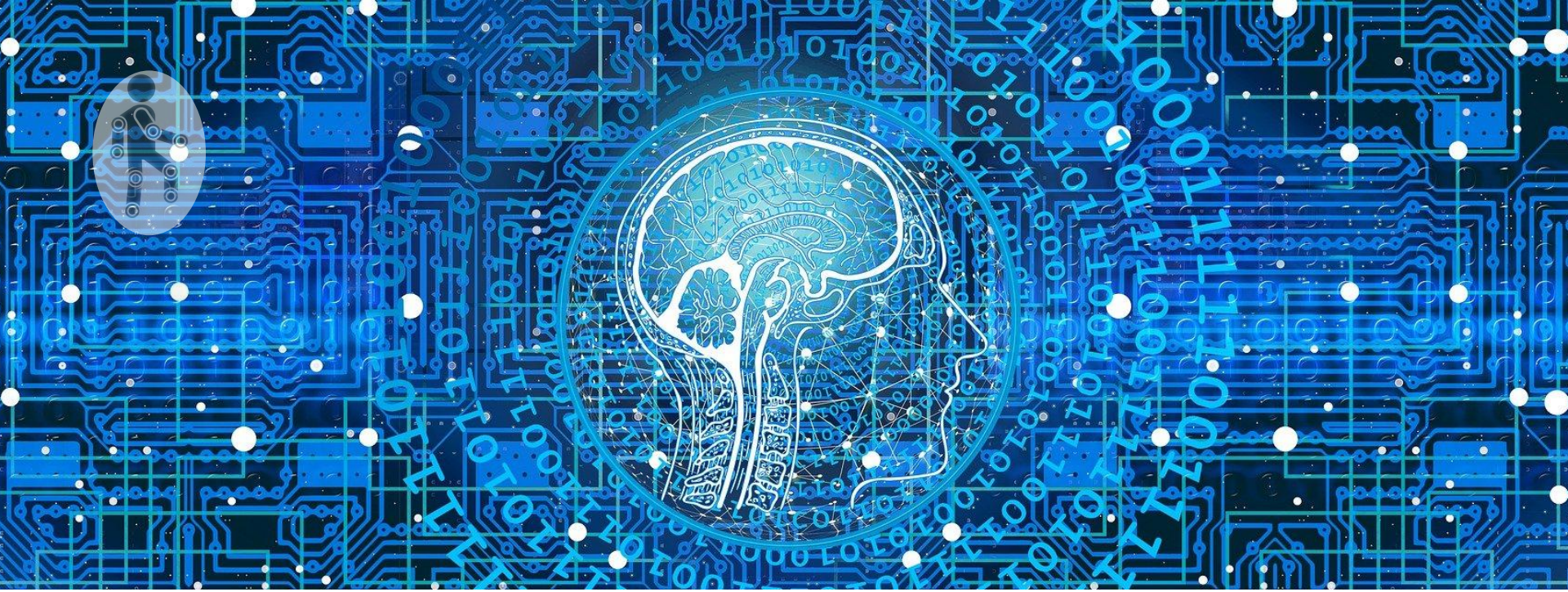


Task – Project A15

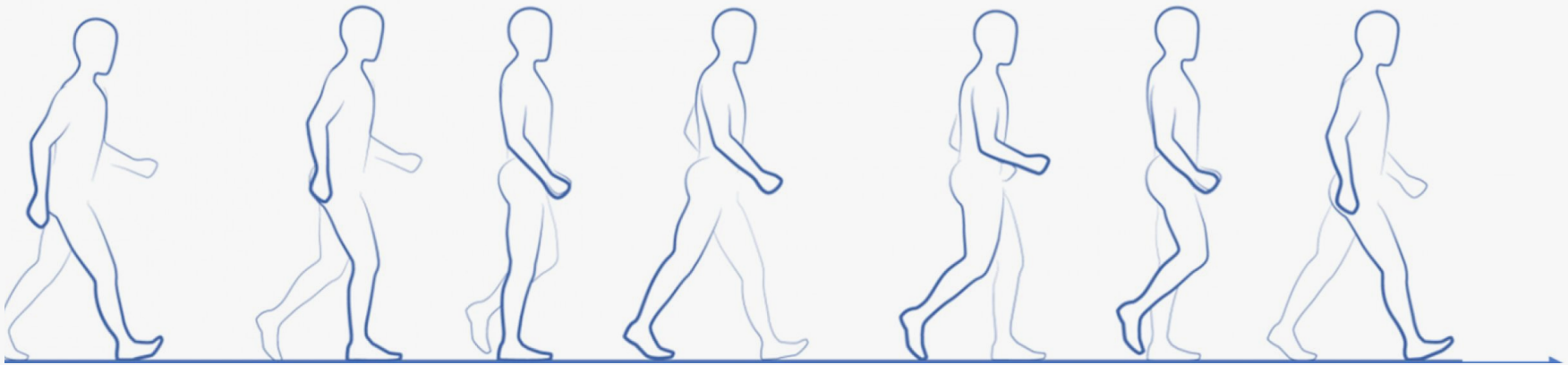
Group – 15

Nikhil Jagtap *Kapil Deshmukh* *Uzair Mukadam* *Aditya Bhat* *Akshay Panchwagh*

Institut für Allgemeine Mechanik | RWTH AACHEN UNIVERSITY

Agenda

- Team Introduction
- Gait Analysis
- Data Preprocessing
- Implementation of Neural Network
- Further Improvements



Team Worked on 2, 5 & 10 Fold Subject wise CV

The Group was assigned with the task of utilizing the data from Smartphone 3 from the accelerometer & gyroscope to perform 2, 5 and 10 fold subject-wise cross-validations in-order to train the system to distinguish between the impaired and normal gait patterns.

