Conditional Diffusion for EEG Data Synthesis

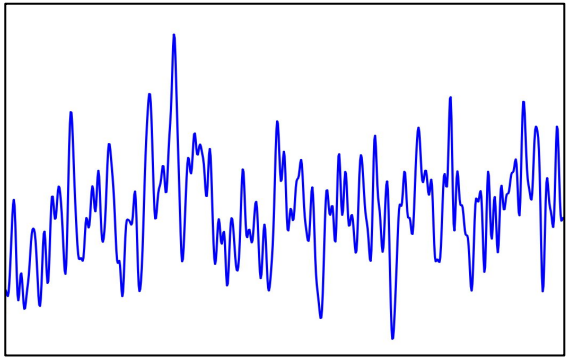
Semester Project for Advanced Machine Learning 2024

27.05.2024

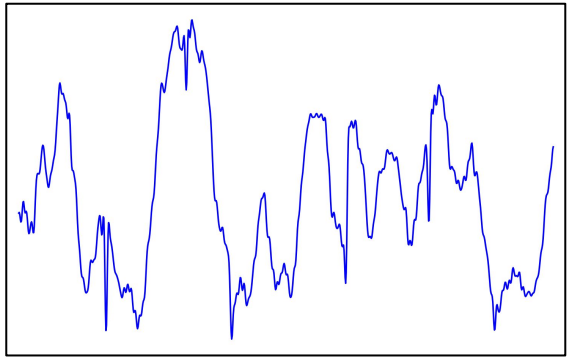
Group 18

Introduction

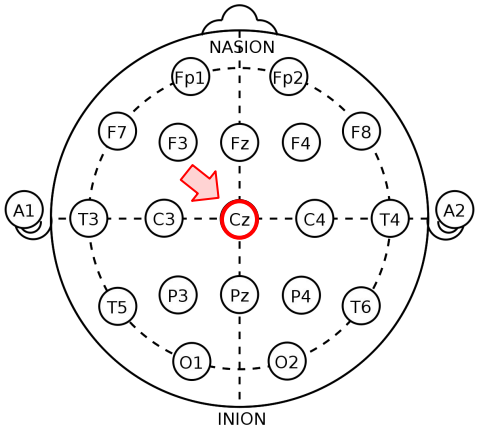
- EEG: the brain activity of different areas of the cerebral outer cortices
- Dataset (TUH EEG) with labels for different kinds of seizure activity
- Generally, seizures are slow waves between 2 - 10 Hz, hyper-synchronous in time
- Idea: Generate synthetic EEG with seizure and non-seizure activity



