FREEZING OF GAIT IN PARKINSONS DISEASE

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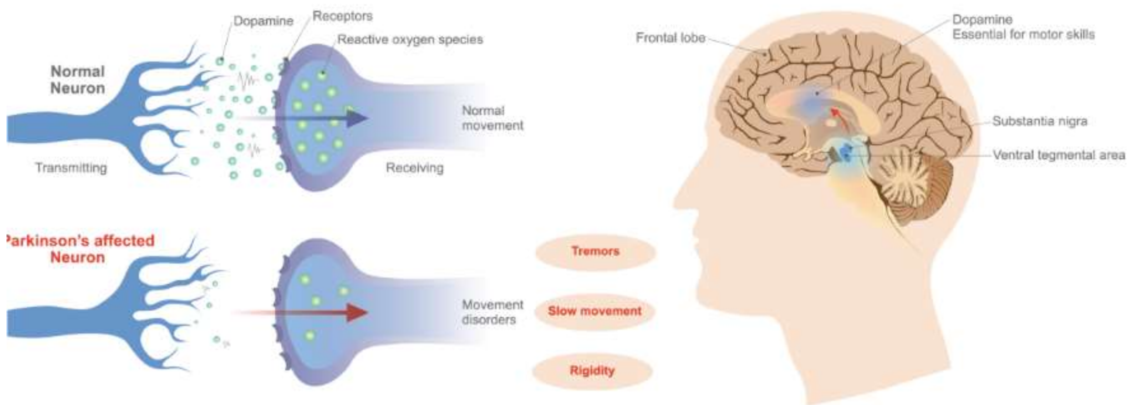
Introduction



Parkinson's disease is a **progressive disorder** that affects the nervous system and the parts of the body controlled by the nerves.

The most prominent signs and symptoms of Parkinson’s disease occur when **nerve cells in the basal ganglia**, an area of the brain that **controls movement**, become **impaired and/or die**. Normally, these nerve cells, or neurons, produce an important brain chemical know as **dopamine**. When the neurons die or become impaired, they produce **less** dopamine, which causes the movement problems associated with the disease. Scientists still do not know what causes the neurons to die.

Parkinson’s has 4 main symptoms:

- **Tremor** in hands, arms, legs, jaw, or head
- **Muscle stiffness**, where muscle remains contracted for a long time
- **Slowness of movement**
- **Impaired balance and coordination**, sometimes leading to falls

This Research paper describes the creation of a dataset focused on **FOG**. The dataset consists the data of both **healthy individuals** and of **PD patients**, including those who experience **freezing of gait (FOG)**, in both the **ON and OFF-medication states**. The dataset was collected while performing **four separate tasks**:

1. **voluntary stop,**
2. **timed up and go,**
3. **simple motor task, and**
4. **dual motor and cognitive task**

There were two problems to solve :

- **Problem1** – To distinguish PD patients from Healthy individuals.
- **Problem2** – Differentiating between patients with PD and FOG in the off and on medication states.

Seven different Classifiers were used :

1. **KNN**
2. **Decision Tree**
3. **Linear SVM**
4. **Random Forest**
5. **Naïve Bayes**
6. **Multilayer Perceptron**
7. **Quadratic Discriminant Analysis (QDA)**

Background and Related Work:

Divided into three parts:

Traditional Algorithms	Evolutionary Computation	Artificial Neural Networks
• Fast implementation, valid results with **least amount of data**, requiring minimum features. • Famous Algorithms – SVM, KNN, Random Forest, Naïve Bayes Classifier, etc.	• In case of **medium-sized dataset**, Genetic Programming (GP), found to perform better than most of the traditional algorithms • Walking data was used, collected from the accelerometer in a smartphone.	• For **big datasets**, with a large number of features, ANNs such as CNN can best handle the high dimensionality, and extract features from them. • Feed forward Multilayer perceptron, Deep Reinforcement Learning Algorithm, Long Short-Term Memory networks, CNN's.

Data Collection

Three Groups were Formed:

Control Group (GC)	GFOG	GFOG+
• 10 subjects • Healthy Volunteers	• 10 subjects • diagnosed with PD who do not have FOG	• 10 Subjects • PD patients with episodes of freezing

