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Haptic Technology: A Touch Revolution

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ABSTRACT

Software engineering finds an extensive variety of applications in wide range of fields. In this cutting edge world, the utilization of various human senses in the area of computer sciences is increasing day by day and the feeling of touch is no special case. Haptic innovation is a field which is yet to be totally investigated. However, individuals are ignorant that they are a part of the haptics worldview and that they are utilizing haptics in their everyday life. Haptics is a science that exploits a person's feelings of touch to interact with computers to feel and manipulate the virtual objects. It is the procedure of perceiving objects through touch. Haptic devices gives individuals a feeling of touch with computer produced situations so when virtual objects are touched, they appear to be real and tangible. In this paper, a humble attempt is made to made to describe how haptic innovation functions, about its devices, its applications, future improvements and inconveniences.

Key Words: Haptic technology, Virtual objects, Sense of touch, Tactile, Sensor.

I.INTRODUCTION

The word Haptic is derived from the Greek word/verb "*haptesthai"* meaning to contact or to touch. Haptic is defined as the "science of applying tactile sensation to human interaction with computers". Haptic therefore permits users to sense (feel) and manipulate three dimensional virtual objects with respect to such features as shape, weight, surface textures, and temperature. It deals with manual sensing and manipulation of surroundings through touch by applying forces, vibrations, and motions to the user. This mechanical stimulation is used to assist in creation of virtual objects (objects existing only in a computer simulation), for control of such virtual objects, and to enhance the remote control of machines and devices (teleoperators). By using Haptic devices, the user can not only feed information to the computer but can receive information from the computer in the form of a felt sensation on some part of the body. This is referred to as a Haptic interface. This emerging technology promises to have wide reaching applications as it already has in some fields.

The idea behind this Touch feeling is to create the illusion that two people, separated by distance, are interacting with a shared physical object. In reality, each user is interacting with his/her own object; however, when one of the objects is manipulated, both users objects are affected. When we examine objects and surfaces in the real world, our sense of feeling (touch) is as important as seeing and hearing. Normally we use all of our senses in continuous and parallel cooperation to observe, orientate, learn and receive information. The most important combination of our senses are seeing, hearing and feeling. For many tasks feeling provides vital information to the operator, such as situations with poor lighting conditions and jobs where details are so small that they are covered by the hands and tools that do the job. An example may illustrate this: Modern surgical robot equipment is still operated by doctors, who have to do their job without the sense of feeling since the robots do not have the ability to pick up and replay this touch information.

II.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 3D objects in virtual environments and tele-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, which we 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 control position information is sent to the OS, which then sends the play command through the control circuitry to the actuator.

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.

III.WORKING OF HAPTICS

Haptics consists of two parts namely human part and machine part as shown in fig. below. Human part controls the position of the hand while machine part exerts force from the hand to stimulate contact with virtual objects. In case of Haptics, computer acts as a brain, sensing devices performs the same function as muscles do in our body and actuators/motors works as a skin surfaces.

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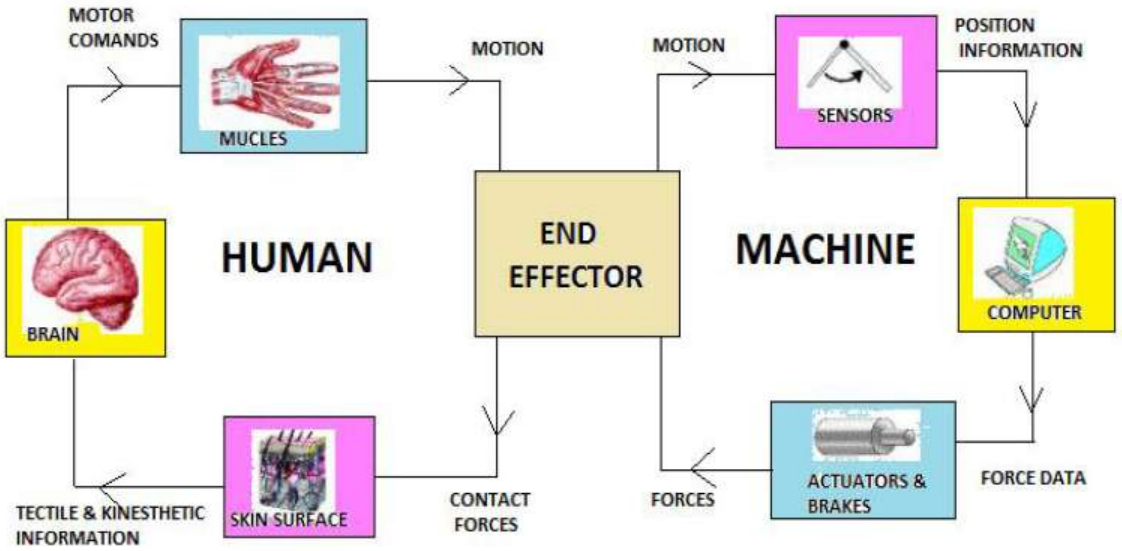

The key elements which are used to interface with computer are sensors, actuators, real time algorithm, and application programming interface. Haptic information provided by the system will be the combination of tactile information and kinesthetic information.

