Detection of Movement Disorders Using Multi SVM

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Abstract - Gait analysis is very significant for early diagnosis of gait diseases and treatment assessment. Gait analysis is used to assess, plan and to treat the individuals with conditions affecting their ability to walk. In recent years, doctors gain more clarity and exact disease assessment by means of machine learning technologies and this has gained much application of gait analysis. The patients suffering from movement disorders such as Parkinson’s disease (PD), Huntington’s disease (HD), and Amyotrophic Lateral Sclerosis (ALS) can best be diagnosed by gait analysis. For these reasons, analysis of the above said diseases are taken into consideration. In this paper we propose an effective method for detection of movement disorders using multi SVM technique.

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GJCST-G Classification: G.1.2
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I. Introduction

Biometrics is an automated method of identifying a person or verifying the identity of a person. It is based on a physiological or behavioral characteristic of human. Physiological characteristics include fingerprint, palm print, face and voice. Behavioral characteristics include signature and gait. Gait can be defined as a style of walking. Interestingly there are studies asserting that every individual has a unique Gait pattern [2], diagnosing different disorders in the correct and fast way is highly important for the correct treatment of the disease. It would be valuable if it was done by a noninvasive approach. Moreover, identifying the disease in a more simplified way will help the physicians in the diagnosis process. Diagnosis time is an important factor in the treatment, especially for progressive diseases. In such a situation, we may need medical imaging or genetic test to detect the disease [1]. In this paper we introduce an effective method to detect the movement disorder which uses wavelet transform for feature extraction and multi SVM for classification. These diseases were selected for the study, as they have similar causes.

Huntington’s Disease (HD) is a genetic neurological disorder characterized by abnormal body movements called chorea and a lack of coordination. As some of its symptoms are similar to other neurological disorders, such as Alzheimer’s disease, it has been extensively studied by different researchers [3]. Parkinson’s Disease (PD) is also a degenerative disorder of the central nervous system that often impairs the sufferer’s motor skills and speech, as well as other functions. It is characterized by muscle rigidity, tremor, a slowing of physical movement (bradykinesia) and, in extreme cases, a loss of physical movement (akinesia). The primary symptoms are due to decreased stimulation of the motor cortex by the basal ganglia. Parkinson’s Disease (PD) is both chronic and progressive [3]. Amyotrophic Lateral Sclerosis (ALS) is a progressive, usually fatal, neurodegenerative disease caused by the degeneration of motor neurons, the nerve cells in the central nervous system that control voluntary muscle movement. As a motor neuron disease, the disorder body because of both the upper and lower motorneurons degenerate, ceasing to send messages to the muscles [3].

II. Related Work

Biometric recognition refers to an automatic recognition of individuals based on feature derived from their anatomical and/or behavioral characteristics [4,5]. Wavelet transforms are based on small wavelets with limited duration. The translated-version wavelets locate where we concern. Whereas the scaled-version wavelets allow us to analyze the signal in different scale [6]. Wavelet transforms are now being adopted for a vast number of applications, often replacing the conventional Fourier Transform. Many areas of physics have seen this paradigm shift, including molecular dynamics, ab initial calculations, astrophysics, density-matrix localization, seismology, optics, turbulence and quantum mechanics [7].

Human movement, especially human gait, provides salient information about people, including features of individuality [9]. SVMs [10] are supervised machine learning methods used for classification and regression [11], and have increasingly been used in the classification of human characteristics, including face recognition [12], human grip configurations under the scaling of object mass and size to the individual hand properties [13], and distinguishing the EEG patterns of individuals with different levels of concussion [14]. [8] Murray strongly believed that gait is unique for every subject, if all the gait movements are considered. As an outcome of his investigation, it was reported that the
motion patterns of the pelvic and thorax regions are highly variable from one subject to another. Gait signal may be a good factor for discriminating movement disorders that is caused by malfunctioning of some brain parts. It can also be used for validation of models that are introduced for the diseases [1].

III. Methodology

a) Feature extraction using wavelet transform

A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. Usually one can assign a frequency range to each scale component. Each scale component can then be studied with a resolution that matches its scale. A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies of a finite-length or fast-decaying oscillating waveform. Wavelet transforms have advantages over traditional Fourier transforms for representing functions that have discontinuities and sharp peaks, and for accurately deconstructing and reconstructing finite, non-periodic and/or non-stationary signals [6, 7]. Different types of wavelet transforms are available. In this study we use continuous wavelet transform for feature extraction.

In continuous wavelet transforms, a given signal of finite energy is projected on a continuous family of frequency bands (or similar subspaces of the $L^2$ function space $L^2(\mathbb{R})$). For instance the signal may be represented on every frequency band of the form $[f, 2f]$ for all positive frequencies $f>0$. Then, the original signal can be reconstructed by a suitable integration over all the resulting frequency components. The frequency bands or sub bands are scaled versions of a subspace at scale 1. This subspace in turn is in most situations generated by the shifts of one generating function $\psi \in L^2(\mathbb{R})$, the mother wavelet.

