BRAIN-COMPUTER INTERFACE APPROACH TO COMPUTER-AIDED DESIGN: ROTATE AND ZOOM IN/OUT IN 3DS MAX VIA IMAGINATION

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ABSTRACT

To increase the efficiency of 3D modeling, the sophisticate CAD users must memorize different hotkey combinations for different softwares. Hence, the challenge of the research is to find out how to create a more intuitive and natural "rotate" and "zoom in/ out" command in 3D CAD modeling. The research creates a "BCI embedded CAD" system prototype via EPOC+ with the connection between 3D studio Max and brainwaves. Through the system, the user can easily control the 3D viewport (zoom in /out) in 3D CAD environment through "thinking the commends". In the future study, the "BCI embedded CAD" can be modified as a cross-platform 3D CAD interface that enables users to use imagination to control 3D modeling among different softwares (Maya, 3D studio Max, and Rihno) rather than traditional text-based commands or graphical icons.

KEYWORDS

Human-Computer Interaction Interface; Brain-Computer Interface; Computer-Aided Design.

1. INTRODUCTION

Sculpturing a physical model in real world is easy and common for a designer. However, in the 20st century, with the development of "Computer-Aided Design/ Computer-Aided Manufactured (CAD/CAM)" (Lichten, 1984), modeling has increased efficiently, but the other problem came along to untrained users. The users need to learn how to use the 3D software via complicated and inconvenient interfaces, especially for the novices. Thus, researchers focus on the 3D input problem for many years (Aish, 1979). Aish (1979) aiming that 3D input systems should be able to create and modify 3D geometry intuitively in order to interpret and evaluate the spatial qualities of a design directly. However, in the 1980s, the CAD interface was limited to text-based commands; in the 1990s, the windows, icons, menu and pointers-based (WIMP) and text hybrid dominated CAD system. We can see that in most 3D modeling systems, text-based command system and Graphic-User Interfaces (GUIs) are still the mainstream. The keyboard and mice are essential for users to type in and select commands, such as the first CAD software—"Sketchpad" (1963, Sultherland), and recently, CAD software—"Maya", "3D studio Max" and "Rihno".

2. PROBLEM AND OBJECTIVE

Regarding to the traditional HCI interfaces (keyboard, mice, gesture and pen), users must spend time learning how to manipulate 3D modeling among different softwares (such as Maya, 3D studio Max and Rihno). For instance, the commands—"viewport rotating and zoom in/ zoom out the object" that the users use frequently in 3D modeling world, users have to memorize the multiple hotkey (keyboard + mice) to reach the goal (rotating object) or use the graphic icon to finish the action (Figure 1-left). Moreover, sometimes it is harder if you cross different 3D modeling softwares (Maya and 3D studio Max). The rotation function hotkeys are

totally different even if there are designed in the same company (Autodesk). To increase the efficiency of 3D modeling, the CAD users must memorize different hotkey combinations for different softwares. Hence, the challenge of the research is to find out how to create a more intuitive and natural "rotate" and "zoom in/ out" command in 3D CAD modeling. Also, this alternative "rotate" and "zoom in/ out" input can be widely applied to different 3D CAD softwares. Brain-computer interface (BCI) has been applied to the various fields: BCI embedded robot arm control (Chapin et al., 1999); BCI game (Krepki, 2007) BCI embedded smart space design (Huang, 2011).

