An Exploratory Study to Bring Meaning of Haptic In Association with Human Emotion

by

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CERTIFICATION OF APPROVAL

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Approved by,

_____

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(NORISMALINA BINTI ISHAK)

ABSTRACT

The popularity of haptic technologies has permitted daily life, allowing intimate and emotional contact to be conveyed from sender to receiver. However there are weaknesses apart when haptic is being applied into an application, which can result misinterpreted, high complexity and confusion to the user. Research shows that emotion comprise close relationship with haptic feedback, this research project will investigate the effectiveness of emotion to bring haptic meaning. The project has predict the weaknesses of emotion in explore the absolute meaning of haptic, however with the present of multi-model technology the weaknesses could be reduce in order to identify the suitable definition of haptic with association to emotion.

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INTRODUCTION

1.1 Project background

Haptic in general word refer to the sense of touch. This type sense is one of the most informative senses that human possess. It operates by organism largest organ which is skin. Skin acts as the protective blockade between internal body systems and the outside world. Its ability to recognize touch sensations gives the brains a wealth of information about the environment and surrounding. The idea produce by brain is known as haptic perception. Without sense of touch, it would be very difficult to get around in this world where individual could not differentiate between hot or cold, pain and pleasant and many other sensation.

In this project the key component is haptic feedback. There are two type of haptic which are kinaesthetic and tactile. Kinaesthetic refer to feeling of moving while tactile more toward physical texture such as rough, smooth, silky and powdery. Haptic had been developed widely in various areas. This kind of technology allow human interact with virtual world. The interactions, generally creates various distinct emotions. In example, there are differences emotions generated when a person walk slowly and walk quickly. One might feel tired and anger and another might feel happy and peaceful. Therefore when we talk about haptic, we have to associate it with

emotion which is not easily expressed between senders and receivers who communicate. Haptic may be difficult to express solely base on textual data.

Haptic technology is technologies that allow human communicate with everything in virtual reality world. Haptic technology captured information from user's feeling by applying touch and vibration. Working with virtual object via touch also requires extra careful haptic control. Haptic has being investigated long years before and this technology enable human complete control on virtual reality object. Because of this relation, it allows advance study on how is human feeling while handling haptic device.

1.2 Problem statement

Light and sound have been a traditional way to communicate and explore the virtual reality world. Scientists have studied haptic for many years and they know quite a little about the biology of touch which is haptic feedback. Haptic also has been used to represent various emotions unfortunately little is understood on the relationship of this two elements to be applied in virtual world. This may result in unsuitable used of haptic feedback to represent a particular emotion in certain haptic applications. There are several problems identified the connection of haptic technology and human emotion.

1.2.1 Complexity to define haptic sensation

Great difficulties faced by computer scientists in order to transfer basic understanding of touch into virtual reality system. Haptic cues are more complicated to be replicate in computer generated model compare to auditory and visual. It is almost impossible to enable a user to feel something happening in the computer's mind through a typical interface. Even though keyboard allow user to type in word, and joysticks and steering wheel can vibrate, but user still could not completely feel what is inside the virtual world. For example in video games player could not feel the hard, cold steel of his her character's weapon. An astronaut also could not feel the weight and rough texture of virtual moon rock.

1.2.2 Ineffective haptic application

There are only certain application able to render how objects feel through haptic technology, therefore the effectiveness of communicating haptic information is still vogue, where user unable to define and explored the feeling completely. According to Saddik (2012) there has been significant progress in haptic technologies but the assimilation of haptic into virtual environments is still in its infancy. A great revolution if human able to manipulate and reproduce haptic sensory stimuli that are nearly indistinguishable from reality. For the field to move forward technologies had developed many application and technological tools, however few obstacles need to be overcome.

1.2.3 Significant of project

Haptic and emotion are clearly complex to represent. For many years, researchers in computer science, engineering and psychology have been working to improved understand our sense of touch and to build, evaluate and understand systems that permit us to interact with computers through our sense of touch. Emotion on the other hand, gives high value and broad description to describe haptic sensation. They have been described as distinct feeling or quality of consciousness, such as happy and sadness that reflect the personal significance of an emotion arousing event. Due to constant improvement in haptic technology and growing levels of research into and development of haptic-related algorithms, protocols and devices, there is a belief that haptic technology has a promising future.

1.3 Objectives

The objectives of this project are:

1. To identify the human emotions and haptic feedback from a set of kinaesthetic activities of various existing haptic applications.
2. To associate the haptic feedback and the human emotion identified based on reported work.
3. To test the association made through a user study.

1.4 Scope of study and limitations

The project focuses on testing on the efficiency of haptic application in which haptic sensation could be incorporated into a virtual reality. Therefore, the study will be on how people or haptic user could describe haptic sensation in word or specifically via emotional cues. Hence as an alternative, I will simulate it through few selected haptic application develop before.

1.5 The relevancy of the project

A proposed project should always have a stand to benefit, worthwhile and necessary. Besides that, a proposed solution should project its primary value as the solution for an identified problem. In this case, relevancy is determined by three evaluation criteria which are potential organizational benefits, strategic fit, and level of resource allocation. Designed for this project is to explore the extent in which haptic sensation could be incorporated into a virtual reality. The statistical study will help to verify the effectiveness of haptic application which already develop by few students for Final Year Project as well as the application that develop originate for the haptic device name PHANToM. The evaluation wills consider the capability of the applications explaining haptic sensation which then interpret through emotion. Therefore, this will definitely help future system engineer to develop better haptic device.

1.6 Feasibility of the project

The assessment of project feasibility is an activity that occurs several times throughout the development cycle. The time frame for this project is divided into two parts. The first 5 months of the project will focus on research base activities and the deliverables will be the research results. Meanwhile, the second half of the time frame will focus on testing and evaluation of haptic application. The research and information uncovered by the study conducted will support the detailed of statistical study. Given the technical expertise and project deadlines, the schedule feasibility of this project is positively reasonable and achievable.

CHAPTER 2

LITERATURE REVIEW

Recently, the combinations of light, sound and touch in virtual world have improved user experience while communicate and explore the new dimension. Due to fast growing field various studies done to enhance the quality of those technologies.

2.1 Emotion

The word 'emotion' covers a broad range of human feelings, behaviour and changes in the body and mind. Six primary or main types of emotions listed by professor and psychologist, Robert Plutchik are fear, joy, love, sadness, surprise and anger. These emotions can be classified as primary, secondary and tertiary level of emotions. Beside the primary emotions, human normally will also experience secondary emotions which are a direct reaction or consequence of the primary emotions. For example, a person may feel ashamed or guilty after experiencing the primary emotion of sadness [16].

Every emotion is product of nature and nurture. It is evolved and constructed where it has its own name. In 1972, anthropologist Paul Ekman and his colleagues establish their research finding which described about six basic emotions felt by all humans. The emotions include surprise, fear, happiness, sadness, anger and disgust [26]. These often been by researchers as the basis for all human emotions. In fact, researchers now believe most animals also experience some or most of these basic emotions as well.

Emotions do not have specific pattern or main activities to indicate specific value of emotion [6]. It is generally accepted to be a short-term implicit response to an experience, as opposed to a mood which is often a longer-term experience. As such, emotions may be experienced as initial responses which may fade quickly unless the emotion is evoked again. But research found that there are several characteristic which can distinguish basic emotions from one another and from other affective phenomena [22].

a) Distinctive universal signals
b) Distinctive physiology
c) Automatic appraisal tune
d) Distinctive universal in antecedent events
e) Distinctive appearance developmentally
f) Brief duration
g) Unbidden occurrence

h) Distinctive thoughts, memories images
i) Distinctive subjective experience

Researches prove that emotion fast response to words compared to action for event which are complex and indirect. In fact, genders also affect the emotional response of an individual where women are high emotionally affected compared to man [23]. Due to the complexity involved, it is difficult to accurately define and identify all the emotions experienced by humans. Generally most of people will say that emotion is a spontaneous feeling about any events or experiences. Each person portrays unique and different perceptions about emotions because it was very are subjective. Some people may have more of one or some may lack in others. It is said the more emotions one experiences the more colourful life is. Emotions help human being to communicate what they feel toward certain situations, people, things and cope with everyday life situations.

2.1.1 Fear

Fear also has various meanings where it refers to response to some dangerous situation that is about to happen. This noun and verb respond is survival mechanism to some negative stimulus. It may be a mild caution or an extreme phobia. Fear is a process of chain reaction in the brain that starts with a tense stimulus and ends with the release of chemicals. Fear cause increment of heartbeat, fast breathing and energized muscles, among other things, also known as the fight-or-flight response [16].

The stimulus often associated with an urge to escape such as when someone put a knife at your throat, an auditorium full occupied by people waiting for you to speak or the sudden knock of your front door against the door frame. This unpleasant feeling could be related to various tertiary emotions such as

anxiety, apprehension, distress, dread, tenseness, uneasiness, horror and worry which also understood as common meaning. Fear produce immediate facial respond as below.

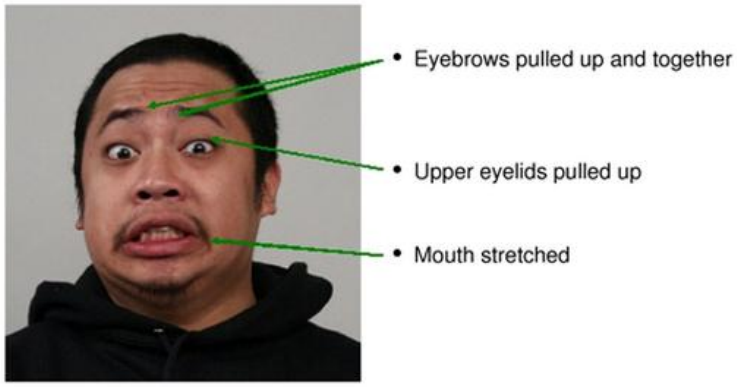


Figure 1: Fear facial expression
Source: http://www.humintell.com/2010/06/the-seven-basic-emotions-do-you-know-them/

2.1.2 Happy

Happiness gives different meaning to different people. However it is a good feeling where this state characterised by several factor such as well-being, contentment, enjoyment, felicity, feeling pleased, feeling satisfied. There is a sense that covers inner peace, love and safety. The existence came up in two forms that are positive thinking and positive activities. Most of the time happy feeling occurs, or is intensified, when our desires are fulfilled. That is, normally happened when we get what we want or stay away from what we want to avoid [16].

Researches by behaviourists portray the zest feeling as a cocktail of emotions where we experience when we do something good or positive. To neurologists identify happiness as an experience of a flood of hormones released in the brain as a reward for behaviour that prolongs survival. According to the beliefs of several major religions people, happiness

indicates the presence of God [6]. There are various other words, such as bliss, euphoria, rapture and ecstasy that are sometimes used to denote great feeling of happiness, but at other times portray different meanings. The pleasant word joy is also used for great happiness and cheerful.

