

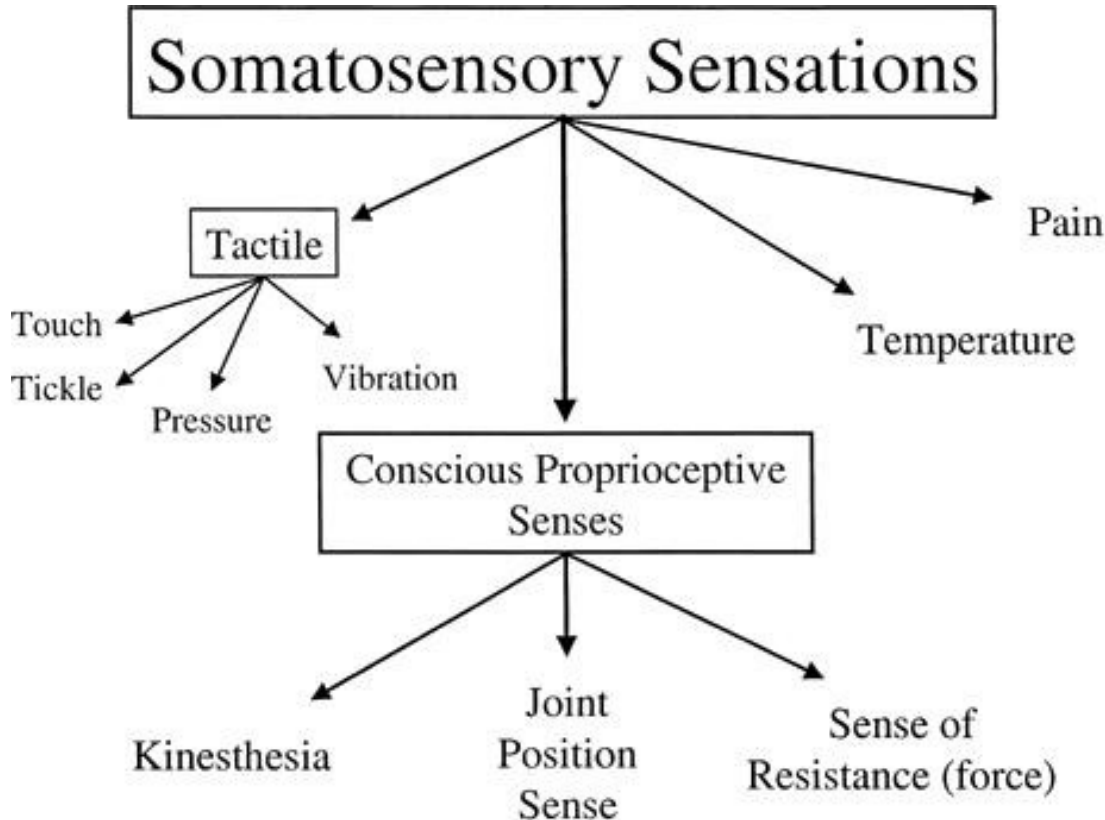
Haptics for Virtual Reality

April 3rd 2009

MAE 574, Virtual Reality Applications and
Research

Instructor: Govindarajan Srimathveeravalli

Interoceptive (as opposed to exteroception)



First sensation to develop in fetus!

Sensation of Self = Kinesthetics + Vision + Vestibular

How does it relate to Immersion?

- What is immersion?

