A Gait Analysis Approach to Track Parkinson's Disease Evolution Using Principal Component Analysis

CBMS 2016

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20/06/2016

Summary

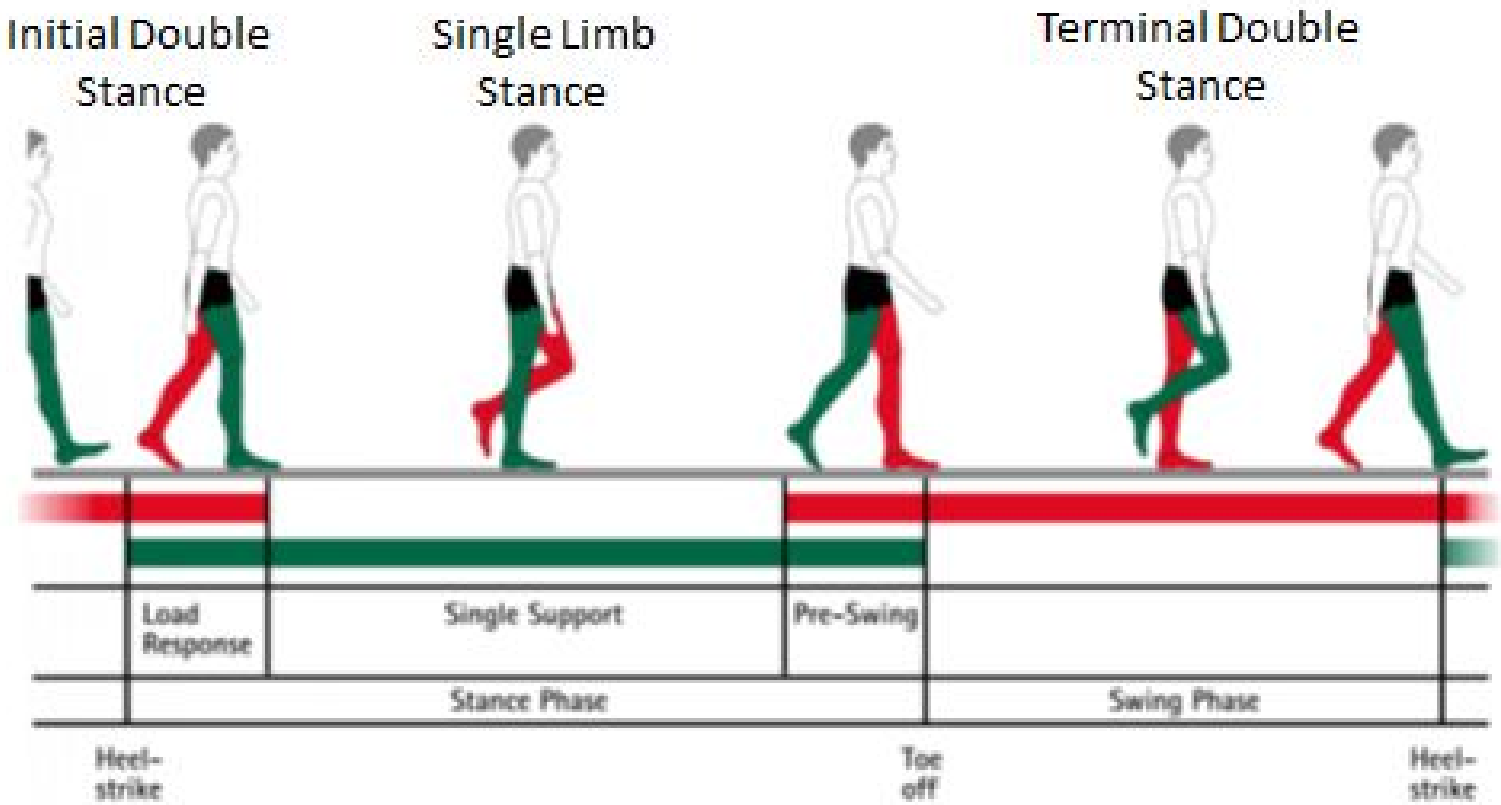
Gait Analysis to Track Parkinson's Disease Evolution

Gait analysis has been strongly applied to evaluate the evolution of neurological diseases such as Parkinson's Disease (PD), which affects about 2% of the world population.