To improve the unintuitive and unfriendly interface of 3D CAD software (eg. Maya and 3D studio Max), this research combines BCI into CAD system to create a better interface in 3D CAD manipulation. By monitoring user's brainwaves generated when intending to perform different commands (see figure 1-right-B), the user is able to easily control the 3D viewport "zoom in/out" command through imagining zoom in/out instead of relying on the traditional input commands (keyboard + mice or graphical icons).
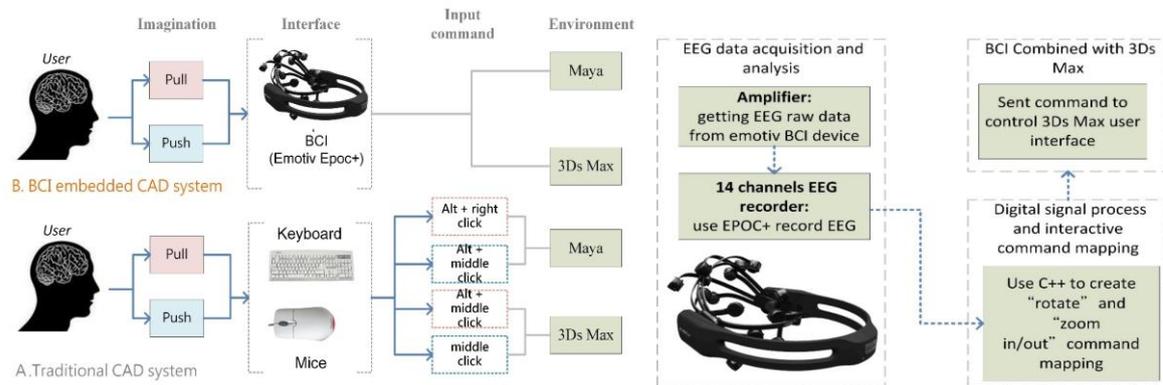

Figure 1. Left) The comparison of BCI CAD system and traditional CAD system; right) BCI CAD system framework.

3. METHOLOGY AND STEPS

In order to implement the "BCI embedded CAD" system, the methodology of the research is divided into three steps: the first step: the BCI training process via EPOC+ for new users; the second step, BCI embedded CAD system implementation; the third step, scenario demonstration and discussion:

The First Step, BCI Training Process via EPOC+ for New Users: In the past BCI devices, a new user's brainwaves could be recognized for high accuracy if the user went through a long time training process to achieve the goal. In order to ensure that the EPOC+ can be widely for every users, the first step of this research is to find out how to create a short and effective training process for new users. After the training process, the user can achieve 90% accurate control the virtual object in 3D environment.

The Second Step, System Implementation: This step divided into three parts, EEG data acquisition and analysis; digital signal process and interactive command mapping; BCI combined with 3Ds Max by using C++ and maxscript (see figure 1-right).

The Third Step, Scenario Demonstration: In order to demonstrate the system prototype the subjects are asked to build a box and try to use the imagination command to zoom in/ out the box in 3Ds Max.

4. BCI TRAINING PROCESS VIA EPOC+ FOR NEW USERS

The first, EPOC+ Installation: in order to acquire the accurate signal, the subject would follow the steps to install the EPOC+ system. First the user has to wear the EPOC+ to his head. Second the user opens the EPOC+ software to check the contact quality of each sensor. The sensor electrode figure appeared the quality of the contact quality from green, yellow, orange, red and black which is mapping with the high quality to low quality. Third the user starts to train the neutral brainwave and any of commands (push, pull, left or right) brainwaves. Forth the user tries to use imagination command to move the virtual box.

The second, Experiments of BCI Training Methods: In order to enable the user wearing EPOC to control the viewport in 3D Max, we need to find out how to complete a training process to successfully zoom in/out of the virtual box via the imagination. Therefore the research firstly establishes an experiment procedure which is able to achieve over 80% accuracy to control the imagination command (which is valid signal). "Valid signal" means, in 5 seconds, after the voice command (e.g. pull), the user can successfully complete a 3D max command (zoom in the virtual box) via imagination through the EPOC device. EEG brainwaves is as the same as fingerprint, different users has their different pattern, in order to over 80% accuracy mind control, every user has to go through the training process before using the BCI embedded CAD system.

Therefore in order to find out a short and effective training process for every new user, we go through three different types of training procedure. In each training process, the user needs to achieve 80% accuracy to control the virtual object in 3D max. In each training experiment, the user will test the "imagination command" by randomly testing push or pull command for 50 times to evaluate the accuracy (see table 1).

Training experiment type 1 the user first goes through the neutral training 1 time and the push training 1 time and then try "imagination of push test" 10 time. And then repeat the previous action for 10 times. Second the user goes through the pull training 1 time and then tries the "imagination of pull test" 10 times. And then repeat the previous action for 10 times. Finally the user test the imaginations of push or pull for 50 times. The accuracy of imagination of push or pull mix command is 76%.

