middle airway obstruction at the level of the vocal cords may convert mild asthma to severe disease if causing obstruction in addition to asthma itself[9]. So asthma is one of the major public health problem worldwide[5]. It can hurt the sound quality of the voice[4]. Bronchial asthma, labored breathing and wheezing, and allergies can also cause sore throat and inflammation around the vocal cords. So the voice sound becomes hoarse or scratchy when Swollen, inflamed cords don't vibrate efficiently[4]. For the asthma's treatment fewer then half of approved daily controller prescription is typically taken by patients. According to refill patterns report among 5500 asthma patients, only 43% filled their inhaled corticosteroid more then once during 1 year[8].

In other research, Adaptive immune system is affected by vitamin D and it may be relevant for the primary prevention of asthma. Some cross sectional data tells that low level of 25(OH)D in patients having mild to moderate asthma are correlated with poor asthma control and it also reduced functions of lungs and response of glucocorticoid[5]. In this paper we have extracted the various voice parameters from the speech signals provided in the database and is used to discriminate non-asthmatic persons from the asthmatic's patients.

2. MATERIALS AND METHODOLOGY

In this paper 25 asthmatic patients having age between 40 to 65 years were taken and a analytical test was done on this group. The results were compared with healthy persons having age between 40 to 65 years. A database was created which consisted of a sustained phonation of vowels. PRAAT software was used for acoustic analysis. The following parameters were analyzed: Jitter (frequency perturbation-local,%), Shimmer (amplitude perturbation –local, %), Harmonic to noise ratio (HNR – dB), Pitch, Mean autocoorelation, Noise to harmonic ratio (NHR).
The block diagram of asthma detection system is shown in figure

1.Input: The voice (a,e,i,o,u) of asthma and healthy persons are recorded with microphone M27 having specifications (Sensitivity: -58db±3db, S/N ratio: more than 60db & frequency response: 100Hz~16kHz) were taken as a input. These voices are recorded at a sampling rate of 16000HZ to minimize the effects of aliasing in the analog to digital conversion process. The voice samples were in .wav format.

2.Feature extraction: The various voice parameters like jitter ,shimmer, HNR, NHR, pitch and mean autocoorelation of asthma and healthy persons were extracted from the different voice samples by using PRAAT software. Following parameters are explained as

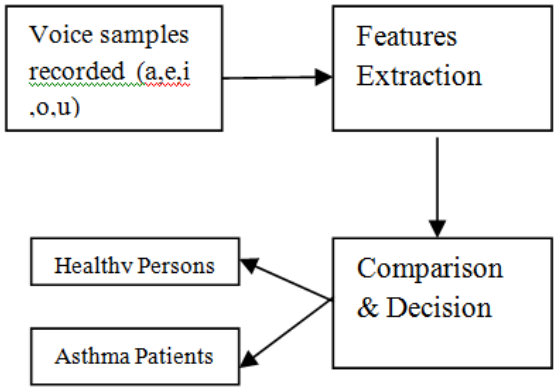

Figure 1 : Block Diagram

a) Jitter: Cycle to Cycle variation of fundamental frequency ,that is the average absolute difference between consecutive periods is called as jitter shown in fig 2. MDVP calls this parameter *Jitt*, and gives 1.040% as a threshold for pathology.

$$\text{Jitter}= \frac{1}{N-1}\sum_{i=1}^{N-1}|T_i - T_{i+1}| \quad (1)$$

b) Shimmer: Average absolute difference between the amplitudes of consecutive periods, divided by the average amplitude shown in fig 3. MDVP calls this parameter *Shim*, and gives 3.810% as a threshold for pathology.

$$\text{Shimmer}=\frac{1}{N-1}\sum_{i=1}^{N-1}|20\log(\frac{A_{i+1}}{A_i}) \quad (2)$$

c) Harmonic to Noise ratio (HNR): A Harmonicity object represents the degree of acoustic periodicity called as HNR. It is expressed in db. It is used as a measure for quality of the voice.

$$\text{HNR}=10*log_{10}\frac{AC_V(T)}{AC_V(0)-AC_{V(T)}} \quad (3)$$

d) Pitch: The degree of a highness or lowness of a tone is called as a pitch.

e) Mean Autocoorelation: It calculates the degree of similarities between a given time series and a lagged version of itself over successive time interval.

$$\hat{R}(k)=\frac{1}{(n-k)}\sum_{t=1}^{n-k}(X_t-\mu)(X_{t+k}-\mu) \quad (4)$$

3.Comparison and Decision: These several voice parameters were then evaluated for further decision. At the output asthma patients and healthy persons are compared with the help of voice parameters.

