

# Haptic Technology and its Implementation in Medical Field

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**Abstract:** In these paper basic concepts behind haptic technology which includes haptic interface and haptic rendering techniques and use of haptic technology in surgical simulation and medical training, and various issues and methods in generating tactile feedback are discussed. In experimental psychology and physiology, the word haptic refers to the sense of touch. So apart of senses like vision and audio one can feel the “sense of touch” of things that are created in the virtual world. Haptic may imply haptic communication, haptic perception and haptic technology. Haptic communication is the way of response given by humans and other animals via touching. Haptic perception is the process of recognizing objects through touch. Haptic technology refers to tactile feedback, which means it provides feedback in the form of touch so one can feel the physical properties and movements of virtual objects created by computer. Haptic technology has wide range of applications in various fields and its implementation in medical field has been extremely useful. It helps to reduce the burden of the surgeon by providing efficient interaction through virtual reality.

**Keywords:** Haptic Technology, kinesthetic, tactile, sensor, actuator.

## 1. Introduction

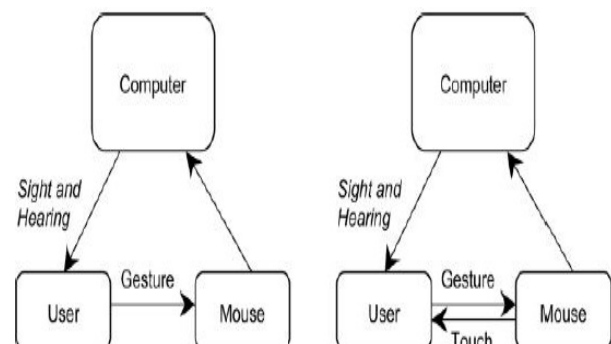
The word Haptic is derived from Greek which means sense of touch. Haptic has been changing the way in which humans interact with the computer and communicate ideas. The recent advances permit to modify and improve the imaginary computer generated objects in a way that evokes a compelling sense of tactile “realness”. The use of haptic technology in surgical simulation and medical training is achieved by various haptic devices which works on force feedback, by means of which the user furnish information to the computer and gain information of sensation on some part of the body.

## 2. Haptic Interface

This is the device which helps the user to get the tactile feedback i.e. it allows user to manipulate objects in the virtual environment. This helps to improve and train the people mainly in medical field such as surgeries to improve the success percentage. A haptic system is defined as “the sensibility of the individual to the world adjacent to his body by use of his body”. The haptic system is unusual which can include the sensory receptor from the whole body and responds according to the movement of body by providing the haptic feedback. Simultaneous exchange of information between the user and machine makes the haptic device more distinguishing compared to the other devices.

The tactile feedbacks received from the haptical devices may be divided into kinesthetic and tactile. The difference could be understood by considering a hand that is trying to pick up a baseball. As the hand reaches the ball it adjusts its shape, which deforms unique set of data points which describes joint angle, muscle length and tension is generated. This

information is collected by specialized group of receptors, proprioceptors and when these signals are carried they are further processed by the somatosensory region of cerebral cortex.

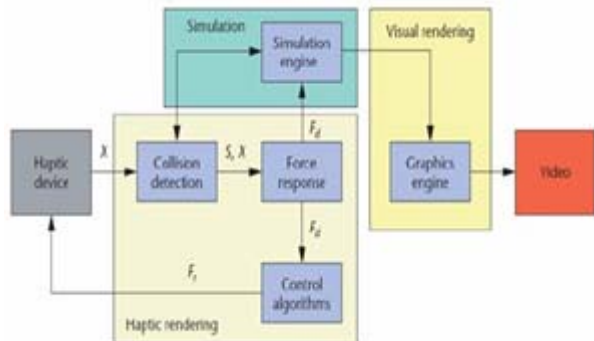


Information regarding change in muscle length is provided by a type of proprioceptor known as muscle spindle. Similarly the change in muscle tension is provided by golgitar organ. The brain processes this kinesthetic information to provide sense of the base ball’s gross size and shape as well as position relative to the hand, arm and body.

## 3. How haptics work

A haptic system generally includes actuator, sensors to communicate data between user and computer that either provide vibration and external forces. The application program interface (API) and product’s operating system is used to give program calls to actuators. These calls specify the particular haptic particular program’s call. When ever user interacts with haptic devices this control position information is sent to the OS and is further given to actuator through control circuitry. In this process haptic applications

use special hardware to provide tactile feedback that simulates physical properties and forces. Haptic interfaces can take many forms such as mechanical linkages to connect a person's fingers to a computer interface in which when ever user moves his fingers, sensors translate these motion into actions on a screen and get the respective feedback. The methods used by the software is to give the accurate feedback to perform calculations is called "haptic rendering".



The haptic rendering algorithms may be divided into

- Force – response algorithms
- Control algorithms
- Collision detection algorithms

**Force – response algorithm:** These algorithms help to calculate the forces that might be evolved due to interaction of haptic device with virtual objects.

**Control algorithm:** The interaction force information is collected using this control algorithms and applies them on the user using haptic device by maintaing overall stable behaviour.

**Collision-detection algorithm:** This algorithm uses the sensors to collect the position information to find collision between objects and haptic devices and report the resulting degree of penetration or identation.

#### 4. Applications of Haptic Technology

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

- Surgical simulation & Medical training.
- Physical rehabilitation.
- Training and education.
- Museum display.
- Painting, sculpting and CAD
- Scientific Visualization.
- Military application.
- Entertainment.

