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Intellect: A Brain Controlled Multi-User Video Game For Enhancing Cognition

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Abstract:- **Brain-Computer Interface (BCI);- A Brain-Computer Interface (BCI) enables communication data recorded from the brain. WIRELESS—EEG The advancement of wireless EEG (electroencephalogram) sensor technology is rapidly changing the way we interact with the world. Many people suffer from lack of concentration and short memory issues. In this paper, we are proposing a gaming platform named intellect that has controlled by our brain signals. For collecting the brain signals we are using wireless EEG technology. α, β or γ activity of EEG signals represent a cognitive state of the human brain. Intellect is designed in such a way that the game only starts functioning whenever our brain state is inattention or cognitive mode. The harder you concentrate it will redirect you to the next levels. This will help the person to improve the cognitive capacity of his brain.**

***Keywords*: BCI, WSN, EEG, FFT.**

I. INTRODUCTION

Many people suffer from lack of concentration and short memory issues. Whether students are attentive in their class or not are a very important issue. Here we are proposing a multi-user game environment that will help the people to improve their cognitive skills like concentration, memory etc., For that we are using the help of BCI and wireless technology. Waves are a means of transferring energy, without actually transporting matter. Wavemotion transfers the energy from one point to another, which displaces particles of the transmission medium–that is, with little or no associated mass transport. Waves consist, instead, of oscillations or vibrations (of a physical quantity), around almost fixed location. Fig 1.1 shows different types of waves.Now world transfers information in waves than by words. Every source generates the required waves, when brain becomes the source then, at the root of all our thoughts, emotions and behaviors is the communication between neurons within our brains, producing brain waves.

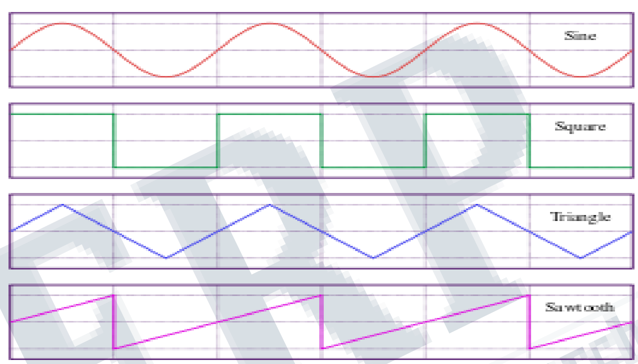

Fig1.1 Different types of waves

What are Brain Waves?

Brainwaves are produced by synchronized electrical pulses from masses of neurons communicating with each other. Brainwaves are detected using sensors placed on the scalp. They are divided into bandwidths to describe their functions (below), but are best thought of as a continuous spectrum of consciousness; from slow, loud and functional – to fast, subtle, and complex. Our brainwaves change according to what we do and feel. When slower brainwaves are dominant we can feel tired, slow, sluggish, or dreamy. The higher frequencies are dominant when we feel wired, or hyper-alert. The descriptions that follow are only broad descriptions - in practice things are far more complex, and brainwaves reflect different aspects when they occur in different locations in the brain. Brainwave speed is

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measured in Hertz (cycles per second) and they are divided into bands delineating slow, moderate, and fast waves.

Brain-Computer Interface (BCI)

A Brain-Computer Interface (BCI) enables communication data recorded from thebrain, the BCI processes it, interprets the intention of the user, and acts on it. The BCI has a robust and flexible design that can be expanded in the future to encompass more complex communication schemes.

1.3 ELECTROENCEPHALOGRAM(EEG)

An electroencephalogram (EEG) is a test used to evaluate the electrical activity in the brain. Brain cells communicate with each other through electrical impulses. An EEG can be used to help detect potential problems associated with this activity. An EEG system tracks and records brain wave pattern. Small flat metal discs called electrodes (sensors) are attached to the scalp with wires. The electrodes analyze the electrical impulses in the brain and send signals to a computer that records the results. The electrical impulses in an EEG recording look like wavy lines with peaks and valleys. These lines allow doctors to quickly assess whether there are abnormal patterns. Any irregularities may be a sign of seizures or other brain disorders. Based on the frequency range, EEG signals can be divided into the following five wavebands.[1]

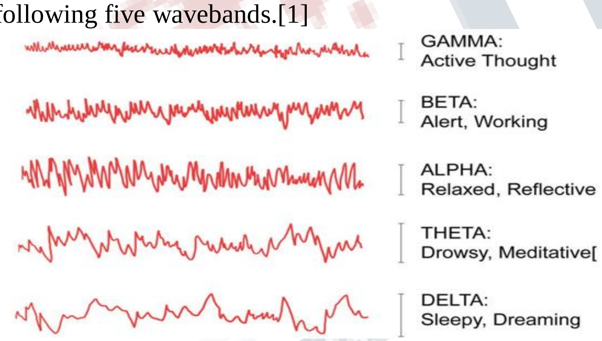

Fig 1.2. EEG Signal Bands

α activity: electromagnetic waves ranging between 8 and 13 Hz in frequency, and between 30 and 50 μV in amplitude. This type of periodic wave is produced in the parietal and occipital regions of the brain when in a state of consciousness, quiet, or at rest. When thinking, blinking, or otherwise stimulated, α wave disappear. This is known as an alpha block.