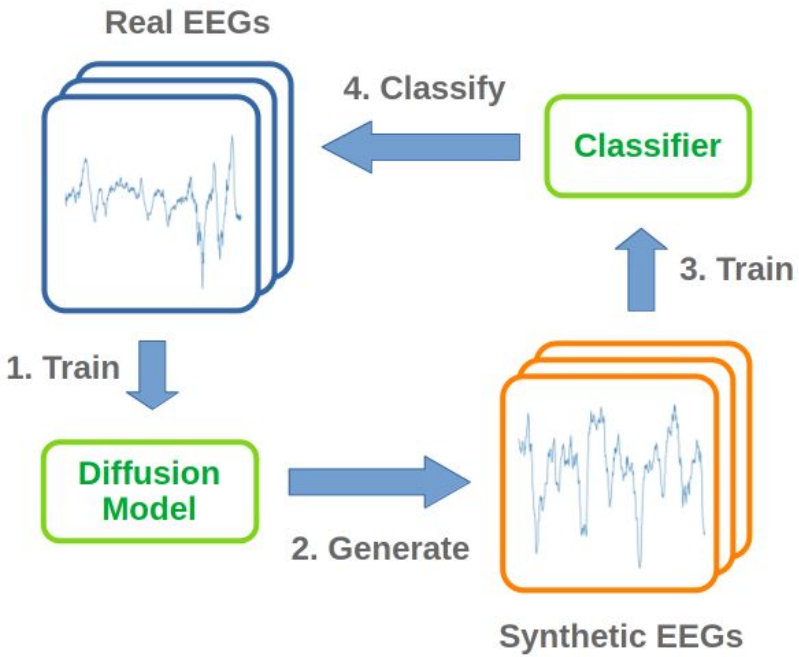
Healthy EEG



Seizure EEG



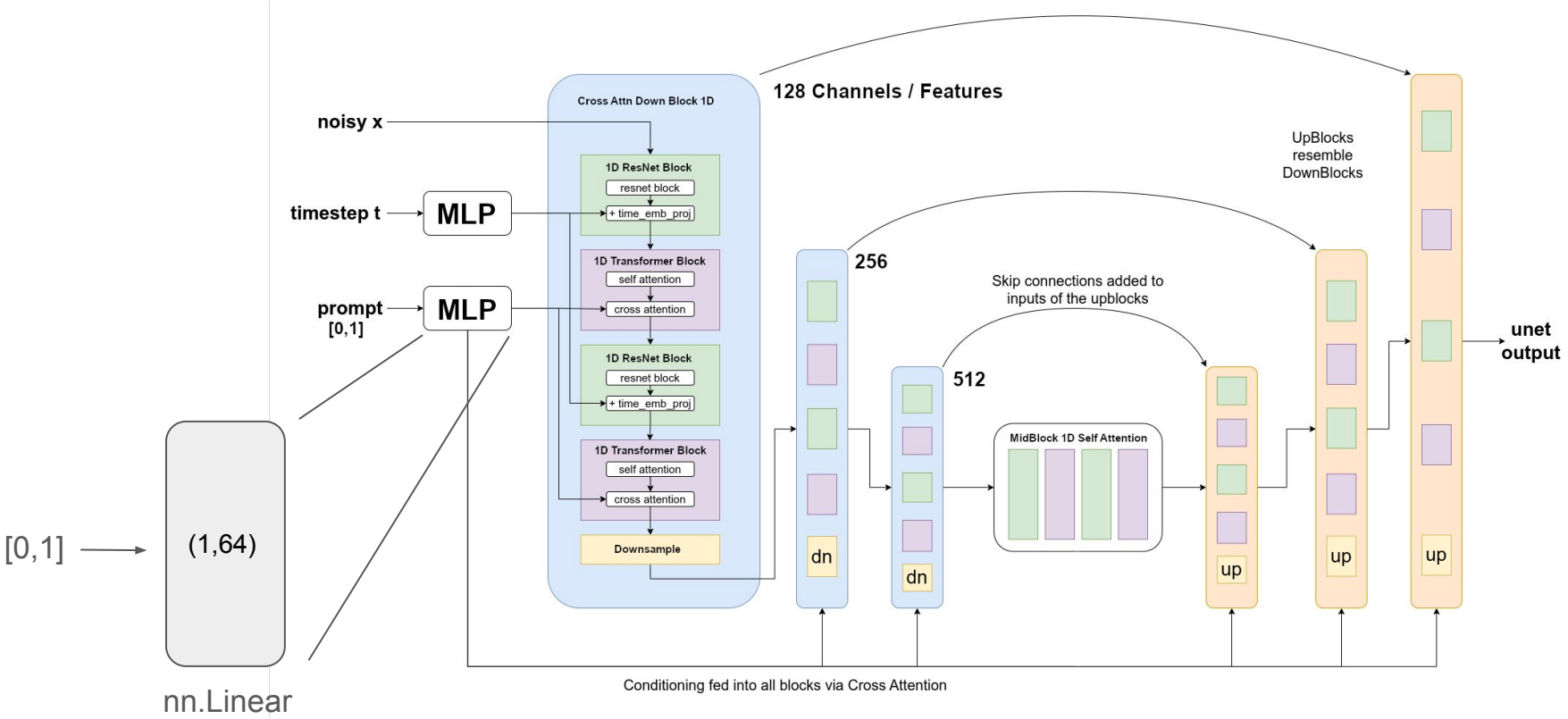
Overview



1. Train a diffusion model using real EEGs with two targets (seizure, non-seizure)
2. Use diffusion model to sample synthetic EEGs (conditioned by target)
3. Use synthetic EEGs to train a (simple) classifier model
4. Evaluate classifier model on real EEGs

