Jurnal
Teknologi

Full Paper

FRAMEWORK OF CONTROLLING 3D VIRTUAL HUMAN EMOTIONAL WALKING USING BCI

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Article history
Received
3 December 2013
Received in revised form
2 July 2014
Accepted
25 November 2014

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Graphical abstract

Abstract

A Brain-Computer Interface (BCI) is the device that can read and acquire the brain activities. A human body is controlled by Brain-Signals, which considered as a main controller. Furthermore, the human emotions and thoughts will be translated by brain through brain signals and expressed as human mood. This controlling process mainly performed through brain signals, the brain signals is a key component in electroencephalogram (EEG). Based on signal processing the features representing human mood (behavior) could be extracted with emotion as a major feature. This paper proposes a new framework in order to recognize the human inner emotions that have been conducted on the basis of EEG signals using a BCI device controller. This framework go through five steps starting by classifying the brain signal after reading it in order to obtain the emotion, then map the emotion, synchronize the animation of the 3D virtual human, test and evaluate the work. Based on our best knowledge there is no framework for controlling the 3D virtual human. As a result for implementing our framework will enhance the game field of enhancing and controlling the 3D virtual humans' emotion walking in order to enhance and bring more realistic as well. Commercial games and Augmented Reality systems are possible beneficiaries of this technique.

Keywords: Component, emotion recognition, EEG, BCI, framework

1.0 INTRODUCTION

3D Virtual Human animation is considered as a main research focus of computer graphics, this research comes from the widest implementation within various fields in this domain i.e. computer games, cartoons, computer simulation, advertisements, movie special effects, etc. From [1] points of view, all the researchers classify computer animation techniques within computer graphics domain. Nevertheless, with the rapid revolution growth of computer graphics in the field of animation, it becomes no longer constrained by traditional computer graphics but in fact widely become promising in many research areas. The previous studies make numerous concerns on visualization and animation through digital environment [2-4].

Occasionally, modeling and designing humans by means of a single body within computer graphics are decreased to a simple 3D Virtual Human, such as arms, trunk and head [14, 15] which makes the control of real human like easy. Flexibility of controlling interactive applications of 3D Virtual Human animation is currently extremely limited [16]. Since common input devices that aforementioned include only a quite small freedom degrees number, the game player feel limited [16], this leads to inhuman-like behavior for the 3D Virtual Human animation. Within the existing control devices, it is quite not possible for gamers to pose the 3D Virtual Human movement freely based on players emotions, or at least to make the 3D Virtual Human perform a variety of actions based on the gamers own style[16].

For instance, gamers may want 3D Virtual Human to perform a various movements in context of fighting action as well as interactive dance animation, or use variety of gestures based on users' emotion feeling in order to interact with the game [17]. Computer animation domain divided as well as categorized into many categories i.e. plain 3D Virtual Human animation, motion capturing based animation, emotion based animation, etc.

Emotion based 3D Virtual Human animation consider to be as one of the promising research domain in the animation field [10-11] since there is a quite lack of interacting between gamers and games in the course of emotions [16,17] . Animation based on emotion is not just visualize emotion in a character, of course no, it is much more than this idea. Visualizing 3D Virtual Human to get an emotional behavior of 3D Virtual Human is beyond over animating a smooth animation process. This means we should comprehend as well as develop 3D Virtual Human environments, circumstances and movements that are emotionally expressive. In such a context we need to generate homogeneity that reflects the emotional feelings to the audience. There are many ideas and concepts that have been explored as well as applied in order to bring greater emotions and devices last few years [13].

