ABSTRACT

Touch is a fundamental aspect of interpersonal communication. Whether a greeting handshake, an encouraging pat on the back, or a comforting hug, physical contact is a basic means through which people achieve a sense of connection, indicate intention, and express emotion. In close personal relationships, such as family and friends, touch is particularly important as a communicator of affection.

Current interpersonal communication technology, such as telephones, video conferencing systems, and email, provides mechanisms for audio-visual and text-based interaction. Communication through touch, however, has been left largely unexplored. In this paper, we describe an approach for applying haptic feedback technology to create a physical link between people separated by distance. The aim is to enrich current real-time communication by opening a channel for expression through touch.

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1. INTRODUCTION

For quite some time, most computer-based simulations of objects were only visual. The user usually had to look at a computer screen or don a headset to give him or her access to three-dimensional objects. Later, sound became possible and it improved the simulation experience. Until recently, however, one key element has been missing: the ability to feel the object, to get a sense of:

- Its shape
- How heavy it is
- How the surface texture feels
- How hot or cold it is

For example, if a user tried to grab a virtual ball, there was no non-visual way to let the user know that the ball is in contact with the user's virtual hand. Also, there was no mechanism to keep the virtual hand from passing through the ball.

Haptic research attempts to solve these problems. Haptics (from the Greek haptesthai "to touch") refers to the modality of touch and its associated sensory feedback. Haptic feedback devices and supporting software permit users to sense ("feel") and manipulate three-dimensional virtual objects in terms of shape, weight, surface textures, and temperature.

Many Haptic devices are employed in the area of Virtual Reality; however, that term refers more commonly to an artificial environment created with computers and software and presented to the user in such a way that it appears and feels like a real environment.

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2. HAPTICS

The term haptics refers to the sense of touch, conveying information on physical properties of tactile reception such as temperature, compliance, change and change in texture.

Because of this, haptic technology holds great potential for interaction designers. Understanding the details of haptic perception and the feasibility of incorporating haptic technology into tangible user interfaces adds a powerful idiom to the interaction design vocabulary, one from which we can develop new interaction paradigms.

This project was comprised of two parts:

- A cursory survey of the technology, research, applications, and industry
- A field trip to a research center where new haptics devices are being developed.

This sense can be divided into two categories:

- The kinesthetic sense, through which we sense movement or force in muscles and joints;
- The tactile sense, through which we sense shapes and textures.

Today, there are many devices that use haptic technology. For example, joysticks and similar devices that employ force feedback were among the earliest developed for a mass market, and were popularized in the mid-1990s when these joysticks became the rage.

Tactile perception provides us with a wide range of immediate information, which we process both consciously and unconsciously. Touching with one’s hands is always a deliberate action and can be used as an effective means of input to a digital device.

2.1 TOWARDS THE TECHNOLOGY
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The idea behind in Touch 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. In our current design, the two connected objects each consist of three cylindrical rollers mounted on a base (Figure 1). When one of the rollers is rotated, the corresponding roller on the remote object rotates in the same way. This behavior can be achieved using haptic (force-feedback) technology with sensors to monitor the physical states of the rollers and internal motors to synchronize these states.

Figure 1. inTouch conceptual sketch

Two geographically distant people can then cooperatively move the rollers, fight over the state of the rollers, or more passively feel the other person's manipulation of the device. The presence of the other person is thus made tangible through physical interaction with the seemingly shared object. Since the two objects are not mechanically linked in reality, inconsistencies in their states must be resolved by the system agreeing on a single consistent state and then employing the motors to guide the objects into that state.

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. Currently, doctors only receive visual (camera) information and in some...
cases doctors only receive visual (camera) information and in some case "force feedback" when they attempt to access "out-of-bounds" areas.

When using computers and software for modeling processes and analyzing complex systems, we often need more than the 2 dimensions, even when using colours and shades.
Techniques for visual representation of the 3rd dimension have been introduced but are still lacking in their presentation of the "real world". Here also the touch channel could provide significant additional information.

2.2 HAPTIC DEVICES AND CLASSIFICATION
The word "haptic" is relating to or proceeding from the sense of touch" A haptic interface is a device which allows a user to interact with a computer by receiving tactile feedback. This feedback is achieved by applying a degree of opposing force to the user along the x, y, and z axes. These devices can be used by people with disabilities or people who learn best through tactile or kinesthetic experiences. The use of haptic devices that once were cost prohibitive but now are incorporated into mainstream devices such as the iFeel Mouse and the IFeel Mouseman, promote inclusion and acceptance of "adaptive" technology into the "daily computer experience" of people with and without disabilities.

