The Method of Integrating Virtual Reality with Brainwave Sensor for an Interactive Math's Game

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Abstract— **The implementation of the Virtual Reality (VR) on game is practical for in various fields, especially in the field of Education. The implementation of a mobile based VR game is example where the players of game feel as in the real world.**

However, the VR game has the weakness on limited interaction of their player with the virtual environment created by the game. Currently, the interactions pass through the buttons on mobile phone and joysticks. For this reason, this research investigates the alternative media to control the virtual environment of the game using brain sensor. The prototype was created using "mindwave neurosky" as brain sensor and thingkgear as sensor drive to construct the experiment of mobile based virtual reality math game

This research tests three modes signal including meditation, attention and beta signal. A meditation signal was taken when the player open and close the eye. While attention and beta signals were taken when the player focuses. The result is some model to control the VR math game with brain sensor for child five or six year old's.

Keywords-component; Math Game; method; VR ; brainwave sensor;

I. INTRODUCTION

In recent years, Information Technology has developed rapidly and contributed of changes in various fields, one of which is virtual reality technology. Virtual reality is a technology describing a three-dimensional environment simulated by a computer and someone can interact with the environment. In virtual reality, the environment is actually imitated and only existing in imagination.

Virtual reality or VR technology is a technology enabling users to interact with the environment virtually. Virtual reality technology is widely used in various fields, including medicine, education, architecture, entertainment. The Implementation of VR Technology in education and entertainment is VR Game. When virtual reality technology is applied in games, players will feel like they live in the game world.

According to Mark Zuckerberg, the founder of Facebook at the CES (Consumer Electronics Show) event on January 2016 in Vegas stated that technology will lead to virtual reality applications in the next 5-10 years [1]. Currently, developers and producers in Information Technology area are competing to develop VR technology such as Google, Facebook, Samsung, LG, Sony, and other IT companies. The effect of this competing can be estimated that the market will be flooded with these VR application products in the coming years.

The advantage of VR games is their players will feel in environment designed a virtually. The player feels experiencing as he is in the game world itself. This experience is not found in other versions of games. However, the VR application has weaknesses, one of which is the interaction with the surrounding environment, or in other words the VR application requires an interface device connected to a VR device. The reason is VR devices are only a tool to see the surrounding environment virtually. Whereas to experience real feelings and other interactions are needed likes the movements of the hands, and feet.

At the present several previous studies have used sensors to detect player movements conducted by Barmpoutis in their research using Kinect sensors [2]. While Yulia, Conn, and Lee used the glove hand sensor in virtual 3D [3], [4], [5]. They use an accelerometer sensor and a gyroscope to detect hand movements. The studied was also done by Tangeldeen with the difference in the sensors was implemented for hand rehabilitation [6].

The sensors have several disadvantages, one of which is the players are not free to move because they are limited by the sensor area. In addition, some of these sensors cannot detect several movements such as the player's forward and backward motions. To overcome this weakness, brain control are used to interact with the VR world. The advantage of this sensor is it does not require a separate area and can detect player's forward and backward motions.

II. RELATED ON WORK

In recent years, a large number of Brain Control Interfaces (BCI) systems have been developed to provide alternative communication tools for people with severe neuromuscular disorders. Hundreds of BCI studies have been published to promote the development or enhancement of methodologies of signal processing, development of new BCI paradigms or improvements of existing BCI, investigation of factors that influence the performance of BCI systems, and practical application of BCI technology [7].

Many of BCI applications are implemented in different areas, namely mental speller [8], [9], mouse control [10], [11], robot arm control [12], game applications [13], [14], navigation [15] , and brain-controlled smart home systems [16],[17].

BCI mobile phone applications have also been developed. One of the first mobile application projects used a prototype wireless Electroencephalography (EEG) headband with 4 electrodes targeting areas of hairless skin on the forehead [18]. This project connects nerve signals to cellphones to display visualization and to analyze the signals simplify. However, cellular devices are more used to a visual than a cellphones. Other EEG and wireless systems can be used with cellular phones. They consist of a bio-signal four-

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line acquisition module and they are used as a telephone that do calling directly with 10 digit telephone numbers [19].

III. LITERATURE REVIEW

A. Neurosky Mindwave Headset

The Mindwave Headset is a device manufactured by Neurosky Technologies [20]. This device consists of a headset, ear clip, and sensor arm (Fig. 1). This device can send signals using Bluetooth technology. The headset and ground electrodes are in the ear clip and the EEG electrodes are on the sensor arm, they are placed on the forehead above the eyes.