Model

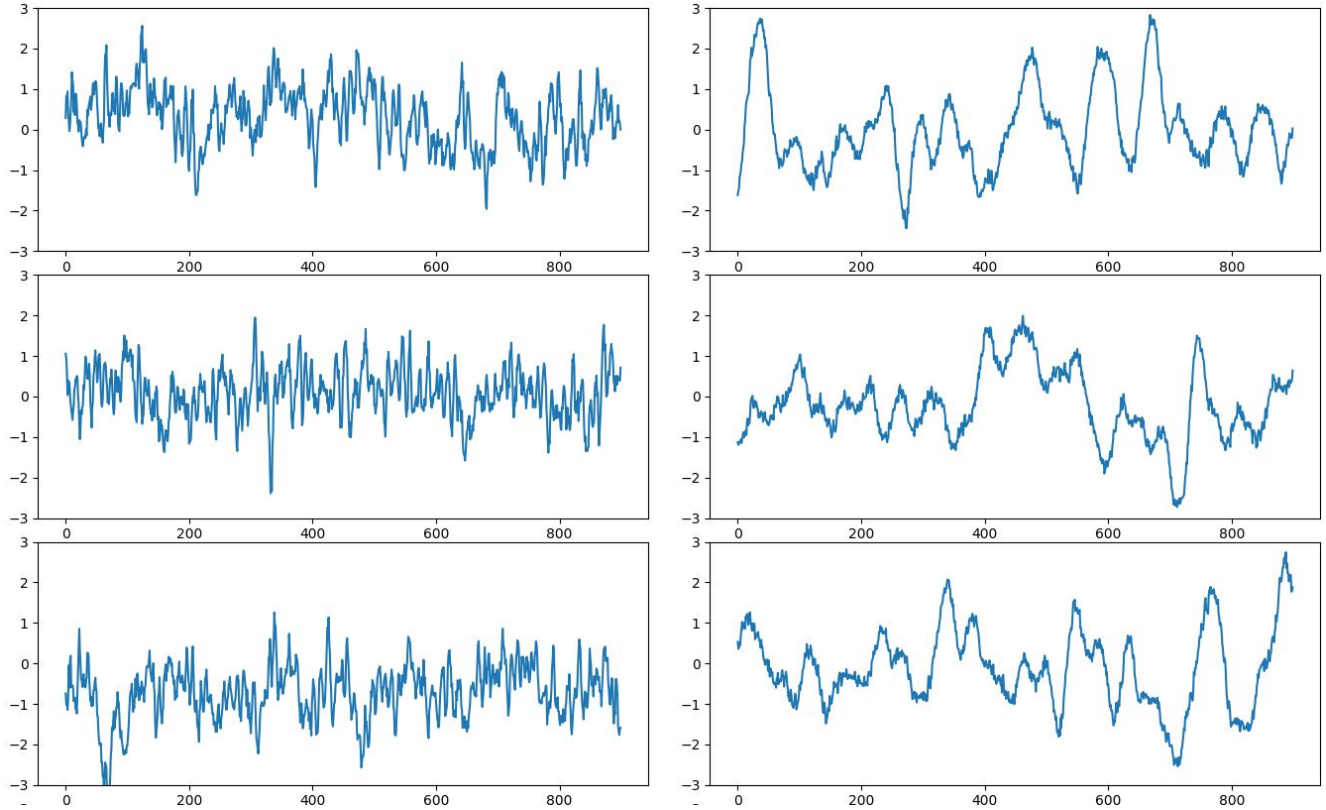
U-Net with Attention



Results

non seizure

(0)



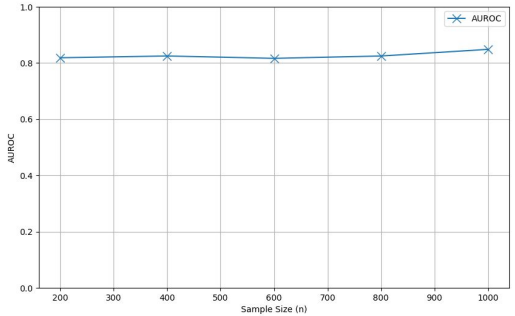
fnsz

(1)

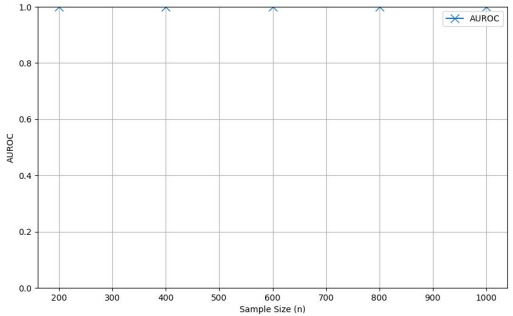
Validation

(w/ perfect class balance)

