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# Face-Touch: An Emotional Facial Expression Technique of Avatar Based on Tactile Vibration in Virtual Reality Game

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## 1. Introduction

Nowadays we can see that avatar expresses their emotional expressions only by using facial animation, gesture and voice. In this research, we present an avatar in a creative way that can attract user attention while they play game and use computer. Human representations like virtual Assistants or virtual humans in the virtual environment are considered as an interface that can make harmonious relationships between human and computer (Wang et al., 2005). A virtual representation of human is expected to become a guideline in the virtual environment. Therefore, studies of artificial psychology have been conducted to create an interface that is able to comply with human satisfaction while they interact with computer. Considering this situation, we can see numerous applications such as Second Life or games like the SIMS manipulates a lot of avatars in their systems. If we look at this matter carefully, the substance of presence, which is the ultimate features for virtual environment application, requires further improvement. The root of the problem is caused by several factors such as: the complexity of virtual human model itself, emotional expression (Wang et al., 2005), or incoherent animation reaction(Rojas et al., 2008). Usually emotion is expressed by facial expression, voice intonation or even using hand gesture.

Researchers in image processing and computer graphics fields tried to combine facial expression with voice expression and hand gesture. Recently Haptics or 'sense of touch' attracted attention to be explored - especially Haptics that is related to emotional expression (Bailenson et al., 2007, Hashimoto and Kajimoto, 2008). In this study, our major concern is to grasp the ways to utilise haptic tactile vibration as an emotional expression of virtual human or avatar that can give the user more sensation during the interactions process. The procedure starts by mapping the human emotion colour diagram into several vibration frequencies. Considering this scenario, a group of frequencies are initiated as a magnetize stimulation to express particular emotional expression such as anger or happiness.

## 2. Literature review

Virtual environments are becoming more interesting and complex. Previous research like (Fabri et al., 1999) stated that non verbal communication in Collaborative Virtual

Environments (CVEs) can be conducted via face, gaze, gesture or even body posture. Now, researchers are making several improvising to human representation by means to increase the interaction and communication level between computer and human. (Wang et al., 2005) has created a virtual assistant that acts according to human emotion rules. He also mentions that there are two main problems with creating a virtual human: Construction of emotion and Generation of affection model. The avatar does not only represent human as physical representation, it also needs some believability context. According to (Rojas et al., 2006) the current avatars need to be improved due to believability setback. He proposed an individualisation method by putting personality, emotion and gender into the avatar. Other research such as (Zagalo and Torres, 2008) created additional features that can turn the avatar into unique character which improves the avatar capability to express their emotions through the involvement of touching process among two characters (Zagalo and Torres, 2008). Meanwhile ((Melo and Paiva, 2007) made some innovations in expressing the emotion of virtual character by putting aside body parts. They used element like light, shadow, composition and filter as tools for conveying the Character's emotion. The basic human emotions have been recognised and formatted into standard form. For example, the emotional facial expression can be detected from the eyes and lips of a human face (Ekman, 1982). Researchers like the following tried to recognise emotions from several ways such as: Colour(Farbenlehre, 1808-1810, Melo and Gratch, 2009, Nijdam, 2006, Sucontphunt et al., 2008), Haptic device(Bailenson et al., 2007, Salminen et al., 2008, Hashimoto and Kajimoto, 2008), Acoustic (Dai et al., 2009), Music (Shan et al., 2009), dance movement(Camurri et al., 2003).

### 2.1 Motivation and main contribution

The motivation of our study is inspired by haptic ability that can give different sensation compared to visual stimulation and acoustic stimulation. Haptic is widely used in games such as: to give impact sensation on racing game or fighting game. As we mentioned before, most users are much not affected by facial expression of avatar because they can only see the changes of avatar facial expression and various tone of voice intonation. These situations motivate us to make a bridge between avatar and user (human) when they communicating each other. See our illustration on Fig.1. Fig.1 explains that user able to see the car crashes with street barrier however, they cannot immerse with strong feeling about the situation. Therefore researcher tends to add vibration to the haptic device to give strong impression of impact. We simulate the same concept by conducting surveys to our students. As we expect, most of them did not impressed with the avatar expression through visual and acoustic. So, we proposed a unique avatar equipped with various range of haptic vibrations to creates better emotional expression than the previous avatar. The avatar has the following features:

**Visual and brain sense**: Provide user a sensation of facial expression based on Facial action coding system, data glove and brain activity.

**Touch Sense:** Stimulating user by creating particular tactile vibration frequency which is connected and synchronized with facial expression of avatar.

The problem on expressing emotion for avatar using vibration is less explored because previous researcher almost concentrates producing facial expression. To our concern, we then mapped the vibration values into emotion appearance followed by synchronizing the avatar facial expression as well as synchronizing the external control system like hand glove and mind controller. In other words we tried to create link between facial appearance and tactile vibration. What we proposed here is straightforward and can be reproduced by using cheap and commercial joystick.


Fig. 1. Tactile and visual representation on demonstrating car crash (collision) with barrier

## 3. Face-Touch construction method

Face-Touch is an integration of three human senses: visual, acoustic and haptic. Haptic is requiring preprocessing to classify the magnitude force into suitable range for emotion expression. The classification is based on colour theory which is mapping the human emotion characteristic into RGB mode, and then RGB property will be converted into magnitude force of vibration. The complete diagram of Face-Touch system can be viewed as Fig.2.

### 3.1 Calculating constant factor (f)

In term of color, emotion has been divided into certain color since long time ago. According to (Nijdam, 2006, Farbenlehre, 1808-1810) human emotion can be divided into areas of color like shown in Fig.3.

Shirley Willett (Nijdam, 2006), creates a circle that represent emotion classification into certain color. The outside circle gives positive impression, the inner circle represents six basic emotions and the centre of circle reassembles all negative impression. See Fig.4 for the detail.

Sucontphunt et.al(2008) propose 3D solid cube technique to convertemotion into color representation (Sucontphunt et al., 2008). It's said that Red equivalent to Anger, green symbolize Happiness and Blue is sadness. Other researcher like Melo also support that certain color, saturation and brightness are carry some emotion information like joy or sadness feeling (Melo & Gratch, 2009). In this pre-processing stage, several parameters

