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Analysis of Voice Parameters for the Discrimination of Healthy Voice and Parkinson Disease Affected Voice

Manish Kumar Jha, Vikas Mittal

Abstract: Parkinson Disease (PD) seems to become one of the most prevalent neurological disorders of the twenty first century. Parkinson Disease is known to be an incurable disease because the clinical motor symptoms appear at later stages of the disease and the condition of patients at that point has become deteriorated. Moreover, the situation is further impaired by the lack of any diagnostic procedures or bio-markers for early evaluation of disease. Some recent studies on Parkinson Patients have concluded that the voice irregularities are the few very early appearing symptoms of Parkinson Disease. In this paper the voice analysis techniques are implemented to classify the Parkinson Patients on the voice parameter scales. The voice parameters which are realized in this approach are frequency, amplitude, pitch and formant, by applying Cepstral voice analysis algorithms. Besides providing patients

Index Terms: Parkinson, PRAAT, Voice Parameters Etc

I. INTRODUCTION

Parkinson's disease (PD) is one of the most prevalent and pandemic neurodegenerative disorders that impair the control-coordination mechanism of nervous system, motor responses and expressive skills of the patient's body. Parkinson's disease was named after an English surgeon James Parkinson, who was first to characterize the disease extensively in his publication an essay on Shaking Palsy in 1817. Parkinson Disease is known to be an incurable disease because the clinical motor symptoms appear at later stages of the disease and the condition of patients at that point has become deteriorated. Moreover, the situation is further impaired by the lack of any diagnostic procedures or biomarkers for early evaluation of disease. Parkinson's disease is called as progressive and chronic disorder because it lingers for years, with each passing day the health of the patient getting worse. Parkinson's disease is commonly found in elderly people, particularly persons above the age group of 50. With the increase in the healthcare facilities more number of people worldwide is reaching this age in their lives, so the number Parkinson's patients are growing with the rate as never before. According to the National Health Service reports in the USA alone, approximately one million adults are thought to live with Parkinson's disease and one and half million Parkinson's patients are present in the United Kingdom.

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The Michael J. Fox Foundation, a leading research organization of Parkinson Disease has stated that more than five million population of the whole world has been suffering from Parkinson's disease and prevalence will double over the next two decades.

Vocal communication skills are among the fundamental traits necessary for the healthy survival of a human being in society. The voice media being the earliest way of communication known to humans since their evolution has always been a subject of interest for scientific studies. The individuals with voice irregularities have to deal with many hardships, even with basic routine tasks of their regular lives. These deviations in a person's voice with reference to normal voice patterns are called as Voice pathologies. Such Voice pathologies are caused by certain medical disorders which directly or indirectly affect the vocal organs of body's biological system [12]. There is a lot of work going on in developing some suitable procedures to diagnose these voice related ailments. Nowadays, analysis and diagnosis of vocal disorders have become an important medical procedure. Thus, the Voice Analysis has emerged as an important area of study for its various applications in medical as well as engineering sciences. Voice analysis basically deals with extraction of some fundamental parameters from voice signal for further using suitable techniques. Voice analysis measures primarily focus on developing models to evaluate human verbal communication capabilities. The earliest attempt of this type was an idea of mechanical mimic of the human vocal apparatus by Wolfgang von Kempelen in 1791 [68]. Charles Wheatstone [67], 40 years later constructed a machine based on Kempelen's hypothesis. Present researchers have exploited vast aspects of voice signal due to the advancements in digital technology that have equipped the speech pathologists with highly versatile, fast, powerful and low cost digital processors. Moreover, voice being a time-varying signal has all the signal information present in its time variable characteristics.

Voice analysis involves the transformation of voice signal into a set of signals or a set of parameters with an objective to simplify the voice signal to extract features directly pertinent for different applications and to suppress redundant aspects of the signal. These techniques assist medical professionals to study and diagnose the voice signals with ease. Voice analysis can be done either in the time domain or in the frequency domain. The time domain waveform of voice signal carries all the auditory information like phonemes, syllables, prosody levels,

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etc. while the frequency domain represents the spectral characteristics of the voice signal such as frequency, pitch, etc. Voice Interactive Biometric systems and Speech Recognition technology are renowned medical applications of voice analysis systems.

II. MATHODOLOGY

The figure 1. summarizes the layout of all major steps involved in this work to yield the objectives.

