Introduction to EEG

This page will give a short introduction in EEG technique, terminology and analysis. When looking at basic techniques, we will quickly zoom in to techniques which are relevant to the EEG KISS project. First I will give a quick introduction to what EEG is. For more information and related reading, take a look at [4].

EEG stands for ElectroEncephaloGraphy, which is the recording of electrical activity of the brain. EEG is one of various ways to measure brain activity among MEG and fMRI. Some advantages are the fact that EEG hardware is relatively cheap, relatively tolerant to subject movement and, very important, EEG has very high temporal resolution and low latency. Some disadvantages are the low spatial resolution of EEG, and bad measurement of sub-cortical brain regions. Another disadvantage of EEG is the poor signal-to-noise ratio.

EEG techniques can be roughly classified in two categories: ERP analysis and spectral analysis. ERP stands for event related potential. Here, the brain gives a specific signal response to certain relevant stimuli as opposed to irrelevant stimuli (or in some other way different types of stimuli).

Spectral analysis of EEG involves looking for cortical rhythms in specific frequency bands in the EEG signal. Relations have been found between certain cortical rhythms and cognitive states or activities.

Analysis

As a reference point to look for relevant signal processing techniques, we will take a paper by Eaton, Jin and Miranda on their project 'The Space Between Us' [1]. This project is comparable to our project in a couple of ways. EEG headsets are used to measure the mental states of two people without conscious control. That data is used for an art performance in real-time. I will describe the processing steps of this project and some additional methods or variations and relate these to our own setup.

Pre-processing steps include processes that remove hardware noise and environmental noise or enhance the signal power. Artefact removal is the process of detecting artefacts and removing them from the signal path. Artefact are events in the signal that are not caused by brain activity, but for instance by muscle tension or other external events. After these processing steps, there are several techniques that can be used for analysis. This projects application does not involve the presentation of stimuli or other timing controlled events. Therefor we choose to Spectral analysis as our main analysis technique.

Pre-processing

Taken from [4]: The digital EEG signal is stored electronically and can be filtered for display. Typical settings for the pass filter and a low-pass filter are 0.5-1Hz and 35–70 Hz, respectively. The high-pass filter typically filters out slow artifact, such as electrogalvanic signals and movement artifact, whereas the low-pass filter filters out high-frequency artifacts, such as electromyographic signals. An additional notch filter is typically used to remove artifact caused by electrical power lines (60 Hz in the United States and 50 Hz in many other countries).

Artefact removal

Taken from [1]: To handle interference from blinking, muscle activity or movement related artifacts we adopt Tenke and Kaysers method of segmenting incoming EEG into epochs of 1 second (50% overlap; Hanning window) and rejecting those that are clipped above a threshold of +100 µv."
Taken from C. E. Tenke. and J. Kayser, Reference-free quantification of EEG spectra: combining current source density (CSD) and frequency principal components analysis (fPCA). Clin Neurophysiol, 2005. 116(12): p. 2826-46.

Spectral analysis

The paper by Muller [2] describes in detail how to extract the activity in different frequency bands, which is a common method. The basis of this method is Fast Fourier Transform. This algorithm transforms time-domain data into frequency data. By applying this transformation using a sliding window, the changes in the frequency domain can be analysed over time. (Sliding window of 1 second and 0.5 overlap in [1].) Activity in a defined frequency band can be extracted from this frequency domain data by averaging the activity values of multiple individual frequencies

Headset specs

Channel 0	Right front C4
Channel 1	Center front Cz
Channel 2	Left front C3
Channel 3	Center back Pz

References

1. **The Space Between Us: A Live Performance with Musical Score Generated via Affective Correlates Measured in EEG of One Performer and an Audience Member**
2. Processing of affective pictures modulates right-hemispheric gamma band EEG activity
3. Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions
4. Electroencephalography - Wikipedia, the free encyclopedia