

A Video Game Design based on Emotiv Neuroheadset

Rijin Raju¹, Chenguang Yang^{*2}, Chunxu Li¹, Angelo Cangelosi¹

Abstract— This paper presents our work on the development of a video maze game in Android system, and a new method to play the game using gyroscope and electromyography (EMG) signals obtained by a wireless Emotiv Neuroheadset. The TeamViewer software is used to share the computer screen and to transfer the data to an Android device, and the Emotiv EPOC headset is used to detect the intension of the user who is playing the game. The cursor position is controlled using information from the gyroscope embedded in the headset. The clicks are generated through the users blinking action based on the expressive suite data acquired from Emotiv headset signal data. A program called Neuro Mousecontrol is used to act as a tool for controlling gyroscope movements and clicking actions together. Extensive tests have demonstrated the effectiveness of the developed system.

I. INTRODUCTION

With the development of human computer interaction (HCI), systemsbio-signals collected from humn users have attracted increasing attention and investigation (electroencephalogram (EEG) and electromyogram (EMG)) [1]. Quite useful information can be obtained from the brain activities to manipulate artificial systems. In spite of the superior fact that the EEG signals enable us to commander external system using brain activities, the weakness of signal-to-noise ratios and the deficiency of signal patterns consistency make the using of EEG signals unreasonable [2]. Owing to the definite disadvantages of EEG signals, the EMG signals with special opportunities can be used in wider fields of interaction with great controllability and insensitiveness for noises variety [3]. It is possible with modern technologies to acquire and to process the electrical signal emitted by our human muscle and then use them for various applications. It is similar to make telekinesis a reality. Virtual applications are still under development, however, it is one of the major steps in technology. It can be implemented for video games, computer applications, robots, mobile devices and many more. In this paper, we collect from the operator EMG signals generated by clenching teeth or blinking eyes, in order to identify the intension of the operator. As a result, we can notice that around the edge of designated eye muscle's contraction, there are several distinguishable signals. Fig.1 demonstrated specified positions where the actions mentioned result in the four electrodes and signal patterns.

Emotiv based game plays an important rule in entertainment area as this will enable people with disability and

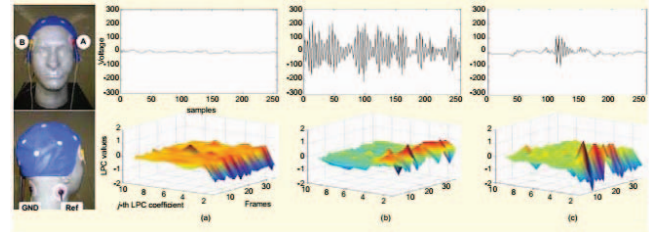


Fig. 1. The predefined actions can cause electrode positions, LPC patterns and signals, such as (a) stationary (b) clenching left molar teeth (c) blinking both eyes. The electrode attached to the left temporalis muscle is used to measure all signals [2].

neuropathy problems, for example, those after stroke cannot move limb to play game [4]. This paper deals with making Android maze game and controlling game objectives with users head movements and brain signals using Emotiv EPOC neuroheadset. It is also a way to help with concentration and improving brain activities. Gaming is popular among the youth and even older people of any age. Advance in technology is growing faster and faster. We now even play games on our mobile devices and tablets now. This paper could help with playing games with just using user's head and face motion and could be further developed to play more complicated.

In this paper, using Game Maker Studio professional edition software develops the maze game to playable in an Android device. The Emotiv headset fitted on the head and in contact with the scalp of the user is used to collect the EMG signals and head motion from the user. The data acquired are processed by Neuro Mousecontrol software to send out commands. Gyroscope is used to control the mouse with users head movements. Eye-blinking action is used for mouse click and clench action for double clicking. Neuro Mousecontrol provides these actions and it does not require any user trainings. TeamViewer software will help with sharing the game screen on device or tablet, so that we can still use the headset to control the game objectives.