Nikhil Jagtap – Research & Comprehensive Primary Coding

Akshay Panchwagh – Research & Data Procurement

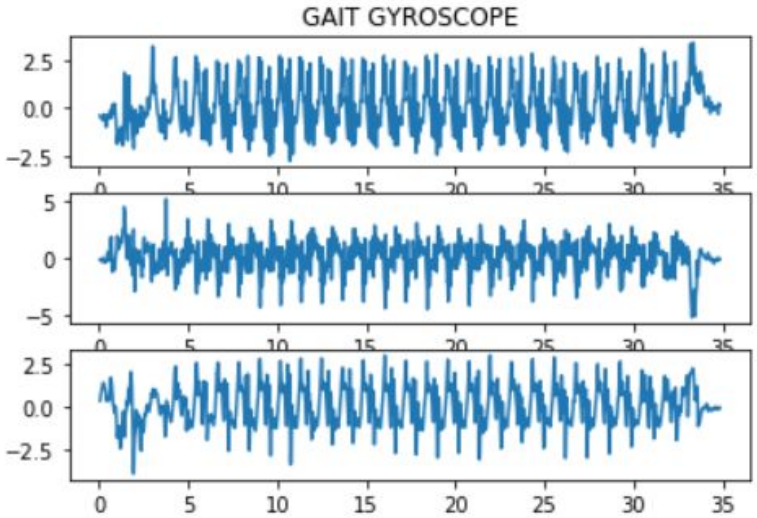
Kapil Deshmukh – Research & Neural Network Coding

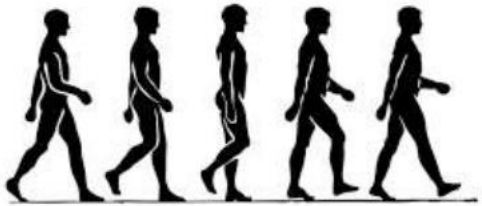
Aditya Bhat – Research & Secondary Coding

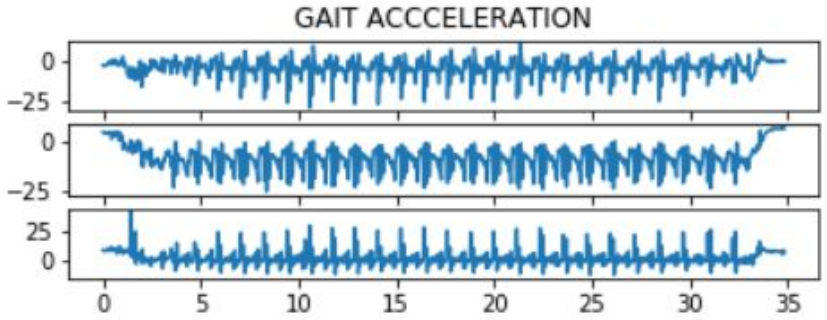
Uzair Mukadam – Research & Presentation Draft

Gait Analysis

Gait is the special pattern of human locomotion & is unique to an individual due to one's specific musculoskeletal bio-mechanism.