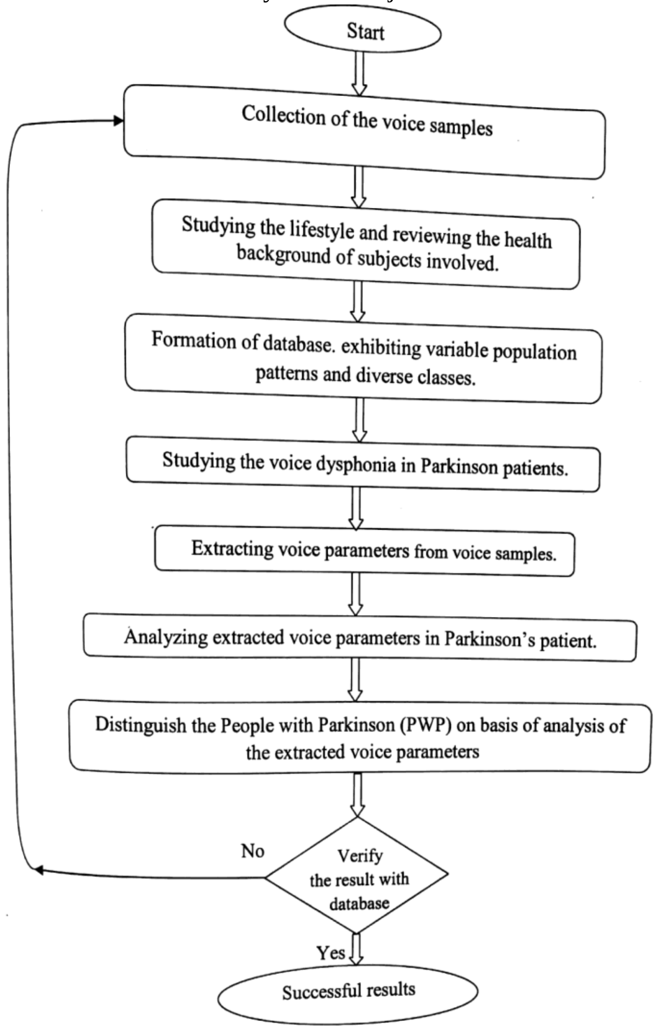

Figure 1: Flow Chart of Methodology Used

III. RESULTS AND DISCUSSIONS

3.1. Results

This chapter presents the results of voice analysis technique implemented for studying Voice Dysphonic in Parkinson's patient's (Perceptual analysis) and discriminating people with Parkinson (PWP) from control subject on the basis of extracted voice features (parametric analysis).These, voice features can be measured by using voice analysis techniques. Parametric analysis is performed in PRATT. The result part is further divided and explained below:

3.1.1. Parametric Analysis for discriminating the PWP

The significance of parametric voice analysis is the extraction of voice features that contain all the auditory information as well as the spectral characteristics for discriminating the People with Parkinson (PWP) on the basis of extracted voice parameters. The features that are extracted are: frequency, pitch, voice intensity, formant, speech rate and pulse functions like Jitter (local), Jitter (local, absolute), Jitter (rap), Jitter (ppq5), Jitter (ddp), Shimmer (local), Shimmer (local, dB), Shimmer (apq3), Shimmer (apq5), Shimmer (apql l), Shimmer (dda) and Harmonic coefficients.

The extracted voice parameters can be describe in detail as follow:

Frequency: The frequency is extracted from the Spectrogram which provides a visual representation of voice in the form of the frequency variation with time of the resonance of a sound or series of sounds. Spectrograms are also called Voiceprints or Voice grams. The spectrogram of a signal s(t) can be represented mathematically as the squared magnitude of the Short-Time Fourier Transform of the signal s(t), as:

$$Spectrogram\ (t, w) = |STFT(t, w)|2 \qquad 3.1$$

- Pitch: Pitch is defined as relative highness or lowness of voice. Pitch plots the perceived range of high versus low fundamental frequency of a person's voice. Pitch of the normal human voice is around the 2000-5000 Hz. Fundamental frequency (F0) is mathematically stated as:

  $F0= 1/T$, where T is fundamental period 4.8 T is define as: x(t) = x (t+T). 3.2

- Voice intensity: Vocal intensity is the major voice parameter, function of the amplitude of vibrations produced by vocal cord and pressure of the subglottic air stream. The Voice Intensity Level can be expressed mathematically as:

$$L = 10 \log(I / Iref), \qquad 3.3$$

- **Formant:** Formants are defined as the spectral peaks of the sound spectrum of the voice. In speech science, formant is used to mean an acoustic resonance of the human vocal tract. A formant is a concentration of acoustic energy around a particular frequency in the voice signal. Formants exist in multiple values, each at a different frequency, roughly one in each l000 Hz band. The formants from resonances produced in the vocal system of body. Thus, an individual can vary the vocal frequencies with the help of "articulator parts" resulting in changing the dimensions of the resonance cavities in the vocal tract. It is measured as peak amplitude in the frequency spectrum of voice given by coefficient of variation:

$$CV= [1/n2\ (xi\text{-}x)\ 2]/x\text{-}2, \qquad 3.4$$

where n is number of peaks measured, xi is individual amplitude value and fl is peak amplitude value.