- Tactile information refers to the awareness of stimulation to the outer surface of the body.
- Kinesthetic information refers to the awareness of limbs position and moment as well as muscles tension.

Haptics can be subdivided into three main areas:

1. **Human Haptics:-** Human haptics is the study of human sensing and manipulation through touch. Human haptic system consists of two subsystems: motor subsystem and sensory subsystem. Both the systems are strongly linked with each other. Human use to different forms of haptic exploration: active and passive. Active haptic exploration is used when user controls its action and passive haptic exploration is used when another person guides the hand or fingers of the user.
2. **Machine Haptics:-** Machine haptics refers to design, construction and use of machine to replace or augment human touch. Haptic interfaces are devices composed of mechanical components in physical contact with the human body for the purpose of exchanging information with the human nervous system. In performing tasks with a haptic interface, the human user conveys desired motor actions by physically manipulating the interface, which in turns displays tactual sensory information to the user by appropriately stimulating his or her tactile and kinesthetic sensory systems. Thus in general, haptic interfaces can be viewed as having two basic functions:
   - To measure the positions and contact forces of the user's hand
   - To display contact forces and positions to the user.
3. **Computer Haptics:-** Computer haptics is an algorithm and software associated with generating and rendering the touch and feel of virtual objects. Computer haptics is a rapidly emerging area of research that is concern with the techniques and the process associated with generating and displaying the touch and feel

of virtual objects to a human operator through a force reflecting device. It includes software architecture needed for haptics interaction and synchronization with visual and other display modalities.

IV.APPLICATION OF HAPTICS

When a human user touches a real object directly or through a tool, forces are imposed on the user's skin. The associated sensory information, mediated by sensors in the skin, joints tendons and muscles, is conveyed to the brain by nervous system and leads to haptics perception. The subsequent motor commands issued by the brain activate the muscles and results in motion that modifies the touch sensory information. In order to create this effect a weak current is given in the area of the device that is being used for interaction. If the material is conductive, a capacitive set up will be created when dry finger touches it. The capacitive set-up will generate an oscillating electric field around the skin and finger tips, which then go on to create a variable sensation of fiction depending on the frequency and applied signal. The ability to control friction by varying the frequency and amplitude will allow to create different 'virtual surrounding' as desired.

There has been significant progress in haptics technology but the incorporation of haptics into virtual environments is still in its infancy. A wide range of the new society's human activities including communication, education, art, entertainment, commerce and science would forever change if we learn how to capture, manipulate and reproduce haptic sensory stimuli that are nearly indistinguishable from reality. For the field to move forward, many commercial and technological barriers need to be overcome.

Graphical User Interface (GUI): GUI forms an integral part of any electronic system if human interaction is involved. GUI allows the user to interact with the system through graphical icons, visual indications on the screen, text based interfaces etc. If a third dimension is added to the graphical user interface, the interaction of the user with the electronic system can be more realistic. This third dimension that can be added to a GUI is haptics.

Tele Robots: Teleoperation means operation of a machine situated at a distance .It is very similar to a remote control but is usually seen in research, academics, and technical environment. Although it is usually associated with robotics and mobile robots, it can still be applied to a machine or a device which a person is operating from a distance. The origin of teleoperation can be traced back to the beginning of radio communication and Nikola Tesla, who developed the fundamental principle and system for teleoperation in 1880's.

Usually scenes are perceived by 3D vision. Hence visual modality is a predominant source of perception, but material as well as surface characteristics are also necessary. Hence haptic exploration is required. Also in telerobotics manipulation is required. Manipulation requires closed human-environment interaction. Thus, exploration and manipulation are necessary for telerobotics. Haptics has led to an increase in precision of teleoperation by force and surface information feedback. Force feedback is obtained by sending back pressure and force through haptic devices at the point of interest. Such applications find use in assistive surgical robotics. They are also used in simulators to train medical and military personnel. In assistive robotic surgery it is possible to carry a precise surgical procedure that will improve and hence shorten the healing process.

Data Visualization: Use of graphics and animation to analyze or solve problems is data visualization. They are used in scientific analysis and also for visually impaired people. Using haptics a high quality and accurate data visualization is possible. For example SCIRun is scientific data visualisation for problem solving. Scientific data visualization is also used for fluid flow model, molecular interaction, force field analysis, etc. For visually impaired people touch is used as a channel to provide information. Using graphical model made from haptic feedback, even a real city can be explored for the blind people.

Geo Sciences: In petroleum exploration, developing accurate models of subsurface environment is complex and challenging problem. Novint has developed customized software to make it possible to work in 3D with 3D data by adding haptic feedback and providing real time 3D interaction to existing visualization techniques.

