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Advancements in Haptic Technology

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Abstract: *Haptic technology, commonly known ashaptics, makes advantage of the tactile sense of the user by applying stresses, motions,and also vibrations. Mechanical stimulation can help with remote control of equipment and devices, the production of virtual things that only exist in computer simulations, and many other tasks. Haptic has been likened to "what computer graphics does forvision does for the sense of touch." It's critical to distinguish between tactile sensors, which detect the force that a user approaches an interface, and hapticdevices, which can measure the reactionary forces applied by the user.*

Keywords: Tactile, Haptic Rendering, Haptic Perception, Virtual Object Creation and Control, and Sense of Touch

I. INTRODUCTION

Haptic technology imparts vibrations,various forces, andalso movements to the user by utilising their sense of touch. The study of touch-based perception and control is known as haptics. The word "haptic" is derived from the Greek word "haptesthai".

It is widely used in several industries, haptic technology is emerging to be useful in a variety of applications. For instance, haptic technology is helpful inbuilding finely controlled haptic virtual objects, enablingin-depth research into how the touch sensitivity in people operates.For operations like surgery and spaceship movements that need hand-eye coordination, people can be trained using haptics technology. It's crucial to distinguish haptic devices, which can track bulk or reactive forces applied by the user, from touch ortactile sensors, which register pressure or force applied by the user to the interface. A person can interact with a computer via haptic interface by moving and detecting their body. Gaming and surgical training are just two useof haptic technology. Haptic technology played important role to fully investigate how the touch sensitivity in human works by enabling the building of painstakingly controlled virtual haptic objects.

II. LITERATURE REVIEW

A subfield of haptics known as force feedback works with the help of hardware and as well as software that activates touch sensitivity in people and sensation by vibrating their hands or applying force. Humans feel as though a force is being applied while using devices that work with muscles and tendons. Robotic manipulators are the key components of these devices; they push backon a user with pressures suited to the environment in which the virtual effectors are placed.

In order to communicate heat to skin nerve endings, tactile feedback is used. Pressure and texture is alsocommunicated with the help of tactile feedback. the Thetypical application of these tools has been to demonstrateif the user is in touch with a virtual object or not. Additional tactile cue devices have been used to activatethe texture of a virtual object.

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III. WORKING PRINCIPLE

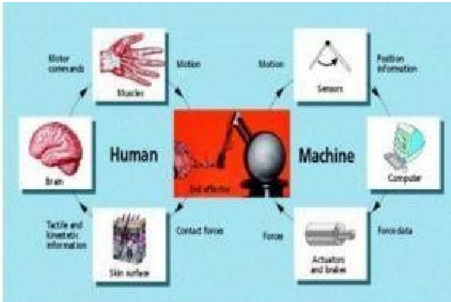

Fig. 1: Basic haptics configuration

Essentially, a haptic system consists of two parts: human element machine element Figure 1 above shows a human controlling the hand's position on the left and a machine controlling the hand's forces on the right to simulate contact with a virtual object. Additionally, the necessarysensors, processors, and actuators will be provided for both systems. In the human system, nerve receptors carryout sensing, the brain does processing, and muscles giveactuation of the motion generated by the hand. In contrast, encoders, computers, and motors do the aforementioned tasks, respectively, in the machine system.

Haptic devices

Haptic devices are electronic devices that provide tactile feedback to users through vibrations, forces, or motions. They allow users to interact with virtual or remote environments as if they were interacting with physical objects. Haptic devices are commonly used in fields such as medicine, gaming, education, and robotics.Examples for this include consumer peripherals with specialised motors and sensors, such as joysticks and steering wheelswith force feedback, as well as more complicated gadgets designed for commercial, medical, or scientific applications, such as the PHANTOM device.

It typically includes the following parts: sensors, actuator and other control circuitry, one or more actuators that apply force or vibration, real-time algorithms, and a library of haptic effects. Utilising the Immersion API, you can incorporate calls to the motor also known as actuator into your product's operating system . It is widely utilised to produce haptic effects.

