Technology Based On Touch: Haptics Technology

Nisha Sharma[1], Swati Uppal[2] and Sorabh Gupta[3]

[1] **MCA Deptt., Surya World Engg. College,**
Village Bapror P.O. Rajpura Distt. Patiala
nisha.neeraj@gmail.com

[2] **MCA Deptt., Surya World Engg. College,**
Village Bapror P.O. Rajpura Distt. Patiala
swatiuppal177@gmail.com

[3] **IT Deptt., Panipat Institute of Engg. & Technology,**
Samalkha Distt. Panipat
sorabhg2003@gmail.com

Abstract

In experiment psychology and physiology, the word haptic refers to the sense of touch. So, haptic technology does for the sense of touch what CG does for vision. Haptic may refer to haptic technology, haptic communication, haptic perception. Haptic technology interfaces with the user through the sense of touch. Haptic communication means by which people and other animals communicate via touching. Haptic perception is the process of recognizing objects through touch. Haptic technologies provide force feedback to users about the physical properties and movements of virtual objects represented by a computer. Currently this involves solving challenging problems in mechanical design, actuators, real time system. Here, we will discuss a distinct property of haptic interfaces, that provides simultaneous exchange of information between a user and a machine. This paper proceeds with a description of the components of haptic devices and use of haptics in our daily life.

Keywords: *Haptic Technology, Phantom***,** *kinesthetic***,** *tactile, sensor , actuator, real time algorithms*

1. Introduction

Haptics is a term derived from the *greek* word which is based on the sense of touch. Haptic is the newest technology to arrive in the world of computer interface devices -- promises to bring profound changes to the way humans interact with information and communicate ideas. Recent advances in computer interface technology now permit us to touch and manipulate imaginary computer-generated objects in a way that evokes a compelling sense of tactile "realness."With this technology we can now sit down at a computer terminal and touch objects that exist only in the "mind" of the computer. These interactions might be as simple as touching a virtual wall or button, or as complex as performing a critical procedure in a surgical simulator. The term "haptics" has been used for years by researchers in human psychophysics who study how people use their hands to sense and manipulate objects. Unique among our sensory modalities, haptics relies on action to stimulate perception. To sense the shape of a cup we do not take a simple tactile snapshot and go away to think about what we felt. Rather, we grasp and manipulate the object, running our fingers across its shape and surfaces in order to build a mental image of a cup. This co-dependence between sensing and manipulation is at the heart of understanding how humans can so deftly interact with the physical world. Recently the term "haptic interfaces" has begun to be used by human interface technologists to describe devices that measure the motions of, and stimulate the sensory capabilities within, our hands. There is a long and respectable history in the development of devices to permit humans to control remotely located robots (tele-manipulators). Yet, it has taken the explosion of computer capability and the yearning for better ways to connect to newly complex computer-generated worlds to drive the creation and development of practical devices for haptic interaction. For as long as people have been remotely controlling machines, devices have been built to give us a sense of feel when controlling remote actions. Even before the days when we needed to safely manipulate hazardous radioactive materials, remote manipulation devices had been built. Early on these took the form of simple lever- and cable-actuated tongs on the end of a pole. These evolved into mechanical contrivances with elbows, wrists and crude hands. So-called "hot-cell manipulators" enabled workers to grasp a flask and pour a dangerous liquid. The worker could move, orient and squeeze a simple pistol grip to control the remotely located "tongs" to perform the work. Mechanical links and cables communicated motions and forces between the humans and a remote hand. Early researchers quickly recognized the

ISSN (Online): 2230-7893
www.IJCEM.org

need to transmit these motions and forces with as much fidelity and speed (bandwidth) as possible. They struggled to find ways to eliminate friction and sloppiness in the mechanical actions. As the need for more distant remote manipulation arose, researchers developed designs that eliminated the direct mechanical connection between the master and remote devices. Using motors and simple electronic sensors, it became possible to connect human hand actions to a remote manipulator via electronic signals. Within these devices, motors provided the force both to perform the task and to provide the user with the feel of doing the task[1].

