Estimation of Severity of Parkinson's Disease Using Gait Analysis

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Abstract- **Parkinson's disease (PD) is one of the very common neural disorders which results in severe disability. Different signals like EEG, speech and gait can be used to detect Parkinson's disease. In this paper gait analysis is used to determine the level of severity of Parkinson's disease in pathological subjects. Here stride time of normal subjects is estimated and threshold value is found. Based on this threshold value, pathological subjects are classified depending on the disease severity.**

Keywords: **Gait, Neural Disorder, Parkinson's Disease, Stride Time, Start point.**

I. INTRODUCTION

Brain is one of the most vital organs of human beings, controlling the coordination of human muscles and nerves. The transient and unexpected electrical disturbances of the brain result in various neural disorders. Such neural disorders can be classified into Parkinson's disease (PD), Alzheimer's and epilepsy [1]. It takes doctors a lot of time for the diagnosis of these diseases. Hence automatic detection of these abnormalities is essential. That can be implemented with modern computing techniques to speed up the diagnosis process of these diseases by medical practioner.

According the recent survey, Parkinson's disease (PD) is the second largest neurodegenerative disorder that affects approximately 1 in 500 people and often leads to severe disability[9][2]. It is characterized by tremor, speech disorders, rigidity, slowness, and postural instability [10][11].

Walking can be defined as a method of locomotion involving the use of the two legs, alternately, to provide both support and propulsion [3].The ability to maintain a steady gait rhythm is impaired in patients with Parkinson's disease (PD). Patients with Parkinson's disease walk with a shortened stride length and high stride-to-stride variability [7]. PD can be quantified by measuring the stride-to-stride variability of gait timing [4][5][6].

In this proposed work, it is intended to develop a methodology which speeds up the diagnosis process of PD using signal processing techniques.

II. PROPOSED WORK

The vertical ground reaction force records of normal and pathological subjects were recorded as they walked at their usual pace for two minutes on level ground. Each foot consists of 8 sensors which were placed under each foot. Those sensors measure force as a function of time. The output of each of these 16 sensors has been digitized and recorded at 100 samples per second. Two signals that reflect the sum of the 8 sensor outputs for each foot are also included. Such signal database which is available at physionet is used for the proposed work execution.

In this work, ten numbers of healthy and physically normal persons/subjects have been considered to create the reference values to compare with the pathological subjects and to conclude the severity of Parkinson's disease.

In each case of normal/ pathological subjects, the two minutes walking data consisting of approximately 12000 samples are considered and further it is divided into ten parts each consisting of one thousand samples, leaving the first and last thousand samples. This is done to avoid startup and ending stage of walking where the normal pace of walking may not have occurred.

Analysis can be done either on left foot or on right foot for start time detection. Since both of them yield approximately similar results, in the proposed work, left foot signals are considered for the analysis purpose. Each group of thousand samples is further processed to determine start point of the left foot.

The sum of the 8 sensor outputs for left foot of a subject is considered and the data is normalized. Each time three consecutive samples are considered and checked whether they are in the increasing order. If this condition is satisfied, then first point is taken as start point of the sequence. Otherwise the algorithm searches for next three consecutive points which are in the increasing order. Once the start point is found, null points are located by again checking for consecutive points which have values close to zero. This process continues to identify all the start points of the considered sequence.

Once the start points for a set of one thousand sample values have been found, stride time is calculated by subtracting previous value from the present value. These stride time values are grouped and mean value is found and

mean deviation is calculated. This process is repeated for entire set of ten thousand values of each subject. The analysis is carried for ten different normal subjects.

The normalized force, start time values , stride time and stride time deviations for one set of one thousand values for normal subject are indicated in figure 1,2,3 and 4 respectively. Here Co1 refers to Control Subject/normal subject 1.

