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Playing games with your mouth: Improving gaming experience with EMG supportive input device

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As the technology improves, video games are becoming more realistic, lifelike and complex than ever. Recent titles feature more choices and actions for players to interact with the virtual world, which requires more key presses and can make controlling the character harder than it need to be. We found that casual players often press the wrong key when the game gets intense due to pressure and casual players' inexperience, which result in frustration and loss of interesting in playing. This article pursues three interrelated goals. First is to present a new way of input which uses electromyography(EMG) to measure the user's mouth movement, allowing the user to control their in-game character or use specific game feature without traditional keyboard input, lowering the chance of mis-input and make playing the game more easy and intuitive. Second, comparing the strength electromyography has with other alternative input methods, especially mouth related control methods. The final goal is to find an optimal way to assist traditional keyboard and mouse layout, allowing players to easily immersive themselves in their game of choice.

Keywords: User Interface; Video game; Input method; User Experience

1. Introduction

In recent years, video game is become more popular than ever. With over 2.4 billion of active players and 115 billion U.S. dollars of revenue, the gaming industry is the 4th largest market in the world. As the technology advances, video games not only become more realistic, to further expand the depth of game and satisfy hardcore players, many new games also introduce more complex gameplay features. To access these additional features, more keys are required to fully enjoy the game, which limits the usability of console controller and may be difficult to understand for new players. To address this problem, we developed a prototype input method based on using electromyography(EMG) to detect the user's mouth movement, allowing them to access specific function in the game with subtle mouth movement such as grinding teeth.

There are currently a few products addressing this problem in different ways, such as "Tilted", a supportive input device which allows players to control their character with head movement. There are already studies and projects conducted on using biomedical signal to directly control video game for disabled users(Kawala-Janik, Podpora, Gardecki, Czuczwara, Baranowski & Bauer, 2015, p.2), but those projects mostly focused on replacing traditional input method for users in need, not assisting traditional keyboard and mouse

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input.
Our goal is finding a new way to assist existing input methods such as keyboard and mouse, replacing complex commands on keyboard with simple mouth movement, lowering the gap between novice players and experienced players, allowing players to fully enjoy the game's feature and immerse themselves in the virtual world without having to overcome a steep learning curve.

In the introduction chapter, the theoretical notions and foundations of this research will be explained, including:

(1) Currently Available Alternative Input Method

(2) Controlling Video Games with EMG

(3) Using EMG to Assist Existing Input Method

1.1. Currently Available Alternative Input Method

Currently, there are a few alternative control methods designed to improve users' gaming experience or enable users with physical disability to access functions that they initially couldn't access.

In this article, we will discuss those alternative control methods and take a closer look at their associated problem, including tongue control, infrared switch and gesture control.

1.1.1. Tongue control

Tongue control system is designed for disabled users who suffer from spinal cord injuries to control wheelchair. With sensors embedded in the user's mouth, this system allows the user to control wheelchair invisibly. By keeping tongue in touch with palate, the system will emulate an analog joystick, thus allows multidirectional control of the wheelchair(Lund, Christiensen, Caltenco, Lontis, Bentsen & Andreasen, 2010, p.3362)

Another system named Tongue Drive System (TDS) provides a wearable solution to Tongue contro(Kim, Bruce, Sutton, Rowles, Pucci, Ghovanloo, 2015, p.2). TDS is a wireless system which uses magnetic tracer temporarily attached to the top surface of the tongue with tissue adhesive to track user's tongue movement and translate it to user-defined commands, allowing user to interact with smartphones and personal computer only with their tongue.