MindWave is mobile device and safe for measuring and producing EEG power spectrum (alpha waves, beta waves, etc.). The flashing power value measured by the Electromyography (EMG) Sensor is in the NeuroSky device. The MindWave Mobile Headset transfers data via Bluetooth. The Headset is non-invasive which will not cause pain in players who use headsets.

Fig. 1. headset Mindwave

The Mindwave headset is a single electrode, non-invasive, and a low-cost device. This tool transmits raw EEG signals, brain waves, blinking data, and other data using Bluetooth. This headset contains ThinkGear NeuroSky technology measuring and sampling EEG signals at a 512 Hz sampling frequency. Electrodes are placed in the Fp1 position like the 10/20 system.

B. Thinkgear - Application Programming Interface (API)

ThinkGear-API is software that is used to interact with NeuroSky Mobile devices. NeuroSky mobile must be connected to external devices such as desktop computers, servers, microcontrollers, cellphones, tablets, or devices that supports Bluetooth connections.

ThinkGear communication drivers can be *.dll; *.bundle, or *.jar files depending on the programming language. A programmer can use the library to call functions in drivers using supporting programming languages such as C, C ++, C #, Objective C, or Java. The research creates experiment using the Android platform. The platform needs library files are needs library file to develop application.

To develop an Android while application using a cell phone connected to mindwave. The Java language environment requires ThinkGear library to compiled into a .jar file. After attaching this library, developers can create applications using ThinkGear technology.

Usually, EEG signal processing and real-time classification algorithms are designed for complex performance. Some of them use a combination of various classification methods for EEG classification. Mobile phones have limited resources with lower power efficiency, so it is impossible to implement and run them in the form of cellular applications. However, the ThinkGear Android API can reduce the complexity of managing connections and handle parsing of streaming data from an EEG headset. This convenient software interface supplies raw data and pre-process data. Software developers can receive values of concentration and relaxation normalized to the range of 0-100%. The muscle movements handling eye blinking are normalized in the same way. This is very convenient and helping to hinder analyzing raw data. Consequently the application of brain wave sensing applications need to import the library by adding the necessary settings and teardown functions, and making the object handler as a notification.

C. Virtual Reality (VR)

The term of Virtual reality (VR) was introduced by Jaron Lanier established a company involved in VR. Virtual reality is a computer technology connecting with the surrounding environment a virtual world in simulation with 3D images. VR is connected with players in real time and can be connected with other players. This technology is pseudo-natural immersion or players can move naturally so that movement in the real world is the same with the virtual world through components of sensors.

Some elements of Virtual Reality [21]:

- The virtual world, which is the content of a virtual medium can be screen play or script. through this element, players will experience the virtual world.
- Immersion, That is sensing existence in an environment. These immersions are divided into several types, namely mental immersion, physical immersion, and mentally immersion.
- Sensory feedback, that is information about cyberspace displayed to the player’s senses. That sensory feedback can be visual, audio, or touch.
- Interactivity, That is a virtual world responding to user actions in real time.

IV. DESIGNING

A. Designing flows

The design of the brain detection sensor for Virtual reality games is shown in Figure 2. The brain detection device in the form of neurosky Mindwave will provide signal raw data for mobile phones with VR games. Communication between neurosky Mindwave to mobile through a Bluetooth signal.

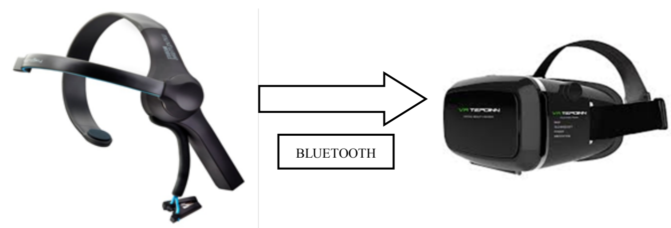


Fig. 2. The Designing of integrating VR with brain sensor (source: http://developer.neurosky.com)

Figure 3 shows a flowchart of integrating virtual reality with brain sensor in programming environment. The virtual game applied in this research was the addition and subtraction math game for five or six year old's. In this game, players will be escorted into a virtual world in which having several questions of addition and subtraction. When any questions are exist to be answered, the program will wait for input signal from the brain sensor. When the question is answered correctly, the score will increase by 10 and it will be decreased by 10 if it is wrong. When all questions have been answered, the total score will be added and then ranked.