II. BACKGROUND

A. Electromyography (EMG)

Muscle signals are the messages transmitted from neurons in the central nervous system along nerves to moto neurons at which point the signal is transmitted along a mass of muscle fibres [5]. The more moto neurons which are fired the stronger the muscle response will be. Different regions of the body are subject to different ratios of moto neurons to muscle fibres. For example, the muscles around the eye have an approximate 1:9 (neurons: fibre) ratio with approximately

*Corresponding author. Email: cyang@theiet.org

This work was supported in part by Engineering and Physical Sciences Research Council (EPSRC) under Grants EP/L026856/2 and EP/J004561/1.

¹Center for Robotics and Neural Systems, Plymouth University, UK.

²Zienkiewicz Centre for Computational Engineering, Swansea University, SA1 8EN, UK.

3000 moto neurons available, which allows for a greater range of very small precise movements [6].

There are two types of muscle fibre; these are determined by their frequency response. Type I is small, fire slowly and less prone to fatigue. Type II can be broken down into 2 sub categories [7]. This information is critical to understanding an EMG signal. By understanding the order in which a muscle fires and the frequency range that the muscle operates in, the shape of a signal can be predicted; knowing the duration of a muscles activity can help isolate triggering signals and stop signals.

The location of a muscle determines the role it plays. All muscles can only contract (pull actively), however the particular muscle controlling an action may differ depending on circumstance or location [8]. For example, when bending forward to pick an item off the floor the initial controlling muscles are the abdominal muscles but, once motion is started, these muscles become almost redundant as gravity will act on the body with a considerable effect [9]. This means that the muscles orientation with respect to gravity will drastically alter the signal shape.

B. Emotiv EPOC Headset

There are a wide range of applications of Emotiv systems by a large number of companies and the EPOC has applied this technology into entertainment area especially video game, which leads to immersive experience with virtual reality and they can also use their mind to play games. There are 14 EEG sensors positioning (shown in Fig.3) around the frontal and prefrontal lobes of the EMOTIV EPOC headset (Fig.2), which can collect signals from facial muscles and the eyes [10]. Precisely, the range of the system spans 30 kinds of different emotions and actions, such as smiling, blinking, which are be processed by the system and translated to an avatars actions on the screen. In this paper, identification of facial expressions is used to add functions like mouse click and mouse double-clicks.



Fig. 2. Emotiv EPOC headset [10]

The electrodes attached to a user's head can be used to measure electrical signals reflecting the motions such as clenching and blinking. There are three types of electrodes; needle electrodes, cup electrodes and saline electrodes [11]. Most commonly used scalp electrodes are made from silver/silver chloride discs (Ag/AgCl). A gel is applied to the electrodes for connection with the scalp. The gel is required and used is to reduce the impedance between the cortex and

electrodes. We need to have as low electrode impedance as possible with a view to limit the distortions in the EMG signal. The conductive gel dries over time and that reduces the accuracy of the signal and so more can be applied as it dries up. To get the best readings, the electrodes have to be positioned specifically and fitted to the right reference points. The headset cost low, which is good for commercial uses for gaming, research and simulations uses.

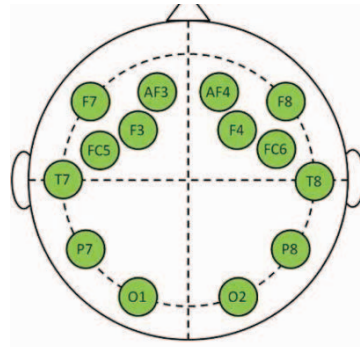


Fig. 3. Emotiv EPOC Electrodes Positions [12]

C. Game Maker Studio

Game Maker Studio illustrated from Fig.4 is a creation platform for game software made by Mark Overmars [13]. Users can use drag and drop action sequence for the creation of multi-genre video games as well as the cross-platform. The software is written in Delphi programming language. It is owned by YoYo Games and the first release was on 15th November 1999 [14].



Fig. 4. Game Maker Studio: Professional Studio [screen snap]

It allows redistribution on multiple platforms, such as, Mac OS, Windows, Ubuntu, Android and Tizen. The basic version of the software can be downloaded free from their official website however, to distribute game on different platforms, we have to buy the full version which costs range from 50 to 800 dollars.

In this paper, Game Maker Studio professional edition is used to develop the Android Maze Game Application. Professional edition enables all features in the software, and able to test the game on an Android device. It costs 50 dollars, however, in order to export the game, it requires

upgrade to master collection of the software, which cost around 800 dollars.

To test the game on an Android device; Android SDK, NDK and Java SDK are required and linked with the software. Android device should be running Android KitKat 4.0 version or above, enabling developer option on the device for testing.

D. Neuro Mousecontrol

As a small Windows application, the Neuro Mousecontrol enhances the possibility to use EPOC as mouse control (shown in Fig.5). It replaces mouse with Emotiv EPOC. Mouse left click action is by winking wer eyes, scroll is by smirking or using wer eyebrows, which supports left, right, double-clicks, scrolling, drag and drop options. User can find a Mouse Emulator in Emotiv Control Panel, which designed to control the cursor of wer mouse for the EPOC Gyroscope. The basic function of EmoKey clicking is provided by using EPOC, however, there are several limitations by using this method, which are explained as follow, in EmoKey, clicks are sometimes not sensitive especilly in the case of Windows application. In addition, the scroll commandit is not easy to send with EmoKey [15].

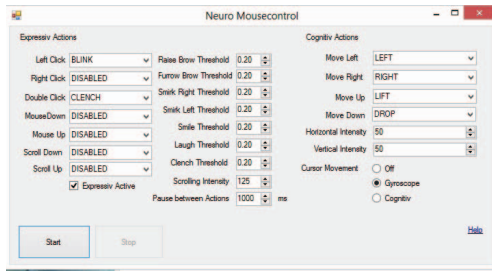


Fig. 5. Neuro Mousecontrol Application [screen snap]

This application works with a different way, which is independent from the currently active window where mouse clicks are directly sent to the operating system. Also it is possible to scroll, point or click. Face Mouse uses data from expressive suite. Mouse Emulator in Emotiv Control Panel can be used extra with this application in order to enhance the efficiency. The method above is one of the easiest way to replace mouse with EPOC [15].

It requires Microsoft Windows and installed NET Framework 4.0 or above to run this application. In this work, this application is used for left click action by blinking both eye together and double-click action by clenching tooth together. This is using the facial expressions data from the expressive suite obtained through users muscle signals. It also cab be used to move the mouse around with gyroscope information.

E. TeamViewer

TeamViewer is a software designed for desktop sharing, remote control and file transferring between different computers (seen from Fig.6) [16]. The software can be operated under the Windows, Mac OS, Ubuntu as well as operating systems for smart phone, such as iOS and Android. It can

also be used under some special case, where this software is free charge for non-commercial users. The software is developed by TeamViewer GmbH.

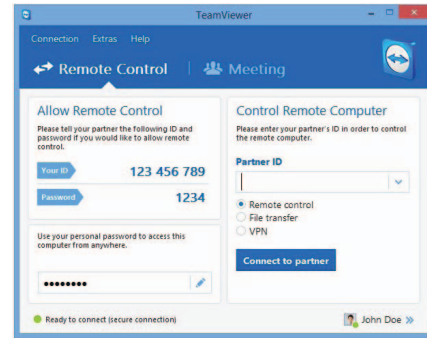


Fig. 6. The operation screen of TeamViewer 10 [screen snap]

To establish connections both operating systems has to be installed and running TeamViewer. When TeamViewer is started, it generates a partner ID and password and by adding these ID and password to the remote client, we can gain access to the generated clients computer. For security, TeamViewer uses AES (256-bit) session encryption and RSA private key exchange (2048-bit) [17].

TeamViewer is used in this paper to establish connection between the computer and Android device. Since Emotiv does not supply an SDK to run on Android device, this is an alternative way used to share the game on Android device and be able to control the game using the Emotiv EPOC headset.

III. DEVELOPMENT ANDROID MAZE GAME

A. Design of the Maze Game

First of all, many elements or sprites, texts, buttons, objects and their actions are created. It can be shown from Fig.7, this maze game consists of a 5 different scenes: beginning scene, instruction to play the game scene, level 1, level 2 and an end scene. All the design drawings are carried out on game maker studio, as it allows more features for developers other than coding. The drawings as created in Sprites section. Sprites, such as, walls, characters, score points, goal points, cursor and buttons drawings are created. These sprites are then turn over to the object section. The object section is where we add an action and an event for that object. The Game Maker allows to drag and drop function and to minimize coding time, which leads to that even non-programmer is able to use the software easily. The sprite of wall for example, is made an object so the actions are, wall should be solid, and it must not move or let other object pass through it. The event of the wall makes speed equal 0 when other object collides with the wall.

The game is fully functional to play on a computer or on an Android device. A system called, virtual keys are added into the game. These keys are important when playing the game on device as it act like a touch button and also these virtual keys helps to interact with the gyroscope movement,

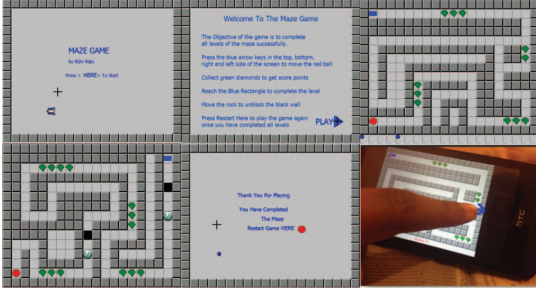


Fig. 7. All game level designs and gameplay on an Android device [screen snap]

therefore game can be played by Emotiv EPOC headset with using only the gyroscope movement. When the mouse hits these virtual keys, the avatar or red ball in the game will move according to the virtual key direction. There are four virtual keys added: right, left, up and down.

The main objective of the game is to move the red ball around the maze and complete all levels in the game. The movements can be controlled by the arrow keys on the computer or by pressing the virtual keys shown in Fig.8. Collecting green shaped diamonds will get we points. 5 points for one diamond and a total of 120 points can be obtained altogether.

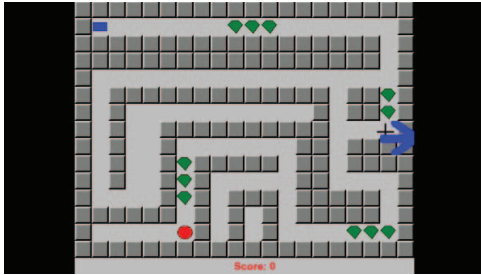


Fig. 8. Blue arrow virtual key on right side [screen snap]

B. Creating Rooms

Rooms are simply the level creators in Game Maker. This is where we add all the objects, backgrounds, text, path and controllers to create the game. In the game, two Levels (Level1 and Level2) has been modified, additional three more rooms, which is intro room, intro2 room and end room (Introduction or starting screen and End game screen). All rooms width and height is 640 x 510 pixels. Light Grey background colour for all rooms.

When opening the game, this is the first scene we will see, the red ball will be invisible, and it is to act as a button. We need to swipe at, "PRESS HERE" text to start the game. The space shuttle animation will loop around the whole screen. Around the scene are grey walls. Grey back ground with blue text and it will also have a cursor as well.

C. Text Backgrounds

In this section, blue coloured 16 pixel text on the intro room and end room has been added. The text can be divided

into three separate background text, which is background0, background1 and background2 respectively. Wherein, background0 is used in the starting room or intro room (824 x 512 pixels). This text is added as a background in the intro room or the text we will see in the beginning of the game. Background1 text is used in the end room (612 x 510 pixels), which is the text used as a background in End room or at the last scene in the game. Background2 text is used in the Intro2 room (612 x 510 pixels), which is a set of instruction of how to play the maze game. This text is added in the Intro2 room or at the second room of the game. Everything works, when operator clicked on the play button, it took me to the next room, which is the maze0 or level 1 of the game.

D. Creating Path and Toggle Full screen on Virtual Keys

One path followed with animation has been created. The object will follow the path points created and the space shuttle object will follow a square path and loops over. Points created are displayed on the left side, which is shown below named path0 in the Fig.9.

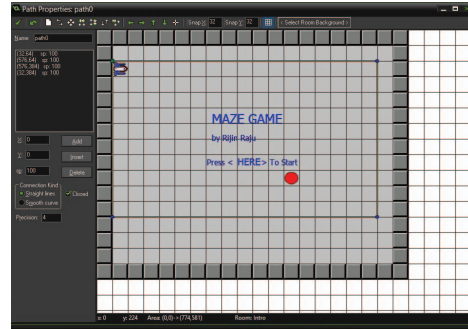


Fig. 9. Animation path to follow [screen snap]

When the game is shown on full screen mode on windows computer, without the virtual keys working or rather, it would not change the place where we set the virtual keys as well. Hence, a small code for key and controller start objects in the Draw GUI to execute need to be added (shown in Fig.10) in order to keep virtual keys in right positions.

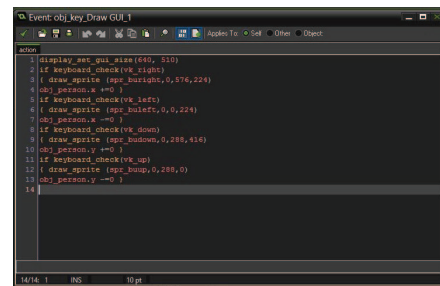


Fig. 10. GUI size code been added [screen snap]

IV. PERFORMANCE

A. Emotiv EPOC Setup

The gyroscope movements, EMG data and muscle signals are collected with the neuroheadset Emotiv EPOC. Connec-

tion of each electrode and a good signal should be needed. The EPOC Control Panel will show connected data such as, expressions, mode changes, and gyroscope movements. In order to get better connection, saline solution should be applied on each electrode before wearing the headset and hold the sensors onto the scalp for few seconds. When connections become fully green, it is possible to start the Neuro Mousecontrol application. The Fig.11 below shows the connection of the headset.

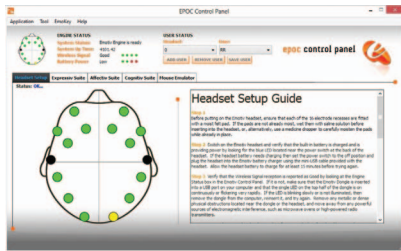


Fig. 11. Emotiv EPOC Signals [screen snap]

Each circle on the figure represents one sensor and approximates location on the scalp. The colour determines the signal quality. According to [18], Black, Red, Orange, Yellow and Green means “No signal”, “Very poor signal”, “Poor signal”, “Fair signal” and “Good signal” respectively. In order to get a green or yellow colour, the electrode can be moved slightly with pressing firmly for 10 seconds or applying more saline solution. With powering on the headset, the gyroscope will work. With few green signals the clench action will work, therefore in double-click action works and more green signals, the blinking will work, this action is used for clicking.

B. Neuro Mousecontrol Setup

Once the EPOC Control Panel is running and getting good connection from the headset, the Neuro Mousecontrol application (shown in Fig.5) is ready to use. Before running the application, some actions are needed to be selected. For left mouse button click, a blink action can be used. When the user blinks, the mouse does the left click itself. The actions are obtained from the Expressive suite in the EPOC Control Panel. The clench action can be used for double clicking. The cursor movement options are turned to gyroscope movement. The motion of the headset will provide the data of gyroscope movement. This movement is used to control the mouse freely with the users head movements.

This program can be used in any online games for basic mouse controlled actions. This paper requires, playing the game with Emotiv EPOC, therefore, this application is used for moving the cursor object in the game using the gyroscope movement and blink action for clicking on virtual keys.

C. TeamViewer Setup

The final step was to connecting the remote desktop sharing software from computer to the device. TeamViewer software is installed both on computer and device, then entered the ID and password provided from the client server

for connection link. After connecting, the game screen can be shown on the device, which is shown in Fig.12. When moving anything on the computer, it will be displayed on the device. Emotiv EPOC does not have an SDK to run on an Android device currently and there are no options to run the Emotiv on Android devices. This method is used as an alternative way to play the game on the device, even though the Emotiv is connected to the computer.

