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Haptic Technology

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Introduction:

Haptic is defined as the “science of applying tactile sensation to humaninteraction 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'.

WORKING OF HAPTICS

To understand the basic working of haptics, consider the following diagram :

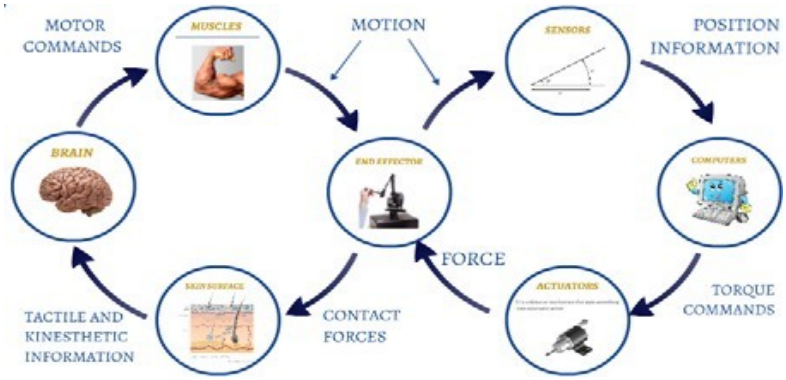


Fig 1. Working of Haptics

The brain controls our body. It gives various instructions to different parts of our body. The brain tells the muscles to give specific input to the end effector .The end effector is a sensitive haptic device .It has various sensors which sense the change in angle, amount of force applied etc and gives this information to the computer. The computer then processes this information and gives specific instructions to an actuator. The actuator is a device that puts something in an automatic action. The actuator then applies force to

haptic device, which , is perceived as feedback force by the user. The feedback force is felt on the surface of the skin and this feeling is interpreted by the brain. This is the basic working cycle of haptics.

Haptics refers to two kinds of information :

1) Tactile information : This refers to the information acquired by the sensors connected to the user's body.

2) Kinesthetic information : This refers to the information acquired by the sensors in the joints.

HAPTIC DEVICES

The Haptics are classified into two devices as :-

Virtual reality devices:-

In virtual devices there are also four sub devices which are as fallows

- Exoskeletons and Stationary device
- Gloves and wearable devices
- Point-source and Specific task devices
- Locomotion Interfaces

Virtual Reality systems present a computer-generated visual and auditory experience that allows a user to be immersed within a computer generated “world” for various purposes. This is used in conjunction with traditional computer input systems. Following figure show the powerful design tool which allowing a user to see objects that he or she is designing.

Fig 2 Virtual environment

The application to training simulation systems is equally useful for the creation of an infinite number of immersive environments. The haptic systems to virtual reality will greatly increase its effectiveness at simulating real-world situations. One example can potentially include a medical training system using a simulator and virtual reality

where a haptic system provides doctors with the “feel” of virtual patients. Following Figure shows the schematic of such a medical simulation system, the visual display and the haptic gloves are combined to simulate.

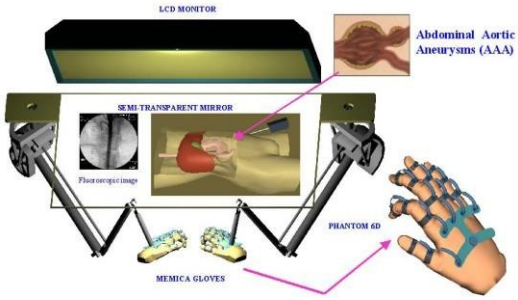


Fig 3 Virtual Reality for Surgical Training

Feedback devices:-

The feedback devices also divided into two sub devices are as

Force feedback devices

Tactile displays

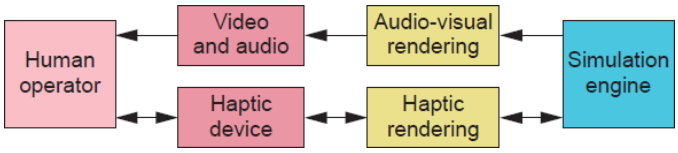


Fig 3 Haptic Feedback Block Diagram

COMMONLY USED HAPTIC INTERFACING DEVICES:-

Two devices are used in haptic interfacing are as:-

PHANTOM:

It is a haptic interfacing device developed by a company named Sensible technologies. It is primarily used for providing a 3D touch to the virtual objects. This is a very high resolution 6 DOF device in which the user holds the end of a motor controlled jointed arm. It provides a programmable sense of touch that allows the user to feel the texture and shape of the virtual object with a very high degree of realism. One of its key features is that it can model free floating 3 dimensionalobjects.

