BE018

Gait Monitoring and Analysis of Parkinson's Disease Patients

Introduction

Parkinson's Disease is:

- A progressive neurodegenerative disorder
- A reduction of cadence, tremors, bradykinesia, rigidity, loss of postural reflexes.

Freezing of Gait (FOG):

- The brief episodic absence or marked reduction of forward progression of the feet despite the intention to walk
- Leads to falls, significantly impacts quality of life
- Triggered by visual stimulation: stress, tight spaces or a sudden change in direction

Aim: To find out which machine learning algorithm is better for analyzing PD gait data

Literature Review

Utilisation of Inertial Measurement Units (IMUs) in analysis:

- Accelerometers
  - Shank
  - Thigh
  - Lower back (Trunk)
- Gyroscopes
- Force-sensitive insoles

Gait parameters to be focused on:

1. Rhythm - step and stride time
2. Phase - gait cycle
3. Variability - step-to-step variability
4. Pace - gait speed, stride and step length
5. Base of support - step width.

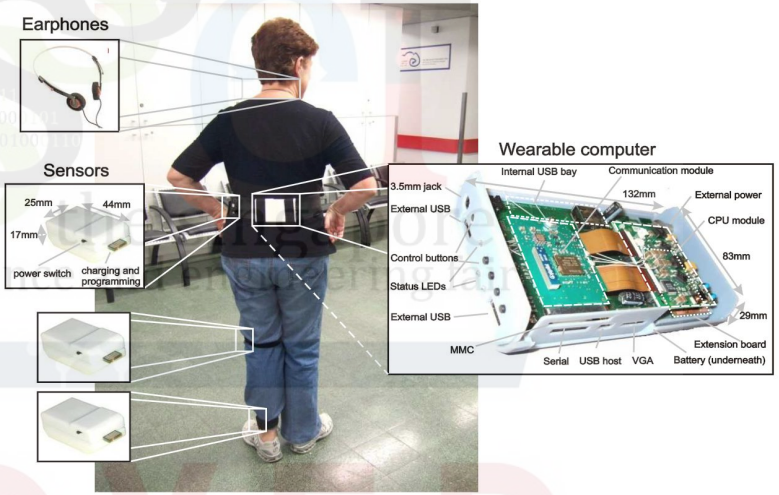

Figure 1: Previous research prototype by Baechlin et al.

Methodology

- DAPHNet Dataset used
  - 17 Samples from 10 PD patients
  - Acceleration data from the thigh used
- Signal Processing Algorithms
  - Windowing of data and performing of Fast Fourier Transform on window
  - postulated Freeze Index, defined as freeze(N) for N-axis acceleration
    - Unitless value portraying resistance experienced (freeze)
- Support Vector Machine (SVM) Analysis
  - Linear and Gaussian SVM kernels against 2D or 3D freeze(N) data

Methodology

- Arduino Program
  - Most accurate SVM Model predicted used for calculations
  - Arduino Nano 33 BLE
    - 3-axial accelerometer IMU
  - Built-in LED lights up upon the predicted freeze event

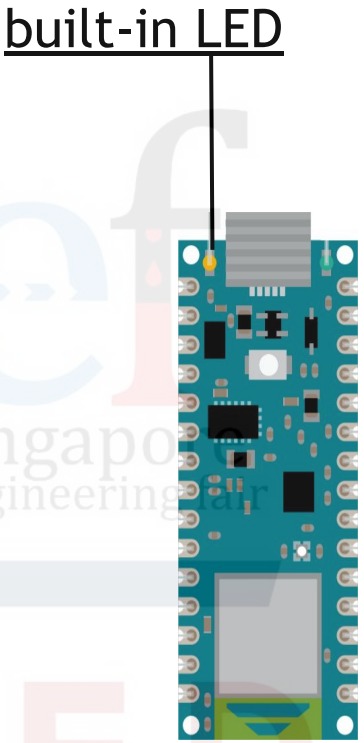

Figure 2: Arduino Nano 33 BLE Board Layout

Results

freeze(Y) and freeze(Z) under a Linear Kernel showed best results:

- ≈ 100% Specificity
- 88.9% Precision
- 90.4% Accuracy
- 90% Weighted Sensitivity
- 86% F_1 score