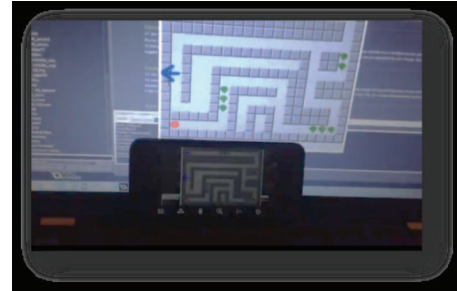


Fig. 12. Sharing the game on device with TeamViewer [screen snap]

In order to work for everything, it needs to make sure Emotiv EPOC headset is charged, USB Dongle is connected, EPOC Control Panel and Neuro Mousecontrol are running, TeamViewer is running on both computer and Android device. Once all of the work above is ready, operators will be able to control the game using their facial motion on an Android device.

V. DISCUSSION

A. Muscle Signal Collection

For Emotiv Neuroheadset, there is no electrode directly touch the face, hence, the method for collecting facial expressions from user is significant. Emotiv processes a subject’s muscle signals in order to understand his/her behaviour. Collecting signals of high quality may not be possible due to various reasons, such as, not having enough saline solution on each electrodes or electrodes not in right place. However, there is no training required to use Neuro Mousecontrol, therefore, the result could vary when a different person uses the headset for the same use.

B. Maze Game Results

The work developed in this paper can be divided into 6 essential parts: developing the maze game application, playing the game on a windows computer, playing the game on an Android device, using Emotiv EPOC headset to control the game on a computer, sharing the computer screen remotely on an Android device via TeamViewer software, and using Emotiv EPOC headset to control the game from on an Android device.

In the first and the second parts, a maze Android game application were created and developed. The game can be controlled by using the arrow keys on a keyboard as designed, such as walls, texts, characters, goals, animations and every element like score system, cursor, and virtual key works successfully. However, the frame rate changes

on the animation when it is looping over a few times. For improvement, we could add more challenging levels, sounds, better score systems, proper buttons and texts.

The third part is running the game on Android device. People can successfully play the maze game on an Android device. When they are playing the game on device, all virtual keys and buttons implemented in the game works well. User will be able to play the game and complete the game on smart device successfully. However, the software Game Maker Studio would not allow to download the game apk file, this is because upgrading the software or buying the full software is required. Only testing the game on an Android device was enabled with the professional edition.

The fourth part is using the Emotiv EPOC headset to play the maze game on a computer. The Emotiv EPOC headset was showing green signals in most of the time and the gyroscope movement, blink action for left click as well as clench action for double click work correctly. If signal on the headset is weak, at least one of the action above will still work. All actions will work if signal is good. People can use the Emotiv EPOC headset to successfully play the maze game on a windows operating computer.

The fifth part, is sharing the game screen onto the device. TeamViewer downloaded and installed on a window computer and on the Android device. Both can share screen remotely.

The last part, is playing the Android maze game using Emotiv EPOC Headset on a smart phone device, which is required when a screen sharing software is used. Operator can successfully play the game on a device and control objectives in the game using the Emotiv EPOC headset. This method is an alternative as Emotiv does not currently provide an SDK for Android devices.

VI. CONCLUSION

In this paper, Game Maker Studio platform is used to develop and to create an Android Maze Game. A user can use arrow keys on the keyboard to play game manually on computer or play the game manually on the Android device by pressing the virtual key buttons. The EMG emitted by the user's facial motion is collected by the Emotiv EPOC headset. Emotiv Control Panel is connected to the Neuro Mousecontrol. The blink action is used as left mouse click; the clench action is used as mouse double click and the gyroscope motion is used to move mouse around. The gyroscope is used to replace a mouse in this manner that the motion detected by the gyroscope is used to move the cursor. The blink action is detected to click the virtual keys in the maze game with the headset for moving the red ball throughout the maze. Using the method in this paper, certain mouse actions in online games is possible to execute. For example, an online multiplayer shooting game called WarFrame, users simply use gyroscope action to control the avatar in the game. Therefore, the blink action will provide a left click, where blink is to fire a weapon in the game and clench is to reload weapon. This paper reports a new way to play virtual reality based video game in the future.

