BME3500 Introduction to Neural Engineering
Homework – 1

INFORMATION

Write appropriate scripts (m-file) and/or user defined functions in MATLAB to solve the given below problem. To be able to write appropriate code snippets that handle the given problems you may need to do some additional research and study. Show your references as a footnote where necessary. You may discuss and work with your friends to find solutions. However, everyone should **write** their **report alone** and use their **own words**. Any **cheating, copy-paste, etc.** will result in **zero grade** for students who are involved. A **report format** is given as a part of this homework, use it to write your own report. Your report (in **pdf** format) should include your code files, your results (images, graphs, text, etc.), as well as your comments about your code and your results. The **deadline** for the report is **08.01.2023, 23:59**. Compress all your materials (**your report, scripts, and function files**) to a **single .zip file** and upload it to the link given below. Homeworks sent as an e-mail will **not** be graded. Any late or no submissions will be **graded with zero**.

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Note: If you do not receive a confirmation e-mail after submitting your homework, you may contact Res.Asst. Fatih Ekrem Onat to verify your submission.

QUESTION 1:

You are given three synthetic EGG datasets which are named as "Q1_Data1.mat", "Q1_Data2.mat" and "Q1_Data3.mat". You will apply event related potential (ERP) analysis to be able to answer below questions which will be related with the given three datasets. Please add your all-necessary code snippets into a single .m file and attach this file to your final .zip file.

a) Please give the specification details of each dataset including the sampling rate, number of channels, number of trials and the length of each trial (in seconds).

b) For the first channel of all three datasets apply ERP analysis (use averaging to all trials for finding the ERP signal) both in time frequency domains. Please plot the average ERP signal in time domain and the power spectrum of the average ERP signal in the same figure. You can use subplot function for this task. Note: The power spectrum of the ERP signal can be obtained by using two approaches: i) you can find the average of all trials in time domain and then apply Fourier analysis to this time domain average signal and ii) you can find the Fourier Transform of each trial and then you can average the Fourier representation of individual trials. Please discuss the findings of each approach in your report.

c) White Gaussian Noise, Uniformly Distributed noise and pink noise are three probability distributions which are employed while constructing the three datasets. If in each dataset only one kind of distribution was employed, please match each dataset to the proper noise distribution by using the finding that you have already obtained in section (b). Please add the necessary explanations.

QUESTION 2:

You re given a synthetic EEG data named as "Q2_Data.mat". In this dataset, each trial is composed of the sum of three sinusoids having different frequencies and amplitudes. Additionally, there exists some degree of random noise in each separate trial.

a) Please plot time domain averaged ERP signal for channel 1 and explain your findings. Can you make any guess about the amplitude or frequency values of three sinusoids from the time domain ERP signal? Give the necessary explanations.

b) Plot the power spectrum representations calculated for following three scenarios on the same figure (subplot can be used):

- Power spectrum of the first trial of channel 1. Use the x-axis limits as [0 100] Hz.

- Power spectrum of the averaged trials in time domain for channel 1. Use the x-axis limits as [0 100] Hz.

- Power spectrum calculated by averaging the Fourier representations of individual trials for channel 1. Use the x-axis limits as [0 100] Hz.

Please explain which Power spectrum representation can be used to find the amplitude and frequency values of the three sinusoids. Is the activity represented in channel 1 phase-locked or non-phase-locked? How did you decide it?

QUESTION 3:

You re given a synthetic EEG data named as "Q3_Data.mat". In this dataset, each trial is composed of the sum of two band-limited signal which have different center frequencies (can be interpreted as the peak values) and bandwidth values. Additionally, there exists some degree of random noise in each separate trial.

a) Please plot time domain averaged ERP signal for channel 1 and explain your findings. Can you make any guess about the center frequency or bandwidth values of these two band-limited signals from the time domain ERP signal? Give the necessary explanations.

b) Plot the power spectrum representations calculated for following three scenarios on the same figure (subplot can be used):

- Power spectrum of the first trial of channel 1. Use the x-axis limits as [0 100] Hz.

- Power spectrum of the averaged trials in time domain for channel 1. Use the x-axis limits as [0 100] Hz.

- Power spectrum calculated by averaging the Fourier representations of individual trials for channel 1. Use the x-axis limits as [0 100] Hz.

Please explain which Power spectrum representation can be used to find center frequencies (can be interpreted as the peak values) and bandwidth. Which band-limited activity has a wider frequency distribution?

QUESTION 4:

You re given a synthetic EEG data named as "Q4_Data.mat". In this dataset, in each trial a band-limited signal, which can be called as a transient activity, is located onto a specific time point. Additionally, there exists some degree of random noise in each separate trial.

a) Please plot time domain averaged ERP signal for channel 1 and explain your findings. Can you make any guess about the location and bandwidth of this transient activity from the time domain ERP signal? Give the necessary explanations.

b) Plot the Short Time Fourier Transform representation of the time-averaged ERP activity by using the "spectrogram()" built-in function of MATLAB. Try different window types, window size, overlap-ratio and FFT size to be able to obtain the best representation. From the Spectrogram visualization, please try localizing transient activity in time and try to find the peak frequency and bandwidth of same activity in frequency. Give the necessary explanations.

You should write a report on your work using the supplied report format. You should be expressive and unique on your explanations and comments.