International Journal of Engineering Research and Reviews ISSN 2348-697X (Online)
Vol. 2, Issue 2, pp: (47-52), Month: April 2014 - June 2014, Available at: www.researchpublish.com

HAPTIC TECHNOLOGY

J.HARI HARA SUDHAN

DEPARTMENT OF MCA, V.S.B ENGINEERING COLLEGE,

KARUDAYAMPALAYAM (PO), KARUR – 639111, INDIA

***Abstract* - Engineering as it finds its wide range of application in every field not an exception even the medical field. One of the technologies which aid the surgeons to perform even the most complicated surgeries successfully is Virtual Reality. Even though virtual reality is employed to carry out operations the surgeon's attention is one of the most important parameter. If he commits any mistakes it may lead to a dangerous end. So, one may think of a technology that reduces the burdens of a surgeon by providing an efficient interaction to the surgeon than VR. Now our dream came to reality by means of a technology called "HAPTIC TECHNOLOGY". Haptic is the "science of applying tactile sensation to human interaction with computers".**

***Keywords* – Virtual Reality, Technology, Burdens, Interaction, Human Interaction**

1.0 INTRODUCTION

Haptic, is the term derived from the Greek word, haptesthai, which means 'to touch'. Haptic is defined as the "science of applying tactile sensation to human interaction with computers". It enables a manual interaction with real, virtual and remote environment. Haptic permits users to sense ("feel") and manipulate three-dimensional virtual objects with respect to such features as shape, weight, surface textures, and temperature.

A Haptic Device is one that involves physical contact between the computer and the user. 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.

In our paper we explain the basic concepts of 'Haptic Technology and its Application in Surgical Simulation and Medical Training'.

2.0 HAPTIC DEVICES

Force feedback is the area of haptics that deals with devices that interact with the muscles and tendons that give the human a sensation of a force being applied—hardware and software that stimulates humans' sense of touch and feel through tactile vibrations or force feedback.

These devices mainly consist of robotic manipulators that push back against a user with the forces that correspond to the environment that the virtual effector's is in. Tactile feedback makes use of devices that interact with the nerve endings in the skin to indicate heat, pressure, and texture. These devices typically have been used to indicate whether or not the user is in contact with a virtual object. Other tactile feedback devices have been used to stimulate the texture of a virtual object.

PHANToM and CyberGrasp are some of the examples of Haptic Devices.

2.1 PHANToM:

A small robot arm with three revolute joints each connected to a computer-controlled electric DC motor. The tip of the device is attached to a stylus that is held by the user. By sending appropriate voltages to the motors, it is possible to exert up to 1.5 pounds of force at the tip of the stylus, in any direction.

2.2 CYBER GRASP:

The CyberGlove is a lightweight glove with flexible sensors that accurately measure the position and movement of the fingers and wrist. The CyberGrasp, from Immersion Corporation, is an exoskeleton device that fits over a 22 DOF CyberGlove, providing force feedback. The CyberGrasp is used in conjunction with a position tracker to measure the position and orientation of the fore arm in three-dimensional space.

2.3 Haptic Rendering:

It is a process of applying forces to the user through a force-feedback device. Using haptic rendering, we can enable a user to touch, feel and manipulate virtual objects. Enhance a user's experience in virtual environment. Haptic rendering is process of displaying synthetically generated 2D/3D haptic stimuli to the user. The haptic interface acts as a two-port system terminated on one side by the human operator and on the other side by the virtual environment.

2.4 Contact Detection

A fundamental problem in haptics is to detect contact between the virtual objects and the haptic device (a PHANToM, a glove, etc.). Once this contact is reliably detected, a force corresponding to the interaction physics is generated and rendered using the probe. This process usually runs in a tight servo loop within a haptic rendering system.

Another technique for contact detection is to generate the surface contact point (SCP), which is the closest point on the surface to the actual tip of the probe. The force generation can then happen as though the probe were physically at this location rather than within the object. Existing methods in the literature generate the SCP by using the notion of a god-object, which forces the SCP to lie on the surface of the virtual object.

3.0 APPLICATIONS

Haptic Technology as it finds it wide range of Applications some among them were mentioned below:

1. Surgical simulation & Medical training.
2. Physical rehabilitation.
3. Training and education.
4. Museum display.
5. Painting, sculpting and CAD
6. Scientific Visualization.
7. Military application.
8. Entertainment.