Medicine: Haptic interfaces for medical simulation have proved very useful. Touch and kinesthesis are subtle, effortless senses which are important for fast and accurate interaction with our environment. These prove to be very crucial for minimal invasive procedures. These include laparoscopy, interventional radiology and remote surgery. In open surgery, surgeons rely heavily on touch to distinguish healthy tissue from disease infected tissue. The advantage of using haptics technique is that surgeons can perform large number of similar operation with less fatigue. Also in opthalmology, the supporting springs that hold artificial lens within lens capsule after removal of cataract are done via haptics. Furthermore the virtual haptic feedback is useful for palpatory diagnosis that means detection of medical problem through touch. Recent technology based on haptics is also utilized in fields of prosthetics. Haptics are also used to provide a feedback from prosthetic limb to its wearer.

Haptics are widely used to help the visually impaired. The feeling of colour can be obtained through a haptic feedback device. A glove consisting of short range optical colour sensors on the fingertips and a belt with haptic feedback actuators constitute the system. The information of colour is provided through vibrations at different location and different modulation. With a small amount of training the person can recognize which vibration associates to the respective colour.

Haptics has a very large future scope in the field of medical application. It will be possible to construct a central work station which will be used by surgeons to perform operations remotely. Thus the surgeon will become a telepresence. This will lead to an increased availability of expert medical care. Haptics provide a tactile and resistance feedback to surgeons operating on robotic devices. As surgery is carried on the ligaments are felt as if being directly worked on patient. Simulated surgery can be used for training. Haptics aids in simulation by creating realistic environment of touch. Similar to telepresence surgery, surgeons can feel simulated ligaments or pressure of virtual incision as if real. This will help in training of surgeons.

Military: Military uses flight simulators to train pilots using haptics. Training missions may include how to fly in battle, how to recover in an emergency, or how to coordinate air support with ground operations. The Army uses several specific haptic devices to train soldiers to drive vehicles like tanks or the heavily-armored Stryker vehicle.

Cultural: Haptic technologies are available that let museums add this missing aspect back into their computer-based exhibits. They allow the visual displays to be extended to make them more realistic, useful and engaging

for visitors and scholars. This has many potential benefits for museums, for example in allowing greater access to rare and fragile objects, allowing access for people who live far away and cannot easily get the museum, improving the opportunities for blind and visually impaired people, and increasing the number of artifacts on display. Haptic devices have a lot to offer museums and are likely to have a big impact on the quality and usefulness of computer-based exhibits.

Education: In the Education field the sense of touch and force feedback can offer great improvements to the existing teaching methods, thus enhancing the quality of education procedures. Haptics Educational Applications (HEA) are an under development research field and some noncommercial applications have been developed for the above haptic interfaces.

V.CHALLENGES

The main challenge in designing a haptic device is to make the control interface feel exactly like the tool being used originally by the operator. Haptic is still not very common technology and is presently facing challenges in terms of cost, complexity, portability and debugging issues. Precision of touch requires lot of advance design. With only a sense of touch, haptic interfaces cannot deliver warnings. Haptic applications require complex and specialized hardware and significant processing power. Complexity means many haptics project rely on fixed installations of equipment. Software compatibility is also another very important issue for the proper usage of haptic technology. Touch plays a key role when examining objects in the real world but until recently it was not possible to use this realistically in virtual environments and computer-based displays.

VI.FUTURE PROSPECTUS OF HAPTIC TECHNOLOGY

Holographic Interaction: Research is carried on by adding haptic feedback to holographic projection. Using this feedback, the user receives tactile response from holograph as if it were a real object. It is based on using ultrasound waves thereby creating acoustic radiation pressure. It is through tactile response that user percieves the object.

Biometric Haptics: Haptics can also be used for biometrics. Conventional biometrics require a unique ID and password. These can be tedious to remember and hence are inconvenient. Further these passwords are less secure. These can be hacked without being known and hence are not very safe and reliable. The haptic based biometeric measure the position, velocity and force. After these measurements using algorithms, unique physical patterns can be developed which can be used for identification.

E-Commerce: Using haptic feedback in electronic commerce enables consumers to physically interact with the commodity. The product can be felt by touching and properties such as texture, roughness can be determined. Consumers usually like to feel and touch the object before buying. For example, while buying a fabric, the roughness, friction and softness can be actually felt by the customer and hence aids in their decision making.

Education: Haptics can allow for visualization of geometric problems in actual 3-D space. This allows a better and clear understanding of the problem which is beneficial in the field of education.

VI.CONCLUSION

Haptic technologies provide the next important step towards realistically simulated environments that have been envisioned by science fiction authors and futurists alike. The sense of touch is so important to the way in which humans interact with the world that its absence in simulation technologies of the past has been a major shortcoming. Adding the sense of touch to the sense of hearing and sight currently addressed by simulation technologies is a very exciting development. Much work is being done and great strides seem to be on the horizon to create useful and practical haptic systems. However, some innovations are still required before the large-scale adoption of haptic technology such as miniaturization, high-speed devices and communications innovations. Many of the haptic devices must be miniaturized so that they are lighter, simpler and easier to use. The introduction of Electro-Rheological Fluid based devices shows one way in which miniaturization of haptic devices can occur.

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