A haptic interface is a device which allows a user to interact with a computer by receiving tactile and kinesthetic feedback. A haptic interface device share the
unparalleled ability to provide for simultaneous information exchange between a user and a machine as depicted below.

An illustration of the unique bi-directional information exchange of a haptic interface.

There are two main types of haptic devices:

- Glove or pen-type devices that allow the user to "touch" and manipulate 3-dimensional virtual objects
- Devices that allow users to "feel" textures of 2-dimensional objects with a pen or mouse-type interface

The 3-dimensional haptic devices can be used for applications such as surgical simulations and remote operation of robotics in hazardous environments.

The 2-dimensional haptic devices can be used to aid computer users who are blind or visually disabled; or who are tactile/Kinesthetic learners, by providing a slight resistance at the edges of windows and buttons so that the user can "feel" the Graphical User Interface (GUI). This technology can also provide resistance to textures in computer images which enables computer users to "feel" pictures such as maps and drawings.

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Two Dimensional Devices

- The WingMan Force Feedback Mouse and the iFeel mouse are some of the haptic devices produced by Logitech.

Three Dimensional Devices

- The Phantom from SensAble Technologies
  3-dimensional pen-style haptic interface, comes in five models.

- CyberGrasp is a glove-style haptic interface that allows users to touch computer-generated objects and experience realistic force feedbacks

2.3 PHANToM

It is a haptic device which enables tactile interaction with a computer. By means of this device, visually impaired people can interact with the computer.

Computers are becoming everyday technology for more and more people. Computers have opened up many doors for disabled people, for example it is now rather easy for a blind person to access written text. Any text in a computer can be read either with a one row Braille-display or a speech synthesizer. This is done in real time and is of course much more flexible and less space consuming than books with Braille-text on paper. There is a big problem though: Since the introduction of graphical user interfaces computers are getting easier and easier to use for sighted people, but GUIs has the opposite effect for non sighted people. The many fast accessible objects on a Windows desktop becomes a big mess for a user who can't see them. And if you don't know what is on the screen it is almost impossible to control the computer.
This is where the haptic interfaces can be a good help. With the PHANToM or a similar device it is possible to feel things represented in a computer. CERTEC has developed a set of programs which demonstrate different ways for a blind user to control a virtual reality with finger movements and to get feedback via the sense of touch. One of the big tasks for the future is to make the Microsoft Windows environment completely accessible through haptics. If you can feel the START-button in the lower left corner etc. it is not only possible to control the environment, but it is also possible to start speaking about how to do things since both sighted and non sighted users have a common ground to start from.

CERTEC is working with the meeting between human needs and technical possibilities. Normally we start with the human needs and develop technical solutions from that aspect. Sometimes though it is motivated to start from the other side.

In this case we have used a technical solution which has been developed for other purposes and modified it to correspond to the needs of a disabled person. We have turned the PHANToM into the Phantasticom.

2.3.1 A short description of the PHANToM
The PHANToM is a small robot which acts as a haptic interface between a human and a computer. A normal program uses vision, sound, a keyboard and a mouse for the interaction with a user. The PHANToM adds a new dimension to human computer interaction, namely haptic interaction. Haptic interaction uses both the sense of touch in a small scale and movement in a slightly bigger scale.
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It is not unusual to connect a robot to a computer as is done with the PHANToM. The special thing in this case is that movement and sense is used for interaction between the human and the computer. With the PHANToM a user can feel objects which are represented inside the computer. At the same time one can use movement to give commands and to get feedback from the program.

When activated the PHANToM works together with the computer to interpret the users finger position in three dimensional spacespace and apply an appropriate and variable resisting force. This process is completed 1000 times per second. It is a 6 DOF device. DOF refers to Degree Of Freedom nothing but the number of dimensions required to completely specify the position and location of the object.

2.3.2 Making a Phantasticon out of the PHANToM
When the PHANToM is extended to meet the needs of disabled persons it becomes a complete system. This system includes the PHANToM itself, and the software from CERTEC. It also includes a lot of ideas and thoughts about what can be done for people with special needs using this hardware and software.

SensAble Technologies Inc., a spinoff from work Salisbury and colleagues did when he was at the Massachusetts Institute of Technology, commercialized one such haptic interface in 1993. Designers have used it to carve out of thin air products from Nike shoe soles to Chicken Run collectibles.