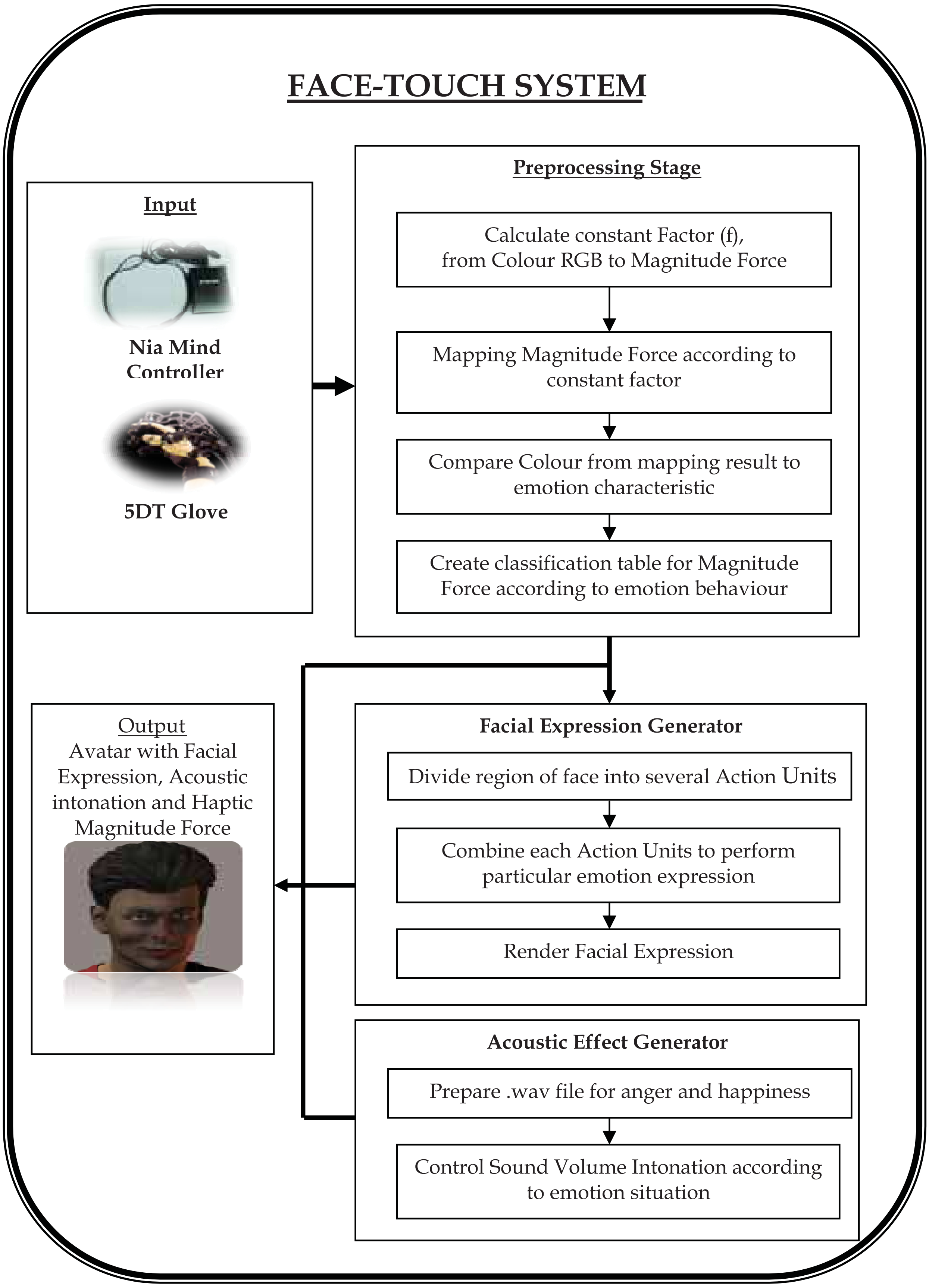



Fig. 2. Face-Touch System Architecture

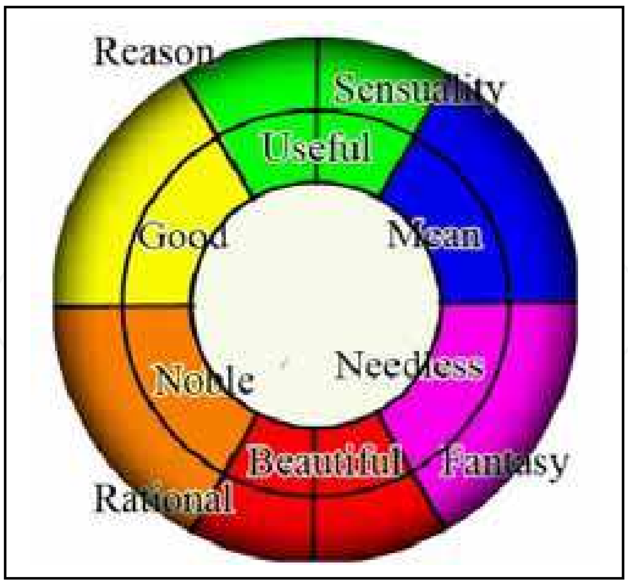



Fig. 3. Emotion-Color Classification(Farbenlehre, 1808-1810)


Fig. 4. Shirley Willett -Color mapping (Nijdam, 2006)

according to the previous researches are being considered when we convert the emotional expressions into vibration. Anger has the characteristics of negative and high, red and raise. This parameter is interpreted into high and long vibration. Happiness in the Circumplex model is represented as positive value but not high. In colour theory, happiness is being suggested as pink color, and also increases the heart rate. To justify our mapping process, the happiness mode is converted into low to medium vibration with short and long duration. High vibration in long duration usually will cause people uncomfortable feeling, anger, frustration and other negative feelings, while low vibration can cause relaxation, joy and even enthusiasm emotion (Griffin, 1990, Hashimoto & Kajimoto, 2008). The detail of emotion characteristic is described in Fig.5.