The role of Haptic Technology in "Surgical Simulation and Medical Training" is discussed in detail below.

4.0 SURGICAL SIMULATION AND MEDICAL TRAINING

Haptic is usually classified as:-

Human haptics: human touch perception and manipulation.

Machine haptics: concerned with robot arms and hands.

Computer haptics: concerned with computer mediated.

A primary application area for haptics has been in surgical simulation and medical training. Haptic rendering algorithms detect collisions between surgical instruments and virtual organs and render organ-force responses to users through haptic interface devices. For the purpose of haptic rendering, we've conceptually divided minimally invasive surgical tools into two generic groups based on their functions.

1. Long, thin, straight probes for palpating or puncturing the tissue and for injection (puncture and injection needles and palpation probes)

2. Articulated tools for pulling, clamping, gripping, and cutting soft tissues (such as biopsy and punch forceps, hook scissors, and grasping forceps).

A 3D computer model of an instrument from each group (a probe from the first group and a forceps from the second) and their behavior in a virtual environment is shown. During real-time simulations, the 3D surface models of the probe and forceps is used to provide the user with realistic visual cues. For the purposes of haptic rendering of tool–tissue interactions, a ray-based rendering, in which the probe and forceps are modeled as connected line segments. 'Modeling haptic interactions between a probe and objects using this line-object collision detection and response has several advantages over existing point based techniques, in which only the tip point of a haptic device is considered for touch interactions'.

Grouping of surgical instruments for simulating tool–tissue interactions.

Group A includes long, thin, straight probes.

Group B includes tools for pulling, clamping, and cutting soft tissue.

- Users feel torques if a proper haptic device is used. For example, the user can feel the coupling moments generated by the contact forces at the instrument tip and forces at the trocar pivot point.
- Users can detect side collisions between the simulated tool and 3D models of organs.
- Users can feel multiple layers of tissue if the ray representing the simulated surgical probe is virtually extended to detect collisions with an organ's internal layers. This is especially useful because soft tissues are typically layered, each layer has different material properties, and the forces/torques reflected to the user depends on the laparoscopic tool's orientation.

Users can touch and feel multiple objects simultaneously. Because laparoscopic instruments are typically long slender structures and interact with multiple objects (organs, blood vessels, surrounding tissue, and so on) during a MIS (Minimally Invasive Surgery), ray-based rendering provides a more natural way than a purely point-based rendering of tool-tissue interactions. To simulate haptic interactions between surgical material held by a laparoscopic tool (for example, a catheter, needle, or suture) and a deformable body (such as an organ or vessel), a combination of point- and ray-based haptic rendering methods are used.

In case of a catheter insertion task shown above, the surgical tools using line segments and the catheter using a set of points uniformly distributed along the catheter's center line and connected with springs and dampers. Using our point based haptic rendering method; the collisions between the flexible catheter and the inner surface of a flexible vessel are detected to compute interaction forces.

The concept of distributed particles can be used in haptic rendering of organ–organ interactions (whereas a single point is insufficient for simulating organ–organ interactions, a group of points, distributed around the contact region, can be used) and other minimally invasive procedures, such as bronchoscope and colonoscopy, involving the insertion of a flexible material into a tubular body .

5.0 DEFORMABLE OBJECTS

One of the most important components of computer based surgical simulation and training systems is the development of realistic organ-force models. A good organ-force model must reflect stable forces to a user, display smooth deformations, handle various boundary conditions and constraints, and show physics-based realistic behavior in real time. Although the computer graphics community has developed sophisticated models for real-time simulation of deformable objects, integrating tissue properties into these models has been difficult. Developing real-time and realistic organ-force models is challenging because of viscoelasticity, anisotropy, nonlinearity, rate, and time dependence in material properties of organs. In addition, soft organ tissues are layered and nonhomogeneous.

Tool–tissue interactions generate dynamical effects and cause nonlinear contact interactions of one organ with the others, which are quite difficult to simulate in real time. Furthermore, simulating surgical operations such as cutting and coagulation requires frequently updating the organ geometric database and can cause force singularities in the physics-based model at the boundaries. There are currently two main approaches for developing force-reflecting organ models:

1. **Particle-based methods.**
2. **Finite-element methods (FEM).**

In particle-based models, an organ's nodes are connected to each other with springs and dampers. Each node (or *particle*) is represented by its own position, velocity, and acceleration and moves under the influence of forces applied by the surgical instrument.

