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Media Communication Center Using Brain Computer Interface

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***Abstract*—This paper attempts to make use of Brain Computer Interface (BCI) in implementing an application called the Media Communication Center for the paralyzed people. The application is based on the event–related potential called P300 to perform button selections on media and communication programs such as the mp3 player, video player, photo gallery and e-book. One of the key issues in such system is the usability. We study how various tasks affect the application operation, in particular, how typical mental activities cause false trigger during the operation of the application. We study the false acceptance rate under the conditions of closing eyes, reading a book, listening to music and watching a video. Data from 5 subjects is used to obtain the false rejection rate and false acceptance rate of the BCI system. Our study shows that different mental activities show different impacts on the false acceptance performances.**

***Index Terms*—EEG, BCI, P300, Event Related Potential, Media Center, Brain Control.**

I. Introduction

Brain-computer interface (BCI) is a fast-growing, emergent technology, in which researchers aim to build a direct channel between the human brain and the computer. Of the two general approaches to recording brainwaves in BCI — invasive and non-invasive — the former provides precise control but requires electrode implantation into the brain to capture neuron signals. Non-invasive methods may find wider application because of their greater convenience and safety. Of all the methods in acquiring brain signals, EEG provides a economic solution with best temporal resolution.

There are several ways of tapping brain signal to build a brain-computer interface [1-6]. In this paper, we use P300 based BCI approach. P300 BCI is based on a visually evoked event-related potential, called oddball paradigm [6,7]. A visual stimulus typically evokes a positive potential in the electrical activity of the brain, 300ms after the onset of the visual stimulus. This P300 potential can be detected with classification methods. As such, the system can accurately detect which button the user is looking at while providing randomly flashing each of the buttons to create a visual stimulus.

We build a Media Communication Center (MCC) based on the P300 BCI system. The Media Communication Center will be an integrated package consisting of media entertainment and communication services. The aim is to create a one-stop center for the paralyzed to enjoy entertainment facilities and enhance communication with the outside world in order to improve their quality of life.

In this paper, the first part will be devoted to introduce the implementation of the interface and the entertainment functions in MCC. Applications like the MP3 player, photo gallery, video-on-demand, e-book services, TV and radio will be integrated. The objective is to create a functional control interface design that is intuitive and easy to use for the user.

In the second part of the paper, we will focus on a key issue in this brain-control system: the reliability. That is, when people use such a system, there are usually false triggers due to the noisy data and user attention. Having high false positives can hinder the use of BCI applications. In this paper, we wil investigate the effect of several typical activities and their impact to the control under a statistical signal verification framework [8]. In particular, we seek to investigate how certain tasks, e.g. closing of eyes, reading an e-book, listening to music and watching a video can affect the operation of MCC. Data from 5 subjects is used to obtain the false rejection rate and false acceptance rate of the BCI system. Our study shows that different mental activities show different impacts on the false acceptance performances..

II. System Design

A. Introduction to MCC

The software will be divided into mainly two modules, namely the media module and the communications module. Each will provide our targeted end user with the capabilities and functionalities of entertainment and communication with people.

B. Data acquisition and software platform

We use EEG equipment from CompuMedics for brain data acquisition. 20 channels out of 40 are used for P300 classification. The GUI is implemented in Microsoft Visual C# under Windows environment. ..

C. Use Case Diagram

The use-case-diagram in Fig.1. depicts a general overview of the Media Communication Center after integration with the BCI system.

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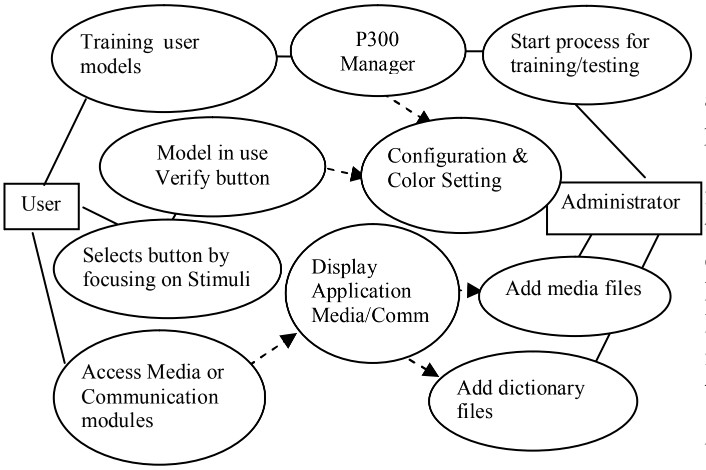

Fig. 1. P300 Based BCI for Media Communication Center

There are two main actors: the user and the administrator. The administrator has the main task of initiating all the training and testing functions as users are targeted at paralyzed individuals who have no means of activating the program.

The administrator can start the training process in order to build a model for use with the application. The training settings and configuration settings can be customized to achieve the best performance. After the model is built, the application is ready for use. The administrator has to load media files like mp3 music, videos and photos for use with the media module. In addition, dictionary files are loaded for use with the communication module to enhance language processing capabilities.