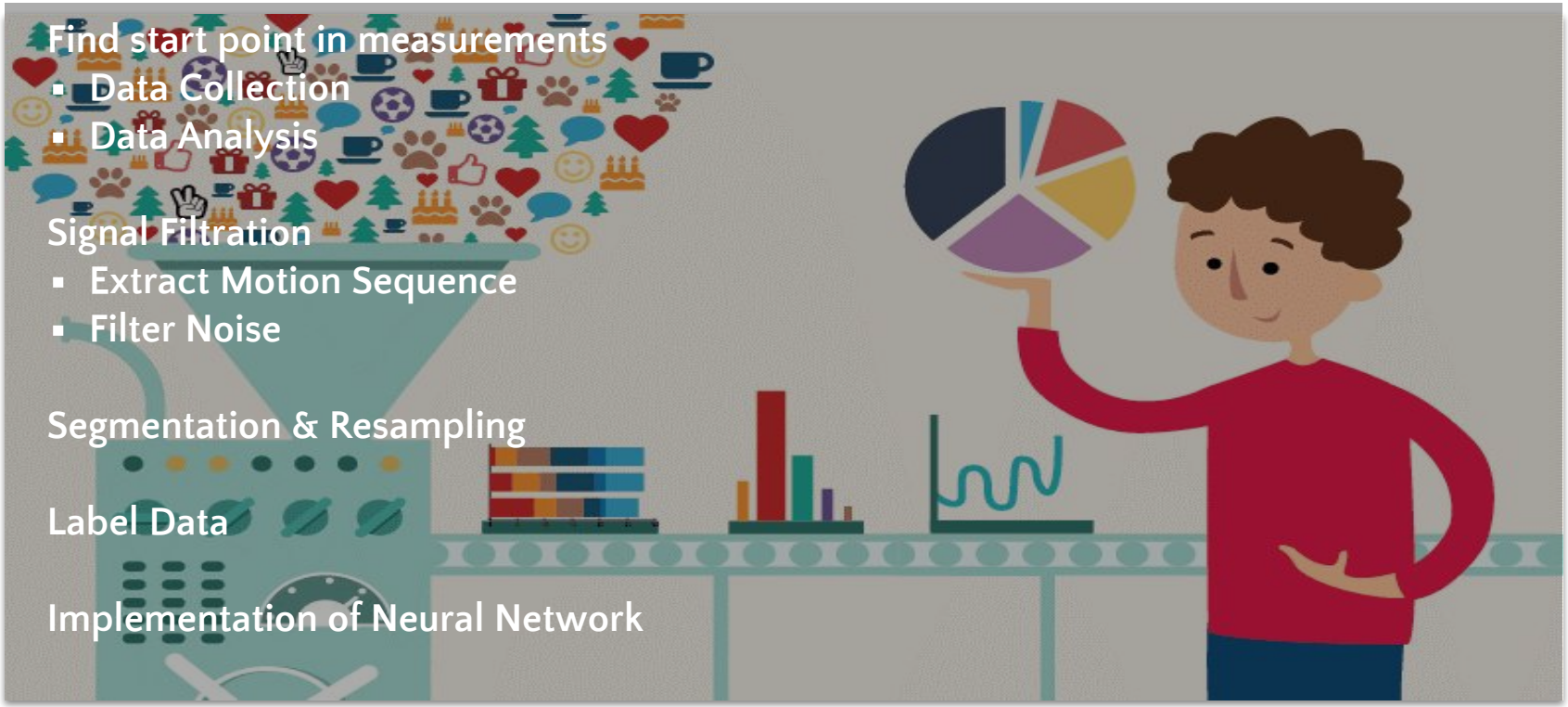






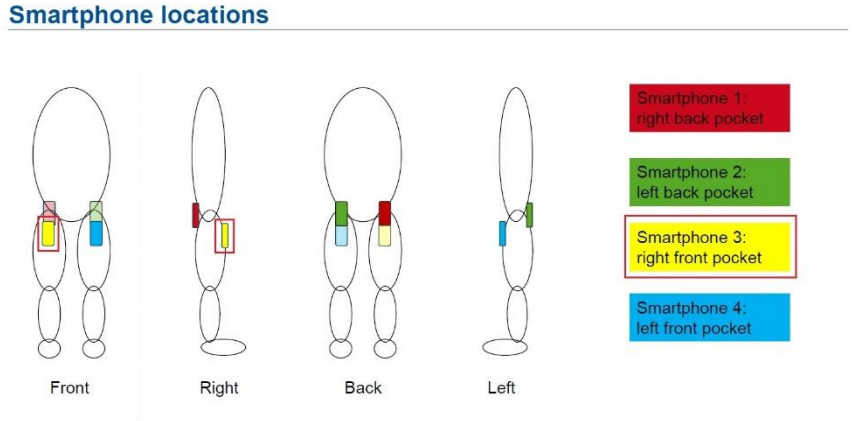
The movement data was measured via inertial sensors to plot the acceleration and gyroscope data (Phyphox application was used to measure data).

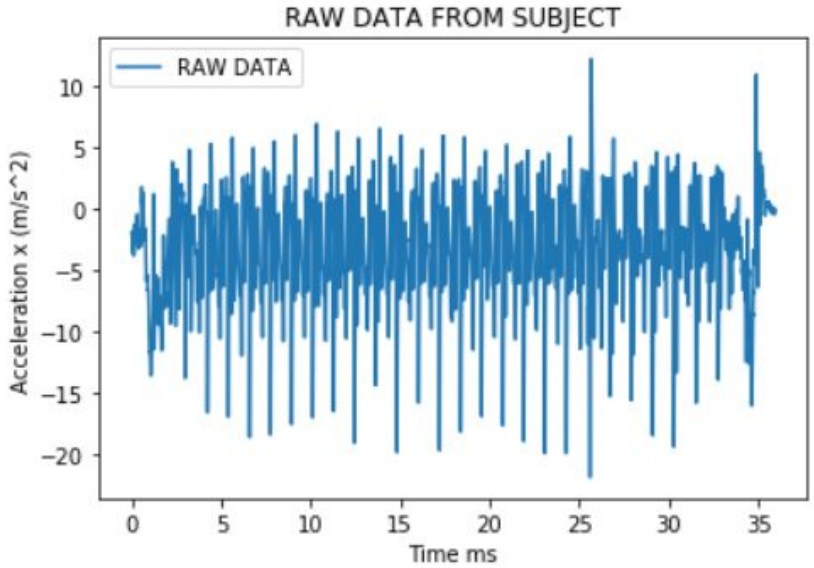
Data Preprocessing



Data Collection

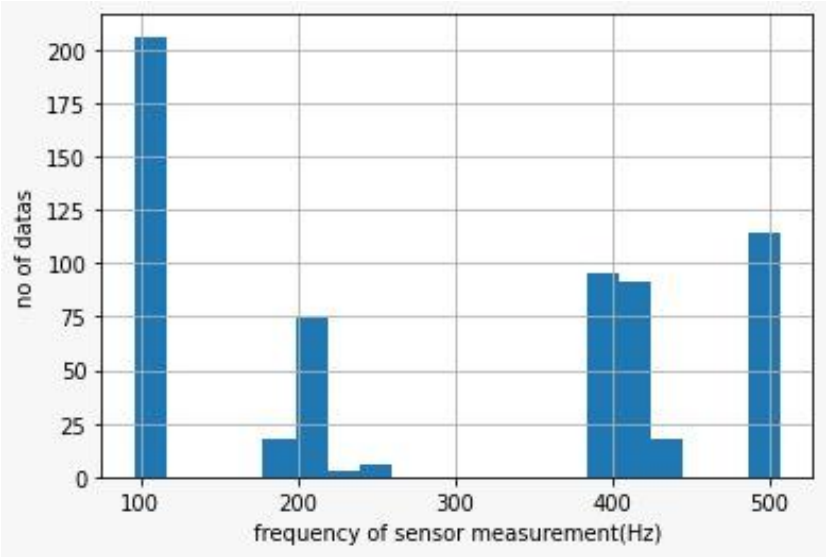
- Phyphox used to collect data in CSV format for gait analysis.
- Data collected for all Subjects with Position- Smartphone 3 (Right Front pocket)





Data Analysis

- Individual frequency of sensors was determined.
- Furthermore, histogram was plotted for the No. of Subjects VS Frequency of Sensor to establish the frequency mode for better understanding of the data.



