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Survey of ExophalanxinRobo Using Haptic Feedback System: A Review

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***Abstract*—*"HAPTICS"-- a technology that adds the sense of touch to virtual environment .Haptic interfaces allow the user to feel as well as to see virtual objects on a computer, and so we can give an illusion of touching surfaces, shaping virtual clay or moving objects around. In this paper, we explplicate how sensors and actuators are used for tracking the position and movement of the haptic device moved by the operator. Then, we move on to a few applications of Haptic Technology. Finally, we conclude by mentioning a few future developments.*

***Keywords*— Sense of touch, holography in haptics, haptics, tactile feedback, exophalanx in robo, haptic rendering, virtual object.**

I. INTRODUCTION

Haptics refers to sensing and manipulation through touch. The word comes from the Greek 'haptesthai', meaning 'to touch'. The history of the haptic interface dates back to the 1950s, when Goertz (1952) proposed a master-slave system. Haptic interfaces were established out of the field of tele- operation, which was then employed in the remote manipulation of radioactive materials. The ultimate goal of the tele-operation system was "transparency". That is, an user interacting with the master device in a master-slave pair should not be able to distinguish between using the master controller and manipulating the actual tool itself. Early haptic interface systems were therefore developed purely for telerobotic applications.

1.1 WORKING OF HAPTIC DEVICES

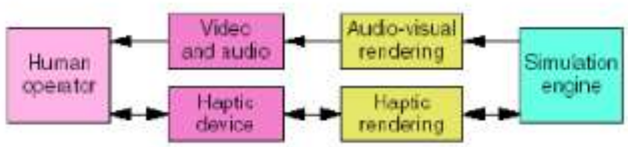

FIGURE 1.1: Architecture for Haptic Feedback

Basic architecture for a virtual reality application incorporating visual, auditory, and haptic feedback.
• Simulation engine: Responsible for computing the virtual environment's behavior over time.
• Visual, auditory, and haptic rendering algorithms: Compute the virtual environment's graphic, sound, and force responses toward the user.
• Transducers: Convert visual, audio, and force signals from the computer into a form the operator can perceive.
• Rendering: Process by which desired sensory stimuli are imposed on the user to convey information about a virtual haptic object.

The human operator typically holds or wears the haptic interface device and perceives audiovisual feedback from audio (computer speakers, headphones, and so on) and visual displays (a computer screen or head-mounted display, for example). Audio and visual channels feature unidirectional information and energy flow (from the simulation engine towards the user) whereas, the haptic modality exchanges information and energy in two directions, from and toward the user. This bi directionality is often referred to as the single most important feature of the haptic interaction modality.

Haptic Technology promises to have wide reaching applications as it already has in some fields. For example, haptic technology has made it possible to investigate in detail how the human sense of touch works by allowing the creation of carefully controlled haptic virtual objects. Haptics technology can be used to train people for tasks requiring hand-eye coordination, such as surgery and space ship maneuvers. Although haptic devices are capable of measuring bulk or reactive forces that are applied by the user,

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it should not to be confused with touch or tactile sensors that measure the pressure or force exerted by the user to the interface. Through haptic interface, human can interact with the computer through body sensation and movement. Several applications such as surgical training, gaming etc use haptic technology. Haptic technology has made it possible to investigate in detail how the human sense of touch works by allowing the creation of carefully controlled haptic virtual objects.

II. LITERATURE REVIEW

2.1 HISTORY:

One of the earliest applications of haptic technology was in large aircraft that use servomechanism systems to operate control surface Such systems tend to be "one-way", meaning external forces applied aerodynamically to the control surfaces are not perceived at the controls. Here, the missing normal forces are simulated with springs and weights. In lighter aircraft without servo systems, as the aircraft approached a stall the aerodynamic buffeting (vibrations) was felt in the pilot's controls. This was a useful warning of a dangerous flight condition. This control shake is not felt when servo control systems are used. To replace this missing the angle of attack is measured and when it approaches the critical stall point, a stick shaker is engaged which simulates the response of a simpler control system. Alternatively, the servo force may be measured and the signal directed to a servo system on the control, known as force feedback. Force feedback has been implemented experimentally in some excavators and is useful when excavating mixed material such as large rocks embedded in silt or clay. It allows the operator to "feel" and work around unseen obstacles, enabling significant increases in productivity.

The first US patent for a tactile telephone was granted to Thomas D. Shannon in 1973.[3] An early tactile man-machine communication system was constructed by A. Michael Noll at Bell Telephone Laboratories, Inc. in the early 1970s and a patent issued for his invention in 1975.