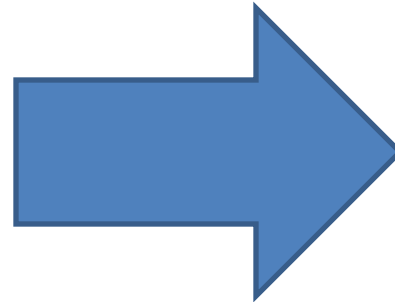
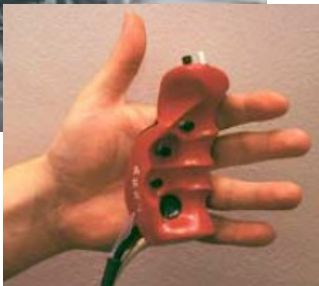
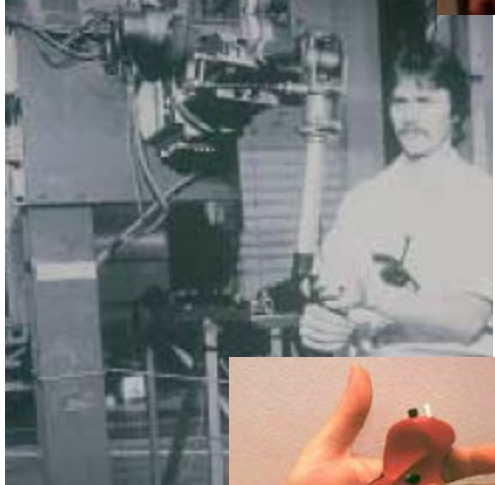
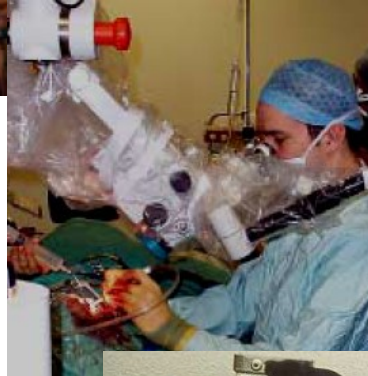
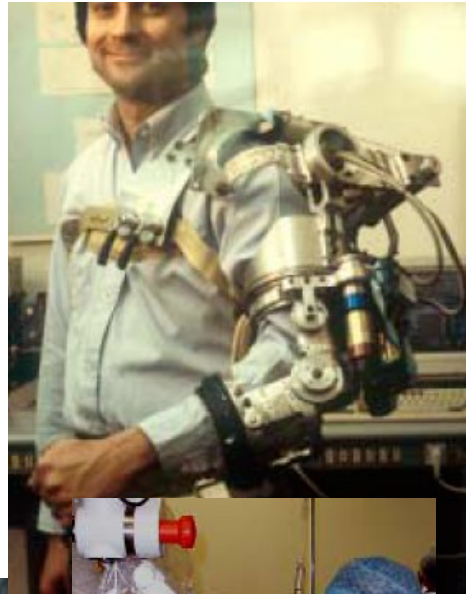
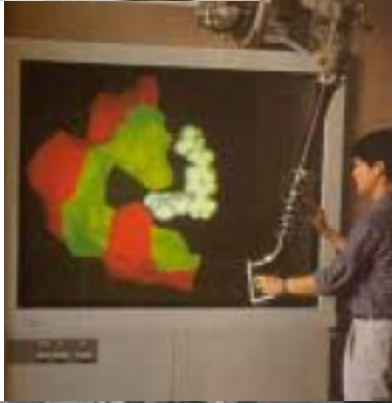
Why can't everything be done with just graphics and sensors?

-Lack of sensory feedback
-Visual – motor conflicts

Image: courtesy Riemann et al.

Haptics = Study/Science/Creation/Feedback for Somatosensory perception?

History and Current Perception of Haptics (Images courtesy: Stone)



Proprioception – How does it work?

- Case study: Waterman
 - Nervous system attacked by virus
 - Could perform motor control, but no feedback
 - What happens?
 - What is the substitution for this sense?
- Nerves work with proprioceptors in muscles – muscle spindles and the golgi tendon
 - Greater density in muscles used for fine movements
- The “phantom limb” phenomenon
 - The neural matrix inside the brain