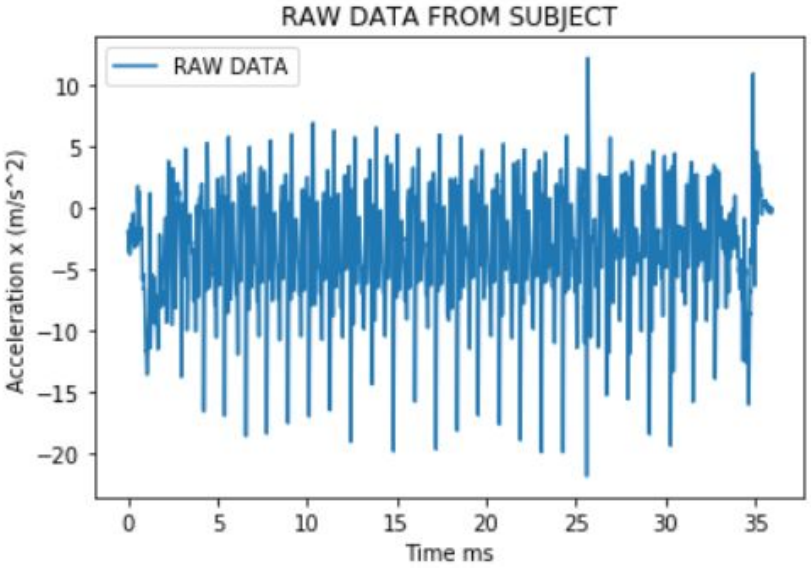
Libraries Used

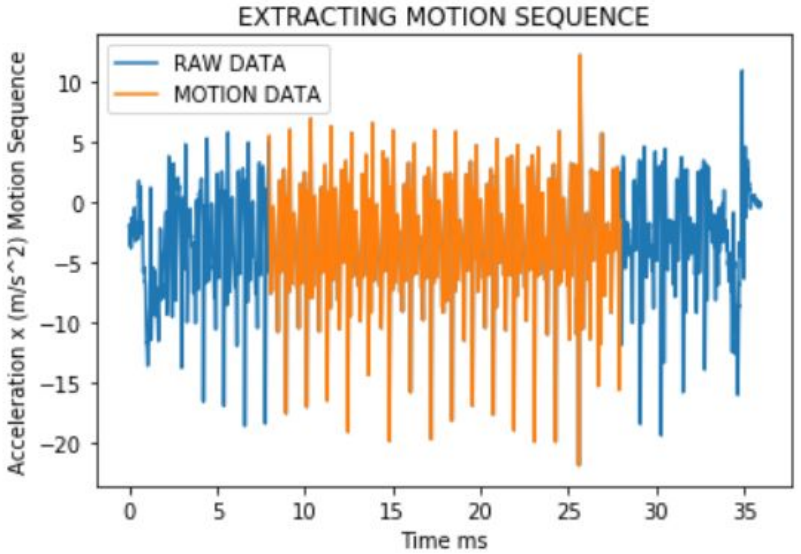
- numpy
- matplotlib.pyplot
- pandas
- tensorflow
- csv
- os
- scipy.signal

```
# IMPORT LIBRARIES

import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import tensorflow as tf
import csv
import os
from pandas import read_csv
import scipy.signal as ss
```

Extraction of Motion Sequence

Data was extracted from the mean value of the time domain for both Accelerometer and Gyroscope of each subject.