2.2 Design By Generation :

Haptics are enabled by actuators that apply forces to the skin for touch feedback, and controllers. The actuator provides mechanical motion in response to an electrical stimulus.

First :Most early designs of haptic feedback use electromagnetic technologies such as vibratory motors, like a vibrating alert in a cell phone or a voice call in a speaker, where a central mass is moved by an applied magnetic field. These electromagnetic motors typically operate at resonance and provide strong feedback, but produce a limited range of sensations and typically vibrate the whole device, rather than an individual section.

Second :Second generation haptics offered touch-coordinate specific responses, allowing the haptic effects to be localised to the position on a screen or touch panel, rather than the whole device. Second generation haptic actuator technologies include electroactivepolymers,piezoelectric, electrostratic and subsonic audio wave surface actuation. These actuators allow to not only alert the user like first generation haptics but to enhance the user interface with a larger variety of haptic effects in terms of frequency range, response time and intensity. A typical first generation actuator has a response time of 35-60ms, a second generation actuator has a response time of 5-15ms. User studies also showed that haptic effects with frequencies below 150 Hz are preferred by users. Frequencies of 250–300 Hz, which is the typical range of electromagnetic systems are well suited for alerts but are perceived as annoying over time, which is why first generation haptic systems used to enhance the user interface are often deactivated by the users.

Third: Third generation haptics deliver both touch-coordinate specific responses and customisable haptic effects. The customisable effects are created using low latency control chips.

To date two technologies have been developed to enable this; audio haptics[1] and electrostatic haptics. A new technique that does not require actuators is called reverse electrovibration. A weak current is sent from a device on the user through the object they are touching to the ground. The oscillating electric field around the skin on their finger tips creates a variable sensation of friction depending on the waveform, frequency, and amplitude of the signal.

Fourth: Fourth generation haptics deliver pressure sensitivity, enabling how hard you press on a flat surface to affect the response.There are currently no commercially available (as of May 2013) platforms that use this functionality, but the technology is in development by a number of firms. KDDI and Kyocera jointly announced in 2011 that they were collaborating on research. And, at the Future World Symposium electronics industry conference, 2012, HiWave's (haptics division now spun out to become Redux) CEO stated that the company was also working on pressure-sensitive technology.

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In June 2013 a fourth generation haptics demonstration platform, called Bulldog, was announced in the UK electronics publication Electronics Weekly. This took the force exerted by a finger into consideration when delivering the haptic feedback and gave three levels of feedback from a flat panel.

Haptic interfaces are divided into two main categories:

- Force feedback
- Tactile feedback

Force feedback interfaces are used to explore and modify remote/virtual objects in three physical dimensions in applications including computer-aided design, computer assisted surgery, and computer-aided assembly. Tactile feedback interfaces deals with surface properties such as roughness, smoothness and temperature.

FIGURE 2.1 Tactile and Force Control

2.3 WORKING OF HAPTICS

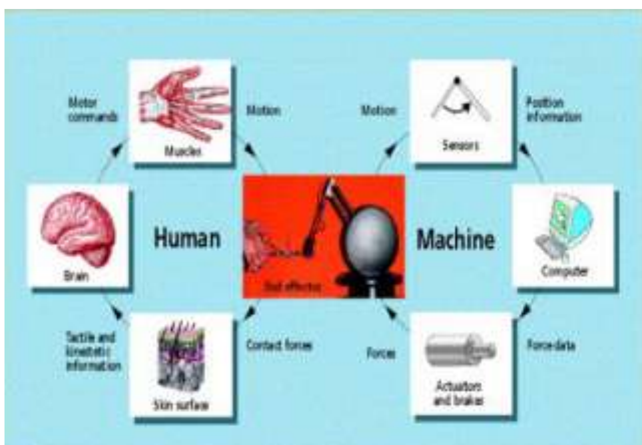

FIGURE 2.2: Basic Configuration of Haptics

Basically haptic system consists of two parts:

- Human part
- Machine part

From the above figure 1, human part (left) controls the position of the hand, while the machine part (right) exerts forces from the hand to simulate contact with a virtual object. Also both the systems will be provided with necessary sensors, processors and actuators. In the case of the human system, nerve receptors performs sensing, brain performs processing and muscles performs actuation of the motion performed by the hand while in case of the machine system, the above mentioned functions are performed by the encoders, computer and motors respectively [2].

