Haptics: Concepts, Interface Design and Rendering[1]

Introductory Concepts

CS 277 – Experimental Haptics

Tues & Thurs 11am – 12:15

Gates B02

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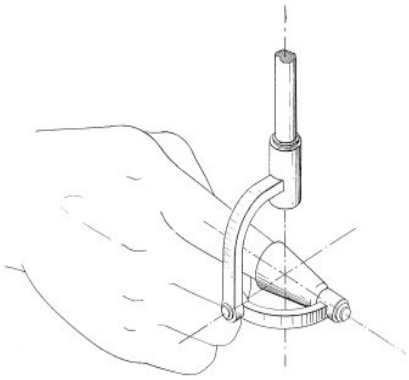
Course Information: http://cs277.stanford.edu

Haptic Interfaces



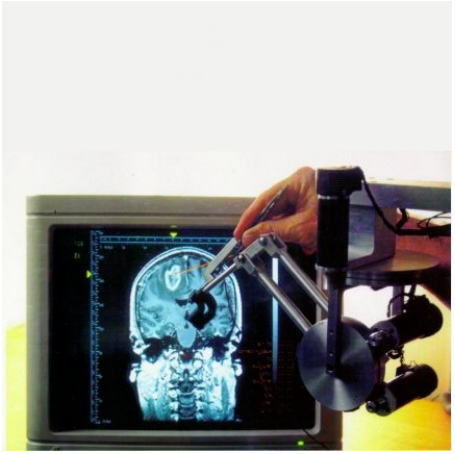
PHANTOM / SENSABLE TECHNOLOGIES

OMEGA / FORCE DIMENSION

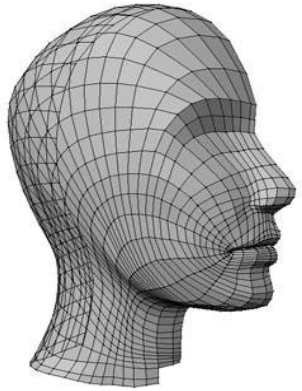
- Enable physical interaction with simulated objects
- Exploit point contact model
- Require
  - good dynamic range & bandwidth
  - Low inertia, low friction
  - Transparency...