Accuracy: 0.80
TPR: 0.89
TNR: 0.71
F1 score: 0.81
AUROC: 0.85



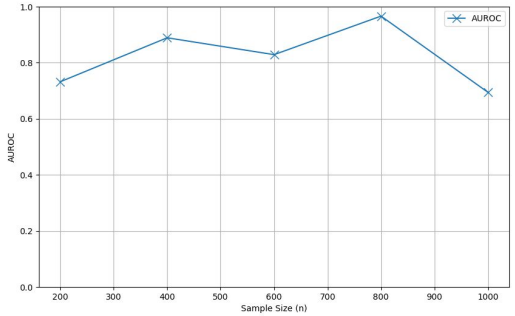
a) Train: Real - Test: Real



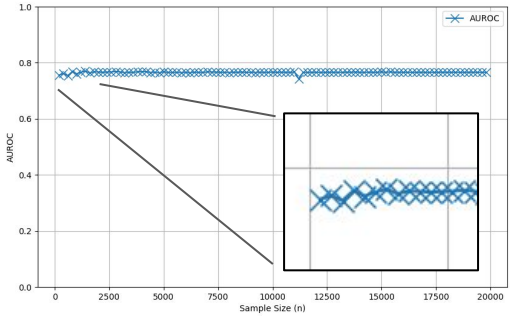
b) Train: Synth - Test: Synth

Accuracy: 1.0
TPR: 1.0
TNR: 1.0
F1 score: 1.0
AUROC: 1.0 😎

Accuracy: 0.5
TPR: 1.0
TNR: 0.0
F1 score: 0.66
AUROC: 0.70



c) Train: Real - Test: Synth



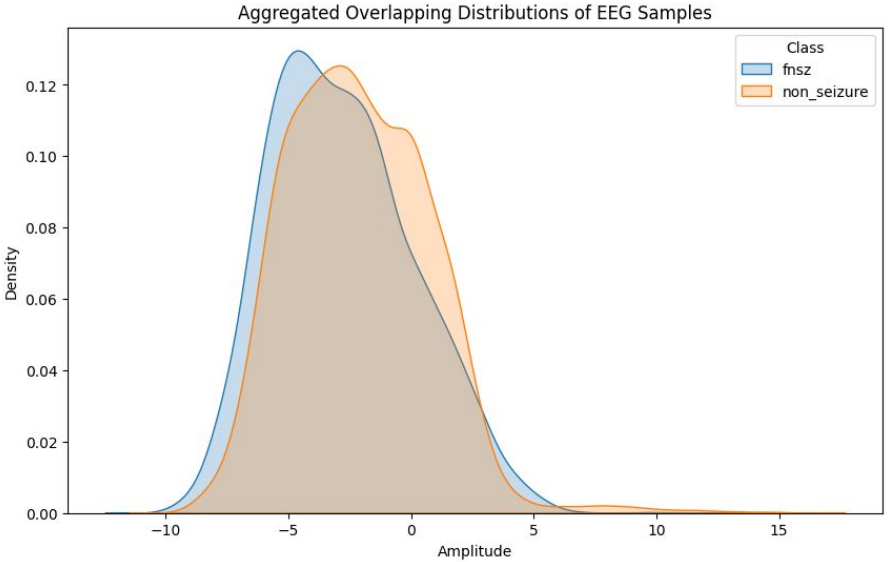
c) Train: Synth - Test: Real

Accuracy: 0.57
TPR: 0.30
TNR: 0.84
F1 score: 0.41
AUROC: 0.77

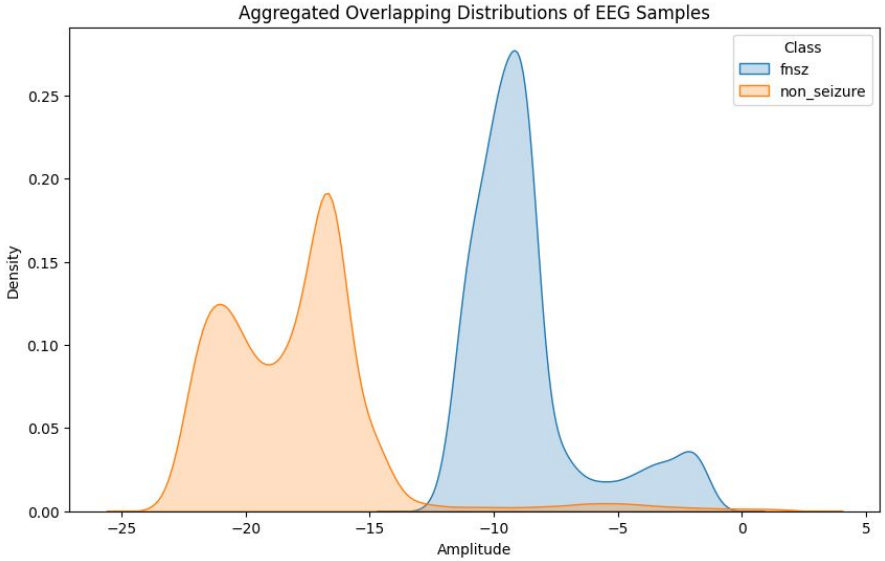
Thank you for your attention

Questions?

