Voice Signal Parameter Analysis towards Measuring the Severity of Asthma

Md. Asim Iqbal[1], K. Rajesh Reddy[2], Sadanandam Manchala[3]
[1 , 2] Department of Electronics and Communication Engineering, KUCE&T
[3]Department of Computer Science and Engineering, KUCE&T
[1,2,3] Kakatiya University, Warangal, Telangana, India.

Abstract

The most characteristic type of correspondence known to human civilization is voice. A human voice is a component of human ailment, feeling and disease, and along these lines, analysis of human voice can help in extracting information about the wellbeing conditions. There exists different voice pathological issues related with neural, larynx, nasal and respiratory diseases, which, when analyzed well in time, using voice analysis, can help in mitigating and/or curing the disease. Voice analysis is, by and by, emerging as one of the potential zones of research in biomedical electronics. The scientific relationship created in this work corresponded human voice parameters with nearness of asthma and its levels, ranging from intermittent to serious.

Index Terms *:* Level of Asthma, Asthma, Acoustic analysis, Multi-Dimensional Voice Program, Regression analysis, Computerized Speech Lab.

I. INTRODUCTION

Voice correspondence is required in a man's professional and also in individual life. It is required for earning business, expressing feelings, and in other ordinary social interactions [1]. In police and Forensic Scientists, every so often voice is the main hint available in identifying the criminal. The voice of each individual is distinctive in light of the fact that the existence structures of vocal gap, oral gap, nasal opening, and vocal strings is specific to the individual. Individuals in different countries, honestly, individuals in different parts of a comparative country, chat with different accents. There are a couple of individuals who run their words together, and there are other individuals who speak with stops between their words [2].

There are a couple of voice pathologic disorders related with nasal, neural, respiratory and larynx diseases. Accordingly, analysis and diagnosis of vocal disorders has transformed into a basic helpful technique. Table 1 shows the parameters that can be removed using voice analysis, and the information that can be isolated from those voice parameters [4].

Voice involves two separate strategies: initial one conveys an initial sound and the other one changes it. For instance, at the larynx, a sound is made whose range contains a couple of one of a kind frequencies. By then, using tongue, teeth, lips, velum and so on., the scope of that sound is changed after some time. The imperativeness required for producing sound while speaking originates from air expelled from the lungs. This stream goes between the vocal folds at the larynx. The vocal folds vibrate in voiced speech, which licenses passage of air puffs, which, in turn, produces sound waves.

Table 1 : PARAMETERIC FEATURES OF VOICE [2]

Parameters	**Features**	**Information extracted**
Amplitude	Shim (local, db)	Variation in loudness of voice.
Frequency	Jitter (local, absolute)	Variation in pitch of voice.
Pitch	Maximum/Minimum pitch	Peaks of the sound spectrum of voice
Harmonic	Noise-to-harmonic ratio	Relative highness or lowness of voice.
Pulse	Standard deviation of period, period of pulses	Speech rate of speaker.

The vocal folds don't vibrate while whispering, yet are held close to each other, which makes an erratic stream of air. This, in turn, makes a sound comprising a mix of a couple of frequencies, which is called broadband sound. This empowers us to parcel speech sounds into voiced and unvoiced [5]. It is possible to expel information about the speaker's sex, wellbeing, feelings, nervousness and so on with the assistance of speech.

Asthma is a perpetual inflammatory disorder related with variable airflow snag and bronchial hyper-responsiveness. Asthma is a

perpetual (whole deal) disease of the lungs. Notwithstanding when you have no symptoms, in spite of everything you have asthma. It is basic to make after your Asthma Move Plan to control your asthma. When you inhale, air goes in through your nose and mouth. It gushes down your wind pipe, through your generous and little flight courses and into the air sacs as showed up in the figure[1].

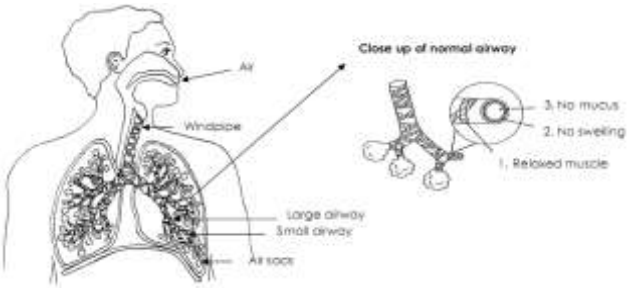

Figure 1(a) : Close up of normal airway in Non Asthma Patient.