In this work, we present a **reproducible gait analysis to track Parkinson's Disease evolution** by monitoring walking abnormalities.

Gait Analysis

Gait analysis is the systematic study of human locomotion, including qualitative and quantitative assessment.



Gait Analysis

The human gait is a periodic movement of the limbs during locomotion over a solid substrate. Each gait cycle starts when a foot initiates contact (i.e., heel strike) with the ground and restarts when it touches the ground again.

Sensors To Acquire VGRF

Nowadays, an effective approach is using foot sensors to collect gait data from the forces between the foot and the ground defined as Vertical Ground Reaction Force (VGRF)

Gait Analysis through VGRF

Gait analysis studies the forces and moments of the movement of body segments in a human gait, including the measurement of VGRF. The patients use adapted force sensors under the feet and attached to the shoes to measure the VGRF.

Motivation

Physicians and physiotherapists apply gait analysis **subjectively in clinical evaluation**, which sometimes is followed by a survey regarding gait quality. This research area has attracted the interest of **multidisciplinary researchers**.

PCA for Gait Analysis

In this paper, we propose a gait analysis approach to **track PD evolution by monitoring walking abnormalities**. We **applied PCA into gait data to detect abnormalities that may indicate the progression of PD**.

Data Collection

We validated our approach with a public database of foot sensor data, which includes vertical ground reaction force records of healthy subjects and PD patients.

How We Detected Gait Abnormalities ?

We used Principal Component Analysis to identify the gait variance.

Principal Component Analysis

PCA is a statistic procedure to reduce data and eliminate redundancies. It identifies the data variance and applies linear data transformation to detect the most relevant data components on the first dimension, called the main axis. The second remaining variance is the secondary axis and so on.

