Human Voice Waveform Analysis for Categorization of Healthy and Parkinson Subjects

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ABSTRACT

Parkinson disease is a neurological disorder. In this disease control over body muscles get disturbed. In almost 90% of the cases, people suffering from Parkinson disease (PD) have speech disorders. The goal of the paper is to differentiate healthy and PD affected persons using voice analysis. There are no well-developed lab techniques available for Parkinson detection. Parkinson detection using voice analysis is a noninvasive, reliable and economic method. Using this technique patient need not to visit the clinic. In this paper the authors have recorded 155 phonations from 25 healthy and 22 PD affected persons. Classification is done using two proposed parameters: Local angular frequency and instantaneous deviation in the waveform. Support vector machine is used as a classifier. Maximum 86.8% classification accuracy is achieved using linear kernel function.

KEYWORDS
Classification, Parkinson Disease, Support Vector Machine, Voice Analysis

INTRODUCTION

Parkinson disease is explained and named first by James Parkinson in 1817. He gave Parkinson characteristics as resting tremor, reduced muscle strength and an unusual posture. Later Konstantin Nikolaevitch Tretiakoff described the degeneration of substantia nigra in Parkinson. A Swedish scientist Aruel Carlson in 2000 was awarded Nobel Prize for his work with dopamine and its affect in Parkinson disease. He explained that in Parkinson, dopamine level falls and causes loss of movement. The dopamine neurons present in the substantia nigra part of brain is a neuro-transmitter which sends message to the brain. It controls coordination and movements of body. As the dopamine level reduces the movements become unbalance. The primary symptoms of Parkinson disease are tremor in hands, arms, legs, jaw and face, stiffness of the limbs, slowness of movement and impaired balance. As disease progresses, condition becomes more worse and even patients have difficulty in walking, talking and in daily routine activities. Parkinson usually affects the persons after the age of 50. However in 4% to 5% cases, it appears in younger age and is known as young onset Parkinson disease. Male has 50% higher risk of developing Parkinson than female. In USA one million people are living with Parkinson disease and annually 60,000 persons are diagnosed with it. No blood test or laboratory test is available for its detection. The diagnosis is based on medical history and neurological examination. There is no cure at present, instead some medications are available which provide some relief. Lavodapa combined with carbidopa delays the conversion of levodopa into dopamine until it reaches the brain. Nerve cells
use levodopa to make dopamine and replenish the brain dwindling supply. Anticholinergics control
tremor and rigidity. Parkinson patients have voice problem because of disorder in laryngeal, respiratory
and articulatory functions. These functional disorders are because of inadequate muscle activation.
Parkinson patient voices are characterized by reduced loudness, monopitch, monoloudness, reduced
stress, breathy, hoarse voice quality, imprecise articulation and dysfluent speech. The reduced ability
to communicate is the most difficult aspect of Parkinson disease. The vocal sound pressure level is
reduced by approx 2-4 decibel. Reduced frequency range is observed for the patients. Control on
voice onset and offset system gets disturbed. LSVT loud treatment is done to remove voice disorders
in Parkinson patients (Ramig, Fox & Sapir, 2008).

Parkinson detection using voice analysis is very reliable and non-invasive method. Also in this
patients need not to visit the clinic frequently. It reduces the discomfort and expenditure of patients.
As Parkinson patients feel it difficult in walking etc in daily routine activities. Many researchers found
some relevant voice characteristics which differentiate healthy and Parkinson persons. Skodda (2015)
recorded the vowel ‘a’, syllable /pa/ and /pa-ti/ of 32 Parkinson patients. In one single breath how
long vowel can be produced is vowel keeping time (VKT). VKT value reduces for Parkinson patients.
Maximum syllable repetition rate (maxsylrep) is how fast participant can reiterate the syllable. The
time intervals between onsets of one vocalization until the following vocalization is known as Interval
Duration (IntDur). These two are not significant one. The coefficient of variation (COV) is significant
one and is defined as stability of pace of utterance. Tahakhan (2014) did the clinical rating of Parkinson
patients as 0, 1, 2 based on UPDRS and used three running texts with different difficulty level. He
found the correlation of feature value according to UPDRS and second correlation according to the
text difficulty level. The phonatory, articulatory and prosodic features are calculated. The phonatory
symptoms were strongly correlated with the clinical rating and this correlation improves with text
difficulty. In articulatory features 7th, 8th, 9th, 10th mel frequency cepstrum coefficients (MFCC)
were strongly correlated where as 1st, 2nd, 5th, 6th are not strongly correlated with the clinical rating.
Phonation parameters are those which are related to vibrations of the vocal folds to create sound. The
articulatory parameters are dependent on shape and position of speech organs. Prosody parameters
are the variation in loudness and pitch. Prosody parameters are the most significant one; in 61% cases
prosodic parameters get affected. Articulation and phonation parameters changes in 39% and 26%
cases respectively (Rusz, Cmejla, Ruzickova, & Ruzicka, 2011).

With the prosody, phonation and articulation; one more parameter is combined that is respiratory
parameter known as sound pressure level decline (SPLD). 85.02% classification score is obtained
with support vector machine (SVM) (Rusz, Cmejla, Ruzickova, Klempr, Majerova, Picmausova, &
Ruzicka, 2011). With the traditional measures like jitter, shimmer, harmonic to noise ratio (HNR);
some new measures are calculated, which are robust to many uncontrolled confounding effects. The
time delay embedding the signal to create the phase space is measured by correlation dimension D2
and extent to which the deviation from periodicity is evaluated by entropy. The Detrended Fluctuation
Analysis (DFA) is based on incomplete vocal fold closure and leads to turbulent noise. It measures
amplitude variation F (l) of speech signal over the time scale l. Pitch Period Entropy (PPE) is the
relative semitone pitch variation (Little, McSharry, Hunter, Spielman, & Ramig, 2009). Pathological
voices exhibit increased Aero acoustic noise because of excessive turbulence noise due to incomplete
vocal fold closure. The HNR, DFA, glottal to noise excitation (GNE), vocal fold excitation ratio
(VFER) and empirical mode decomposition excitation ratio (EMD-ER) are such measures related
to turbulent noise (Tsanas, Little, McSharry, Spielman, & Ramig, 2012).

Formant frequencies are a function of movement of the articulators. The vowel space area (VSA)
is constructed by Euclidean distance between the F1 and F2 co-ordinates of vowels/i/, /u/ and /a/. VSA
is highly sensitive to interspeaker variability. For reducing the variability, VSA is plotted such that
frequencies are logarithmically scaled. For lessening interspeaker variability Formant Centralization
Ratio (FCR) is defined as
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