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HAPTICS TAKES HOLD

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Haptics!!.....What's That??

• Derived from the Greek verb "haptesthai" meaning "of or relating to the sense of touch."

• Science of manual sensing and manipulation of surrounding objects and environments through the sense of touch.

• "Touching" of objects - could be by man, machine, or both. Objects and environments - can be real, virtual, or both.

• Multidisciplinary
  - Engineers - design devices
  - Mathematicians – design efficient algorithms
  - Psychologists – how the sense of touch really works

Why Haptics?

- Limitations of what can be achieved by sight and sound.

- Haptics is based on the way the brain processes information.

- Information based on physical sensations = faster responses.

- Possibilities infinite!!! … Imagine
  - ➢ Drivers being alerted by a tap on their shoulder when another car is riding on their blind spot.
  - ➢ Feel the fabric of a piece of clothing before buying it on the Internet.

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Haptics Subareas

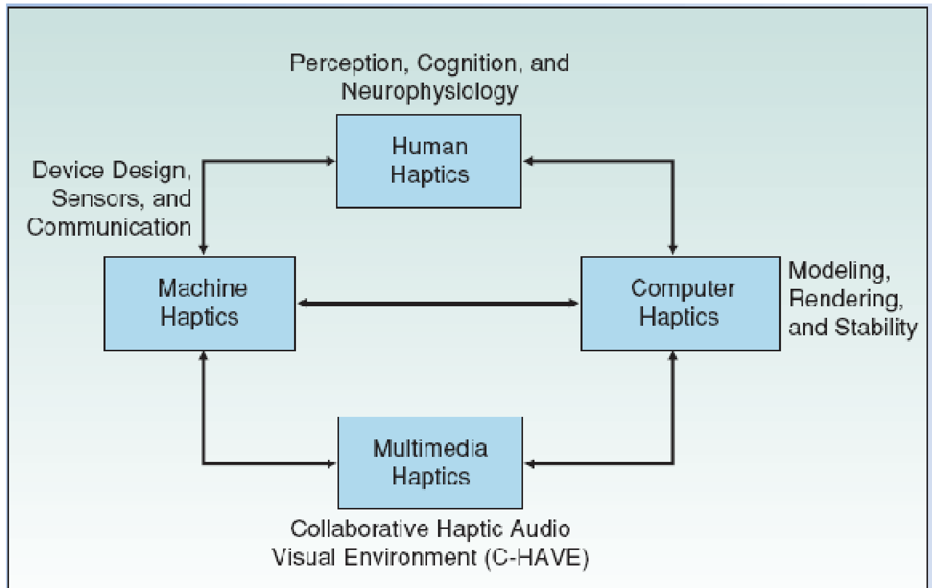


Fig. 1. Interdisciplinary haptic research branches.

- **Human Haptics:** study of human sensorimotor loop and human perception of the sense of touch.
- **Machine Haptics:** designing, constructing, and developing mechanical devices that replace or augment human touch.
- **Computer Haptics:** develop algorithms and software to generate and render the “touch” of virtual environments and objects, just as computer graphics generate and render visual images. (ex. 3DSMax)
- **Multimedia Haptics:** integrating and coordinating the presentation of haptic interface data, and other types of media (audio-visual), in the multimedia application. (ex. Games)

Architecture of a Collaborative Haptic Audio Visual Environment

Simulation engine: Computes virtual environment behavior over time
Visual & Auditory Modules: rendering algorithms and transducers that convert media signals from the virtual environment into a form the human operator can perceive.
Network Interface Module: connects the local haptic system to the collaborative networked environment (telehaptics).
Collaborative Virtual Environment: shared virtual world (computer nodes)that supports collaborative manipulation of objects in the virtual environment

