Haptic Technology- Comprehensive Review Study with its Applications

Tanya Jaiswal[1], Rambha Yadav[2], Pooja Kedia[3]

[1,2]*Student, Department of Computer Science and Engineering, Buddha Institute of Technology, (India)*

[3]*Assistant Professor, Department of Computer Science and Engineering,*

Buddha Institute of Technology, (India)

ABSTRACT

"Haptics" is derived from "hapticos" which means "being able to come in contact". It refers to technology that uses to control and interact with computers. Haptic technology makes the user able to interact and interface with virtual environment created by the computer via sense of touch by applying force, vibration and/or motion of user. A haptic device gives people a sense of touch with computer generated environment. So, that when virtual object is touched, they seems real and tangible. Computer Science has variety of applications in different fields. Now days, the combination of human sense and touch is becoming popular. This paper is a detailed study of haptic technology, haptic devices, its applications and also include the limitations of this technology.

Keywords: Virtual Reality, Haptic rendering, Visual rendering, Force feedback.

I.INTRODUCTION

Haptic is the recent technology arrived in the world, which makes the human interact with real, virtual and remote environment. It permits the users to sense and manipulate virtual object with features such as shape, size, weight and temperature [1]. From the five senses of human body, touch is most proficient and only one that is capable of simultaneous input and output, it is the bi-directional energy and there is flow of information between real and virtual environment and the end user and such kind of touch is called "active touch" [2].

On touching virtual object interaction are felt on skin and these forces convey the information and lead to awareness of the physical world, when perception is received, the muscles are activated by brain which results in movement. Haptic feedback also provides a measure of force exerted by user on an interface.

Mechanical, sensor, motor and cognitive components constitute the human haptic system. The mechanical components include the body part which work as per the brain retort. Sensory mechanism includes nervous system receptors, which gets activated when the physical stimulus occurs and thus message is conveyed to brain. The cognitive mechanism includes the brain which analyses and perceives the conveyed information and then activates motor components thereby completing the circle. The main of haptic is to access forces on any part of the body. Computer haptics consists of generating algorithms to create and touch the virtual atmosphere and objects [3].

In our paper we have discussed the basic concept of haptic technology along with its devices and how does this technology works. Haptic has wide variety of application in fields such as Medical training, Aircraft mechanics, Military training, helping the blind to feel a city.

II. LITERATURE REVIEW

Haptic Information acquired by system are the combination of-

1. Tactile Information

2. Kinesthetic Information

Tactile information refers to the information provided by the sensors which are actually connected to the skin of the human body with a particular reference to be the spatial distribution of pressure, or more generally traction across the contact area. For example, when we handle a flexible material like fabric and paper, we sense the pressure variation across the finger tip. This is actually a sort of tactile information. Tactile sensing is also the basic of complex perceptual tasks like medical palpation , where physician locate hidden anatomical structure and evaluate structures and evaluate tissues properties using their hands [4].

Kinesthetic information refers to the information provided through the sensors in the joints. Interaction forces are normally achieved through a combination of these two information [4].

Computer haptics consists of generating algorithms to create and touch the virtual atmosphere and objects. The two important criteria are visual rendering and haptic rendering which indicate the exchange the information about virtual environment to the user. Haptic rendering includes software based on algorithm to find the area of contact and also force between user and the virtual environment [3]. Moreover, haptic rendering algorithms ensure that the haptic device correctly renders such forces on the human operator. Several components compose typical haptic rendering algorithms. We identify three main blocks, illustrated in figure 1.

Collision detection algorithm detects the collision between objects and avatars in the virtual environment where avatar is the virtual representation of haptic through which the users interact in the virtual environment physically [4].

Force-response algorithms compute the interaction force between virtual objects and avatars when a collision is detected.