Salisbury's Stanford lab also uses a haptic interface from Force dimension, a company co-founded by graduate student Francois Conti. Conti is using one such device to take tactile "pictures." The spiderlike spider like robot handle presses on a surface and records the forces causing deformation. It can then play back the forces it experienced.

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and make a person holding the handle feel like he's poking the surface himself. The computer communicates sensations through interfaces such as the PHANTOM® Haptic Interface, produced by SensAble Technologies, Inc. of Woburn, Mass.

2.3.3 Software development for the Phantasticon
CERTEC is continuously developing programs for the Phantasticon. At this moment we have the following programs ready:

"Paint with your fingers"
A program with which the user can paint computer pictures with a finger. One can choose a colour from a palette and paint with it on the screen. The harder you push with your finger, the thicker becomes the line. Each color has an individual structure. When you are painting you can feel the structure which is being painted. You can also feel the structure of the whole picture by changing program mode with a simple click on the space key.

"Mathematical curves and surfaces"
Mathematics is a partially visual subject. That is often noticed by people who try to explain mathematics for blind persons. With the help of the Phantasticon also blind persons can learn to understand equations as curves and surfaces. CERTEC has developed a program which makes it possible to feel any mathematical curve or surface with the PHANToM.

"Submarines"
"Submarines" is a PHANToM variant of the well known battleship game. The player can feel 10x10 squares in a coordinate system. In the game your finger is a helicopter which is hunting submarines with depth charge bombs. If you put your finger on the "water surface" you can feel the smooth waves moving up and down. The surface feels different after you have dropped a bomb, and it also feels different if a submarine has been sunk. This computer game uses the PHANToM, the screen and the keyboard for the interaction with the user.

2.3.4 Touch Windows Andand Work In Progress
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The big efforts at this moment is efforts at this moment are laid on developing a general user interface which is easily accessible for blind people. As a test bench for haptic interface objects and at the same time a haptic computer game we have developed Haptic Memory. The task for the user is to find pairs of sounds which are played when the users pushes different buttons. The Memory program is a good base to find out how different parts of a haptic interface should be designed to work as good as possible for low vision users.

The Haptic Memory has also been expanded into "the HOuSe". The HOuSe is CERTECs "first steps towards a Haptic Operating System". The HOuSe is a bigger haptic memory with five floors and five buttons on each floor. With this program we can gain some experience about how blind persons can use haptics to build inner pictures of complex environments. That knowledge is an important cornerstone when we start building the complete haptic windows system or other haptic programs for visually disabled people.

"The HOuSe" has been tested with four children and five adults. All of them are blind. A reference group of 21 children in the age of 12 has tested a program with the same function and layout, but with a graphical user interface. Since the haptic interface has the same layout as the graphical interface and both programs work the exactly same except for the way of interacting with the user it is possible to compare to results of the blind users with the results of the sighted users. All of the blind testers had a little more than one hour of experience with the phantom before the test started.

The tests show that a majority of the blind users could complete the task using as many button pushes as the sighted users, but the blind users generally needed more time. The differences in the results where bigger in the group with blind users and two of them did not finish the task at all.

The results imply that it is meaningful to keep trying to make graphical user interfaces accessible for blind people using haptic technology. Most of the blind users showed big confidence when using the haptic interface even with the rather limited experience they had and the differences in time will probably be lower after more training.
As mentioned in the introduction there is a big problem for non sighted users that computer nowadays mostly have graphical users interfaces. However, Windows and other graphical user interfaces are widespread and accepted, so almost all new programs are made for those environments.
3. METHODS OF SUPPLYING GOOD SIMULATION

Good simulation creates illusion of real objects by reflecting the proper amount of force feedback to the user. The difficulty in providing this illusion is what makes haptics a challenging area of robotics. The three main components of haptic simulation are haptic software, human perception, and haptic hardware.

1. HAPTIC SOFTWARE: Haptic devices possess the ability to simulate different objects in varying environments. This ability comes from the control algorithm governing the haptic simulation. Because haptic simulations are governed in software, a great deal of research has focused on designing the control algorithms.

2. HUMAN PERCEPTION: Another component of haptic simulation is human perception of virtual objects. By suitably controlling the relationship between visual and haptic displays in the multimodal virtual environments, it may be possible to overcome the limitations of haptic interfaces.