CYBERGLOVE / IMMERSION

Haptic Rendering



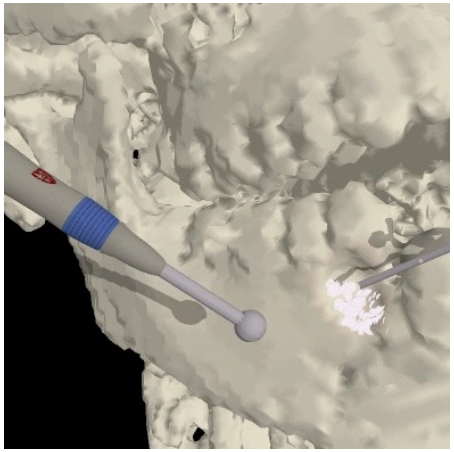
Potential Functions



Polyhedral Surfaces

$S(x,y,z) = (2 x^2 + y^2 + z^2 - 1)^3 - (0.1x^2 + y^2) z^3$

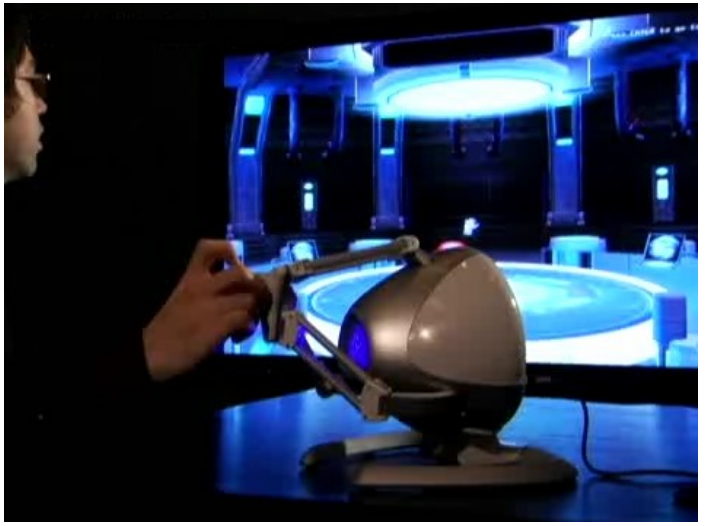
Implicit Surfaces



Volume Representations

Applications

CAD / SENSABLE TECHNOLOGIES

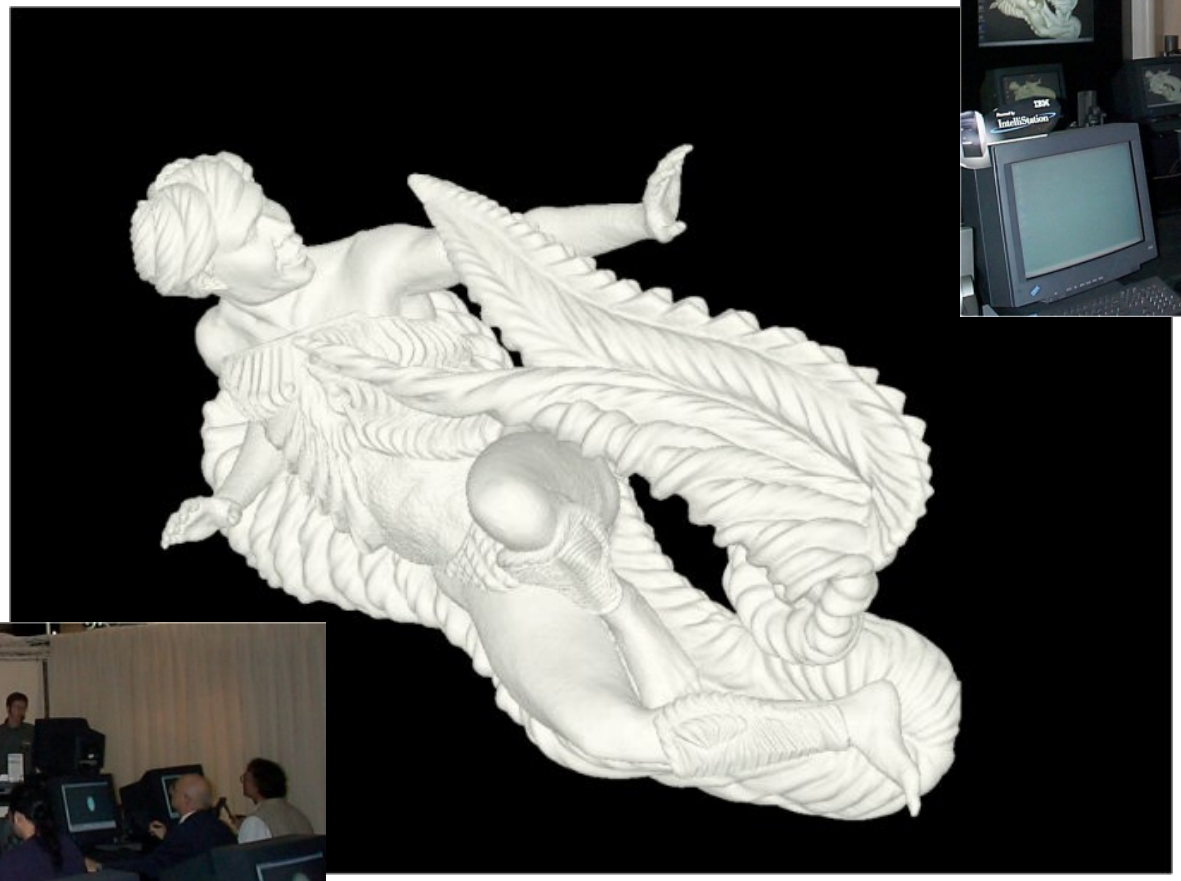


ENTERTAINMENT / NOVINT TECHNOLOGIES

MEDICAL / HANSEN MEDICAL

MEDICAL / PHILIPS

Collaborative Haptics & Training



Content of the course

- Human haptics
- Psychophysics
- Haptic interfaces
- Haptic rendering
- Dynamic models & simulation
- Applications
- Paper presentations

Haptic Interfaces

What is haptics?

- Physical interaction via touch
- Uniquely bi-lateral sensory modality
- Touching and interacting with real, virtual and remote environments

Why is it interesting and important?

- Primal
- Intuitive
- Pervasive
- Expressive
- Unexplored….

According to Webster

Main Entry: hap·tic
Pronunciation: 'hap-tik
Function: adjective
Etymology: International Scientific Vocabulary,
from Greek haptesthai to touch
Date: circa 1890
1 : relating to or based on the sense of touch
2 : characterized by a predilection for the sense of touch <a haptic person>

Merriam-Webster, Incorporated, http://www.m-w.com/cgi-bin/dictionary

Nomenclature

haptic: an adjective, as in "a haptic interface"

haptic interaction: the act of touching objects

haptics: use as a noun, the study/practice haptic interaction

haptically: making use of touch interaction

haptic interface: device permitting human to have touch interaction with real or virtual environments

haptisize - bad English :) but, like sensorize, found

haptical - yikes, no, no.

