Haptic Interfaces

(ASSISTIVE REHABILITATIVES AND SOFTWARE TECHNOLOGIES)

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Abstract-
"HAPTICS"- A technology that adds the sense of touch to virtual environment. Haptic Interfaces allow the user to feel as well as to see virtual objects on a computer, and so we can give an illusion of touching surfaces, shaping virtual clay or moving objects around. The sensation of touch is the brain's most effective learning mechanism –more effective than seeing or hearing—which is why the new technology holds so much promise as a teaching tool. Haptic technology is like exploring the virtual world with a stick.

If you push the stick into a virtual balloon push back .The computer communicates sensations through a haptic interface –a stick, scalpel, racket or pen that is connected to force-exerting motors. In combination with a visual display, haptic technology can be used to train people for tasks requiring hand-eye coordination, such as surgery and space ship maneuvers'.

In this paper we explicate how sensors and actuators are used for tracking the position

And movement of the haptic device moved by the operator. We mention the different types of force rendering algorithms. Then, we move on to a few applications of Haptic Technology. Finally we conclude by mentioning a few future developments.

KEYWORDS: - haptic devices, haptic rendering, haptic treatment, future enhancement in haptic

1. WHAT IS HAPTICS?

Haptic refers to sensing and manipulation through touch. The word comes from the Greek 'haptesthai', meaning 'to touch'. The history of the haptic interface dates back to the 1950s, when a master-slave system was proposed by Goetz (1952). Haptic interfaces were established out of the field of teleportation, which was then employed in the remote manipulation of

Radioactive materials. The ultimate goal of the tele-operation system was

"Transparency". That is, a user interacting with the master device in a master-slave pair should not be

Able to distinguish between using the master controller and manipulating the actual tool itself.

Early Haptic interface systems were therefore developed purely for telerobotic applications.

2. WORKING OF HAPTIC DEVICES:

2.1 HAPTIC FEEDBACK:

Basic architecture for a virtual reality application incorporating visual, auditory, and haptic feedback.

• Simulation engine:

Responsible for computing the virtual environment's behavior over time.

• Visual, auditory, and haptic rendering algorithms:

Compute the virtual environment's graphic, sound, and force responses toward the user.

• Transducers:

Convert visual, audio, and force signals from the computer into a form the operator can perceive.

• Rendering:

Process by which desired sensory stimuli are imposed on the user to convey

Information about a virtual haptic object.

The human operator typically holds or wears the haptic interface device and perceives audiovisual feedback from audio (computer speakers, headphones, and so on) and visual displays (a computer screen or head-mounted display, for example). Audio and visual channels feature unidirectional information and energy flow (from the simulation engine towards the user) whereas, the Haptic modality exchanges information and energy in two directions, from and toward the user. This bi directionality is often referred to as the

Single most important feature of the haptic interaction modality.

Thus this mainly deals of the working of the haptic devices in the terms of the interfacing devices.

HAPTIC RENDERING:

An avatar is the virtual representation of the haptic interface through which the user physically interacts with the virtual environment.

Haptic-rendering algorithms compute the correct interaction forces between the haptic interface representation inside the virtual environment and the virtual objects populating the environment. Moreover, haptic rendering algorithms ensure that the haptic device correctly renders.

Such forces on the human operator.

1.) Collision-detection algorithms detect collisions between objects and avatars in the virtual environment and yield information about where, when, and ideally to what extent collisions (penetrations, indentations, contact area, and so on) have occurred.

2.) Force-response algorithms compute the interaction force between avatars and virtual objects. When a collision is detected. This force approximates as closely as possible the contact forces that

Would normally arise during contact between real objects. Hardware limitations prevent haptic devices from applying the exact force computed by the force response algorithms to the user.

3.) Control algorithms command the haptic device in such a way that minimizes the error between ideal and applicable forces. The discrete-time nature of the Haptic- rendering algorithms often makes this difficult.

The force response algorithms' return values are the actual force and torque vectors that will be commanded to the haptic device.

Existing Haptic rendering techniques are currently based upon two main principles: "point interaction" or "ray-based".

In point interactions, a single point, usually the distal point of a probe, thimble or stylus employed for direct interaction with the user, is employed in the simulation of collisions. The point penetrates the virtual objects, and the depth of indentation is calculated between the current point and a point on the surface of the object. The intersection point between the ray and the surface of the simulated object.

