CSC650 Final Project Report: EEG peak detection algorithm

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Introduction

In recent years, electroencephalogram (EEG) has been widely used to measure electrical activities in the brain. EEG signals are recorded and displayed as waveforms. The signal recordings under different conditions are called event-related potentials. By analyzing them, we can have a better understanding of how relevant pathways work. An important step is to locate and label the significant ERP components, also known as peaks (such as P100, N1, etc.). This can help us extract the important features under different brainwave patterns. The task can be very time-consuming if done manually. When the amount of data sets increases, the effort required also rises exponentially.

To free the hands of neuroscience researchers, this project aims to develop a peak detection algorithm that can identify specific peaks from EP (electrical potentials) recordings through heuristic and statistical features in the literature and data, and then automatically label them on the waveforms. Therefore, the functions we expect of this algorithm are as follows: Firstly, convert the raw data points into EEG waveforms; The algorithm will learn and extract the peak features and properties from the data. We then use the approach of machine learning to do peak isolation, extraction and identification. Finally, when given random EP recordings, it can automatically label potential peaks on the waveform graphs.

Method

This model uses the audio-visual interaction EEG data recorded by SmartEP software in Dr. Ozadamar's Neurosensory lab. The experiment collected the VEPs (Visual Evoked Potentials: N35, P50, N75, P100, N170, P200) and AEPs (Auditory Evoked Potential: N0, P1, N1, P2, N2, P3) data of 10 subjects under 9 external stimuli conditions through two electrode channels respectively. Before importing them into the algorithm, we manually labeled the peaks of interest and exported the demographic information, treatment, peak information and raw data points into an Excel file. This project will use Matlab to develop the peak detection algorithm because it contains many toolboxes which help process EEG signals.

1. **Data Visualization**

In the Excel file, each EP recording is represented as 4096 data points with a sampling rate of 125 μs. Therefore, the time series of a single recording is approximately 512 ms. It also recorded the positive and negative latencies (ms) for each particular peak in each recording, as well as its amplitude (μV). The treatments recorded in the Comment column are the main variable.

For the convenience of observation, the first thing we need to do is to convert a large number of data points into EEG waveform plots and EEG amplitude plots. The most important part was rescaling the X-axis, which means changing the serial number of the data point to the actual time. We then wrote functions named EEGPlot and EEGMagPlot.

In addition, we also want to visualize the peak labels on the EEG waveform plots. In that case, the algorithm can do automatic labeling later. We only need to find the corresponding data points based on the actual or predicted positive and negative latencies and place marks there. Thus, we wrote a function named labelPeaksOnEEGPlot. All you need to do is input the index of rows, frequency and the peak name.

2. **Peak Detection**

Peaks in an AEP or VEP EEG recordings are labelled empirically based on certain time windows in which these peaks are observed. It should be clarified that the same peak may be named differently in various literatures. Due to different data collection systems and the subjects' individual differences, the positive latency of peaks may not be consistent either. However, they all have specific ranges. In this project, we take the peak properties in the following table as the standard.

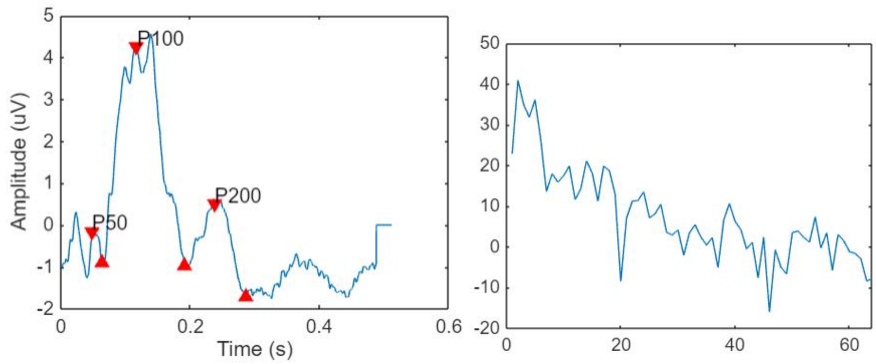
VEPs	Time Window (post stimulus)	AEPs	Time Window (post stimulus)
N35	35 ms	N0	Not sure, <50 ms
P50	45-60 ms	P1	50-100 ms
N75	75ms	N1	100 ms
P100	80-130 ms	P2	150-200 ms
N170	170 ms	N2	170-250 ms
P200	180-250 ms	P3	250-500 ms

TBC

Result

1. **Data Visualization**

We successfully visualized the raw data points and peak information. Take the plots of the first EP recording of the first subject as an example (Plots are as below). The one above is an EEG waveform plot with peak labels on it. The one beneath is the EEG amplitude plot. These two plots can directly show us the important information recorded in this EP. Obviously, this is a VEP recording.



2. **Peak Detection**

TBC

Discussion

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Github Link

You can find the raw data, the experimental description, relevant literature and the Matlab code files of our project here:

https://github.com/inpinseptipin/PeakyFinders

Reference

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