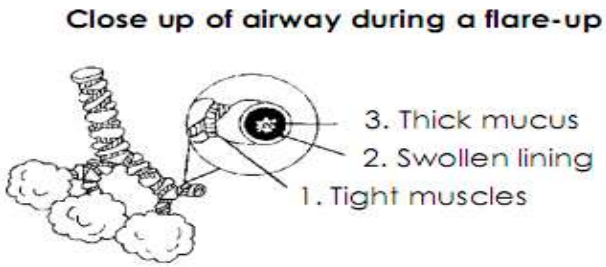

Figure 1(b) : Close up of abnormal airway in Asthma Patient

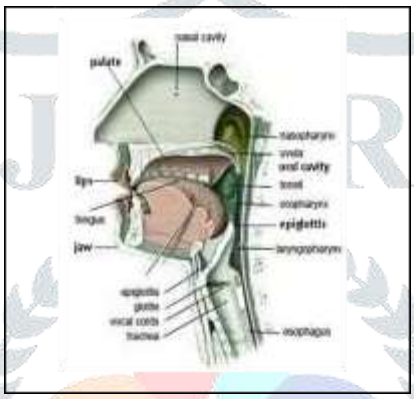

Figure 1(c). Elements involved in speech production [1].

During an asthma episode:

1. The muscles around the airways tighten, making the airways smaller.
2. The lining of the airways becomes swollen.
3. Thick mucus forms, blocking small airways.

These changes make it hard for air to flow in and out of the lungs. You may have one or all of the following symptoms:

- Coughing
- Wheezing
- Shortness of breath
- Chest tightness

This makes the avionics courses swollen and outstandingly sensitive. They tend to react immovably to certain substances that are taken in. Exactly when the flying courses react, the muscles around them settle. Flight course inflammation caused by sensitivities and asthma can hurt the sound idea of the voice. The vocal strings cover the larynx, the best bit of the trachea. These organic liquid anchored solid bands are the vibrating "strings" that make voice sound, which is then isolated and shaped by the resonating holes of the throat, nose, and mouth. Inflammation along the ways starting from the nose to the larynx can cripple vocal quality. Bronchial asthma, labored breathing and wheezing, and sensitivities can likewise cause sore throat and inflammation around the vocal strings. Swollen, inflamed ropes don't vibrate proficiently and can make the voice sound rough or scratchy . A spirometer (spyrometer) measures the greatest measure of air you can inhale out, or inhale out, in the wake of taking a full breath. The spirometer can measure wind current when you use asthma medicine. Notwithstanding, clinical experience has pointed out that dysphonia is often had a poor opinion of by patients and sometimes, even by family specialists. All around, target speech quality measures are by and large evaluated in the spooky, time or cepstral domains. In the unearthly analysis procedures, researchers have endeavored to screen the awful assortments of banner, for instance, adequacy, bandwidth and repeat of formants including sub-band processing systems. In time domain, procedure in perspective of common estimations of banner and their statistics, for instance, ordinary pitch assortment, jitter, shimmer, and so on to distinguish among regular and pathological speech is used. Furthermore, Speech processing in perspective of cepstral analysis has wound up being an amazing instrument for voice disorder acknowledgment. Mel-repeat cepstral coefficients (MFCC) have for the most part been used as a grammatical feature applications. A human voice is immovably related to the human wellbeing conditions, both physical and mental [6]. Changes in voice quality and contribute happen a significant part of the time hormonal unbalanced characteristics or insufficiencies [7]. If a man is having some kind of disease, for instance, cough, cold, fever and so forward., or feeling some kind of feeling, for instance, happiness, misery, drive, uneasiness and so on., by then their voice would be not exactly the same

as what they sound when they are ordinary. By performing acoustic analysis on a man, different voice parameters can be isolated which can help in the diagnosis of various diseases like Parkinson, dysphonia, cardio-vascular diseases, and other respiratory tract infections and diseases, like asthma, Chronic Obstructive Pulmonary Disease (COPD) and so forward., which influence the individual's voice [4].