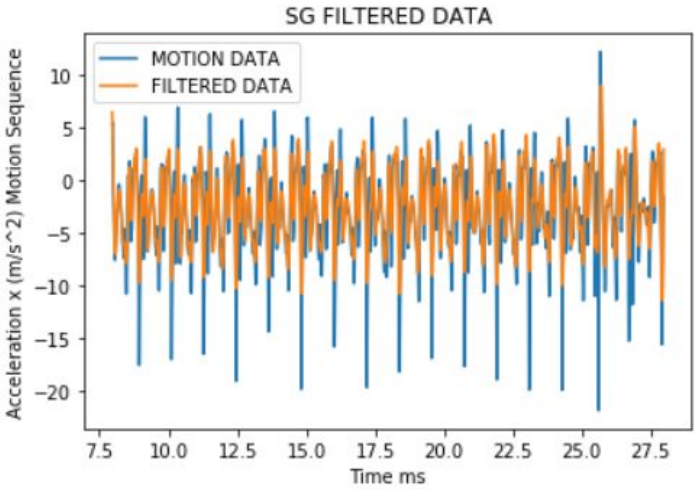




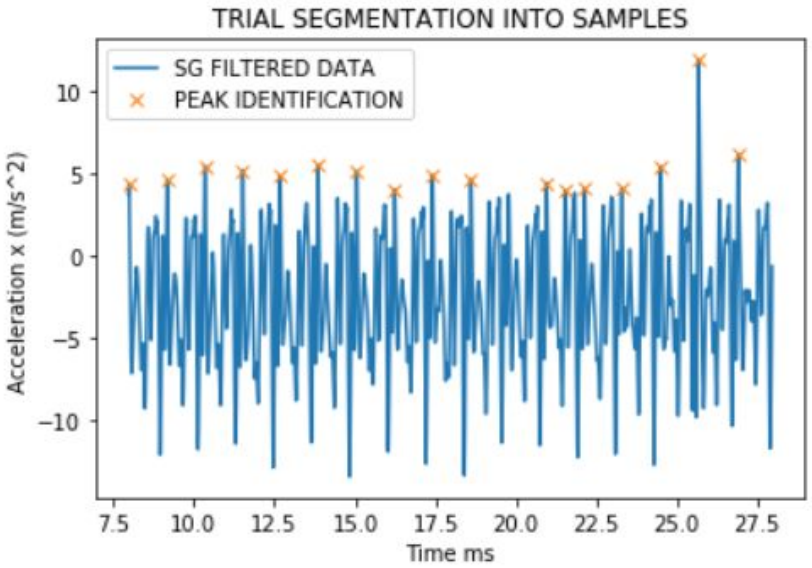
Filtering Noise

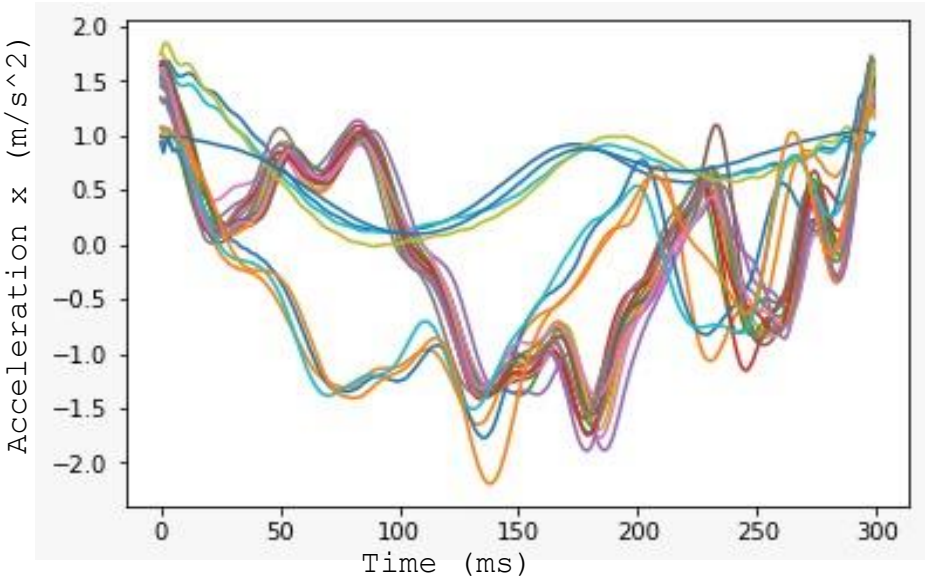
Filters significant for Gait Analysis are:
1.) Butterworth
2.) Infinite Impulse Response (IIR)
3.) Savitzky-Golay (SG)

SG filter was chosen as it retains the original shape of the signal.