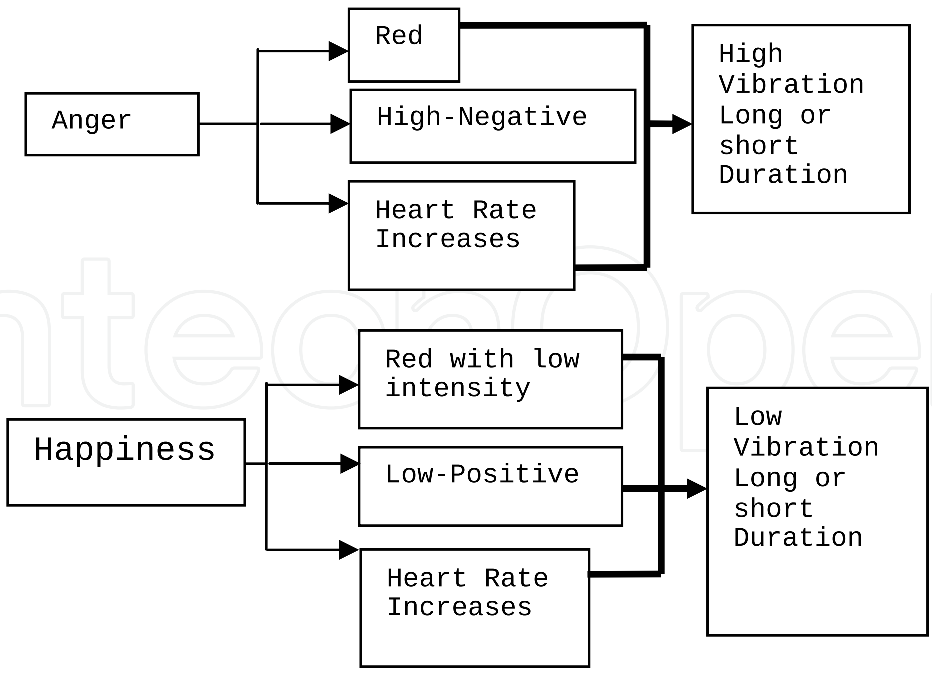



Fig. 5. Flow for mapping color to vibration

In this paper, the emotion value is transferred through red colour. Why red colour?, this is due to red colour has strong and close relationship with anger and happiness (Farbenlehre, 1808-1810, Melo & Gratch, 2009, Nijdam, 2006, Sucontphunt et al., 2008). In this case, each vibration from 0-1000 Hz will be segmented into red colour intensity from 0-255. In implementation, Hue of the colour is set to 0 and R (red) value hold in 255. The G (green) and B(blue) will run from 0-255 and colour will change from full red then degrade until close to white. From conducted experiment, we found out that the RGB values (1-255) can easily be mapped into given magnitude force (1-1000 Hz) as suggested by vibration frequency classification(Griffin, 1990, Hashimoto & Kajimoto, 2008). To plot the given vibration frequency into emotion we used the following equation where the constant factor (f) denoted for colour and vibration. When intensity of red colour need to be changed, this mean RGB value of red hold in 255, hue=0, saturation move from 100% to 0%, and RGB value green and blue move from 0-255.

$$f = \frac{V_{\max}}{RGB_{\max}} \tag{1}$$

$$Vcolour_i = f \; x \left|RGBblue - 255\right|)_i \tag{2}$$

Note:
f = variable for constant
Vmax = maximum value for vibration (10000)
RGBmax = maximum RGB value for Red, Green or Blue Colour (255)

$$f = \frac{10000}{255} = 39.21$$

This conversion process can be illustrated like in Fig.6, where vibration magnitude power increase or decrease linearly according to colour intensity.

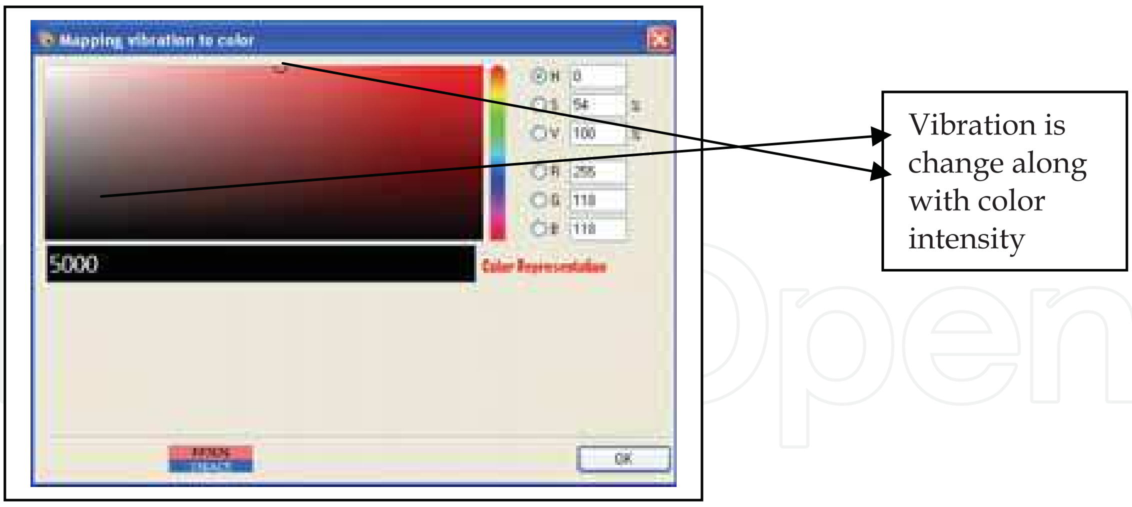



Fig. 6. Flow for mapping colour to vibration

### 3.2 Mapping magnitude force and create classification table

Based on mathematics formula in (1) and (2), the classification of emotion according to magnitude force can be described like in Table 1.

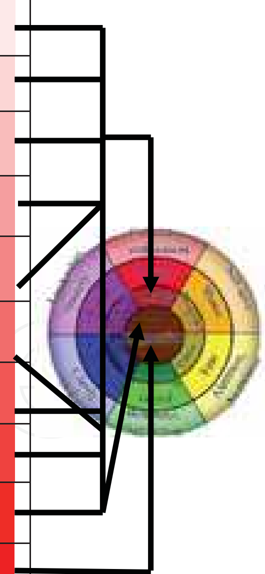
| RGB Colour Value | | | | | | Magnitude Force Based on Colour intensity ($Vcolour_i = f \times R_i$) | Colour | Emotion value |
|---|---|---|---|---|---|---|---|---|
| H | S | V | R | G | B | | | |
| 0 | 8 | 100 | 255 | 234 | 234 | 823.536 | |  |
| 0 | 16 | 100 | 255 | 215 | 215 | 1568.64 | | |
| 0 | 26 | 100 | 255 | 190 | 190 | 2549.04 | | |
| 0 | 37 | 100 | 255 | 162 | 162 | 3647.088 | | |
| 0 | 46 | 100 | 255 | 137 | 137 | 4672.488 | | |
| 0 | 57 | 100 | 255 | 110 | 110 | 5686.32 | | |
| 0 | 66 | 100 | 255 | 85 | 85 | 6666.72 | | |
| 0 | 77 | 100 | 255 | 60 | 60 | 7647.12 | | |
| 0 | 86 | 100 | 255 | 35 | 35 | 8627.52 | | |
| 0 | 100 | 100 | 255 | 0 | 0 | 10000.08 | | |

Table 1. Conversion from emotion into vibration power based on colour theory

Data on Table 1 have proved that emotion can be mapped into magnitude force value by transferring the emotion in colour perception into magnitude force. High magnitude force more than 5000 is potential for carrying the 'anger' emotion and magnitude force lower than 5000 similar to emotion 'happiness' characteristic. This finding is very useful for foundation of synchronizing vibration tactile with facial expression and acoustic. By applying the formula, we successfully create the conversion procedure from colour value into vibration power. We found as well that the speed of motor rumble increases linearly with vibration frequency. For example, anger emotion will trigger high speed which is proving the initial experiment conducted by (Bailenson et al., 2007).

## 4. Facial expression generator

### 4.1 Facial region partition and combination

In this paper, FACS is also adopted to create facial expression by changing the eyebrow, eyes and the lips. The position of the face offset in 3D face model is set by using blender. The face offset of 3D face is created in x, y, z vertex in 3D virtual environment. This pose offset is implanted to FACS elements in our 3D face model to create a particular expression of emotion. The detailed illustration FACS in this research system can be described in detail in Fig.7. AU1 and AU2 are responsible to manage the eye brow area and generate wrinkle in forehead in order to show particular emotions. By creating an emotional expression, this means combining each action units (AU). This combination also shows the strength of certain emotion expressions. For example, in this study, an anger emotion is created by AU1+AU2. However, when the level of anger gets higher it also involves AU4. Furthermore, emotional expression is also expressed by the changing of the lips shape as well.