- **Speech rate:** The Speech rate measures the speed of speaking in words per unit interval. The normal averaging rate of speech in humans is about 100 to 125 words per minute. Speech rate is part of the paralanguage of speech along with loudness and pitch. It conveys attitude and emotion.
- **Pulse:** The Pulse is an important feature for voice analysis which plots visible part of the sound wave.

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The Pulse shows multiple intonation about the voice measurements as: Jitter (local), Jitter (local, absolute), Jitter (rap), Jitter (ppqS), Jitter (ddp),Shimmer (local), Shimmer (local, dB), Shimmer (apq3), Shimmer (apqS), Shimmer (apql l), Shimmer (dda) and Harmonicity of the voiced parts.

- **Jitter:** Jitter defines variation in the pitch of voice. Jitter is the undesired deviation hum true periodicity of a voice signal. Jitter may be observed in characteristics such as the frequency of successive pulses, the signal amplitude, of signals. Jitter is computed as the average absolute difference between the successive periods of fundamental frequency divided by the average period .
- **Shimmer:** Shimmer defines variation in loudness of voice. This is measured as the average absolute difference between the amplitudes of consecutive periods, divided by the average amplitude.
- **Parameter generation in PRAAT:** The parameter generation procedure involves the loading of the voice input into the PRAAT tool installed in Windows7 operating system as wave file. PRAAT tool decomposes the voice signal into pulses of short time windows to extract the desired voice parameters of signal. These parameters. The generated values corresponding to each extracted feature in tables stood as base in distinguishing the People With Parkinson (PWP) from those of control subjects. Thus the voice parameters analysis on PRAAT platform is an efficient tool discriminating the People With Parkinson (PWP) from control subjects and generated positive results.

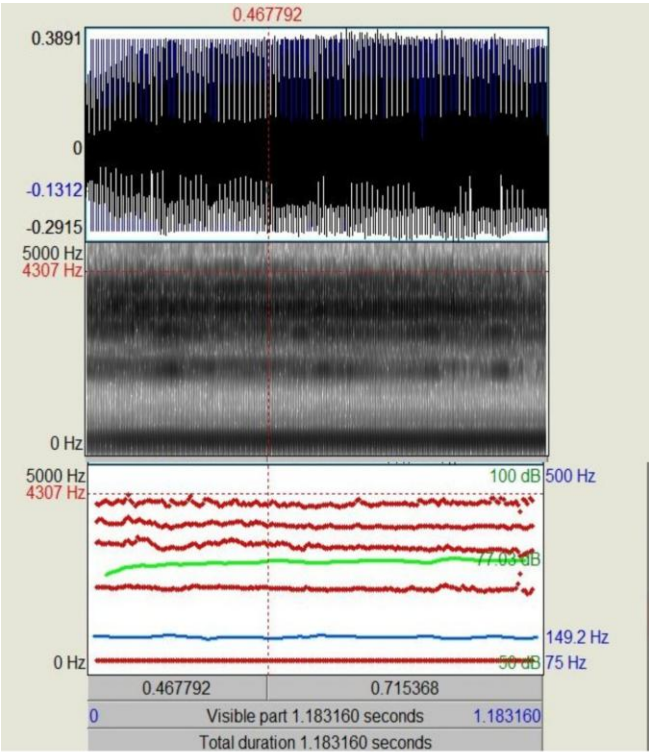

Figure 2(a):Visual presentation of healthy voice sample 1 on PRATT window which shows (i) input voice sample, (ii) frequency spectrum (grey colour), (iii)Pitch(blue), (iv) Vocal Intensity(green), (v) Dominal analysis of vocal signal or Formant (Red)

