A Vibration Tactile Aesthetic to Enhance the Realism of Interactive Game Avatar

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Abstract

This study proposes a new method to augment the realism of avatar by using tactile vibration and facial expression. Currently, interactive game *still lack of interactivity and immersiveness. In this paper, we create an avatar with some intelligence and emotional features in order to support the realism of avatar. Our approach based on mapping the 2D valence emotion diagram to particular magnitude vibration. We also consider the duration of vibration and the acceleration time that occurred during vibration. Through the experiment we succeed for classifying and mapping into two emotion states: angry and happy. Furthermore, our result has proven to differentiate in detail the emotion levels of angry. The result also compared to the previous result and we have obtained 35% until 55% better than the previous avatar in term of human perception that involved into avatar. This result is believed as well to enhance the interactivity and immersiveness of interactive game for overall.*

Keywords

Tactile Vibration, avatar, emotion, interactive game

1. Introduction

Research on Virtual reality and Game still need a lot of improvement especially on how to immerse user and provide user with attractive interaction [1,2,4]. We will be discussing a lot of previous research in virtual reality game that has been conducted by other researcher in order to search for any chance for improvement. The interactivity and immersiveness are considered as the main goal that need to be achieved in virtual reality (VR), especially when it used for educational purpose, virtual training, virtual institution and etc [1]. On the other hand, virtual environment potentially gives user a lot of educational information such as how to study ethics and science during the early age. Children for example can easily learn about trustworthiness and honesty, basic justice, being fair, preventing harm and etc through real example A.Meyeen[1,2]. Furthermore, M.Rossou in [4] suggested that virtual reality (VR) has a great potential to educate children by providing synthetic example as add-on to the traditional educational method. Therefore by manipulating VRG as an educational tool, numbers of research have been proposed as initial steps to provide better educational approach. The studies covered the impact, readiness of the tools and potential of VRG to improve the learning process [2,3,4,5,6]. Virtual reality has been a greater focus on fundamental application in most of engineering fields (medical systems like surgery simulation), government defend system (military simulation training, flight simulation), and other engineering fields that related to real life [5,6,7].
In order to produce the virtual reality convincingly and look realistic, previous researchers also combine emotion and social parts to control the navigation of virtual characters in order to respond and move the virtual characters according to the emotional condition of the player [3]. Emotion expression in computer usually express by facial expression and acoustic. Furthermore, the emotion is also added to avatar with the intention to increase the realism of avatar itself [7,8,15]. From the cues that we have explained above, we will have an idea to enhance the realism of avatars by expressing their emotion through haptic vibration. Utilizing haptic will make us able to sense more on avatar emotional expression and behavior.

This paper is classified into six sections; Section 1 introduces the research and the background of the idea, Section 2 highlights the current and previous research that focuses on avatar, haptic and virtual reality

environment, Section 3 present about review in vibration tactile, game environment and avatar. In Section 4, Experiment has been conducted. Finally, the conclusion and future works is drawn in section 5.

2. Related Studies

Previous studies also reveal that many devices potentially can be used to produce high quality virtual reality and game, and one of the devices is called haptic devices. Bailenson et.al [11] explored about how to analyze human emotion through haptic device. Virtual environment constructed from 3 basic elements: immersion, interaction, and presence. Head Mounted Display (HMD) can help user to give an immersion sensation, the other devices like trackers and hand glove also have high possibility to give immersion [10,16,17]. Those devices can be used for navigation and interaction between user and object inside of virtual environment [16]. Problem in developing virtual reality for health application is how to immerse user if the object cannot respond to user action [16]. In order to achieve action-reaction between human and virtual reality system, it's essential to involve cognition model[16]. There are several elements that create cognitive science such as: philosophy, psychology, neuroscience, linguistics, anthropology, computer science elements and artificial intelligence elements[19,20]. Furthermore, Pimental and Teixeira,1993, stated that immersion and interactivity are vital elements inside of virtual reality; "The question isn't whether the created world is as real as physical world, but whether the created virtual world is real enough for you to suspend your belief in a period of time".