Control algorithm command the haptic device in such a way that minimizes the error occurred between applicable force and ideal force.
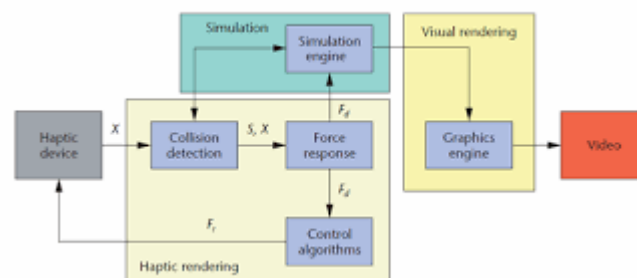

Fig 1: Haptic Rendering Architecture [4]

Visual rendering is a process of generation algorithm to compute real time behaviour of virtual environment graphics.

III. WORKING OF HAPTICS

Basically haptic system consists of two parts:

- Human part
- Machine part

In the figure 2, the left part signifies human part which sense and control the position of hand where as the right part signifies machine part which exerts forces from the hand to simulate content of virtual object. Both the system i.e., human part and machine part are provided with the required sensor, processor and actuators. In case of human part, brain performs processing, muscles perform actuation of motion performed by hand and nerves receptors perform sensing. In machine part the above mentioned functions are performed by computers, motors and encoders respectively [3].
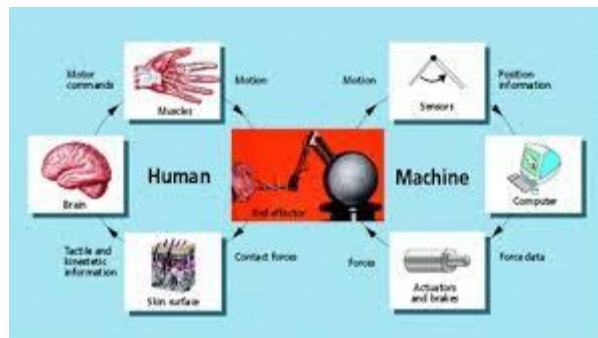

Fig 2: Haptic System Configuration [4]

The working principle of haptic system is shown in figure 3:
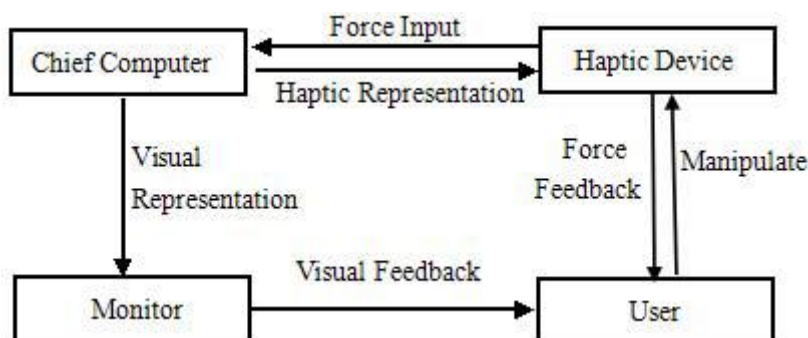

Fig 3: The system architecture diagram [5]

The block Chief Computer act as the core of whole haptic system which is used to tackle with input of external device, to do the processing of visual and haptic data, to perform the real time rendering and graphic and haptic information and send the processed force to the haptic devices. Haptic devices act as the key part of the whole haptic system. It allows the user to feel the interaction with the virtual object and receive effects of force. The

monitor works as GUI and is used to render is used to render the virtual scene, in order to help users have an intuitive and better understanding of virtual environment [5].

IV. HAPTIC DEVICES

Haptic devices act as a interface between user and computer. Haptic devices are classified as:

A. Virtual Reality/ Tele robotics based devices

B. Feedback devices

Virtual Reality/Tele robotics based devices: Virtual reality is the technology which allows a user to interact with a computer simulated environment, whether that environment is a simulation of the real world. It can be used to describe a variety of application associated with its immersive, highly visual 3D environment. The most successful use of virtual reality is computer generated 3D simulator. The pilots use flight simulators. The screen in front of pilot creates virtual environment and trainer outside simulator commands the simulator to adopt different modes. Since, they are trained to control the planes in different difficult situation and emergency landing. The simulator provides the environment and these simulators costs millions of dollars. In similar fashion, virtual reality games are also used. The players of games have to wear special gloves, headphones, goggles, full body wearing and sensory input devices. The player feels that he is in real environment. The special goggles have monitor to see. As the moments of player changes the environment changes. These games are very expensive [4].