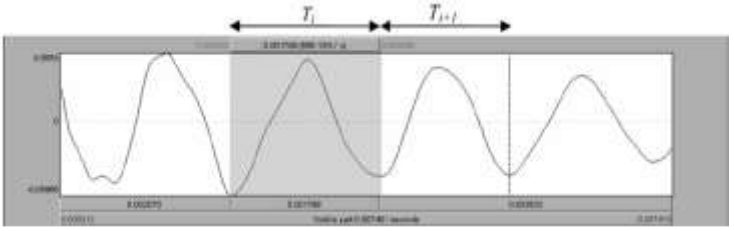

Figure 2 : Jitter in voice signal

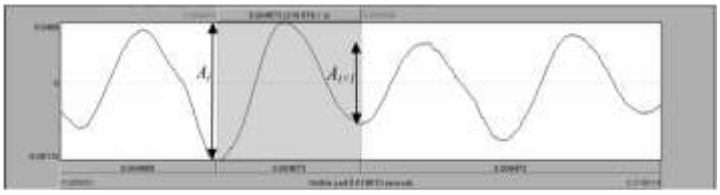

Figure 3 : Shimmer in voice signal

3. Results and Discussions

We recorded 25 phonation spoken by the asthmatic patients and 25 phonation by healthy persons. For the acoustic analysis 15 phonation of vowels (a,e.i.o.u) per person were considered. Following graphs shows the results obtained by acoustic analysis using Praat software.

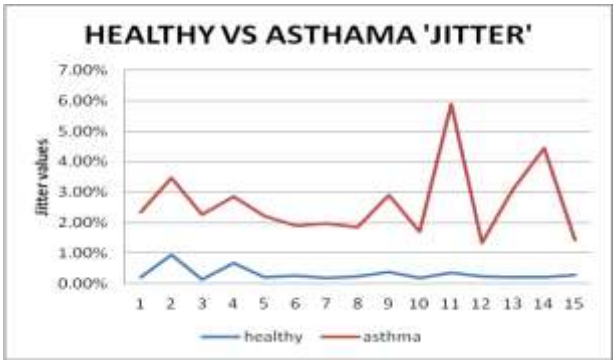

Figure 4 : Mean of Jitter

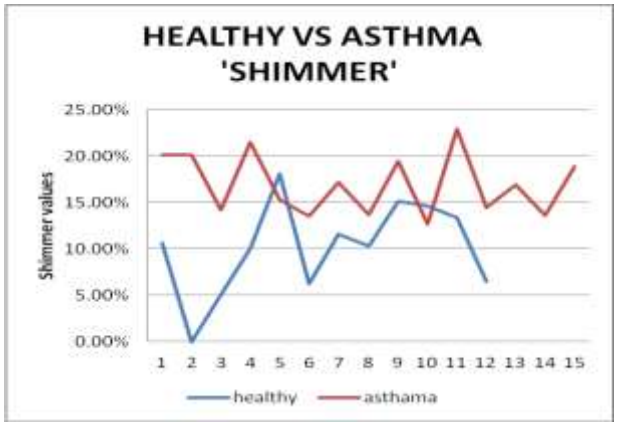

Figure 5 : Mean of Shimmer

In the above graphs an analysis of mean of five vowels (a,e,i,o,u) for males and females are presented for various voice parameters like JITTER, SHIMMER, MEAN AUTOCOORELATION, HNR and NHR of different asthma and healthy persons are compared. In Fig 4 the graph shows that the mean value of voice parameter that is jitter of asthma persons having high value ranges from 1.5% to 6% and healthy persons having very low value of jitter ranges from 0.1% to 1%. In Fig 5 it was observed that the Shimmer values of asthma and healthy persons are contradict to each other. So shimmer has no result for comparison of healthy and asthma persons.