J.Brayton[10] stated that ideal virtual reality should provide user an environment that can be controlled and sensed by touch, sound, taste, and smell. Big goal of Human computer interaction application like virtual reality is how to involve more than one user and combine multiple human senses such as: vision, speech and haptic in order to acquire more interactivity and immersiveness [17,18,19,26,27]. G.Ye in [17] declared that Vision-based interaction can be used to replace traditional tools like mouse, keyboard and joystick. While other researcher tries to make virtual human (avatar) able to show a particular emotion using facial expression, sound effect and even with sense of touch [15,18,21,22,25].

N.Zagalo in [21,22]created virtual human that can express their emotion using body touch and even supported by the alteration of environment like hue, brightness and saturation. D.Traum in [15] concentrate on how virtual human can behave like human being by increase their ability to make a dialogue that more interactive. J.N.Bailenson in [11], has conducted an experiment for recognizing human emotions from experimental result are classified into different seven emotions, such as: anger, fear, disgust, sadness, joy, interest and surprise. Their emotions are expressed through joystick haptic devices, and later the application will record every interaction of human characters for documentation. Bailenson et.al [11], has focused his research on how the to describe the human emotion from real human experiments using DOF Joystick (one of haptic devices). The research involves experiments on several students to express their emotion by touch and moving the keypad of joystick. Their emotion will be recorded during their activities and saved into digital format. According to previous research they can model and recognized seven human emotions during the experiment [11]:

1. Anger
2. Fear
3. Disgust
4. Sadness
5. Joy
6. Interest
7. Surprise

Numerous researchers tried to increase the interactivity and immersiveness by enhancing the visualization and animation using particular game engines. However sense of touch still remains rarely unexplored even tough haptic considered as the third main bottleneck problem in virtual reality game. Virtual human (avatar) has been studied often in recent times. Previous researches add human emotion from visual (facial expression) or sound effect to show behaviour of virtual human in virtual environment[12,13,14]. Touch gives a better opportunity to put on virtual human and add his ability to imitate real human due to haptic that can give bilateral exchange from physical world to virtual environment. The possibilities of involving the human behaviour into virtual human characters and the technology of haptic device give us a chance to conduct research on combining human emotion and haptic in order to realize the goal: augmenting interactivity and immersiveness.

3. Vibration Tactile, Game Environment and Avatar

Tactile haptic display makes a concern on measuring the skin ability in order to translate specific responses such as pressure, temperature, electricity and pain. There are two methods that usually used to affix user into display are attach actuators to participant

hand or instruct the user to grasp wand, joystick or steering wheel. Tactile display has several actuators such as inflatable bladders, vibrators, pin arrangements, temperature-regulating devices and specialized pressure device.

3.1 Vibration Tactile

Virtual reality systems give a valuable research on voice and facial expression. But voice expression is considered as not an advanced problem since it can be recognize easily using digitized audio stream. Facial expression gives a lot of empty rooms for research especially using computer vision tracking algorithm. However, one-on-one interaction between haptic device and person still less explored rather than voice and face. Touch already become more trustable, for example Crusco &Wetzel, 1984 in [11] explains that "waiters who briefly touch their customers receive higher tips than those who do not". Even though touch becomes more trustable, it also still less being used because touch can be turn into problematic and it also need close distance or close relationship [11].

Bailenson in [11] add the classification of human emotion based on characteristic from haptic experimental result. He classified the measurement of human emotion into several measurement points such as distance, mean speed, standard deviation of speed, mean acceleration, standard deviation of acceleration, angle, standard deviation of position, standard deviation of the major axis. The detail of human emotion information listed in Figure 1.

Measurement	Disgust	Anger	Sadness	Joy	Fear	Interest	Surprise
Distance	Short	Long	Short	Long	Short	-	-
Speed(M)	-	Fast	Slow	Fast	-	-	-
Speed(SD)	-	Jerky	Steady	Jerky	-	-	Jerky
Accel(M)	-	Faster	Slower	Faster	-	-	-
Angle(SD)	-	-	-	-	-	-	-
Position(SD)	-	-	-	-	-	-	-
Major(SD)	-	-	-	-	Short	-	-
Minor(SD)	-	-	-	-		-	-
Major (%)	Square	-	Rectangular	Square	Square	-	-

Figure 1. List of human experimental result on emotion measurement [11]

J.N.Bailenson in [11] has record the angle of joystick direction from players during the experiment. The experiment use scaling method and axis to measure and decide the direction of object then calculate the angle of joystick. The complete angle recording can be shown in Figure 2.