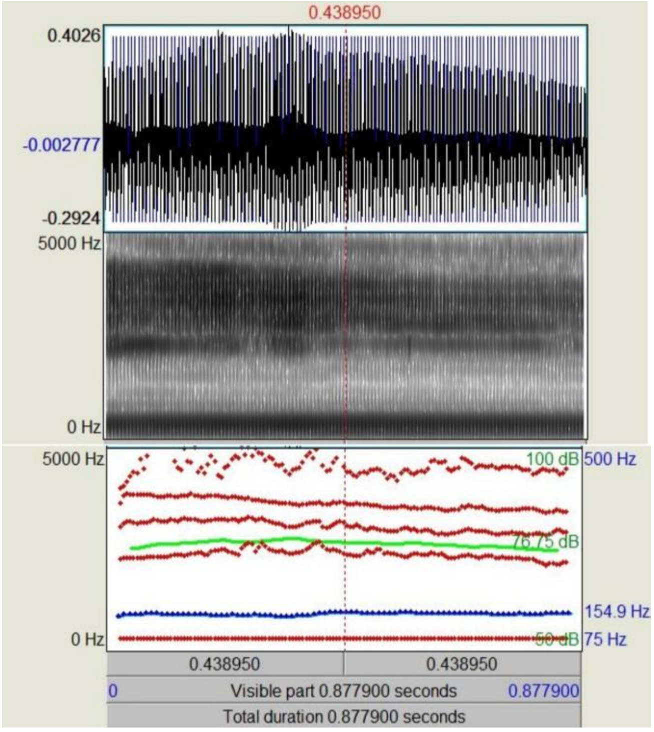

Figure 2(b):Visual presentation of healthy voice sample 2 on PRATT window which shows (i) input voice sample, (ii) frequency spectrum(grey colour), (iii) Pitch(blue), (iv) Vocal Intensity(green), (v) Dominal analysis of vocal signal or Formant(Red)

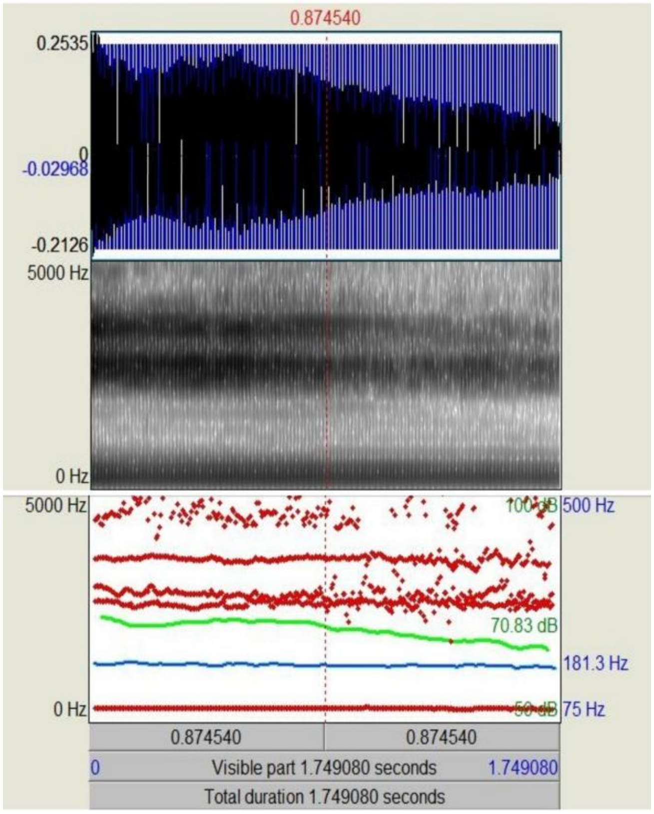

Figure 2(c):Visual presentation of healthy voice sample 3 on PRATT window which shows (i) input voice sample, (ii)frequency spectrum(grey colour),(iii)Pitch(blue), (iv)Vocal Intensity(green), (v)Dominal analysis of vocal signal or Formant(Red)

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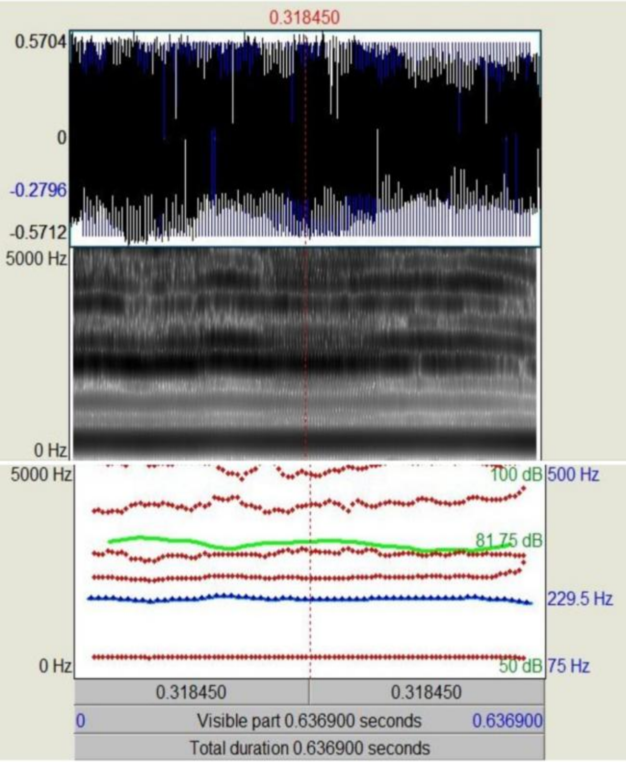