Asthma is a chronic lung disease, depicted by means of avionics course inflammation, flight course hindrance and aeronautics course hyper-responsiveness. The ordinary signs and symptoms of an intense asthma episode include coughing, wheezing, shortness of breath, increased respiratory rate, chest coziness, chest or abdominal pain, shortcoming, fomentation, inability to appreciate sports and increased pulse rate [2]. Coughing and wheezing are particularly experienced by the individual during evening time in view of which they sometimes find inconvenience while sleeping. Asthma can be ominously helpless, exercise-induced, word related, nighttime or steroid-resistant. Steroid-resistant asthma is believed to be to a great degree genuine kind of asthma. At its beginning, an asthma strike empowers enough air to get into the lungs, anyway does not allow CO2 to leave the lungs at an adequately fast rate. During a deferred strike, CO2 can create in the lungs, which in turn, can bring about lowering of level of oxygen getting into the course framework. In comparison to a strong individual's bronchiole, an asthmatic individual's bronchiole has swollen dividers, stores of natural liquid and settled muscles [8]. The level of asthma strikes can be (I) intermittent, (ii) smooth, (iii) direct, or (iv) extraordinary [9]. Due to swelling and inflammation, the vocal strings don't vibrate gainfully, thusly, make the individual's voice sound unpalatable, harsh or scratchy [10]. In addition, due to inflammation, superfluous mucous is conveyed, which brings on extra obstruction in the flight course [11]. In this route, by performing acoustic analysis and extracting the parameters, an asthmatic individual's voice can be isolated from a sound individual's voice. It is possible to control asthma indications by taking arrangement, general registration by specialist, taking a couple of prescriptions through inhalers and so on [12]. Individuals suffering from asthma often have a history of cool before the beginning of compounding. The explanation behind most intensifications, in any case, remains disputable notwithstanding different investigations [13]. In Australia, asthma is the leading explanation behind hospitalization of adolescents with an increasing regularity. The risk of asthma in kids is through and through reduced if select chest feeding is enhanced the circumstance no under 4 months. Distinctive segments appear in early life, for instance, being male, low birth weight, young maternal age, maternal smoking and so forward., may bring around an increased susceptance to asthma [14]. Scarcely any arrangements with the area of asthma using voice analysis have been done previously. The estimation of Jitter and NHR is high for asthmatic individuals when differentiated and sound individuals [4]. It is discovered that the estimation of Intensity is bring down for asthmatic individuals when differentiated and the Intensity regards for strong individuals [10]. The overall public suffering from Chronic Obstructive Pulmonary Disease (COPD) have higher Shimmer regards than strong individuals [11]. The all inclusive community having chronic cough (CC) and paradoxical vocal fold movement (PVFM) have low Maximum Phonation Time (MPT) and Intensity than sound individuals [15]. This paper displays a strategy to determine the Level of Asthma deductively, using voice analysis. For doing this, initially, the voice tests are accumulated (both sound and asthmatic), and by then, the parameters are isolated using the Multi-Dimensional Voice Program (MDVP) mechanical assembly of Computerized Speech Lab (CSL) system. Following this, the parameters showing enormous assortments are decided for definition of the numerical condition. Finally, a numerical formula is made in perspective of analysis of extensive number of voice tests. This formula isolates strong individuals from those having asthma, and besides, determines if the Level of Asthma is intermittent, smooth, coordinate, or genuine. Keeping in mind the end goal to find a connection between's human voice parameters and Level of Asthma, a sum of 62 voice tests were gathered.

The quantity of tests gathered for every one of the five gatherings is determined in Table 2.

The general population belonging to solid gathering matured between 18 to 31 years, and those of asthmatic issues matured between 17 to 55 years.

Table 2 : NUMBER OF SAMPLES COLLECTED

Category	Severe Asthma	Moderate Asthma	Mild Asthma	Intermittent Asthma	Healthy
No. of samples	10	5	15	10	22

The sequence of steps involved in the process is listed below:

1. Collection of voice samples of people from all the five groups.
2. Extraction of voice parameters using Multi-Dimensional Voice Program feature of Computerized Speech Lab.
3. Comparison between the five groups based on the values of extracted voice parameters.
4. Selection of voice parameters exhibiting significant changes.
5. Formulation (mathematical correlation) to determine Level of Asthma based on the selected voice parameters. The detailed description of each step involved in the process is given below.