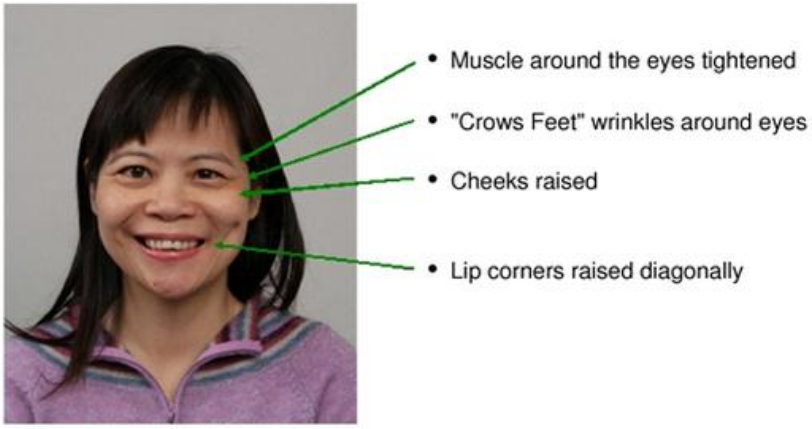


Figure 2: Happy facial expression
Source: http://www.humintell.com/2010/06/the-seven-basic-emotions-do-you-know-them/

2.1.3 Sadness

Feeling of loss and disadvantage is always associated to sadness. This negative feeling may cause a depression state to an individual. Nevertheless, psychologists regard sadness as having a functional value. This is because it could turning our attention inward, by provides some space for important reflection. Some researchers have even established that sadness leads to better accuracy in life by reducing tendencies toward biases and false judgments. When a person was observed to be quiet, less energetic and withdrawn to him it may be inferred that sadness exists. Such an individual usually has a sloping body, stuck out lips and a downcast appearance of the head.

Contrasting with depression, which is categorized as unproductiveness, sadness has qualitative benefits. When a person sad, he or she will be more prone to take stock of our lives and revise certain aspects of it. For instance, heart-wrenching break-ups are often followed by personal re-evaluations. In this state, someone may decide to concentrate more on his or her career, get in shape or relocate. Other words that can describe sadness are depression, unhappiness, misery, melancholy, gloom, despair.

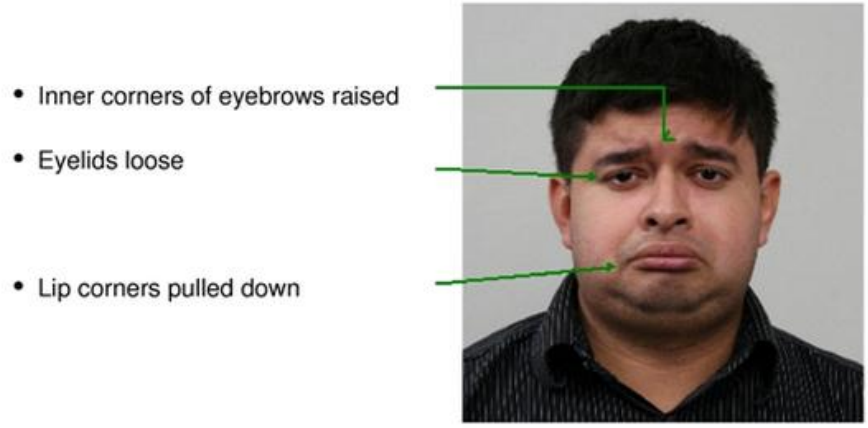


Figure 3: Sad facial expression
Source: http://www.humintell.com/2010/06/the-seven-basic-emotions-do-you-know-them/

2.1.4 Surprise

Surprise could also say as shock means the showing up of an unexpected result. When one experiences surprise, it is accompanied by rising of the eyebrows, horizontal lines on the forehead, open mouth, stretched skin below the eyebrows and wide open eyelids. The mouth may not open, but only the jaw may drop depending on the intensity. In fact, the most common evidence of surprise is the moment once eyebrow is raise. There are related tertiary emotions like astonishment, amazement.

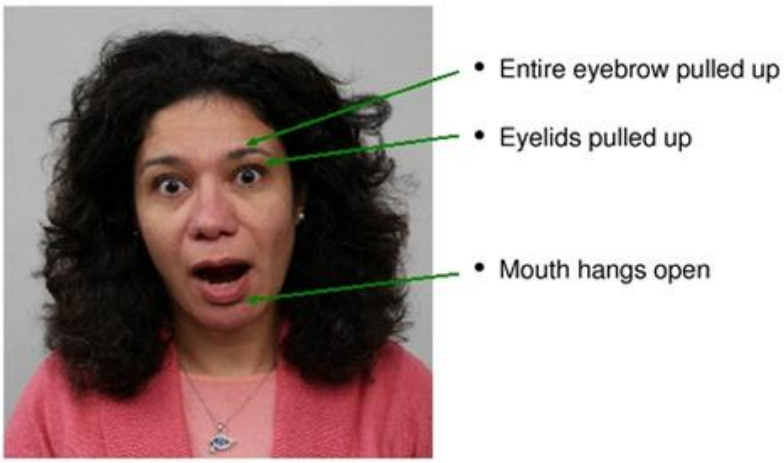


Figure 4: Surprise facial expression
Source: http://www.humintell.com/2010/06/the-seven-basic-emotions-do-you-know-them/

2.1.5 Anger

Anger is natural emotion that encompasses everything from minor frustration to intense rage. It may evoke due to injustice, conflict, humiliation, negligence or betrayal that happened in daily life. There are two type of anger. First is active anger where the individual attacks the target, verbally or physically. Second is passive, the person silently sulks and feels tension and hostility. Often, when one empathizes with anger the feeling could be read from facial expression as below.

Anger alerts a person when something has violated the natural order. It helps us on how to react accordingly. The bodily effects of anger are meant to motivate us to take charge and restore the balance of right and wrong provide a person get angry for the right reason and express anger appropriately. This feeling triggers differ for everyone. They vary by age, gender, even culture. One study evaluated anger in babies of different ethnicities. In one study, in which a cloth was briefly put against the baby's

face, American babies tended to get fussy and push the cloth away, while Chinese babies usually put up with the cloth, not letting it anger them [16].

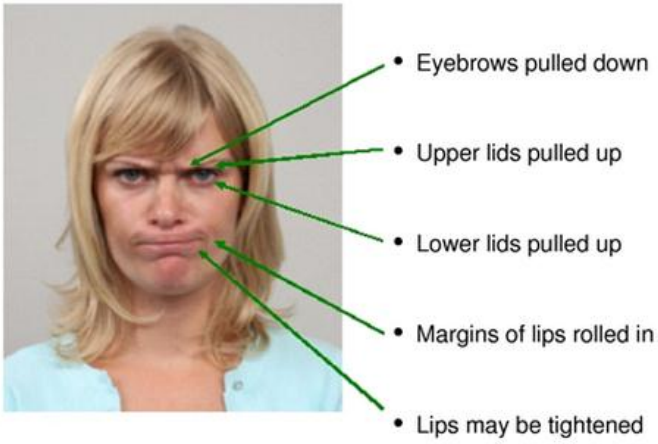


Figure 5: Anger facial expression
Source: http://www.humintell.com/2010/06/the-seven-basic-emotions-do-you-know-them/

2.1.6 Disgust

Disgust feeling is an emotion defined by hatred to something that is highly distasteful. Other related to disgust are feelings of repulsion, abhorrence, loathing, revulsion, and sickness. People that feel disgust would experience a strong impulse to avoid the thing that caused them to feel this emotion. Theoretically disgust is opposite to desire, which is a positive emotion that motivates approach and longing.

As an example, things that cause disgust are rotting food, human or animal's biological waste, offensive smells and unexpectedly moist surfaces. In fact many people, feeling disgusted is a negative experience. Other than that, nausea or vomiting develops initiate the tight throat feels or full, drops of heart rate and the vomit reflex. Sometimes, the sound effects as vocalization for disgust often just like when people cough or clear throats. The facial expression of disgust involves is just like in the Figure 6.

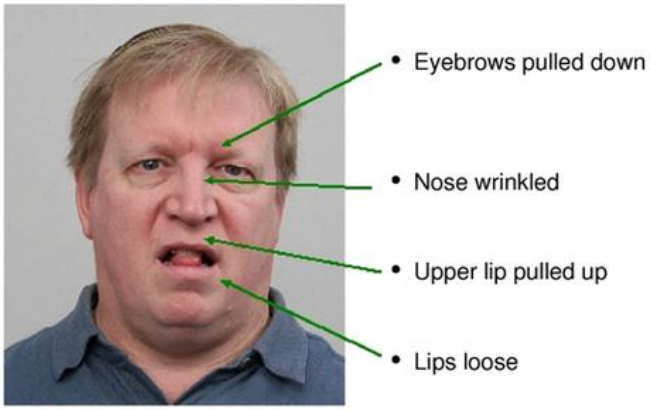


Figure 6: Disgust facial expression
Source: http://www.humintell.com/2010/06/the-seven-basic-emotions-do-you-know-them/

2.2 Haptic feedback

The word haptic taken from Greek word which is ’haptios’. This word describes something which can be touched. Aristotle puts the sense of touch in the last places when naming five senses [2] there is sight, hearing, smell, taste and lastly touches. Numerous specialized nerve ending are found in the skin which play an important role in sense of touch.

These also include corpuscular mechanoreceptor which specializes in monitoring movement of dermis or ligament and joint capsule and vibration transmission from tools to hand. The length and tension of muscle is controlled by information provided that is muscle Spindle and Golgi tendon organ so the brain could interpret the stimuli into an understandable and meaningful idea [12]. Therefore, this sense was identified as one of the immediate exterior perceptions as it enables fast respond to the environment.

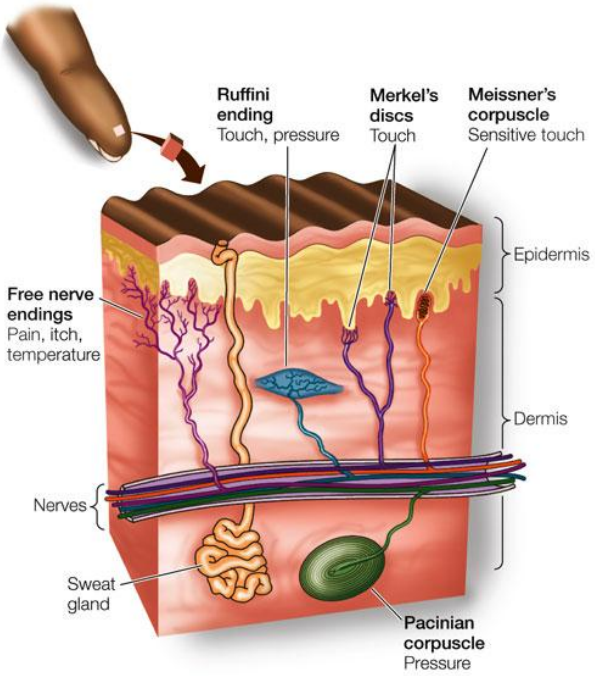


Figure 7: Skin cross section

Haptic feedbacks which also referred haptics which take advantage of the sense of touch in user interface design to provide information to an end user [11]. This technology applies mechanical stimulation including forces, vibrations or motions. Electronic devices such as mobile phones and similar devices, adopt the implementation of haptic feedbacks through vibrations from the device's vibration alarm to represent that a touchscreen button has been pressed. The devices would vibrate slightly in response to the user's activation action.

Haptic feedback is more sophisticated compared to simple event notification. It offers a user with varying vibration strengths, frequency, and patterns which categories as tactile information. This particular technology is found in popular game consoles and capacitive touch panels. The controllers or panels will provide haptic feedback in the form of vibration

depending on the circumstances in the game, thus provide user with additional information through touch.

Haptic feedback contributes massive benefit in electronic technology, and as a result, it is a fast growing field in the meantime. It can be applied to a widespread range of products to improve user experience, growth productivity, increase safety, or provide other benefits depending on its employment. For product manufacturers it is great way of differentiating from the competition, and for customers the extra dimension of tactile feedback can be essential. Haptic feedback is being used in more and more applications; some typical markets include tablet PC touchscreens, medical equipment and automobile dashboards.