Figure 2(d):Visual presentation of Parkinson affected voice sample 1 on PRATT window which shows (i) input voice sample, (ii) frequency spectrum(grey colour), (iii)Pitch (blue), (iv)Vocal Intensity(green), (v) Dominal analysis of vocal signal or Formant(Red)

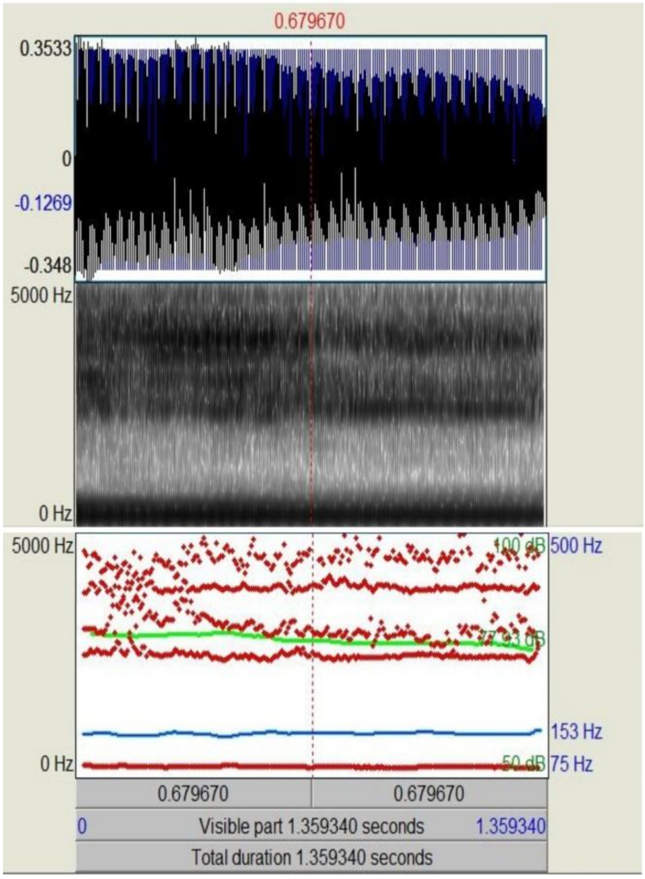

Figure 2(e):Visual presentation of Parkinson affected voice sample 2 on PRATT window which shows (i) input voice sample, (ii)frequency spectrum(grey colour),(iii)Pitch(blue), (iv)Vocal Intensity(green), (v)Dominal analysis of vocal signal or Formant(Red)

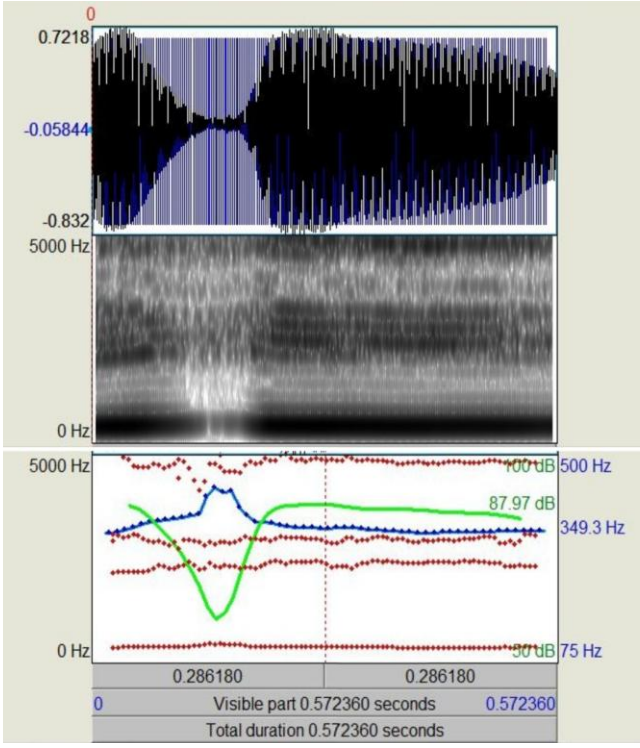

Figure 2(f):Visual presentation of Parkinson affected voice sample 3 on PRATT window which shows (i) input voice sample, (ii)frequency spectrum(grey colour),(iii)Pitch(blue), (iv)Vocal Intensity(green), (v)Dominal analysis of vocal signal or Formant(Red)