3. HAPTIC HARDWARE: The final component of haptic simulation, haptic hardware, encompasses issues regarding motor/actuator specification, transmission specification, transmissions and overall design. Some of these issues include elimination of backlash using belt drives rather than gears, use of composite material to reduce the overall inertia thereby decreasing momentum.

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4. APPLICATIONS

Gaming is one of the first applications of haptics that is being realized. Two students in Salisbury's experimental haptics course last spring programmed a forceful version of virtual ping-pong they called "Haptic Battle Pong." Interest in the game caused an Internet traffic jam that shut down the haptic interface manufacturer's website for a day.

Haptic technology emerged as the technology of touch has already been explored in contexts as diverse as modeling and animation, geophysical analysis, virtual analysis, virtual museums, assembly museums, assembly planning, mine planning, mine design, surgical design, surgical simulation, design simulation, design evaluation, control evaluation, control of specific instruments and robotic simulation. Thus it is a most exhilarating possibility to use the Phantasticon for widening the touch based experiences and learning outside an arm's length.

So far, we have not come across any unclimbable obstacles.

This technology has been used for cultural applications namely in museums. It is used in interacting with three-dimensional ultrasonic data. It has been applied in the medical field too specially in maxillofacial surgery. It is used as a chemist's tool in viewing the internal orbitals of an atom. By means of this it is possible to visualize the cells clearly. It has been widely used in automobiles.

Also in the works of simulated surgery. Just as commercial pilots train in flight simulators before they're unleashed on real passengers, surgeons will be able to practice their first incisions without actually cutting anyone. Simulation for surgical training is a major focus in Salisbury's lab. This work is funded by the National Institutes of Health and Stanford's Bio-X Program.

Creating a realistic, interactive internal organ is no easy feat. "It's not just something that you can touch and say, 'OK, it's round and it's squishy and it's got a bump..."
here,' but something that you can then cut and it will bleed, or sew and it will stop bleeding," Salisbury says.

Haptic technology has great potentials in many applications. This paper introduces our work on delivery haptic information via the Web. A multimodal tool has been developed to allow 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, the Logitech WingMan Force Feedback Mouse, and Web audio. The Web-based tool also provides blind people with the convenience of receiving information at home. In this paper, we present the development of the tool Introduction The Haptic Sense

New Virtual Reality technologies provide the possibility of widening access to information in data. Haptics, the technology of touch, could be an interesting future aid and have large impact on medical applications. The use of haptic devices allows computer users to use their sense of touch, in order to feel virtual objects with a high degree of realism.

4.1. HAPTIC TECHNOLOGY IN MEDICINE-MAXILLO FACIAL SURGERY
The aim of the thesis is to investigate the potential deployment and the benefits of using haptic force feedback instruments in maxillo-facial surgery. Based on a produced test application, the thesis includes suggested recommendations for future haptic implementations.

At the Department of Maxillo-Facial Surgery, at the Karolinska Hospital in Stockholm, Virtual Reality technologies are used as an aid to a limited extent during the production of physical medical models. The physical medical models are produced with Rapid Prototyping techniques. This process is examined and described in the thesis. Moreover, the future of the physical medical models is outlined, and a future alternative visualizing patient data in 3D and use haptics as an interaction tool, is described. Further more, we have examined the present use of haptic technology in medicine, and the benefits of using the technology as an aid for diagnostic and treatment planning.
Based on a presented literature study and an international outlook, we found that haptics could improve the management of medical models. The technology could be an aid, both for physical models as well as for virtual models. We found three different ways of implementing haptics in maxillo-facial surgery.

A haptic system could be developed in order to only manage virtual medical models and be an alternative solution to the complete Rapid Prototyping process. A haptic system could serve as a software, handling the image processing and interfacing from a medical scanner to an Rapid Prototyping system. A haptic system could be developed as an alternative interaction tool, which could be implemented as an additional function in currently used image processing software, in order to improve the management of virtual medical models before the Rapid Prototyping process.

An implementation for planning and examination in maxillo-facial surgery, using haptic force feedback interaction, is developed and evaluated. The test implementation is underlying our aim of investigating the potential deployment and the benefits of using haptic force feedback instruments in maxillo-facial surgery.

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4.2. IMPACT. IMPACT OF HAPTIC TECHNOLOGY ON CULTURAL APPLICATIONS

Four main benefits might come from the use of haptics. These extend the use of graphics and three-dimensional models already used in some museums; others provide new experiences that are not currently available.