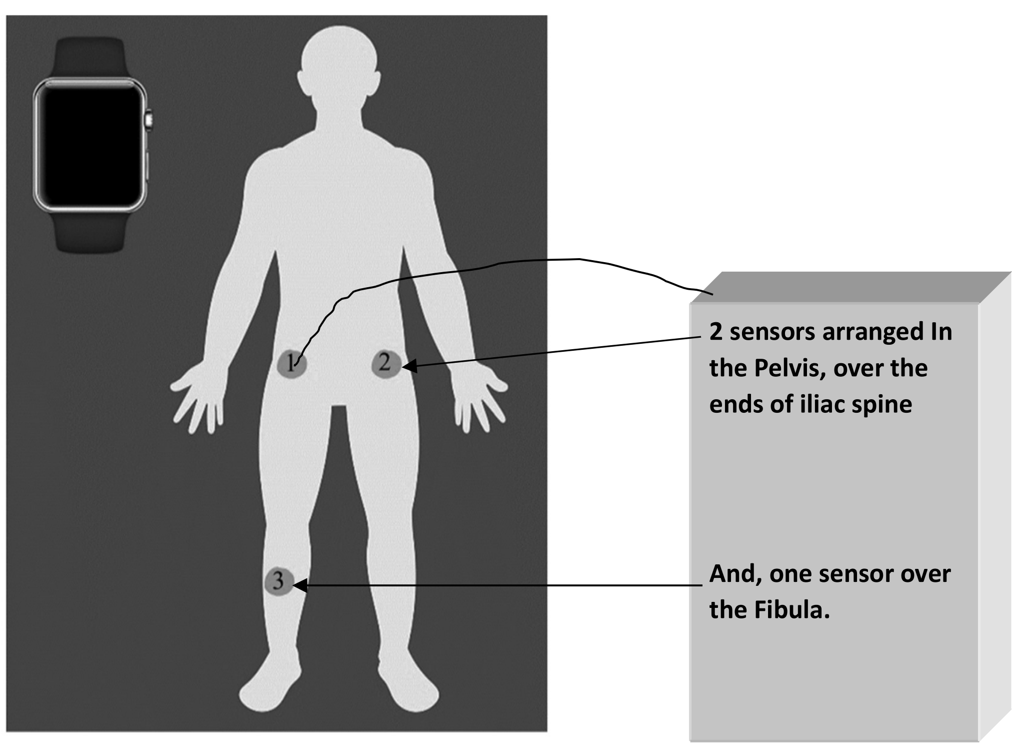
- 6 Females and 4 male subjects in each group.

Technology

- For data collection, **inertial sensors** were used to collect gait and episode information of FOG were coupled to **three smartwatches**, with a **Movement Disorders Monitoring System** (NetMD), in order to analyze and remotely and continuously **monitor movement disturbances** through inertial signals.

- This NetMD was based on the joint action of an **Android mobile device** with **smartwatch** devices with communication being established via **Bluetooth.**

- The system used to generate a **text file with 10 columns** containing the values of the inertial signals for **each smartwatch** (time in milliseconds, sensor name, battery status, and accelerometer and gyroscope on the x, y and z axes).



Methodology

- Using the Tsfresh Library, **200 features** were extracted. These include, for example, absolute energy, absolute maximum, and absolute sum of changes.
- All the extracted features were stored in **CSV files**. At this step, all the Not A Number (NaN) records were removed.
- In this experiment, **9 individuals** from **each of these groups** were selected. Each individual carried out the same task **three times** at different time intervals to ensure result validity. This results in **27 healthy subjects** and **27 PD subjects** for each task.
- The initial **67%** of the data was employed for **training**, while the remaining **33%** was designated for **validation.**
- The training dataset was further divided into **five distinct** subsets for **cross-validation**, to **avoid overfitting**, and also to ensure the **consistency** of the accuracy result.

Results

Distinguishing PD patients from healthy individuals

Accuracy, F1 score, precision, and recall for PD patients vs healthy volunteers on all tasks.

Classifier	Accuracy	F1-Score	Precision	Recall
K-Nearest Neighbors	86%	87%	90%	84%
Decision Tree	96%	94%	94%	99%
Linear SVM	94%	95%	93%	96%
Random Forest	76%	75%	87%	65%
Naive Bayes	74%	74%	81%	68%
Multilayer Perceptron	96%	96%	94%	99%
QDA	61%	65%	62%	48%

While the majority of the classifiers displayed satisfactory results, the **MLP outperformed** others, achieving a **96% F1-score**, **96% accuracy**, and **99% recall**.

The **ANN** model **discriminated feature** dimensions more **effectively** compared to prior methods, particularly when considering the multitude of features extracted.

Effectiveness of medication

Accuracy, F1 score, precision, and recall - Effectiveness of medicine on patients.

Classifier	Accuracy	F1-Score	Precision	Recall
K-Nearest Neighbors	95%	95%	99%	92%
Decision Tree	99%	99%	99%	99%
Linear Support Vector	87%	88%	80%	100%
Random Forest	57%	58%	55%	62%
Naive Bayes	61%	59%	60%	58%
Multilayer Perceptron	96%	95%	92%	99%
QDA	55%	60%	53%	70%

Because it had a score of **99%** in all four categories of accuracy, F1-score, precision, and recall, the **Decision Tree** was considered the most effective method of categorization for this issue.

However, a number of other methods, most notably **MLP and KNN**, also produced very **good outcomes**, with scores above **90%** for every metric, in most of the tasks.

Conclusion and Future work

In using this data, two main problems were considered by the authors, namely classifying PD patients from healthy individuals, and assessing the degree to which medication was effective. Several classifiers were implemented and their performance were analyzed. Although most of the classifiers performed well with the extracted features, the **multilayer perceptron (MLP)** and **Decision tree classifiers** showed the **most consistent results** for both challenges.

The authors also talked about the **future work** their suggestion were:

- A **patient-wise analysis** may also give an opportunity to further understand the patient's symptoms, leading to more effective treatment strategies in the future.
- Furthermore, **feature importance** can be calculated to better understand gait impact in Parkinson's disease. This can be achieved through methods such as feature selection, dimensionality reduction, and model-based methods. The results can provide valuable insight into the most effective features for analysis and the underlying biological mechanisms of the disease.
- In detecting the **time periods during which FOG occurs**, it would be useful to identify features that occur near that time period.

The authors suggested that the findings of this study can be used to design a system that alerts patients when they are about to have FOG. This type of information may assist individuals in preventing falls and injuries.