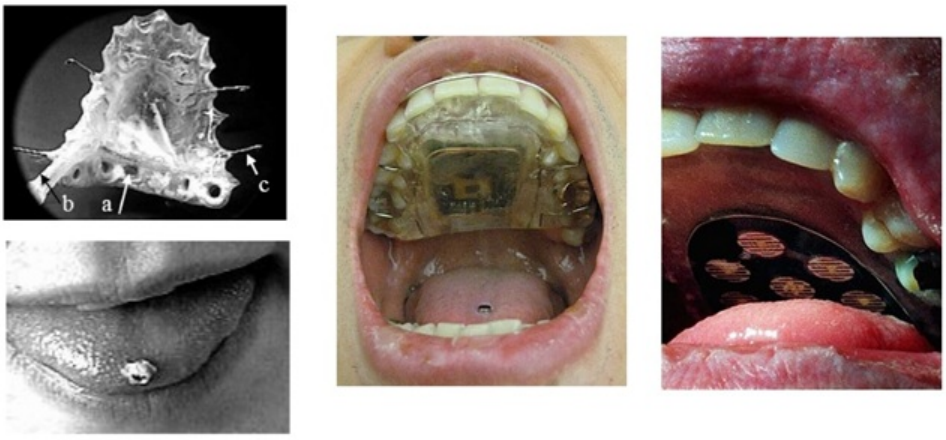

Figure.1 In-mouth control grants spinal cord injured users a way to interact with computer
Source: assistivetech

1.1.2. Infrared switch

Infrared Switch is used by prestigious theoretical physicist Stephen Hawking. Suffered from amyotrophic lateral sclerosis (ALS), he had little control over his muscles, keeping him from typing or clicking buttons. This system mounted on his spectacles can catch twitches or movements in his cheek, combined with an interface called EZ Keys, he is able to move the cursor on screen through columns or rows, and stop the cursor with a twitch of his cheek.

1.1.3. Gesture control

Gesture control is the most commonly used alternative input method by general public due to its ease of use and relatively low cost. Since the late 1990's, gesture control has been a major development goal, using motion detect devices or other peripheral, gesture control systems can analyze user's body movement and translate them into in-game action. Currently, Xbox's Kinect system is one of the most popular full body gesture control solution for basic research use(Zhang, 2012, p.5).

Figure.2 Kinect is one of the first consumer product that successfully brings full body control to public market
Source: Microsoft

1.2. Controlling Video Games with EMG

Some studies have been done on controlling video games with biomedical signals including EEG and EMG, but those studies usually focus on implanting biomedical signal controller for medical and rehabilitation use(Brianna,2017). These control methods make it possible for disabled users to enjoy games as all other players. These input methods are designed for disabled users to replace traditional mouse and keyboard layout, and have a relatively limited versatility, most of the ordinary gamers have little use for these kinds of input device.

Figure.3 EMG input makes controlling video game possible for physical disabled users
Source: Brianna LaBelle-Hahn

1.3. Using EMG to Assist Existing Input Method

Though replacing typical keyboard and mouse layout with alternative input method such as gesture control may be fun or even more immersive, but the lack of accuracy and need of space prevents it from taking over the role of the main mean of input in gaming sessions.

Many veteran gamers express that quick and accurate input is essential for good gaming experience. Because of this, EMG control which requires specific training and provides less input commands should not be replacing traditional keyboard and mouse layout, instead, we can use a simplified version of it to assist existing input method, improving user's immersion, providing more intuitive ways to access certain gameplay functions and will not drastically alter user's primary way of input and cause inconvenience in gaming sessions.

2. Background

Keyboard has been a standard input method for personal computer since its debut, when talking about playing video games, other than using keyboard and mouse, game controllers are also used by a large portion of the whole user base. In recent years, as technology advances, many new and creative control methods hit the market, such as Wii's motion control and Kinect's gesture control. These new control methods provide users new ways to interact with their games, but some of them suffer from inaccurate input detection, making these input methods not suitable for hardcore gamers and more competitive game genres.

2.1. Typical Mouse and Keyboard Layout

In the 1990's, operating system has changed drastically due to the introduction of graphic user interface (GUI). GUI changed the way users interact with their computers, using a mouse to navigate has become a necessity for the majority of users. Since most of the users are using keyboard and mouse as their primary input method, game developers started to implement mouse support into their games. Other than that, the 1990's saw a new genre of

games in desperate of a new and precise control method – first person shooter (FPS). Using a mouse to navigate 3D environment and aim provides a natural and precise experience.