β activity: electromagnetic waves ranging between 14 and 30 Hz in frequency, and between 5 and 20 μV in amplitude. This type of activity occurs in the frontal region when people are conscious and alert. These waves are particularly apparent when a person is thinking or receiving sensory stimulation.

θ activity: electromagnetic waves ranging between 4 and 7 Hz in frequency, with an amplitude of less than 30 μV. This activity primarily occurs in the parietal and temporal regions of the brain. Such waves are produced when people experience emotional pressure, interruptions of consciousness, or deep physical relaxation.

δ activity: electromagnetic waves ranging between 0.5 and 3 Hz in frequency, and between 100 and 200 μV in amplitude. In a conscious state, most adults exhibit almost no δ activity; instead, this activity occurs when in a deep sleep, unconscious, anesthetized, or lacking oxygen.

γ activity: electromagnetic waves ranging between 31 and 50 Hz in frequency, and between 5 and 10 μV in amplitude. Recent studies have found that γ activity is related to selective attention. Other studies have also highlighted that this activity is related to cognition and perceptual activity

Wireless EEG: The advancement of wireless EEG (electroencephalogram) sensor technology is rapidly changing the way we interact with the world. Through the use of EEG headsets, EEG sensors measure the brain's electrical activity, or brainwaves. In early research, EEG testing was invasive and complex. It typically involved the use of silver needles and electrode attachments to the scalp, and had to be done in hospitals or research settings. Fig 1.3 shows a Wireless EEG set up.

Fig 1.3. Wireless EEG set up

II. INTRODUCING DEEP LEARNING AND ARTIFICIAL NEURAL NETWORKS ;-

2.1 Deep learning (also known as deep structured learning or hierarchical learning) is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms.

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Learning can be supervised, partially supervised or unsupervised.
Deep learning architectures such as deep neural networks, deep belief networks and recurrent neural networks have been applied to fields including computer vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation and bioinformatics where they produced results comparable to and in some cases superior to human experts.

2.2 Artificial neural networks (ANNs),a form of connectionism are computing systems inspired by the biological neural networks that constitute animal brains. Such systems learn (progressively improve performance) to do tasks by considering examples, generally without task-specific programming. For example, in image recognition, they might learn to identify images that contain cats by analyzing example images that have been manually labeled as "cat" or "no cat" and using the analytic results to identify cats in other images. They have found most use in applications difficult to express in a traditional computer algorithm using rule-based programming.

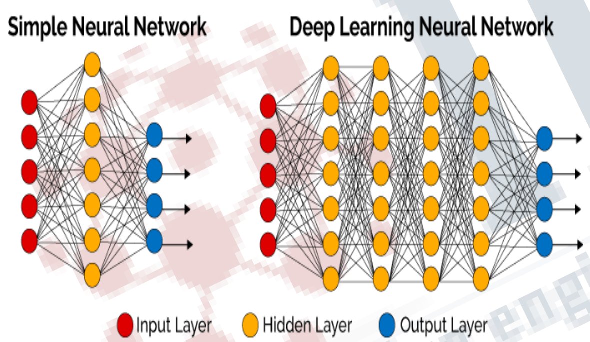

Fig 2.1 and 2.2 Neural network and deep learning.

III. RELATED WORKS

The Adventures of NeuroBoy [2] –As NeuroBoy, you will use your special telekinetic powers to push, pull, lift or burn objects. Different objects in the world weigh different amounts, so you will need to flex your mental muscle to pick up the heavier items. Papers [3],[4],[5] and [6] explain different mechanisms to in cooperate BCI systems to gaming and other machine control.

IV. PROPOSED WORK-INTELLECT

A game designed with the wireless EEG concept Intellect, works with your mind and its present mood. Fig 4.1 and 4.2 shows the inner and the outer look of the game platform, Distributed applications commonly require the sharing of computation and storage between their components. In this project, we have used a distributed architecture for playingvideo games with the brain signals. While mobility has been added by introducing a wireless EEG acquisition machine and wireless application device, performance is kept the same as previous BCI solutions. This has been done by keeping the entire computational intensive tasks (e.g. machine learning and signal processing) on the stationary base computer like laptop.