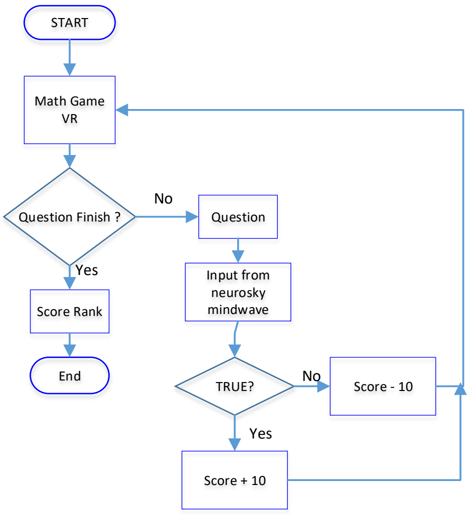


Fig. 3. Integrating virtual reality with brain sensor

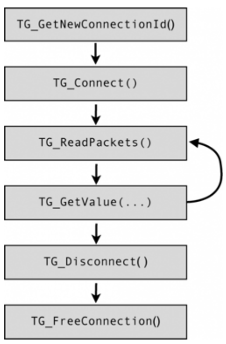


Fig. 4. The steps design neurosky brain sensor (source from http://developer.neurosky.com)

V. DISCUSSION

The signal output of Neurosky Mindwave used as an input of VR game can be visualized by brainwave visualizer application. The application helps to detect the signal from Neurosky Mindwave. Figure 5 shows a visual and graphical display of visualization (Brainwave Visualization) that displaying each data sent by the headset.

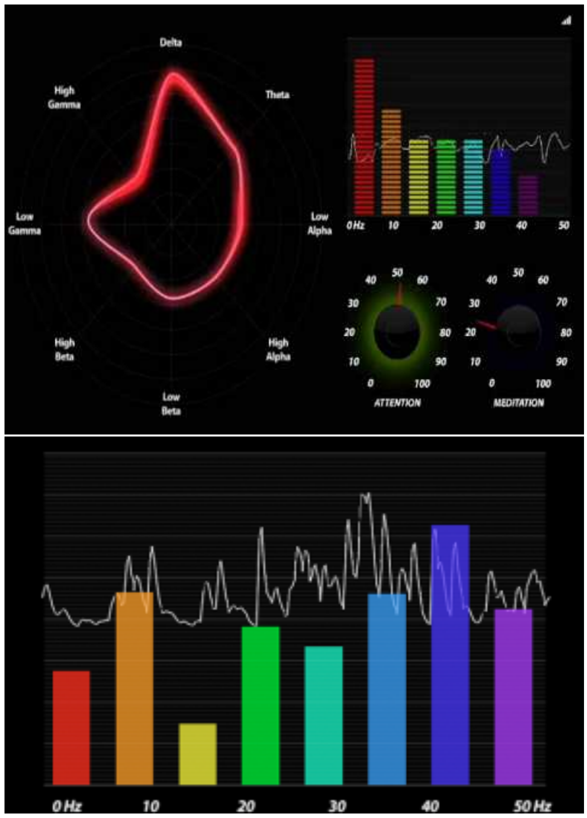
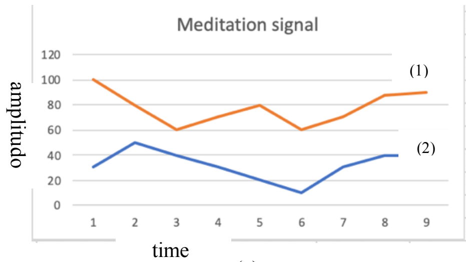


Fig. 5. Graphic of parameter brainwave sensor with Brainwave Visualization application(source from http://developer.neurosky.com)

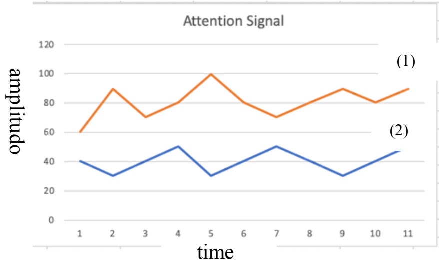
The Brain Visualizer application can display several types of output data, namely Attention, Meditation, and 8 other types of brain signals (Delta signals, Theta, Low Alpha, High Alpha, Low Beta, High Beta, Low Gamma, and mid Gamma).

The next step is the selection of signals through testing. The selected signal is a signal can trigger the answer needed, namely the meditation signal and attention signal and beta signal. Meditation signals are chosen to represent the situation of closing eyes of the player. While the attention signal and beta signal are chosen to represent the state of the player when focusing his attention. The sampling of testing adjusted for who is play the game VR. This Game VR has been taken for children aged 5 and 6 years old. The results are shown in Figure 6.