Scientific disciplines categorized haptic feedback studies of into two categories which are Psychophysics and Neurobiology. Psychophysics is an analysis of the impression of physical stimuli to create a model or definition in explaining perception of each sensation. Neurobiology is the studies of observing biological measurable connections so can analyse the conversation of stimuli into neuronal signal before input process within brain.

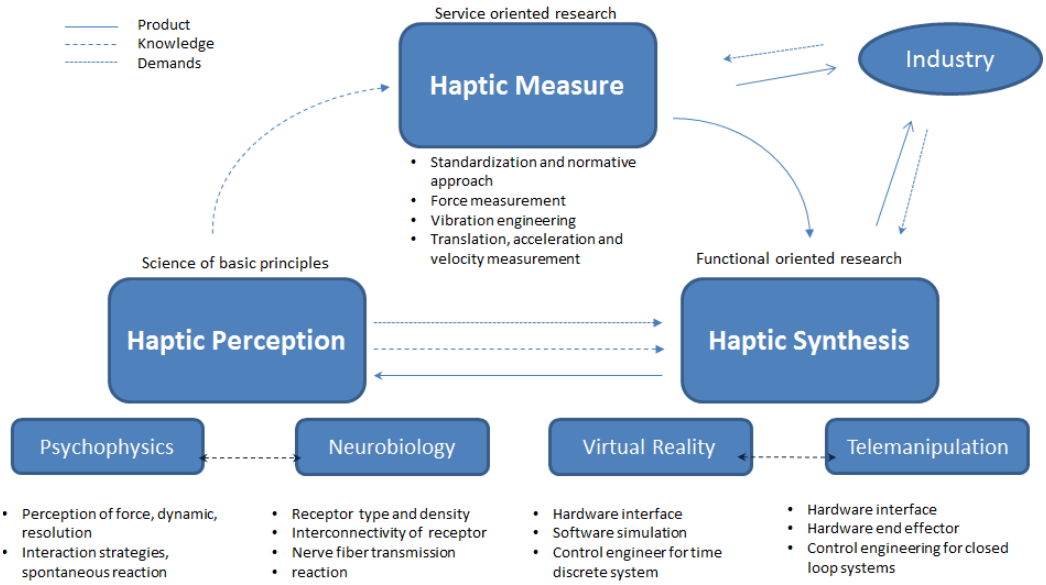


Figure 8: Discipline in participating in haptic research

One motion theory brought by Minsky suggests that, people facing certain stimulations have a wide ranging language of description and metaphor about the composition and nature of the experimented surfaces [4]. They qualitatively list the types of surfaces according to perceived surface features or textures. He supported that, there are three styles in descriptive strategies which are physical or metric description styles, perceptual description and cognitive description.

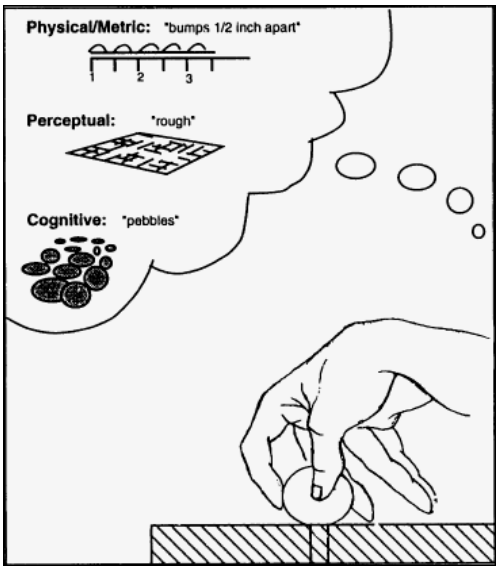


Figure 9: Three style people describe things

In physical or metric description, subjects describe haptic feedback indicating for instance 'the bumps on the surface are ½ inch apart'. In perceptual description subjects describe the texture base on what they perceive of it for instance slippery, rough or sharp. Subsequently cognitive descriptions are those that can invoke particular objects or situations. There are four distinctive categories under this description which are semantic, metaphorical, functional and affective. Semantic describe things by giving meaning or real name of the particular things. Metaphorical describe how the thing look or feel similar with:

1. Semantic which concerned with the interpretation of the particular object such as pebbles, stones, balls, nuts.
2. Metaphorical is comparing simile a figure to an object or action that it does not literally denote in order to imply a resemblance for example 'feels like corduroy'.
3. Functional is serving a utilitarian purpose for example 'like driving on a road'.

4. Affective which concerned with or arousing the emotions or affection such as pleasant ‘feeling’ or ‘uncomfortable’ feeling

2.3 Haptic application

Haptic technologies provide force feedback to users about the physical properties and movements of virtual objects represented by a computer. For example, a haptic joystick offers dynamic resistance to the user based on the actions of a video game. Human -computer interaction has been visual in words, data, or images on a screen. Input devices like the keyboard or the mouse translate human movements into actions on the screen but provide no feedback to the user about the actions [14]. Haptics incorporates both touches which refer to tactile element and motion as kinaesthetic elements. Applications that simulate real physical properties such as weight, momentum, friction, texture, or resistance, haptics communicates those properties through interfaces that let users feel what is happening on the screen.

Figure 10: Virtual world communication

Haptics tools are used in a variety of educational settings, both to teach concepts and to train students in specific techniques. In education, some faculty employs haptic devices to teach physics, for example, giving students a virtual environment in which they can manipulate and experience the physical properties of objects and the forces that act on them. The devices allow students to interact with experiments that demonstrate gravity, friction, momentum, and other forces [17]. In subjects such as biology and chemistry, haptic devices create virtual models of molecules and other microscopic structures that students can manipulate. In this way, students can "feel" the surfaces of B cells and antigens, for example, testing how they fit together and developing a deeper understanding of how a healthy immune system functions [13].

Haptic technology has well developed in various fields. In educational, secondary school as well as high learning institution had employ this technology to create impactful, real and practical learning environment. There are several examples of high haptic technology application such as MAKO's robotic arm system that can simulation system for orthopedic surgery. This system improved surgical outcome by setting up a high level of accuracy and optimal positioning of the implants. Other than that, in medical educational field an intravenous catheterization simulator was developed to provide interactive self-directed learning system for training [17]. This technology consist of powerful 3D graphics with real visual experience, while a state-of-the-art force feedback device can accurately simulates the sense of touch for a truly immersive experience.

Figure 11 : The MAKO RIO

Figure 12: Laerdal's Virtual I.V. Simulator

Entertainment industry also had familiar with haptic technology. As an example, new application named as accelerometer. This console able recognizes casting and jerking to set the hook, while the force feedback enable user feel the real weight of the fish both through the rod and the reel. Other than that, there is also. Force feedback car racing controller which can recreates bumps, crashes, and traction loss with jaw-dropping realism [17]. This controller provides wide range of wheel rotation. This allow actually feel the way the car is handling, where it is enabling to react much faster than if user had to rely on visual cues alone

Figure 13: Griffin's the Strike Rod Controller

Figure 14: G27 Racing Controller

Many disciplines depend on the execution of physical techniques with a high degree of precision and dexterity, and instruction in these fields can take advantage of haptic technology to help students hone those skills. Medical students can use haptic devices to develop a sense of what it feels like to give an epidural injection, perform laparoscopic surgical procedures, use dental or orthopaedic drills, or any number of other highly tactile techniques. Such simulators give users the opportunity to develop a tactile sense of the structures, organs, and tissues of the body. Flight simulators combine visual and auditory elements with haptic technology, including

resistance and vibrations in the controls, allowing student pilots to experience the kinds of sensations they will feel when flying real planes [7].

The interface between humans and computers has been described as an information blockage. Computers can store and process huge amounts of data and humans experience and learn through five senses. But computers typically only take advantage of one or two sensory channels (sight and sound) to transmit information to people. Haptics allow opening this blockage by adding a new channel of communication using the sense of touch [30]. Haptics expands the notion of two-way communication between humans and computers to include sensory feedback.

Active learning strategies result in a stronger comprehension of subjects, and haptics provides a mechanism through which students can actively engage in learning a range of ideas and skills, putting control of learning literally into their hands. Haptics also has a growing role in assistive technologies. The haptic mouse provides sensory feedback that allows users with visual impairments to read a computer screen by feeling buttons and other elements. This device can also benefit users without disabilities but who are tactile or kinaesthetic learners.

2.4 Significance of haptics and emotion

Previous work by Ekman (1972; 1995) shows that emotions could be associated to haptics based on identified gesture as table 1 below. According to the finding by previous researcher as below, several haptic feedback application have been identified to be used in this project. Two projects were taken from previous project developed by UTP student and another four were taken from SensAble Technologies' applications.

Basic Emotions by Ekman (1972;1995)	Reference identified by Paiva et al (2002)	Gesture identified by Paiva et al (2002)	Corresponding gestures with haptic cues to express emotion
Fear	Lazarus (1991) associate fear with **avoidance**	Put SenToy's hands in front of its eye or move it backwards vigorously	Moving the object backwards vigorously, disappearing out of sight
Happiness	Joy is portrayed by Darwin (1872) with open arms, movements such **as rhythmic movement**	Swing SenToy and make it dance	Moving the object in small rhythmic movement upwards without constrain on movement
Sadness	Scherer (2002) explain sadness by expressing it through **slow movement** inward and head down	Bend down SenToy's neck or bend down the entire torso	The object can be move inwards and downwards slowly
Anger	According to Lazarus (1991) anger related to **tendency to attack**	Locate SenToy's arms crosswise or shake it vigorously	The object vibrates vigorously when users interact with it.
Surprise	Laban (2001) associated surprise with **sudden event**	Open SenToy's arm backwards inclining its torso slightly backward	A large amount of force-feedback is produced when user initially interact with the object
Disgust	Lazarus (1991) disgust is action to **move away**, nausea and vomiting	Move SenToy slightly backwards, squeezing it slightly	Moving object backwards, whilst making squeezing hand gesture and force-feedback produced by machine

Table 1: Research descriptions

CHAPTER 3

METHODOLOGY

The result of this research project will be derived based qualitative and quantitative result. Experiment is dependent on user testing, survey and interview toward 30 students of University Technology PETRONAS from various courses and range of ages. In order to eliminate possible gender effect, the participants were only female in the sense that female are more sensitive toward emotion compared to male.

3.1 Apparatus

The tool which will be used in this project is PHANToM Desktop Haptic Device. This is one of the SensAble Technology that allow user to touch and manipulate virtual objects. PHANToM provides force-feed back experience with high resolution, six degrees-of-freedom (DOF) and deform object with a high degree of realism. It also provides 3D touch-enabled for various purposes such as academic and commercial research, commercial software development and digital content creator. Famous entities such as Boeing, General Electric, Stanford University, Tokyo University and many other entities have already used this tool for their several important operations (Stylus Adapter Kit for PHANToM Desktop haptic Device, 2006).

Figure 15: PHANToM Desktop

Source: http://www.sensable.com/haptic-phantom-desktop.htm

PHANToM has various abilities which always promised researchers an interesting exploratory experience in haptic world. In example PHANToM can demonstrate free-floating object, such as cube or sphere which can bounce upon the wall. Hence, this enable absolute and real feeling just as the user is holding the object in his or her own hand. Meaning it covers whole side of the virtual object either from back, front, left and right side, top or bottom.

The object can be move if suitable amount of force give to it by pushing or pulling it front with appropriate level of friction, resistance and gravitational force. Microsoft Visual C++ is used to manipulate and program the object in conjunction with OpenGL as well as GHOST SDK libraries. Table 2 shows the features and specification of PHANToM Desktop.

