Applying Brain Computer Interface Technology for Playing Games

Ankit Mehta¹, Adarsh Singh², Anshu Kumar³, Ankit Katewa⁴ and Dr. N K Bansode⁵
¹Student, Department of Computer Engineering, Army Institute of Technology, Pune, INDIA
²Student, Department of Computer Engineering, Army Institute of Technology, Pune, INDIA
³Student, Department of Computer Engineering, Army Institute of Technology, Pune, INDIA
⁴Student, Department of Computer Engineering, Army Institute of Technology, Pune, INDIA
⁵Professor, Department of Computer Engineering, Army Institute of Technology, Pune, INDIA

ABSTRACT

Brain Computer Interfaces are specialized systems that allows users to control computer applications using their brain waves. Initially, BCI were mostly used in medical field. But after some research and thanks to consumer-grade electroencephalography (EEG) devices, many applications and research opportunities were opened outside of the medical field. One particular area that is gaining more evidence due to the arrival consumer-grade devices is that of computer games, as it allows more user-friendly applications of BCI technology for the general public. In this report, we are going to talk about one of those games, Maze game. It will be a 2D maze, path known to the user. Using the EEG device named Neurosky Brain Wave Kit user will be able to move the avatar in order to reach the goal from the starting position.

Keywords—Neurosky Brain Wave Kit, Electroencephalography (EEG) Devices, Human Computer Interaction, Brain Computer Interface, Maze Game, Games, A-Star

I. INTRODUCTION

Brain Computer Interface is a fresh field which is in the research phase. Mainly this technology is used in the medical field for blind people, making prosthetic body parts and many more. But recently the flow of research had changed. Due to many consumer-grade electroencephalography (EEG) devices, the main focus is making the computer games, as it allows user-friendly applications of BCI. Some of the EEG devices are Open BCI, Neurosky Brain Wave Kit, Senzeband, etc.

Our main objective is to make a game (2D maze) that is controlled by the user using brain waves recorded with the help of Neurosky Brain Wave Kit.

In this paper, we are going to discuss about the program for maze in which the entity will be controlled by the human brain waves using Neurosky Brainwave Kit.

Scope of This Project

This Project can become one of the steps towards future of making Realtime VR games.

This project can also be used to as a basis for making different advanced games.

Research Domain

Brain Computer Interface, to read mind waves to control different devices.

II. LITERATURE SURVEY

In late 2016, Neurable a start-up made a “brain mouse” that will make it possible for users to control virtual and augmented reality.

Studies have demonstrated examples of BCI applications in different well-known games such as “Pacman”, “Pinball”, etc.

These games are not 100% efficient though as it all depends on the imagery and emotion recognition. How well the EEG device is interpreting the brain signals into a successful operative command to carry out an action. It is said that the idea of implanted sensors for things like gaming/convenience is maybe on the scale of 40-50 years away. That is, we are still a five to six decades behind in regards of making a efficient systems for gaming using BCI.

III. RESEARCH

Product Functions

The brain is full of neurons; these neurons are connected to each other by axons and dendrites. Your neurons - as you think about anything or do anything - are at work. Your neurons connect with each other to form a super highway for nerve impulses to travel from neuron to neuron to produce thought, hearing, speech, or movement. The function of our product is to record the brain waves of the user and based on these waves an output signal is created that will act as a command function for the game avatar motion within the maze.

Operating Environment

This application runs on Windows. The user interfaces is developed with a python and py-game library. The machine when starting the application must have
access to Bluetooth to connect to the NEUROSKY BRAINWAVE STARTER KIT.

**Assumptions and Dependencies**

**Operational Risk:**
- Dealing with brain waves data is risky. Game success will depend on a person’s calmness

**Technical/Performance Risks:**
- Data collection from brain waves

**Movement Risks:**
- Player continuous movement in case of failure

**Solution:** Player movement is done discreetly (Cell by Cell)

**Cost Risk**
- Increased deployment/Computing cost.

**User Interfaces**
- Users can login using multiple ways. They will have the option of login using their Google accounts, Facebook accounts or through their registered account. In registration the system will require user age, gender and nationality which will be valuable for recommendation.

**Hardware Used**

We have used NeuroSky Mindwave Mobile Kit as EEG device to record the brain waves in order to play maze game.

It observes the electrical signals of the neurons and outputs the EEG power spectrums (alpha, beta, gamma, theta and delta) with their own frequency range.

It also measures the e-Sense (attention and meditation) and eye blinks.

This device consists of a headset, an ear-clip, and a sensor arm. The headset’s reference and ground electrodes are on the earclip and the EEG electrode is on the sensor arm, resting on the forehead above the eye.

It uses a single AAA battery with 8 hours of battery life for working.

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**Figure 3.1: App UI**
IV. DESIGN

Architectural Design

We have divided the project into three parts or phases.

**Phase 1**

In this phase, we are going to store the value of brainwave signals based upon alpha, beta, gamma, theta, and delta waves. This phase will include the analysis of the behavior of the individual when he is thinking of moving forward, or thinking of moving backwards or thinking of moving left or right. Based upon the data acquired, we are going to create a model that will be used to compare the incoming live input that we will get while playing the game and as per the comparison, the required action will take place.

