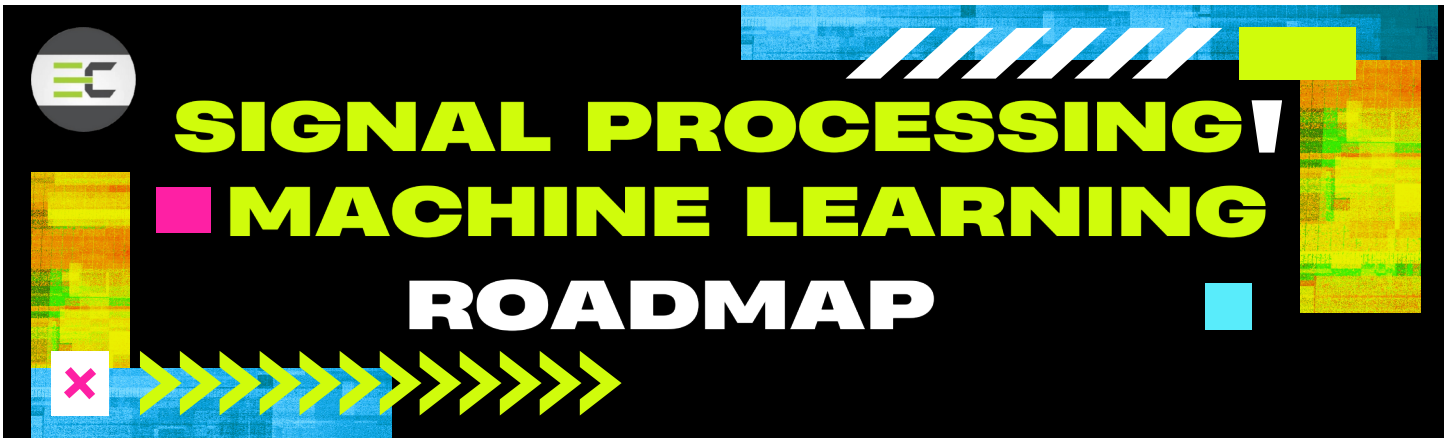


PREREQUISITES

1. Matrices :
   - For the visualisation of the Linear Algebra concepts, refer to the following playlist : https://youtube.com/playlist?list=PL0-GT3co4r2y2YErbmuJw2L5tW4Ew2O5B&si=htLx9lwFkR6a8ukI
   - For Overview : ML-linear-algebra-operations
   - For understanding how Linear Algebra concepts are behind ML : linear-algebra-that-every-data-scientist-should-know-eb585e0ef18d
   - Courses :
     - linear-algebra
     - linear-algebra-machine-learning
   - Demos for the book " Linear Algebra for DS,ML and SP„ : book-la-demo
   - Books for deeper dive :
     - Mathematics for ML : mml-book.pdf
     - Pure Linear Algebra : Linear Algebra by Gilbert Strang
     - For SP and ML : Linear Algebra for DS,ML and SP
2. Probability and Statistics :
   - https://www.stat.cmu.edu/~larry/all-of-statistics/index.html
   - http://www.greenteapress.com/thinkstats/
   - http://online.stanford.edu/course/probability-and-statistics-self-paced

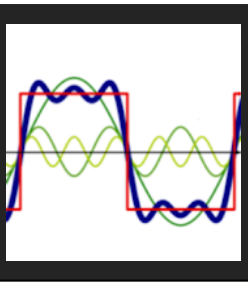
PHASE 1

Digital Signal Processing Basics

1. 📉 Signal Processing with Python | Kaggle
2. Allen Downey – Introduction to Digital Signal Processing – PyCon 2018
3. Digital Signal Processing – DFT Introduction
4. Digital Filter Design in Python and C++ | by Markus Buchholz | Geek Culture | Medium
5. https://www.kaggle.com/competitions/g2net-gravitational-wave-detection/discussion/250297

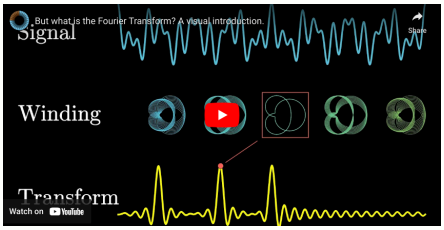
Signal Processing Reading List

1. Sampling Theorem
2. Sampling Theorem Part 2 v2
3. Fourier Transform
4. Frequency Resolution
5. More Fourier Transform
6. Windowing
7. Windowing Part2
8. Windowing Part3
9. Filtering
10. Filtering Part2
11. Filtering Part3
12. Compressive Sampling