Figure.4 With more keys on the keyboard than on the controller and more intuitive mouse movement in 3D environment, mouse and keyboard quickly became the new main input method in PC gaming
Source: stickpng

2.2. Modern Games with Complex and Realistic Features

With the rapid advance in technology, video game designers are able to create a more realistic game world and add more detailed gameplay features. Take first person shooter as an example, early games only feature basic functions such as walk and shoot, games nowadays allows player to fully control their character, players are able to peek through corner by leaning, change to different stances, aim with their weapon and perform more even sophisticated actions. These advanced mechanics not only increased the game's fidelity, but also heightened the skill ceiling of the game, veteran players are able to utilize these mechanics to their advantages, making the game more challenging and exhilarating, yet require new players to invest more time practice with new mechanics.

2.3. Alternative Input Method Designed for Disabled Users

Many of the alternative input methods are designed for disabled users, due to their lack of ability to use traditional keyboard and mouse layout as their primary way of input. To make controlling computer possible for disabled users, these alternative input methods usually don't require direct hand input, such as EEG, EMG or tongue control, duo to the method of input itself, the complexity of inputs are still relatively limited compare to their keyboard and mouse counterpart, which make these input methods not useful for other users.

Recently, Microsoft announces a new accessibility controller which allows users to individually bind every controller input with a wide range of input devices, making it a central hub for all the inputs. The capability of hooking up with other input devices makes it a

optimal way for disabled users to enjoy most of the popular games today, but some PC based simulation titles still require more keys to be fully enjoyed.

Figure.5 The new Xbox accessibility controller aims to provide handicapped users a new way to interact with their game console
Source: Microsoft

3. System Structure

The EMG supportive input device contains 2 parts, frame and electronic components.

The frame is made of stereolithography processed 3D printed plastic. Model after wireless behind-the-head style headphones, the frame features light weight and ergonomic design, allowing users to wear this device in long gaming session with comfort.

The electronic components are based around Arduino, with 2 electromyography sensors attached to the main Arduino system can make use of the electromyography signal provided by 2 signal receiver patches sticking on user’s face to monitor user’s mouth movement. After collecting user’s mouth movement signals, the program can translate those signals into input control, allowing users to make direct control input with mouth movement.