2. Haptic Interface

This is a force reflecting device which allows a user to touch, feel, manipulate, create, and/or alter simulated D-objects in a virtual environment.• This could be used to train physical skills such as those jobs requiring specialized hand-help tools (e.g. surgeons, astronauts, mechanics), to provide haptic feedback modeling of three dimensional objects without a physical medium (such as automobile body designers working with clay models), or to mock-up developmental prototypes directly from CAD databases (rather than in a machine shop). 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 perceptual system is unusual in that it can include the sensory receptors from the whole body and is closely linked to the movement of the body so can have a direct effect on the world being perceived. A distinguishing feature of haptic interfaces is the simultaneous exchange of information between the user and the machine.[2]

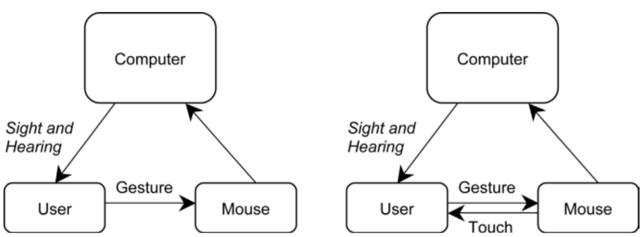

Fig. 1 Two types of Haptics.

When we use our hands to explore the world around us, we receive two types of feedback -- **kinesthetic** and **tactile**.[3] To understand the difference between the two, consider a hand that reaches for, picks up and explores a baseball. As the hand reaches for the ball and adjusts its shape to grasp, a unique set of data points describing joint angle, muscle length and tension is generated. This information is collected by a specialized group of receptors embedded in muscles, tendons and joints.

Known as **proprioceptors**, these receptors carry signals to the brain, where they are processed by the somatosensory region of the cerebral cortex. The **muscle spindle** is one type of proprioceptor that provides information about changes in muscle length. The **Golgi tendon organ** is another type of proprioceptor that provides information about changes in muscle tension. The brain processes this kinesthetic information to provide a sense of the baseball's gross size and shape, as well as its position relative to the hand, arm and body.

When the fingers touch the ball, contact is made between the finger pads and the ball surface. Each finger pad is a complex sensory structure containing receptors both in the skin and in the underlying tissue. There are many types of these receptors, one for each type of stimulus: light touch, heavy touch, pressure, vibration and pain. The data coming collectively from these receptors helps the brain understand subtle tactile details about the ball. As the fingers explore, they sense the smoother texture of the leather, the raised coarseness of the laces and the hardness of the ball as force is applied. Even the thermal properties of the ball are sensed through tactile receptors.

Force feedback is a term often used to describe tactile and/or kinesthetic feedback. As our baseball example illustrates, force feedback is vastly complex. Yet, if a person is to feel a virtual object with any fidelity, force feedback is exactly the kind of information the person must receive. Computer scientists began working on devices -- haptic interface devices -- that would allow users to feel virtual objects via force feedback. Early attempts were not successful. But as we'll see in the next section, a new generation of haptic interface devices is delivering an unsurpassed level of performance, fidelity and ease of use.

3. HOW HAPTICS WORKS

Typically, an Immersion 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). The calls specify which effect in the haptic effect library to play. 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.[4] Haptics applications use specialized hardware to provide sensory feedback that simulates physical properties and forces. Haptic interfaces can take many forms; a common configuration uses separate mechanical linkages to connect a person's fingers to a computer interface. When the user moves his fingers, sensors translate those motions into actions on a screen, and motors transmit feedback through the linkages to the user's fingers. The screen might show a ball, for example, and by manipulating a virtual hand through the device, the user can "feel" the ball, discerning how much it weighs or the texture of its surface. Because the ball and its environment are purely virtual, the properties can be changed—adding more air to an under inflated ball to make it less squishy, or altering the amount of gravity to let users feel how much the ball would weigh on the moon. This way, your product's haptic effects are context-appropriate, making operation engaging, intuitive, and natural.

"The actual process used by the software to perform its calculations is called **haptic rendering**."

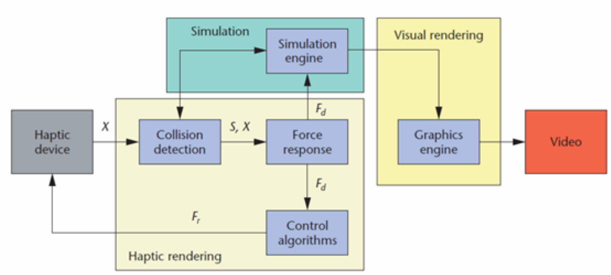

Fig. 2 Haptic System Diagram

We split haptic rendering[5] into three main blocks.