The user is to go through the training process with the help of the administrator. The user will go through training and testing process. After which, the user is able to control the program wholly on his own, with a model built based on the brain signal data collected earlier. The user can access the Media or Communication modules by looking at the buttons to obtain a visual stimulus. Data is compared using the model built earlier and respective instructions are sent to the media and communication application forms for display and feedback to the user.

D. Modular Design

The MCC application will be divided into various modules for implementation. The following list shows the modules to be implemented.

1. Graphical User Interface (GUI) Module

The GUI is coded under Windows Form designer generated code. This will determine the appearance of the main menu form.

2. Control Panel Module

The control panel takes care of button clicks and sends the instructions coded with each button click to the application forms for execution and display.

3. Media Module

Windows Forms will be used to design the media modules application interface. They include the mp3 player, video player, photo gallery, and e-book services.

In order to implement the mp3 player and video player function, Windows Media Player ActiveX control is required to be embedded into the C# windows form. Instructions for embedding the ActiveX control are spelt out in the Windows Media Player 10 SDK. AxInterop.WMPLib.dll and Interop.WMPLib.dll are the two required libraries when installing the Media Communication Center application. The two libraries contain the functions to control the media player.

Photo gallery and e-book services will be implemented in Windows Form using the basic list box and control methods found in C# programming interface. StreamReader will be used to read streams of text from a text file (e-book). The scrolling of the e-book is controlled using win32 native library defined in user32.dll.

For photo gallery, a picture box will be used to display the photos and a timer will be used for the slideshow function.

The timer will be initialized with a regular ticking interval. When the time interval has passed, the timer will call an event handler to perform specific functions. In this case, it is to continuously rotate the photos on display.

4. BCI Module (P300Manager Class)

BCI integration takes advantage of C# ability to perform multithreading. Concurrent threads will run the main menu form as well as the BCI framework. BCI threads will take care of the button flashing and data acquisition.

This class is used to manage the training and testing process of the P300 Based BCI application.

The training process will be used to collect data and build a model based on this data collected.

The testing process collects data that will be used to verify the accuracy of the model built. Scores will be given to the data collected from the testing process based on the model. Scores higher than a certain threshold will then be accepted as true button clicks. Classification accuracy can then be determined from this process.

E. Design Finals

The following is the finalized design of the Media Communication Center. The project aims to achieve a fully practical, yet aesthetic design that can be readily marketable. In addition, the final design seeks to emulate the look and feel of programs used by any ordinary person so that paralyzed individuals will feel comfortable using it. The final design GUI is shown in Fig.2.

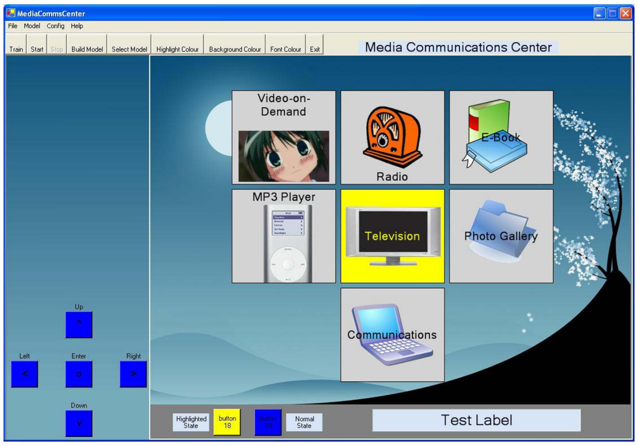

Fig. 2. Graphical User Interface of MCC

III. Usability Study

A. Introduction to Usability Study

Upon completion of the MCC application, the project seeks to further understand the reliability and usability of such a BCI system. We want to study the effect of false positives being an important issue in control methods. We seek to understand the problem of false acceptance during the operation of MCC. And in addition, the project wishes to seek a balance between the false acceptance rate and false rejection rate to ensure optimum control.

In the case of MCC, users will spend a considerable amount of time viewing photos or watching video in proportion to button clicking. Thus, false acceptance can be a problem during the operation of MCC.

During the building of the model based on the obtained data sets, a threshold value will be set. This threshold will be used to determine whether a button click is true or false. Only values above the threshold will be accepted by the system. However, the button click may not be intended by the user. This gives rise to a false acceptance.

BCI systems often have a problem of balancing the false acceptance rate and false rejection rate. Different BCI systems would have to weigh the importance of each error, and determine which to sacrifice to obtain the best performance.

B. Experiment Protocol

A total of five subjects were invited to participate in this research study. The subjects were free of medication and central nervous system abnormalities, normal or corrected-to-normal eyesight. These subjects also had no prior experience with BCI systems.

After setting up the equipment, the subjects were asked to go through a training process and a testing process. After which they were told to perform the following tasks:-

1) Reading
2) Closing of eyes
3) Listening to music
4) Watching a video

This data collected are labeled as non-P300 elicited/garbage signals as the user should not have any P300 signal since they are not looking at the flashing buttons. This garbage data is used to test against the model built earlier to determine the false acceptance rate.

C. Results and Analysis

The first two graphs in Fig. 3 and Fig. 4 shows the plot of false rejection rate and false acceptance rates against the threshold at 16 rounds and 8 rounds of training respectively.