Phantom Device

Fig 2: Phantom Device

The Phantom device is shown in Figure 2 above. The stylus-like input device and motorised arm that make up the Phantom haptic device are connected. The motorisedarm responds to the user's stylus movements with force feedback, simulating the experience of touching andinteracting with virtual items. The system makes use of sensors to keep track of the stylus's location and direction, and software algorithms are employed to determine the force that should be applied to the user.

Human Senses

Although the other senses are also significant, the visionand hearing sense give the most in-depth information about an environment. Therefore, over the past few decades, researchers have put a lot of effort into studyingthese characteristics, which has led to the creation of trustworthy multimedia environments and systems.

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Vision
The foundation of vision is how much light energy is absorbed by the human eye and transformed into brain impulses. For human eyes, the ideal wavelength range isin between 0.3 m and 0.7 m. Because of biologicallimitations, the human visual system is unable to notice the display of video frames in order at rates over aspecific threshold. This is the reason we see a digital movie as a collection of moving images rather than fixedphotos.

Audio
The auditory system in humans sends sound waves to themiddle, inner, and outer ears. The inner ear converts thissound wave into neuronal energy. After then, informationis delivered for processing to the cortex of the auditory nerve. The most effective frequency range for human hearing is between 1,000 and 4,000 Hz, with 16 to 20,000 Hz being the lowest.

Touch
Our hands and other primarily active tactile senses are linked to touch. These senses, which are connected to the kinesthetic senses, fall into a variety of categories. The human palm's skin receptors have been found to be highly sensitive to vibrations up to 1KHz, with the greatest sensitivity occurring around 250 Hz, and they are capable of sensing displacements as small as 0.2m.
Hapticfeedback
The use of touch or other tactile sensations to interact with a user is known as haptic feedback. The applications for this type of sensory feedback, including in virtual reality, video games, mobile technology, and medical apparatus. Delivering haptic feedback can be done in a variety of ways, for as by changes in pressure, warmth, or vibration. For instance, a user's smartphone may vibrate when they receive a notification, providing haptic input they can feel. In a virtual reality setting, haptic feedback can be used to simulate the touch experience ormanipulating objects, enhancing the user's sense of presence.

III. HAPTICS CONCEPTS

A few tactile cues are bumps, vibrations, and textures. Acouple of kinesthetic cues are weight and impact. We outline some key terms and concepts for haptics in the section that follows:
Haptic: Haptic describes a person's touch perceptionor their capacity to recognise and understand tactileexperiences. It involves the tactile sense, including the perception of pressure, warmth, vibration, and other stimuli that are recognised by skin receptors and sent to the brain for interpretation.
Cutaneous: Skin and its function in the perception and processing of tactile sensations are referred to as cutaneous in haptic technology. In order to imitate the touch perception, pressure, vibration, and other tactile stimuli, cutaneous haptic technology uses sensors and also various actuators that are in direct contact with the skin.
Tactile: The ability to perceive and process tactile stimuli as well as the touch perception are all referred toas "tactile" in haptic technology. Users can physically engage with a device or environment and feel and manipulate virtual or remote items as if they were real thanks to tactile haptic technology.
Kinesthetic: Kinaesthetic, which is also written kinesthetic, is a term used in haptic technology to definethe capacity to perceive and process sensory data relatedto muscle and joint movement as well as the sensation ofbody position and movement. Kinaesthetic haptic technology uses sensors and actuators that provide feedback on body position and movement to let users engage with a virtual or distant environment as if they were actually there.
Force Feedback: A sort of feedback called force feedback, commonly referred to as haptic feedback, gives the user the impression of touch, pressure, or resistance in reaction to their actions. Force feedback isa technique used in haptic technology that simulates physical interactions with the user and a virtual or remote environment. This allows the interaction of users with items as if they were real.
Haptic Technology: A new, interdisciplinary field that researches human touch, machine motor features, and computer-controlled system development to enable physical interactions with actual or virtual surroundings through touch.
Haptic Communication: This is a touch-based methodof communication between people and machines. Most of the challenges relate to networking.

Haptic Interface: A haptic device and methods of computer control that are based on software are used in this. It makes it possible for people and machines to communicate by using touch. One can communicate witha computer using a haptic interface and can also obtaining data or comments from it in the form of physical sensations on certain body parts.