For the example of the scale one frequency band $[1, 2]$ this function is

$$\psi(t) = 2 \sin(2t) - \sin(t) = \frac{\sin(2\pi t) - \sin(\pi t)}{\pi t}$$

The subspace of scale $a$ or frequency band $[1/a, 2/a]$ is generated by the functions (sometimes called child wavelets)

$$\psi_{a,b}(t) = \sqrt{a} \psi \left( \frac{t - b}{a} \right)$$

Where a is positive and defines the scale and b is any real number and defines the shift. The pair $(a, b)$ defines a point in the right half plane $\mathbb{R}_+ \times \mathbb{R}$.

The projection of a function $x$ onto the subspace of scale $a$ then has the form

$$x_a(t) = \int_{\mathbb{R}} WT \{x\}(a, b) \cdot \psi_{a,b}(t) \, db$$

with wavelet coefficients

$$WT \{x\}(a, b) = \langle x, \psi_{a,b} \rangle = \int_{\mathbb{R}} x(t) \psi_{a,b}(t) \, dt$$

Using the above formula we extract feature from the gait signal.

b) Classification using multi SVM

SVMs are inherently two-class classifiers. The traditional way to do multiclass classification with SVMs is to use one of the methods in particular, the most common technique in practice has been to build $|C|$ one-versus-rest classifiers and to choose the class which classifies the test datum with greatest margin. Another strategy is to build a set of one-versus-one classifiers, and to choose the class that is selected by the most classifiers. While this involves building $|C|(|C| - 1)/2$ classifiers, the time for training classifiers may actually decrease, since the training data set for each classifier is much smaller. However, these are not very elegant approaches to solving multiclass problems. A better alternative is provided by the construction of multiclass SVMs, where we build a two-class classifier over a feature vector $F(\sim x, y)$ derived from the pair consisting of the input features and the class of the datum. At test time, the classifier chooses the class $y = \text{argmax}_y \langle w, F(\sim x, y) \rangle$. The margin during training is the gap between this value for the correct class and for the nearest other class, and so the quadratic program formulation will require that $A_i A_j y_i y_j \langle w, F(\sim x, y) \rangle \geq 1 - x_i$. This general method can be extended to give a multiclass formulation of various kinds of linear classifiers [8]. Using this technique we classify our gait signals by HD with PD and PD with ALU.

Database Detail

Gait signals are collected from the public database physionet. The records in this database are from patients with Parkinson's disease (n= 15), Huntington's disease (n= 20), or Amyotrophic lateral sclerosis (n= 13). Records from 16 healthy control subjects are also included. The raw data were obtained using force-sensitive resistors, with the output roughly proportional to the force under the foot. Stride-to-stride measures of footfall contact times were derived from those signals.

IV. Result and Analysis

We divided the dataset to train and test sets randomly. However, we have tried to select our test set among those recordings which had been recognized as
the most severe cases by a physician. So we have selected 10 of 64 recordings as test and remaining as training set. The result of the classification is given below.

Table 1: Accuracy percentage of classification

<table>
<thead>
<tr>
<th>Classes</th>
<th>HD</th>
<th>PD</th>
<th>ALU</th>
<th>CO</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>71.42</td>
<td>40</td>
<td>50</td>
<td>100</td>
<td>65.21</td>
</tr>
<tr>
<td>B</td>
<td>71.42</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>89.95</td>
</tr>
<tr>
<td>C</td>
<td>57.14</td>
<td>60</td>
<td>16.66</td>
<td>100</td>
<td>56.52</td>
</tr>
<tr>
<td>D</td>
<td>71.42</td>
<td>70</td>
<td>83.33</td>
<td>80</td>
<td>60.87</td>
</tr>
<tr>
<td>E</td>
<td>42.86</td>
<td>60</td>
<td>66.66</td>
<td>100</td>
<td>65.21</td>
</tr>
<tr>
<td>F</td>
<td>71.42</td>
<td>40</td>
<td>50</td>
<td>100</td>
<td>65.21</td>
</tr>
<tr>
<td>G</td>
<td>28.57</td>
<td>40</td>
<td>83.33</td>
<td>20</td>
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</tr>
<tr>
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<td>40</td>
<td>50</td>
<td>80</td>
<td>60.87</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>60</td>
<td>33.33</td>
<td>100</td>
<td>43.47</td>
</tr>
<tr>
<td>J</td>
<td>57.14</td>
<td>20</td>
<td>33.33</td>
<td>100</td>
<td>52.17</td>
</tr>
</tbody>
</table>

HD - Huntington disease
PD - Parkinson’s disease
ALS - Amyotrophic lateral sclerosis

V. Conclusion

An automated method for detecting movement disorder may be useful for physicians to diagnose the disease more easily and immediately. This in turn will result in faster and effective treatment of the disorders. In this study, we have tried to introduce an automated approach to diagnose three similar movement disorders, Huntington’s disease (HD), Parkinson’s Disease (PD) and Amyotrophic Lateral Sclerosis (ALS) by classifying the features that are extracted from the gait signals of a patient. As, we had limited access to clinical records needed for the training and testing process, the accuracy stated here may not reflect pertaining to a large database. Thus, training the classifier using more recordings might result in better accuracy percentage.

References

1. Masood Banaie a,1, Mohammad Pooyan b, Mohammad Mikaili b, Introduction and application of an automatic gait recognition method to diagnose movement disorders that arose of similar causes, 0957-4174 (2010).