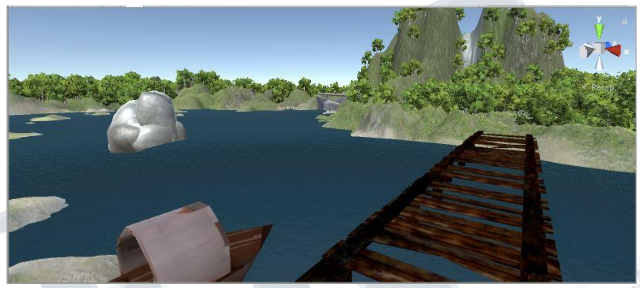

Fig 4.1 Inner of intellect gaming platform

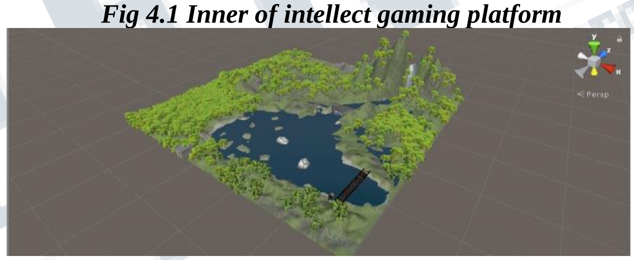

Fig 4.2 Outer view of intellect gaming platform

Intellect consist of a signal acquisition unit using EMOTIV's EPOC wireless EEG headset, a signal processing unit in server system, mental state to command generator module and a gaming interface created in C#.

5.1. Signal Acquisition Unit (EPOC Wireless Headset)

The data acquisition is done by Emotiv Epoc neuro headset. EPOC is a low cost EEG recording device comprised of 14channels of EEG data. The electrodes are located at positionsAF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8 and AF4. The EPOC internally samples at a frequency of 2048 Hz which is then down-sampled to 128Hz per channel and the data is then sent to a computer viaBluetooth. It utilizes a proprietary USB dongle tocommunicate using the 2.4 GHz band. Prior to use, all feltpads on top of the sensors have to be moistened with a saline solution[7].

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5.2. Signal Processing Unit

EEG signal processing unit transform raw EEG signals into class estimated mental states of the user. This transformation is achieved using a pattern recognition approach, whose two main steps are the following:

Feature Extraction: In this step EEG signals are grouped into some patterns known as features that are relevant to describe the mental states to identify, while rejecting the noise and other non-relevant information.

Classification: In this step we assign a class to a set of features. This class corresponds to the kind of mental state identified.Previous works in feature extraction and classification are used FFT (fast Fourier transform) But for noisy signals the SVM (support vector machine) technique shows better results compared to FFT. So here we are using SVM for classification. This module classify the EEG raw signal into α , β, θ, δ and γ patterns. But we are only interested in α,θ and γ patterns. So SVM classify these 3 patterns only.

5.3. Command Generator module Threeparameters, the ratio of alpha power to theta power denoted as α / θ, ratio of beta to alpha power denoted as β / α and γ are extracted from second module to assess the attention level of the players.The α / β value increases when player begins to concentrate on the video whereas α / β significantly increases when player is focusing and/or actively thinking. γ values indicate other cognitive features. We calculated three threshold values that are used to calculate the concentration levels of user.
Based on these values, the game moved into different levels.

5.4. Gaming Interface

Purposiveness;-

Goals: The goal of the game is to stay safe and survive the entire time you stay on the game's sight.
Challenges: As concentration is the main trigger to start the game, the player has to maintain his/her clam state and at the same time in the movements.

Navigation:-

Reversibility: Navigation is almost, always reversible. Entering a room through a doorway means that you can exit the room using it as well. This lets the gamer know that exploration is (usually) harmless and is therefore encouraged, since any navigation act can be undone simply and naturally.

Mystery: Not all of the space is revealed at once. Gamers have to travel around to see new things. Of course, once a thing or a place is seen a few times it might be reachable much more easily by other means.

Reality: Every movement takes a certain amount of time regardless of how fast the computation could actually occur. This increases the sense of objects being moved, or distance being covered.

Reality cues:-

Sounds: Incidental or background sounds (wind, water, surf, birds, insects, animals, machines) give cues about location and state and thereby increase the believability of the scene.

Music: Music soundtracks for cutscenes heighten the sense of motion between locations.
Animation: Smooth animation increases the believability of active entities in the space and helps place gamers in the space as they move through it.

Solidity: Objects are three-dimensional and texture-mapped. Animated objects move under acceleration; they don't simply have constant velocity.

Stability: Objects don't arbitrarily change size or position.

Shadows: Light has a source and objects cast shadows.

Realism: Instead of buttons and menus and text, controls are more interesting: your concentration on what you will to do. Realistic controls make it easier to see what state a controller is in.

Interaction:-

Feedback: Newton's Fourth Law of Games: Controls give immediate visual and aural feedback. This gives the gamer a feeling of being in direct control---things in the world exist and can be directly manipulated.

Unity: Controls are embedded in the space, not external to it. This increases the closure of the space and aids belief in its existence as a real place. For example, games don't have scroll controls; seeing more of the scene is as natural as turning in the real world.

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VI. CONCLUSION

This paper proposed a 3-D video game driven by EEG features related to different levels of attention and a set of keyboard inputs. The game named as "INTELLECT" employs sample entropy as well as band power estimates of alpha, beta and theta rhythms of EEG to differentiate between different brain states of players. The complex attention control mechanism proposed in this paper helps players to improve attention and over all game control skills. SVM technique used for classification helps to improve the accuracy of the system. Further experimental analysis is necessary to make the control mechanism simpler and more robust for optimizing the benefits of neuro-feedback training. As a future work we are planning to add deep learning technique for automatic game playing.

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