IV. CONCLUSION

The broad aim of this work is to study the Parkinson's disease; its etiology, pathology, symptoms; effect of Parkinson's disease on patient's voice and to avail an efficient tool for the diagnosis Parkinson's disease. Parkinson's disease has been an epidemic since the last decade due to the absence of evaluation test. Being an old age disorder its patients are growing day by day as ever because of improving healthcare facilities and decreasing mortality rate. So there is a need of some clinical tool and assessment procedure to diagnose PD early, so to leave the patient in state to receive timely and proper treatment. The statistical data from Parkinson research studies have implicated the presence of vocal impairment in majority of PD subjects and struggle faced by the PD patients due to these voice pathologies. . This had inspired a great deal of research in biomedical engineering for developing clinical tools to evaluate pathological voice patterns. This work entitled "Discrimination of People with Parkinson (PWP) Disease on the basis of Voice Parameter Analysis" has been mostly implemented on PRAAT, an virtual computer operated phonetics application. This dissertation work has been helpful in enriching the knowledge about various aspects of Voice Analysis and applications of voice analyzing tools in our daily lives. Voice analysis involves the transformation of voice signal into a set of parameters with an objective to simplify the voice signal to extract desirable features.

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The major challenge in analyzing voice signal is the time-varying nature of voice that contains all the useful information as its time variable characteristics. The PRAAT works on the principle of short-time window analysis which allows the grasping of these distinguished time-varying features of voice, in order to ease the tasks of understanding, comparison, modification, and resynthesis. Thus, PRAAT tool Voice can be used by speech pathologists and medical professionals to study evaluate and diagnose the quality of the patient's voice signal on the basis of measurable features.

The results achieved in this dissertation work are given as a record for future reference. This dissertation report has been prepared by keeping in mind the ease of non disciplinary reader and anyone can extend this work by finding information about each and every step involved from the report. This topic of dissertation work projects an interdisciplinary approach. It involves the application of the electronic voice processing measures in the field of biomedical signal processing. It is really an immense pleasure to contribute something for such a noble cause of enhancing diagnosis procedure for a fatal health ailment. It can be said that, "Efforts always yield good results."