1. Allow rare, fragile or dangerous objects to be handled

Objects that are very fragile, rare or dangerous may not be handled by museum visitors or scholars. Visual models can be created but there are many aspects that this does not capture, for example how heavy does it feel? How rough is its surface? To solve this problem objects could be haptically modelled and then visitors or researchers could feel them using a haptic device. This means that these objects can be made available to large numbers of people.

2. Allow long distance visitors.

There are many potential visitors to a museum who cannot get to visit. They might live far away or be immobile. If objects are haptically modelled and then made available on a museum’s website then other access methods become possible. School could buy a haptic device so that children can continue to feel and manipulate objects after they have been for a visit. A scholar could examine the haptic aspects of an object from a university across the world. With a haptic device at home a visitor could feel and manipulate the object via the internet.

3. Improve access for visually disabled people.

Visually impaired and blind people often lose-out when going to museums because objects are behind glass. There are over one million people in the UK who are blind or partially-sighted. Some museums provide special exhibits that the blind can feel. However these exhibits are usually small and may not contain the objects that the blind visitor is interested in. With haptic technologies, such tools could feel and interact with a much wider selection.
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range of objects, enriching objects, enriching their museum. Many museum.
normally sighted users could also enjoy the opportunity to touch. Increase. Increase the number of artefacts on display.

experiences in the museum exhibits.

With limited amount of space museums can only show a limited range of artifacts from their collections. If other objects that are not on the show are modelled graphically and haptically then visitors could experience these on computer, without computer, without taking up museum space. Several haptic devices a museum could allow many people to feel objects at the same time, sharing the experience.

4.3 AUTOMOTIVE USE

ALPS Corporation tried to develop and commercialize products which has products which have applied numerous patents in haptic technology for automotive use. Immersion’s haptic technologies are controls touch sense and operational directions with using programmed operation knob, various restriction force and alarm which are produced by mechanical and electrical effects with actuator and position sensor. Since touch sense can be adjusted easily, the multiple operations of car equipment can be controlled by single knob.

When applied this technology on automotive devices, the unique operational features of such electronic components as car audio, air conditioning, power mirrors and power seats are combined to enable control through a single knob. When something trouble or operating error occurs, the product notifies and alert the driver via restricted movement or vibration of the knob. Consequently, the driver is ensured safe, comfortable control of devices while in motion without averting attention from the road.

ALPS and Immersion previously made a joint development contract in July 2000 to apply haptic technology on automotive devices and carried out development under it. This cooperative endeavor is proliferated in the development of the iDrive for recently released BMW 7 Series.

ALPS will expand haptic technology applied products line in a global scale, and keep advanced development in various automotive products currently undergoing computerization and advanced safety concept.

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"The Immersion-ALPS partnership comes at a time when automotive manufacturers are actively seeking compelling alternatives to traditional user interface methods. Since our first discussions together, our collective mission for haptics in the automotive space has been to enable users to more intuitively control user interfaces through their sense of touch thereby allowing them to visually focus on the road," said Vic Viegas, president and chief operating officer for Immersion. "The collaboration that started with the new BMW iDrive Controller is continuing with this multi-million dollar opportunity which will help to proliferate the use of haptic interfaces in the automotive industry."

How Haptic Technology Works in Cars

Cars:

In today's cars, various functions require individual controls including dials, sliders, and buttons—many with a distinct mechanical feel. With haptics, a single user interface can replace the complex array of dials and buttons, while still maintaining the unique feel of each function. For example, as the driver operates the control in radio-tuning mode, the device will move smoothly until a preset station is reached. Tactile cues then indicate to the driver that a desired station is 'locked' in. Similarly, for balance or tone controls, programmable tactile sensations can be used to represent the neutral position and end of range. This interface can also recreate the unique and intuitive feel of many other basic functions including climate control, seat adjustments, and navigation systems.

Salient features

Demonstrating the most advanced auto-interface design technologies for the first time, four leading technology companies have fully integrated haptic controls with the industry's standard graphics, operating system and API. The term "haptics" refers to the science of touch, also known as force feedback. The demonstration in Wind River's booth No. 10-11 is a result of the collaboration among Immersion Corp. (NASDAQ: IMMR), a leading developer of haptic technology; Tilcon Software Ltd, one of the world's leading suppliers of visual user interface technology; Wind River Systems Inc. (NASDAQ: WIND), the worldwide market leader in embedded software and services; and Renesas Technology America Inc., a subsidiary of the new joint-venture semiconductor
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company established by Hitachi, Ltd. and Mitsubishi Electric Corp. The new all-in-one solution brings together graphic and haptic human-machine interaction (HMI) interfaces in an embedded platform with a real-time OS.