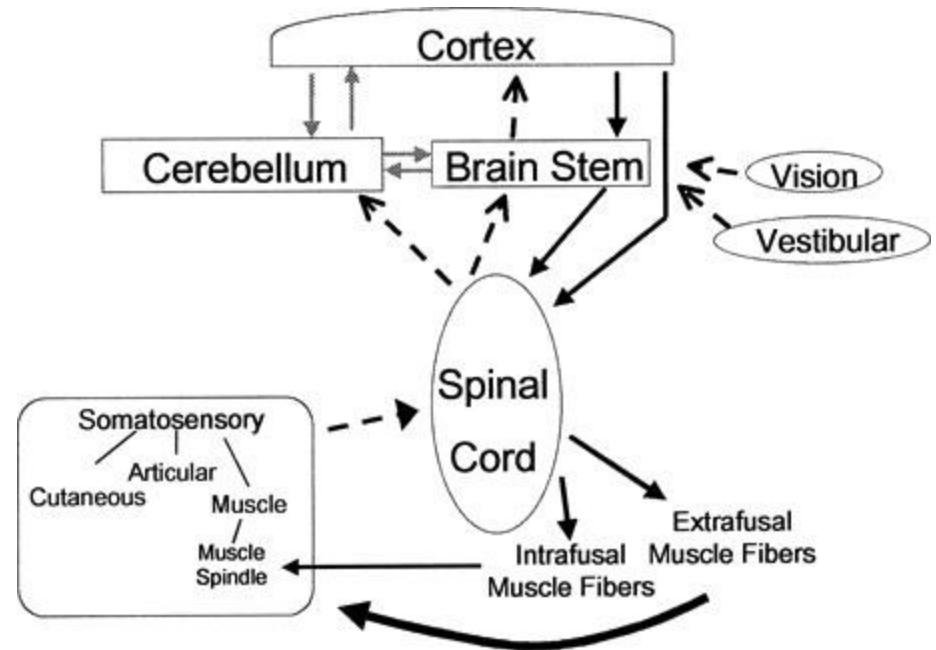
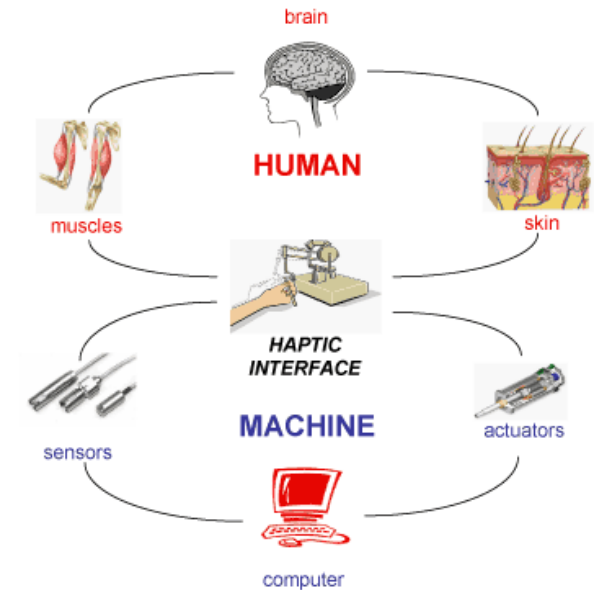
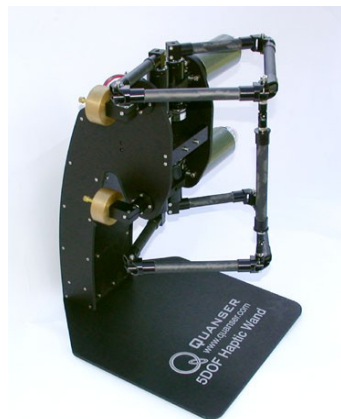
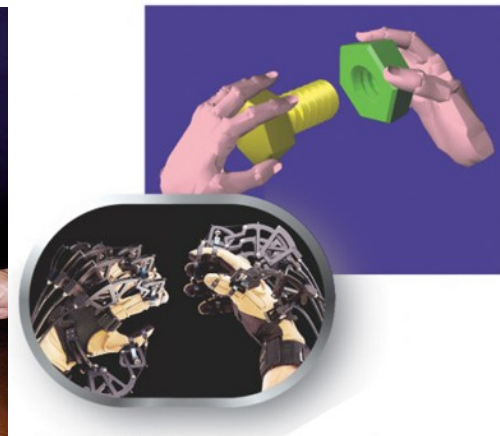
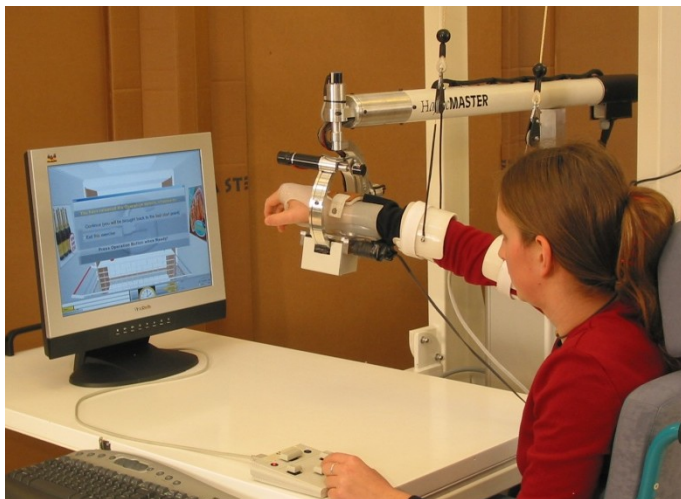
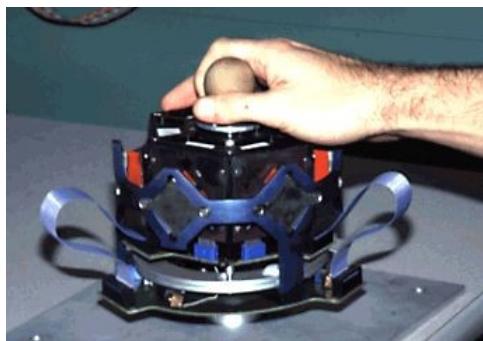


Image: courtesy Riemann et al.