Features	Specification
Force feedback workspace	~6.4 W x 4.8 H x 4.8 D in > 160 W x 120 H x 120 D mm
Footprint	5 5/8 W x 7 1/4 D in

	~143 W x 184 D mm
Weight	6 lbs 5oz
Range of motion	Hand movement pivoting at wrist
Nominal position resolution	> 1100 dpi ~ 0.023 mm
Back drive friction	< 0.23 oz (0.06 N)
Maximum exertable force at nominal	1.8 lbf (7.9 N)
Continuous exertable force (24 hrs)	0.4 lbf (1.75 N)
Stiffness	X axis > 10.8 lbs / in (1.86 N / mm) Y axis > 13.6 lbs / in (2.35 N / mm) Z axis > 8.6 lbs / in (1.48 N / mm)
Inertia	~0.101 lbm (45 g)
Force feedback	x, y, z
Position sensing [Stylus gimbal]	x, y, z (digital encoders) [Pitch, roll, yaw (± 3% linearity potentiometers)
Interface	Parallel port and FireWire® option*
Supported platforms	Intel or AMD-based PCs
Applications	FreeForm® Modeling™, and the FreeForm® Modeling Plus™ systems

Table 2: PHANToM's features and specifications
Source: http://www.sensable.com/haptic-phantom-desktop.htm

3.2 Experimental design

This study applies six basic emotion states classified by psychological research which correspond to distinct universal human emotions. The feelings that involve are disgust feeling, sadness, happiness, fear, anger; surprise that normally human feel in real life. It is interesting to note all of the emotions can be represented by haptic feedback cues. The description of haptic feedback that can be represent by six basic human emotions. This experiment design was arrange based on three stages which are pre-experimental tasks, experimental tasks and post experiment.

Figure 16: Basic interface for experiment

3.2.1 Pre Experimental

Participants will be given a brief introduction about the objectives and procedure of the experiment, to ensure clear picture about the experiment given to the participant. Then, participants were informed that the experiment will take about 20 minutes to 30 minutes to finish and they were allowed to ask question pertaining to any task given. Participants were also informed that they required filling in a form (Appendix 1.1) at the end of the experiment.

Participants were then shown the device that will be used in the study. Function of the PHANToM was being explained detail including component and the usability aspect of the device. Simple demonstration was conducted and participant was asked to try to manipulate the application and communicate with the virtual object in the programme. Participant were ask to exemine five 3D object which are sphere, cone, pyramid, cube and

pentagon using PHANToM device as figure 17. By interacting with the demonstration the user could gain confident in using PHANToM machine, which will give the participant exposure to force-feedback generated. This would in turn, reduce the chances of erroneous result.

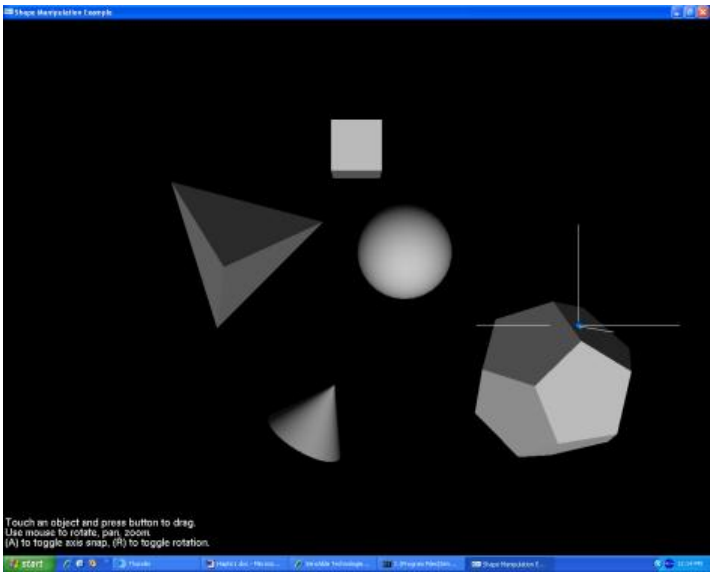


Figure 17: Shape manipulator

3.2.2 Experimental tasks

The participants would perform a gesture adhering to the cues from the emotional theories on the table 1. This part of experiment involves interaction with 6 force feedback generated interfaces. Each interface will represent one emotion that suitable to it. In example, figure 18 and 19 show the interface designed for the emotions of happiness and sadness. The participant than asked about emotions felt through this experiment. It was important to change the order of these demonstrations in this stage, to ensure lack of bias.

Perception of haptics and benefits of multi-model related application were gathered, to see if though of the subject had changed during the course of experiment. Participants were also asked about the usability of multi-model technology whether it effective to explore haptic feedback, resulting from the force feedback generated could complement existing cues and whether advantage would be gained. The participants were asked whether emotions could be felt through making gestures, using haptic technology.

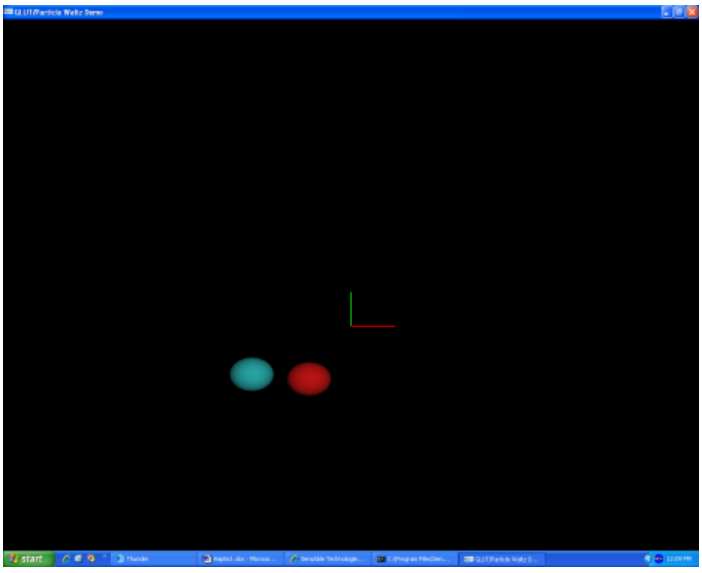


Figure 18: Particle waltz

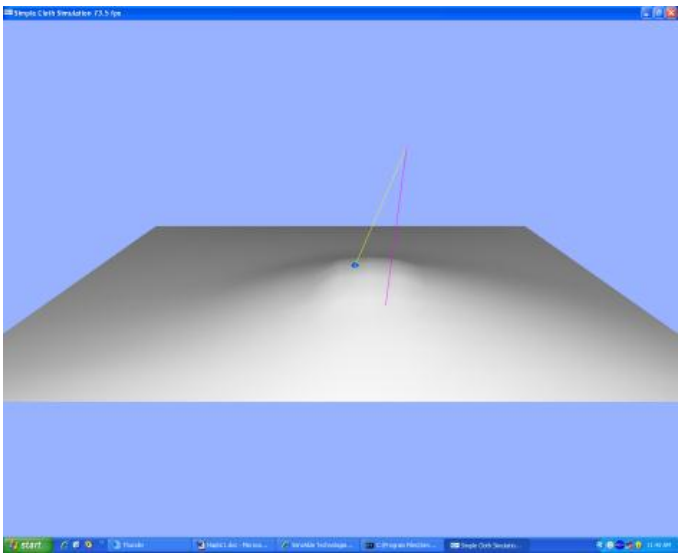


Figure 19: Simple pinch

The conditions surrounding the experiment were conducted in a control environment. Due to university policy the experiment was conducted in the General Assistant (GA) office where the equipment could not be removed. Participants were guided throughout the experiment to reduce human error especially during handling the apparatus. The analyst sat beside the participants to ensure that the device was calibrated in between experiment.

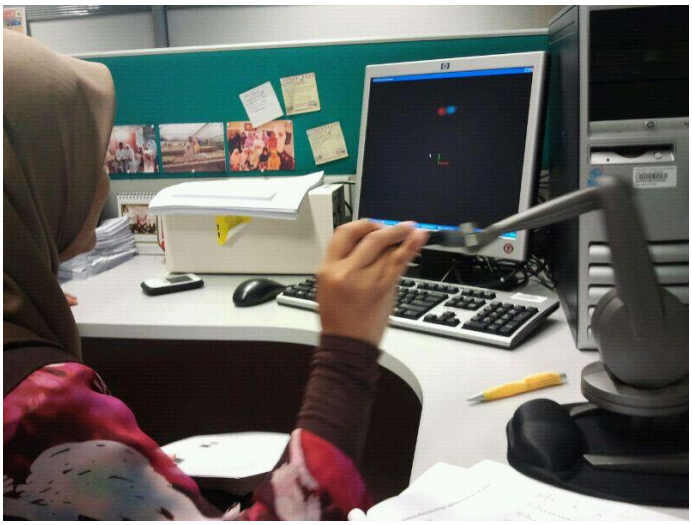


Figure 20: Participant makes gesture using PHANToM

3.2.3 Post experiment tasks

Participants were asked to fill in the questionnaire to assess the usability, presence and engagement of the multi model application. The result would indicate whether users are involved in their environment and whether the experience is natural, arousing and stimulating enough for them. During the initial part, demographic information and details of previous exposure to force feedback device were asked. This would help analyst to identify level of ability and knowledge of each participants. This represents the level of information and instruction should be given to each of them as well as the credibility of the respond given.

For the questionnaire, participants need to tick one or more emotion in the table given according to force feedback received as figure 15. They were also need to rate the intensity of the emotion from 1 to 5, representing strong levels of disagreement to agreement concerning statement listed. Emotional responses could be classified under a series of basic emotion, based on studies by Ekman & Rosenberg (1995).

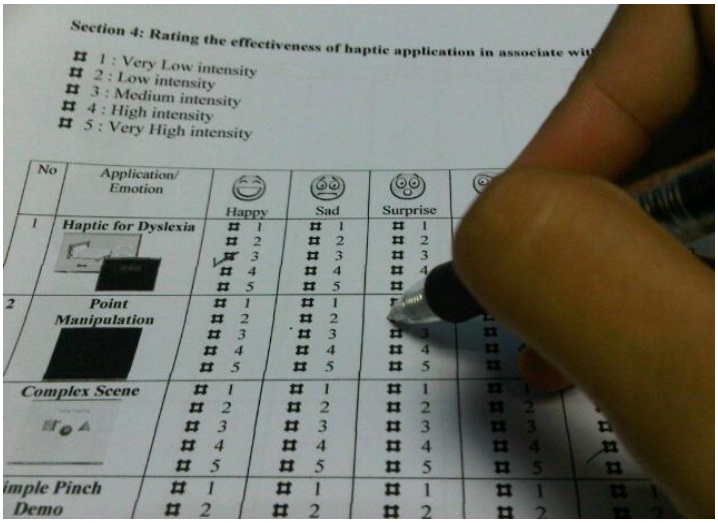
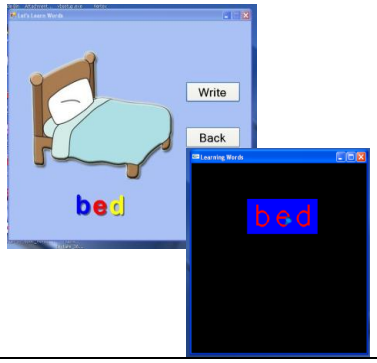
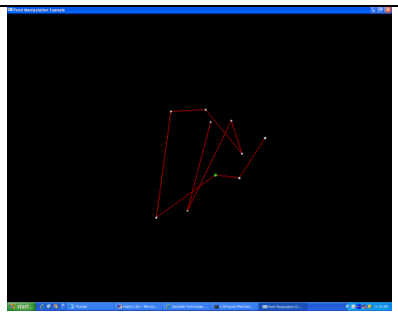
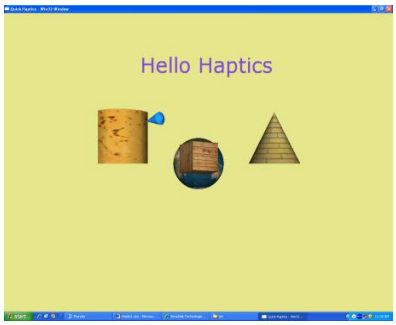
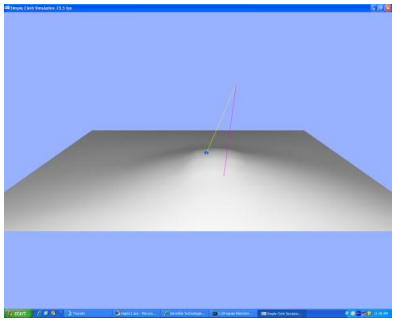
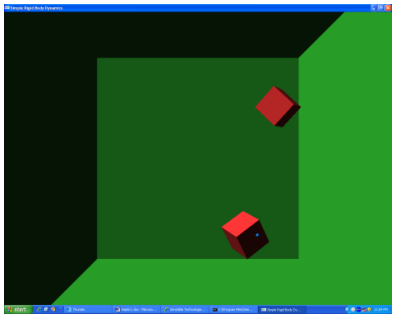