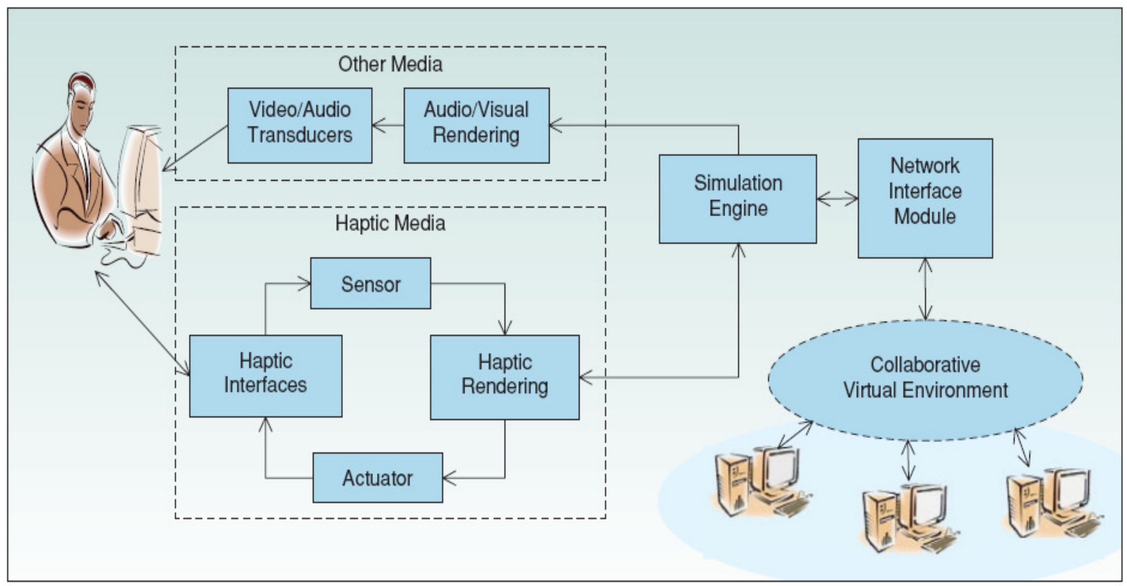


Fig. 2. Virtual reality system with emphasis on haptic modality.

Haptic Interfaces/Devices

- Small robots that exchange mechanical energy with users

- **Hardware** : Consist of one or more input transducers (sensors to measure position and/or forces acting on part of human body) and at least one output transducer (displays the position and forces to user)

- Two major features characterize haptic devices
  - Degree of freedom: number of axes around which the haptic device can exert a force.
  - Haptic refresh rate: maximum speed at which the device can generate forces to the user. Must be at least 1KHz to create a smooth illusion of haptic interaction.

Haptic Rendering

Refers to a group of algorithms used to compute and generate forces in response to interactions between haptic interface avatar in the virtual environment and virtual objects in the environment.

• Avatar – a virtual representation of the haptic interface, position controlled by user
•Interaction between avatars and objects is bidirectional, i.e. energy flow both from & toward user.
•Collision detection – ability to find point(s) of contact.
•Force response algorithm – on collision, interaction forces between avatar & virtual objects calculated, used to generate sensations
•Computed forces help represent stiffness of the object, damping, friction, surface texture, etc.
•All algorithms must repeat computations at a rate of 1KHz or higher to avoid instability.

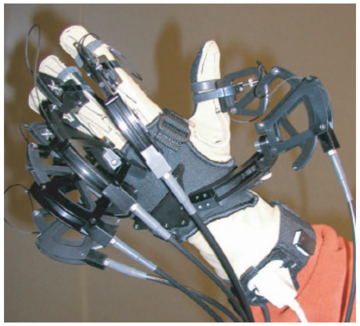
Applications

•“Sensing Chair”, made by Purdue - potentially useful aid to rehabilitation (wheelchairs), cockpits and gaming.

•“Origami desk”, made by MIT - users create origami structures through sensors embedded in the paper.

•“Sensing vest”, made by MIT being tested by NASA in near-zero gravity environments in planes to help pilots. Also being used in gaming.

“Glove” developed by Tokyo University – allows wearer to "crush" objects by clenching their fists.



• Japanese Project: robotic arm to enable users to "feel" resistance between two surfaces whose boundaries couldn't normally be sensed –ex. boundary between oil and water.

•Disney Theme Parks: Alien Encounter - visitors spooked into believing something's right behind them by a computerized puff of air on their backs.

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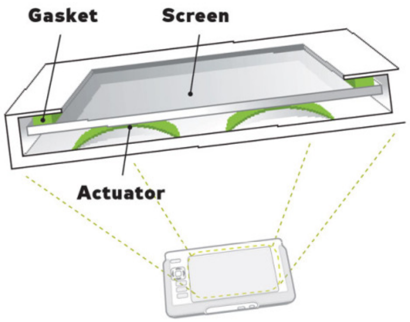
Applications contd..

•Rumbling video-game controllers (ex. Novint Falcon)and buzzers that alert you to a cellphone call.

• Touchscreens - and touch-sensitive surfaces ex Neonode N2 & Nokia Haptikos Web Pad (piezo actuators below the screen).



•TN Games 3rd Space vest and HXT helmet -with a built-in air compressor that punches gamers in the chest and head with up to 25 psi of pressure when they get shot by onscreen bullets

•Surgical simulations, telesurgery systems, rehabilitation and medical training.

• Haptics in biometrics

Current Challenges

- High cost involved.

- Large weight and size of haptic devices (especially wearable ones).

- High bandwidth requirement. Need for better haptic compression algorithms.

- Network latency must be extremely low.

- High stability and synchronization requirements.

- Haptic devices need update rates of at least 1KHz, else leads to vibration and instability.