Proprioception – Input

- What can it perceive?
 - Joint positions
 - Resistive forces
 - Controlled joint movements (without visual assistance)
- What needs to be input
 - How to provide forces? (every joint/limb region can sense forces)
 - How much to provide? (force sensing capacity varies from child – adult, from limb to limb)
 - How to constrain limb movements? (see above)
 - ?
- Options for actuation (and constraint)
 - Articulated
 - Serial
 - Parallel
 - Pneumatic
 - Electromagnetic
 - Passive (Resistive)
 - Active (Reactive)



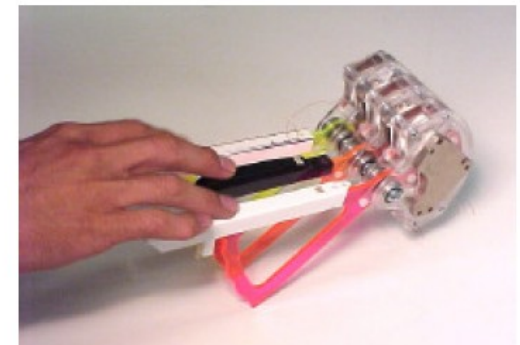
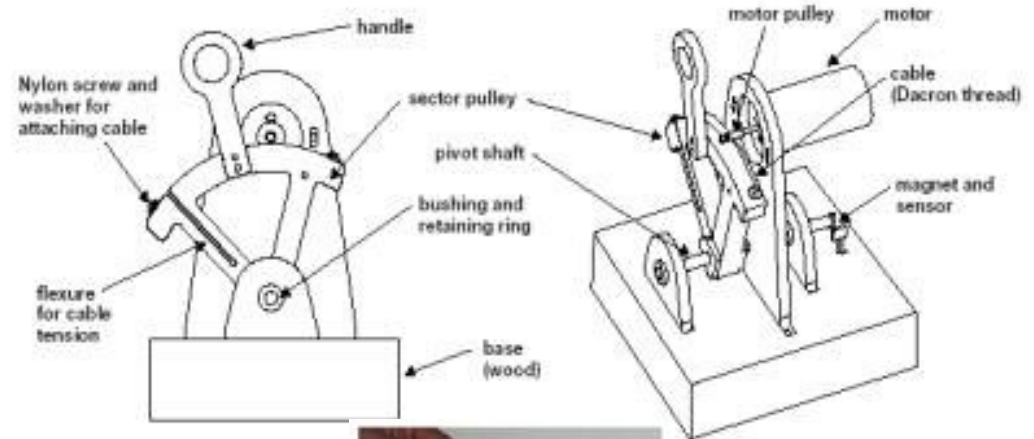


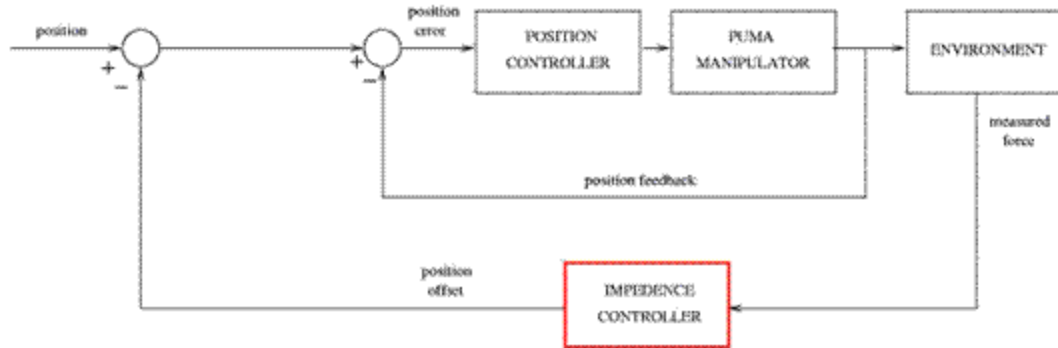
All these are the equivalent of the mouse and keyboard!!

Types: (Courtesy: Robles-delaTorres)

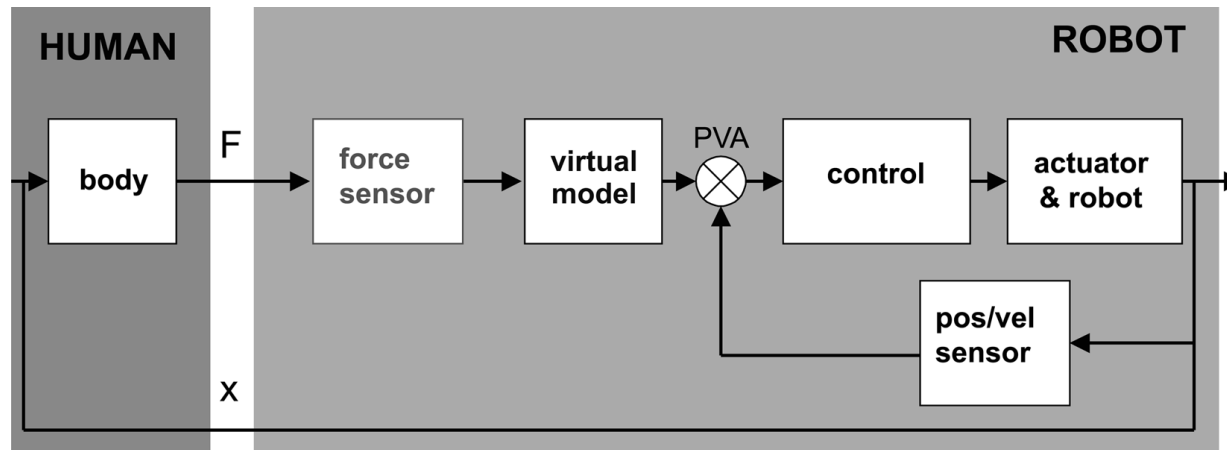
1. Keyboard
 2. Exoskeletons
 3. Desktop devices
 4. Grasping
 5. Point interaction
 6. High power devices
 7. Mice
 8. Joystick
 9. Pantographs (Planar)
 10. Rotary controllers
- More ...