**Phase 2**

In this phase, we will create a basic 2D maze game where the user has to enter the maze and exit it successfully, fully depending upon the input we are getting from the Neurosky Mindwave headset.

**Phase 3**

It will be the integration of both Phase 1 and Phase 2 and testing it and fixing the bugs.

**Module Description**

**User:** User wears the EEG device and thinks of the movement of the avatar to reach the end point.

**Input Features:** User can view the maze and according to the maze visible can think of direction to go in order to reach the goal.

**Model:** Multi-layer perceptron: To train the model and use it as training data.

**Prediction:** Receive numerical data denoting the direction to move.

**Admin:** Load Data Set:

Admin load dataset for the training purpose and receives output data which is to be interpreted into command.

**Export to Server:** Sending normalized data to the server for training.

**UML Diagrams**

*Figure 4.1: Architectural Diagram*
**Use Case Diagram**

![Use Case Diagram](image1)

*Figure 4.2: Use Case Diagram*

**Activity Diagram**

![Activity Diagram](image2)

*Figure 4.3: Activity Diagram*
Sequence Diagram

![Sequence Diagram Image]

Figure 4.4: Sequence Diagram

Class Diagram

![Class Diagram Image]

Figure 4.5: Class Diagram
V. PLANNING, ALGORITHM, OPTIMIZATION AND MATHEMATICAL MODEL

In our project there are three important things to do, and these things are as follows:

- Gather data from the Neurosky Mindwave Mobile Kit and train the model using appropriate machine learning algorithm (e.g., Random Forest classification).
- Creating a UI for our Maze.
- Completing the application by integrating both the model and the maze

Now to gather the data for the model which will be trained in the Jupyter Notebook using Random Forest Algorithm for best accuracy will be gathered using Neurosky Mind Wave Mobile Kit. Now to gather the optimal data following measures has been taken:

- Data has been taken for left, right, up and down movement of the entity by focusing on a particular point and moving that point in different directions.
- Since the BCI is a very fresh topic, the accuracy of the model is tried to be as best as possible.

VII. ALGORITHM

- Firstly, we will capture the brain signals while wearing the Neurosky Mindwave.
- We will fetch the brain waves value like alpha, beta, gamma, delta and theta and store it in a excel sheet. This will be our model.
- We will create the model using multi layer perception.
- Then we are going to make a web application for a maze game in which we are going to move our avatar.
- Then by using the classifed model and Neurosky mindwave reading while playing the game we will control our avatar.
- Testing and debugging of the errors.

Mathematical Model

Multi-layer perceptron is a type of DEEP NEURAL NETWORK.

Our model will have 15 or more hidden layers as and each hidden layer will have more than 50 units depend on our model efficiency.

Output layer ill have 4 units each for individual prediction and we will use SoftMax activation function for the output layer which will give the prediction of every predicted value and we will choose the one which will have highest probability.

Testing and Optimization

Testing of the training model is done using many classifications model like Random Forest Classifier, SVM Kernel, AdaBoost, KNN, K-means, etc. to find the maximum efficiency. Since there are so many noises and interruption the efficiency received for these models are around 50-60%.

We also jumped to deep neural networks like multilayer perceptron for model training and results were still the same. So, to increase the efficiency of the system, the model is supported by A*star algorithm which helps in the support function, \( f(x) \)

\[ f(x) = \text{Probability of model} \times \text{model output} + \text{Support probability} \times (\text{A* algorithm output}) \]

A threshold will be set, say “t”, so if the \( f(x) \) is greater than the threshold then the model output will be considered otherwise A* algorithm output will be considered.

After applying this optimization there is an increase in the efficiency of the model.

VIII. RESULT AND ANALYSIS

Testing of the training model is done using many classifications model like Random Forest Classifier, SVM Kernel, AdaBoost, KNN, K-means, etc. to find the maximum efficiency. Since there are so many noises and interruption the efficiency received for these models are around 50-60%.
We also jumped to deep neural networks like multilayer perceptron for model training and results were still the same. Above diagram shows the variation and density of different brain signals (alpha, beta, gamma, theta and delta) for particular direction (1, 2, 3, 4 for left, right, up and down).

Given figure shows our UI for 10 X 10 maze where this is played.

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**Figure 8.1:** Scatter plot of the test result

**Figure 8.2:** UI for 10X10 maze

**Figure 8.3:** Final Output when completed the maze successfully
After the completion of the maze the complete time taken to complete the maze is shown.

IX. CONCLUSION

We have done survey regarding BCI technologies used in different fields like medical, gaming, sentiment analysis, etc. Based on our survey we came to the conclusion that research on BCI field is a still has ways to go and will be a big help in HCI field in near future. In our project, we are taking the gaming domain and are going to create a maze game that will be controlled by the mind waves using Mindwave Neurosky. The future for BCI domain is very promising and by contributing small percentage of research may help someone in the near future.

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