Neuromancer

Wireless EEG machine with designed for easy BCI implementation

Preliminary Design Report

EEL 4924 – Electrical Engineering Design II

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Team: Skinheads

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Abstract

Our project consists of designing a wireless EEG machine that will be ready for easy BCI integration. Brain signals will be captured with electrodes connected to buffer amplifiers. The signals will be passed from the buffer to an analog amplifying circuit. The amplified signal will be passed to a digital device that samples the data and transmits it via serial communication. The serial data will be transmitted wirelessly to a PC that will read in the data and display it through various methods for easy data analysis. The data will be displayed in a GUI created with MATLAB. The GUI will also identify actions using a BCI algorithm and output the data via an emulated serial port. The active electrode amplifier circuit, digital sampling circuit, wireless transmission system, and PC software will be designed by our group. The analog amplifier will be purchased. The BCI algorithm will be taken from other researchers.

Introduction

The neuromancer is a wireless EEG device. The headset will require minimal set up time, no assembly, and easy to use software. The whole package will allow for the analysis of individual brainwave channels as well as the isolation of key frequency bands for more in depth signal analysis. The project will require a firm understanding of both hardware and software. The hardware will involve both analog and digital components. The software will involve serial data communication, wireless transmission, digital signal processing, computational learning algorithms. The analog amplifier will be purchased. The BCI algorithm will be taken from other researchers.

Figure 1: Emotiv EPOC active electrode headset

Features

Users of the Neuromancer will be able to:

- Use an adjustable active electrode helmet like the one shown above.
- Be able to transmit wirelessly, brain signals captured by the active electrode helmet, to user designed software that will isolate and separate specific brain waves into the time and frequency domains.
- Will be able to easily incorporate the system with BCI devices. (i.e. controlling an emulated video game with the device.)

Technical Objectives

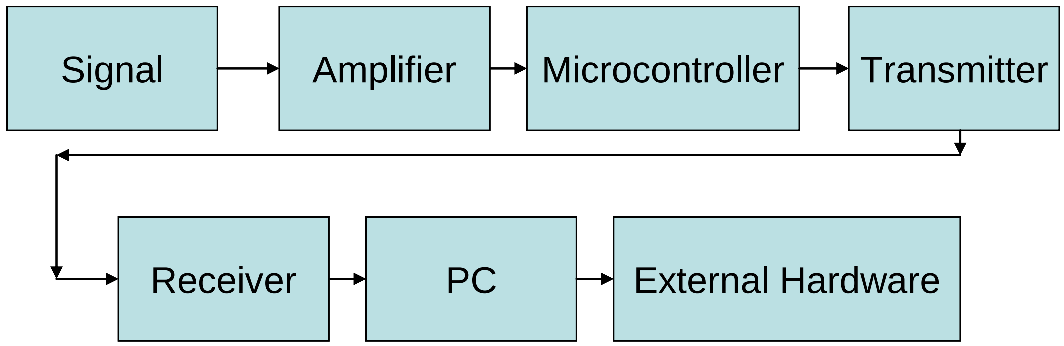

Figure 2: Flowchart of Neuromancer Project

Pictured above is a flowchart describing the technical aspects surrounding neuromancer. An input brain signal is passed through an amplifier to ADC port into a microprocessor (the atmega 324p for our project.) The signal is then transmitted wirelessly to a computer with software that will analyze and separate the sampled frequency in real-time and allow for easy BCI incorporation.

A list of specific technical goals is listed below:

- Design a buffer circuit to improve the detection and amplification of small signals (10~250 uV) in the presence of noise (~10 mV).
- Digitally sample the signal (fmax = 60 Hz).
- Wirelessly transmit the sampled signal to a PC.
- Create a user friendly GUI that reconstructs the signals and displays them in real time. The program will also allow for easy signal analysis and BCI application design by including bandpass filters, FFTs, and learning algorithms. The software will detect specific signals and output some form of pseudo-interrupt signal for BCI implementation in software/hardware.
- The external hardware will include a sophisticated helmet to mount the electrodes on.