Trial Segmentation into Samples & Resampling





Identification of peaks using local maxima method via “peaks” function from the “scipy” library

Data Labelling

eg. inputs=Subject25_normal01

inputs=subject25_normal01

file_split=['subject25', 'normal01']

subject=25

sample=01

gait =0 (normal subject)

Metadata = [‘25’,0]

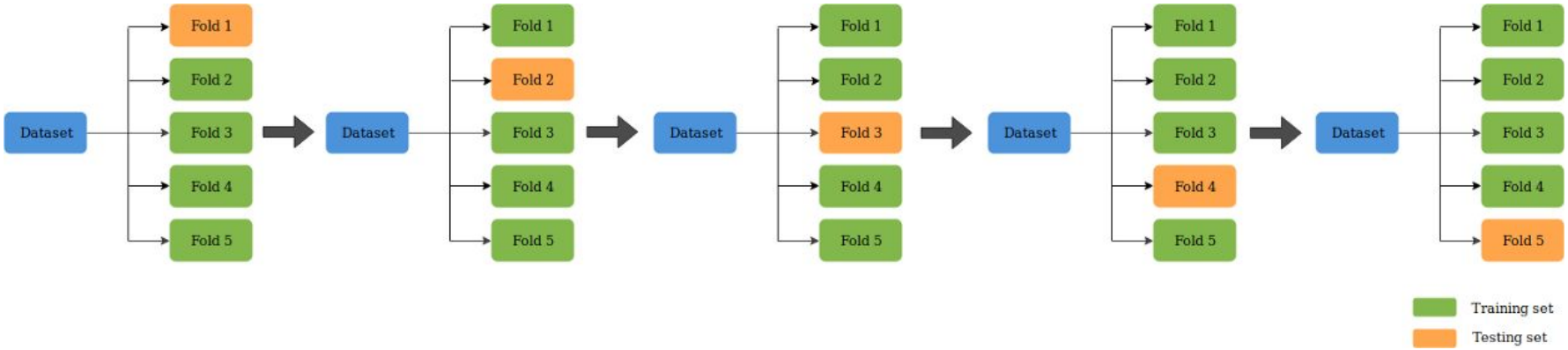
```
def label(inputs):

    inputs = inputs.lower()

    file_split = ((inputs).replace("_"," ")).split()

    subject = ''.join(filter(lambda j: j.isdigit(), file_split[0]))

    sample = ''.join(filter(lambda j: j.isdigit(), file_split[1]))

    #gait
    if ((inputs.find('nor') or inputs.find('rma') or inputs.find('mal')) != -1):
        gait = 0

    elif ((inputs.find('imp') or inputs.find('pai') or inputs.find('red')) != -1):
        gait = 1

    else:
        gait = -1

    metadata = [subject, gait]

    #print(file_split)
    #print(subject)
    #print(gait)


    return metadata
```

Implementation of Neural Network

1. Split Data (Cross-Validation)
2. Hyper Parameter of Neural Network
3. Comparing Accuracy Results

Split Data (Cross-Validation)

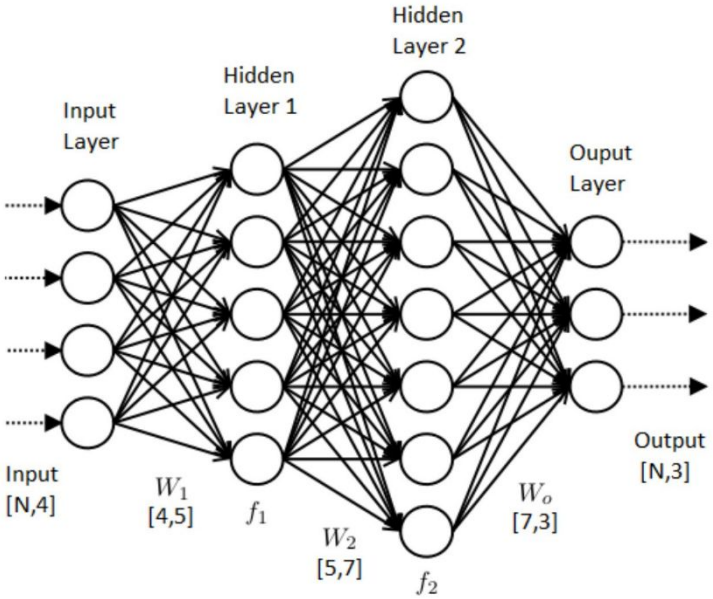
- Cross validation is a resampling procedure used to evaluate machine learning models on a limited data sample.
- The procedure has a single parameter called ‘k’ which refers to the number of groups the given data sample will be split into.
- In this task, the data sample was split into 2,5 and 10 folds.