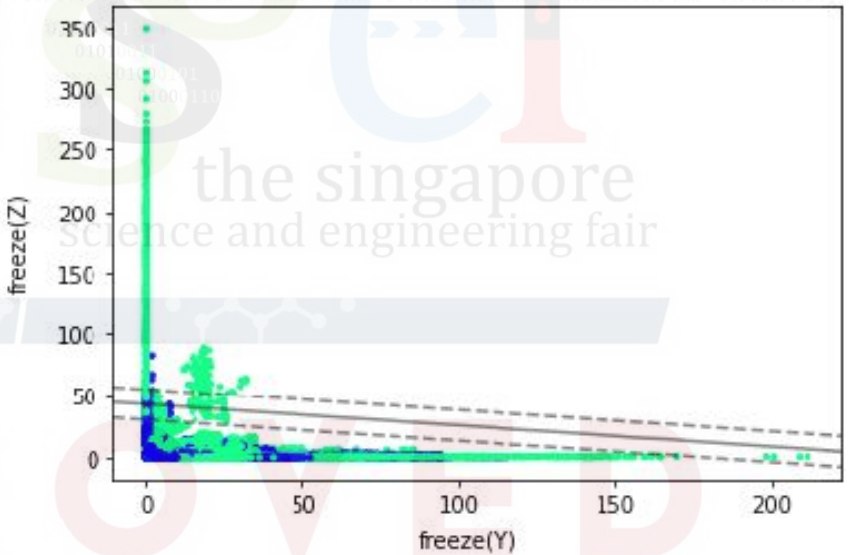

Figure 4: Graph of the freeze(Y) and freeze(Z) Linear Kernel Distribution Function

Prototype

Figure 5: Prototype created using Arduino Nano board

Arduino Nano 33 BLE board consisting of a 3D accelerometer and 3D gyroscope attached to an elastic band for wearability

Conclusion

- Algorithm was developed to identify the **most suitable parameter** for the classification of FOG: acceleration in the y and z axes.
- Best machine learning model determined --> **Linear Kernel model.**
- Prototype created using an Arduino Nano 33 BLE

Limitations & Future Work

- **Only accelerometers** were studied in this experiment.
- **Multiple sensors** and **multiple parameters** could be used when computing the general gait freeze moment.

In the future:

- Connecting this system to earbuds and implementing **biofeedback** via audio → mediate FoG episodes and prevent risk of falls
- Connecting the system to an App such that notifications can be sent to the caregiver's phone to alert them to a fall.

References

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[18] Hollman, J. H., McDade, E. M., & Petersen, R. C. (2011). Normative spatiotemporal gait parameters in older adults. Gait & Posture, 34(1), 111–118. https://doi.org/10.1016/j.gaitpost.2011.03.024

Results

Computed Freeze Indices in all three axes were tested

- freeze(X) and freeze(Y)
- freeze(X) and freeze(Z)
- freeze(Y) and freeze(Z)
- All 3 parameters

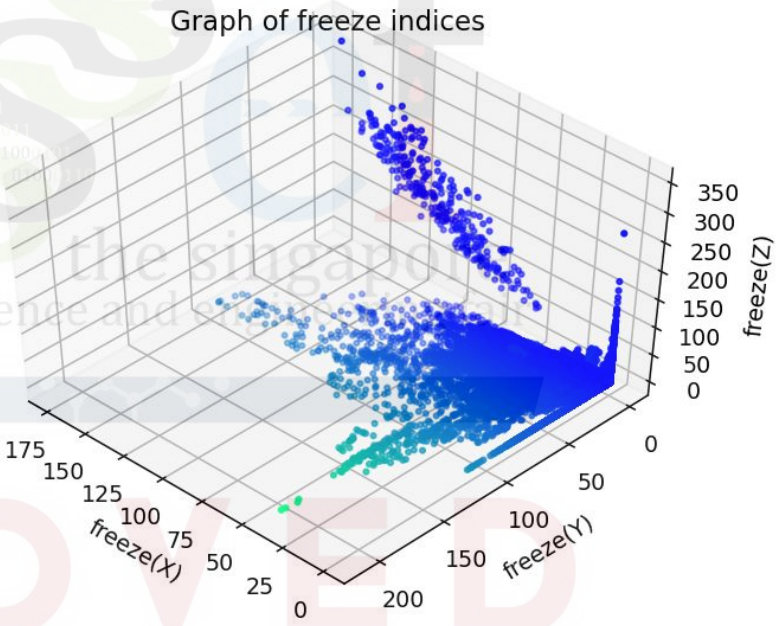

Figure 3: Graph of freeze indices