Figure 2. Angle direction recording result [11]

3.2 Interactive Game Environment

The ability of VR system to respond 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 [16]. This environment allows VR user to interact among each other and shared their experience together. M.Rossou [4], interactivity is a function of input that needed by the users during their interaction with computers. Interactivity has a lot of usability on social interaction especially when it applied in education. Amthor in [32] "people retain about 20% of what they hear; 40% of what they see and hear; and 75% of what they see, hear, and do ….". Therefore virtual reality that consist digital multi environment has a chance in order to facilitate interactivity on digital environment from psychological aspect and also action-reaction aspect.

3.3 Avatar

Virtual human or virtual actor (avatar) inside of virtual environment pay a great importance to an avatar's ability due to be equipped with decision making intelligence, visual perception or even to make a contact with their surrounding environment [8,15,21]. An avatar is the improvement of virtual human which is capable to behave like human being because of their controlled by human data from motion capture [22,23,25]. The sample from virtual human (avatar can be found at Figure 3)

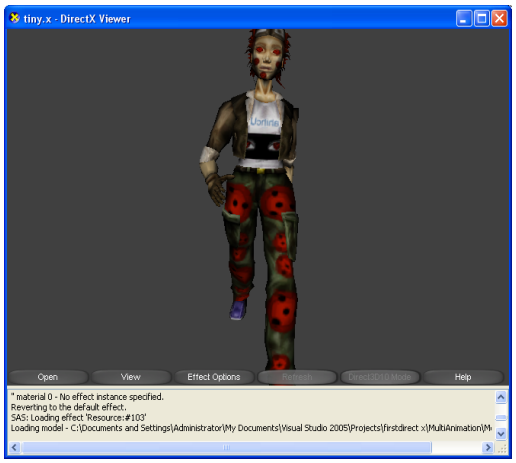

Figure 3. Sample for Virtual human (avatar) [Source:Microsoft Directx-3D object-tiny.x

Facial expression and movement like smile or laugh is needed to construct a semantic function or to communicate emotions. Ekman in [26] developed some application for facial analysis. They grouped some facial expression of human into numerous action components. After that they illustrate the facial expression into six fundamental emotions: joy, anger, surprise, disgust, fear and sadness. The first researcher that works on facial animation is Frederic I.parke in 1970's. Recently, the quality of facial animation is growing rapidly together with the maturity of hardware and software technology (see figure 4 and 5) [26].

Figure 4. Avatar-Angry Expression

This avatar is created to show the facial expression through visual perception of user. The emotion of avatar that has been investigated in this research is angry and happy. From the emotion theory these two emotions are contradictive. This can be illustrated by looking at Figure 4 and 5. The avatar-angry has little smile and large eyes than avatar- happy. Figure 4 and 5 show the dissimilarity between two emotional expression by changing eyes and mouth.

Figure 5. Avatar-Happy Expression

4. Experimental Results

4.1 Experimental preparation

Our experiment save run on PC Pentium 4 with RAM 2 GB and VGA card 512 MB. We connected two haptic devices that commonly used by peoples such as joystick and wii mote. We choose those haptic devices due to its affordable to use. The joystick was connected using USB cable and wii mote linked by wireless connection. To hold both devices, various design grip has been introduced. Gripping such device comes into considerable because the grip is designed to show that vibration on hand is able to measured and reach the maximum effect based on human response to vibration by M.J Griffin in [31]. Based on Griffin method we have come up with our own designed like shown in Figure 6 and 7.