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

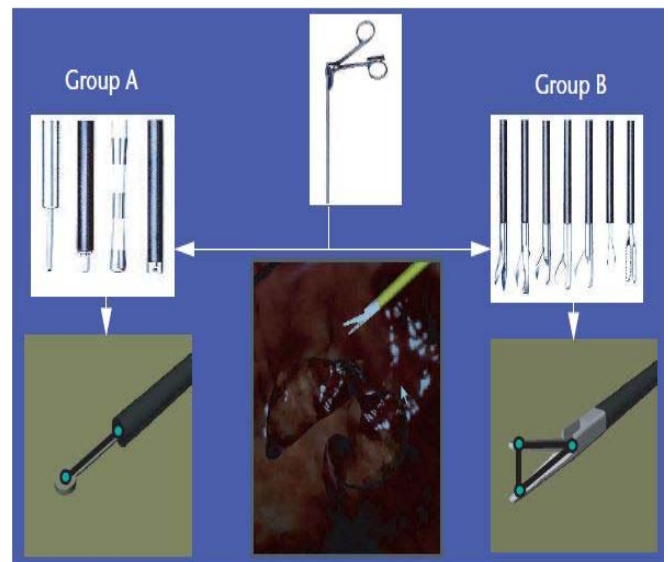
#### 5. Haptic technology in surgical simulation and medical training

Haptic technology finds its major area of application in surgical simulation and medical training. Haptic technology

uses haptic rendering algorithms to recognize collisions between virtual organs and haptic devices such as surgical instruments. The forces are thus accordingly generated are provided as feed back to the user.

Various tools that are used in medical training of surgeries like minimal invasive surgery, colonoscopy and hystoscopy are classified below based on their behavior on the body parts.

#### 6. Tools for palpating and punctuating the tissue



The long thin and straight probes shown above in group A may be used for palpating or punctuating the tissue and for injection.

#### 7. Tools for pulling, cutting, and gripping the soft tissue

The tools shown in group B may be considered as articulated tools for pulling, cutting and gripping the soft tissues during the surgeries. A three dimensional view of each of tools from group-A and group-B are also shown in their respective set in the figure above. Using the above in the medical training a user can feel the force at the tracer point and forces or coupling movements generated due to the contact of the devices with the virtual body organs at the instrument tip.

#### 8. Methods used for Haptic rendering

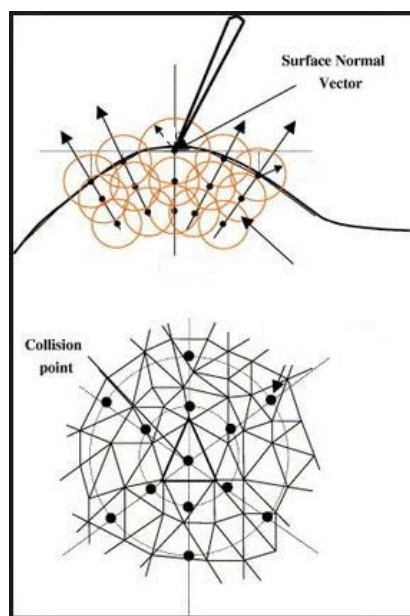
Ray-based rendering or point based rendering may be employed in designing for feedback in these probes or forceps, but ray-based rendering has advantage over point based rendering technique because in ray based rendering technique these tools are modeled as connected line Segments, where as in point based techniques the end point or tip of the haptic devices is considered for tactile feedback or for touch interaction.

## 9. Various tactile feedbacks a surgeon/user receives with these Haptic devices

A surgeon may receive tactile feedback due to side collisions of haptic device with the 3D models of the organs. Generally the tissues are of different layers with varying roughness and surgeon practicing with these devices can feel the softness of tissues which are of different layers. In case of laparoscopic surgery, minimal invasive surgery and laparoscopic surgery the surgeon comes across various organs, blood vessels and tissues and ray-based rendering methods helps to identify and feel these forces that occurs due to this interaction.

## 10. Various issues and methods in generating tactile feedback

Various issues that challenge in designing the haptic device for tactile feedback are viscous elasticity, non-linearity, anisotropy, and rate and time dependency in material properties of organs. In addition to these soft organs tissues are layered and non-homogeneous which further add the complexity. To overcome the above problems and to obtain corresponding tactile feedback two methods namely particle based methods and finite element methods are used.



In particle based methods the virtual organ designed using the computer is divided into nodes and are connected together using dampers and springs. Every node has its corresponding position, acceleration and velocity and responds according to the movement of surgical instrument to provide tactile feedback.

In finite-element modeling every organ is divided into smaller units of surface or volumetric elements. The properties of each of these elements are decided and finally all these small surfaces are put together to compute the forces that occurs during deformation by the surgical instruments.

## 11. Conclusion

Development and refining various kinds of haptic interfaces with more flexibility and freedom of rotation will provide more accuracy and skill in medical environment and haptic technology has become one of the efficient technologies that provide high range of interaction which are not provided by other technologies.

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## Author Profile



**Mr. P. V. Phani Teja** was born in 1992 in Guntur district. He is currently pursuing B. Tech final year in K.L.UNIVERSITY. His areas of interest are cyber physical systems, wireless communication.



**Mr. Rayala Ravi Kumar** pursued his masters, M.E. in Communication systems from P.S.G. College of technology, Coimbatore in the year 1998. For the past 15 years he is associated with Telecom industry and Academia at various capacities. For 9 years in association with Academic Institutions worked as lecturer, Associate Professor, Professor and Head of the Department and Prof. In-charge for industry institute interaction cell. Currently he is working as associate professor in Dept. of E.C.E. at K. L. University, Guntur.