Figure 21: Questionnaire

3.3 Experimental design

Research done pertaining to the relation between haptics and emotion, author had chosen six applications to indicate each emotion respectively according to the functionality and descriptions as stated below in Table 3.
Disturbing weekend

Emotional cues represent	Application and descriptions
Sadness	**Haptic for Dyslexia** Demonstrate the learning experience of Dyslexic children by enable the cursor to follow the shape of each alphabet. 

Surprise	**Point Manipulation** Curser snaps to 3D points and then manipulates them in 3D. Snapping is implemented using a depth independent technique, which allows the user to select a point independent of depth in the view. In addition, this example demonstrates how to initiate 3D manipulation in a depth independent manner. 
Anger	**Complex Scene** Multiple objects in to the scene each with a texture set special rendering effects like the vibration which attracts the haptic cursor and makes it stick to an object. 
Sadness	**Simple Pinch Demo** Shows how to implement a simple deformable surface and use the thumb pad/ scissors as a pinch & pull accessory. 
Disgust	**Simple Rigid Body Dynamics** Shows the integration of haptic into a rigid body simulation. Demonstrates a variety of different dynamics scenarios and interaction modes, such as falling blocks, dominos, and catapults. 

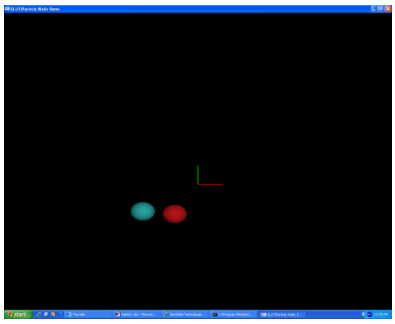
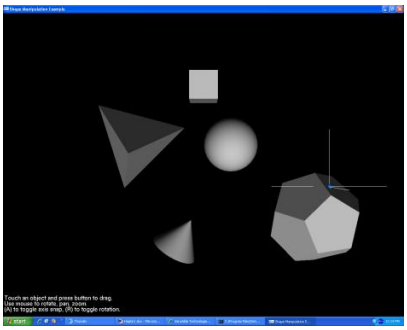
Happy	**Particle Waltz**  Shows simple constrained dynamics between two particles. The haptic device end-effector controls the position of the "master" particle, which is connected to a "slave" particle by a spring with a non-zero rest length.
Fear	**Shape Manipulation**  Shows using constraints to allow precise manipulation of objects with the haptic device. This example also shows how to track the changes in position and orientation of the haptic device and how to apply those changes to an object in the scene.

Table 3: Applications indicating each emotion

3.3 Gantt chart

Milestone	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Planning														
• Proposal														
• Preliminary report														
• Seminar 1-Preliminary reporting														
Analysis														
• Research haptic feedback														
• Research on related work on haptics														
• Research on types of emotion														
• Progress report														
Design														
• Prepare experimental procedures														
• Prepare data collection procedures														
• Prepare system user interface														
• Identify suitable application														
• Prepare interim report														
• Oral presentation-Final reporting														

Table 4: FYP I Milestone

Milestone	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Implementation														
• Prepare experimental tool														
• Conduct experiment														
• Analysing data														
• Poster presentation														
Final Documentation														
• Oral presentation														
• Submission of hard bound dissertation														

Table 5: FYP II Milestone

CHAPTER 4

RESULTS & DISCUSSION

This research project examines the quantitative and qualitative data gathered based on 30 participants as project sample space. The significant findings are noted, showing which emotions were randomly or infrequent selected and which is more commonly reported by participants.

4.1 Results

Touch is powerful signal for emotional content [7]. In order to identify whether most people realize the relationship between this two elements, participants were do they agree that emotions and haptic have close relationship. As a result as stated in table 6 and figure 22, 96% participants agree that haptic do have close relation with emotions. In fact, results prove that most of the participants realize the relationship between haptic feedback and emotion regardless of their background of study. Therefore, it can be synthesized that most of people whether they are IT or non-IT field people really acknowledge the complimentary element between haptic and emotions.

Then, participants were asked about their understanding on haptic and emotions. This indicates that haptic feedback technologies are able to be

improved provided with the present of the meaningful definition of each haptic sensation. For example happy emotion should be associated to active and rhythmic movement. Below shows the responses of all participants pertaining to the relationship of emotions and haptic feedback

Rating	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Emotion and haptic have close relations	0	0	1	8	21
Haptic can be explained by emotional cues.	0	0	4	9	17

Table 6: Relation between haptic and emotions

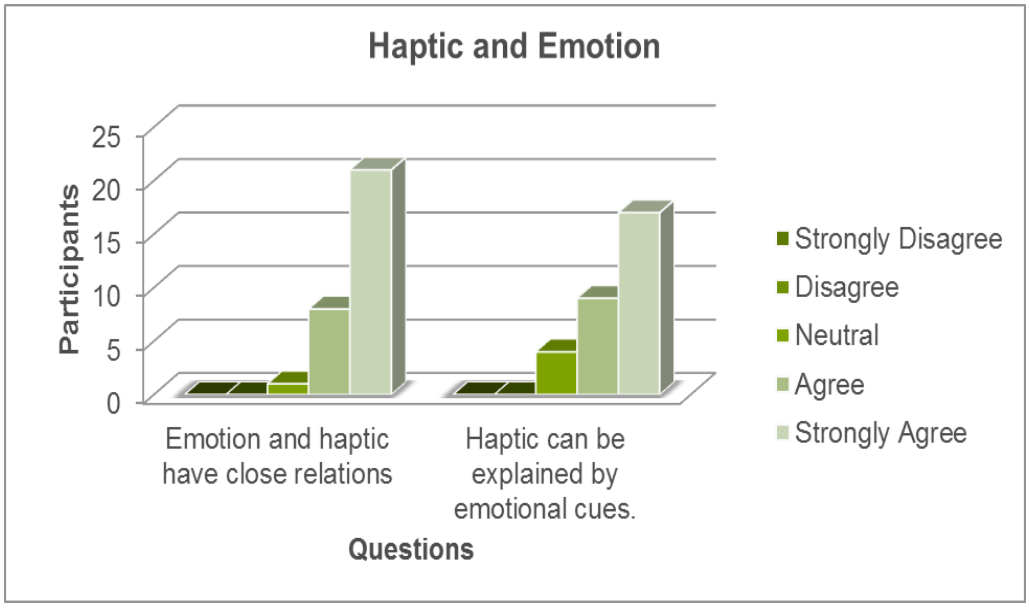


Figure 22: Relation between haptic and emotions

Demonstration		Cues	Happy	Sad	Surprise	Fear	Anger	Disgust	% Effectiveness
Student Project	Haptic for Dyslexia	Sad	10	4	9	1	4	2	13.33
	Point Manipulator	Surprise	9	0	17	2	1	1	56.67
PHANToM Demo	Complex Scene	Anger	12	0	8	1	8	1	26.67
	Simple Pinch	Sad	13	6	3	3	3	2	20.00
	Rigid Body	Disgust	8	0	7	1	7	7	23.33
	Particle Waltz	Happy	24	0	4	1	1	0	80.00
	Shape Manipulation	Fear	15	1	8	4	1		13.33

Table 7: Participants correctly identified the emotions

Figure 23: Participants correctly identified the emotions

Table 7 and figure 23 above shows the end result of the experiment. Every single thing respond by every participant in the questionnaire was recorded. The outcomes of the experiment then undergo some analysis according to their categories of emotion. Result shows that, 80% participants able to identify happy emotion while testing application named Particle Waltz. Approximately 56% of participants correctly identified surprise emotion while testing application named Graph Pointer. 26% and 23% correctly identify anger and disgust feelings respectively. Fear and sadness show the result of 20% and 13% of participants respond correctly to each feeling.

Haptic generally are able to be represented by human emotions. All participants respond to cues with emotional feedback, no participants could not describe the feeling and respond as emotion. The emotion of happy was significantly more meaningful to be associated with human emotion followed by surprise feeling with 52% participants admit that particular application did convey the surprise feeling to it user. The outcome clearly show that the combination of sensory cues balanced, creating a natural environment and enjoyable feeling such as happy and surprise feeling. Detail qualitative raw data and information is available in Appendix.

Emotions were identified to communicate haptic feedback based on appropriate gestures and textures. These were adapted from demonstration originally develop by SensAble Technologies. When participants were asked to touch virtual static surface of haptic interface such as cube, they will immediately found to evoke more positive feeling of happy and calmness. The moving or floating cube that hit the cursor was found to be conveying a feeling of fear, anger or other negative feelings.

4.2 Data analysis

Majority of the participants selected the emotion of happy for this cues which is 80% out of 24 users. Other user respond this application represent evoke the feeling of joy. According to Darwin sense of joy is associated to rhythmic movement. The demonstration was developed using three floating dimensional particles which can be manipulated and swing away as such a boy playing yoyo. Interestingly the sphere particles are floating where it enable users to move the object without resistance. The integration between moving visual and haptic feedback create an exciting experience where it evoke positive emotions. Nevertheless, most of the users are able to identify the emotion correctly with high rating.

As happy is the only positive emotion many participant choose this emotion as option, closest to their feeling. Happy has been described as complex emotion to represent because the term in not specific enough. Based on study here, the responses are varies in term of the intensity. Most of the participants rate this haptic cue as high intensity which is 5 and four people rate 4 as the intensity. Future testing would need to be completed to establish whether participant really did feel the emotion of happiness. Figure below shows various intensity responds by the participants throughout the experiment.