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REFERENCES

1. De Lau L. M., Tan LC., "Epidemiology of Parkinson's disease", *Neurology Asia*, Vol. 18, Issue 3, pp. 231 -238, 2013.
2. Sakar B.E., Isenkul M.E., Sakar C.o., Sertbas A., Gurgen F., Delil s.,Apaydin H., Kursun O., "Collection and Analysis of a Parkinson SpeechDataset With Multiple Types of Sound Recordings*", IEEE Journal of Biomedical and Health informatics*, Vol. 17, Issue 4, pp. 828-34, 2013.
3. Athanasios Tsanas, Max A. Little, Patrick E. McSharry, Jennifer SpielLorraine O. Ramig, " Novel Speech Signal Processing Algorithms for High-Accuracy Classification of Parkinson's Disease*", IEEE Transactions on Biomedical Engineering*, Vol. 59, Issue 5, pp. 1264-1271, 2012.
4. Rektorova I., Mikl M., Barrett J., Marecek R., Rektor I., Paus T., "Functional neuroanatomy of vocalization in patients with Parkinson's disease*" Journal of the Neurological Sciences, Elsevier,* Vol. 313, pp. 7-12, 2012.
5. Miller N., "Speech, voice and language in Parkinson's disease: changes and interventions", *Future Medicine, Future science group*, 10.2217 NMT.12.15,2012.
6. Shirvan R. A., Tahami E., "Voice Analysis for Detecting Parkinson's Disease Using Genetic Algorithm and KNN", *IEEE Conference on Biomedical Engineering*, pp. 978-1005, 2011.
7. Rouzbahani H. K., Daliri M.R., "Diagnosis of Parkinson's Disease in Human Using Voice Signals", *Basic and Clinical NEUROSCIENCE*, Vol. 2, pp. 12-20, 2011.
8. Bocklet T.,Noth E., Stemmer G., Ruzickova H., Rusz J., "Detection of Persons with Parkinson's Disease by Acoustic, Vocal, and Prosodic Analysis",*IEEE Conference on Automatic Speech Recognition and Understanding,*Waikoloa, HI, pp. 478-483, 2011.
9. Sidtis D.V.L., Rogers T., Godier V., Tagliat M., "Voice and Fluency Changes as a Function of Speech Task and Deep Brain Stimulation", *American Journal of Speech, Language, and Hearing Research,* Vol. 53, pp. 1167-1177, 2010.
10. Constantinescu G., Theodoros D., Russell T., Ward E., Wilson S., Wootton R. "Assessing disordered speech and voice in Parkinson's disease: a telerehabilitation application", *Informa healthcare, Royal College of Speech & Language Therapists University f Queensland,* pp. 1460-6984, 2010.
11. Yang X., Tan B., Ding J., Zhang J., Gong J., "Comparative Study on Voice Activity Detection Algorithm", *IEEE International Conference on Electrical and Control Engineering (ICECE)*, pp. 599-602, 2010.
12. Hirschberg J., A. Neustein (ed.), Advances in Speech Recognition: Mobile Environments, Call Centers and Clinics, "You're as Sick as You Sound": Using Computational Approaches for Modeling Speaker State to Gauge Illness and Recovery, *Springer Science+Business Media*, Vol. 13, pp. 305-22, 2010.
13. Skodda, Sabine; Rinsche, Heiko; Schlegel, Uwe, "Progression of dysprosody in Parkinson's disease over time-A longitudinal study", *Movement Disorders*, Vol. 24, Issue 5, pp. 716-22, 2009.
14. M. A. Little, P. E. McSharry, E. J. Hunter, J. Spielman, and L. O. Ramig, Suitability of dysphonia measurements for telemonitoring of Parkinson's disease", *IEEE Transactions on Biomedical Engineering*, Vol. 56, Issue 4, pp. 1015-1022, 2009.
15. Paulraj M.P, Yaacob S., Hariharan M., "Diagnosis of vocal fold pathology using time-domain features and systole activated neural network", *IEEE 5th International Colloquium on Signal Processing & Its Applications*, pp. 29-32,2009.
16. Quek F., Bryll R., Harper M., Chen L, Ramig L., "Audio and Vision-Based Evaluation of Parkinson's Disease from Discourse Video*", IEEE Xplore*, pp. 10-21, 2009
17. Ehrlich J., "Asthma, Allergies, Articulation: a Speech Therapy Perspective." *Asthma Allergies Children parent's web guide,* 2009.
18. Jankovic J. "Parkinson's disease: clinical features and diagnosis*", J. Neurol. Neurosurg. Psychiatr*., Vol. 79, Issue 4, pp. 368-76, 2008..
19. Proakis J.G.Manolakis D.G., "Digital signal processing*", Pearson Prentice hall*.2007
20. Press W.H., Teukolsky S.A., Vetterling W.T., Flannery B.P., "Support Vector Machines*", Numerical Recipes: The Art of Scientific Computing (3rd ed.)* New York: Cambridge University Press, 2007.
21. Earl Gosh et al, "Pattern recognition", School of computer science, Tele-communciations and information system, DePaul University, *Prentice Hall of India*, New Delhi, 2007.
22. Gold B., Morgan N., "Speech and Audio Signal Processing", *John Wiley & Sons,* 2006.
23. Waters C.W., "Diagnosis and management of Parkinson's disease", *NY: Professional Communications,* Vol. 4, 2005.
24. Duffy J. R., "Motor speech disorders: Substrates, differential diagnosis, and management*", 2nd ed., St. Louis, MO: Elsevier Mosby*, 2005
25. H. Peng, F. Long, and C. Ding, "Feature selection based on mutual information: criteria of max-dependency, max-relevance, and minredundancy," *IEEE Trans. Pattern Anal. Mach.,* Vol. 27, Issue 8, pp. 1226-1238, 2005.
26. Dauer W., Przedborski, S., "Parkinson's Disease: Mechanisms and Models" *Neuron, Cell Press*, Vol. 39, pp. 889-909, 2003.
27. Huber J. E., Stathopoulos E. T., Ramig L. O., Lancaster S. L.,"Respiratory function and variability in individuals with Parkinson disease: Pre- and post-Lee Silverman Voice Treatment", *Journal of Medical Speech-Language Pathology,* Vol. 11, Issue 4, 185-201. (2003).
28. Arfib D., Keiler F., Zolzer U., "Source-filter processing", *Digital Audio Effects, John Wiley and Sons Ltd,* pp. 299-372, 2002.
29. Shaughnessy DO., "Speech Communication", *University press Ltd,* Vol. 2,2001
30. Geralyn M., Schulz, Megan K., "Grant effecets of speech therapy and pharmacologic and surgical treatments on voice and speech in Parkinson's Disease", *Elsevier Science*, Vol. 33, pp. 59-88, 2000.
31. Bower J. H., "Multiple system atrophy", *Parkinson's disease and movement disorders: Diagnosis and treatment guidelines for the practicing physician In C. H. Adler &J. E. Ahlskog, Totowa, Humana Press*, pp. 235-242, 2000.
32. Stacy M., "Progressive Supranuclear Palsy", *Parkinson's disease and movement disorders: Diagnosis and treatment guidelines for the practicing physician, In C. H. Adler & J. E. Ahlskog, Totowa, Humana Press,* pp. 229- 234, 2000.
33. Dewey R. B., "Clinical features of Parkinson's disease", *Parkinson's disease and movement disorders: Diagnosis and treatment guidelines for the practicing physician, In C. H. Adler & J. E. Ahlskog, Totowa, Humana Press*, pp. 71-84, 2000.
34. LeWitt P. A., "Parkinson's disease: Etiologic considerations", *Parkinson's disease and movement disorders: Diagnosis and treatment guidelines for the ticing physician in C. H. Adler & J. E. Ahlskog, Totowa, Humana Press,*
rac pp. 91-101, 2000

