Brain-Computer Interaction using Functional Near-Infrared Spectroscopy

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Introduction

The brain-computer interaction project aims to explore new methods of human computer interaction, determining if brain activity can be measured and used effectively as an input to a user interface. This brain activity is measured using functional near-infrared spectroscopy, a new technology that measures blood flow to the brain.

If used as input to a user interface, this type of measurement would allow computer programs to respond to changes in a user's brain activity - for example, if the user felt overloaded or frustrated, the program would decrease the difficulty of the current task.

What is functional near-infrared spectroscopy?

Functional near-infrared spectroscopy, or fNIRS, is a new method of measuring brain activity. Like magnetic resonance imaging (MRI), the fNIRS device measures changes in the blood flow to the brain. It does so by detecting levels of oxygenated and de-oxygenated hemoglobin in the blood - shining near-infrared light into the tissues of the brain and measuring how much of the light is absorbed by the oxygenated and de-oxygenated hemoglobin.

This can be used to measure levels of brain activity because cells in the body require more oxygen to function when they are active. The body responds by increasing the blood flow to where it is needed, bringing these active cells more oxygen carried by the hemoglobin in red blood cells. Therefore, if a region of the brain is more active, this can be detected by the fNIRS device by a change in its levels of oxygenated and de-oxygenated hemoglobin.

The advantages of using fNIRS are that the device is portable and noninvasive, and is simply placed on the subject's forehead.

Experiments

Previous research conducted by the brain-computer interaction team aimed to determine how feasible it was to use fNIRS to measure and classify brain activity. Subjects were asked to count the number of squares of each color displayed on a rotating three-dimensional shape. This shape was colored with two, three, or four colors in order to measure different workload levels, as increased effort and mental activity were needed to count shapes with more colors. This experiment allowed the brain-computer interaction team to conclude that it was possible to classify levels of high, low and no workload with promising levels of accuracy.

More recent research includes:

- Determining the feasibility of using fNIRS to measure emotions. Subjects were shown both pleasant and unpleasant images to determine if it would be possible to classify different emotions from the fNIRS data.

- Determining the feasibility of using fNIRS to measure working memory. Subjects were tasked with memorizing a string of numbers and their location in a diagram to determine if it would be possible to classify their use of the phonological loop and their visuospatial sketchpad.

HomER

Hemodynamic Evoked Response (HomER) is a program used for analyzing near-infrared spectroscopy data. It allows the data from experiments to be displayed graphically.

HomER has the following features which make it extremely useful:

- **Filtering**: Updating the data to prepare it for analysis and filtering out noise and anomalies

- **Averaging**: Averaging the results of different trials of the same experiment

- **Image reconstruction**: After filtering and averaging, create images and movies for stimulus conditions

Currently, the brain-computer interaction team is attempting to find a way to use HomER on the data acquired from the fNIRS device. In order to do so, a method to modify the results from the fNIRS device to the format that HomER accepts was needed. Other issues that were and are being addressed include how to specify the time a stimulus occurs in an experiment, how to combine different data files, and how the different placements of the light sources and detectors in the fNIRS device affects how the data is analyzed in HomER.

For more information, visit the brain-computer interaction website at: