

## BE280A Final Project Assignment

**Due Date:** Final project presentations will be given on Tuesday, December 11, 2012 from 11:30 am to 2:30 pm.

### Overview and General Guidelines:

- 1) Select one of the project options from below.
- 2) You may work by yourself or work with 1 partner.
- 3) Each group should be prepared to give a 15 minute presentation with 5 minutes allotted for questions.
- 4) Send an e-mail to the instructor (tliu@ucsd.edu) indicating your choice of project and the name of your partner (if applicable) by 10 am on Wednesday, November 28, 2012.
- 5) Be prepared to submit an electronic version of your presentation on a thumb drive before the end of the session.

### Option 1

The goal of this project is to create a short presentation that explains key concepts of magnetic resonance imaging (MRI). Your target audience member is a first year graduate engineering student who knows very little about either Fourier transforms or MRI. The presentation should be technically accurate, concise, and engaging. Rehearse your presentation so that you can meet the time limit! If you would like, you may pre-record the 15 minute presentation as a well-edited movie (an example will be shown in class).

The required components of the presentation are as follows:

- a) Explain how one can make up an image from its Fourier components.
- b) Explain the notion of k-space.
- c) Go over precession in the presence of a magnetic field, the concept of a rotating frame, and the importance of spin phase.
- d) Explain how the use of gradients in MRI enables us to form an image.
- e) Address aliasing and resolution requirements.
- f) Provide an example of at least one MRI pulse sequence.
- g) Cover one additional aspect of MRI that you think is important.

### Additional notes:

- 1) The presentations will be graded using the following criteria: (i) coverage of all required elements (20 pts); (ii) accuracy and clarity of concepts introduced (60 pts); (iii) quality of presentation (20 pts);
- 2) Discussion of **general ideas** is encouraged between groups, however, each presentation submitted should reflect each group's own understanding of the material. MATLAB code should be **unique** to each group. Significant discussions with other groups should be given appropriate credit (e.g. we discussed part (a) with so and so).
- 3) It is recommended, although not required, that you use MATLAB or some other software package to create animations and simulations. You may find it useful to adapt some of the MATLAB exercises you did for the homeworks.
- 4) You may NOT use pre-existing movies, unless they demonstrate a physical phenomenon that is not easy to recreate on your own (e.g. a movie of a metal object

being pulled into a magnet). If you use a scene from a pre-existing video, please make sure to cite the source.

- 5) Where appropriate, title and label the axes on plots and images in your presentation.

## Option 2

For this option, you may design your own project that is related to the course material. Some examples include: (1) analysis of an RF coil design from a published journal paper; (2) analysis of an MRI pulse sequence from a published journal paper; (3) projects from prior years ( these can be seen by starting at the course website browsing back through the web pages from prior years; e.g. [http://cfmriweb.ucsd.edu/ttliu/be280a\\_05/BE280A\\_05\\_project.pdf](http://cfmriweb.ucsd.edu/ttliu/be280a_05/BE280A_05_project.pdf)).

Potential past projects include: 2010 midterm project on CT; 2006/2007/2008 final project on echoplanar imaging; 2005 final project on parallel imaging).

Guidelines:

- (a) You will need to obtain prior approval for your project from the course instructor by Wednesday, November 28, 2012. Provide a short description (< 1 page) of what you plan to do, including what papers you are planning on looking at (if applicable).
- (b) Make sure to use course concepts in your presentation and provide enough background material so that your fellow students can follow the presentation.
- (c) Grading criteria: clear connection to course content and sufficient coverage of the necessary background material (30 pts); (ii) accuracy and clarity of concepts introduced (50 pts); (iii) quality of presentation (20 pts).

## Option 3

The goal of this project is to further explore EEGLAB and its plug-ins. You will use the dataset from Homework #7 and #8 or your own EEG dataset. The required components of the presentation are as follows:

- a) Compare channel ERPs and Component ERPs across multiple conditions. Note: you can basically use the pre-processing (Steps 1-8) you performed on stern.set (or stern\_125Hz.set) for Homework #7. Extract/epoch different groups of trials under different conditions (e.g. memorized vs ignored). You need to document the pre-processing steps you applied to the data. Do any of the channel ERPs and Component ERPs show differential activity between different conditions [20 points]
- b) Identify at least **three** independent components from the Component ERP plots that are event related. Use ERP image plots to explore the nature of event-related components, e.g. are the brain responses consistent across trials, are they time-locked to stimulus onsets, etc.? [25 points]
- c) Use an inverse-solution toolbox (e.g. DIPFIT which is included in EEGLAB) to find equivalent dipoles of event-related components. Plot and report the fitting errors (residual variances). Note: you can download a pdf file, 3\_Dipfit.pdf, from [http://dl.dropbox.com/u/105916411/3\\_Dipfit.pdf](http://dl.dropbox.com/u/105916411/3_Dipfit.pdf) to learn how to perform DIPFIT. [15 points]
- d) Use time-frequency analysis (ERSP) to explore the spectral changes of event-related components. Carefully report the spectral changes following stimulus presentation across different frequency bands. [20 points]
- e) Presentation [20 points].

#### Option 4

The goal of this project is to apply time-frequency analysis method to EEG signals collected in a brain-computer interface (BCI) experiment. Prof. Jung will provide the EEG data. Figure below depicts the basic scheme of the BCI experiment. The visual stimulator comprises a laptop monitor with a 4 x 3 stimulus matrix constituting a virtual telephone keypad which includes digits 0-9, BACKSPACE (\*) and ENTER(#). The stimulus frequencies ranged from 9Hz to 14.5Hz with interval of 0.5Hz between two consecutive digits. EEG signals were amplified, sampled at 128Hz, band-pass filtered (0.01-50 Hz) and digitized by analog-to-digital converters (ADC) with a 12-bit resolution. Three subjects were instructed to input a 5-digit number, one digit at a time for 24 seconds. The data from each of the three subjects consist of 4-channel,  $5 \times 24 = 120$  seconds of EEG data.

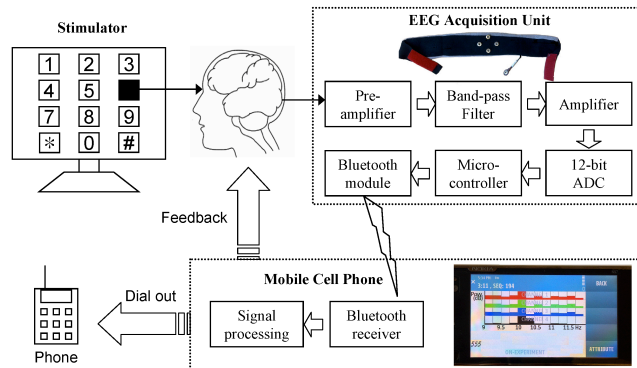


Figure 1. The diagram of the BCI experiment. This figure is from Yu-Te Wang et al, *Journal of Neural Engineering*, 8, 2011. Available online at [stacks.iop.org/JNE/8/025018](http://stacks.iop.org/JNE/8/025018)

#### Background of Steady-state Visual Evoked Potential (SSVEP) based BCI

SSVEP is the electrical response of the brain to the flickering visual stimulus at a repetition rate higher than 6 Hz, which is characterized by an increase in amplitude at the stimulus frequency. In SSVEP BCI, the attended frequency-coded targets of the user are recognized through detecting the dominant frequency of the SSVEP. For example, when you look at the flickering stimulus (flashing on and off) at 10 times per second, your visual cortex will exhibit rhythmic activity with the same frequency (10 times per second). Several signal-processing methods have been proposed and demonstrated in the past. Among them, power spectrum density (PSD) estimation (e.g., Fast Fourier Transform (FFT)) is most widely used in online SSVEP BCIs.

The required components of this project are as follows:

- Decode the five digits the three subjects intended to dial with their EEG (Channel 1 is recommended). (15 pts)
- Repeat the analysis in a), but use all 4 channels of EEG. Do you obtain the same results from different channels? (15 pts)
- Find at least another time-, frequency-, or time-frequency domain analysis method to decode the digits the three subjects intended to dial. Do you obtain the same results? If so, let assume the 5 digits you decode are correct sequence for the following problem. (25 pts)
- Explore the changes in the detection accuracy as you decrease the window length of the EEG data. For example, detecting the 5-digit sequence based on first 4 sec, instead of 24 sec, of EEG signals. Plot a detection accuracy vs window length figure. You can use the method you develop in either a) or b). (25 pts)
- Additional grading criterion: Quality of presentation (20 pts).