"In support of safety and new vehicle information systems, haptics is happening in the auto industry," said Joe DiNucci, Vice President of Sales and Marketing at Immersion Corp. "The sense of touch is already in high-end cars, and is scheduled to reach the broader auto market over the next few years. Previously a complex, laborious process, our four-way collaboration now fully integrates haptics with other state-of-the-art automotive design tools. For auto manufacturers and integrators, this integration means a significant savings of time and money while also giving them more design flexibility."

"Working with Immersion enables us to offer automotive manufacturers a ready-made solution combining cutting-edge haptic technology with superior dashboard display technology," says Ernest Hollander, Vice-President of Engineering at Tilcon. "Car manufacturers plan to deploy very elaborate information systems within automotive dashboards. A plan that will fail if these systems aren't easy to use. Drivers employ their sense of sight and touch to control a car. Integration of haptic and visual display technologies provides superior feedback both in what the driver sees by way of Tilcon's dashboard instruments and what the driver feels through Immersion's haptic controls. The integration of these technologies makes the information system usable and the car easier to drive."

Haptic

Steering

Wheel

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Haptic Pedal

Haptic Steering Haptic Pedal

Haptic Pedal

Systems that operate automobiles and aircraft by means of computer-controlled electronic signals instead of direct action on control devices are called "X-by-wire" systems. For instance, previous systems used hydraulics to operate control surfaces when the pilot of

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an aircraft manipulated the joystick. In fly-by-wire systems, the action of the joystick is converted into an electronic signal used by a computer to control the movement of aircraft and the operation of other equipment.

Today, most automobiles are operated by mechanical steering systems that transmit steering-wheel movement to the wheels by means of shafts and gears. However, in response to demands for greater safety, we are beginning to see the increasing use of drive-by-wire systems that employ computer control.

These mechanical systems convey haptic information on road-surface conditions to the driver through the mechanical linkage between wheel and steering wheel. A drive-by-wire system controls the information on road-surface conditions conveyed to the driver, thereby enhancing safety. In addition, the steering yoke required in mechanical systems is eliminated, allowing greater freedom in design of steering systems and auto interior layouts. This reduces the number of chassis and body components, contributing to reductions in vehicle weight.

One problem with computer control of steering systems is that, because operational information is conveyed by means of electronic signals, there is no mechanism for feedback of information to the driver on actual road-surface conditions, vehicle status, and cautionary information. ALPS turned to the capabilities of haptic technology to solve this problem and further improve safety by eliminating such deficiencies. Employing the force feedback technology of the Haptic Commander™, ALPS' drive-by-wire system conveys required information to the driver in tactile form.
For instance, feedback on irregularities in the surface of an unpaved road is transmitted via movement of the steering wheel, while information on the gradient of a hill is conveyed via an increase or decrease in the resistance of the accelerator pedal.

Merits

ALPS has developed a proprietary drive-by-wire system using a force feedback function through haptic technology

1. Haptic technology realizes tactile feedback to the driver in a drive-by-wire system.
2. Through the application of haptic technology, artificially generated cautionary information can be conveyed to the driver.
3. Contributes to increased safety in the operation of automobiles.
4. Contributes to increased freedom in auto interior layout and lighter vehicle weight.

4.4 HAPTIC MOUSE

This mouse employs haptic technology, or virtual touch. A growing rage in computer circles, haptic technology builds the illusion of tactile dimension into virtual worlds. In a flight simulator, it rocks the real hand of a pilot during feigned turbulence. On a standard computer desktop, it lends the feeling of mass and texture to icons made of nothing more than pixels.
The Haptic mouse is motorized, which creates sensations such as resistance and vibration clearly felt by the user. The concept is called forced feedback. When the pointer of the mouse sweeps across a computer screen, software recognizes the motion and affects the mouse's response. Icons feel different than the desktop pattern and can be made to feel.
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distinguishable from each other. More than that, the pointer reacts like it is being pulled towards icons. The point-and-click interface shifts into a pulled-and-click interface.

The mouse offers "an artificial mode of what the icons would feel like if you could actually pick them up," said Dennerlein. More importantly, the haptic mouse saves time. The users of the haptic mouse performed point-and-click tasks 25 percent faster than standard-mouse users. The technology decreases the need for precision, but it also decreases risk of work-related musculoskeletal injuries correctly.