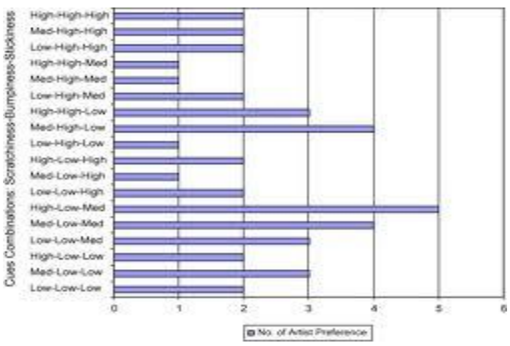
Computing contact-response forces:
Humans perceive contact with real objects through sensors (mechanoreceptors) located in their skin, joints, tendons, and muscles. We make a simple distinction between the information these two types of sensors can acquire.

1. Tactile information refers to the information acquired through sensors in the skin with particular reference to the spatial distribution of pressure, or more generally, tractions, across the contact area. To handle flexible materials like fabric and paper, we sense the pressure variation across the fingertip. Tactile sensing is also the basis of complex perceptual tasks like medical palpation,
Where physicians locate hidden anatomical structures and evaluate tissue properties using their hands.

2. Kinesthetic information refers to the information acquired through the sensors in the joints.

Controlling forces delivered through haptic interfaces:

Once such forces have been computed, they must be applied to the user. Limitations of Haptic device technology, however, have sometimes made applying the force's exact value as computed by force-rendering algorithms impossible. They are as follows:
• Haptic interfaces can only exert forces with limited magnitude and not equally well in all directions
• Haptic devices aren't ideal force transducers. An ideal haptic device would render zero impedance when simulating movement in free space, and any finite impedance when simulating contact with an object featuring such impedance characteristics. The friction, inertia, and backlash present in most Haptic devices prevent them from meeting this ideal.
• A third issue is that Haptic-rendering algorithms operate in discrete time whereas users
As shown in below graph



3. HAPTIC DEVICES:

TYPES OF HAPTIC DEVICES

There are two main types of haptic devices:
• Devices that allow users to touch and manipulate 3-dimentional virtual objects.
• Devices that allow users to "feel" textures of 2-dementional objects.

Another distinction between haptic interface devices is their intrinsic mechanical behavior.

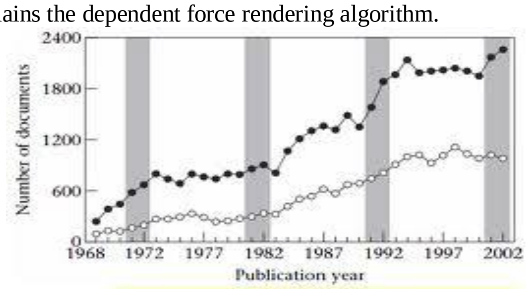
LOGITECH WINGMAN FORCE FEEDBACK MOUSE

It is attached to a base that replaces the mouse mat and contains the motors used to provide forces back to the user.

Interface use is to aid computer users who are blind or visually disabled; or who tactile/Kinesthetic learners are 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.

3.1GEOMETRY DEPENDENT-FORCE RENDERING ALGORITHM

The first type of force-rendering algorithms aspires to recreate the force interaction a user would feel when touching a frictionless and texture fewer objects. Force-rendering algorithms are also grouped by the number of Degrees-of-freedom (DOF) necessary to describe the interaction force being rendered. This in turns explains the dependent force rendering algorithm.



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3.2SURFACE PROPERTY DEPENDENT FORCE RENDERING ALGORITHM

All real surfaces contain tiny irregularities or indentations. Higher accuracy, however, sacrifices speed, a critical factor in real-time applications. Any choice of modeling technique must consider this trade off. Keeping this trade-off in mind, researchers have developed more accurate Haptic-rendering algorithms for friction.

In computer graphics, texture mapping adds realism to computer-generated scenes by projecting a bitmap image onto surfaces being rendered. The same can be done haptically.

3.3PHANTOM:

The PHANTOM provides single point, 3D force feedback to the user via a stylus (or thimble) attached to a moveable arm. The position of the stylus point/fingertip is tracked, and resistive force is applied to it when the device comes into 'contact' with the virtual model, providing accurate, ground referenced force feedback. The physical working space is determined by the extent of the arm, and a number of models are available to suit different user requirements.

The phantom system is controlled by three direct current (DC) motors that have sensors and encoders attached to them. The number of motors corresponds to the number of degrees of freedom a particular phantom system has, although most systems produced have 3 motors.

CYBER GLOVE:

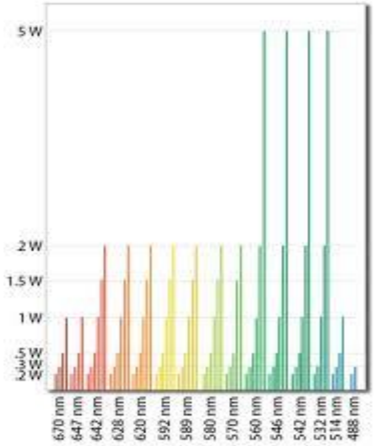
Cyber Glove can sense the position and movement of the fingers and wrist. The basic Cyber Glove system includes one

Cyber Glove, its instrumentation unit, serial cable to connect to your host computer, and an executable version of Virtual Hand graphic hand model display and calibration software. The Cyber Glove has a software programmable switch and LED on the Wristband to permit the system software developer to provide Cyber Glove wearer with additional input/output capability. With Appropriate software, it can be used to interact with systems using hand gestures, and when combined with a tracking device to determine the hand's position in space, it can be used to manipulate Virtual objects.