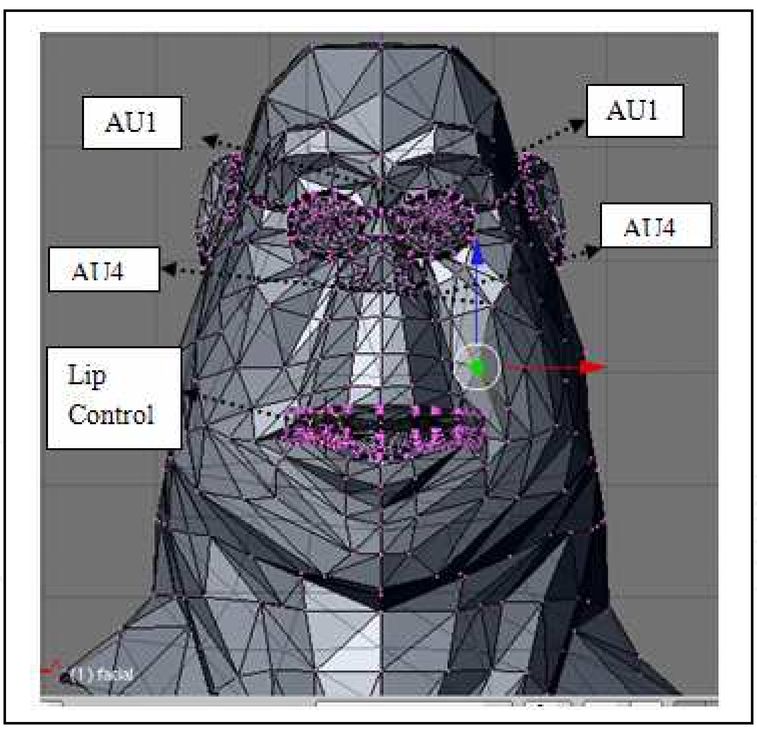



Fig. 7. 3D humanoid model

According to FACS, certain facial avatar expressions such as anger and happiness were created. In this study, we focus only on two emotions which are anger and happiness. According to the previous emotion theories, anger is usually related to something that makes people feel uncomfortable. This kind of feeling is represented in many ways such as: high speed of movements, high temperature, red colour, high heart rate, high blood pressure and high vibration frequency (Hashimoto & Kajimoto, 2008, Russell, 1980, Rollin McCraty, 1993, Rollin McCraty, 1995, Nijdam, 2006, Nasoz et al., 2003, Bailenson et al., 2007, Basori et al., 2008). The facial expression computation is based on calculation of each Auction point as shown in Fig.7. Every action units is responsible to the strength and type of the emotion that has been expressed. In this study, the expression of anger is more complex than happiness. The complexity will increase accordingly when the level of anger rises up.

AngryE= AU1+AU2+(Level*AU4)

AU1 and AU2 are used to control the expres-sion near to the eyebrow, while AU4 and Level generates the wrinkle and rise up the area near the nose. On the other hand, expression of happiness has different characteristics. It involves 4 controls to express the emotional condition.

HappyE= AU1+AU2+(Level*AU4)+(Level*lip Control)

AU1 and AU1 hold the role to manage the eyebrow muscle and together with AU4 to perform expression of happiness. Lip control manages lip movement while emotion is being generated. All elements work together to perform a happy appearance while Level is used as power control that determines how strong the expression of happiness needs to be made. Fig.8 shows happiness in facial expression of avatar in various level of happiness.

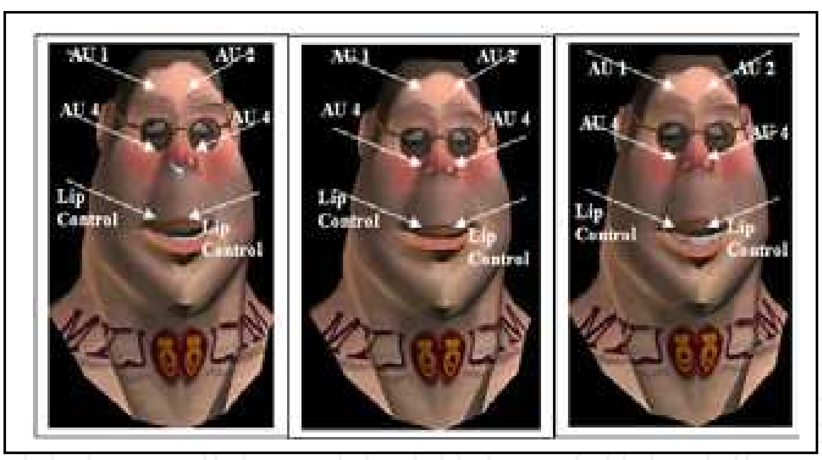



Fig. 8. Happiness mode of 3D humanoid model based on combination of Action Units(AUs)

### 4.2 Avatar rendering and controller synchronization

This study is run on PC Pentium 4 with RAM 2 GB and VGA card 512 MB. Three haptic devices that are commonly used by people such as XBOX windows controller and Wii mote were connected. In order to obtain the optimum functionality of haptic devices, the grip of haptic device is designed according to (Griffin, 1990). Fig.9 and Fig.10 illustrates the user interaction with avatar. Avatar model that we used is modified model of dr.headBunsen from OgreGameEngine (OGRE, 2010). Fig.9 and Fig.10 shows the interaction between user and avatar through haptic glove and mind controller to interact with 3D facial expression of humanoid model and Xbox joystick to feel touch sensation. 3D humanoid model will create emotional expression based on user current behaviour. Like in Fig. 9, user tried to show their anger by creating fist in his hand and it change facial expression of 3D humanoid model. The face of avatar will be changed to anger and the strength of anger is depending on glove and mind controller intensity. The magnitude force of this Xbox joystick is controlled by level of avatar emotion.