Musculoskeletal disorders include conditions such as carpal tunnel syndrome, lower back pain and some head and neck injuries. These types of injuries often result from repetition and force and were formerly called repetitive stress disorders. Each year, more than one-half million American workers take time off from work because of these disorders, according to Organizational Safety And Health Standard.

Haptic technology could help prevent musculoskeletal disorders or perhaps rehabilitate them because it could be used to teach good habits," said Dennerlein. The haptic mouse, for example, controls the range of motion of the hand and wrist and for some tasks decreases the physical stress on the body. Researchers, with the goal of building a better mouse, have focused on changing how one holds the mouse but had not examined incorporating forced-feedback models into the workplace.

"People have been suffering from musculoskeletal disorders for years," said Dennerlein, "but now it is a hot topic because the computer has brought manual labor into the office environment. What is known is that the more time you spend in front of a computer, the more likely you are to develop one of these disorders. The specific causes remain unknown. He is developing a monitoring system to be used in the field, as opposed to the lab, to characterize the physical exposures that may lead to injuries such as carpal tunnel syndrome. He also is investigating why more women than men suffer from chronic musculoskeletal disorders of the upper body.

In the meantime, haptic technology is being applied to an astonishing variety of fields. Joysticks and controllers in some video game systems use the technology to create the feel of rapid gunfire.

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4.5 Haptic Phones
The announcement from Samsung opens up a wide myriad of possible applications that could be enabled by Haptic technology on mobile. Most obvious of which would be gaming, similar to what we have experience on the console game pads and controllers. Games could provide the stunning realism of effects like explosions and collisions, making the experience more fun and enjoyable. Music, video, and other mobile applications could also be enhanced with tactile rhythms, beats, effects, and usability cues. Mobile device could support different tactile sensation to identify different caller while in silent mode or even drawing focus to specific email message from the clutter of mails downloaded to the mobile to signify higher priority messages when scrolling through.

Just like graphics and sound, touch can be coded as digital bits and sent in packets over the internet or a cell phone network then reassembled or "rendered" in some form on the receiving device. The transmission of data would however need to be fairly robust as a minute delay of 200 milliseconds, something which is acceptable for phone.
conversation or watching of video on the mobile, would make a difference in the replication of accurate tactile feedback for the receiving device.

Samsung Haptic technology is based on Immersion's VibeTonz platform. The platform comprises of a SDK library that allows the developer to simulate four basic sensation namely, vibrational (periodic), positional (texture, enclosure, ellipse, spring, grid), directional (constant, ramp) and restrictive (damper, friction) effects. Currently the SDK is only available as BREW extension for CDMA phones but Immersion is already working on making the VibeTonz platform available on the Symbian smart phone OS which is widely supported by handset manufacturers like Nokia and Sony Ericsson.

Immersion will provide the handset manufacturers with a hardware design spec related to the power amplifier and associated circuitry as well as the VibeTonz mobile player for embedding into the phone.

For the general users tactile feedback on mobile is something that may be good to have but would be extremely beneficial for the visually handicapped. Imagine the use for RFID implanted around the MRT station sending directional information to a Haptic phone that provides accentuated feedback that is more innate to the human sense of touch. The world would surely become more interesting for these less fortunate folks.
who may then be able to interact and move freely amongst us without fear or embarrassment. And advocates for the blind hope that the haptic-computer interface will help blind people navigate desktops more easily because they will be able to distinguish icons by the resistance of the mouse combined with acoustic cues.

4.6 HAPTICS AND EDUCATION
Haptics involves both kinesthetic movement and tactile perception. The term tactile is used primarily in referring to passive touch (being touched); but haptics involves active touch such as a student manipulating an object during hands-on science explorations. This active touch involves intentional actions that an individual chooses to do, whereas passive touch can occur without any initiating action.

For educators, involving students in consciously choosing to investigate the properties of an object is a powerful motivator and increases attention to learning. Contrast this active manipulation with passive learning, such as watching a science video. In active manipulation the student expends energy and makes a decision to manipulate materials. In more passive learning, such as watching a video, the student is asked only to sit and observe. It is more difficult to maintain attention and motivation in a passive learning context than an active one. Associated with active manipulation is the opportunity for the student to control actions, learning, and even the speed of exploration. Control has been shown to be an important part of intrinsic motivation. Thus far, the results of our studies have supported these assertions, students find the haptic technology exciting, engaging, and interesting.