2.0 PROBLEM BACKGROUND

3D Virtual Human animation in the field of game research still requires a quite lot of enhancement particularly on how to provide users attractive interaction. Many researches on 3D Virtual Human animation have been conducted by previous researchers, in order to be well knowledge and to have a chance for improving this related field in term of realistic. The main goal to be highly achieved is the interactivity between gamers or users and 3D Virtual Human animation regarding the behavior based on gamers emotions [6, 21, 22, 23, 24]. Many methods have been proposed in order to be a method of bringing emotions into a 3D Virtual Human animation [18, 12, 16]. All about the interactivity that considered as the most important aim to be accomplished in the course of games that based on the virtual reality environment. [19] Believed that the main component that makes the 3D Virtual Human animation realistic, possibly will be walking as real, feeling as real, acting as real, gaze moving as real and talking as real. Currently, in the course of 3D Virtual Human animation in gaming domain the 3D Virtual Human come into sight to be quite real like, however there are still existing barriers in expressing emotions of 3D Virtual Human in depth. Nevertheless, expressing 3D Virtual Human animation in colors, wearing cloths, shadowing the moving cloths and facial expression have been quite successes, but still very weak in term of emotion walking. Mainly, in several interactivity models like dancing motion, fight games, 3D Virtual Human walking and real-time interactivity using 3D Virtual Human animation still mainly limited [16, 17]. For instance, gamers may perhaps want a 3D Virtual Human to do different moves in walking, interactive dance animation, fighting games [16, 17], without real emotion feelings how it will be done perfectly to simulate human.

As a primary concern, supposed to be focused on how making a reaction within 3D Virtual Human motion walking in term of players' emotions. Any produced digital environment have to be understood regarding gamers emotional feelings to facilitate gamers improving as well as understanding the familiarity of playing 3D Virtual Human motion walking in games.

3.0 PROBLEM STATEMENT

In the previous section we have discussed a lot of several issues that mainly possible considered to be as research issues on virtual reality domain. The above- mentioned discussion explains obviously that there are lot of opportunities to improve virtual reality environment in term of emotion to be more realistic and real humanlike. On this work we focused on emotional mood that referred to real life human emotion in order to map it to 3D Virtual Human walking in virtual reality.

Why we focus on real life human emotion?, based on our previous discussion in the problem background, there are several researchers developed virtual 3D Virtual Human to simulate real human, that should be act and behave in term of emotions, mostly like real life human which based on facial expression and sound effect. But the aforementioned approach in the problem background section, still lack of sense to be emotionally human like. Making 3D Virtual Human emotionally humanlike, considered to be an essential element that gives more presence to 3D Virtual Human emotion walking. Our study focuses on finding the optimal approach to synchronize and control human emotion with 3D Virtual Human animation, in order to increase the capability making it quite real in term of emotions.

Deeply, producing various types of real-life emotions and synchronize these emotions with 3D Virtual Human, gives an accurate human-like 3D Virtual Human. Generally the idea, is to propose new interaction model that based on human emotions, which are suitable for representing the emotional states of real human on the 3D Virtual Human. This emotion representation has been mapped by using Circumplex emotional model, then synchronized these emotions with the 3D Virtual Human animation for representing a real-life of human like 3D Virtual Human animation walking system.

4.0 CONCLUSION

Game in virtual reality environment has been used in several areas i.e. medical domain simulation [32]. In all previous studies most of concentration are to increase the virtual environment reality in term of emotion. One of the researches applied the emotion with interaction in virtual environment [1, 26, 27, 28, 29]. Because of the expanding range of applying the human emotion within the virtual environment still need much more of definition with more efforts. Moreover, real life human emotion has strong effect on enhancing the interactivity. Therefore, this scenario depicts us a significant research area to be further investigated. Basically, our propose approach tries to combine real life human emotions with 3D Virtual Human animation walking, in the context of human virtual reality within game system based on brain computer interface (BCI). As a result, our proposed approach involves real life human emotion within 3D Virtual Human animation walking, which is very important for the future reality game that quite reflect the reality [19, 26].

5.0 LITERATURE REVIEW

VR gaming comes from VR as well as game. So, hereafter we will clarify a lot that related to VR and gaming. After that we will give details regarding the VR gaming that has been produced throughout the development of VR and gaming technology. VR grow to be highlighted concern in order to imitate the real interaction as of real life to the VE on PC. Furthermore, many fields used as significant games in order to simulate and handle medical status, training of military and education fields [2].

The aptitude of VR arrangement to react according to the user action is called interactive. Interactivity has several ability such as the ability to persuade the virtual world in computer, the ability to change point of view inside the virtual world [40]. Another interactivity element is collaborative environment (see Figure 1). This environment allows VR user to interact among each other and shared their experience together. Sims (1997) in M. Rossou [5], interactivity is a function of input that needed by the users during their interaction with computers.