2.4 Haptic Devices

Haptic devices (or haptic interfaces) are mechanical devices acts as mediator in communicating between the user and the computer. Haptic devices allow users to touch, feel and manipulate three-dimensional objects in virtual environments and tele-

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operated systems. Haptic devices are input-output devices that track a user's physical manipulations (input) and provide realistic touch sensations coordinated with on-screen events (output).

Examples of haptic devices include consumer peripheral devices equipped with special motors and sensors such as force feedback joysticks and steering wheels and more sophisticated devices designed for industrial, medical or scientific applications such as PHANTOM device.

Typically, a haptics system includes;

- Sensor(s)
- Actuator (motor) control circuitry
- One or more actuators that either vibrate or exert force
- Real-time algorithms (actuator control software, whichWe call a "player") and a haptic effect library
- Application programming interface (API), and often a haptic effect authoring tool
- The Immersion API is used to program calls to the actuator into your product's operating system (OS).

When the user interacts with your product's buttons, touch screen, lever, joystick/wheel, or other control, this controlposition information is sent to the OS, which then sends the play command through the control circuitry to the actuator.

Phantom Device :

The above figure 2.2 shows Phantom device. PHANTOM haptic interface is one of the widely used haptic devices. This device measures a user's finger tip position and exerts a precisely controlled force vector on the finger tip. The device has enabled users to interact with and feel a wide variety of virtual objects and will be used for control of remote manipulators [3].

FIG 2.3 PHANTOM

2.5 Human Senses

It is believed that vision and audition convey the most information about an environment while the other senses are more subtle. Because of this, their characteristics have been widely investigated over the last few decades by scientists and engineers, which have led to the development of reliable multimedia systems and environments.

Vision : The visual sense is based on the level of absorption of light energy by the eye and the conversion of this energy into neural messages. The acceptable wavelength range forhuman eyes is between 0.3 and 0.7_m (1_mD10_6m). The temporal resolution sensitivity of the human visual system is biologically limited and not sufficient to detect the presentation of sequential video frames past a certain speed. This is the reason why we do not perceive a digital movie as a series of still images, but rather as moving pictures.

Audition: The human auditory system transmits sound waves through the outer, middle, and inner ears. This sound wave is transformed into neural energy in the inner ear. It is then transmitted to the auditory cortex for processing. The audible frequency of humans ranges from 16 to 20,000Hz and is most efficient between 1,000 and 4,000Hz.

Touch: The sense of touch is mainly associated with active tactile senses such as our hands. Such senses can be categorized in several ways, and they have a link to the kinesthetic senses. According to Heller and Schiff, touch is twenty times faster than vision, so humans are able to differentiate between two stimuli just 5ms apart; Bolanowskiet al. found that touch is highly sensitive to vibration up to 1KHz, with the peak sensitivity around 250 Hz; and skin receptors on the human palm can sense displacements as low as 0.2_m in length

Haptic Feedback: Haptic / Tactile feedback (or haptics) is the use of advanced vibration patterns and waveforms to convey information to a user or operator. Haptic feedback has two major benefits for manufacturers. Firstly, it can improve user experience. Even everyday products are now being built with touch displays and interfaces. They are cheaper to construct than control panels with buttons or switches, and designers can make context specific user interfaces simply by changing the graphical layout on the screen.

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III HAPTICS CONCEPTS

3.1 Concepts

Tactile cues include textures, vibrations, and bumps kinesthetic cues- include weight, impact. In the following section, we present some crucial concepts and terminology related to haptics:

Haptic: Haptic is the science of applying tactile, kinesthetic, or both sensations to human–computer interactions. It refers to the ability of sensing and/or manipulating objects in a natural or synthetic environment using a haptic interface.

Cutaneous: Relates to or involving the skin. It includes sensations of pressure, temperature, and pain

Tactile: Pertaining to the cutaneous sense, but more specifically the sensation of pressure rather than temperature or pain.

Kinesthetic: Relates to the feeling of motion. It is related to sensations originating in muscles, tendons, and joints.

Force Feedback: Relates to the mechanical production of information that can be sensed by the human kinesthetic system.

Haptics or Haptic Technology: An emerging interdisciplinary field that deals with the understanding of human touch (human haptics), motor characteristics (machine haptics), and with the development of computer controlled systems (computer haptics) that allow physical interactions with real or virtual environments through touch.

Haptic Communication: This means by which humans and machines communicate via touch. It mostly concerns networking issues.

Haptic Device: It is a manipulator with sensors, actuators, or both. A variety of haptic devices have been developed for their own purposes. The most popular are tactile-based, penbased, and 3 degree-of-freedom (DOF) force feedback devices.