Research results

One of the most commonly used devices, and one of the interfaces employed in our studies, is SensAble Technologies’ PHANTom (shown below). It is a small, desk-
grounded robot-like arm that permits simulation of fingertip contact with virtual objects through a pen-like stylus.

The PHANTom desktop device from SensAble Technologies, Inc.

With this new haptics application, students are able to feel nanosized materials such as viruses that are imaged under the AFM. In essence the user is afforded the opportunity to have a hands-on experience with objects at the nanometer scale that are too small to be touched or even seen otherwise. The study experience was engaging and developed more positive attitudes about science. Additionally, students showed significant gains in their understanding of viruses. The cost and logistics of delivering the live interaction with the atomic force microscope and virus samples limits the availability of this type of haptic instruction and prompted a second study. Here, students experienced a computer mediated inquiry program that incorporated stored images of the nanoManipulator's interaction with a virus sample. The goal of this exploratory study was to examine the differential impact of augmenting the computer mediated inquiry with three feedback devices: the PHANTom, a Sidewinder, and a mouse. Results suggest that the addition of haptic feedback provides a more immersive learning environment that not only makes the instruction more engaging but may also influence the way in which the students construct their understandings about viruses as evidenced by an increase in their use of spontaneously generated analogies.

Currently work is underway to explore how the addition of haptic feedback to computer-generated 3-D virtual models of understandings of cell concepts.

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The Haptic Cell Passive transport simulation: users can feel the organelles

The structural differences (i.e. relative size, surface area, texture, shape, elasticity & rigidity) of the parts are emphasized. Students can 'poke' through the cell membrane, 'feel' the viscosity of the cytoplasm, and 'touch' the rough endoplasmic reticulum. The program also highlights the mechanisms behind the cell membrane's selective permeability. Students learn how certain molecules traverse the membrane via the various types of passive transport by trying to pass these substances through the membrane and 'feeling' the associated forces.

Passive transport simulation
Haptic Learning

Haptic learning plays an important role in a number of different learning environments. Students with visual impairments depend on haptics for learning through the use of Braille as well as other strategies. Looked at from a constructivist's perspective, the haptic augmentation of computer-generated 3-D virtual environments, in which the student is an active participant, can be a powerful teaching tool. Learning is often defined as the construction of knowledge as sensory data are given meaning in terms of prior knowledge. The addition of haptics affords students the opportunity to become more fully immersed in this process of meaning-making; taking advantage of tactile, kinesthetic, experiential, and embodied knowledge in new ways. This prospective new instructional tool can have direct implications on the way in which students are taught. Perhaps soon students will be able to become immersed in a virtual animal cell; more fully exploring its structure and functioning. Physics instruction will make use of haptic feedback devices to teach students about invisible forces like gravity and friction more completely. Visually impaired students will learn math by touching data represented in tangible graph and chemistry by feeling the attractive and repulsive forces associated with various compounds. In the end, the use of haptics in education is bound only by our imagination.

"Blind people, especially those who are blind since birth, can't perceive depth so they don't read graphics well," said Brent Gillespie, assistant professor of mechanical engineering at the University of Michigan in Ann Arbor. "But you can motorize a mouse and then they can feel things on the screen and navigate a little more easily." Haptic researchers are also working on hardware and software that will enable people to feel fabric in great detail—right down to the grain of the thread and the bias. But, he said, mainstream commercial use of haptics for e-commerce is years away.
4.7. HAPTIC. HAPTIC INTERACTION WITH 3D-ULTRA SOUND DATA.

The initial focus on parental interaction with ultra sound allows us to introduce haptic technology into clinical environment in a way that has clear benefits today and allows the medical/diagnostic uses of haptic interaction with 3D ultrasonic sound to be more gradually explored.

The e-Touch SonoTM System:

The e-Touch SonoTM System is a turnkey hardware and software system that allows users to interactively feel and see 3D ultrasonic images. Sono also allows the 3D images to be interactively cleaned-up and exported for generation of 3D hardcopy or imagery.

Fig: The e-Touch SonoTM System

The system consist of a computer work station, a graphical display, a 3D touch interface device and the e-Touch SonoTM software. Sono can also be done on a laptop computer system.
5. CONCLUSION
Touch plays a key role when examining objects in the real world but until recently, it was not possible to use this realistically in the virtual environments and computer based displays. Now haptic technologies are available that let museums add this missing aspect back into their computer based exhibits to make them more realistic, useful and engaging. Now there is migration from software to hardware.

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