Nomenclature

Human Haptics

human touch perception and manipulation

Machine Haptics

concerned with robot arms and hands

Computer Haptics

concerned with computer mediated haptics

Haptic interaction occurs in many contexts

Human haptics

- every-day manipulation
- tools, controls
- music, art, etc.

Machine haptics

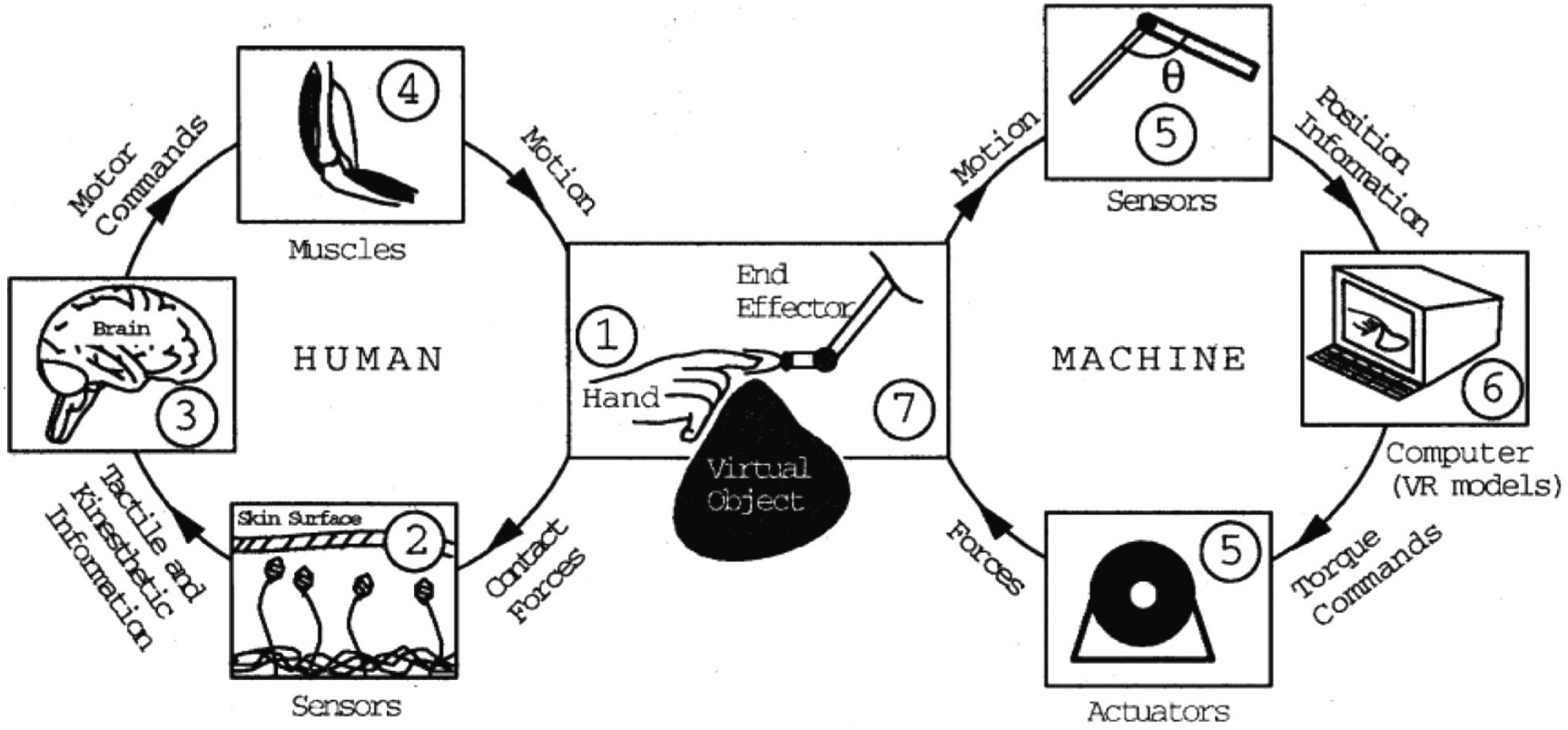
- autonomous robots
- remote manipulator systems
- surgical robots, etc.