In Fig 2 it was observed that the mean auto coorelation that shows the degree of similarities between given time series and its lagged version, of healthy persons having some high value as compared to asthma patients.

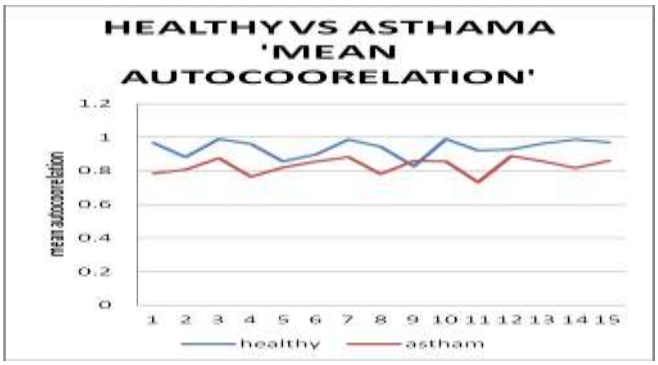

Figure 6 : Mean of Mean autocoorelation

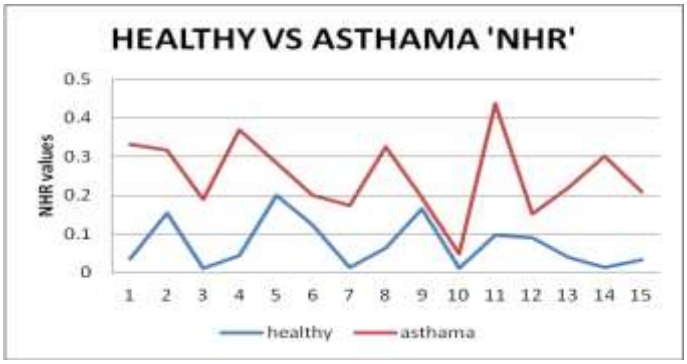

Figure 7 : Mean of NHR

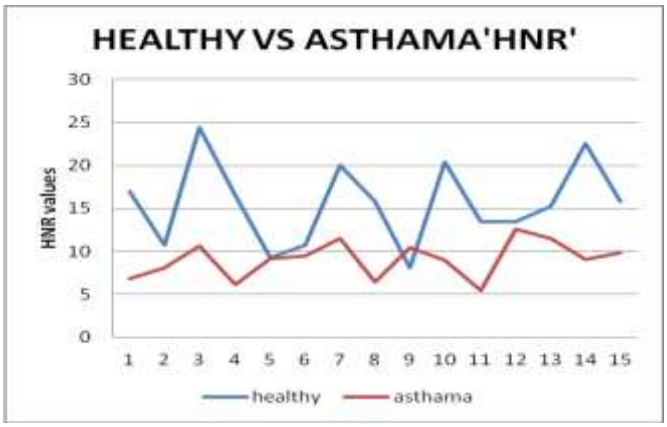

Figure 8 : Mean of HNR

Similarly In Fig 3 the noise to harmonic ratio (NHR) of asthma and healthy persons are compared. This shows that the value of NHR for asthma patients are high but the value of healthy persons are low. In Fig 4 the harmonic to noise ratio that is HNR value of healthy persons are high as compared to asthma patients. The values of NHR and HNR are taken in db.

4. CONCLUSION

In this paper acoustic analysis is used for the detection of asthma disease. This analysis is an efficient tool for the diagnosis of asthma disease. In this analysis some standard features such as jitter, shimmer, mean autocoorelation, HNR and NHR are consindered. The mean of various voice parameters of five vowels (a,e,i,o,u) for male and female voices were documented. Consindering the results of the asthma and healthy persons comparison the jitter parameter are most significant. For asthma patients the value of jitter are high as compared to healthy persons. The voice parameters HNR and NHR also used to differentiate the asthma and healthy persons. The results for these two parameters are converse for both asthma and healthy persons. As the value of HNR is high for healthy persons and low for asthma patients. Similarly the value of NHR is low for healthy persons and high for asthma patients.

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