PCA Step by Step

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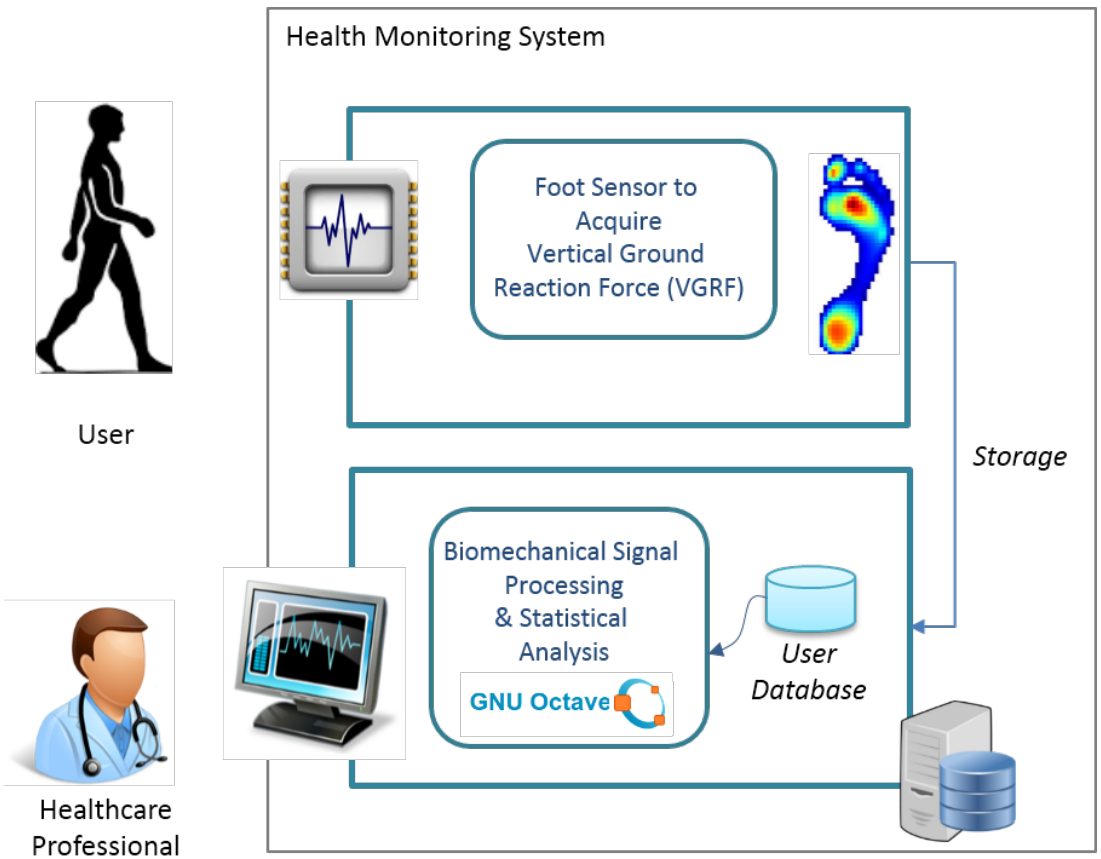
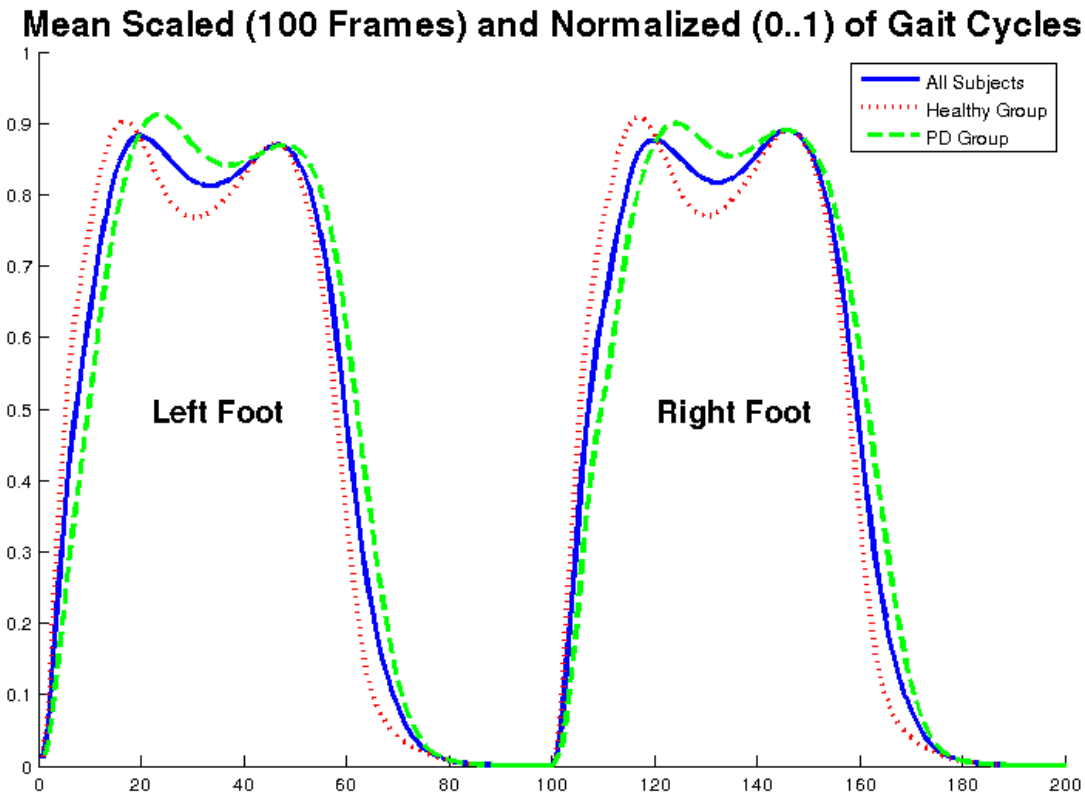
4. The Calculated *eigenvectors* and *eigenvalues* can be used to project the data into a new space called *eigenspace*.