The results are positive and all of the applications work well, and significantly, using this method to control many applications are possible. In future, the game can be improved by adding challenging levels and export games to another platforms. Considering a new way to collect EMG easily is useful. Emotiv works well but its implementation has to be done with good signals. Finally with the support of Emotiv EPOC neuroheadset, we will be able to play a game with people's facial motion.

REFERENCES

- [1] P. Grosse, M. Cassidy, and P. Brown, "Eeg-emg, meg-emg and emg-emg frequency analysis: physiological principles and clinical applications," *Clinical Neurophysiology*, vol. 113, no. 10, pp. 1523–1531, 2002.
- [2] K.-H. Kim, H. K. Kim, J.-S. Kim, W. Son, and S.-Y. Lee, "A biosignal-based human interface controlling a power-wheelchair for people with motor disabilities," *ETRI journal*, vol. 28, no. 1, pp. 111–114, 2006.
- [3] M. Struys, L. Versichelen, E. Mortier, D. Ryckaert, J. De Mey, C. D. Deyne, and G. Rolly, "Comparison of spontaneous frontal emg, eeg power spectrum and bispectral index to monitor propofol drug effect and emergence," *Acta anaesthesiologica scandinavica*, vol. 42, no. 6, pp. 628–636, 1998.
- [4] Q. Wang, O. Sourina, and M. K. Nguyen, "Eeg-based" serious" games design for medical applications," in *Cyberworlds (cw), 2010 international conference on*, pp. 270–276, IEEE, 2010.
- [5] X. Li, W. Z. Rymer, G. Li, and P. Zhou, "The effects of notch filtering on electrically evoked myoelectric signals and associated motor unit index estimates," *Journal of neuroengineering and rehabilitation*, vol. 8, no. 1, p. 1, 2011.
- [6] S. Day, "Important factors in surface emg measurement," *Bortec Biomedical Ltd publishers*, pp. 1–17, 2002.
- [7] A. Buller, J. Eccles, and R. M. Eccles, "Interactions between motoneurons and muscles in respect of the characteristic speeds of their responses," *The Journal of physiology*, vol. 150, no. 2, p. 417, 1960.
- [8] D. A. Neumann, *Kinesiology of the musculoskeletal system: foundations for rehabilitation*. Elsevier Health Sciences, 2013.
- [9] M. Holland, L.-A. Sharp, C. Woodcock, J. Cumming, and J. L. Duda, "Validity and reliability of the behavioral regulation in sport questionnaire (brsq) with youth athletes," *Journal of Sport & Exercise Psychology*, vol. 32, pp. s175–s176, 2010.
- [10] M. Duvinage, T. Castermans, M. Petieau, T. Hoellinger, G. Cheron, and T. Dutoit, "Performance of the emotiv eepoc headset for p300-based applications," *Biomedical engineering online*, vol. 12, no. 1, p. 56, 2013.
- [11] M. A. Imran and M. L. Pomeranz, "Catheter for rf ablation with cooled electrode and apparatus for use therewith," Dec. 16 1997. US Patent 5,697,927.
- [12] U. Herwig, P. Satrapi, and C. Schönfeldt-Lecuona, "Using the international 10-20 eeg system for positioning of transcranial magnetic stimulation," *Brain topography*, vol. 16, no. 2, pp. 95–99, 2003.
- [13] J. Habgood and M. Overmars, *The Game Maker's Apprentice*. Springer, 2006.
- [14] Y. Games, "Game maker," 2007.
- [15] A. T. Pope, C. L. Stephens, and T. Habowski, "Method and system for physiologically modulating videogames and simulations which use gesture and body image sensing control input devices," Mar. 15 2013. US Patent App. 13/836,609.
- [16] C. John, "Teamviewer new technology," *Business wire*, vol. 33, pp. p25–28, 2013.
- [17] T. M. Mullen, *Thor's Microsoft Security Bible: A Collection of Practical Security Techniques*. Elsevier, 2011.
- [18] K. Stytsenko, E. Jablonskis, and C. Prahm, "Evaluation of consumer eeg device emotiv eepoc," in *MEi: CogSci Conference 2011, Ljubljana*, 2011.