Fig 4 PHANTOM

CYBER GLOVE:

Cyber glove consists of opposing the movement of the hand in the same way that an object squeezed between the fingers resists the movement of the latter. The glove must therefore be capable, in the absence of a real object, of recreating the forces applied by the object on the human hand. The two conditions can be simplified by requiring the glove to apply a torque equal to the interphalangian joint.

(1) The same intensity and

(2) The same direction.

Following figure shows how cyber glove used

Fig 5 Cyber glove

Mechanical structure of a Cyber glove

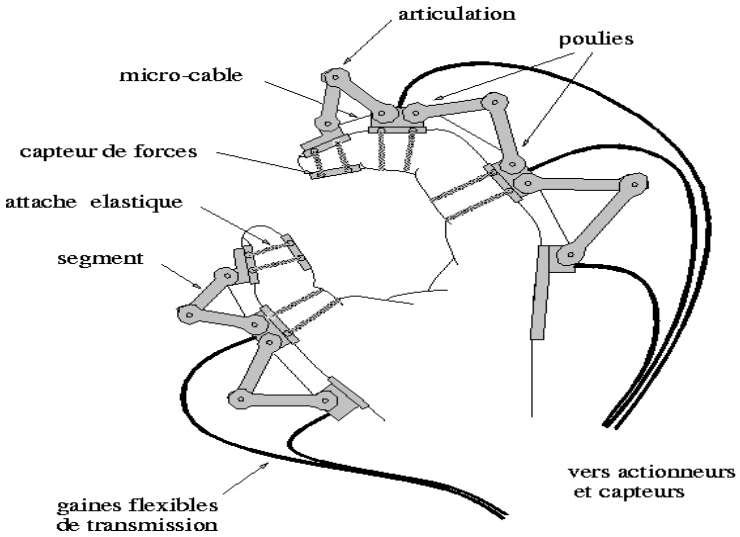
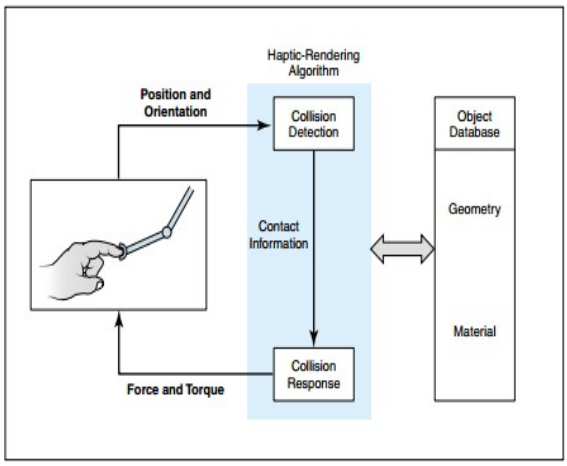


Fig 6 Mechanical structure

HAPTICS RENDERING

Haptic rendering is the process of generating and computing forces in response to the user's interaction with the virtual object. The process of interacting with the virtual object has been of great interest to many researchers worldwide. Rendering refers to a process by which desired stimuli are imposed on a user to convey the information about the virtual object. New technology always amazes people and just as the people were amazed to see the computers a few decades back, people are amazed to feel the virtual objects today. Haptic rendering is one of the most important part of the haptic interfaces as, better the haptic rendering better the virtual feel. To enhance the haptic rendering various rendering algorithms are implemented. Here we will study the approach of designing and implementing a haptic rendering algorithm.



As shown in the above figure, the haptic rendering algorithm forms the most important integral part of the haptic system[2]. The haptic rendering algorithm generally consists of two sub-algorithms, collision detection algorithm and collision response algorithm. As the user changes his position or the force feedback (shown in Fig 2- a fingertip) the change in position or orientation is acquired and the Collision Detection algorithm detects the collision between the fingertip and the virtual environment. If a collision is detected, then the Collision Response algorithm calculates the force of interaction between the user and the virtual environment and then instructs the response device to generate the required force, thus generating the actual representation of the virtual object. The update rate of the haptic feedback loop must be at least 1KHz, in order to maintain the feel of the virtual object. The Object Database should be maintained so that all the physical properties of the object can be replicated correctly in the virtual environment. Moreover calculation of the contact forces is equally important than just calculating the collisions. Thus, better the haptic rendering algorithm, better the imitation of the real environment. Further we will see the applications of haptic interfaces which constitute the rendering algorithms to give accurate results for the respective application.