In finite-element modeling, the geometric model of an organ is divided into surface or volumetric elements, properties of each element are formulated, and the elements are assembled together to compute the deformation states of the organ for the forces applied by the surgical instruments.

Capture, Storage, and Retrieval of Haptic Data:

The newest area in haptic is the search for optimal methods for the description, storage, and retrieval of moving-sensor data of the type generated by haptic devices. This

techniques captures the hand or finger movement of an expert performing a skilled movement and "play it back," so that a novice can retrace the expert's path, with realistic touch sensation; The INSITE system is capable of providing instantaneous comparison of two users with respect to duration, speed, acceleration, and thumb and finger forces.

Techniques for recording and playing back raw haptic data have been developed for the PHANToM and CyberGrasp. Captured data include movement in three dimensions, orientation, and force (contact between the probe and objects in the virtual environment).

6.0 HAPTIC DATA COMPRESSION

Haptic data compression and evaluation of the perceptual impact of lossy compression of haptic data are further examples of uncharted waters in haptics research.

Data about the user's interaction with objects in the virtual environment must be continually refreshed if they are manipulated or deformed by user input. If data are too bulky relative to available bandwidth and computational resources, there will be improper registration between what the user sees on screen and what he "feels."

On analyzing data obtained experimentally from the PHANToM and the CyberGrasp, exploring compression techniques, starting with simple approaches (similar to those used in speech coding) and continuing with methods that are more specific to the haptic data. One of two lossy methods to compress the data may be employed: One approach is to use a lower sampling rate; the other is to note small changes during movement. For example, for certain grasp motions not all of the fingers are involved.

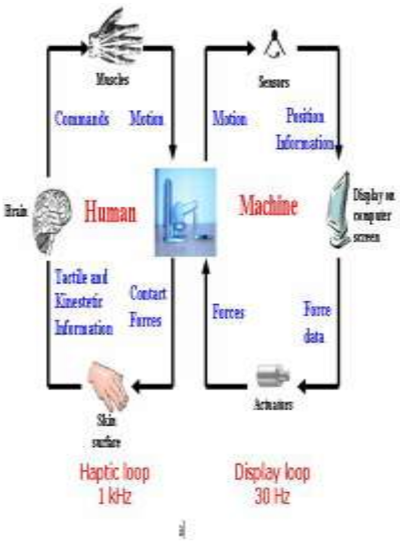
Further, during the approaching and departing phase tracker data may be more useful than the CyberGrasp data. Vector coding may prove to be more appropriate to encode the time evolution of a multi-featured set of data such as that provided by the CyberGrasp. For cases where the user employs the haptic device to manipulate a static object, compression techniques that rely on knowledge of the object may be more useful than the coding of an arbitrary trajectory in three-dimensional space.

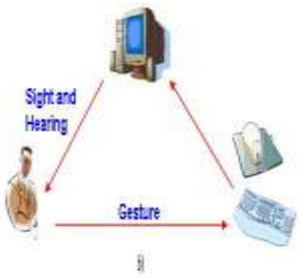
7.0 COMMERCIAL APPLICATIONS

7.1TELEOPERATORS AND SIMULATORS

Teleoperators are remote controlled robotic tools—when contact forces are reproduced to the operator, it is called *haptic teleoperation*. The first electrically actuated teleoperators were built in the 1950s at the Argonne National Laboratory by Raymond Goertz to remotely handle radioactive substances. Since then, the use of force feedback has become more widespread in other kinds of teleoperators such as remote controlled underwater exploration devices.

7.2 MOBILE DEVICES





Tactile haptic feedback is becoming common in cellular devices. Handset manufacturers like Nokia, LG and Motorola are including different types of haptic technologies in their devices; in most cases, this takes the form of vibration response to touch. Alpine Electronics uses a haptic feedback technology named *PulseTouch* on many of their touch-screen car navigation and stereo units.[16] The Nexus One features haptic feedback, according to their specifications.

7.3 VIDEO GAMES

Haptic feedback is commonly used in arcade games, especially racing video games. In 1976, Sega's motorbike game *Moto-Cross*,[6] also known as *Fonz*, was the first game to use haptic feedback which caused the handlebars to vibrate during a collision with another vehicle.[8]Tatsumi's *TX-1* introduced force feedback to car driving games in 1983.