35. Schroeder M. R., "Computer Speech: Recognition, Compression, and Synthesis", *Springer Verlag*, 1999,
36. Kondaz A.M., "Digital Speech coding for low bit rate Communication Systems", *John Wiley & sons*, 1999.
37. Luschei E.S., Ramig L.O., Baker K.L., Smith M.E., "Discharge characteristics of laryngeal single motor units during phonation in young and older adults and in persons with parkinson disease", *Journal of Neurophysiology*, Vol. 81, pp. 2131-39, 1999.
38. Michaelis D., "Selection and combination of acoustic features for the description of pathologic voices", *Journal of Acoustical Society of America Vol. 10, Issue 3*, pp. 1628-40, 1998.
39. Mitra S.K., "Digital Signal Processing: A computer-Based Approach", *McGraw-Hill, New York*, 1998.
40. Yegnanarayana B., Veldhuis R.N.J., "Extraction of vocal-tract system characteristics from speech signals*", IEEE Transactions on Speech and Audio processing*, Vol. 6, pp. 313-327, 1998.
41. Lang E., Lozano A. M., "Parkinson's disease", *New England Journal of Medicine, Vol. 339, Issue 15*, pp. 1044-1053, 1998.
42. Baker, K.K., Ramig, L.O., Luschei, E.S, & Smith, M.E., "Thyroarytenoid muscle activity associated with hypophonia in Parkinson disease and aging", *Neurology, Vol. 51*, pp. 1592-1598, 1998.
43. Fox, C.M., & Ramig, L.O., "Vocal sound pressure level and self-perception of speech and voice in men and women with idiopathic Parkinson disease*" American Journal of Speech-Language Pathology,* Vol. 6, pp. 85-94, 1997,
44. De Rijk M. C., Tzourio C, Breteler M. M, Dartigues J. F, Amaducci L. Lopez-Pousa S., et al., "Prevalence of parkinsonism and Parkinson's disease in Europe: The EUROPARKINSON collaborative study. European community concerted action on the epidemiology of Parkinson's disease", *Journal of Neurology, Neurosurgery and Psychiatry, Vol. 62, Issue* 1, pp. 10-15, 1997,
45. Hammen, V.L., & Yorkston, K.M., "Speech and pause characteristics following speech rate reduction in hypokinetic dysarthria*", Journal of Communication Disorders*, Vol. 29, pp. 429-444, 1996.
46. Perez,K.S., Ramig, L.O., Smith, M.E., & Dromey, C., "The Parkinson larynx: Tremor and videostroboscopic findings", *Journal of Voice*, 10, 354-361.(1996).
47. Theodoros D. G., Murdoch B. E., Thompson E. C, "Hypernasality in Parkinson's disease: A perceptual and physiological analysis", *Journal of Medical Speech-Language Pathology*, Vol. 3, Issue 2, pp. 73-84, 1995.
48. Smith, M.E., Ramig, L.O., Dromey, C., Perez, K.S., & Samandari, R., Intensive voice treatment in Parkinson disease: Laryngostroboscopic findings", *Journal of Voice*, Vol. 9, pp. 453-459, 1995.
49. Moulines E., Verhelst W., "Time-Domain and Frequency-Domain Techniques for Prosodic Modification of Speech*", Elsevier Science B.V., Speech Coding and Synthesis*, 1995.
50. Solomon, N.P., & Hixon, T.J., "Speech breathing in Parkinson's disease" *Journal of Speech and Hearing Research*, Vol. 36, pp. 294-310, 1993.