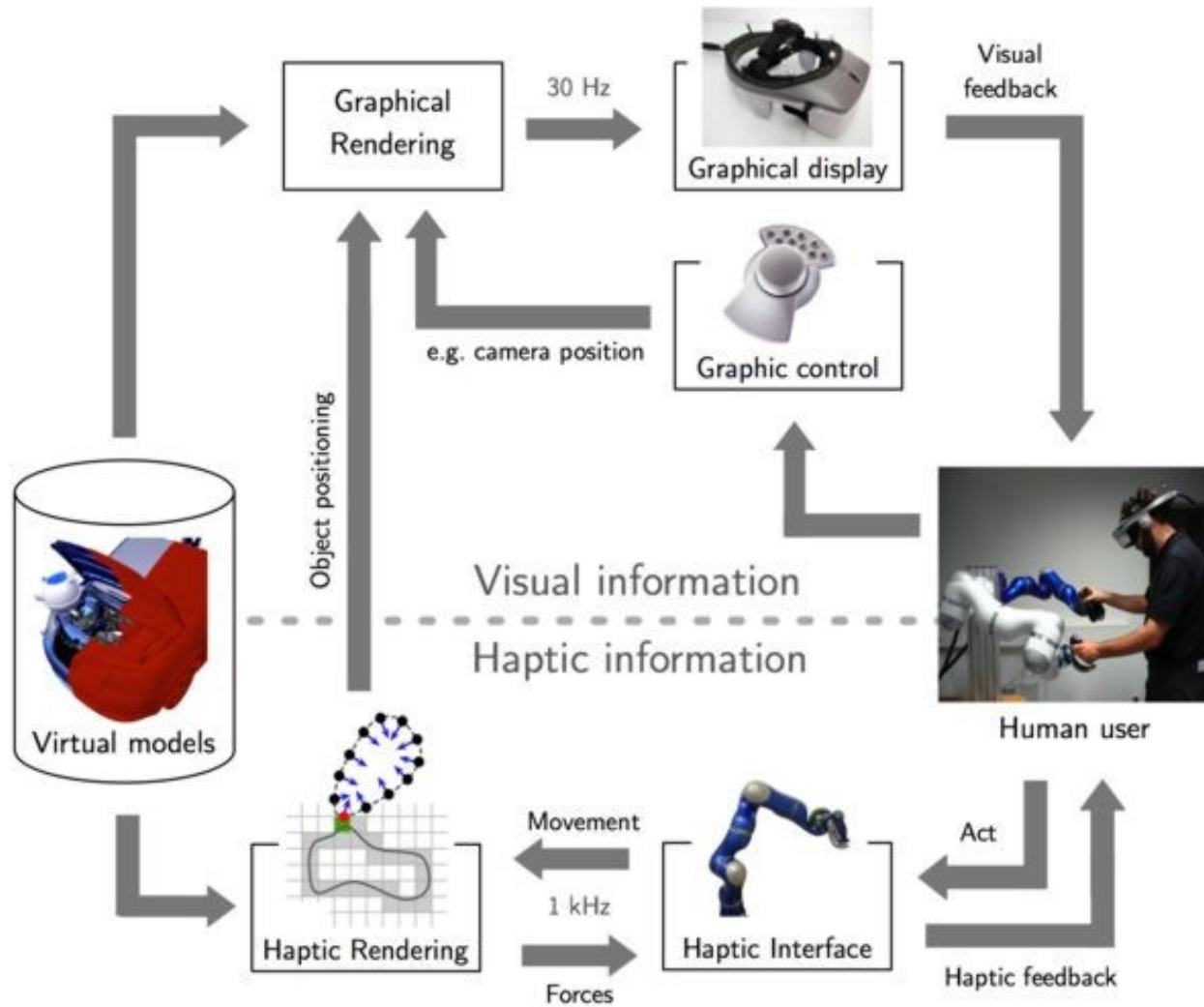
The Sn(H)aptic Paddle, courtesy: Okamura, Gillespie and O'Malley