Training experiment type 2 the user goes through the each of neutral training, push training and pull training for 10 times. And then the user test the imaginations of push or pull for 50 times. The accuracy of imagination of push or pull mix command is 84%.

Training experiment type 3 the user goes through each of neutral training, push training and pull training for 20 times. And then the user test the imaginations of push or pull for 50 times. The accuracy of imagination of push or pull mix commands is 84%.

Table 1. BCI training experiments

Experiment type	Training procedure	Randomly test imagination of push or pull 50 times (Accuracy %)
Experiment type I	First step: Neutral training x1 time / Push training x1 time } Imagination of Push test x 10 times Second step: Repeat first action 10 times Third step: Pull training x1 time } Imagination of Pull test x 10 times Firth step: Repeat third action 10 times Fifth step: Randomly test imagination of push or pull 50 times	76%
Experiment type II	First step: Neutral training x10 times / Push training x10 times / Pull training x10 times Second step: Randomly test imagination of push or pull 50 times	84%
Experiment type III	First step: Neutral training x20 times / Push training x20 times / Pull training x20 times Second step: Randomly test imagination of push or pull 50 times	84%

In three different types of experiments, we can find that the imagination of push or pull test would not affect the result of accuracy. Therefore this research declared that the new user can achieve the 80% accuracy to use the mind command controlling the virtual box by going through the experiment type III.

5. SYSTEM IMPLEMENTATION

In the system framework, there are two building blocks, namely, 3ds Max plug-in and Emotiv API, respectively. The main task here is to provide an interface between 3ds Max plug-in and Emotiv API to realize the communication in one direction from EPOC+ hardware to 3ds Max software. Therefore, the requirement is just a single plug-in file in 3ds Max by using the Emotive API. Customizing our own plug-in function in 3ds Max is easy since the software itself is formed of many plugins. The most well-known part is the user interface around the 3ds Max which allows user to set their own way via Maxscript or dynamic link library. All the design of user-specified plug-in can accomplish by using 3ds Max SDK. Hereby, to our proposed system, the plug-in is event-triggered by the zoom in/out signals from EmoEngine, provided by Emotiv API and response zoom in/out of the object in 3ds Max. Keep reading the state of the user and

provide signal to judge whether the object should zoom in or out is the main program of our plug-in software. When one completes the training step, he or she can simply download the plug-in and start to customize the zoom in/out feature by imagination. That is, a simplest and most intuitive way.

6. SCENARIO DEMONSTRATION

In order to demonstrate the system, the subject goes through the training procedure. The user approximately used 18 minutes to finish the training procedure. In the scenario demonstration, the subject first wore the EPOC+ headband and checked all electrode contacts quality achieving green color. After the subject building a virtual box in 3Ds Max, he began to use the imagination command to "pull" the box. After 1.5 second the subject successfully zoom out the box of the viewport. And the subject keeps using mind command to zoom in the virtual box. After one second, the subject smoothly zooms in the box.

Figure 2. Scenario demonstration: A) user wears EPOC+, and check the electrode contact quality; B) the user started to use imagination command to zoom out the box of the viewport; C) the user smoothly zoom in the box of the viewport.

7. CONCLUSION

The research creates a "BCI embedded CAD" system prototype with the connecting with the connection between EPOC+ 3D studio Max via maxscript and C++. Through the system, the user is able to enhance the ability in 3D modeling through "thinking the commands". For a new user, after going through the training procedure this research designed, he/she can finish the training process within 20 minutes. And the user is able to achieve the 80% accuracy using the mind command to push or pull the viewport in 3Ds Max.

However, in the scenario demonstration, sometimes the user used both "mind command" and "physical interface (keyboard or mice)" to control the virtual box. Therefore, the future study would focus on applying "BCI embedded CAD" system to cross 3D CAD platforms (3Ds Max, Rihno, and MAYA). It can be better to understand if the BCI embedded CAD users can perform higher efficiency than traditional users.

As to the contribution, the research would be significant not only in the architecture engineering but also the wide design fields. The limitation of the study, the system can only control on/off signal (pull or "invalid pull") to zoom in/ out the viewport. In the future study, the system can be improved to precisely zoom in a bit, more, or partially viewport.

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