

Integrating BCI with Virtual Reality

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Abstract: The purpose of this project is to implement a VR game in which the EEG headset is trained to respond to the stimuli within the game by capturing a player's EEG signals. These EEG signals are generated by the player's emotions such as attention and meditation. Using the values obtained from the EEG headset we will enable the player to control the game using the headset. The main objective of this project is to empower a person with the ability to control any object in a virtual environment by analysing brain wave patterns and applying the resultant data to train the Brain Control Interface (BCI) device. The vision of the project is to make a player free from using hardware plug-ins and control the game using BCI.

Keywords -- EEG, BCI Headset, VR Headset, Unity

I. INTRODUCTION

The BCI (Brain Control Device) is a device which gathers EEG signals from the Brain and helps us establish a direct communication link between the Brain and external Devices. Due to the high temporal resolution and portability of EEG (Electroencephalogram), the BCI system based on it is easy to put into practice. The BCI system transforms the EEG signals to corresponding commands to control external devices. The performance of the device is best implemented in a Virtual Environment as it is a cost-effective method, it gives the feel of working in a real environment, changes can be easily implemented and simulation testing is much efficient than testing it in real environment. The VR (Virtual Reality) technology has the capability of creating an immersive and interactive environment. Meanwhile, it can configure the ideal environment of the BCI practical system at a lower cost. So, the VR technology can be used to achieve the high quality simulated system. Unity3D, as an integrated game engine and editor, is one of the VR technologies. It is known that components are used to develop games in Unity3D, which include mesh component, physics component, audio component, rendering component and script component, etc. Unity3D provides rich resource packages, such as terrain creation tools, common scripts, collision detection, sky boxes and so on. High-level programming languages like C# and JavaScript are used for implementing the script functions [1]. In short, all of these are beneficial to create high-performance multimedia applications or games efficiently.

Rest of the paper is organised as follows: Section-I contains the Introduction. Section II contains the basic

overview of BCI and EEG technology. Section-III contains information about an EEG headset, HTC VIVE a VR headset. Section-IV contains information about UNITY3D game engine to be used to design the game. Section-V contains the Methodology to be followed during the entire game design. Section-VI contains the Conclusion.

II. BCI AND EEG OVERVIEW

Using the BCI system, Artificial Intelligence system, we can recognize a certain set of patterns in brain signals in consecutive stages: signal acquisition, pre processing or signal enhancement, feature extraction, classification, sensory evoked potential and the control interface. Reducing the noise and the artifact processing in the captured brain signals is done in the signal acquisition stage. The task of making the brain signals suitable for future processing is done in the preprocessing stage. Distinguished information in the recorded brain signals will then be identified in the feature extraction stage. After all this processing the signal is then mapped onto a vector containing effective and particular features from the recorded signals. The extraction of different signals coming from various brain activities is a challenging task as they overlap in both time and space.

EEG is the electric activity generated by brain. Our brain contains millions of neurons these neurons. These neurons tend to generate millions of small electric voltage fields. The detection of these aggregate fields is done by electrodes placed on the scalp. EEG is the superposition of many smaller signals. EEG contains different electric frequencies which can be associated with different physical actions and mental states. The different frequency bands are delta, theta, alpha, beta and gamma.

Table 1: EEG frequency bands

Brainwave type	Frequency range(Hz)	Mental states and conditions
Delta	0.1 to 3	Deep, dreamless sleep, unconscious
Theta	4 to 7	Intuitive, creative, recall, fantasy
Alpha	8 to 12	Relaxed but not drowsy, tranquil
Low Beta	12 to 15	Formerly SMR, relaxed yet focused
Midrange Beta	16 to 20	Thinking, aware of self & surrounding
High Beta	21 to 30	Alertness, agitation
Gamma	30 to 100	Motor functions, higher mental activity

III. HTC VIVE

The platform for which the game is to be developed is the HTC VIVE. The reason for selecting HTC vive over other virtual reality devices is the fact that the Vive has a total resolution of 2160*1200 pixels and an aspect ratio of 9:5 which is not found in other VR headsets. This results in the vive having a taller image which feels more immersive. The Vive has a refresh rate of 90 Hz, meaning that the game to be developed should run at a smooth 90 fps for the best experience. The HTC Vive can track head movements and controller movement with the help of lighthouse stations which are placed in opposite corners of the room. The headset and the controllers have laser position sensors which are detected by the stations emitting infrared rays. The headset also requires a pretty capable machine to actually work. The headset also requires a minimum area of 2 meters by 1.5 meters or 6.5 feet by 5 feet.

IV. UNITY-3D GAME ENGINE

Unity3D game engine and editor will be used for actual development of the VR game .The components used to develop games in Unity3D include mesh component, physics component, audio component, rendering component and script component. Native support for HTC vive makes it the best option for the development of the VR game. The pro version of Unity3D also supports plug-ins for the NeuroSky MindWave EEG headset. In this project however, we will be using the TCP protocol to actually send data to the Unity3D engine and develop the game to respond to the concentration, meditation levels of the player. For example, if the concentration levels of the player are above a certain value, we can trigger an animation or load a new level. The language used for development of the game is C#. We will use Visual Studio Community IDE.

V. METHODOLOGY

The entire system consists of three major parts. The EEG signal detection and processing system, the VR game developed on the Unity3D game engine and the HTC Vive

VR headset on which the entire game is supposed to run. The below figure gives an overview of the entire BCI integrated virtual reality system.