Figure 6. Grip handling based on M.JGriffin[31]- Joystick

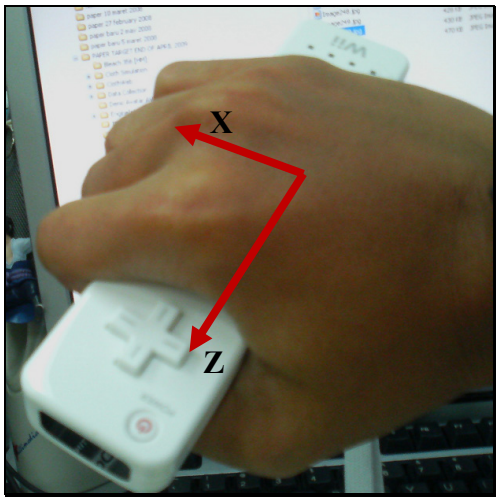

Figure 7. Grip handling based on M.JGriffin[31]-wiimote

4.2 Method

Our method was implemented by mapping the 2D human emotion diagram like which is inspired by N.zagalo and Antonio Camurri [21,22,28,29] in figure 8.

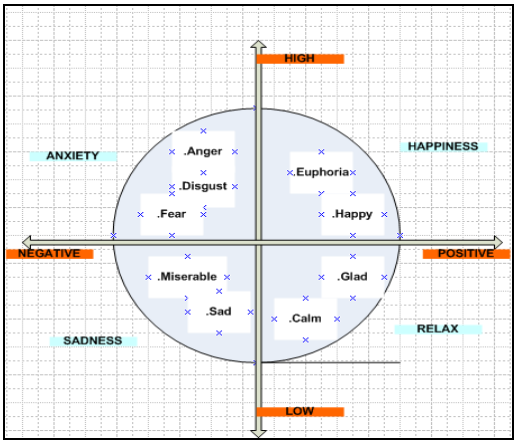

Figure 8. 2D emotion diagram

In order to realize our goal on finding the suitable vibration of haptic device we have classified the emotion of anger and happy like shown in Table 1.

Table 1. Emotion Mapping Result

Emotion	Characteristic
Anger	High and Negative
Happy	Somewhat high and Positive

In our research, we have made a hypothesis based on "human response to vibration M.J Griffin (1990)" that anger can be stimulated by high vibration and long duration. While happy has lower frequency than anger due to a lot of human pleasant with medium vibration frequency [30,31]. From our experiment we observed several frequencies from haptic device that able represent emotional condition of avatar. We also created and synchronized several magnitude frequencies with facial, body expressions, and acoustic of avatar to support the believable avatar expression during the process. The detail about our methodology can be viewed at figure 9.

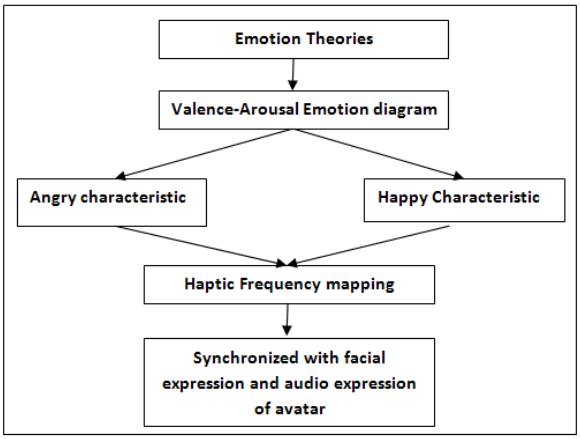

Figure 9. Methodology for Haptic vibration mapping

Assuming the vibration is the only component to stimulate expression might be meaningless and not accurate. This is due to the fact that human emotion expressions work by manipulating number of input such as tactile frequency, facial expression, body gesture and even audio representation. We have synchronized every avatar action with tactile frequency. In addition it also added with highest frequency (10000Hz) of haptic tactile and with magnitude period of time. In Figure 10 and 11 avatar seems to be more relax and happy and the magnitude vibration is decreased into 7000 Hz.

Figure 10. Avatar- Rilex-Walking

In Figure 10 and 11, avatar seems to express its emotion in happy mode and try to waling calmly.