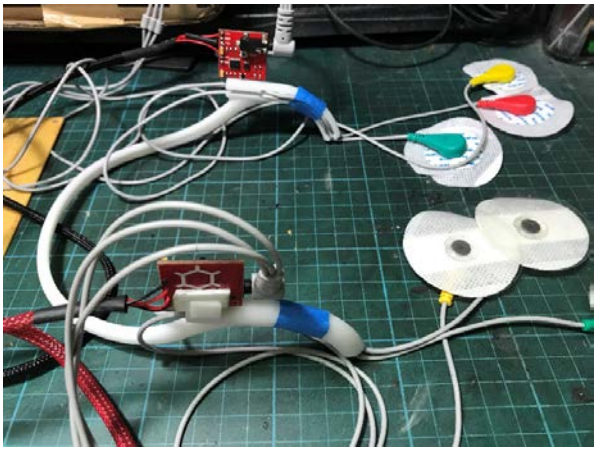

Figure.6 The frame collects all the wires and make the sensors in place

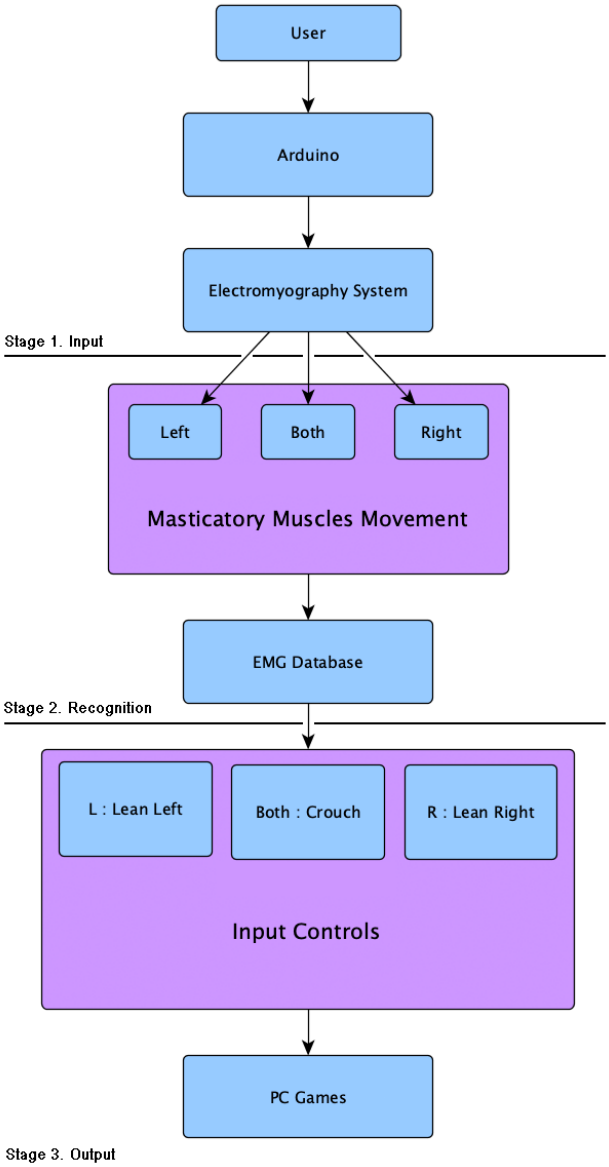

Figure.7 The structure map of EMG input hardware design

4. Experiment and Methods

4.1. Participants

The participants were selected from university students and will be separate into 2 groups, inexperienced and veteran. Players having less than 1 year of FPS experience will be considered inexperienced (Group A), and veteran group (Group B) requires players to have over 5 years of FPS experience. Making the experience gap larger allows us to better understand the different in players having different experience level. Inclusion criteria for all participants includes being fluent in Chinese and being in age of 18 to 30 years old, gender is not taken into consideration. There are total of 21 participants signing up for this experiment, 2 participants were excluded from the study for being older than 30 years old, and 5 were excluded for having more than 1, but less than 5 years of experience., making the final sample size 14 (Group A: 8, Group B: 6), and all participants are male.

4.2. Materials

The whole experiment contains 3 separate phases, pre-test, controlled test and field test. In the first phase, we created a simple program that ask participants to bite with either left or right side of their mouth in random order and record participants' response time and accuracy for us to find the best sensor placement and force threshold.

In the second phase, we developed a test program with Unity, providing participants with a controlled and pressure free environment to familiarize themselves with the device. This program only tasks participants with one objective: lean the player character's body to the side which light turns green from red. This action doesn't require input other than EMG, grinding teeth in certain direction will make the player character lean to that direction, participants have to utilize EMG control to complete the objective.