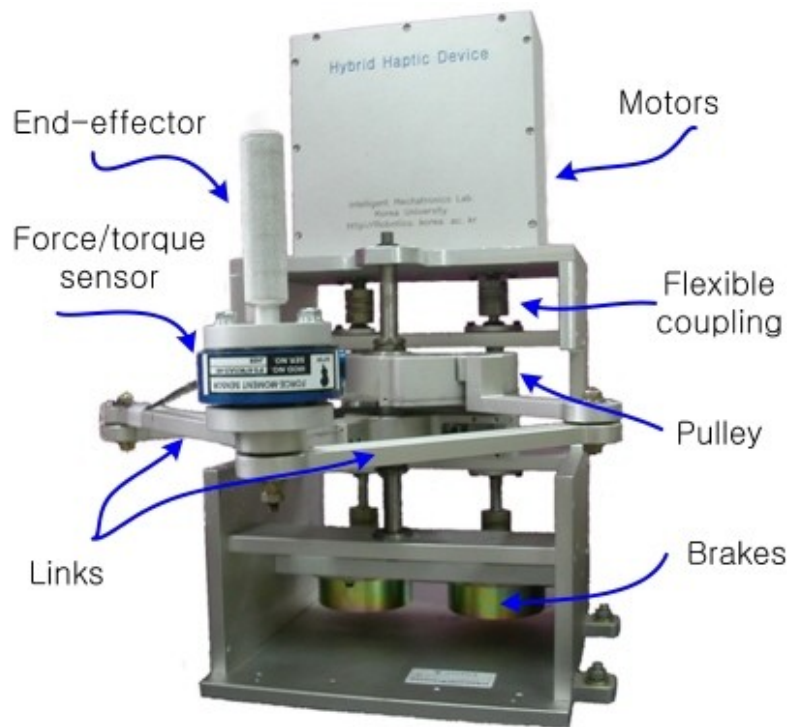


Impedance vs Admittance control



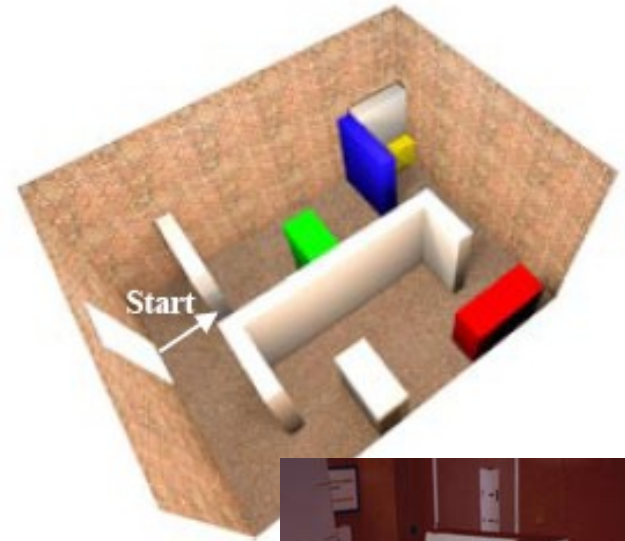


Passive haptic devices



	Advantages	Disadvantages
Active actuators	<ul style="list-style-type: none"> Torque generation in all directions Fast response Good linearity 	<ul style="list-style-type: none"> Active behavior → unstable system Poor ratio of torque-to-mass
Passive actuators	<ul style="list-style-type: none"> Stable force display → High stiffness Safe operation Good ratio of torque-to-mass 	<ul style="list-style-type: none"> Torque generation in limited range (only against their motion or the external torques) Poor linearity Relatively slow response

