

Cursor Control Using EEG Signals from Eye Movement Potentials

By Grant G. Connell

Introduction

This paper describes a method of controlling the mouse cursor on a computer screen using the electrical potentials developed by eye movements. The data from the eye potentials and the hardware and software to process the data is described. Finally the results are summarized along with a description of the advantages and disadvantages of using this technique to move the mouse cursor.

Eye Potentials

It is a well known that the movement of the eyes causes electrical potentials that are artifacts during EEG measurements of brain waves. Instead of being a detriment, these voltages can be used to also move the mouse cursor with the correct software. The voltages are much larger than normal EEG brainwave signals and can easily be distinguished from their low levels. The voltages developed are unique in polarity when the eyes are moved in the up, down, left, or right directions. A plot of each of the captured potentials is shown in the four figures below:

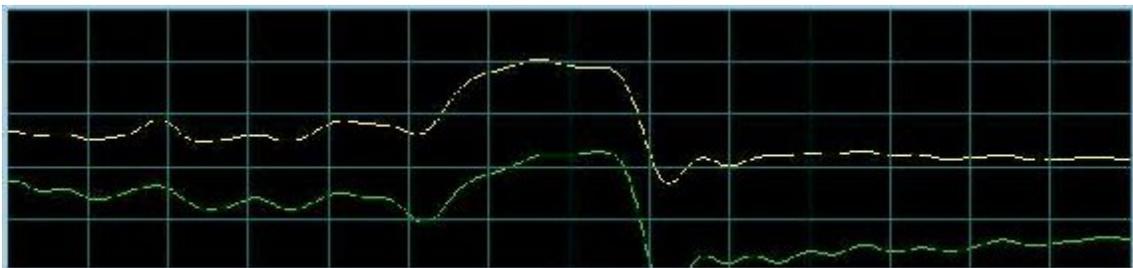


Figure 1, Looking Down Eye Movement

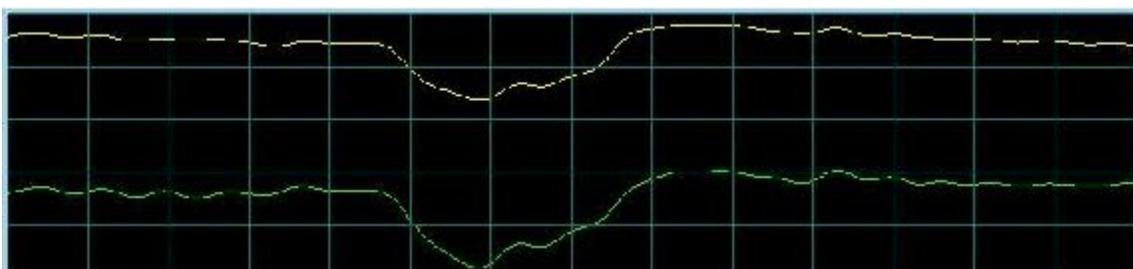


Figure 2, Looking Up Eye Movement

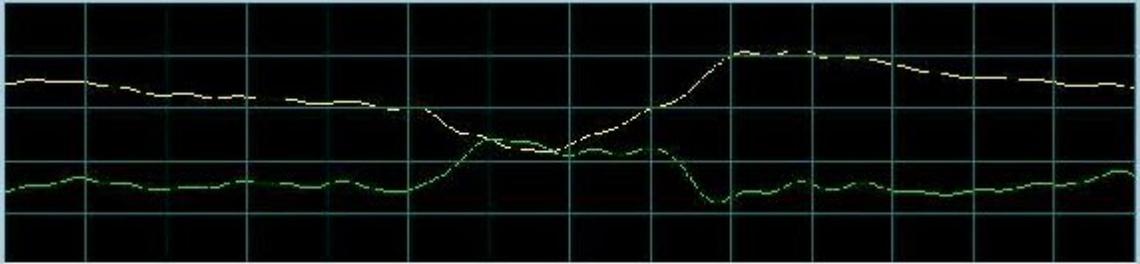


Figure 3, Looking Left Eye Movement

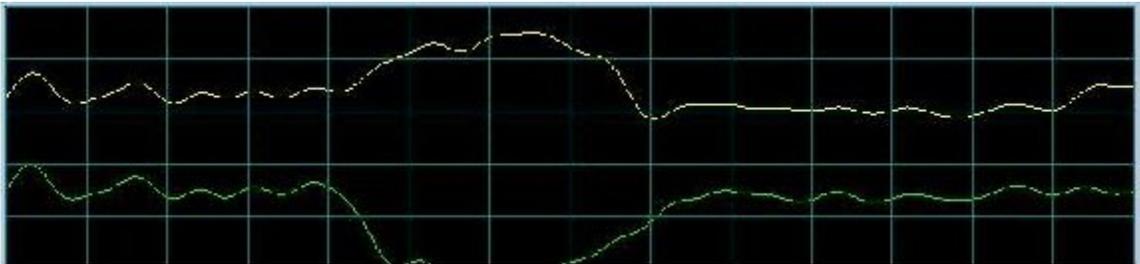


Figure 4, Looking Right Eye Movement

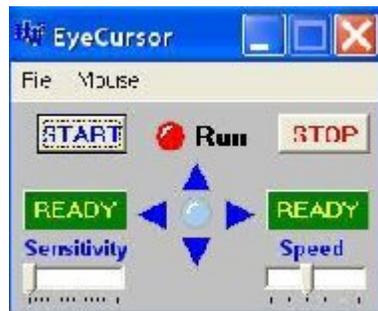
It can be seen that a unique signature (different polarities) exists for the two eyes in each of the four movement directions. This unique information can be decoded in software and used to generate mouse movements. Another characteristic of the signals is the short duration of any given pair of signals. This short duration makes the encoding of the signals time dependent. The software has to be tuned to a timed sequence every time the eyes are moved. This also means that the individual has to practice to keep the timing consistent.

Cursor Movement

Movement of the cursor is started when the software decodes a given pair of movement potentials when the eyes are moved to a given direction. At this point the cursor starts moving from the rest (center) position. Movement of the cursor is stopped when the eyes are moved in the opposite direction and the software decodes the associated potentials for that direction. Moving the eyes again in the same opposite direction will cause the cursor to move again but in the opposite direction to the first movement. This sequence can be repeated for cursor movement/stopping in any given direction. Clicking is performed by double-blinking of the eyes or by dwelling on a given object on the screen for a given time (this is software selectable).

Software

The software implementation was based on the basic structure of the BioSphere program with each EEG channel being filtered with a low pass filters (12 Hz). An output screen was created to control the cursor enabling and movement. A picture of the application screen is shown in the figure below:



Eye Cursor Output Screen