Fourier Transforms

Visual introduction to Fourier Transform :



https://www.youtube.com/watch?v=spUNpyF58BY

All about Fourier :

https://www.thefouriertransform.com

An Interactive Guide To The Fourier Transform : an-interactive-guide-to-the-fourier-transform

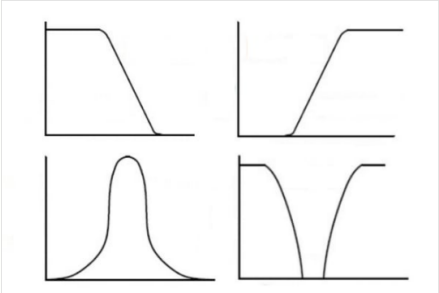
FS, FT, DFT, DTFT : frequency.pdf

Codes :

- fft.html
- Fourier Transform, the Practical Python Implementation | by Omar Alkousa | Towards Data Science
- routines.fft.html

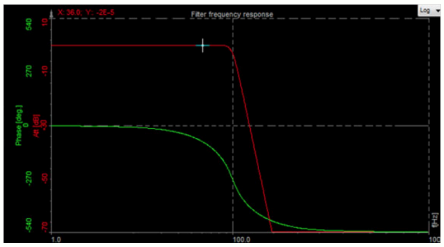
Filters

Introduction:



https://www.allaboutcircuits.com/technical-articles/an-introduction-to-filters/

Course:



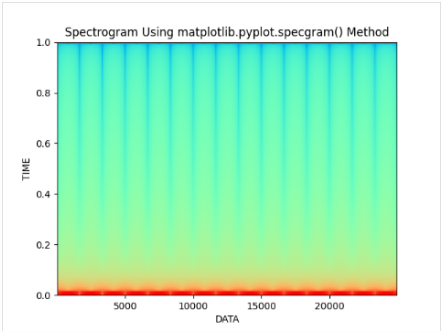
https://training.dewesoft.com/online/course/filters

Codes:

- Filters.html

Spectrogram

Getting started:

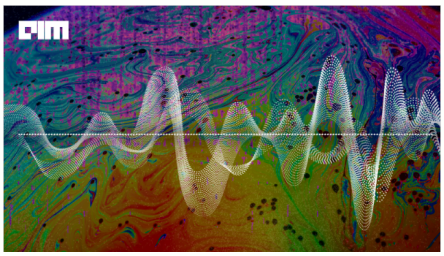


https://www.geeksforgeeks.org/plotting-a-spectrogram-using-python-and-matplotlib/

Audio Visualisation:

https://dolby.io/blog/beginners-guide-to-visualizing-audio-as-a-spectogram-in-python/

Tutorial:



https://analyticsindiamag.com/hands-on-tutorial-on-visualizing-spectrograms-in-python/

Mini Projects

- Hands On Signal Processing with Python | by Piero Paialunga | Towards Data Science

PHASE 2

Machine Learning Basics

Intro

- A Gentle Introduction to Machine Learning

Basic libraries (Kaggle)

- Best Python libraries for Machine Learning with usage | Kaggle
- Best Python libraries for Machine Learning - GeeksforGeeks

Feature engineering

- What is Feature Engineering? - GeeksforGeeks
- Also there is a course on feature engineering:
- Feature Engineering in Machine Learning and Data Science

Supervised and unsupervised learning -

- Types of Machine Learning
- Supervised and Unsupervised learning - GeeksforGeeks

Basic ML models (Classification + Regression)

- [ ] Linear Regression
  - The Main Ideas of Fitting a Line to Data (The Main Ideas of Least Squares and Linear Regression.)
  - Linear Regression, Clearly Explained!!!
  - Multiple Regression, Clearly Explained!!!
- [ ] Logistic Regression
  - StatQuest: Logistic Regression
  - Logistic Regression Details Pt1: Coefficients
  - Logistic Regression Details Pt 2: Maximum Likelihood
  - Logistic Regression Details Pt 3: R-squared and p-value
  - Saturated Models and Deviance