Appendix A



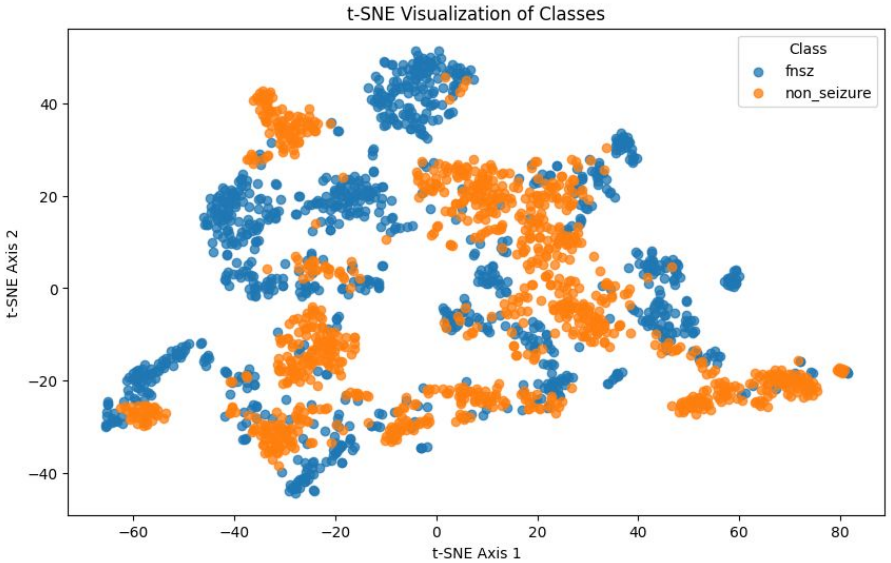
a) Real samples



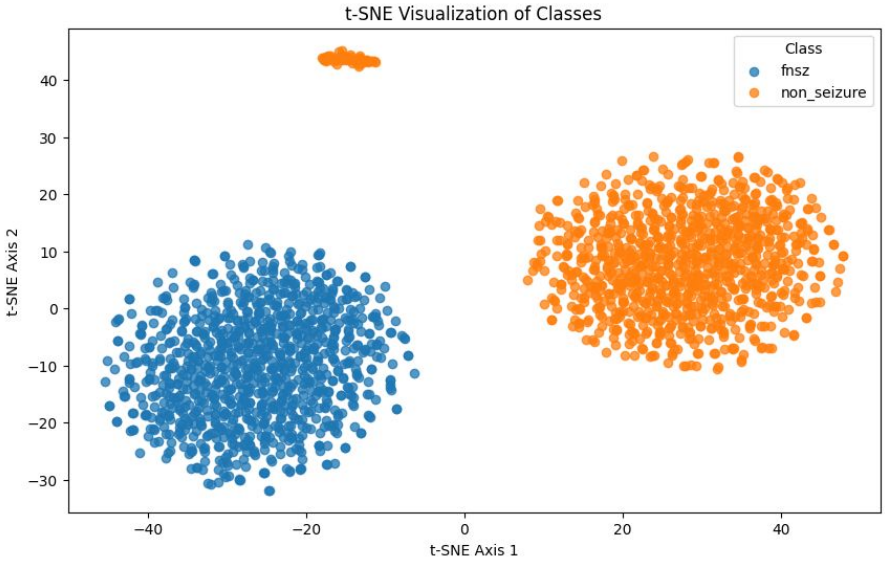
b) Synthetic samples

Frequency features

Appendix B



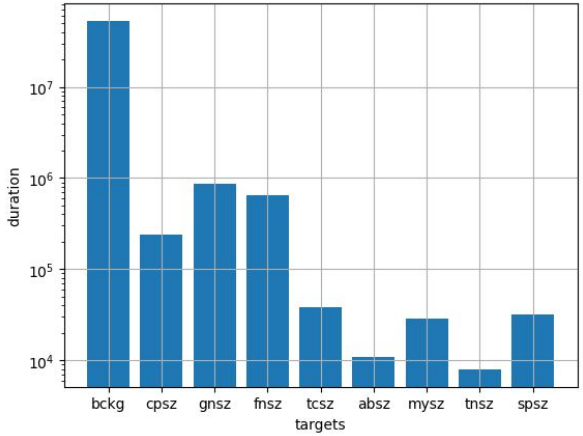
a) Real samples

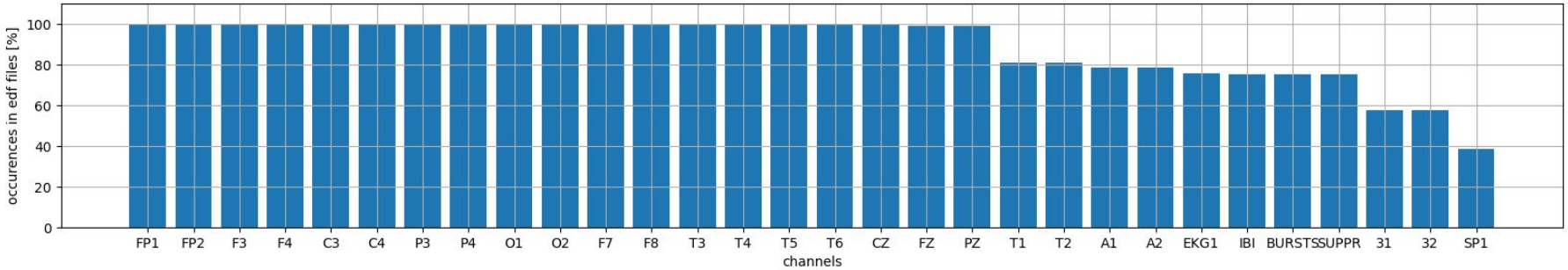


b) Synthetic samples

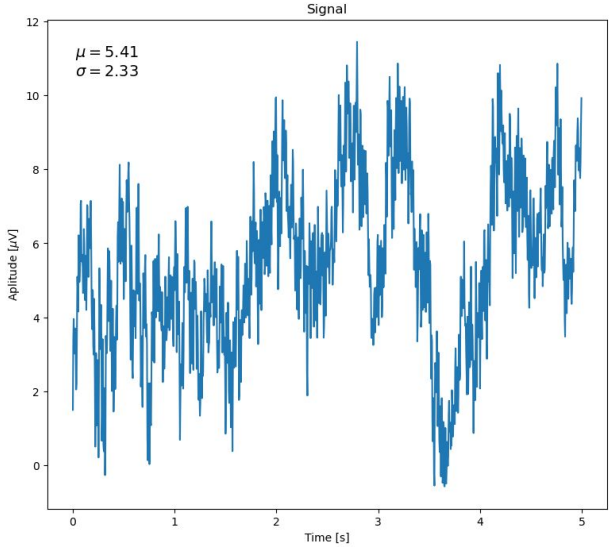
Frequency features

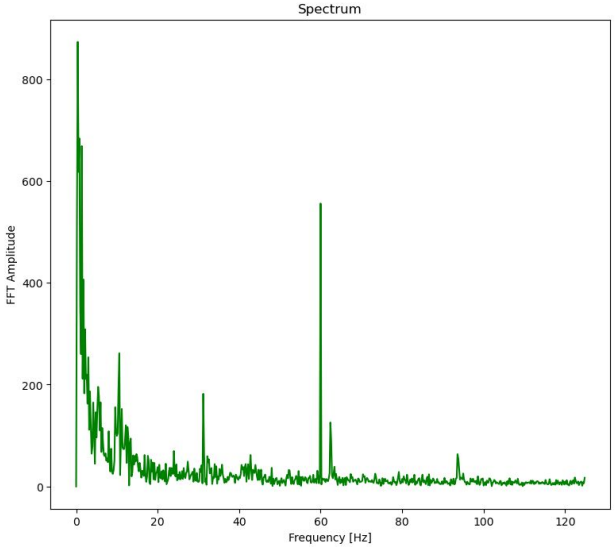
Appendix C: Channels and classes