Virtual human within the simulated surroundings turn out to be some significant due to his capacity to be prepared by means of judgment making intelligence, visual perception otherwise producing an interaction through their near surroundings [29]. An avatar stands as the enhancement of virtual human which is accomplished to perform alike social existence since they are organized through the information of human from gesture capture [29].

3D Virtual Human animation in the field of game research still requires a quite lot of enhancement particularly on how to provide users attractive interaction.

Figure 1 Interactivity of virtual reality [loaded from http://www.motionanalysis.com/html/temp/bellhelicopter.html]

Many researches on 3D Virtual Human animation have been conducted by previous researchers, in order to be well knowledge and to have a chance for improving this related field in term of realistic. The main goal to be highly achieved is the interactivity between gamers or users and 3D Virtual Human animation regarding the behavior based on gamers emotions [6, 21, 22, 23, 24].

As a primary concern, supposed to be focused on how making a reaction within 3D Virtual Human motion walking in term of players emotions. Any produced digital environment have to be understood regarding gamers emotional feelings to facilitate gamers improving as well as understanding the familiarity of playing 3D Virtual Human motion walking in games.

So that, the main obstacle in 3D Virtual Human animation environment is how to simulate the 3D Virtual Human motion walking that covers all emotional domain [30] as well as to control them to be humanlike in term of emotions. Humanlike 3D Virtual Human emotion walking by means of performing convinced action in term of emotions.

Generally, the foremost purpose of the Brain-Computer Interface (BCI) investigations was to, controller and replacement of motor performances aimed at patients with pure inabilities considerately since of unjustified decisions that might the mind harvests that motive particular limitation for persons who repose on a BCI arrangement to achieve their work. Thus that it was an irrepressible intention to contemplate any sort of standardization of BCI. Joining VR with BCI equipment has rapidly been estimated as very promising. Here, we have investigated the relative relation among VR and BCI.

The brain computer interface (BCI) knowledge permits a straight joining among the computer and the brain lacking any well-built action vital (Aloise *et al.*, 2010) [1]. This knowledge is encouraging for incapacitated people, (BCI) presentation intensive attention to the governor of a wheelchair [2], BCI has perceived considerable amount of development in the medical domain, for instance, for prosthesis governor or by means of biofeedback rehabilitation for the management of neurological disorders [3]. In the further sideways of BCI practice are video games, BCI castoff toward regulating video games by means of mind signal in its place of old-style controllers (e.g., joystick, mouse, keyboard, etc.) to be castoff over well people at the same way castoff by disabled people. Currently, full body interface through 3D VG is considered to be the new development [4]. Along with the mentioned, BCI used in instructive requirements, the shared pattern in this ground is a dropping paradigm. P300 BCIs are characteristically castoff to invocate [7], [8], [9].

6.0 THE FRAMEWORK

As we aforementioned in previous sessions, this paper is focusing on developing a new approach that combines human emotion with 3D character walking, in order to realize our research goal 3D virtual human motion walking in term of emotion. Basically, this paper will be constructed as well as designed in models, construction boxes and evaluating result for the new output (see Figure 2).

Basically, in details the proposed approach needs to be developed according to three main steps based on objectives that aforementioned in previous sessions, which have been involved in the research.

First step is brain signal classification which includes Brain signals using Brain Computer Interface BCI and Real Human Emotion Classification.

Second step covers all processes in emotion mapping such as HIGUCHI fractal dimension Feature extraction, Emotion classification based on Circomplex model and Emotion Dataset.

Third step of 3D virtual human motion there are three main processes, namely virtual human Walking, Behavior Controlling and Emotional Walking.

6.1 Brain Signal Classification

We mentioned at the beginning of this paper, that the game field within virtual reality domain requires much more interactivity in order to obtain users interaction as well as their attention in term of emotion and then reflect the players' behavior to the game 3D character. Basically, in order to solve the problem we will use brain controller that enables the players to transfer the emotions to the 3D virtual human as well as control that character in order to interact with the virtual environment. In the course of the previous chapter we explain about the brain activity, brain signal, emotion recognition and emotion classification, also about human emotion enabled interaction recognition based on EEG and dominance level [25]. In addition, [33] and [31] also explained about emotion diagram model based on human emotion.