Intensity	Frequency
Very low	0
Low	1
Neutral	6
High	5
Very high	12
Total response	**24**

Table 8: The intensity of happiness

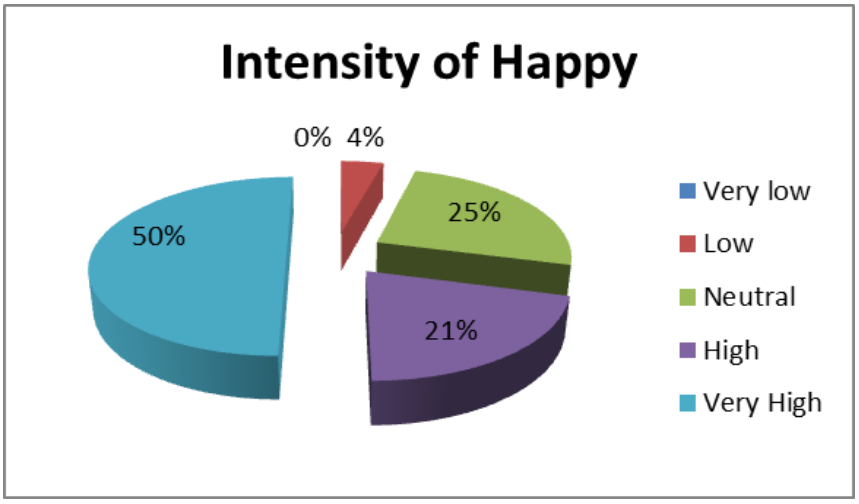


Figure 24: The intensity of happiness

Surprise emotion was successfully identified by 17 participants. User responses included that they felt a sense of shock or felt suddenly alerted by the force feedback provided. Research stated that surprise is associated with attention and sudden event and inclination of torso backwards. Graph manipulator give user magnetic attraction when curser pointing at each point in the graph. Therefore it is conclude that positive emotions could effectively being interpreted and represented by haptic feedback. The motions are really signified happy emotion. Surprise also categorized as positive emotion as one might get it positive and other might not agree.

CHAPTER 5

CONCLUSION & FUTURE WORK

5.1 Conclusion

It is apparent from the data gathered, that there are still some weaknesses in identifying the absolute meaning of haptic. Emotions could be the closest element that able to bring meaning to haptic feedback sensation, unfortunately lack of cues can cause meaning, feelings and haptic feedback to be misinterpreted. As an effect the useful of haptic could be degraded.

This project is aim to determine whether haptic feedback could be define using human emotional cues. The result have reveal that majority of the participants are happy with haptic technologies. This indicate that haptic are efficiently communicate positive emotion compared to negative emotion. Therefore, four out of six emotions could not be defined completely using haptic feedback technology. Perhaps with the improvement of haptic feedback cues and help by tactile element will enable deeper exploration on haptic sensation.

The conclusion drawn include that advantage will be brought to user, if technology is designed taking into account the important of cross-model channel which is visual, auditory and haptic modalities to work together in harmony. If the element of texture force feedback could be include and are enjoyable to interact with, motivation and engagement level will increase, making the experience more interactive.

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APPENDIX

Appendix I: Participant Initial Questionnaire

Participant Name : _____ Participant No : _____

Course : _____ Year : _____

Section 1: Demographic information

1. Gender

   Male □ Female □

2. Age Range

   18-24□ 25-31□ 32-38□ 39-45□ Over□

Section 2: Experience with multi-model technologies

3. Have you seen any multi-model technologies – real life or video before?

   No □
   Yes □

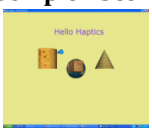
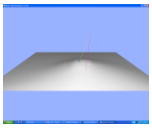
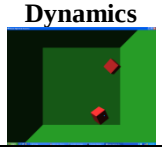
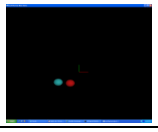
4. Have you experience Force-feedback (FF) device:

No experience	□	FF Mouse	□
FF Joystick	□	FF from VR equipment	□
FF from arcade machine	□	FF console accessories	□

5. Force-feedback (FF) device usage:

Never used	□	Less than once a year	□
Less than once a month	□	Less than once a week	□
Used on daily basis	□		

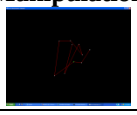
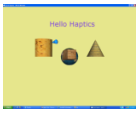
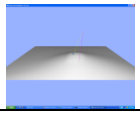
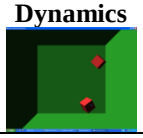
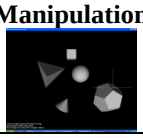
Section 3: Identify suitable emotion of each haptic application

No	Application/ Emotion	 Happy	 Sad	 Surprise	 Fear	 Anger	 Disgust
1	**Haptic for Dyslexia** 	☐	☐	☐	☐	☐	☐
2	**Point Manipulation** 	☐	☐	☐	☐	☐	☐
3	**Complex Scene** 	☐	☐	☐	☐	☐	☐
4	**Simple Pinch Demo** 	☐	☐	☐	☐	☐	☐
5	**Simple Rigid Body Dynamics** 	☐	☐	☐	☐	☐	☐
6	**Particle Waltz** 	☐	☐	☐	☐	☐	☐
7	**Shape Manipulation** 	☐	☐	☐	☐	☐	☐

Tick **(/)** according to your preference.

Section 4: Rating the intensity of haptic application in associate with emotion

- ☐ 1 : Very Low intensity
- ☐ 2 : Low intensity
- ☐ 3 : Medium intensity
- ☐ 4 : High intensity
- ☐ 5 : Very High intensity

No	Application/ Emotion	 Happy	 Sad	 Surprise	 Fear	 Anger	 Disgust
1	**Haptic for Dyslexia** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
2	**Point Manipulation** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
3	**Complex Scene** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
4	**Simple Pinch Demo** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
5	**Simple Rigid Body Dynamics** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
6	**Particle Waltz** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
7	**Shape Manipulation** 	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Tick **(/)** according to your preference.

Section 5: Usability of multi-modal technology

1: Strongly Disagree
2: Disagree
3: Neutral
4: Agree
5: Strongly Agree

No	Statement	1	2	3	4	5
6.1	I think I would like to use these haptic demonstrations frequently					
6.2	I found these demonstrations unnecessarily complex					
6.3	I thought the demonstrations were easy to use					
6.4	I think that I would need the support of a technical person to be able to use these demonstration					
6.5	I could infer how to access haptic					
6.6	I would imagine that most people would learn to use these haptic demonstrations very quickly					
6.7	I found the demonstrations very cumbersome to use					
6.8	I felt very confident using the demonstrations					
6.9	I need to learn a lot of things before I could get going with the haptic applications					

Section 6: Engagement, presence & cue strength

No	Question	1	2	3	4	5
7.1	Navigating using the haptic demonstration enable and encourage real feel in the environment (i.e. sounds, room temperature)					
7.2	Haptic cues seem very clear and natural to me					
7.3	I able to feel the complete engagement of my senses in my real life					
7.4	I believe all things that I do and see are happened naturally and without much mental effort					
7.5	I really dependent on my visual aspects to interact with the environment					
7.6	I really dependent on my auditory aspects to interact with the environment					
7.7	I realize that haptic aspects effect my life very much					
7.8	Did the haptic cues complement other cues?					
7.9	In my opinion interact in the haptic world is very amazing					
7.10	I believe that emotion, texture and haptic have a close relations					
7.11	I believe that haptic and texture can be explained by emotional cues.					

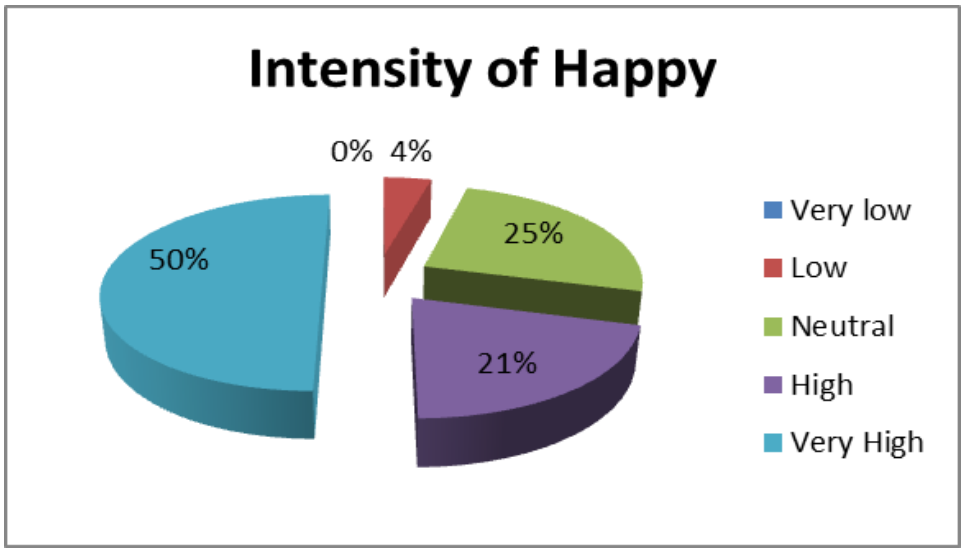
Appendix II
Qualitative: Intensity of emotions

Cues	Sad		Surprise		Anger		Sad		Disgust		Happy		Fear	
User	**Haptic for Dyslexia**	**Rate**	**Graph Manipulator**	**Rate**	**Complex Scene**	**Rate**	**Simple Pinch Demo**	**Rate**	**Simple Rigid Body**	**Rate**	**Particle Waltz**	**Rate**	**Shape Manipulator**	**Rate**
1	Happy	3	Surprise	1	Anger	4	Happy	5	Surprise	3	Anger	4	Happy	1
2	Sad	3	Surprise	4	Anger	5	Sad	5	Disgust	5	Happy	5	Fear	4
3	Sad	2	Surprise	5	Anger	2	Sad	1	Disgust	2	Happy	3	Fear	5
4	Happy	4	Surprise	5	Happy	5	Happy	5	Surprise	3	Happy	2	Happy	5
5	Happy	3	Surprise	3	Anger	1	Disgust	3	Disgust	2	Surprise	2	Anger	3
6	Surprise	5	Happy	5	Happy	5	Happy	4	Fear	4	Fear	5	Happy	5
7	Happy	4	Surprise	1	Surprise	4	Happy	4	Surprise	3	Happy	4	Fear	1
8	Sad	0	Surprise	4	Happy	5	Happy	5	Happy	5	Happy	5	Happy	4
9	Surprise	4	Happy	4	Happy	4	Surprise	2	Anger	4	Happy	5	Surprise	4
10	Surprise	2	Happy	5	Surprise	4	Surprise	4	Happy	4	Happy	3	Happy	5
11	Disgust	5	Anger	4	Surprise	5	Fear	1	Happy	4	Happy	5	Fear	4
12	Happy	4	Happy	4	Happy	4	Anger	5	Surprise	4	Happy	4	Surprise	4
13	Surprise	5	Happy	5	Surprise	5	Happy	5	Happy	5	Happy	5	Happy	5
14	Anger	2	Fear	3	Happy	5	Happy	5	Happy	5	Happy	4	Surprise	3
15	Sad	3	Surprise	3	Surprise	3	Sad	4	Anger	4	Surprise	5	Sad	3
16	Surprise	5	Disgust	5	Fear	5	Anger	3	Surprise	4	Happy	3	Happy	5
17	Surprise	4	Happy	2	Anger	2	Surprise	3	Anger	1	Happy	3	Happy	2