Figure 11. Avatar- Happy-Walking

The highest level of angry emotion from avatar is expressed via facial and body expression that is shown in Figure 12. We have organized the level of angry into 3:

- Low Level
- Medium Level
- High Level.

Figure 12. Avatar- Angry-Walking

Testing was performed some data mapping from emotion valence-arousal diagram into a particular of haptic tactile frequency by utilizing directX and XNA library. The time period was plugged to each vibration from 1000000µs -10000000µs (maximum). The detail about the emotion classification from each emotion can be seen in Table 2 and 3. The original wave length theory is based on wave length speed and time. This equation is also used by M.J Griffin to measure human response to vibration in term of vibration signal effects:

$$Speed(S) = \frac{Wavelength(\lambda)}{Period\ Time(t)} \quad (1)$$

We also use the wave theory with some modification to evaluate the tactile emotional frequency with speed measurement and magnitude duration. The formula of speed can be measured by calculating the magnitude frequencies and the Startup Period Time. Startup Period Time which is needed to start the motor tactile vibration until it reaches the stable rotation. This formula is modified from wave length theory.

$$Speed(S) = \frac{Magnitude\ frequencies(M)}{Startup\ Periode\ Time(ST) - Magnitude\ Duration(M)} \quad 2$$

Table 2. Magnitude vibration table for avatar using

Haptic Measurement				
Emotion	Tactile Frequencies	Magnitude Duration (in ms)	Startup Period Time /(in ms)	Speed (in 1/µs)
Anger (High)	10000	1000	1420	23809.5238
Anger (Medium)	9000	1000	1360	25000.0000
Anger (Medium)	8000	1000	1240	33333.3333
Anger (Low)	7000	1000	1180	38888.8889
Anger (Low)	6000	1000	1120	50000.0000
Happy	5000	1000	1060	83333.3333

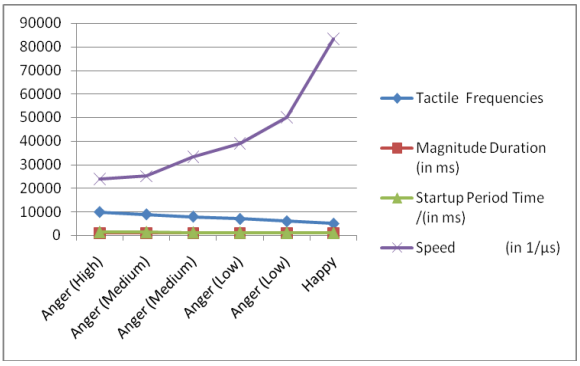

Figure 13. Graph representation for 1000 ms duration

The evaluation of tactile classification based on speed and period time as a parameter for evaluating the emotion. The emotion of avatar is not easily be expressed by tactile frequency. However, we have conducted several experiments to come up with Table 2 and 3 by measuring speed, strength and time period of vibration.

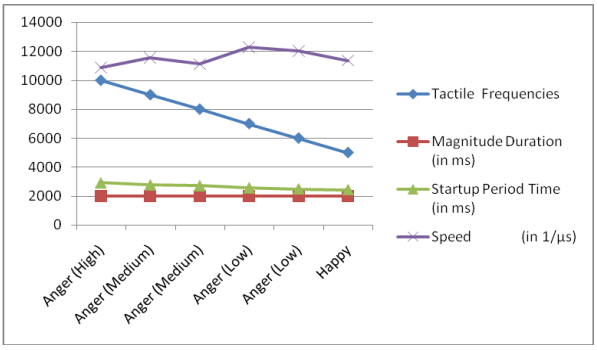

Figure 14. Graph representation for 2000 ms duration

Table 3. Magnitude vibration table for avatar using 2000 milisecond duration

Haptic Measurement				
Emotion	Tactile Frequencies	Magnitude Duration (in ms)	Startup Period Time (in ms)	Speed (in 1/µs)
Anger (High)	10000	2000	2920	10869.5652
Anger (Medium)	9000	2000	2780	11538.4615
Anger (Medium)	8000	2000	2720	11111.1111
Anger (Low)	7000	2000	2570	12280.7018
Anger (Low)	6000	2000	2500	12000.0000
Happy	5000	2000	2440	11363.6364

