## Block 3. Signals

### Module 1. Introductory Signals

**1.1** Brain Signals

Brain signals are electrical or hemodynamic activity generated by neural processes, commonly measured using techniques like EEG, fMRI, and ECoG. Software in neurotechnology processes these signals to extract meaningful patterns for applications such as brain-computer interfaces and cognitive state monitoring.

Task: Watch these videos to learn about neuroimaging and electroencephalography.

- Lesson 1
- Lesson 2

**1.2** EEG Signals

Electroencephalography (EEG) is a non-invasive method used to record the electrical activity of the brain. EEG measures voltage fluctuations resulting from ionic current flows within neurons in the brain.

Task: Follow along on GitHub 3.1.2 Lesson and Practice here to better understand the components of EEG and practice signal processing. Submit a screenshot of your progress throughout the module.

### Module 2. Signal Processing

**2.1** Bandpass and Notch Filtering

Bandpass filtering allows frequencies within a specific range to pass while attenuating frequencies outside that range. It is used to isolate signals of interest, such as detecting brain wave activity in EEG signals.

Notch filtering (or band-stop filtering) removes a specific frequency range while allowing others to pass. It is useful for eliminating unwanted noise, such as removing 60 Hz power line interference from biosignals.

Task: Follow along on the GitHub 3.2.1 Lesson here to better understand how real-time EEG signal proceeding works. Submit a screenshot of your progress throughout the module.

**2.2** Fourier Transforms

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 you can access using your utexas email, to get an understanding of fast FT and complete the GitHub 3.2.2 Lesson. Submit a screenshot of your progress throughout the module.

**Module 3. Data Analysis**

**3.1** t-SNE

t-Distributed Stochastic Neighbor Embedding (t-SNE) is a dimensionality reduction algorithm used in software pipelines for visualizing high-dimensional neural data. It helps cluster similar neural activity patterns, making it useful for feature exploration and anomaly detection in brain signal processing.

Task: Read this article to understand t-SNE and watch these videos to help you get a better understanding:

- Lesson 1
- Lesson 2

**3.2** PCA

Principal Component Analysis (PCA) enhances software efficiency by reducing the dimensionality of neural datasets while preserving key variance. It is commonly used for noise reduction, feature extraction, and optimizing machine learning models in neurotechnology applications.

Task: Read this article to learn more about PCA, and watch the following videos to get a better understanding.

- Lesson 1
- Lesson 2