Furthermore, in order to produce an accurate classified emotion to be ready for synchronizing with 3D character emotion walking as well as controlling the walking behavior, the acquired mental activity that represented by brain signals must subject to pre-process by means of features recognition . Therefore, there are lots of BCI- based emotion recognition methods that have been proposed and implemented for the last few years. All of these works involved the extraction of Electroencephalogram (EEG) signals of brain activities (see Figure 3). Then, the signals are classified into several parameters which are suitable for controlling the emotion specifically.

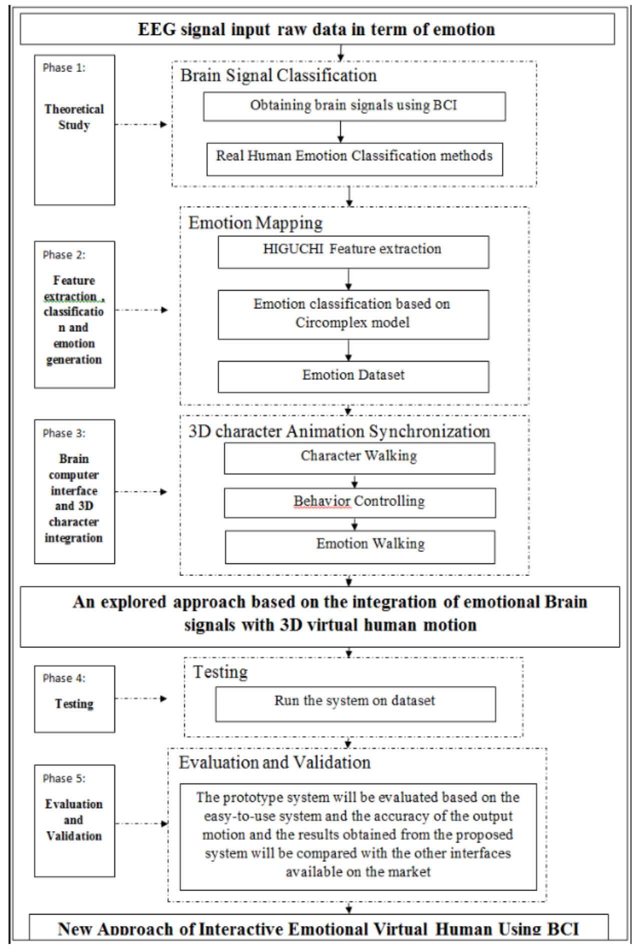

Figure 2 Illustrates the detail of our research methodology

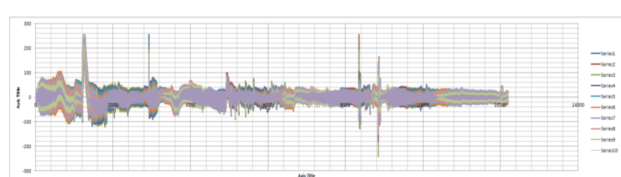

Figure 3 Emotional brain signals sample

6.1.1 Obtaining Brain Signals using Brain Computer Interface BCI

Brain computer interface BCI is the advance rebellion in the technology of the media of communication, in other word, it is known as a communication structure that does not need any activities of peripheral muscular [34]. Certainly, BCI arrangements permit a matter to direct the features extraction to an electronic device by the help of brain activity [35]. These states of features identified above denoted through the signals of ElectroEncephaloGraphy EEG. Where there is various mental activity have been considered through the investigators (emotions, movement, motor imagery and talking) [36]. Basically Brain-Computer Interface is not being applied for simulating the virtual human yet. In order to adapt the BCI with the virtual human field, a set of new methods need to be proposed to match the purpose of this research. All these new methods can be patented separately or entirely.