Fig. 9. User Interaction with avatar through XBOX windows controller and 5DT Data Glove-1

Fig. 10. User Interaction using NIA Mindcontroller

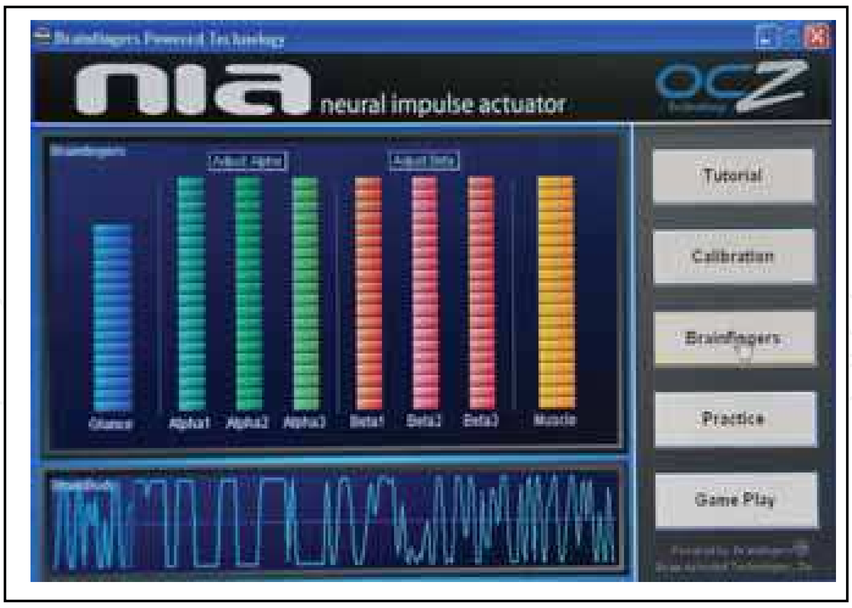



Fig. 11. Brain activity of users during interaction

Activity of user brain is illustrated in Fig.11.Glance sensor record eye muscle movement, Muscle responsible for forehead muscle activity, Alpha 1,2,3 and Beta 1,2,3 tell us what's going on brain activity. This neural impulse actuator is used to record the user activity during their interaction with the avatar. The result of this recording is utilized as benchmark parameter to user testing. The constructed avatar is produced based on facial expressions and mapping vibration parameters. Facial expressions of the avatar are used as the supporting visual element to the vibration frequency. Therefore, when the avatar is smiling, user will able to see their facial expressions and feel their emotions through haptic vibration. Nia mind controller will control the facial expression of avatar or it can be said as that nia mind controller is synchronized with facial expression of avatar. The anger emotion will increase brain activity and it will change the facial appearance as well.

The joystick that used in this experiment has two motor rumbles which are able to produce certain magnitude force and frequency. This subsection will proved empirically the effect of magnitude vibration power of joystick. Joystick has magnitude force, this force able to produce certain rotational speed or velocity (V) and acceleration (A). Based on (Griffin, 1990) there are several physic formulas that very important to this experiment .

$$\text{Velocity (V)} = 2\pi f = \frac{2\pi}{T} \tag{3}$$

$$\text{Acceleration (A)} = (V)2\,X \tag{4}$$

$$= (2\pi f)2\,X$$

$$\text{r.m.s Magnitude } (\grave{A}) = \frac{A}{\sqrt{2}} \tag{5}$$

Note:
f = frequency of joystick
T = duration or period
X=displacement, the distance from rotational source

V in SI unit is symbolized with metre per second (ms-1)
A in SI unit is symbolized with metre per second (ms-2)
À is r.m.s Magnitude in symbolized with root mean square metre per second (ms-2r.m.s)
In the conducted experiment the velocity, acceleration and frequency of joystick in several magnitudes can be seen in Table 2, 3, 4.

| Magnitude Force | Velocity (ms-1) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1s | 0.2s | 0.3s | 0.4s | 0.5s | 0.6s | 0.7s | 0.8s | 0.9s | 1s |
| 10000 | 63.333 | 73.333 | 63.333 | 62.292 | 60.833 | 60.972 | 60.833 | 59.792 | 58.889 | 58.750 |
| 9000 | 61.667 | 57.917 | 63.333 | 61.042 | 58.500 | 58.889 | 58.214 | 58.021 | 57.222 | 56.583 |
| 8000 | 53.333 | 56.667 | 58.056 | 57.500 | 55.833 | 56.250 | 55.119 | 56.875 | 53.241 | 53.167 |
| 7000 | 40.000 | 47.917 | 52.500 | 52.917 | 52.667 | 53.611 | 52.619 | 53.125 | 51.204 | 49.583 |
| 6000 | 32.500 | 39.167 | 40.833 | 39.792 | 40.333 | 40.417 | 39.643 | 40.417 | 39.907 | 38.750 |
| 5000 | 21.667 | 25.417 | 28.333 | 32.708 | 36.500 | 36.528 | 36.310 | 37.396 | 36.667 | 36.833 |
| 4000 | 0.000 | 13.333 | 20.278 | 21.250 | 24.667 | 25.139 | 27.381 | 30.521 | 31.574 | 30.333 |
| 3000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 6.667 | 8.333 | 9.063 | 10.278 | 9.667 |
| 2000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Table 2. Velocity of joystick based on conducted experiment

The graph representation of this velocity of motor rumble joystick vibration can be viewed as Fig.12.

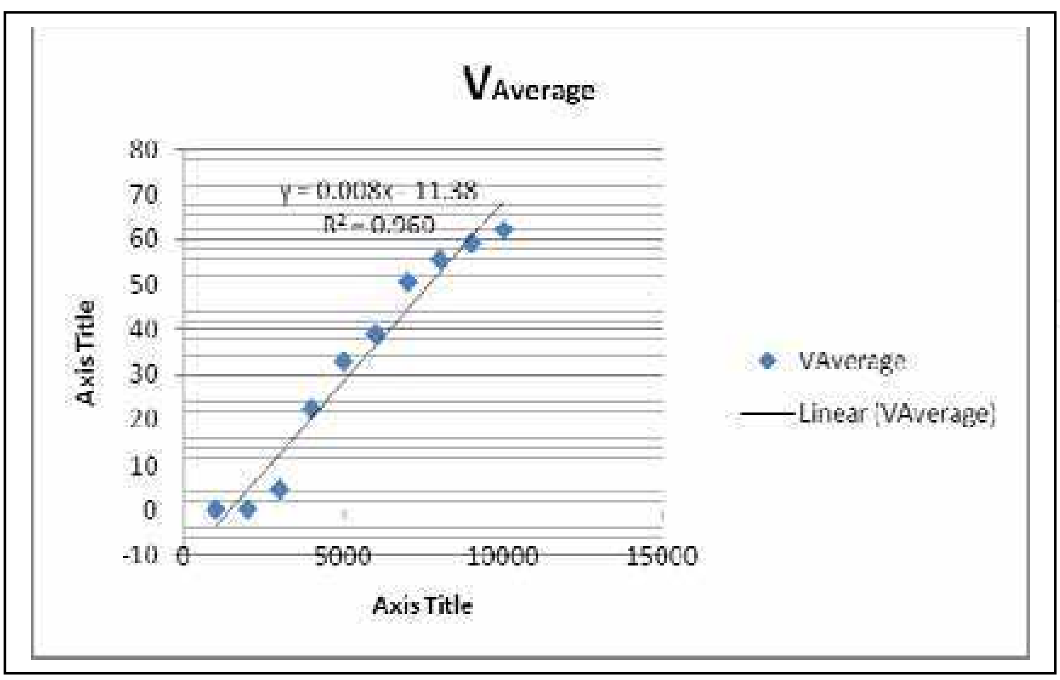



Fig. 12. Velocity of motor rumble joystick

Fig 12 shows that highest magnitude force will cause peak velocity that increase rapidly along with the magnitude force power level.