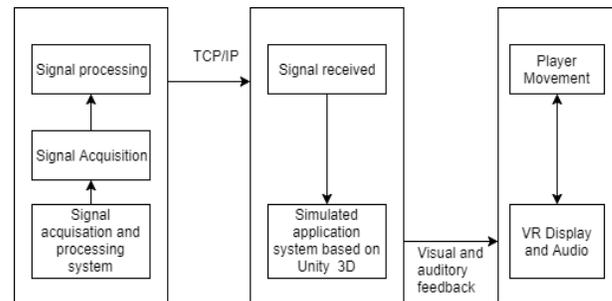


Figure 1. BCI integrated VR System

The EEG signal is acquired from the BCI device and stored in the raw format into the database .This raw data contains useless noise and high frequency signals that are not required and are filtered in the Preprocessing stage using convolution. This filtered data is then passed into the feature extraction process where the signals are converted into frequencies using Fourier Transform and these frequencies are then sorted into 5 categories namely Delta, Theta, Alpha, Beta, Gamma as mentioned in the above table . Alpha Beta frequencies are implemented in the game. The second step is the game development in Unity3D, which is further divided into 4 parts. They are development of 3D models, importing the models into Unity3D, importing data from EEG headset to Unity and development of the required behaviour according to the feature extraction done using the NeuroSky MindWave.

A .Development of 3D models:

The models used in the project are not developed by the team in order to save time.

Instead, the models are purchased or downloaded from various other online sources like Unity Asset Store, Turbo-squid, etc. The models used are low poly in nature to help us hit the 90 fps goal of our game. Some tools like Blender, 3DS Max can also be used to make modifications as and when required.

B .Importing the 3D models:

The developed 3D models are imported into Unity3D and the level design is done in this step. Some details that require high computing and rendering power, effectively slowing down the engine are turned off. This is also done keeping in mind our 90 fps goal for the game.

C .Importing data from EEG headset into Unity:

The Pro version of Unity has support for plug-ins. Neurosky has already released a plug-in called the Think-Gear Native Library.

We will be using the free version of unity and instead of using the library. We will be using the Think-Gear socket protocol based on TCP to import the feature extraction data in Unity.

The socket connection is opened on the port number 13854 with host address of 127.0.0.1(Local-host).The data is sent as a stream in JSON (JavaScript Object Notation) and is parsed using the Think-Gear Socket protocol. This data can now be used in Unity for development of the behaviour we want the game to exhibit.

D. Development of the required behaviour:

In this step, actions to be performed for certain values of the attention, meditation, blink detection etc are specified. The player controlled aspects of the game like player movement, loading of levels, setting animations are done in this step. The score systems, debugging and modifications are also taken care of in this step. After completion of development, the game is tested in a room where the player can explore the space and use his mind to play the game.

VI. CONCLUSION

In this paper we have explained the integration of BCI with a VR game. The methodology, the devices and the techniques to collect and transfer data are explained in a detailed manner. The entire over-view of the devices used is specified in a protracted way. Starting from the collection of signals, distinguishing them, extracting data from it, sending it over to the game engine, rendering it and actual development of the game as well as deployment on the HTC Vive is illustrated.

REFERENCES

- [1] Banghua Yang, Tao Zhang, Kaiwen Duan “Development of a BCI Simulated Application System Based on Unity3D” Virtual Reality and Visualisation (ICVRV), 2015 International Conference
- [2] C. Umale, A. Vaidya “Feature Extraction Techniques and Classification Algorithms for EEG Signals to detect Human Stress - A Review” International Journal of Computer Applications Technology and Research, Volume 5 – Issue.1, 08-4-2016.
- [3] Sadiq J. Abou-Loukh, Arwa Ra'ad Obaid “Comparison of Preprocessing Algorithms using an Affordable EEG Headset”, International Journal of Computer Applications, Volume 160-No 1, February 2017
- [4] “EEG control of devices using sensory evoked potentials” patent no.US 8155736 B2
- [5] “Sensory-evoked potential (SEP) classification/detection in the time domain patent no US 8391966 B2
- [6] Perception based predictive tracking for head mounted displays patent no CA 2912109 A1
- [7] Karolina Holewa, Agata Nawrocka “Emotiv EPOC neuroheadset in Brain – Computer Interface” Control Conference (ICCC), 2014 15th International Carpathian
- [8] C. Guger, C. Holzner, C. Grönegress, G. Edlinger, M. Slater “Brain-Computer Interface for Virtual Reality Control” European Symposium On Artificial Neural Networks (ESANN), 22-24 April 2009.
- [9] Fabien Lotte, Josef Faller, Christoph Guger, Yann Renard, Gert Pfurtscheller, Anatole Lécuyer, Robert Leeb. “Combining BCI

with Virtual Reality: Towards New Applications & Improved BCI” ,Toward Practical Brain Computer Interfaces

- [10] Doron Friedman “Brain-Computer Interfacing and Virtual Reality”, Handbook of Digital Games and Entertainment Technologies
- [11] Swati Vaid, Preeti Singh “EEG SIGNAL ANALYSIS FOR BCI INTERFACE: AREVIEW”, Advanced Computing & communication Technologies (ACCT), 2015 5th International Conference

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