Appendix D: Original signal and spectrum



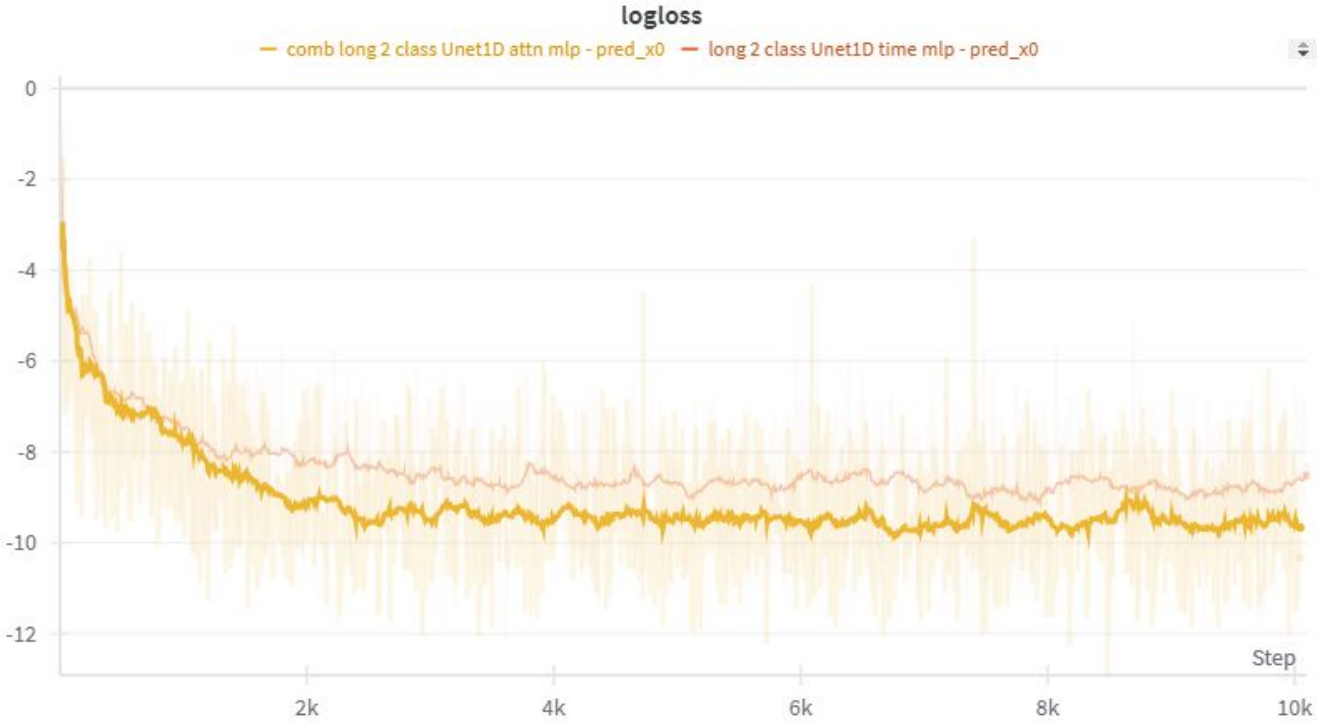


Appendix E: Choice of classifier

- Try out different classifier models
- Train on real data, test on real data
- Features:
  - FFT
  - Discrete wavelet transform
  - Mean, Standard deviations, Percentiles
  - Welch's PSD
- Models:
  - Gradient boosting
  - SVC
  - Multilayer perceptron

- Model chosen: FFT + SVC

Appendix F


logloss
comb long 2 class Unet1D attn mlp - pred_x0
long 2 class Unet1D time mlp - pred_x0
0
-2
-4
-6
-8
-10
-12
Step
2k
4k
6k
8k
10k

Appendix G: Dataset

- https://isip.piconepress.com/projects/tuh_eeg/html/downloads.shtml
- Access on request
- 26 846 clinical EEG recordings collected at Temple University Hospital (TUH) from 2002 - 2017
- EEGs stored as EDF files (EDF = European Data Format)
- Annotations stored as CSV (channels, start, stop, class [e.g. fnsz])