| Magnitude Force\ Duration | Frequency(f) in Hz | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | f0.1 | f0.2 | f0.3 | f0.4 | f0.5 | f0.6 | f0.7 | f0.8 | f0.9 | f0.10 | f average |
| 10000 | 31.67 | 36.67 | 31.67 | 31.15 | 30.42 | 30.49 | 30.42 | 29.90 | 29.44 | 29.38 | 28.18 |
| 9000 | 30.83 | 28.96 | 31.67 | 30.52 | 29.25 | 29.44 | 29.11 | 29.01 | 28.61 | 28.29 | 26.74 |
| 8000 | 26.67 | 28.33 | 29.03 | 28.75 | 27.92 | 28.13 | 27.56 | 28.44 | 26.62 | 26.58 | 25.14 |
| 7000 | 20.00 | 23.96 | 26.25 | 26.46 | 26.33 | 26.81 | 26.31 | 26.56 | 25.60 | 24.79 | 22.83 |
| 6000 | 16.25 | 19.58 | 20.42 | 19.90 | 20.17 | 20.21 | 19.82 | 20.21 | 19.95 | 19.38 | 17.65 |
| 5000 | 10.83 | 12.71 | 14.17 | 16.35 | 18.25 | 18.26 | 18.15 | 18.70 | 18.33 | 18.42 | 14.58 |
| 4000 | 0.00 | 6.67 | 10.14 | 10.63 | 12.33 | 12.57 | 13.69 | 15.26 | 15.79 | 15.17 | 9.71 |
| 3000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.33 | 4.17 | 4.53 | 5.14 | 4.83 | 1.72 |
| 2000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 3. Frequency of joystick based on conducted experiment

The frequency of joystick also has been measured as seen in Table 3, with graph representation like show in Fig.13 faverage ca be viewed as linear function with f(x)=0.003x-5.358.

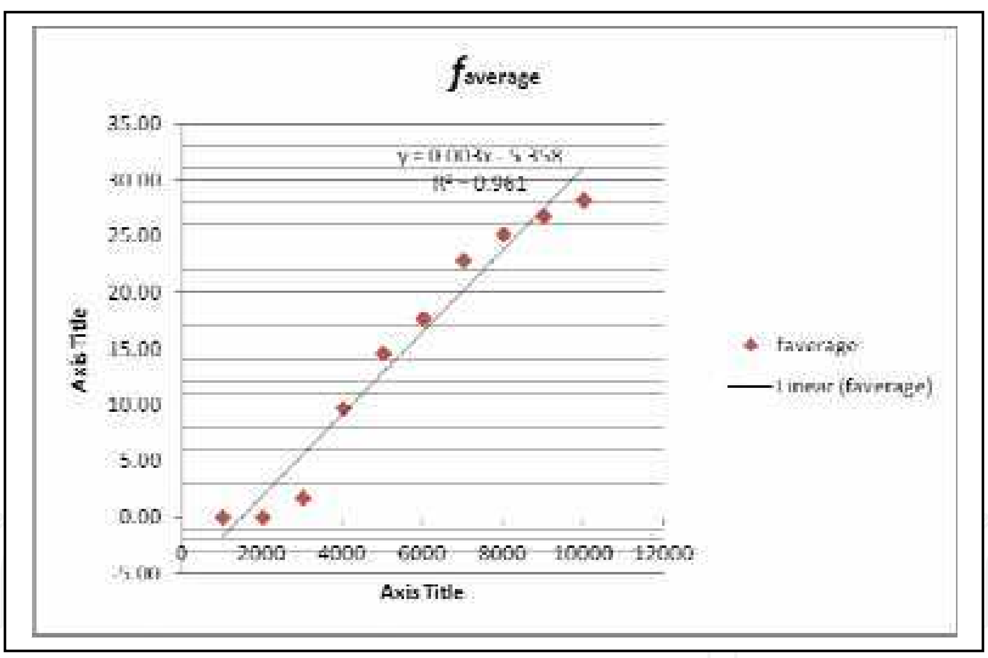



Fig. 13. Average frequency of joystick motor rumble

The acceleration of joystick has shown promising result like the further discussion. This acceleration is able to show particular emotion information. In Fig.14 Aaverage has function y=0.01x-3.217 while r.m.sA has function y=0.01x-2.275. Table 4 has listed all acceleration result for various magnitude force and duration.

These results have been compared with previous result to prove the similarity behaviour of vibration effect and emotion classification. Derived from Griffin (1990) there are numerous previous researchers have described the implication of vibration to human. (Oborne & Clarke, 1974) have classified the vibration based on mean magnitude and semantic scales:

| Magnitude Force | Acceleration (ms-2) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_{0.1}$ | $A_{0.2}$ | $A_{0.3}$ | $A_{0.4}$ | $A_{0.5}$ | $A_{0.6}$ | $A_{0.7}$ | $A_{0.8}$ | $A_{0.9}$ | $A_{1.0}$ | Aaverage | r.m.s A |
| 10000 | 12.03 | 16.13 | 12.03 | 11.64 | 11.10 | 11.15 | 11.10 | 10.73 | 10.40 | 10.35 | 11.67 | 8.25 |
| 9000 | 11.41 | 10.06 | 12.03 | 11.18 | 10.27 | 10.40 | 10.17 | 10.10 | 9.82 | 9.61 | 10.50 | 7.43 |
| 8000 | 8.53 | 9.63 | 10.11 | 9.92 | 9.35 | 9.49 | 9.11 | 9.70 | 8.50 | 8.48 | 9.28 | 6.57 |
| 7000 | 4.80 | 6.89 | 8.27 | 8.40 | 8.32 | 8.62 | 8.31 | 8.47 | 7.87 | 7.38 | 7.73 | 5.47 |
| 6000 | 3.17 | 4.60 | 5.00 | 4.75 | 4.88 | 4.90 | 4.71 | 4.90 | 4.78 | 4.50 | 4.62 | 3.27 |
| 5000 | 1.41 | 1.94 | 2.41 | 3.21 | 4.00 | 4.00 | 3.96 | 4.20 | 4.03 | 4.07 | 3.32 | 2.35 |
| 4000 | 0.00 | 0.53 | 1.23 | 1.35 | 1.83 | 1.90 | 2.25 | 2.79 | 2.99 | 2.76 | 1.76 | 1.25 |
| 3000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.21 | 0.25 | 0.32 | 0.28 | 0.12 | 0.08 |
| 2000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 4. Acceleration of joystick based on conducted experiment