- ***Collision-detection algorithms***. The collision-detection algorithm uses position information collected through sensors to find collisions between objects and avatars and report the resulting degree of penetration or indentation.
- ***Force-response algorithms*** The force-response algorithm computes interaction forces between avatars and virtual objects involved in a collision
- ***Control algorithms*** The control algorithm collects interaction force information from force response and applies them on the operator through the haptic device while maintaining a stable overall behavior.

4. HAPTIC DEVICES

Haptic devices (or haptic interfaces) are mechanical devices that mediate communication between the user and the computer. Haptic devices allow users to touch, feel and manipulate three-dimensional objects in virtual environments and tele-operated systems. Haptic devices are input-output devices, meaning that they 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 (e.g., force feedback joysticks and steering wheels) and more sophisticated devices designed for industrial, medical or scientific applications (e.g., PHANTOM)
Other Low-cost Haptic Devices:

1. Haptic Paddles
2. Haptic knobs
3. Novint Falcon
4. Force Feedback Gaming Joystics
5. SensAble's Omni Phantom

This section provides information on the designs of various low-cost haptic devices that would be appropriate for use in teaching and learning about haptics, or using haptic devices to enhance the teaching of topics such as physics, system dynamics, or other kinds of interaction phenomena. These devices include "haptic paddles" and other inexpensive haptic device designs, such as haptic knobs, gaming joysticks, and the Novint Falcon.

Haptic Paddles

A Haptic Paddle is a 1 degree-of-freedom (1-DOF) impedance-type haptic force feedback device. All current haptic paddle designs are driven by an electromagnetic actuator such as a DC Motor to create force feedback at the end of a rotating joystick-like handle. Generally these devices are interfaced with an amplifier and a computer running associated control software. A variety of designs have been created and have been used to teach topics such as system dynamics, physics and, of course, haptics. For more information on haptic paddles, please refer to the Haptic Paddles page.

Force Feedback Gaming Joysticks

There are a variety of 2 degree-of-freedom (2-DOF) force feedback gaming joysticks, such as Microsofts sidewinder force feedback joystick and others by logitec. While these devices provide only limited force capabilities and have a fair amount of backlash, they are quite adequate for providing force feedback for representing physical phenomena studied in courses such as physics or dynamics or illustrating interaction forces experienced by atoms in a molecule. As such, a moderate number of educational haptic demos have been created in the past that utilize these devices

SensAble's Omni Phantom

The Omni Phantom is a 6 degree-of-freedom (6-DOF) serial linkage haptic force feedback device. It has 3 actuated degrees of freedom that provide force feedback to the end point of the device. The user interacts with the device through a gimbaled stylus interface that is instrumented to measure its 3 rotational degrees-of-freedom. The Omni is a smaller, lower cost version of the Phantom Premium force feedback device that is sold by Sensible Technologies that is commonly used in haptics research labs. The Omni has a smaller workspace and force capability than the Phantom Premium, but is still quite a capable device. It retails for ~$2,200 so it is more expensive than the other devices, but since quite a few people have used the Omnis for teaching haptics and conducting science outreach activities.

5. APPLICATIONS

1) FOR THE VISUALLY IMPAIRED:

The haptic display device, will include an integrated touch-screen so that users can push on areas of the screen to activate menus and other graphical icons that they feel there. With the ability to display graphical images and activate them by touch, the wide world of graphical information displays available on computers today can finally be accessed by the blind. . A multimodal tool allows blind people to create virtual graphs independently. Multimodal interactions in the process of graph creation and exploration are provided by using a low-cost haptic device. Haptic technology can be incorporated into touchable maps for the blind. To create a map, a video is shot of a real-world location, either an architectural model of a building or a city block. Software evaluates the video frame by frame to determine the shape and location of every object. The data results in a three-dimensional grid of force fields for each structure. Using a haptic interface device, a blind person can feel these forces and, along with audio cues, get a much better feel of a city's or building's layout.

2) AUTOMOTIVE:

Today's new car buyers want separate climate controls for the driver and front seat passenger, triple-zone rear A/C, and separate controls in the rear. The problem is that the more sophisticated the climate control system, the more complex it can be to operate. Many motorists don't fully understand their systems. Touch Guides and Informs. Haptics can help make climate control systems more intuitive to operate. Research shows that touch feedback can convey significant quantities of information and use does not need to be confined to simple notifications. Touch Makes It Easier. The climate control system may be complex, but touch feedback can make it seem easier. Human touch reaction is immediate, so receiving information this way improves user accuracy and speed therefore reduces distractions. With touch feedback guiding control settings, users may not even need to look at the controls, which further improves safety. Research also shows that using the touch channel for information reduces complication and stress.