Collection of voice samples

A vocal microphone (SM48-LC, SHURE) was used to record the samples with the adjustments as listed in Table 3. The routine used while recording the samples is described below:

1. Production of sustained phonation of /a/ sound at normal pitch and loudness, for 4 seconds.
2. Repetition of Step 1 for five times.
3. Phonation of /a/ sound for as long as possible.

4. Repetition of Step 3 thrice.

Table 3 : ADJUSTMENTS FOR THE MICROPHONE

S.No.	Requisites	Value
1	Sampling Rate	44.1 kHz
2	Distance between microphone and mouth of person	12 cm
3	Angle between microphone and horizontal	45^0

Extraction of voice parameters

The first two steps of the routine (given in A) were used to extract the following voice parameters: Fo: Average Fundamental Frequency
Jitt: Jitter (%) Shim: Shimmer (%)
vFo: Coefficient of fundamental frequency variation DUV: Degree of Voiceless
DSH: Degree of Sub-Harmonics SPI: Soft Phonation Index DVB: Degree of Voice Breaks NHR: Noise-to-armonic Ratio
PPQ: Pitch Period Perturbation Quotient (%) RAP: Relative Average Perturbation (%) To: Average Pitch Period
The above parameters were extracted using the MDVP (Model 5105, KayPENTAX) tool of CSL (Model 4500, KayPENTAX) system.
The last two steps of the routine (given in A) were used to determine Maximum Phonation Time (MPT).

Comparison of parameter values

The values, so obtained, were compared for further analysis.

Selection of desired parameters

Upon comparing, it was found that there were several parameters that showed variation in values. Amongst all, few parameters showed significant variations, which were selected for developing the mathematical formula.

Numerical Analysis

The selected parameters were used for developing a linear relation of the form:
LoA = n0 + (n1×p1) + (n2×p2) + (n3×p3) +…
where LoA represents Level of Asthma, n0, n1, n2, n3, … represent real values,
p1, p2, p3, … represent MDVP parameters.
For example:
LoA= (0.025×Fo) + (0.08×DSH) - (0.012×Jitt) +…
LoA = 0-0.99, would indicate that person is healthy.
LoA = 1-1.99, would indicate that person is suffering from asthma and Level of Asthma is Intermittent. LoA = 2-2.99, would indicate that person is suffering from asthma and Level of Asthma is Mild.
LoA = 3-3.99, would indicate that person is suffering from asthma and Level of Asthma is Moderate. LoA = 4-4.99, would indicate that person is suffering from asthma and Level of Asthma is Severe.
The values of n0, n1, n2, … are determined using regression analysis. In this technique, a linear transformation of the predictor variables (here, n0, n1, n2, …), also called regression weights, is done in such a way that the sum of squared deviations of the observed and predicted output (here, LoA) values is a minimum [16].

II. RESULTS AND ANALYSIS

According to the procedure, voice tests from various gatherings were gathered and analyzed. There were certain parameters that demonstrated huge varieties, which were finally considered for generating a numerical relationship for the computation of Level of Asthma. The chose parameters are explained beneath:

Jitter – It is assessed as the relative time frame to-period variety in pitch within the voice test. Because of aviation route inflammation and swelling of aviation routes, the variety in voice pitch is required to increase because of the inability of vocal ropes to help an occasional vibration for a defined period. Intemperate creation of mucous further increases the pitch varieties. Accordingly, an increase in estimation of jitter would increase the seriousness of asthma.

Sparkle – It is assessed as the relative time frame to-period variety of the crest to-top abundancy within the voice test. Because of the nearness of noise in the voice flag, typically dry and hoarse voices, the sparkle esteem is relied upon to decrease, however, the variety could be pretty much nothing.

Major Frequency – It is assessed as the normal of all extricated period-to-period crucial recurrence esteems. Because of swelling of aviation routes and mucous creation, the basic recurrence is required to decrease, however, not all that much.