Passive haptics, images courtesy: Insko



Some Challenges

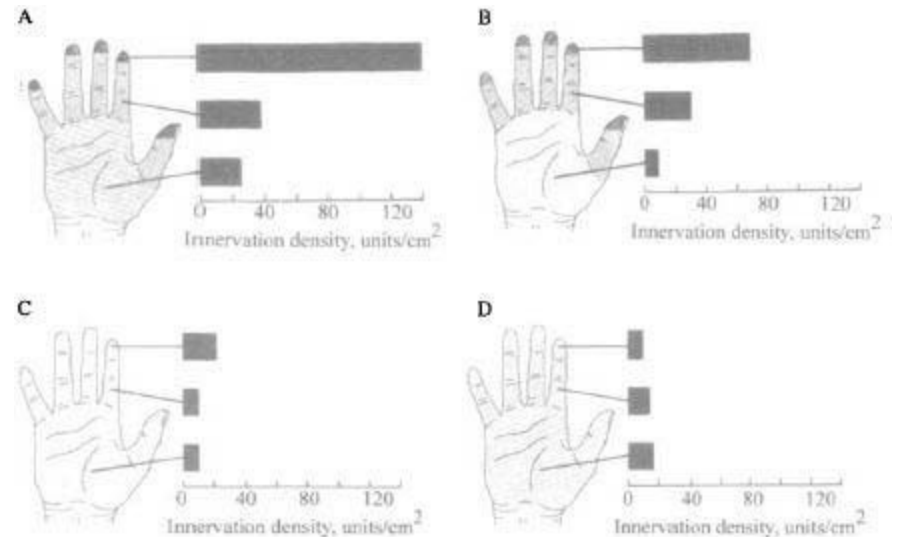
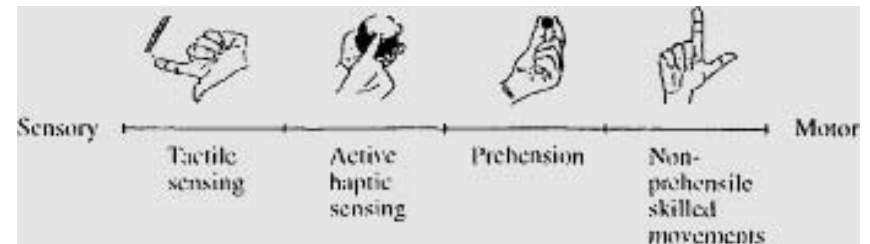
- Provide feedback at 1000 Hz (human hand can perceive at that rate)
- Haptic/Graphic loop calculations and interactions
- Stability devices

Visuo motor interaction

- Haptic space is “calibrated” by vision
- Often, when conflict occurs we depend on vision
- BUT, in absence of vision, haptic modality takes precedence
- Also, one can do pseudo-haptic feedback (Lecuyer)
 - By simulating the graphics right and syncing with the input device, the brain “perceives” haptic feedback
 - Tested for friction, stiffness and textures
- Sensory substitution

From Proprioception to Tactile behavior

- Tactile feedback more difficult for a number of reasons
 - Hand has a variety of nerve endings
 - Nerve ending density varies vastly
 - Types of forces experienced by the hands can be very broad
- Types of sensation
 - Pressure
 - Tapping
 - Rubbing
 - Tracing
 - Caress
 - Vibration



Images courtesy: Jones et al.

Mechanoreceptors in the Skin

FA

Meissner corpuscles

- pressure change
- rough texture
- vibrotactile patterns
- slip detection

Pacinian corpuscles

- vibration (250 Hz)
- fine texture
- almost no spatial info

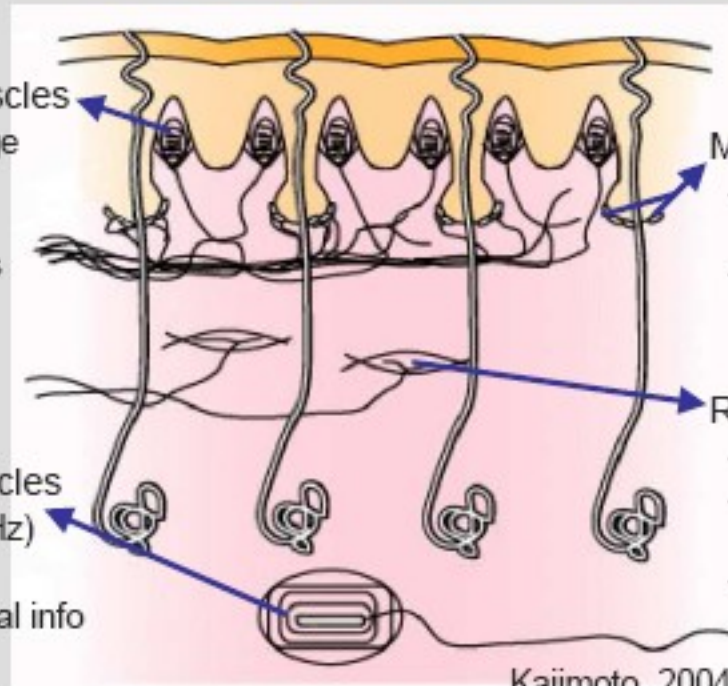
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Merkel disks

- small scale shape
- finest details (e.g. Braille)

Ruffini endings

- warmth
- direction of stretch
- in glabrous skin??