Haptic Rendering: The three processes of sensing, calculation, and actuation are commonly involved in haptic rendering. Sensing devices pick up on the user's motions or interactions with the virtual environment. Algorithms use this information during the computing stage to determine the right haptic feedback to provide to the user. The haptic feedback is produced by actuators, such as motors or pneumatic systems, during the actuation step and is transmitted to the user. In order to respond to a user's interactions with a virtual world or distant system, haptic rendering generates and transmits haptic feedback. A crucial component of haptic interfaces, it enables users to feel forces and tactile sensations that replicate interactions in the actual world.

Sensors and Actuators: Detecting the user's applicationof force to a particular object is the responsibility of a sensor, which then sends this information to the haptic rendering module. The haptic data received by the haptic rendering module will be translated into a human- readable format by the actuator.

Tele-Haptics: The phrase "tele-haptics" refers to the use of haptic technology for remote communication and cooperation, allowing users to interact through touch and tactile feedback even while they are physically apart.Tele-haptic systems typically use sensors, actuators, and communication networks to transmit tactile information between users in multiple locations.

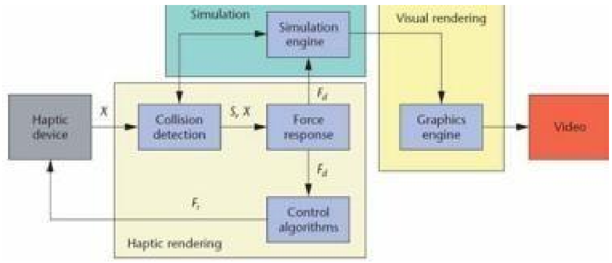
Tele-Presence: In this scenario, the goal is to collect enough information about the distant work environment and present it to the human in such a way that theoperator feels as if they are truly there. The user's voice, gestures, and other activities may all be picked up, transmitted, and recreated in a remote location. Data can be transmitted both ways involving the user and thedistant location.

Virtual Reality : Users can engage with this a virtual oractual world created by a computer in real time and change its status to increase realism. Haptic interfaces are occasionally utilised in these interactions to allow users to communicate using the virtual setting through touch and movement.

Virtual Environment: A virtual environment is a computer-generated simulation of a real or made-up world that enables people to engage with it and interact with it as if it were genuine. Virtual reality, augmented reality, and mixed reality are just a few of the technologies that can be used to construct virtual environments.

Collaborative Virtual Environments: A Collaborative Virtual Environment (CVE) is a kind of virtual environment that enables numerous users tocommunicate with one another in a real-time shareddigital space. Users can collaborate and communicate while working remotely, just as if they were in the samephysical location, on a job or project.It can come in a variety of shapes, like 3D virtual worlds, augmented reality settings, and video conferencing equipment. They often feature a variety of communication and interactiontools that let users share information and plan their actions, like chat, voice communication, and shared whiteboards.

Simulated Engine: A computer programme called a"simulated engine" uses mathematical equations and algorithms to imitate an engine's behaviour. It is intended to replicate an engine's performance and behaviour under various circumstances, including variations in temperature, altitude, and load.



Haptic system block schematic, Figure 3.

Haptic Rendering, Visual Modelling, and Simulation arethe three components that make up Figure 3.

Control detection algorithm: Information is obtained by detecting collisions between virtual items and avatars.

Control Algorithms: In order to reduce the discrepancy between ideal and application forces, command the haptic device.

Force Response Algorithm: when a collision isdetected, the interaction between the virtual objects and the avatar is computed.

IV. APPLICATIONS

Uses for haptic technology include medical training andsurgical simulation, physical therapy, education and training, museum displays, painting, sculpture, and computer-aided design, as well as scientificvisualisation, military uses, and entertainment.

V. CONCLUSION

Finally, we conclude that haptic technology is the most effective means of interacting with virtual surroundings,which is widely used in many applicationsHaptic devicesare devices that track human motion as an input and produce lifelike touch sensations as an output in sync with display events. As technology and computer powerincrease, haptic devices and effects get better and more lifelike. With the use of this technology, it is now feasibleto interact with and modify virtual things.It is necessary to simplify and make haptic devices easier to use, and it is also necessary to make this technology affordable.

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