3) VIRTUAL EDUCATION:

Research indicates that a considerable portion of people are kinesthetic or tactile learners—they understand better and remember more when education involves movement and touch. Because formal education has traditionally focused on visual (reading) and auditory (hearing) learning, these learners have been at a disadvantage. Haptics opens the door to an entirely different learning method and style, one that for many students provides the best opportunity to learn. Moreover, even for visual and auditory learners, haptics can improve learning. For a broad range of subject matter, incorporating sensory data and feedback allows for a richer understanding of the concepts at hand. Haptics tools are used in a variety of educational settings, both to teach concepts and to train students in specific techniques. Some faculties employ haptic devices to teach physics, for example, giving students a virtual environment in which they can manipulate and experience the physical properties of objects and the forces that act on them. Such devices allow students to interact with experiments that demonstrate gravity, friction, momentum, and other forces. In subjects such as biology and chemistry, haptic devices create virtual models of molecules and other microscopic structures that students can manipulate. In this way, students can "feel" the surfaces of B cells and antigens, for example, testing how they fit together and developing a deeper understanding of how a healthy immune system functions.

4) RESEARCH:

Some research has been done into simulating the different kinds of tactition by means of high-speed vibrations or other stimuli. One device of this type uses a pad array of pins, where the pins vibrate to simulate a surface being touched. While this does not have a realistic feel, it does provide useful feedback, allowing discrimination between various shapes, textures, and resiliencies.

5) MEDICINE:

Various haptic interfaces for medical simulation may prove especially useful for training of minimally invasive procedures (laparoscopy/interventional radiology[6] and remote surgery using teleoperators. 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.[7] 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 (SensAble Technologies, PHANToM 3.0).

6. CONCLUSION

Development and refining of various kinds of haptic interfaces will continue, providing more and increasingly lifelike interactions with virtual objects and environments. Researchers will continue to investigate possible avenues for haptics to complement real experiences. Advances in hardware will provide opportunities to produce haptic devices in smaller packages, and haptic technology will find its way into increasingly commonplace tools. Additionally, consumer-grade haptic devices are starting to appear on the market. As access to haptics increases, usage patterns and preferences will inform best practices and applications—ultimately, users will decide which activities are appropriately represented through haptics and which are perhaps better left in the real world. Haptic is the future for online computing and e-commerce, it will enhance the shopper experience and help online shoppers to feel the merchandise without leaving their home. Because of the increasing applications of haptics, the cost of the haptic devices will drop in future. This will be one of the major reasons for commercializing haptics. With many new haptic devices being sold to industrial companies, haptics will soon be a part of a person's normal computer interaction.

7. APPLICATIONS

Future applications of haptic technology cover a wide spectrum of human interaction with technology. Some current research focuses on the mastery of tactile interaction with holograms and distant objects, which, if successful may result in applications and advancements in gaming, movies, manufacturing, medical, and other industries. The medical industry will also gain from virtual and telepresence surgeries, providing new options for medical care. Some speculate the clothing retail industry could gain from haptic technology in ways such as being able to "feel" the texture of clothes for sale on the internet[8]. Future advancements in haptic technology may even create new industries that were not feasible or realistic before the advancements happening right now.

References

[1] Introduction http://www.sensable.com/documents/documents/Salisbury_Haptics95.pdf
[2] "Haptic interfaces and devices" by *Vincent Hayward* et al. Sensor Review Volume
[3] http://electronics.howstuffworks.com/gadgets/other-gadgets/haptic-technology.htm
[4] http://www.immersion.com/licensing/what-is-haptics/how-does-haptics-work.html
[5] http://www.yuvaengineers.com/?p=691
[6] Jacobus, C., et al., Method and system for simulating medical procedures including virtual reality and control method and system,US Patent 5,769,640
[7] "Honors And Awards". Ent.ohiou.edu. Archived from the original on April 2, 2008. http://web.archive.org/web/20080402111612/http://www.ent.ohiou.edu/~bobw/html/VHB/VHB.html. Retrieved 2010-02-26.
[8] "Haptic technology simulates the sense of touch - via computer". News-service.stanford.edu. 2003-04-02. http://news-service.stanford.edu/news/2003/april2/haptics-42.html. Retrieved 2010-02-26.