Hyper Parameter of Neural Network

Parameters used:

Loss function : Mean Square Error
Optimizer : Adam
Activation Function : Relu, SoftMax
No. of Epochs: 10
Batch Size: 20
Input Layer: 6 Neurons in the Input
Hidden Layer: 5



General Representation of Neural Network [1]
*Image only for representation

[1] https://medium.com/coinmonks/the-artificial-neural-networks-handbook-part-1-f9ceb0e376b4

Comparing Results

No. of Folds	2	5	10
Loss	0.2500	0.2500	0.2500
Accuracy	0.50515	0.50375	0.4723

Further Improvements

- Data Rotation
- Removing Outliers
- Fine Tuning the Neural Network

References

1. https://medium.com/towards-artificial-intelligence/importance-of-k-fold-cross-validation-in-machine-learning-a0d76f49493e
2. https://machinelearningmastery.com/k-fold-cross-validation/#:~:text=Cross%2Dvalidation%20is%20a%20resampling,is%20to%20be%20split%20into.
3. https://pythonprogramming.net/resample-data-analysis-python-pandas-tutorial/
4. https://www.researchgate.net/publication/322796242_Advanced_Methods_for_Gait_Analysis_Data_Processing
5. https://dl.acm.org/doi/10.1145/1921081.1921099
6. https://machinelearningmastery.com/how-to-model-human-activity-from-smartphone-data/
7. https://www.python-course.eu/principal_component_analysis.php
8. https://www.kaggle.com/hbaderts/simple-feed-forward-neural-network-with-tensorflow
9. https://hub.packtpub.com/feedforward-networks-tensorflow/
10. https://stackabuse.com/tensorflow-neural-network-tutorial/
11. https://docs.scipy.org/doc/scipy/reference/generated/scipy.signal.resample.html
12. https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.Series.interpolate.html
13. https://scipy-lectures.org/intro/scipy/auto_examples/plot_resample.html
14. https://towardsdatascience.com/human-activity-recognition-har-tutorial-with-keras-and-core-ml-part-1-8c05e365dfa0
15. https://statinfer.com/204-4-11-k-fold-cross-validation/
16. https://www.machinecurve.com/index.php/2020/02/18/how-to-use-k-fold-cross-validation-with-keras/
17. https://towardsdatascience.com/pca-using-python-scikit-learn-e653f8989e60
18. https://www.geeksforgeeks.org/ml-principal-component-analysispca/
19. https://stackabuse.com/implementing-pca-in-python-with-scikit-learn/
20. https://towardsdatascience.com/reshaping-numpy-arrays-in-python-a-step-by-step-pictorial-tutorial-aed5f471cf0b
21. https://www.geeksforgeeks.org/multi-dimensional-lists-in-python/
22. https://stackoverflow.com/questions/51505504/pandas-nesting-dataframes

References

1. Markus Lueken, Warner ten Kate (2019), IEEE, “Peak Detection Algorithm for Gait Segmentation in Long-Term Monitoring for Stride Time Estimation Using Inertial Measurement Sensors”
2. Manuela Galli and Mariano Serrao (2018), Springer Int. Publishing, “Advanced Methods for Gait Analysis Data Processing”
3. Nooshin Haji Ghassemi, Julius Hannink (2018), MDPI Sensors, “Segmentation of Gait Sequences in Sensor-Based Movement Analysis: A Comparison of Methods in Parkinson’s Disease”
4. Faisal Jamil, Naeem Iqbal (2020), MDPI Sensors, “Toward Accurate Position Estimation Using Learning to Prediction Algorithm in Indoor Navigation”
5. Yu Zhong and Yunbin Deng (2014), IJCB, “Sensor Orientation Invariant MObile Gait Biometrics”