EEG-BASED CONTROL OF VIRTUAL BUTTONS

M. S. Middendorf
Middendorf Scientific Services, Inc.

The Alternative Control Technology program, located in the Air Force Research Laboratory, Wright-Patterson AFB, Ohio, has developed a brain-computer interface (BCI) system that allows operators to select virtual buttons on a computer screen simply by looking at the desired button. A virtual button is a small area of the screen, similar to an icon, that can have a control action associated with it. Control inputs are achieved by modulating the luminance of the virtual buttons at different frequencies, thereby causing a frequency-specific steady-state visual evoked response (SSVER) to appear in the operator's EEG when the operator fixates on a button. Once an SSVER is reliably detected, the corresponding virtual button is selected. Accordingly, the SSVER is the central component of the EEG that enables this technology. At present, a maximum of two virtual buttons can be displayed at one time.

The BCI system being demonstrated consists of a 486 PC operating at 120 MHz with a standard video card, color monitor, and a Scientific Solutions Labmaster AD analog-to-digital (A/D) converter. The software is written in Microsoft™ Visual C 1.5.2 and is run under DOS. The I/O board controls the software timing which is updated at 70.25 Hz.

EEG signals are acquired with three silver chloride-coated, plastic surface electrodes, that are mounted in a headband and located over occipital sites O1, O2, and Oz. The scalp is cleaned with alcohol to reduce impedance and a small drop of aloe vera gel is placed on each electrode to improve conductivity. Impedance between electrode pairs is typically below 35K ohms. The bipolar EEG signal (O1-O2, with Oz as ground) is amplified and filtered using a S75-01 biological signal amplifier manufactured by Coulbourn Instrumentation, Inc.

EEG signals are processed using lock-in amplifier systems (LAS), that produce an estimate of amplitude at a specified frequency. Three LAS's are implemented for each virtual button - one LAS computes amplitude at the stimulus frequency, while the other two compute amplitude at frequencies slightly above and below that frequency.

The control algorithm monitors the LAS outputs to determine if a selection should be made. The algorithm requires that certain criteria be satisfied for a fixed time duration. First, the amplitude at the stimulus frequency must be above a threshold value (to prevent an unwanted selection due to natural EEG fluctuations). Second, the amplitude at the stimulus frequency must be larger than the average of the lower and upper frequencies by a fixed ratio (to ensure that broad-band increases in activity do not trigger the system). When these criteria are met, a red border appears around the corresponding virtual button. If these criteria are maintained continuously for 0.3 seconds, the button is selected.

In support of the demonstration, we would appreciate two chairs, a small table, and access to a power outlet. Some control over room lighting may be necessary if the ambient light level is very bright. Conference attendees will be invited to try the system.