The software performs the following functions: starting and stopping of the cursor control, sensitivity control of the EEG signals to cursor movement, and speed of the cursor movement. The software displays the movement of the cursor with arrows that turn red in color when the cursor is moving. Up/down and left/right ready states are displayed when the EEG signals are in the “rest” state (when the eye movements are not detected). A light blue LED located in the center of the up, down, left, and right arrows, shows when a click has occurred. At this time the LED turns red in color.

Hardware

The hardware implementation was a sound card dual channel FM EEG unit. Visit the web site www.hotamateurprograms.com/eeg.htm for a description of the sound card technology used. However, any two channel EEG unit may be used. The unit was run in the dual channel mode with the electrodes located just above the eyebrows and biased towards the temples. A linked ear reference was used for both of the two EEG channels. A wrist strap was connected to the DRL output of the unit. This helped to reduce the 60 Hz interference.

Results

The eye cursor output screen used in conjunction with a soft keyboard application showed that eye potentials can be used to move the cursor and generate text on a screen. The cursor was moved to a keyboard letter and then the letter was transferred onto a text screen during the click event. There is a learning period in which the person has to be consistent in looking at the center of the screen and then looking in the direction at which the cursor is to be moved. There was some false triggering in the down direction due to a decoding

sequence that sees a slow blink as a down signal. Another issue was wide screen viewing. At the extremes of the screen there was not enough eye movement to over the cursor in that direction again. The key is to limit the viewing window to the center of the screen. With training and operating time all these artifacts were overcome. Although time consuming, the technique allows a person who is physically disabled and cannot move any portion of their bodies to move the mouse cursor on the screen.

The advantages of this technique are:

1. One can use a small, low cost (\$150-\$250) EEG unit to move the mouse cursor.
2. Only eye movements are needed to move the cursor.
3. The technique can be used for general computer use.
4. Relatively easy to learn to use and setup.

The disadvantages of this technique are:

1. Physical electrodes must be connected to a person with precautions taken in equipment design to prevent electrical shock.
2. Eyes can tire quickly.
3. Must use larger icons to click upon. This is due to eye motion slow timing. This forces the screen to be larger with large text and symbol icons (about ½ inches square).
4. Blinking must be controlled (not too slow) to prevent a down signal from being identified.
5. It takes time to generate text. Although this may not be a problem for the disabled persons who cannot move their bodies.

Summary

Given that there are limited options of communications for some disabled persons, the eye movement and the associated cursor control using EEG signals may be a valid option for communication and computer control.