Block 4. Machine Learning

Module 1. Introductory Machine Learning

1.1 Linear Regression and Classification

Linear regression is used for predicting continuous values by modeling the relationship between variables with a linear equation, while classification is used for predicting categorical outcomes by assigning inputs to predefined classes.

Task: Watch this video to learn about the basics of linear regression and classification. We will go more in depth into code examples throughout this block.

1.2 Neural Networks Basics + Math Behind It

Neural networks are computational models inspired by the human brain, designed to recognize complex patterns and relationships in data. At their core, they consist of layers of interconnected neurons, each performing weighted computations followed by activation functions to introduce non-linearity. The mathematical foundation involves linear algebra for weight manipulation, calculus for backpropagation-based optimization, and probability theory for handling uncertainty in predictions.

Task: Read this article and watch the following lessons to understand the basics of neural networks and how you can work with them.

- Lesson 1
- Lesson 2

Module 2. Advanced Neural Networks

2.1 PyTorch

PyTorch is an open-source deep learning framework developed by Meta (formerly Facebook) that provides flexibility and efficiency for building and training neural networks. It is widely used for research and production due to its dynamic computation graph, GPU acceleration, and ease of use with Python.

Task: Follow along on the GitHub 4.2.1 Lesson and Practice here to practice using Pytorch for linear regression. Submit a screenshot of your progress throughout the module.

2.2 Convolutional Neural Networks (with EEG Applications)

Convolutional Neural Networks (CNNs) enable advanced analysis of brain signals such as Electroencephalography (EEG) data. By leveraging spatial and temporal patterns, CNNs can efficiently extract meaningful features from raw EEG signals, improving the accuracy of brain-computer interfaces (BCIs) and neurological disorder detection. Their ability to

automatically learn representations makes them ideal for real-time applications, from cognitive state monitoring to assistive neuroprosthetic control.

Task: Read the following article and watch this video to learn about CNNs and how they are used for EEG data. If it's not quite making sense yet, try watching this video on a more classic example of number recognition in images.

Module 3. Signal Processing

3.1 Bandpass Filtering, Segmentation, Normalization

Bandpass filtering extracts signals within a specific frequency range, removing unwanted noise. Segmentation divides data into meaningful sections, such as time windows in EEG analysis. Normalization scales data to a standard range, improving consistency in machine learning and signal processing.

Task: Follow along on the GitHub 4.3.1 Lesson here to better understand bandpass and notch filtering signal processing. Submit a screenshot of your progress throughout the module.

3.2 Fast Fourier Transform (FFT)

Fourier Transforms (FT) are a powerful tool for analyzing signals by converting them from the time domain to the frequency domain. This allows for the identification of dominant frequencies, filtering of noise, and extraction of meaningful patterns from complex data. In neurotechnology, they help analyze EEG and fMRI signals, detecting neural oscillations and brain activity. This improves signal clarity and enhances neural signal processing applications.

Task: Read this article, which can be accessed using your utexas email, to get an understanding of fast FT and complete the GitHub 4.3.2 Lesson. Submit a screenshot of your progress throughout the module.

Extra resources:

- Machine Learning by StatQuest YouTube Playlist
- FreeCodeCamp YouTube Channel
- Google Teachable Machine (for fun!)

When it comes to machine learning, there's always more to learn. We encourage you to have conversations, ask questions, and choose curiosity during this process, and do not hesitate to reach out if you have any questions!