System Overview



Mean Vector

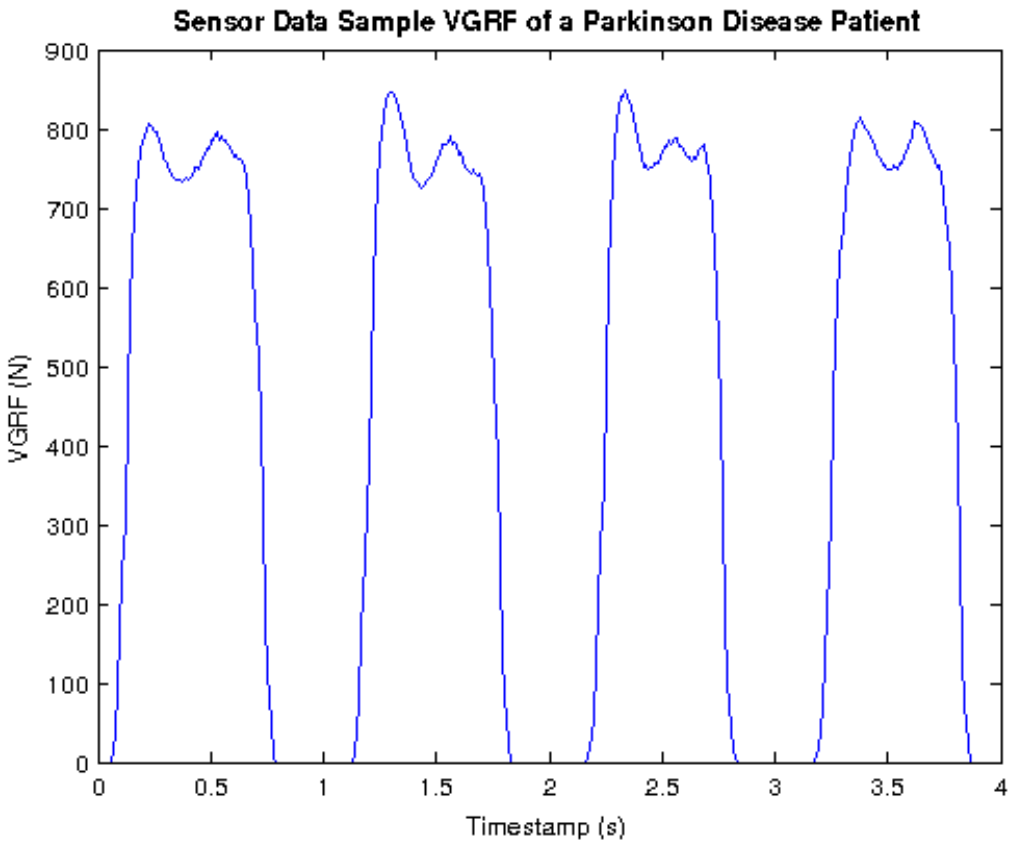

Mean Scaled (100 Frames) and Normalized (0..1) of Gait Cycles
All Subjects
Healthy Group
PD Group
Left Foot
Right Foot
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
120
140
160
180
200

Developed Approach

To automate the identification of each gait phase in the VGRF data, it is necessary to use **signal processing techniques**.

In this work, we focus on the VGRF of each foot and identifying when the foot initiates contact (i.e., start of stance phase) with the ground and when it is off the ground. For this purpose, **we used the peaks and valleys technique** to identify the beginning and end of each gait cycle.

Peaks and Valleys



Data Collection

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n this work, we used an database under ODC Public Domain Dedication and License. Available at**physionet**, which contains the VGRF records of subjects as they walked at their usual pace for approximately 2 minutes on level ground.