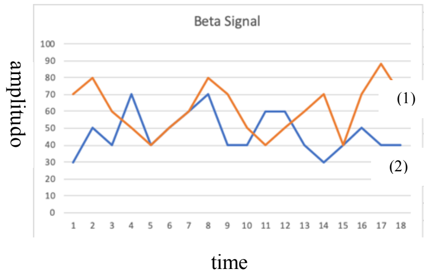
Figure 6 (a) shows a graph of the meditation signal when the eyes are open and eyes are closed. The view of signal (1) represents the state when the eyes are closed and signal (2) represents the state of the eyes are opened. Whereas Figure 6 (b) views the attention signal when the player focuses on something. Signal (1) is an attention signal that representing the state of the player is focusing on something and signal (2) is a attention signal representing the state of the player not in focus. Both of graphs are viewed in Amplitude and time axis. Figure 6 (c) views the beta signal when the player focuses on something. Signal (1) is an beta signal that representing the state of the player is focusing on something and signal (2) is a beta signal representing the state of the player not in focus. Both of graphs are viewed in Amplitude and time axis.



(a)



(b)



(c)

Fig. 6. (a) the graphic of meditation signal when closed eyes (1) and open eyes(2). (b) the graphic of attention signal when focusing sometimes (1) and not focusing sometimes (2).(c) the graphic of beta signal focusing sometimes (1) and not focusing sometimes (2).

TABLE I. THE AVARAGE OF BRAINWAVE SIGNAL

Average Amplitude	Signal	Condition
32.22	Meditation signal	Open eyes
77.55	Meditation signal	Closed eyes
40	Attention signal	Not focusing
80.9	Attention signal	Focusing
47.22	Beta Signal	Not focusing
61	Beta Signal	Focusing

From table 1, shows that the average meditation signal and attention signal have more range than beta signals. that it is easier to use meditation signals and attention signals than beta signals. In the practice, Meditation signals have more easier than attention signal because the players are children aged 5 and 6 years who are easier to close their eyes than focus on something. The next testing is the detection of brain signals and the results are shown in Table 2. Table II shows that when player choose the right answer, he will close his eyes for a moment about 1 second.

TABLE II. THE METHOD OF DETECTION BRAINWAVE SIGNAL

Signal meditation	time	Condition VR Game
< 60	∞	idle
> 70	1-2 second	Choosing the answer

The math VR game is made using unity game engine. the player choose menus and answers of question using meditation signal. To detect meditation signal, Unity game engine need think gear library. There is a procedure for reading meditation signal :

- connecting

```
int handleID = ThinkGear.TG_GetNewConnectionId();
int connectStatus = ThinkGear.TG_Connect(handleID,
                    "/dev/tty.MindSet",
                    ThinkGear.BAUD_9600,
                    ThinkGear.STREAM_PACKETS);
```

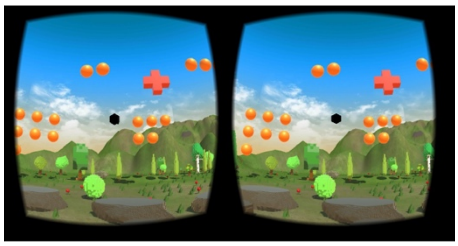
- reading data

```
float meditation = ThinkGear.TG_GetValue(handleID,
                   ThinkGear.DATA_MEDITATION);
```

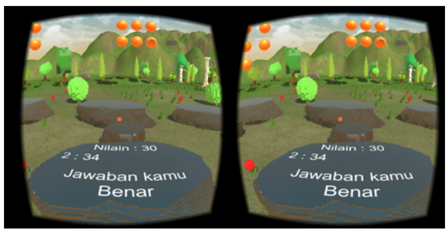
- disconnecting

```
ThinkGear.TG_Disconnect(handleID);
```

The last testing uses a VR game application. On each question asked on the screen, the player was helped to focus on choosing the answer he wanted and then closing his eyes for a moment. Then proceed with the other questions. Figure 7 shows the questions, the answers, and the total score of games.



(a)



(b)

(c)

Fig. 7. (a) the questions on VR Game,.(b) the answer on VR Game (c) Total Score of the game

VI. CONCLUTION

Detection of brain signals is used to select answers from the questions given in VR games. The choosing of answers is helped by the focus point in the game. The player is a child aged 5 and 6 years. That is why the signal used in brain detection is meditation signal and Meditation signal used when the player can choose the answer by closing their eyes for a moment.

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