PORTUGAL

RESEARCH CENTER FOR ASSISTIVE INFORMATION AND COMMUNICATION SOLUTIONS

1 *Gait activity.*

FOGSensor4PD

Real time detection of fog in patients with parkinson's disease

Parkinson's Disease and FOG

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that affects 1% of the worldwide population over the age of 65. It is mainly characterized by symptoms involving the motor domain, such as bradykinesia, tremor, postural instability and rigidity. Even though pharmacological treatments can mitigate the effects of associated symptoms, the disease progression is likely to restrict their effect. In the advanced stages of the disease, Freezing of Gait (FOG) episodes can appear.

FOG is characterized by a sudden block of movement that can occur while walking or when trying to initiate gait. It is the main cause of falls and significantly affects patients' quality of life. Currently, symptoms evaluation is performed through the application of questionnaires and rating scales and visual examination of the motor performance. Although validated, they can be unreliable due to the subjective perspective of patients and caregivers and also to the subjective analysis by the clinician.

Objective quantification and monitoring of FOG, using wearable technologies, would have a key role, with advantages for both patients and clinicians. Combining freezing events monitoring to auditory stimulation strategies, one can build a system capable of helping clinicians to manage disease treatments and, on the other side, of helping patients to deal and overcome these events.

In recent years, inertial sensors systems have been used in the monitoring of human motion during the performance of tasks of daily living, in unsupervised environments and in a continuous and non-invasive way. They have also been used in a large number of studies to evaluate motor symptoms of PD, namely FOG. Inertial sensors can also be used for the detection and analysis of these episodes, to characterize its severity and enable the application of rhythmic auditory cueing, that acts in the shortening of FOG episodes.

Detecting FOG

In this project acceleration data recorded from 8 patients was analyzed to detect FOG episodes. The acceleration data (DAPHNet

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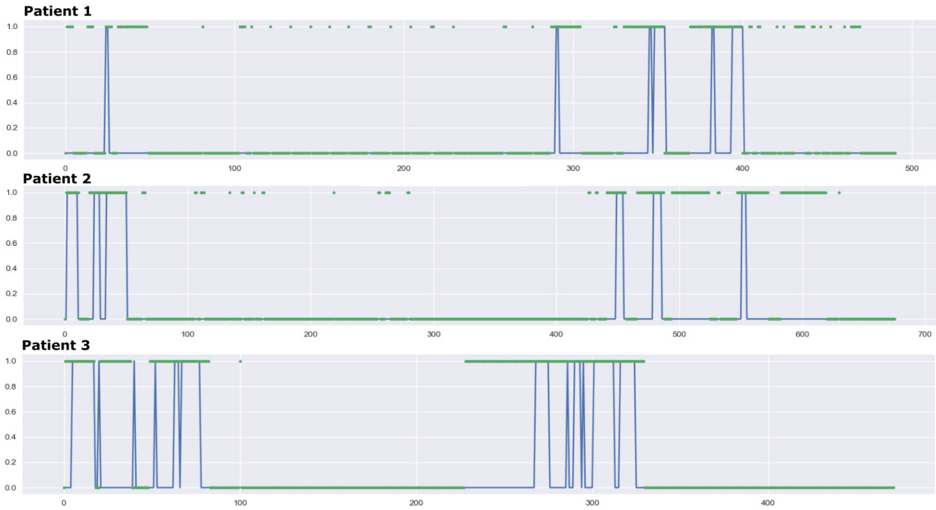

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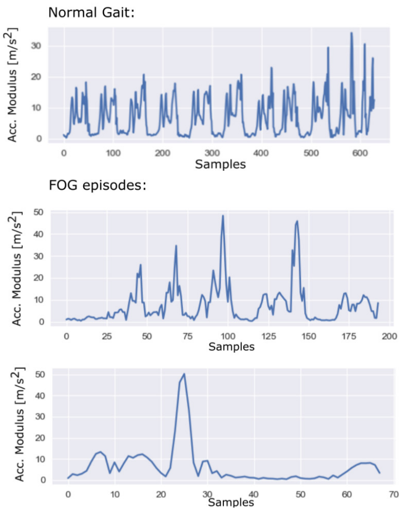

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dataset) were used as the input of a supervised machine learning classifier – Support Vector Machines. Due to the patient dependent nature of the freezing events, a personalized algorithm is proposed. It only uses data from the concerned patient and performs the signal segmentation based on the gait cycle of each individual. Additionally, similarity measures are extracted between a gait template and portions of the recorded signal, through the calculation of the Dynamic Time Warping. Frequency-based features are also extracted to improve the analysis.

Detecting pre-FOG

The existence of a pre-FOG phase, that is, a period before the freezing where the characteristics of the gait start to degrade before a true episode of FOG occurs, was also explored. The similarity and frequency features where computed in windows of normal gait and windows of pre-FOG (3 gait cycles before each FOG) and then a statistical analysis was performed to check if the differences of the features in the periods of normal gait and pre-FOG are significant or not, pointing out to the existence of this phase.

Results and Conclusions

The analysis on the behavior of the similarity and frequency features have shown that they have a good potential to distinguish between gait and FOG. The use of the similarity features is particularly advantageous because they are adapted to each patient, as a template needs to be created for each individual. Moreover, it is a simple measure, with an intuitive meaning, making easier to understand its behavior.

The effectiveness of the developed algorithm was evaluated in the DAPHNet dataset, achieving a specificity of 82,0%, a sensitivity of 85,1% and a F1-score of 58,9%. The results appropriate, however, many false positives are being detected, most of them concentrated before the beginning of a FOG.

Concerning the pre-FOG analysis, the results suggest that the pre-FOG phase is also highly patient dependent and that there are features able to capture gait degradation prior to FOG.

The main limitation of this study is the reduced amount of data to be used in a patient dependent approach and the small number of subjects involved. A phenomenon with such a patient dependent nature should be studied in a larger population of subjects in order to draw more reliable conclusions about the results.

Future work

Further developments can be done to improve and better validate results. First, the acquisition of a new dataset, with data from accelerometers and gyroscopes, placed on different locations. Additionally, the algorithm needs some optimization to be implemented in a real time application. Finally, concerning the pre-FOG analysis, it would be interesting to analyze the performance of a classifier in the detection of these regions.

2 *Inertial Sensors Systems.*

3 *Results. Real FOGs (blue lines) and detection (green dots).*

4 *Acceleration signal from a normal gait period and from two FOG episodes.*