1. Exoskeletons and stationary devices: In technical sense, the word exoskeleton refers to a system that has to be wored.

2. Gloves and wearable devices: They are not limited to a constrained workspace. Therefore, they allow user to move freely and perceive haptic feedback in much larger range, much like in real world.

3. Point-sources and specific task devices

4. Locomotion interfaces: The interesting application of force feedback is in the form of full body force feedback [4].

Feedback devices are divided into two sub-devices i.e.,

1. Force feedback

2. Tactile feedback

Force feedback is the process in which computer respond to user's force input through haptic devices and deliver the haptic information to the user via haptic device at the time of human computer interaction. It has variety of applications, example: in the batting training, when user in virtual stadium, hitting the ball via haptic device he/she can feel the immersive intensity and shock [5].

Tactile feedback makes the use of devices that interact with the nerve ending in the skin to indicate heat, pressure and texture [6].

V. COMMONLY USED HAPTIC DEVICES

1. Phantom

Phantom is a haptic interfacing device and was developed by Sensible Technology. Initially, it is used for providing 3D touch to virtual objects. It provides a programmable sense of touch that allows the user to feel the texture and shape of virtual object [1]. Phantom design allows the user to interact with the computer by inserting his/her finger in to its thimble. It is unique in that it offers realistic 3D touch, the ability to fee the physical properties of virtual 3D object, with much high fidelity and much lower cost than previous for feedback devices.

Fig 4: PHANTOM

2.Cyber Grasp

It is a force feedback system for our finger and hand. It is a light weight, force reflecting exoskeleton device that fits over the user's entire hand and adds resistive force feedback to each finger. There are 5 actuators one for each finger.

Fig 5: Cyber Gloves

VI. APPLICATIONS

- In Graphical User Interface

Graphical User Interface, like those that define window and Mac OS will also benefit greatly from haptic interactions. Imagine being able to feel graphic button & receive a force feedback when you press a button [7].

- Museum display

Haptic technology are available that let museums add this missing aspects back into their computer based exhibits. This allows the visual displays to be extended to make them more realistic, useful and engaging for visitor and scholars [8].

- Military application

Soldiers can prepare for battle in variety of ways from learning how to defuse a bomb to operating a helicopter, tank and fighter jat.

- Aircraft Mechanism

It can work with complex part and services procedures by touching everything that they only see on computer screen.

Training and education

Training with haptics is becoming very common. Example- Medical students can now perfectly delicate surgical technique on the computer, feeing what its like to suture blood vessels in an inject BOTOX into the muscle tissues of the virtual face.

- Helping the blinds to feel a city

Incorporate haptic technology into touchable maps for the blind. To create map, researchers shoot video of a real world location either an architectural model of a building or a city block. Software evaluates the video frame by frame to determine the shape and location of every object. The data results in a 3D grid of force for each structure. Using a haptic interface device, a blind person can feel these forces and, along with audio cues, get a much better feel of a city's or building's layout.

VII. CASE STUDY

In this section, we demonstrate the HAVE architecture by considering a specific haptic application called as the **HugMe system, it is an interpersonal communication system**. It is an excellent example of a complete HAVE system incorporating haptic, audio and visual information. HugMe system enables a parent child to communication over internet using multimodal interactions (haptic, audio and visual information [9]. In the figure 6, the child is wearing haptic suit called as haptic jacket that is capable of simulating
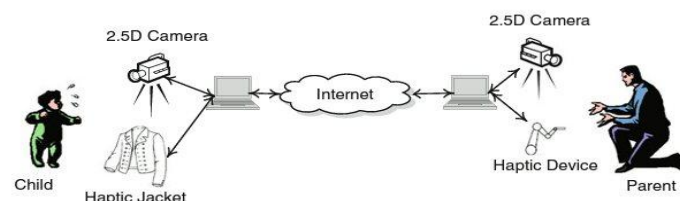

Fig 6: HugMe application scenario [9]

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nurturing physical stimuli. On the other side of network, the parent uses a haptic device to communicate his/her feeling to child. A 2.5D camera is used to capture the image and depth information of the child and send it to the parent. The parent uses the haptic device to apply force to child representation shown on the screen.

