EXPERIMENT OF CONTROLLING A WHEELCHAIR USING VIRTUAL AND AUGMENTED REALITY WITH BRAINWAVES

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Abstract: *This paper describes a development of a non-invasive experiment based on automated navigation. In operation, the subject faces a screen with a real-time virtual of the convention center scenario, and concentrates on the area of the space to reach. First, a visual training process for register the neurological phenomenon and the EEG signal processing as preparation of the navigation system, which drives the person to the desired place while avoiding collisions. In this work presents a general introduction to the topic of EEG, data-acquisition, processing of the EEG-signal and evaluation about interfaces, implications on the performance to translating through into actions.*

Keywords: *Brainwave, Virtual Reality, EEG, BCI, Augmented Reality.*

Introduction

In 1929, the German psychiatrist Hans Berger published [1], his invention denominate of electroencephalogram [2]. The electroencephalogram, or commonly cited as EEG, it is defined as electrical activity, of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media [3]. Brain electrical current consists mostly of Na+, K+, Ca++, and Cl- ions that are pumped through channels in neuron membranes in the direction governed by membrane potential [13].

The EEG has a very high time-resolution, that's change in the electrical activity of the brain show up very quickly in the in the signal of EEG [6], and The EEG's main drawback is its poor spatial resolution that is one can never measure a single neurons activity but instead only the sum of hundreds of thousands of neurons [4], it is the most used method in the research of Brain-Computer-Interface (BCI), because if his potential non-invasive interface integrated with 3D technology.

The term Virtual Reality - VR - has many definitions, due to the interdisciplinary nature of the area and its evolution. According to [8], one can define Virtual Reality as a way for people to visualize, manipulate and interact with computers and extremely complex data, in which ideas such as immersion, interaction and involvement with the virtual environment are considered basic and fundamental. One of the main advantages of this technology is the broad involvement of the human senses in man-machine interaction, with impacts of improved visualization components and assimilation of content (learning and training).

The goal is to design and develop Virtual and Augmented Reality Solution (software and hardware specific suitability, based on components available on the market) with the integrated system, which supports training and visualization, with navigation requirements, immersion and interaction system developed. In this work we present, a general overview over the data-acquisition and processing of the EEG-signal for controlling a Virtual Environment for AR/VR.

Biomedical Background

Brain patterns form wave shapes that are commonly sinusoidal [5]. Usually, they are measured from peak to peak and normally range from 0.5 to 100 µV in amplitude, which is about 100 times lower than ECG signals. By means of Fourier transform power spectrum from the raw EEG signal is derived. In power spectrum contribution of sine waves with different frequencies are visible. Although the spectrum is continuous, ranging from 0 Hz up to one half of sampling frequency, the brain state of the individual may make certain frequencies more dominant. Brain waves have been categorized into four basic groups: beta (>13 Hz), alpha (8-13 Hz), theta (4-8 Hz) and delta (0.5-4 Hz) [9].

Architecture

The prototype has an electroencephalogram EEG signal acquisition system with Emotiv EPOC that collects signals proveniences from the brainwaves are treated to identify intention of movement, the Google Glass to display information with augmented reality.

Figure 1: First version of the prototype.

Layer of Architecture – The architecture is designed in 4 layers: connection with Emotiv Epoc, module of training, pattern classification and virtual environment to better understand each of which will be detailed below:

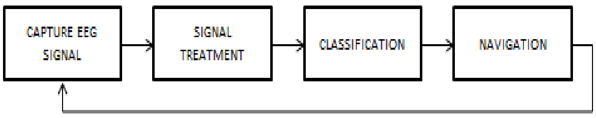

Figure 2: Logic Architecture.

Hardwares – *Emotiv's Neuroheadset* is equipped with 14 saline sensors: AF3, AF4, F3, F4, F7, F8, FC5, FC6, P7, P8, T7, T8, O1, O2 and two additional sensors that serve as CMS/DRL reference channels (one for the left and the other for the right hemisphere of the head).

Figure 3: Emotiv Epoc.

The *Google Glass* is a type of wearable technology with an optical head-mounted display (OHMD) [12], used in that project for show up information about the environment like temperature and speed.

Figure 4: Google Glass device developed by google.