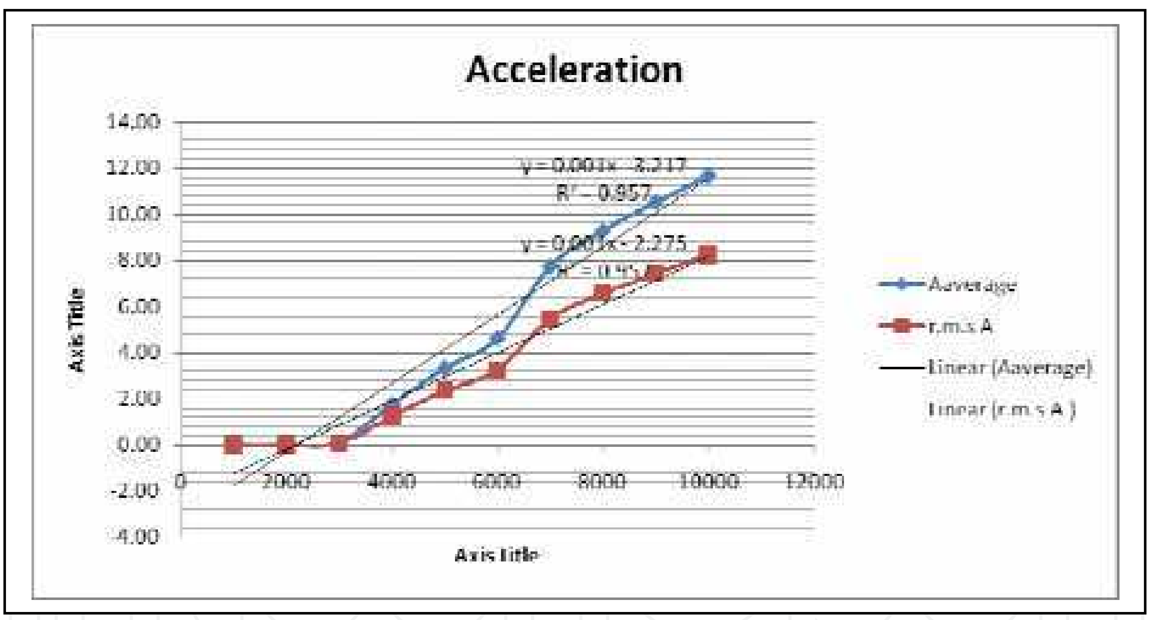



Fig. 14. Joystick acceleration

- Mean magnitude (ms-2r.m.s): >2.3 →very uncomfortable
- Mean magnitude (ms-2r.m.s): 1.2-2.3→Uncomfortable
- Mean magnitude (ms-2r.m.s): 0.5-1.2 } Fairly Uncomfortable / Fairly Comfortable
- Mean magnitude (ms-2r.m.s): 0.23-0.5 →Comfortable
- Mean magnitude (ms-2r.m.s):<0.23 →Very Comfortable

According to result on Table 2 until 4, we have found an interesting finding that magnitude force above 5000 potential to represent anger emotion and below 5000 has characteristic for happy emotion due to magnitude force more than 5000.

### 4.4 Acoustic effect generator

Acoustic is an element of human sense that affect human through ear. The sound effect will stimulate user from two aspects: "Emotional word" and intonation volume level that heard from sound. In term of sound environment the angle of sound position also determine user reaction for example surround system has better effect to user rather than normal stereo sound. The intonation of acoustic is consist of some parameters that related to emotion condition such as pitch, loudness and length (Banziger & Scherer, 2005).

In the paper, acoustic will focus on loudness level to increase the realism and synchronization process with facial expression through windows API by changing the master volume according to emotion that occur Face-Touch. The sound effect is based on emotion word that has been chosen before sound file is created. For example anger.wav that consists of word "Annoy" or for happy "Nice" or "Good".

## 5. Result analysis and discussion

Two analyses on measuring the systems were conducted. These three steps are designed to investigate the emotional characteristics and how strong is the impression that has been given to user through facial expression of avatar and haptic-tactile. Besides, this research also aims to make a comparison with the previous existing avatar like Alfred and Xface.

### 5.1 Analysis on emotion based on vibration characteristic

Earliest, we have evaluated our technique by measuring the speed and wave length based on joystick motor rumble characteristic. According to Microsoft MSDN one cycle is equivalent into full one wavelength. During our experiment, we have found that speed of motor rumble increase while vibration is rising up. Angry emotion will trigger high speed is similar with the result of previous research that conducted by (Bailenson et al., 2007). We are able to produce certain data to measure the characteristic of joystick from their period and speed. The vibration will follows the color intensity transformation as well like shown in Table 5 and Fig.15. The Fig.15 also shows that speed will rise linearly with the growth of vibration.

| Magnitude Force based on color intensity | VAverage | faverage | Aaverage | r.m.s A |
|---|---|---|---|---|
| 10000.08 | 62.23611 | 28.18 | 11.67 | 8.25 |
| 8627.52 | 59.13879 | 26.74 | 10.50 | 7.43 |
| 7647.12 | 55.60403 | 25.14 | 9.28 | 6.57 |
| 6666.72 | 50.61422 | 22.83 | 7.73 | 5.47 |
| 5686.32 | 39.17586 | 17.65 | 4.62 | 3.27 |
| 4672.488 | 32.83581 | 14.58 | 3.32 | 2.35 |
| 3647.088 | 22.44759 | 9.71 | 1.76 | 1.25 |
| 2549.04 | 4.400694 | 1.72 | 0.12 | 0.08 |
| 1568.64 | 0 | 0.00 | 0.00 | 0.00 |
| 823.536 | 0 | 0.00 | 0.00 | 0.00 |

Table 5. Data relationship between Velocity,Acceleration,r.m.s Acceleration, frequency and Magnitude force