6.1.2 Real Human Emotion Classification

After acquiring the desired data signal that represents the real human emotion, still we need to find out the real human emotion. Therefore, new representation of emotion based on BCI need to be introduced before we can proceed. The proposed emotion representation has future potential to be patented in the 3D character animation walking in the course of emotion. Several BCI-based emotion recognition methods have been proposed for the last few years. The signals are classified into several parameters which are suitable for controlling the emotion specifically.

6.2 Emotion Mapping

After acquiring as well as classifying the real life human emotion, we need to map the real human emotion to Circumplex emotional model. This process involves all real human emotions that represent all categories of human emotion expression. Two main elements of emotion mapping process namely, real human diagram [31] and the human emotion measurement results that we obtained through the experiment [12].

6.2.1 HIGUCHI Feature extraction

Liu *et al*. [37] introduced fractal dimension based algorithm of quantification of basic emotions and describe its implementation as a feedback in 3D virtual environments. User emotions are recognized and visualized in real time on his/her 3D character by adding a parameter called "emotion dimension" to human computer interfaces.

In our research study, we will use Higuchi algorithm [40] based on fractal dimension computation values. Higuchi algorithm provided improved accuracy not like other fractal dimension algorithms as stated in [41]. At this point, the Higuchi algorithm was evaluated using Brownian and Weierstrass functions where theoretical FD values are known.

In conclusion, the HIGUCHI fractal dimension calculated values with the Mean will be recognized as an emotion state through mapping to the emotion that represented in the arousal-valence model. Any changing of HIGUCHI fractal dimension result value will be mapped alongside the axis of arousal refer to Figure 4, the high value of HIGUCHI fractal dimension result positively related to high arousal level.

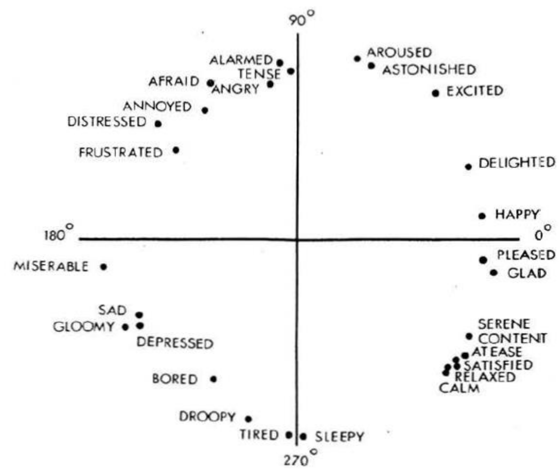

Figure 4 Valence-arousal model for emotions recognition [64]

6.2.2 Emotion Classification Based on Circomplex model

We put in our consideration that each emotion relates to an approximation interval within the Arousal Valence model based on Circumplex emotional model [31] refer to Figure 4. To analyze the EEG signals in term of human emotion, two frequency bands are usually considered: alpha (8-13 Hz) and beta (13-30 Hz). It has been shown that the power of these sub-bands carry useful information about the emotional states. [38, 39] shown that disgust feeling mood caused minimal amount of alpha band power meanwhile, happy caused minimal alpha power. Moreover, [39] found that the peak in the frequencies of alpha band power increases when the human subject mood practices anger or joy, and decreases when the human subject mood practices sorrow or fear.

6.2.3 Emotion Dataset

Basically, since emotion recognition is approximately new domain, an emotional dataset of EEG signals benchmark of dissimilar emotions is quite required to be set up, which might be used in additional emotion recognition research based on EEG. In this study, by depending on NIA brain controller device the dataset will be collected after applying a certain stimulus scenario in the course of emotion, that will be analyzed to come across the inner human emotion patterns (see Figure 5).

Figure 5 Collecting emotional brain EEG data signals

In addition, side by side we depend on building questionnaires that furnish us the right subject reaction regarding stimuli. In the subject matter, we use an individually random persons that should subject to a certain stimuli in order to acquire emotions i.e. anger, happy and fear etc.