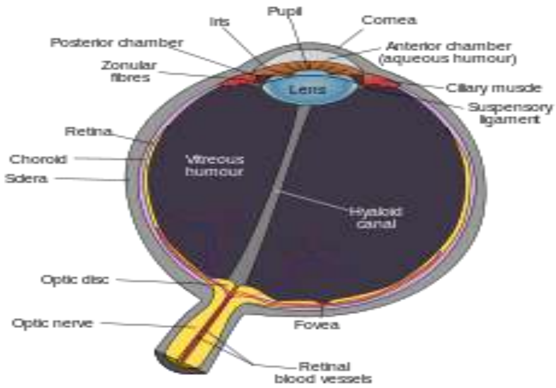
Simple haptic devices are common in the form of game controllers, joysticks, and steering wheels. Early implementations were provided through optional components, such as the Nintendo 64 controller's *Rumble Pak*. Many newer generation console controllers and joysticks feature built in feedback devices, including Sony's DualShock technology.

Some automobile steering wheel controllers, for example, are programmed to provide a "feel" of the road. As the user makes a turn or accelerates, the steering wheel responds by resisting turns or slipping out of control.

In 2007, Novint released the Falcon, the first consumer 3D touch device with high resolution three-dimensional force feedback; this allowed the haptic simulation of objects, textures, recoil, momentum, and the physical presence of objects in games.

7.4 MEDICINE

Haptic interfaces for medical simulation may prove especially useful for training in minimally invasive procedures such as laparoscopy and interventional radiology,[19] as well as for performing remote surgery. A particular advantage of this type of work is that surgeons can perform more operations of a similar type with less fatigue. It is well documented that a surgeon who performs more procedures of a given kind will have statistically better outcomes for his patients. Haptic interfaces are also used in rehabilitation robotics.



In ophthalmology, *haptic* refers to supporting springs, two of which hold an artificial lens within the lens capsule after the surgical removal of cataracts.[*citation needed*]

A Virtual Haptic Back (VHB) was successfully integrated in the curriculum at the Ohio UniversityCollege of Osteopathic Medicine.[20] Research indicates that VHB is a significant teaching aid in palpatory diagnosis (detection of medical problems via touch). The VHB simulates the contour and stiffness of human backs, which are palpated with two haptic interfaces (SensAble Technologies, PHANToM 3.0). Haptics have also been applied in the field of prosthetics and orthotics. Research has been underway to provide essential feedback from a prosthetic limb to its wearer. Several research projects through the US Department of Education and National Institutes of Health focused on this area. Recent[*timeframe?*] work by Edward Colgate, Pravin Chaubey, and Allison Okamura et al. focused on investigating fundamental issues and determining effectiveness for rehabilitation.

8.0 CONCLUSION

We finally conclude that Haptic Technology is the only solution which provides high range of interaction that cannot be provided by BMI or virtual reality. Whatever the technology we can employ, touch access is important till now. But, haptic technology has totally changed this trend. We are sure that this technology will make the future world as a sensible one.

Table 1: Needs of haptic technologies for MEMS

Application	Needs	Benefits of haptic technologies
CAD/CAM design	-Guide designers during assembly and disassembly process -Conception -Tolerance	-Manufacturing of mould at micro-scales for LIGA processes - Sense surface, shape of components, deformation - Sense and effect of forces at nano, micro-, meso-scale structures
Virtual Prototyping	-Replace physical prototype by virtual models -Enhance product development	-Combination of physical and digital modeling -Improve manufacturing lead times
Visualization	-Analyses of any parts of the system request -Ergonomic Analysis -Cost of manufacturing	-Scale-up/down -Increase information flow between user and the computer -Better understanding
Maintenance	-Diagnosis -Verification	-Quick analysis of any default, the cause and solution -Security
Training	- Simulation - Useful for application related manipulation	-Force-feedback -Sense gravity, inertia -Motion of components

REFERENCES

[1] http://haptic.mech.nwu.edu
[2] http://www.webopedia.com/TERM/H/haptic.html
[3] http://www.stanford.edu/dept/news/report/news/2003/april2/haptics-42.html
[4] http://www.utoronto.ca/atrc/rd/vrml/haptics.html