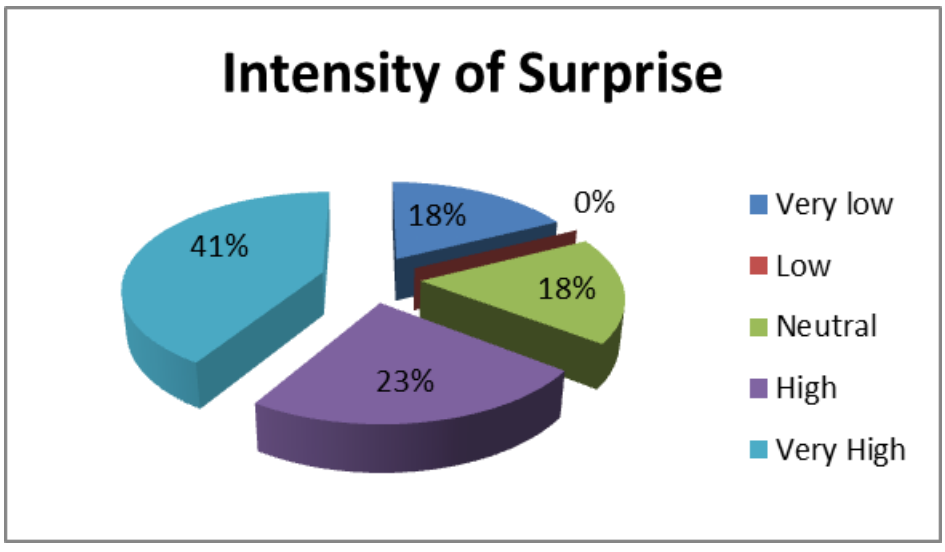
18	Surprise	5	Surprise	5	Happy	1	Happy	5	Anger	1	Happy	5	Happy	5
19	Happy	4	Surprise	1	Disgust	4	Anger	3	Disgust	4	Surprise	3	Happy	1
20	Happy	5	Happy	5	Happy	5	Happy	5	Happy	5	Happy	5	Happy	5
21	Happy	3	Happy	3	Happy	4	Happy	4	Happy	4	Happy	4	Happy	3
22	Surprise	3	Fear	2	Anger	3	Fear	1	Disgust	4	Happy	5	Surprise	2
23	Surprise	2	Surprise	4	Anger	5	Sad	2	Disgust	5	Happy	5	Surprise	4
24	Happy	4	Surprise	5	Surprise	3	Sad	4	Surprise	5	Happy	3	Surprise	5
25	Anger	2	Surprise	5	Anger	4	Sad	4	Surprise	4	Happy	5	Happy	5
26	Happy	3	Surprise	3	Surprise	4	Fear	4	Anger	4	Happy	4	Happy	3
27	Anger	3	Happy	2	Happy	4	Happy	1	Anger	4	Happy	5	Surprise	2
28	Anger	2	Surprise	4	Happy	5	Disgust	2	Happy	5	Happy	5	Happy	4
29	Fear	4	Surprise	5	Surprise	3	Happy	4	Disgust	5	Happy	3	Surprise	5
30	Disgust	2	Surprise	5	Happy	4	Happy	4	Anger	4	Surprise	5	Happy	5

Appendix VI

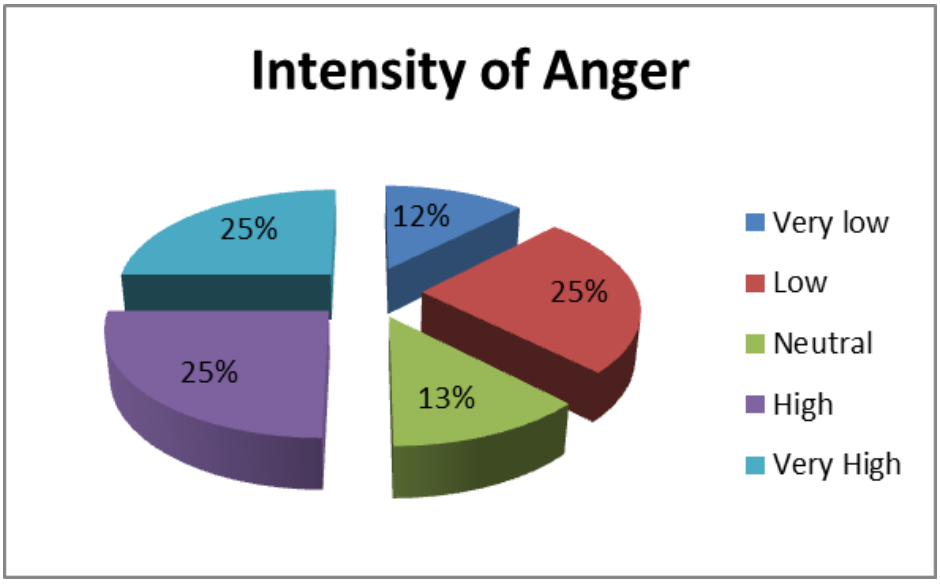
Qualitative data: Intensity of emotions



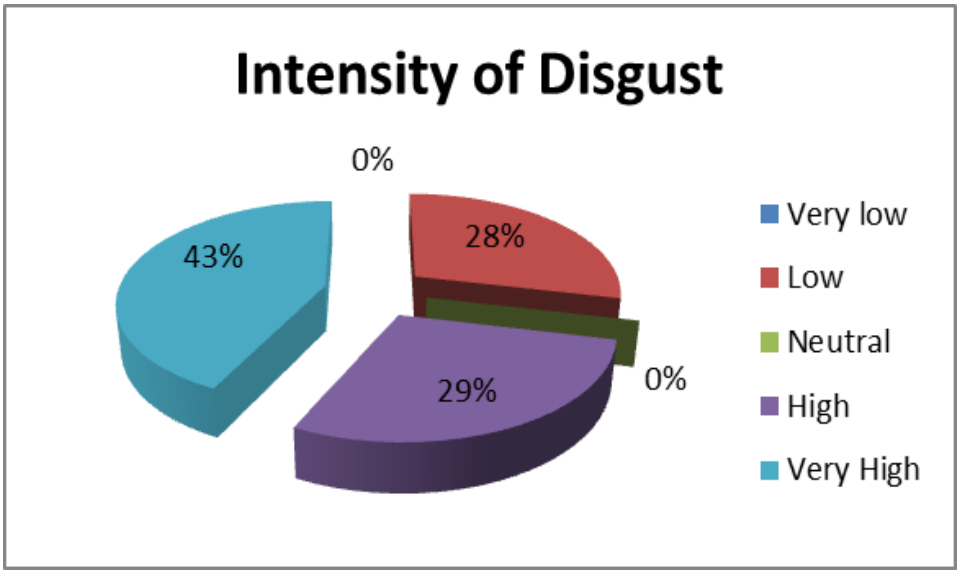
Intensity of happy	Frequency
Very low	0
Low	1
Neutral	6
High	5
Very high	12
Total respond	**24**



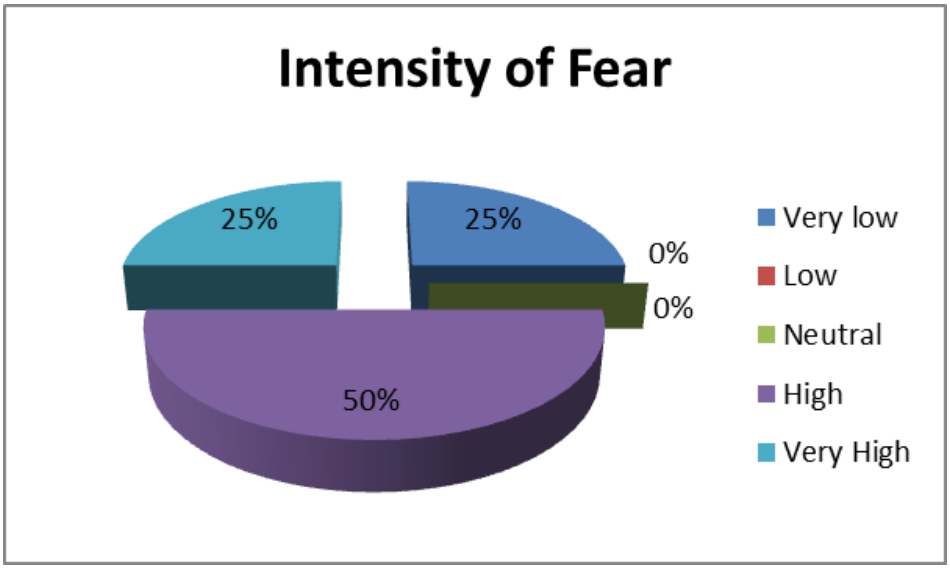
Intensity of surprise	Frequency
Very low	3
Low	0
Neutral	3
High	4
Very high	7
Total respond	**17**



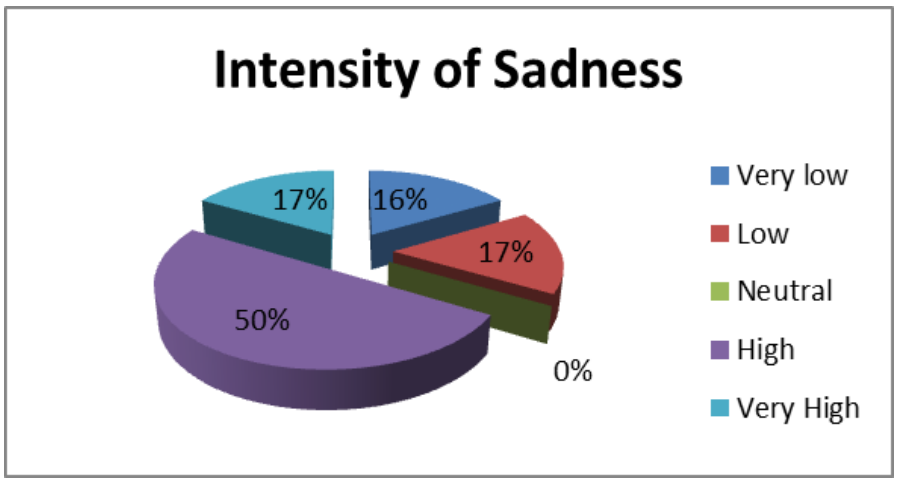
Intensity of anger	Frequency
Very low	1
Low	2
Neutral	1
High	2
Very high	2
Total respond	**8**



Intensity of disgust	Frequency
Very low	0
Low	2
Neutral	0
High	2
Very high	3
Total respond	**7**



Intensity fear	Frequency
Very low	1
Low	0
Neutral	0
High	2
Very high	1
Total respond	**4**



Intensity of sadness	Frequency
Very low	1
Low	1
Neutral	0
High	3
Very High	1
Total respond	**6**

An Exploratory Study to Bring Meaning of Haptic In Association with Human Emotion

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***Abstract* — The popularity of haptic technologies has permitted daily life, allowing intimate and emotional contact to be conveyed from sender to receiver. However there are weaknesses apart when haptic is being applied into an application, which can result misinterpreted, high complexity and confusion to the user. Research shows that emotion comprise close relationship with haptic feedback, this research project will investigate the effectiveness of emotion to bring haptic meaning. The project has predict the weaknesses of emotion in explore the absolute meaning of haptic, however with the present of multi-model technology the weaknesses could be reduce in order to identify the suitable definition of haptic with association to emotion.**

I. INTRODUCTION

Haptic in general word refer to the sense of touch. This type sense is one of the most informative senses that human possess. There are two type of haptic which are kinaesthetic and tactile. Kinaesthetic refer to feeling of moving while tactile more toward physical texture such as rough, smooth, silky and powdery.

Haptic had been developed widely in various areas. This kind of technology allows human interact with virtual object in virtual world. The interactions, generally creates various distinct emotions. In example, there are differences emotions generated when a person walk slowly and walk quickly. One might feel tired and anger and another might feel happy and peaceful.

Haptic technology captured information from user's feeling by applying touch and vibration. Therefore it allows human complete control on virtual reality object. Because of this relation, it allows advance study on how is human feeling while handling haptic device.