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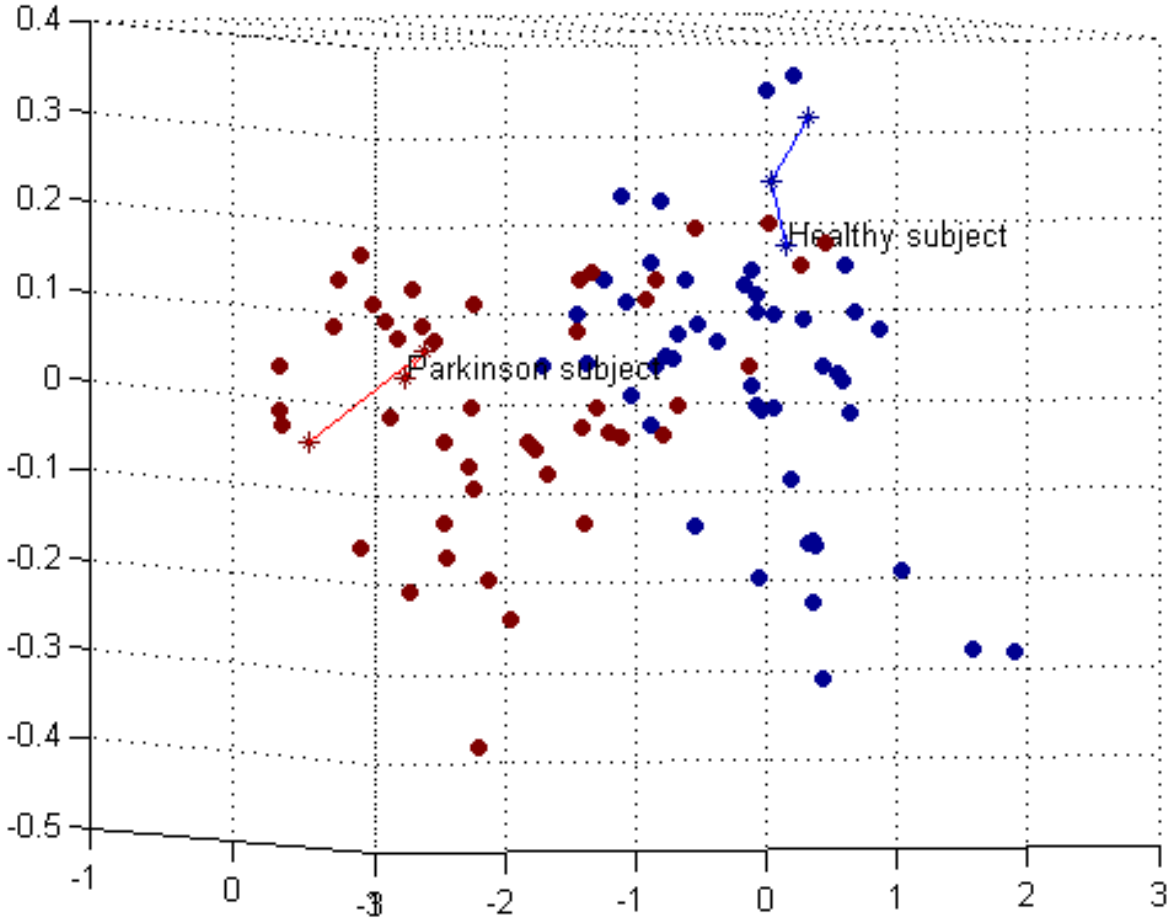
- We project this data creating a new space;
- So, we used the euclidean distance of the test data to the training data to classify each subject as **PD's Group or Control Group**.

Projection of PD's (RED) and HEALTHY (BLUE dots)



PCA with Euclidean Distance Classifier Performance

	Predictive Class	
	Parkinson	**Control**
Parkinson	43	7
Control	12	38

Classifier Metrics	
TpRate	86.00%
FpRate	24.00%
Precision	78.18%
Accuracy	81.00%
F-Score	81.90%

Questions

Reproducible Research

Our source code is under GPL License Version 3.0 and can be reproduced using an Open Source Application for numerical computations (Octave Version 3.8.1).

Source Code and Relevant Data

To reproduce our results we created a web page containing all the relevant information `http://gaitparkinson.wordpress.com`.