Kajimoto, 2004

Haptic Rendering Workshop, Eurohaptics

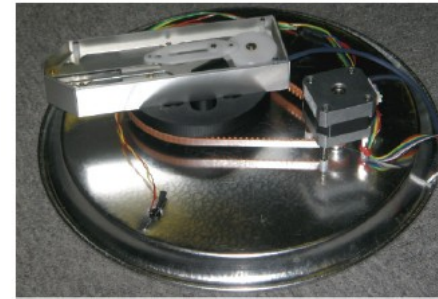
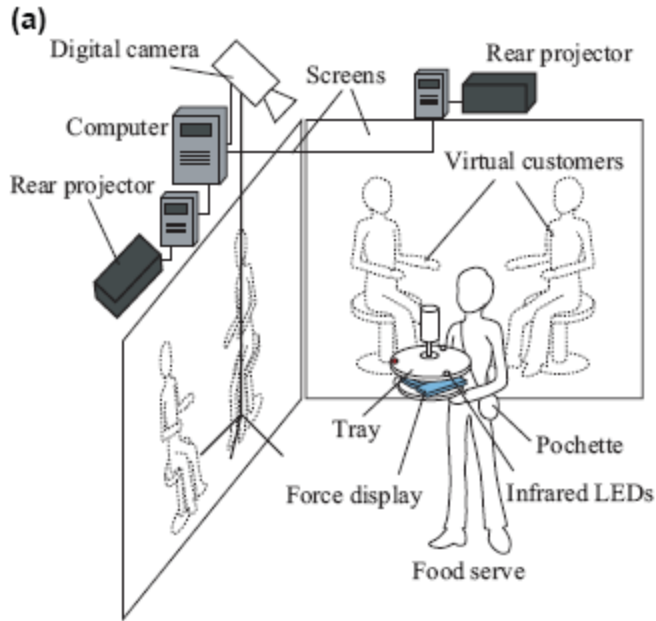
Madrid

10-06-2008

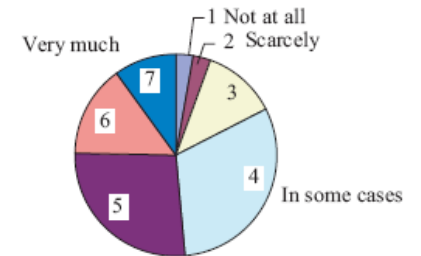


Image courtesy: Goethal et al

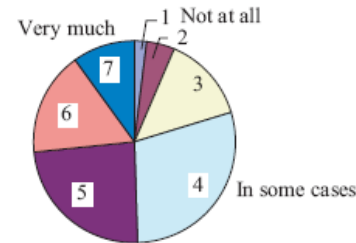
Amemiya et al. : Using acceleration for guidance



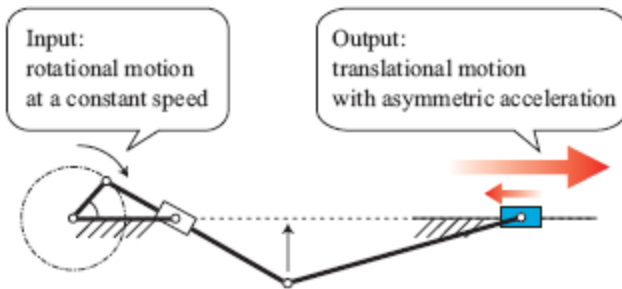
Q1: Did you experience pulled or pushed force sensation? Q2: Did you find a directional cue?



Q3: Was it intuitive to present directional information?



Q4: Do you think that haptic sensations are necessary for interactive systems?



Jones et al. : Haptic Vest

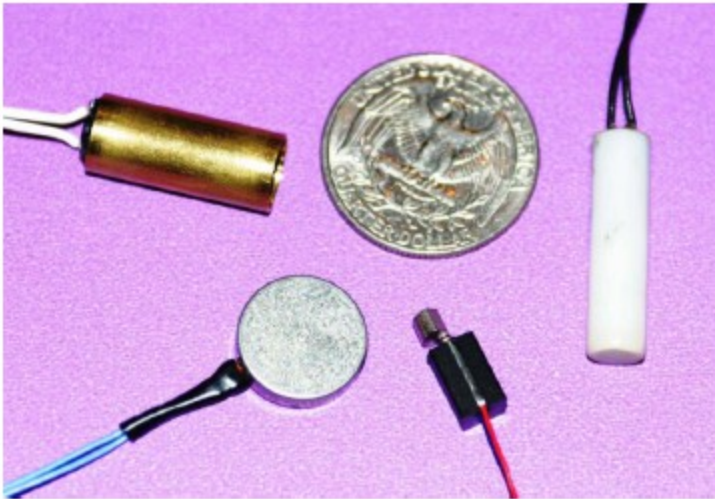


Figure 1. Vibrotactile actuators. From the upper left corner they are in a counter-clockwise direction: the MIT factor, pancake motor, vibration motor and Rototactor.