Maximum Phonation Time – It is assessed as the time for which a man can phonate/a/continuously with no breaks. In this procedure, three preliminaries were done per individual and the most elevated esteem was considered. Because of hindrance in the aviation routes and breathiness, the maximum phonation time is relied upon to diminish.

After acoustic analysis was performed on every one of the members, it was discovered that there were a few parameters that demonstrated varieties in values when the diverse gatherings were looked at. The estimations of the acoustic parameters for

guys, females and individuals (include combined information for the two guys and females) were thought about independently. Tables 4, 5, 6, 7 and 8 demonstrate the minimum, maximum and mean estimations of the MDVP parameters for sound and asthmatic guys, females and individuals separately. The shortenings utilized as a part of these tables are as following:
Min – Minimum, Max – Maximum M – Males, F – Females
P – People (males and females combined)

Table 4 : PARAMETER VALUES FOR HEALTHY GROUP

MDVP Parameter	Min Value			Max Value			Mean Value		
	M	F	P	M	F	P	M	F	P
Jitt	0.25	2.17	0.25	2.72	5.53	5.53	0.90	3.83	2.10
Shim	3.09	5.89	3.09	10.92	15.35	15.35	6.32	11.66	8.51
Fo	103.42	199.01	103.42	144.73	249.96	249.96	122.03	212.96	159.23
MPT	12.49	8.84	8.84	25.1	15.42	25.1	18.28	11.90	15.67

Table 5 : PARAMETER VALUES FOR INTERMITTENT ASTHMATIC GROUP

MDVP Parameter	Min Value			Max Value			Mean Value		
	M	F	P	M	F	P	M	F	P
Jitt	0.87	0.44	0.44	1.54	0.64	1.54	1.07	0.50	0.79
Shim	5.82	2.87	2.87	7.23	3.46	7.23	6.43	3.05	4.74
Fo	106.07	175.75	106.07	106.87	179.49	179.49	106.43	177.92	142.18
MPT	8.39	8.25	8.25	8.39	8.25	8.39	8.39	8.25	8.32

Table 6 : PARAMETER VALUES FOR MILD ASTHMATIC GROUP

MDVP Parameter	Min Value			Max Value			Mean Value		
	M	F	P	M	F	P	M	F	P
Jitt	0.41	1.35	0.41	0.9	4.22	4.22	0.69	2.62	1.98
Shim	3.59	5.21	3.59	4.23	9.05	9.05	3.86	6.97	5.93
Fo	123.43	227.98	123.43	130.84	239.32	239.32	126.73	234.01	198.25
MPT	7.53	7.5	7.5	7.53	7.86	7.86	7.53	7.68	7.63

Table 7 : PARAMETER VALUES FOR MODERATE ASTHMATIC GROUP

MDVP Parameter	Min Value			Max Value			Mean Value		
	M	F	P	M	F	P	M	F	P
Jitt	0.90	-	0.90	5.28	-	5.28	2.47	-	2.47
Shim	3.45	-	3.45	9.84	-	9.84	5.37	-	5.37
Fo	145.65	-	145.65	150.89	-	150.89	146.97	-	146.97
MPT	10.95	-	10.95	10.95	-	10.95	10.95	-	10.95

Table 8 : PARAMETER VALUES FOR SEVERE ASTHMATIC GROUP

MDVP Parameter	Min Value			Max Value			Mean Value		
	M	F	P	M	F	P	M	F	P
Jitt	1.83	2.07	1.83	2.56	5.73	5.73	2.21	3.06	2.63
Shim	8.44	3.50	3.50	9.82	14.43	14.43	9.31	6.87	8.09
Fo	133.86	167.29	133.86	136.09	175.72	175.72	134.75	169.87	152.31
MPT	8.58	7.12	7.12	8.58	7.12	8.58	8.58	7.12	7.85

The mean values of the four selected parameters for different categories (male, female, people) can also be seen in Figures 2, 3 and 4. The graphs in these figures have been plotted on a logarithmic scale using base 10.