Helmet Hardware

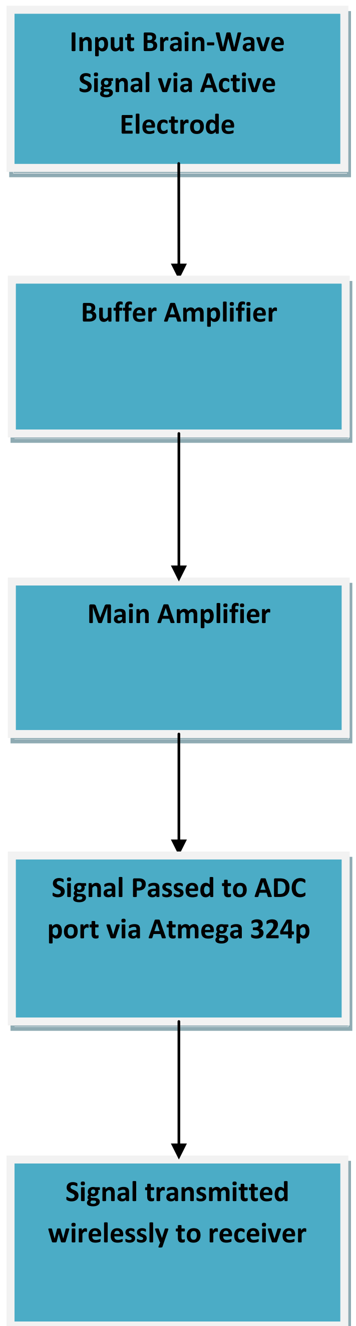

Figure 3: Flowchart of active electrode helmet

Software Layout

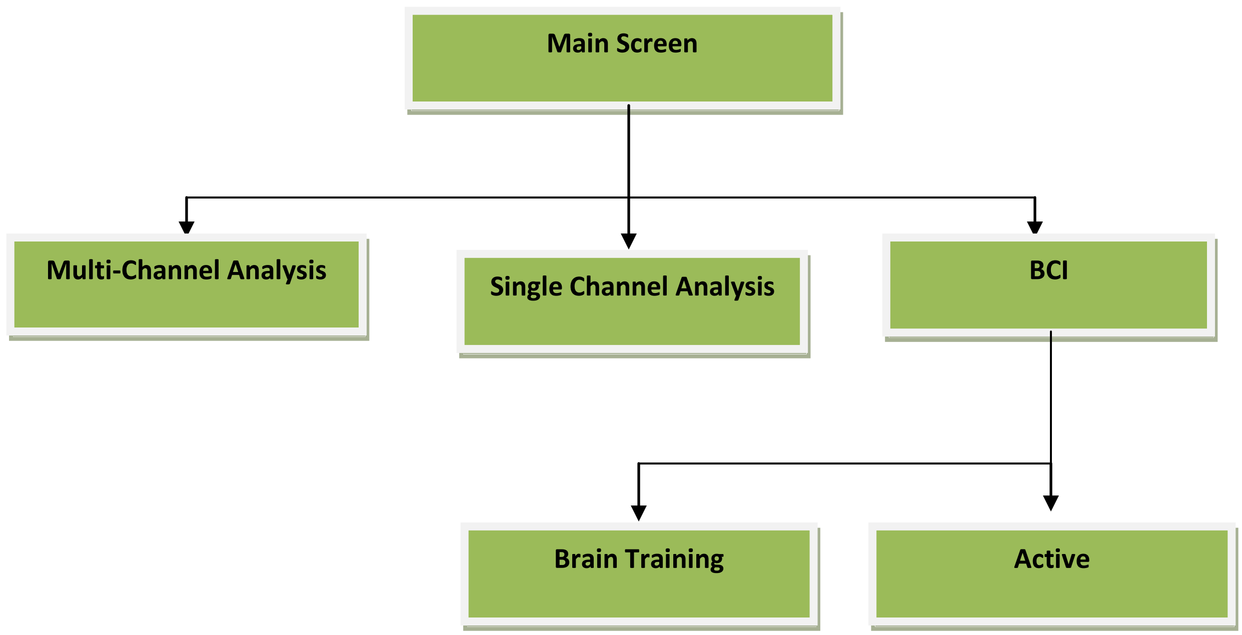

Figure 3: Software Flowchart

Main Screen – options to select what output functions to use.

Multi-Channel Analysis – analyze all signals in the time and frequency domain.

Single Channel Analysis – analyze one signal in frequency domain, polychoherence, time domain and split into individual frequency bands.

BCI – Select user profile, select whether to train program or use BCI.

Brain Training – run brain training methods.

Active Mode – run as active, trained BCI.