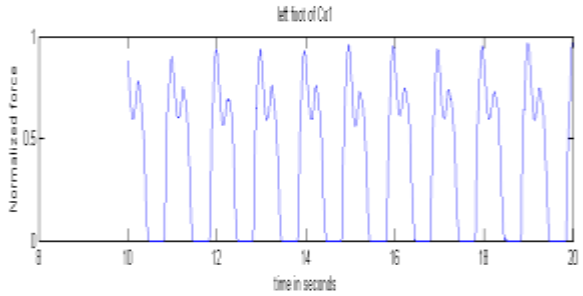

Figure 1. Normalized Force

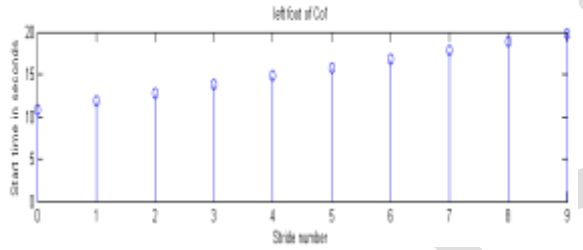

Figure 2. Start time values

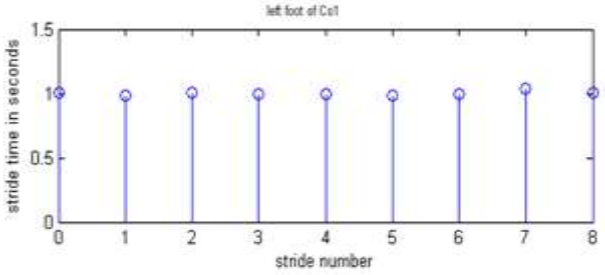

Figure 3. Stride time

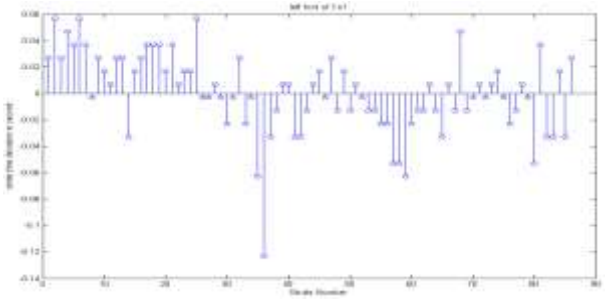

Figure 4. Stride time deviation

The same analysis is repeated for a set of pathological subjects with varying level of severity of Parkinson's disease and results are indicated. The severity of disease is classified based on the threshold values. The threshold value of normal is calculated as follows: The stride time deviation of ten normal subjects is calculated. The deviation is both on the positive side and is also on the negative side. The maximum value of deviation on the positive side is considered as maximum positive value and minimum value of deviation on the negative side is considered as minimum negative value. In the case of normal subjects, maximum positive value is 0.15 and minimum negative value is -0.27. Therefore the range [0.15 to -0.27] is considered as threshold value. The range up to 0.3 on the positive side and -0.7 on the negative side is considered as mild; up to 0.7 on the positive side and -1.3 on the negative side is considered as moderate. The values >0.7 on positive side and < -1.3 on the negative side are considered as severe. The graph of stride time deviation for all the three different cases is indicated in figure 5, 6 and 7.

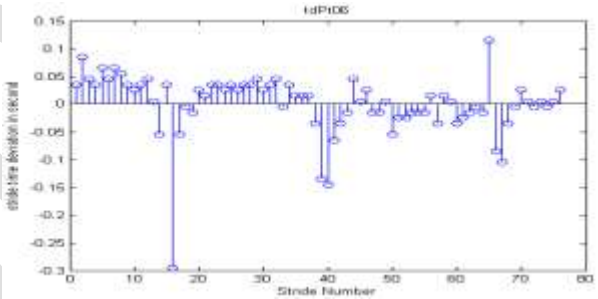

Figure 5. Stride time deviation of pathological subject (mild)

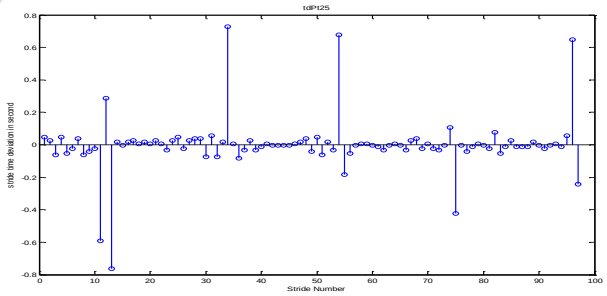

Figure 6. Stride time deviation of pathological subject (moderate)

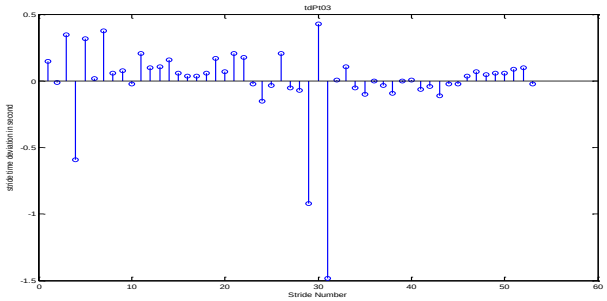

Figure 7. Stride time deviation of pathological subject (severe)

III. RESULTS

The result of above analysis for different pathological subjects is indicated in Table 1.

Table 1. Analysis result of pathological subjects

Patient No.	Stride Time Deviation in Second		Inference
	Maximum	Minimum	
PD06	0.115	-0.3	Mild
PD03	0.427	-1.482	Severe
PD04	0.1415	-1.02	Moderate
PD07	1.2	-0.428	Severe
PD08	0.187	-0.19	Mild
PD12	0.24	-0.302	Mild
PD13	0.3	-0.13	Mild
PD14	0.23	-0.68	Mild
PD18	0.16	-0.141	Mild
PD21	0.7566	-0.553	Severe
PD23	0.306	-1.8338	Severe
PD25	0.727	-0.7627	Moderate
PD27	0.16	-0.238	Mild
PD28	0.12	-1.13	Moderate
PD40	0.73	-0.29	Moderate

IV. CONCLUSION

In this paper, determination of stride time and stride time deviation of both normal and pathological subjects is discussed. This method provides an easy way of determination of severity of Parkinson Disease in different pathological subjects. This method is simple and less time consuming.

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