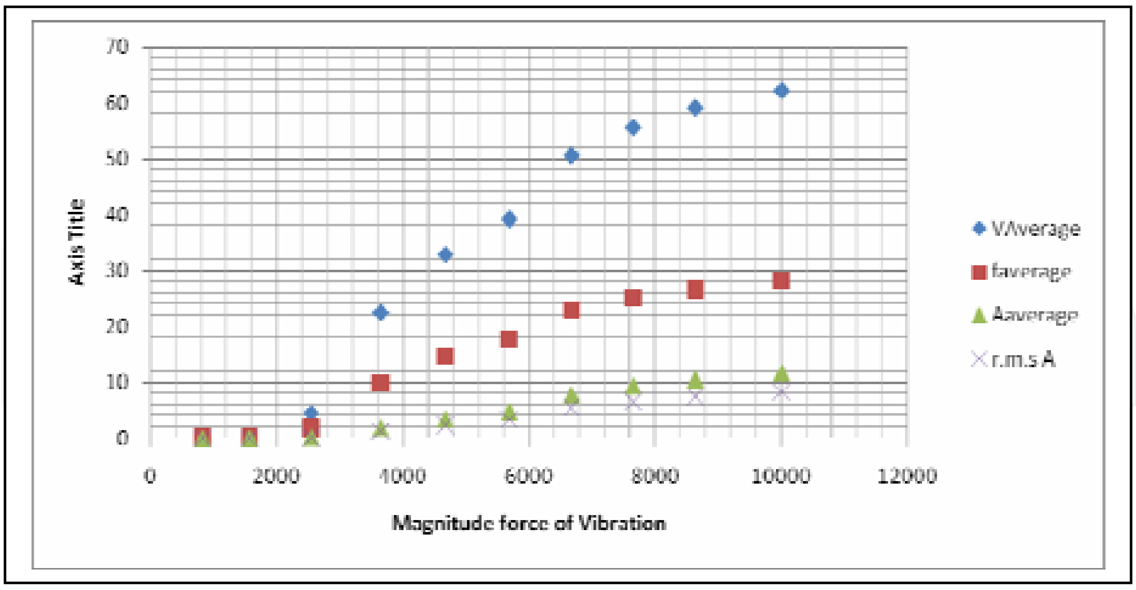



Fig. 15. Vaverage, faverage, average and vibration to colour relationship

### 5.2 Statistical analysis on usability testing

This study has recruited: 8 male and 13 female that comes from undergraduate, Post graduate student (Master and PhD). Each student is required to make interactive interaction with system and after interaction student will be asked to answer some questions in questionnaire. Question will base on data profile, emotion background, experience emotion, interaction, and benchmarking. This study conducts two user interactions. First, user will interact with Face-Touch system, and secondly, user will interact with Alfred and Xface (Balcı et al., 2007, Bee et al., 2009) system as our benchmarking system. Alfred initiated by Nikolaus, Bee in (Nikolaus et al., 2009) from university of Augsburg. While Xface was initiated by Balci from University of Trento (Balcı et al., 2007).

All participants are trained to interact with this study's application and Alfred for a certain period of time. During the interaction, user activity and expression through figure were gathered. Participants need to conduct interaction with this study's system and Alfred system for a certain period of time. The interactions with Alfred system and Xface system is to investigate whether users satisfied or not with current emotion expression (facial expression). See Fig.16A and Fig.16B for the task completion. This comparison has a goal to measure how realistic is the created avatar expression compares to Alfred system itself. In this section, statistic analyses have been computed to compare whether Alfred system or this study's system is more exciting for user.

In Fig.17, study's system obtains significant result. XFace able show emotion by facial expression and voice intonation while Alfred only capable by showing facial expression. This result is very interesting when user get more excited when they stimulated by combination of facial expression, voice intonation and magnitude fore vibration. Most of users are feel something different when they were triggered by numerous vibration frequencies. Some of Participants feel relax in particular low vibration and feel inconvenient when shocked by high vibration. Fig.17 and Table 6 show user rating on recognizing and ranking emotion.

(a) (b)

Fig. 16. Task Completion by interacting with Alfred Sytems(A) and Xface(B)(Balcı et al., 2007, Bee et al., 2009)

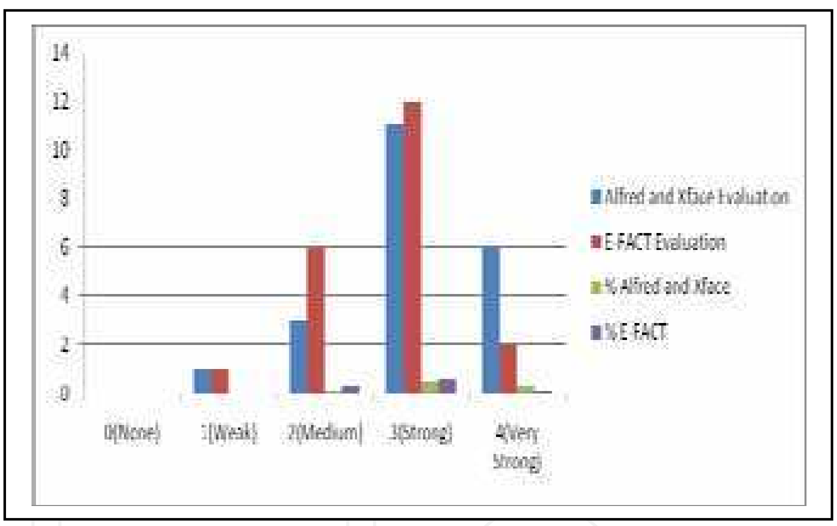



Fig. 17. Questioner Summary on usability user testing



| Level of Emotion | Alfred and Xface Evaluation | Face-Touch Evaluation | % Alfred and Xface | % Face-Touch |
|---|---|---|---|---|
| 0(None) | 0 | 0 | 0% | 0% |
| 1(Weak) | 1 | 1 | 5% | 5% |
| 2(Medium) | 3 | 6 | 14% | 29% |
| 3(Strong) | 11 | 12 | 52% | 57% |
| 4(Very Strong) | 6 | 2 | 29% | 10% |
| Mean | 4.2 | 4.2 | | |
| Variance | 15.76 | 19.36 | | |
| STDev | 4.438468204 | 4.91934955 | | |

Table 6. User rating on recognizing and ranking emotion representation strength

From the graph that shown in Fig.17, the experiment give significant positive result which is able to drive avatar to give more realistic expression. All users have strong confidence rate on differentiate and recognizing emotion of users. From the user testing, we obtain 67% user give strong and very strong impression that our system gives stronger emotional expression than Alfred systems. 29 % user give medium values to our system compare to Alfred system. Finally, around 5% users said that our system provide a little impression than Alfred system. Furthermore, we have found an interesting finding that all users agree that high vibration of joystick equivalent to anger emotion

## 6. Conclusion

The aim of this research is to integrate three element of human sense (visual,acoustic and haptic) to increase the realism of virtual reality game. Our conducted experiments proved that user manages to have strong feeling and impression while they interact and communicate with Face-Touch. The study has proved that high magnitude force of haptic device like joystick capable to create emotional sensation which is classified by intensity of RGB colour. Furthermore, it is able to be synchronized with facial expression of 3D humanoid model as well. From user study, the feedback from user is very exciting while 67% user give strong and positive response to Face-Touch system. In addition, 15 users from 21 participant (71%) agree with classification of magnitude force into emotion representation, they said high magnitude force create similar sensation when they feel anger. While low magnitude force is more relaxing to them. This integration between facial expression, acoustic and magnitude force is believed to bring strong impression and believability to user in real world and even strengthen the interactivity and immersiveness of virtual reality or serious game it self.

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**Virtual Reality**

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Technological advancement in graphics and other human motion tracking hardware has promoted pushing "virtual reality" closer to "reality" and thus usage of virtual reality has been extended to various fields. The most typical fields for the application of virtual reality are medicine and engineering. The reviews in this book describe the latest virtual reality-related knowledge in these two fields such as: advanced human-computer interaction and virtual reality technologies, evaluation tools for cognition and behavior, medical and surgical treatment, neuroscience and neuro-rehabilitation, assistant tools for overcoming mental illnesses, educational and industrial uses In addition, the considerations for virtual worlds in human society are discussed. This book will serve as a state-of-the-art resource for researchers who are interested in developing a beneficial technology for human society.



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