Cost Objectives

A general list of component and material costs is given below:

Estimated Cost for Neuromancer

Component/Item	Estimated Cost ($)
Atmega324p Microprocessor	$7.05
Misc Electrical Components(i.e. resistor, capacitor…)	$15.00
Electolosis Gel (per bottle)	$3.00
Silver Wire	$3.50
Helmet Materials	$35.00
Total Cost	$63.55

Division of Labor

Kenny Orkis is responsible for:

- Design Active Electrode and cables
- Redesign Amplifier Board
- Create MATLAB GUI
- Create MATLAB functions for reading in digital board data, time and frequency signal analysis, polycoherence analysis, BCI algorithm
- Design wireless transmitters

Chris Carter is responsible for:

- Design and build power circuit which includes:
    - Multiple Voltage Regulators
    - Rechargeable Li-Ion battery
    - Battery voltage level monitors
    - Recharging circuitry
- Design and build the helmet
- Help Michael program the microprocessor

Michael Carnevale is responsible for:

- Design circuit, schematic, and PCB layout for digital board which includes:
  - Multiple ADCs
  - Interrupt inputs
  - FTDI Chip for serial communication
- Programming the microprocessor
- Setting up the Emulator and interfacing it with MATLAB
- Help Ken design Active Electrode
- Help Ken redesign Amplifier Board
- Help Chris build the helmet

Gantt Chart

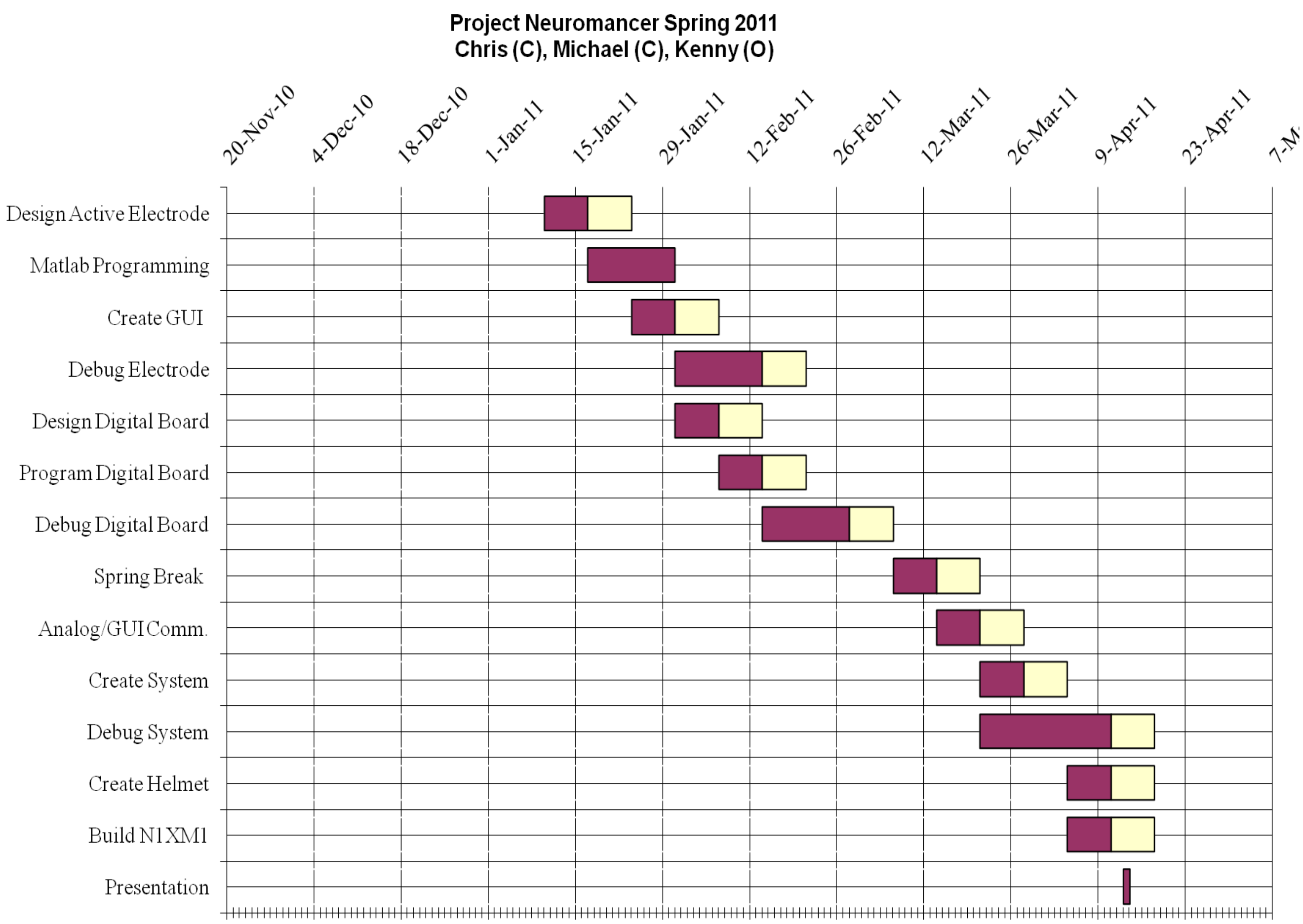

Figure 5: Gantt Chart