VIII. L IMITATIONS

- High initial investment.
- High cost involved.
- Large weight and size of haptic devices especially wearable ones.
- Instability and vibration: The update rate of graphic rendering is 60 Hz. But haptic rendering must be 100Hz. It leads to instability if required rates are not met. Thus system becomes unstable [3].
- Haptic interfaces can only exert forces with limited magnitude and are not equally well in all directions.
- Haptic rendering algorithm which provides the virtual environment operate in discrete time where as the real time users operate in continues time [2].

IX. FUTURE VISION

- E-Commerce

  User could study and feel the texture and quality of material during sale of product through online [3].
- Medical Application

  Use of a central workstation from which surgeons would perform operation in various locations with machine setup and patient preparation are performed by local nursing staff.
- Holographic Interaction

  By this feedback, user receives response from hologram. It is based on ultrasound waves. Through, tactile response that the user perceives from the object [3].
- Biometric Haptics

 A unique ID and password is used for conventional biometrics. Hence to remember these password and Id is difficult thus less secure. This can be easily hacked. The haptic based biometric system measures the position, velocity and force and thus unique physical patterns are developed which are used for identification [3].

X. CONCLUSION

Haptics is still in its initial phase. It has variety of application as discussed above. However, it has variety of limitations. As we know, everything in life has some limitations and to remove the limitations a lot of works are done, then there is change occurs that is called as development. Similarly, with the increase in applications and achieving future aspects we are able to reduce the limitations also. Because of increase in need of haptic applications, the cost of haptic devices will surely drop in future. Haptic in future will bring a change in online computing and e-commerce. It will make the user able to feel the texture of product quality during online shopping . Then customer will have a better experience on shopping while being at their home. Haptic will soon will be party of person's normal computer interactions.

REFERENCES

[1] Snehal N. Meshram , Amit M. Sahu, " Haptic Science and Technology in Surgical simulation, medical training and military application", (IJCSMC)International Journal of Computer Science and Mobile Computing vol 3 issue 4, April 2014.

[2] Anupam alur, Pratik Shrivastav, Aditya Jumde "Haptic Technology-A Comprehensive Review of its Application and Future prospects", (IJCSIT) International Journal of Computer Science and Information Technologies vol 5(5), 2014.

[3] Sreelakshmi M., T.D. Subash "Haptic technology: A Comprehensive review on its application and future prospects" Materials Today: Proceedings, 4(2):4182-4187, 2017, Science Direct.

[4] N. F. Vaibhav, V. S. Mohit, A. A. Anilesh "Applicaton of Haptic Technology in advance Robotics" in INTERACT- 2010, pp.273-277, IEEE. Dec. 2010.

[5] Lu-miao liu, Wei Li, Jia-Jia Dia "Haptic Technology and Its Application in Education and learning" International Conference on Ubi-media Computing and workshops (Ubi-media)-2010.

[6] S. Sri. Gurudatta Yadav, Dr. R.V. Krishnaiah "Haptic Science and Technology" International Journal of Computer Engineering and Application, vol-II, ISSUE I/III 2014.

[7] https://electronics.howstuffworks.com/everyday-tech/haptic-technoogy4.htm

[8] Megha Goyal, Dimple Saproo, Asha Bagashra, Kumar Rahul Dev "Haptic Technology based on Touch" International Journal of Scientific Research Engineering & Technology (IJSRET) 2013.

[9] http://www.springer.com/978-3-642-22657-1