Computer haptics

- training
- design
- entertainment

Haptic Interaction with Virtual Objects

Information and power flows



Courtesy Mandayam Srinivasan, MIT

Haptic Devices Past And Present - Outline

- Haptic stimulation modalities
- Basic device characteristics
- Example devices: passive
- Example devices: active
- Other stimulation modalities
- Ehat makes a good haptic interface

Haptic Stimulation Modalities

- Force and position
- Tactile
- Vibration
- Thermal
- Electrical

Basic Device Characteristics

- Degrees of freedom
  number of joints
- Active and/or passive
  force reflecting or not
- Grounding location
  grounded versus exo-skeletal
- Sensing quality
  resolution, maximum and dynamic range
- Actuator quality
  resolution, maximum and dynamic range
- Bandwidth

Example Devices: Passive (1)

Ground-based

- Keyboards, knobs
- Trackballs, mice, pens
- Joysticks
- MicroScribe-3D (Immersion)

Example Devices: Passive (2)

Exo-skeletal

- Dexterous Hand Master (U. Utah/EXOS)
- Gloves (VPL, Virtual Technologies)

Example Devices: Passive (3)

Hand-held

- Optical (Optotrack)
- Electromagnetic devices (Polyhemus, Ascension)
- Accelerometer devices (InterSense)
- Wii (Nintendo)

Example devices: Active, Exo-skeletal

1-6 degrees of freedom

- UTAH/Sarcos Research Arm
- CyberForce (Virtual Tech.)
- Rutgers Master (Burdea, Rutgers Univ.)
- PERCRO Human Interface (Scuola Superiore S.Anna)

Example devices: Active, Ground based – 1 DOF

1 Degree-of-freedom

- Steering Wheels
- Hard Driving (Atari)
- Ultimate Per4mer (SC&T^2)

Example devices: Active, Ground based – 2 DOF

2 Degree-of-freedom

- Pens and Mice
- Pen-Based Force Display (Hannaford, U. Wash)
- MouseCAT/PenCAT (Hayward, Haptic Tech., Canada)
- Feel-It Mouse (Immersion)
- Joysticks
- Force FX (CH Products)
- Sidewinder Force Feedback Pro (Microsoft)

Example devices: Active, Ground based – 3 DOF

3 Degree-of-freedom

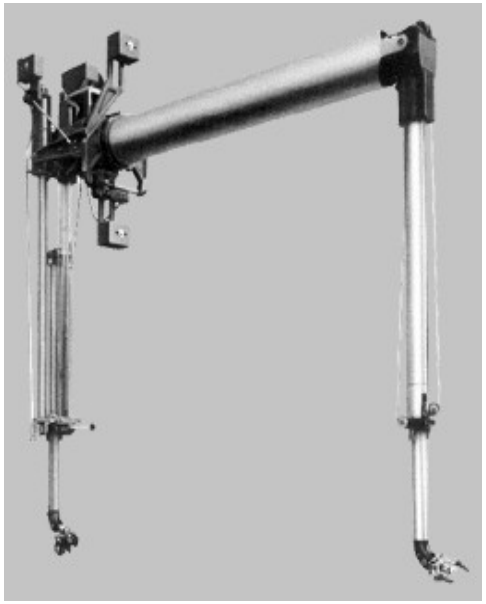
PHANToM (SensAble Technologies)
DELTA & OMEGA (Force Dimension)
Impulse engine (Immersion)

Example devices: Active, Ground based – 6+ DOF

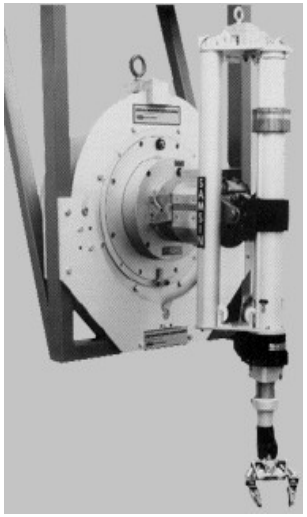
6+ Degree-of-freedom

- Teleoperator masters (MA-23, Argonne, CRL)
- Freedom 6/7 (Hayward, MPB Technologies)
- OMEGA.7 (Force Dimension)
- LR 500 (Xitact)
- 6DOF (Cybernet)
- PHANTOM Premium 6 DOF