Figure 2. Mean values of acoustic parameters for male

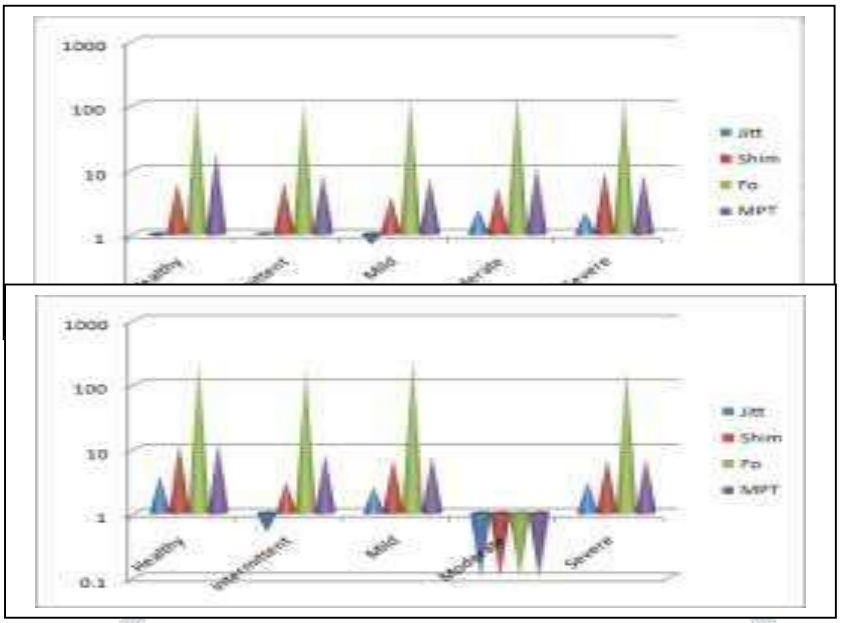

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Figure 3. Mean values of acoustic parameters for female

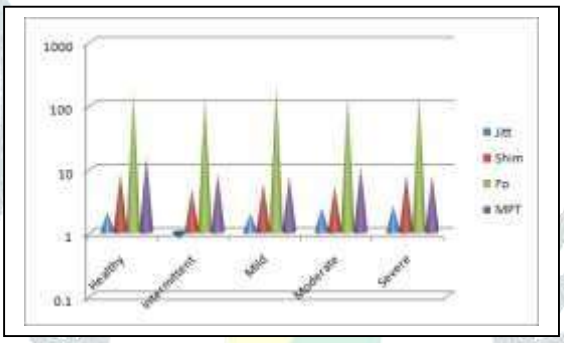

Figure 4. Mean values of acoustic parameters for people

Based on the selected parameters, a mathematical formula, as stated in eqn. 1, was developed, using regression analysis, to determine the Level of Asthma in a person.

LoA = (1.126×Jitt)-(0.045×Shim)-(0.012×Fo)-(0.285×MPT)+ 5.319 (1)

When the above formula was tested, 93% of the samples showed satisfactory results. The results obtained for Level of Asthma are shown in Figure 5.

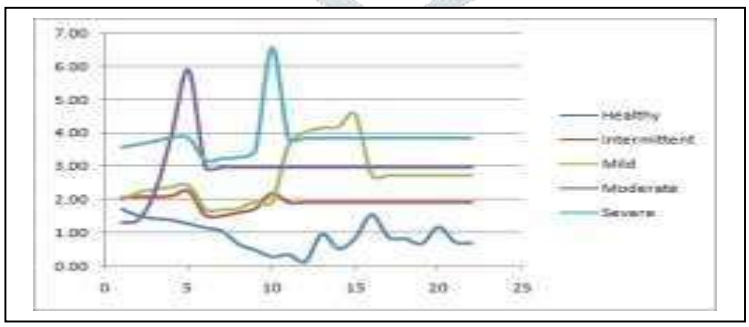

Figure 5. Values of Level of Asthma

III. CONCLUSION

It can be reasoned that the scientific recipe produced yields exact outcomes, since 93% of the examples agreed to the equation. The equation, so created, can, in this way, be used to determine the Level of Asthma in a man, if jitter, sparkle, normal key recurrence and maximum phonation time can be aggregated by a few means. In this manner, voice analysis has turned out to be a critical measure for determining the seriousness of asthma in a man. The created numerical recipe can be actualized using electronic and mechanical parts, similar to resistors, springs, inductors and capacitors. The circuit, so created, can specifically be

linked to the human voice, which would fill in as the input, and the yield delivered would indicate the Level of Asthma.

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