System architecture for haptic rendering:-

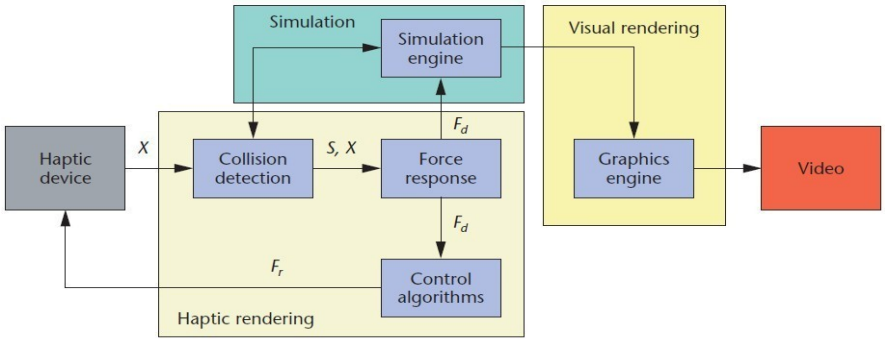


Fig 8 Architecture of Haptic Rendering

APPLICTIONS:-

There are various application used in haptic technology

- Surgical simulation & Medical training.
- Physical rehabilitation.
- Training and education.

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

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.

Various haptic interfaces for medical simulation may prove especially useful for training of minimally invasive procedures (laparoscopy/interventional radiology) and remote surgery using teleoperators. In the future, expert surgeons may work from a central workstation, performing operations in various locations, with machine setup and patient preparation performed by local nursing staff. Rather than traveling to an operating room, the surgeon instead becomes a telepresence.

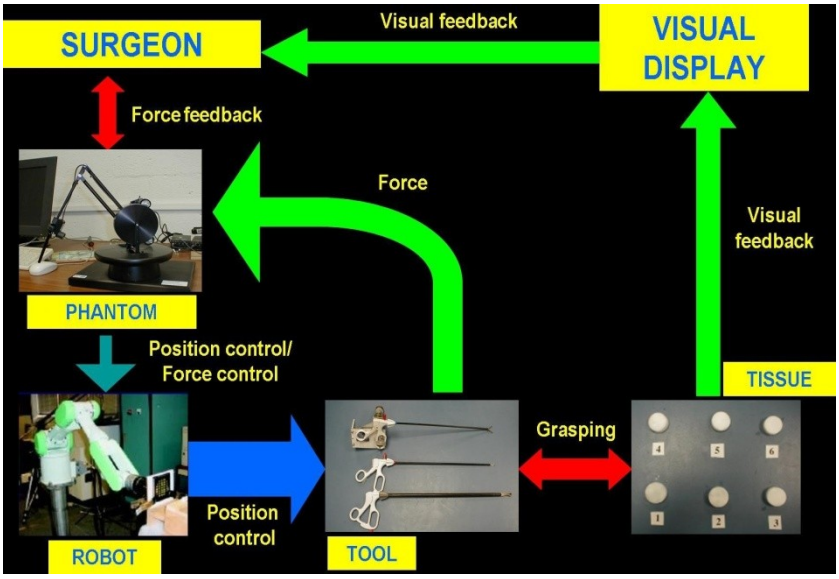


Fig 9 Medical Training Purpose

A particular advantage of this type of work is that the surgeon can perform many more operations of a similar type, and 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 a supporting spring, two of which hold an artificial lens within the lens capsule (after surgical removal of cataracts).

A 'Virtual Haptic Back' (VHB) is being successfully integrated in the curriculum of students at the Ohio University College of Osteopathic Medicine Research indicates that VHB is a significant teaching aid in palpatory diagnosis (detection of medical problems via touch). The VHB simulates the contour and compliance (reciprocal of stiffness) properties of human backs, which are palpated with two haptic interfaces .

Reality-based modeling for surgical simulation consists of a continuous cycle. In the figure given above, the surgeon receives visual and haptic (force and tactile) feedback and interacts with the haptic interface to control the surgical robot and instrument. The robot with instrument then operates on the patient at the surgical site per the commands given by the surgeon. Visual and force feedback is then obtained through endoscopic cameras and force sensors that are located on the surgical tools and are displayed back to the surgeon.

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.

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