This conceptual model defines structure, behavior and components. The experiment is composed in three modules: Capture, Pattern Classification and AR/VR environment.

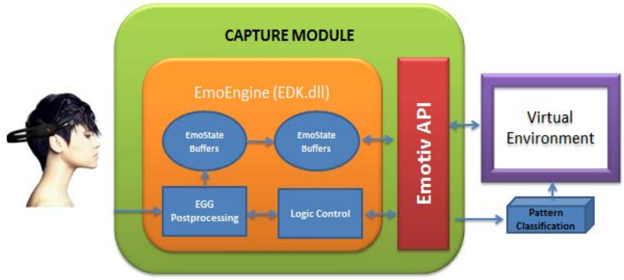

Figure 5: layers of system architecture.

Communication Protocol – The communication protocol is text based for message exchange between modules using archive with the follow format:

COUNTER INTERPOLATED AF3 F7 F3 FC5 T7 P7 O1 O2 P8 T8 FC6 F4 F8 AF4 RAW_CQ CQ_AF3 CQ_F7 CQ_F3 CQ_FC5 CQ_T7 CQ_P7 CQ_01 CQ_02 CQ_P8 CQ_T8 CQ_FC6 CQ_F4 CQ_F8 CQ_AF4 CQ_CMS CQ_DRL GYROX GYROY MARKER

Signal Treatment

Data is stored in a standard binary format, EDF, and analyzed the brainwaves signals generating a personalized signature which correspond to each particular action, as well as the background state.

Classification

Finally, the EEG signals were recorded from subjects performing the following three mental tasks: a) back; b) Front; and c) Rotation d)Stop. For each trial, EEG was recorded from six electrodes (d = 6) at positions (AF3,AF4,P7,P8,O1,O2) for 10 seconds sampled at 1280Hz. Each task was repeated five times The information is sent for virtual environment with action to be executed based in that definition: #1 Back, #2 front , #3 Rotation and #4 stop.

Navigations

For simulation purposes, we have created two simple virtual environments using VR and AR. Virtual Reality Environment – convention center with an exhibit hall to simulate a tour inside a large place that the user navigate in "First Person". And AR Environment – interface that shows the direction based in brainwave processing.

Figure 6: Augmented Reality Interface.

Interacion considerations

The interaction with the modeled environment is directly connected to the computer's capacity to detect the user's inputs and modify the virtual world in real time. To make the Virtual model more realistic, the virtual environment needs to be interactive [8]. For these purposes, the system requires an interaction module, in order to provide the following degrees of freedom for the user: a) #1 Back; b) #2 front; c) #3 Rotation d) #4 Stop.

API Considerations – Shows a high-level flow chart related to implementation of application that incorporate the EmoEngine. During initialization, and prior to calling Emotiv API functions, your application must establish a connection to the EmoEngine by calling EE_EngineConnect.

The acquisition/extraction live EEG data is using the EmoEngine in c# from the headset and sent to an output file for later analysis. To enable access to the EmoEngine via managed code, it is necessary to reference the DotNetEmotivSDK.dll..

Results

This section reports the results of the experiments previously described. Notice that experimental methodology has two preparatory phase. We established various technical metrics, obtaining the best result with the group of factors. The system was tested initially with 02 people, and each command evaluated 50 times per command in the tree environment characteristics: response capability, accuracy, persistence.

Table 1: Results of navigation tests.

Command	Correctly	Unknown
Front	78%	22%
Rear	76%	24%
Rotate	65%	35%
Stop	72%	28%

The speed was always constant (pre-configuration of the virtual environment). To increase the assertiveness more studies are necessary, e.g: improve the user training, reduce noise (leads), improve the virtual environment control engine, etc. In general the navigation was successfully solved all the navigation missions with different conditions and constraints..

Conclusion

This work still at the early stages of development and the initial results is presented in a prototype of a laboratory and needs a set of tests for future comparison and statistics.

The BCI accuracy, the performance of the graphical interface and the performance of the navigation system was high, indicating that the integration of these technologies was satisfactory. In the near future, we are working on the improvement of the system to address the common problem of all event related potential approaches: the low information transfer rate.

As future work, it would also be important to perform experimental complete validation with potential users based on psychological metrics.

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