4. APPLICATION

MEDICAL TRAINING APPLICATION

Such training systems use the Phantom's force Display capabilities to let medical trainees experience and learn the subtle and complex. Physical interactions needed to become skillful in their art. A computer based teaching tool has been developed using haptic technology to train veterinary students to examine the bovine reproductive tract, simulating rectal palpation. The student receives touch feedback from a haptic device while palpating virtual objects. The teacher can visualize the student's actions on a screen and give training and guidance.



4.1COLLISION DETECTION:

Collision detection is a fundamental problem in computer animation, physically-based modeling, geometric modeling, and robotics. In these fields, it is often necessary to compute distances between objects or find intersection regions.

In particular, I have investigated the computation of global and local penetration depth, distance fields, and multiresolution hierarchies for perceptually-driven fast collision detection.

These proximity queries have been applied to Haptic rendering and rigid this has been used for the body dynamic rendering and this investigations are proved at the analogy of the global and depth in the fields.

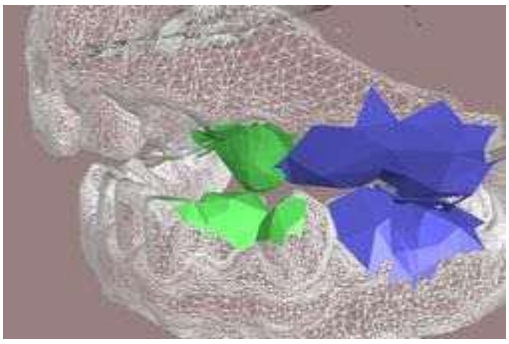

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Fig 1: Collision Detection

5. MINIMALLY INVASIVE SURGERY

The main goal of this project is to measure forces and torques exerted by the surgeon during minimally-invasive surgery in order to optimize haptic feedback. A standard da Vinci tool affixed with a 6 DOF force/torque transducer will be used to perform basic surgical procedures and the forces applied by the tool will be recorded and analyzed. This will help determine in which degrees of freedom forces are most commonly applied.

Fig 2: **Standard da Vinci tool**

6. STROKE PATIENTS:

Stroke patients who face months of tedious rehabilitation to regain the use of impaired limbs may benefit from new haptic systems -- interfaces that add the sense of touch to virtual computer environments -- in development at the University of Southern California's Integrated Media Systems Centre (IMSC).

The new systems, being designed by an interdisciplinary team of researchers from the Viterbi School of Engineering and the Annenberg School for Communication, are challenging stroke patients to grasp, pinch,

Squeeze, throw and push their way to recovery.

Fig 4: Integrated Media Systems Centre

7. PROSTATE CANCER:

Prostate cancer is the third leading cause of death among American men, resulting in approximately 31,000 deaths annually. A common treatment method is to insert needles into the prostate to distribute radioactive seeds, destroying the cancerous tissue. This procedure is known as brachytherapy.

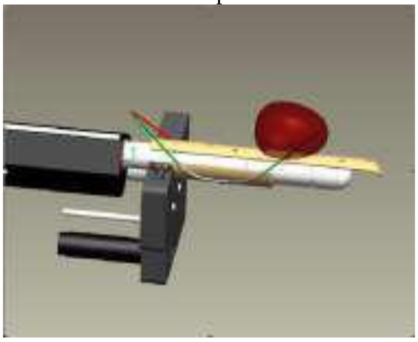


Fig 3: Brachytherapy.

The prostate itself and the surrounding organs are all soft tissue. Tissue deformation makes it difficult to distribute the seeds as planned. In our research we have developed a device to minimize this deformation, improving brachytherapy by increasing the seed distribution accuracy.

8. REMOVAL OF LEG SEGMENT:

Surgeons complete removal of the lens segments in the same way: by holding them at the mouth of the laser/aspiration probe using vacuum and firing the laser to fragment them for aspiration. However, several surgeons have developed different techniques for nuclear disassembly. These include: Nuclear prechop. This technique, developed by Dr. Dodick himself, involves inserting two Dodick-Kallman Choppers under the anterior capsulotomy, 180? Apart and out to the equator of the Lens. The surgeon rotates the choppers downward and draws them towards each other, bisecting.