We can see from the two graphs that the equal error rate decreases from around 10% to 5% when we increase the number of rounds of training from eight to sixteen. This generally tells us that the application performance increases as we have a higher number of training rounds.

The third graph in Fig. 5 depicts the equal error rate from one round to sixteen rounds of training. The graph is a declining graph indicating the decrease in error rate, generally signifying increase in the performance of the control system.

At sixteen rounds of flashing, although the equal error rate is low at around 5%, there is still motivation in trying to reduce the error rates even further in order to improve the reliability. As such, the following section will try to look at the difference in the error rates and provide some explanation and suggestion to the problem.

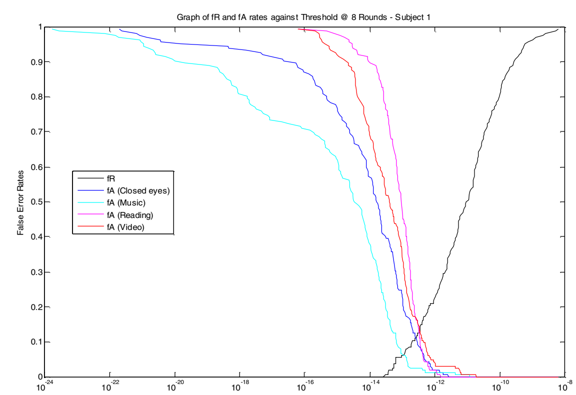

Fig. 3. False Rejection and False Acceptance Rates against Threshold at 16 Rounds

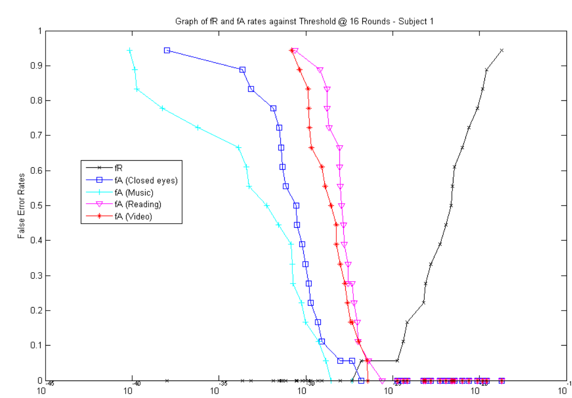

Fig. 4. False Rejection and False Acceptance Rates against Threshold at 8 Rounds

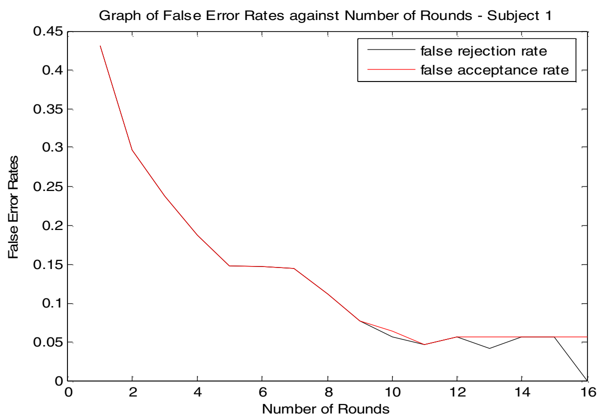

Fig. 5. Equal Error Rate Graph for All Numbers of Rounds

Comparing Fig. 3 and Fig. 4 above, we see the general shape of the graphs to be similar, with subtle differences between performing different tasks. There is a need for better algorithms for classification to be built to detect different non-P300 elicited signals.

It is interesting to observe that the false acceptance rate for reading is exceptionally high in Fig. 3 and Fig. 4 at low thresholds. A possible reason is that when a user focuses on reading, his engagement suppresses the μ or β waves in his brain signal, thereby resulting in the high occurrence of false positives. Further study need to be done to decipher this result.

In the MCC, there is a better tolerance for false rejection compared to false acceptance. When users are using the application, a large proportion of the time will be used to watch a movie, reading and e-book or listening to music. Frequent false clicks of buttons would disrupt the task that the user is performing. Thus, one of the solutions would be to set a higher threshold to reduce the rate of false acceptance.

Another solution could be to set a lower threshold to achieve a low false rejection rate. However, to deal with the high false acceptance rate, a workaround could be done. The MCC application can set an idle time during which the user is not looking at the flashing buttons. After the elapse of the idle time, the control panel could be disabled and hidden, leaving one button to reactivate the control panel. Thus, the false acceptance of button clicks that affect the application operation can be reduced.

IV. Conclusion

We have built a prototype of Media Communication Center for people who cannot control and browse with either limbs or speech. Our experimental results suggest it is feasible to build such a system with BCI.

The problem of false acceptance rate is an important study in improving the reliability of BCI systems. We addressed this issue under MCC environment and we found we can achieve reasonably good balance between false acceptance and false rejection. The differences of false acceptance pattern for different activities are. of particular interest.

Possible research can be done to integrate other modalities of signals (e.g, muscle movement or eye blinking) into these applications to improve the overall reliability.

V. Acknowledgment

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VI. References

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