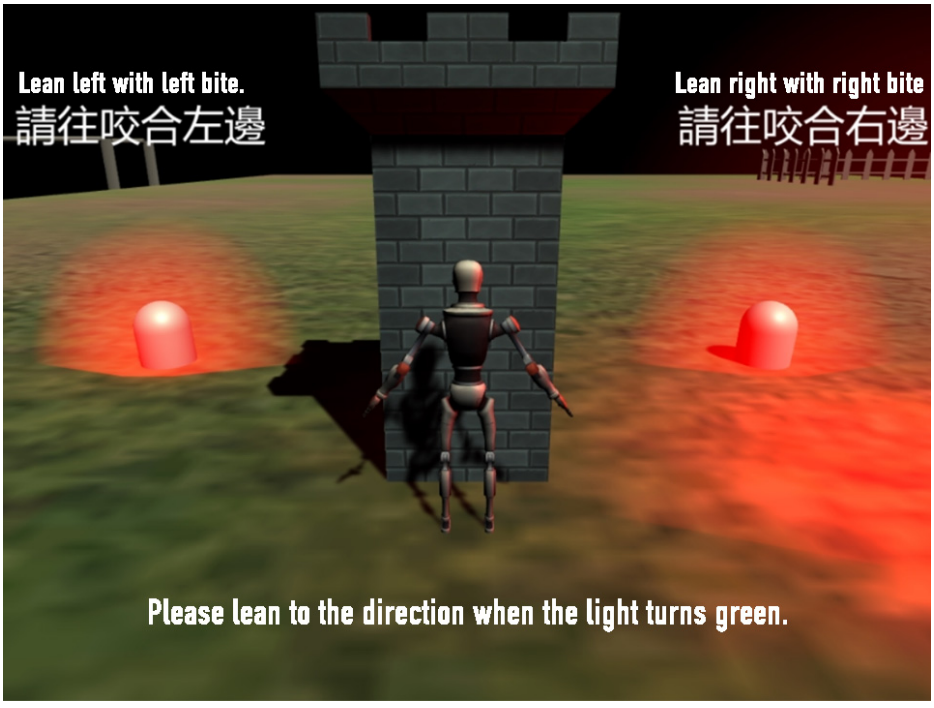

Figure.8 A screen shot of phase 2 test program

The final phase requires participants to utilize EMG control in real gaming situation, testing the usability of EMG input in intense scenarios. We choose "Player Unknown's

Battlegroudns” as our testing material, since this game is one of the most popular game in FPS genre and features more advance mechanics including leaning and toggling weapon firing modes.

4.3. Procedures

The experiment has 3 different phases, pre-test, controlled test and field test. The goal of the first phase is finding out the optimal position for sensor placement and pressure threshold. Participants have to place sensors in 3 different ways and complete the same objectives to compare the different in sensor placement. This phase requires all participants to try out 3 different sensor placement for 3 times each, and each time requires 10 inputs to complete. The first two times are the same, instructing participants to get used to EMG control by asking them grind their teeth one side then the other side alternately, the third time requires participants to follow the order which generates randomly.

With the knowledge of first phase, we can proceed to the next phase. Phase 2 tasks participants to control a game character with EMG input only to simulate gameplay condition in a controlled environment. Using the specially designed application, participants can lean the player character’s body with EMG input system. Participants have to lean the character’s body toward the direction with green light. Same as phase 1, this phase also will be repeated for 3 times, the first two-time signal lights will turn green alternately, but the last time is randomized, participants have to react to the light’s changing themselves, keeping them from predicting which light is going to change. After this phase completes, participants are asked to do the experiment one more time with mouse for response time reference.

Figure.9 A participant in phase 2 experiment

Final phase tasks participants to utilize EMG input system with traditional keyboard and mouse input together in real gameplay scenarios. Participants will be playing “Player Unknown’s Battlegrounds”, one of the most popular FPS game in recent years, with the new input system. The EMG signal is bind to leaning action, the same as phase 2. This phase will last for 4 weeks, every participant is asked to play for one hour every week. After the whole phase comes to an end, a post-test questionnaire will be distributed and a focus group meeting will be held.

5. Conclusion and Limitations

5.1. Conclusion

In the first phase, we found that in general cheek area, sensor placement doesn't' have a big impact on signal strength as long as two sensors has at least 5cm between each other. The second phase shows that using EMG control makes response time slightly longer than mouse. Except for one participant with significant higher peak signal strength (200mv), most of the participants has an average of 43 mV.

After the third phase ended, group A participants expressed that using EMG to control increases their probability of using leaning mechanic and is more fun to play, yet group B participants generally prefer accessing functions with traditional keyboard input. While most of the participants didn't encounter problem wearing the device, but 3 participants wearing glasses expressed that wearing the device with glasses and headphone on may be uncomfortable in long gameplay session.

Table 1 Phase 2 EMG supportive input system performance chart

	Group A (Inexperienced)	Group B (Veteran)
Average Response Time with EMG	435 ms	373 ms
Average Response Time with mouse	352 ms	274 ms
Average Peak Signal Strength	42 mV	43 mV
Average Accuracy	92%	94%

5.2. Limitations and Possible of Future improvements

Because of limited time and resource, we only have 14 legitimate participants, and all of them are male. In future research, to further expand the scope, the next step is to recruit more participants including female participants.

Other than the experiment itself, the structure of the device still need some improvements. 3 glasses wearing participants addressed wearing the device with glasses and headphone on for a long time may be uncomfortable. A new design which can adapt to headphone or a system combining headphone and EMG input system is needed.

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