Settings: Aspiration: 275 to 300 mmHg; Air infusion: 80 to 100 mmHg; Laser pulses: 1 Hz.

Wehner back cracking. This technique, developed by Wolfram Wehner, M.D., uses the Wehner Spoon, an irrigating hand piece that resembles a shovel at the tip. The surgeon lifts the nucleus using the laser/aspiration probe, inserts the Wehner spoon underneath, and uses the two probes to backcrack the nucleus. The Wehner spoon provides support during removal of the lens segments.

Settings: Aspiration: 275 mmHg; Air infusion: 95 mmHg; Laser pulses: 3 Hz**.**

9. INTELLIGENT MACHINES:

The Centre for Intelligent Machines is an inter-departmental inter-faculty research group which was formed to facilitate and promote research on intelligent systems. Intelligent systems and machines are capable of adapting their behavior by sensing and interpreting their environment, making decisions and plans, and then carrying out those plans using physical actions. The mission of CIM is to excel in the field of intelligent machines.

10. GAMING TECHNOLOGY

Flight Simulations: Motors and actuators push, pull, and shake the flight yoke, throttle, rudder pedals, and cockpit shell, replicating all the tactile and kinesthetic cues of real flight. Some examples of the simulator's haptic capabilities include resistance in the yoke from pulling out of a hard dive, the shaking caused by stalls, and the bumps felt when rolling down concrete runway.

Today, all major video consoles have built-in tactile feedback capability. Various sports games, for example, let you feel bone-crushing tackles or the different vibrations caused by skateboarding over plywood, asphalt, and concrete. Altogether, more than 500 games use force
Feedback and more than 20 peripheral manufacturers now market in excess of 100 haptic hardware products for gaming.

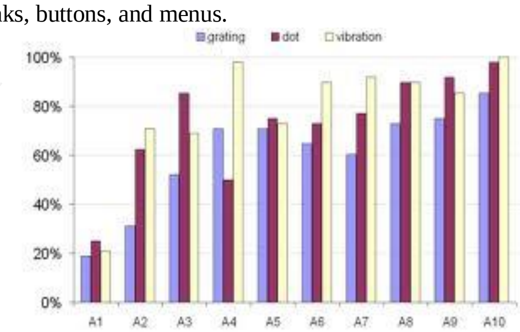
MOBILE PHONES Samsung has made a phone, which vibrates, differently for different callers. Motorola too has made haptic phones.

CARS: For the past two model years, the BMW 7 series has contained the drive (based on Immersion Corp's technology), which uses a small wheel on the console to give Haptic feedback so the driver can control the peripherals like stereo, heating, navigation system etc. through menus on a video screen.

11. FUTURE ENHANCEMENTS

Force Feedback Provided In Web Pages

This underlying technology automatically assigns "generic touch sensations" to common Web page objects, such as hyperlinks, buttons, and menus.



12. VIRTUAL BRAILLE DISPLAY

The Virtual Braille Display (VBD) project was created to investigate the possibility of using the lateral skin stretch technology of the Stress tactile display for Braille. The project was initially conducted at Visualize Inc. and is now being continued in McGill's Haptic Laboratory.

Fig 5: Virtual Braille Display

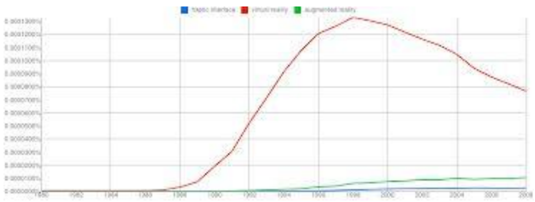
HAPTIC TORCH FOR BLIND

The device, housed in a torch, detects the distance to objects, while a turning dial on which the user puts his thumb indicates the changing distance to an object. The pictured device was tested and found to be a useful tool.

13. TACTILE SLIP DISPLAY

Human fingers are able to manipulate delicate objects without either dropping or breaking them, but lose this ability to a certain degree when using a tele-operated system. One reason for this is that human fingers are equipped with sensors that tell us when our fingerprints at the edge of the contact area start to come off the object we are holding, allowing us to apply the minimum force necessary to hold the object.

While several other researchers have built synthetic skins for their robot fingers that work in a similar way to human fingerprints, a tactile haptic device is needed to display these sensations to a human using a tele-operated system. For this purpose we have designed the 2 degree of freedom Haptic Slip Display.



14. CONCLUSION:

Haptic is the future for online computing and e-commerce, it will enhance the shopper experience and help online shopper to feel the merchandise without leave their home. Because of the increasing applications of haptic, the cost of the haptic devices will drop in future.

This will be one of the major reasons for commercializing haptic. With many new Haptic devices being sold to industrial companies, haptic will soon be a part of a person's normal computer interaction.

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