- Deviance Residuals

- [ ] Support Vector Machine
  - Support Vector Machines Part 1 (of 3): Main Ideas!!!
  - Support Vector Machines Part 2: The Polynomial Kernel (Part 2 of 3)
  - Support Vector Machines Part 3: The Radial (RBF) Kernel (Part 3 of 3)
- [ ] Classification and Regression Trees
  - Decision and Classification Trees, Clearly Explained!!!
  - StatQuest: Decision Trees, Part 2 – Feature Selection and Missing Data
  - Regression Trees, Clearly Explained!!!
  - How to Prune Regression Trees, Clearly Explained!!!
- [ ] Decision Trees
  - StatQuest: Random Forests Part 1 – Building, Using and Evaluating
  - StatQuest: Random Forests Part 2: Missing data and clustering
- [ ] Random Forest
  - StatQuest: Random Forests Part 1 – Building, Using and Evaluating
  - StatQuest: Random Forests Part 2: Missing data and clustering
- [ ] Gradient Boost
  - Gradient Boost Part 1 (of 4): Regression Main Ideas
  - Gradient Boost Part 2 (of 4): Regression Details
  - Gradient Boost Part 3 (of 4): Classification
  - Gradient Boost Part 4 (of 4): Classification Details
- [ ] XGBoost
  - XGBoost Part 1 (of 4): Regression
  - XGBoost Part 2 (of 4): Classification
  - XGBoost Part 3 (of 4): Mathematical Details
  - XGBoost Part 4 (of 4): Crazy Cool Optimizations
- [ ] AdaBoost

AdaBoost, Clearly Explained

Evaluation metrics

Evaluation Metrics in Machine Learning - GeeksforGeeks

Assignments

https://www.kaggle.com/c/predicting-family-household-income/overview

https://www.kaggle.com/competitions/disease-classification/overview

PHASE 3

Neural Networks and Deep Learning

- [ ] CNN :-

Convolutional Neural Network (CNN) in Machine Learning - GeeksforGeeks

But what is a neural network? | Chapter 1, Deep learning

Gradient descent, how neural networks learn | Chapter 2, Deep learning

What is backpropagation really doing? | Chapter 3, Deep learning

Backpropagation calculus | Chapter 4, Deep learning

https://colab.research.google.com/github/google/eng-edu/blob/main/ml/pc/exercises/image_classification_part1.ipynb?hl=en

Assignment :-

MNIST Dataset | Kaggle

- [ ] Deep Learning:-

But what is a GPT? Visual intro to transformers | Chapter 5, Deep Learning

Attention in transformers, visually explained | Chapter 6, Deep Learning

Assignment -

Intro to Deep Learning

PHASE 4

Machine Learning for Signal Processing

1. Audio Classification : [Audio Signal Processing for Machine Learning and Deep Learning]

   (Video 4 - 8, assuming you have completed SP Basics ;) - it has a project walkthrough
2. Speech Recognition : [13. Speech Recognition with Convolutional Neural Networks in Keras/TensorFlow] (Follow along)
3. EEG Analysis: [EEG Signal Processing - Python - YouTube]

   (Video 2-5 are relevant and will help you in upcoming final project, rest can be referred with interest)
4. Mini Project :
   - [ ] Signal processing with machine learning (Human Activity Recognition, EDA)
   - [ ] Signal processing with machine learning (Human Activity Recognition, Classical ML)
   - [ ] Signal processing with machine learning (Human Activity Recognition, Neural Networks)

FINAL PROJECT

[BCI Challenge @ NER 2015 | Kaggle]

(Probably being your first competition on Kaggle, here is a reference to follow, no need to stick to it, be creative and use as many tools at hand)

Target 1: Data Preprocessing & Feature Engineering

1. Load the EEG data (.csv files) and explore it using libraries like pandas or matplotlib. Understand the structure of timestamps, electrode readings, and feedback events.
2. Apply filtering techniques (e.g., notch filter) to remove noise from power lines (50/60 Hz). Implement algorithms to remove eye movement artifacts based on EOG channel data.
3. Extract relevant features from the preprocessed EEG data. Explore techniques like Common Spatial Patterns (CSP) or time-domain features (e.g., variance) to capture brain activity related to feedback events.

Target 2: Model Selection & Training

1. Considering the binary classification task (error vs. correct feedback), choose a suitable machine learning algorithm like Support Vector Machines (SVM) or Logistic Regression.
2. Analyze the extracted features and identify the most informative ones for classification. Techniques like feature importance scores can guide this selection.
3. Train your chosen model on the provided training data (.csv files) using features and corresponding labels (0 for bad feedback, 1 for good).

Target 3: Evaluation & Submission

1. Evaluate your model's performance on a separate validation set (a portion of the training data). Calculate metrics like Area Under the ROC Curve (AUC) to assess its effectiveness in error detection.
2. Use your trained model to predict error probabilities (between 0 and 1) for each feedback event in the unseen test data set.
3. Create a submission file in the required format. Each line should include "IdFeedBack" (e.g., "S01_Sess01_FB001") and your model's predicted error probability for that feedback. Ensure a header row with "IdFeedBack,Prediction" labels.

4. Submit the prepared file on Kaggle according to their specific guidelines. The platform will evaluate your model's AUC score for the final ranking.