6.3 3D Virtual Human Animation

Basically, based on external effects as well as user interaction the 3D character will be animated. in the aforementioned researches the main controller for 3D character animation was keyboard, joystick, gamepad and mouse [20]. 3D character animation based on Emotion, consider to be as one of the promising research domain in the animation field[10-11] since there is a quite lack of interacting between gamers and games in the course of emotions [16, 17]. Animation based on emotion is not just visualize emotion in a character, of course no, it is much more than this idea. Visualizing 3D character to get an emotional behavior of 3D character is beyond over animating a smooth animation process. This means we should comprehend as well as develop 3D character environments, circumstances and movements that are emotionally expressive.

In such a context we need to generate homogeneity that reflects the emotional feelings to the audience. There are many ideas and concepts that have been explored as well as applied in order to bring greater emotions and devices last few years [13]. Moreover, in former studies as well make known that numerous devices are likely to be used in order to generate high quality of game as well as virtual reality related to emotions. Meanwhile, [12] showed that an exploration has been done about the procedure of analyzing human emotion through emotion based on devices, and then implement the analyzed emotion to 3D character animation model (see Figure 6). Most of 3D Character models are frequently simple in order to enhance the performance of simulation as well as to control in somehow. Devices that have been mentioned upward of the introduction considered as popular devices as much as without gamers or users feelings reflection.

6.3.1 Virtual Human Walking

Basically real human motion generates from mental activities, means that the main controller of any human movement is the human mind based on certain feelings. In this research our concern focuses on human movement that stimulated by their emotions. Each motion have an approximation degree of angle that represents the changing direction of motion process[12] which expresses the emotion feelings i.e. anger has certain motion with certain angle process as well as happy (see Figure 6).

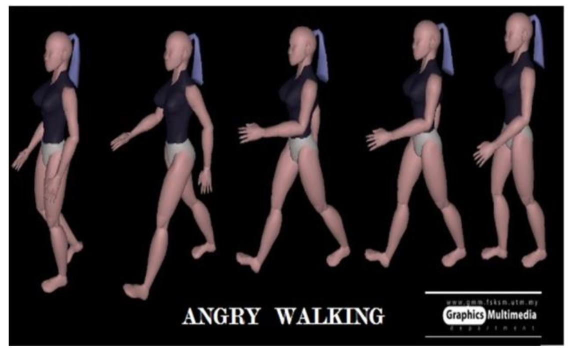

Figure 6 Angry walking transition

6.3.2 Behavior Controlling

Mental role control works by emotionally action reaction. Real human behavior and characteristics simulation in virtual humans has been growing in the field of computer graphics and multimedia [42]. However, there are many scientific studies regarding Real human behavior and characteristics that involve their recognizing as well as their application [42]. Thus, numerous respections have to be considered into view of point of real human characteristics like emotions [42] to express the behavior, that should be added into virtual humans with the goal of making them more conceivable and believable [42].

A quite many architectures based on emotions have been proposed [43–44] in the course of generating and improving the virtual creatures credibility in the field of virtual environments, like 3D character simulation.

Based on previous methods, we come up with a parameters in order to control the behavior of the 3D virtual human in term of emotion i.e. happy, angry, sad, disgusting, fear and frustrated etc., each of these emotion types represented by a certain parameter to come up with its related behavior. By using mind controller we transfer as well as control emotion mental activities. In our study we will use one of the famous devices for mind controller namely NIA, which is consists of number of sensors, we will depend on a certain sensor that called Alpha 1,2,3 and Beta 1,2,3 that show the emotional mental activity level. This sensor type correlates with human mental activity or excitation feelings. This is why this sensor is very suitable for human emotion recognition out of brain tension in the course of emotions.

6.3.3 *Emotional Walking*

Real human emotion will reflect the walking movements of the 3D character animation in term of emotions in virtual environment. From the previous study as well as previous methods we come up with new technique of controlling the 3D character walking based on emotion, it is 3D character emotion walking technique. The technique of emotion walking derived from mapping real human emotion to the virtual environment, then synchronizing these emotions with 3D character animation walking to produce real humanlike 3D character walking in term of emotions. This technique involve main factor of human sense, it is about behavior that represent the human emotion expression. Human emotion expressed by changing the human behavior, that considered as the key of behavior source (see Figure 7). By synchronizing the human emotion with the 3D character animation walking we construct the sense of a real life at virtual human environment.