5. Result Analysis and Discussion

The previous graph has shown very promising outcome for avatar expression through haptic magnitude vibration. The graph on Figure 13 and 14 shows the comparison between each emotion. In those graphs, happy has greatest speed due to happy emotion that has stable psychology effect to physiology. From previous work this result can be compared like shown in table 4:

Table 4 has shown some parameters comparison with the previous work. It is proved that our method is using similar parameter with the previous work. It means the avatar that we have created will present more realistic expression to the user due to particular frequency carried emotion meaning. During our experiment, we also observed that haptic is slower comparing to visual and audio perception. This is due to haptic is require startup period of time for stabling the position of the motor.

Table 4. Parameters comparison with the Previous Works

Comparison with the previous research			
Our Parameter	Bailenson et.al (2007)	M.J.Griffin (1990)	Camurri et al. (2003) and Lagerlof and Djerf, 2002

Anger: - High Magnitude vibration - High Speed - Long Startup Period Time - Slow Acceleration **Happy:** - Medium Magnitude vibration - High Speed - Short Startup Period Time - Fast Acceleration	**Anger:** -High Speed (Fast) -High Acceleration -Long Distance **Happy** -High Speed (Fast) -High Acceleration -Long Distance -Wide Angle transformation	**High Vibration:** - Very unpleasant	**Anger:** -Short duration of time -Frequent tempo changes -Short stop between changes **Happy** - Frequent tempo changes -Longer stops between changes

Amthor (1992) in [32] "people retain about 20% of what they hear; 40% of what they see and hear; and 75% of what they see, hear, and do ….". Therefore virtual reality that consist digital multi environment has a chance in order to facilitate interactivity on digital environment from psychological aspect and also action-reaction aspect (see table 5).

Table 5. Result comparison with the Previous Works

Result	Percentage (in %)
Our technique	75
garcia Rojas 2006	20
N.zagalo 2008	40
R.Bolic(2007)	20
Z.Wang (2005)	40
Parameters Evaluation:	
Hear	25.00%
See and Hear	40.00%
See, Hear and Do	75.00%

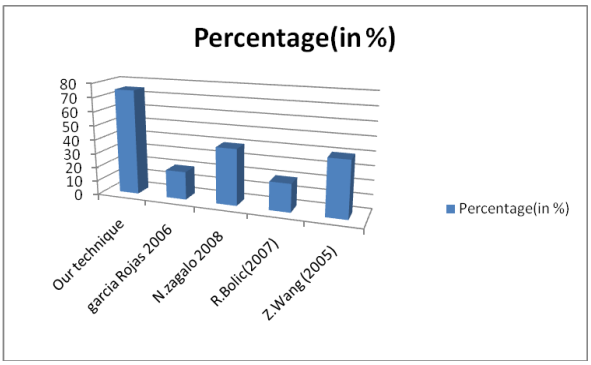

Figure 15. Graph representation for result comparison with previous result

From the result comparison in table 5, we found that lot of previous research still not considered haptic as a part of emotion expression tool. We calculate the percentage from the how many elements that injected to the avatar. The table has shown that our result get 70%. That is why our method will create better avatar in term of realism and interactivity.

6. Conclusion

This main point of this study is how to analyze and implement tactile vibration frequency to be implemented into avatar features. The constructed avatar was 35% better than N.Zagalo and Z.Wang work, and 55% better than R.Bolic and Garcia Rojas avatar. The magnitude vibration of haptic tactile on the highest value (10000) is representing anger emotion, and the medium magnitude vibration has revealed happy states. This finding give us promising feature in the future when avatar not only able to convey their expression by their face and voice but also by sense of touch. Emotion expression by using haptic tactile itself is not powerful to create a believable and realistic avatar. However, when haptic be combined with facial expression and acoustic of avatar it turns out to be promising to bring a believable and realistic avatar in virtual environment. In future, we will add more intelligence to avatar to give more sensible appearance and believability.

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