Haptic technology captured information from user's feeling by applying touch and vibration. Therefore it allows human complete control on virtual reality object. Because of this relation, it allows advancestudy on how is human feeling while handling haptic device.

The project focuses on testing on the efficiency of haptic application in which haptic sensation could be incorporated into a virtual reality. Therefore, the study will be on how people or haptic user could describe haptic sensation in word or specifically via emotional cues. Hence as an alternative, I will simulate it through few selected haptic application develop before.

I. RELATED WORKS

A. Emotions

Emotions do not have specific pattern or main activities to indicate specific value of emotion [2]. It is generally accepted to be a short-term implicit response to an experience. As such, emotions may be experienced as initial responses which may fade quickly unless the emotion is evoked again. Research found that there are several characteristic which can distinguish basic emotions from one another and from other affective phenomena [3].

Researches also prove that emotion fast response to words compared to action for event which are complex and indirect. In fact, genders also affect the emotional response of an individual where women are high emotionally affected compared to man [6]. Due to the complexity involved, it is difficult to accurately define and identify all the emotions experienced by humans.

Generally most of people will say that emotion is a spontaneous feeling about any events or experiences. Each person portrays unique and different perceptions about emotions because it was very are subjective [7]. Emotions help human being to communicate what they feel toward certain situations, people, things and cope with everyday life situations.

B. Haptic feedback

Haptic feedbacks which also referred haptics which take advantage of the sense of touch in user interface design to provide information to an end user [1]. This technology applies mechanical stimulation including forces, vibrations or motions.

Haptic feedback contributes massive benefit in electronic technology, and it is a fast growing field in the meantime. It can be applied to a widespread range of products to improve user experience, growth productivity, increase safety, or provide other benefits depending on its employment.

For product manufacturers it is great way of differentiating from the competition, and for customers the extra dimension of tactile feedback can be essential [4]. Haptic feedback is being used in more and more applications; some typical markets include tablet PC touchscreens, medical equipment and automobile dashboards.

C. *Haptic Technology*

Haptics incorporates both touches which refer to tactile element and motion as kinaesthetic elements [5]. Applications that simulate real physical properties such as weight, momentum, friction, texture, or resistance, haptics communicates those properties through interfaces that let users feel what is happening on the screen.

Haptic technology has well developed in various fields. There are several examples of high haptic technology application such as MAKO's robotic arm system that can simulation system for orthopedic surgery. This system improved surgical outcome by setting up a high level of accuracy and optimal positioning of the implants.

Other than that, in medical educational field an intravenous catheterization simulator was developed to provide interactive self-directed learning system for training [8].

D. *Significant of haptic and emotions*

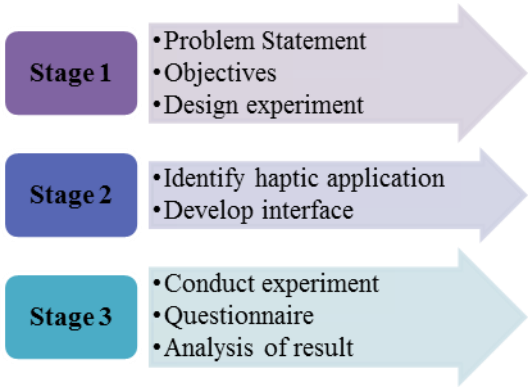
Haptics had adding a new channel of communication using the sense of touch. It expands the notion of two-way communication between humans and computers to include sensory feedback. Previous work by Ekman (1972; 1995) shows that emotions could be associated to haptics based on identified gesture as table 1 below**.**

Basic emotions	Reference identified by Paiva et al (2002)
Fear	Lazarus (1991) associate fear with **avoidance.**
Happiness	Joy is portrayed by Darwin (1872) with open arms, movements such **as rhythmic movement.**
Sadness	Scherer (2002) explain sadness by expressing it through **slow movement** inward and head down.
Anger	According to Lazarus (1991) anger related to **tendency to attack.**
Surprise	Laban (2001) associated surprise with **sudden event.**
Disgust	Lazarus (1991) disgust is action to **move away**, nausea and vomiting.

Table 9: Haptic and emotions

II. METHODOLOGY

A. *Research Methodology*



B. *Experimental Design*

This experiment design was arrange based on three stages which are:

(1) Pre-experiment tasks:
Participants were given brief introduction about the objectives and procedure of the experiment, to ensure clear picture about the experiment. Then they were being introduced to the device and the function of the PHANToM. Then simple demonstration was conducted and participant was asked to try to manipulate the application and communicate with the virtual object in the programme.

(2) Experimental tasks
The participants would perform a gesture adhering to the cues from the emotional theories on the table 1. Each interface will represent one emotion that suitable to it. The participant than asked about emotions felt through this experiment. This part of experiment involves interaction with 6 force feedback generated interfaces as listed below:

i. Happy : Particle Waltz
ii. Surprise : Graph Manipulator
iii. Anger : Complex Scene
iv. Disgust : Rigid Body Dynamic
v. Fear : Shape Manipulator
vi. Sadness : Simple Pinch & Haptic For Dyslexia

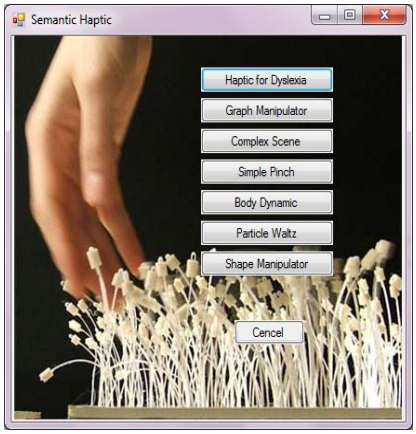


Figure 25: Basic interface for experimental testing

(3) Post Experimental tasks
Participants were asked to fill in the questionnaire to assess the usability, presence and engagement of the multi model application. Then participants need to fill in questionnaire, by identifying suitable emotion they feel according to force feedback experience during testing. They were also need to rate the intensity of the emotion in order to classified the force feedback strength of each application.

C. Tools and Equipments

This is one of the SensAble Technology that allow user to touch and manipulate virtual objects. PHANToM provides force-feed back experience with high resolution, six degrees-of-freedom (DOF) and deform object with a high degree of realismSystem Methodology

III. RESULT AND DISCUSSION

This research project examines the quantitative and qualitative data gathered based on 30 participants as project sample space. Below shows the responses of all participants pertaining to the relationship of emotions and haptic feedback.

Rating	1	2	3	4	5
Emotion and haptic have close relations	0	0	1	8	21
Haptic can be explained by emotional cues.	0	0	4	9	17

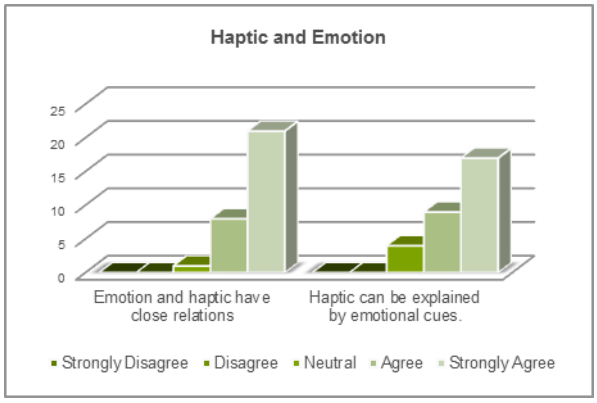


Figure 26: Relation between haptic and emotions

As results as stated in table and figure 2, 96% participants agree that haptic do have close relation with emotions. In fact, results prove that most of the participants realize the relationship between haptic feedback and emotion regardless of their background of study. Therefore, it can be synthesized that most of people already acknowledge the complimentary element between haptic and emotions.

Then, participants were asked about their understanding on haptic and emotions. This indicates that haptic feedback technologies are able to be improved provided with the present of the meaningful definition of each haptic sensation. Below shows the responses of all participants pertaining to the relationship of emotions and haptic feedback

Demonstration		Cues	%
Student Project	Haptic for Dyslexia	Sad	13.33
	Point Manipulator	Surprise	56.67
PHANTM Demo	Complex Scene	Anger	26.67
	Simple Pinch	Sad	20.00
	Rigid Body	Disgust	23.33
	Particle Waltz	Happy	80.00
	Shape Manipulator	Fear	13.33

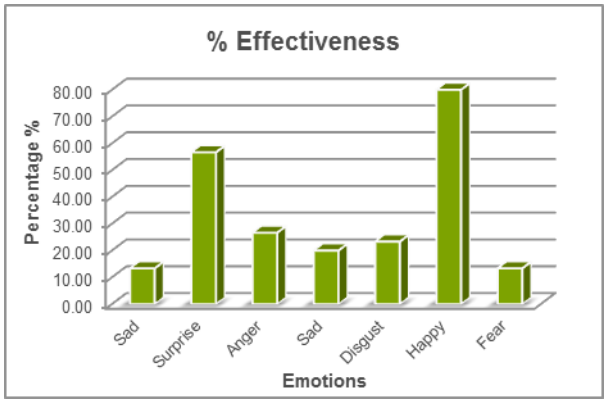


Figure 27: Effectiveness of participants who correctly identified the suitable emotions

Result shows that, 80% participants able to identify happy emotion while testing application named Particle Waltz. Approximately 56% of participants correctly identified surprise emotion while testing application named Graph Pointer. 26% and 23% correctly identify anger and disgust feelings respectively. Fear and sadness show the result of 20% and 13% of participants respond correctly to each feeling.

Haptic generally are able to be represented by human emotions. All participants respond to cues with emotional feedback, no participants could not describe the feeling and respond as emotion. The emotion of happy was significantly more meaningful to be associated with human emotion followed by surprise feeling. The outcome clearly show that the combination of sensory cues balanced, creating a natural environment and enjoyable feeling such as happy and surprise feeling.

Majority of the participants selected the emotion of happy for this cues which is 80% out of 24 users. Other user respond this application represent evoke the feeling of joy. According to Darwin sense of joy is associated to rhythmic movement. The demonstration was developed using three floating dimensional particles which can be manipulated and swing away as such a boy playing yoyo.

Intensity	Frequency
Very low	0
Low	1
Neutral	6
High	5
Very high	12
Total response	**24**

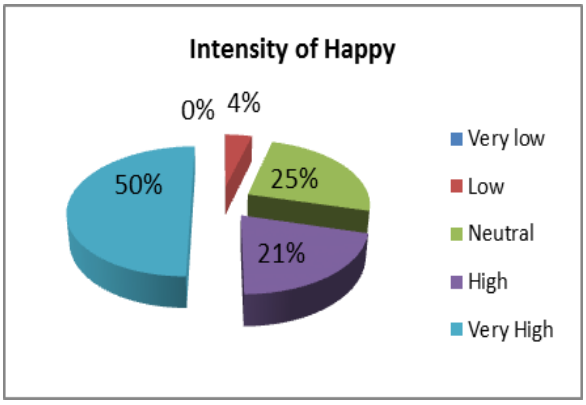


Figure 28: The intensity of happiness

Interestingly the sphere particles are floating where it enable users to move the object without resistance. The integration between moving visual and haptic feedback create an exciting experience where it evoke positive emotions. Nevertheless, most of the users are able to identify the emotion correctly with high rating.

As happy is the only positive emotion many participant choose this emotion as option, closest to their feeling. Based on study here, the responses are varies in term of the intensity. Most of the participants rate this haptic cue as high intensity which is 5 and four people rate 4 as the intensity. Figure above shows various intensity responds by the participants throughout the experiment.

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