Haptic Interface: This consists of a haptic device and software-based computer control mechanisms. It enables human–machine communication through the sense of touch. By using a haptic interface, someone can not only feed the information to the computer but can also receive information or feedback from the computer in the form of a physical sensation on some parts of the body.

Haptic Perception: This is the process of perceiving the characteristics of objects through touch

Haptic Rendering: This is the process of calculating the sense of touch, especially force. It involves sampling the position sensors at the haptic device to obtain the user's position within the virtual environment. The position information received is used to check whether there are any collisions between the user and any objects in the virtual environment. In case a collision is detected, the haptic rendering module will compute the appropriate feedback forces that will finally be applied onto the user through the actuators .Haptic rendering is, therefore, a system that consists of three parts, a collision detection algorithm, a collision response algorithm, and a control algorithm.

Sensors and Actuators:

A sensor is responsible for sensing the haptic information exerted by the user on a certain object and sending these force readings to the haptic rendering module. The actuator will read the haptic data sent by the haptic rendering module and transform this information into a form perceivable by human beings .

3.2 Tele Operations

Tele-Haptics:This is the science of transmitting haptic sensations from a remote explored object/environment, using a network such as the Internet, to a human operator. In other words, it is an extension of human touching sensation/capability beyond physical distance limits.

Tele-Presence: This is the situation of sensing sufficient information about the remote task environment and communicating this to the human operator in a way that is sufficient for the operator to feel physically present at the remote site. The user's voice,

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movements, actions, etc. may be sensed, transmitted, and duplicated in the remote location. Information may be traveling in both directions between the user and the remote location .

Virtual Reality (VR): This can be described as the computer simulation of a real or virtual world where users can interact with it in real time and change its state to increase realism. Such interactions are sometimes carried out with the help of haptic interfaces, allowing participants to exchange tactile and kinesthetic information with the virtual environment.

Virtual Environment (VE): This is an immersive virtual reality that is simulated by a computer and primarily involves audiovisual experiences. Despite the fact that the terminology is evolving, a virtual environment is mainly concerned with defining interactive and virtual image displays.

Collaborative Virtual Environments (CVE): This is one of the most challenging fields in VR because the simulation is distributed among geographically dispersed computers. Potential CVE applications vary widely from medical applications to gaming.

Simulation Engine: This is responsible for computing the virtual environment behavior over time .

Collaborative Haptic Audio Visual Environment (CHAVE):
In addition to traditional media, such as image, audio, and video, haptics as a new media plays a prominent role in making virtual or real-world objects physically palpable in a CVE. A C HAVE allows multiple users, each with his/her own haptic interface, to collaboratively and/or remotely manipulate shared objects in a virtual or real environment.

Figure 3 consists of three blocks, Haptic Rendering, Visual modeling and Simulation. Haptic rendering is divided into three blocks.
Control Detection Algorithm: Detects collision between objects and avatar in the virtual environment and yield information.
Force Response Algorithm: Computes interaction between the virtual objects and avatar when the collision is detected
Control Algorithms: Command the haptic devise in order to minimize the error between ideal and application forces.

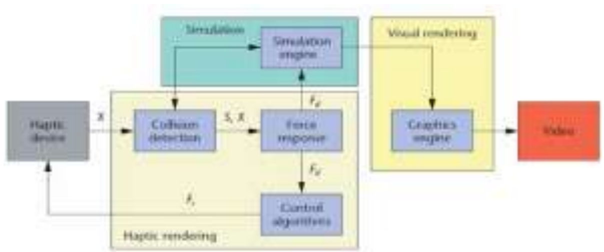

Figure 3.1: Haptic system block diagram

IV CONCLUSION

Haptic is the future for online computing and e-commerce, it will enhance the shopper experience and help online shopper to feel the merchandise without leave their home. Because of the increasing applications of haptics, the cost of the haptic devices will drop in future. This will be one of the major reasons for commercializing haptics. With many new haptic devices being sold to industrial companies, haptics will soon be a part of a person's normal computer interaction.
We finally conclude that the haptic technology is the solution for interacting with the virtual environment and used widely in many applications Haptic device acts as an input and output device tracking user physical manipulations as an input and providing realistic touch sensations as an output coordinated with onscreen events. As technology evolves and computer power grows, haptic devices and effects evolve and get more realistic. This technology has proved that virtual objects can also be touched, felt and controlled. This technology must be made available for the affordable cost and the haptic devices must be made simpler and easier to use.

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