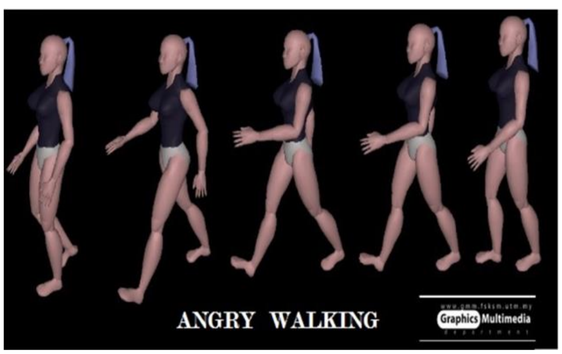

Figure 7 Emotional walking transition (angry)

In this proposed framework, the 3D character animation walking will be classified in the course of emotion. The walking movement represented based on game player emotion. For instance, if the player feel angry, his emotion will be mapped based on the mapping method we use and then will be synchronized with the 3D character, all of the aforementioned steps will be done using mind controller BCI. The result here will be 3D character that behaves in term of emotion quite as the real human behavior, the same for any other emotion that we recognized i.e. fear, happy, joy and angry etc. For further explanation refer to Figure 8.

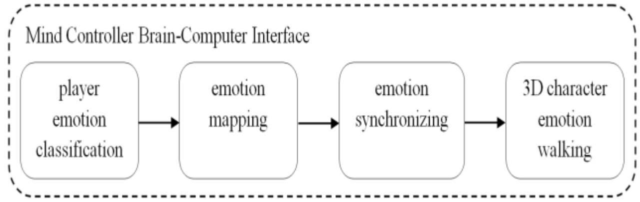

Figure 8 Operational framework for 3D character emotion walking

6.4 Testing Based on Real Case

Basically, this phase of testing is designed to measure the satisfaction of specific condition toward selected real case study. It designed to test the result in order to evaluate each process regarding our proposed method. Initially, we will test using white unit testing method in order to test and measure the functionality of each unit (function) in our application. For instance, testing for emotion mapping part, we will test as well as measure if the emotion mapping can be mapped and synchronized or not. After this stage of unit testing we will go forward for an application testing as a one block, in order to test as well as measure the whole application which considered as one block itself.

6.5 Validation and Evaluation

Validation and evaluation of testing result are obligatory in order to measure if the system whether successful or not in the context of achieving the research aim. [45] Suggested a technique that provides the ability to capture the usability of the game application based on users experience. Nowadays, evaluating game application methods simply based on objective as well as qualitative features of object, that depends on questionnaires data analysis [45]. Questionnaire considered to be general, quite statistical analysis and simple. However, we can gather data based on interview technique, which considers a direct meeting with focus group of players. [46] Explain that the concept of research evaluation technique work on focusing at the research goal.

[46] Classified the research goal into: quantity with quality and subjective mood with objective reality. On the other hand, [47] proposed an evaluation method depending on analyzing video. Since our concern is about behavior that derived from emotion, this type of analysis considered to be well-heeled.

Our evaluation method based on real-time surveys as well as questionnaire, also with video analysis, this leads to get a reasonable balanced evaluation between quantity with quality and subjective mood with objective reality.

7.0 CONCLUSION

The brain interface utilization provides strong credibility and impression to the users in any fields. In this paper, an innovative framework was proposed to synchronize and control the 3D virtual humans' emotional walking based on emotion recognition from EEG signals using BCI. Higuchi FD algorithm with 3D virtual humans' animation system is implemented due to its capability to provide real-time analysis and sufficient accuracy. It allows visualization and simulation of the recognized human emotions as emotion expressions of 3D virtual humans' behavioral to adapt with its environment in real time.

The present work can be used in many fields such as augmented reality, virtual reality, virtual environments and games. This technique renders the virtual emotion more realistic considering the real emotion to be captured from the real life human using BCI.

Acknowledgement

This research is supported UTMVicubeLab, Department of Computer Graphics and Multimedia, Faculty of Computing, Universiti Teknologi Malaysia.

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