Haptic Interfaces



CENTRAL RESEARCH LABORATORIES
A DOVER DIVERSIFIED COMPANY



Haptic Interfaces

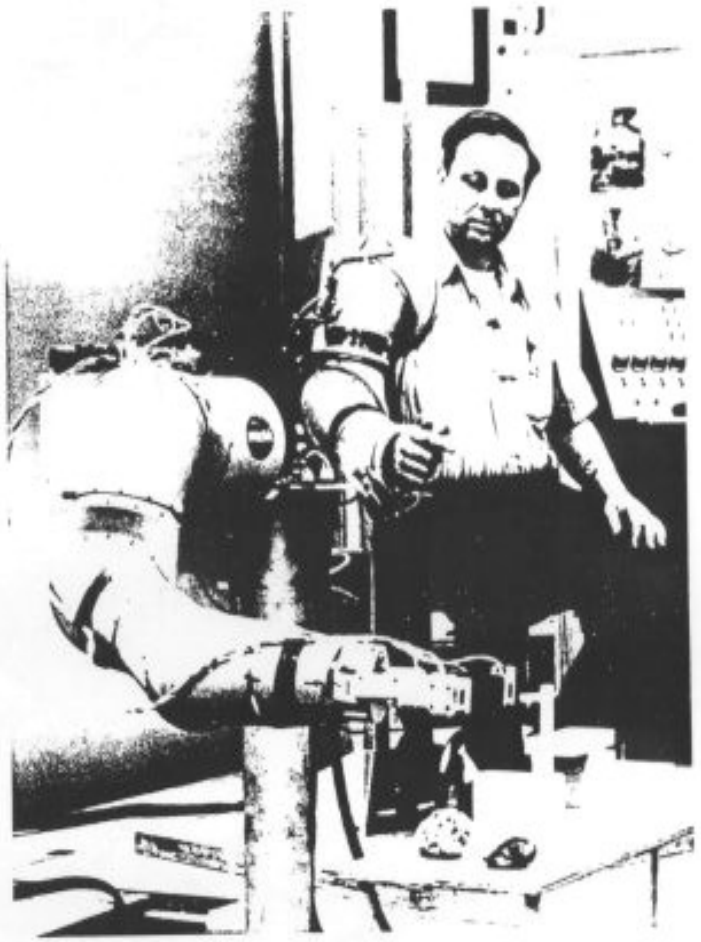
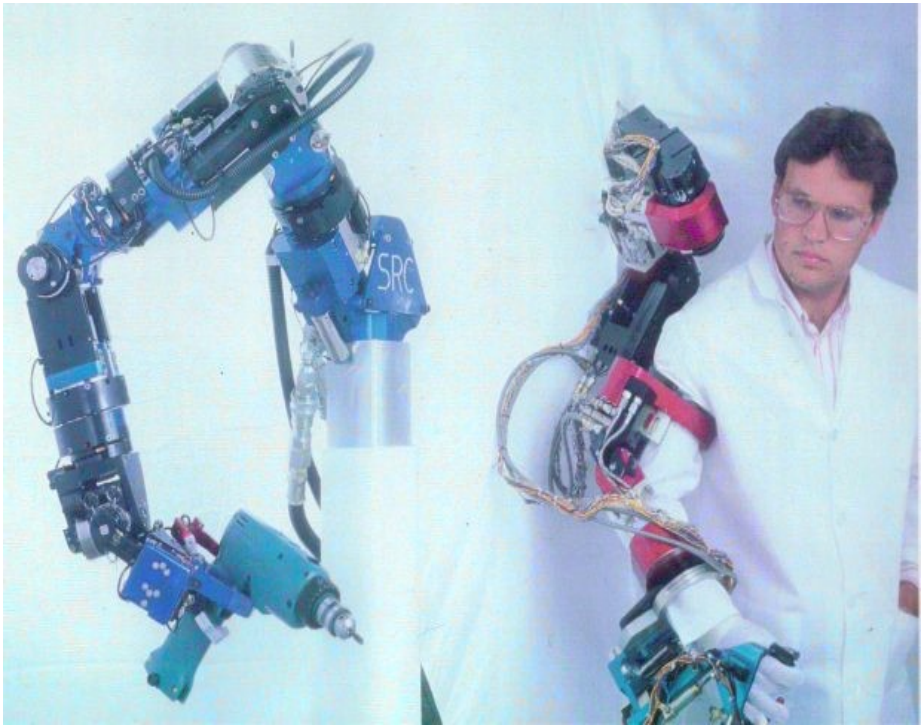


Figure 3-8. Ames Anthropomorphic Exoskeleton Controller and Geometrically Similar Slave [41]



Haptic Interfaces

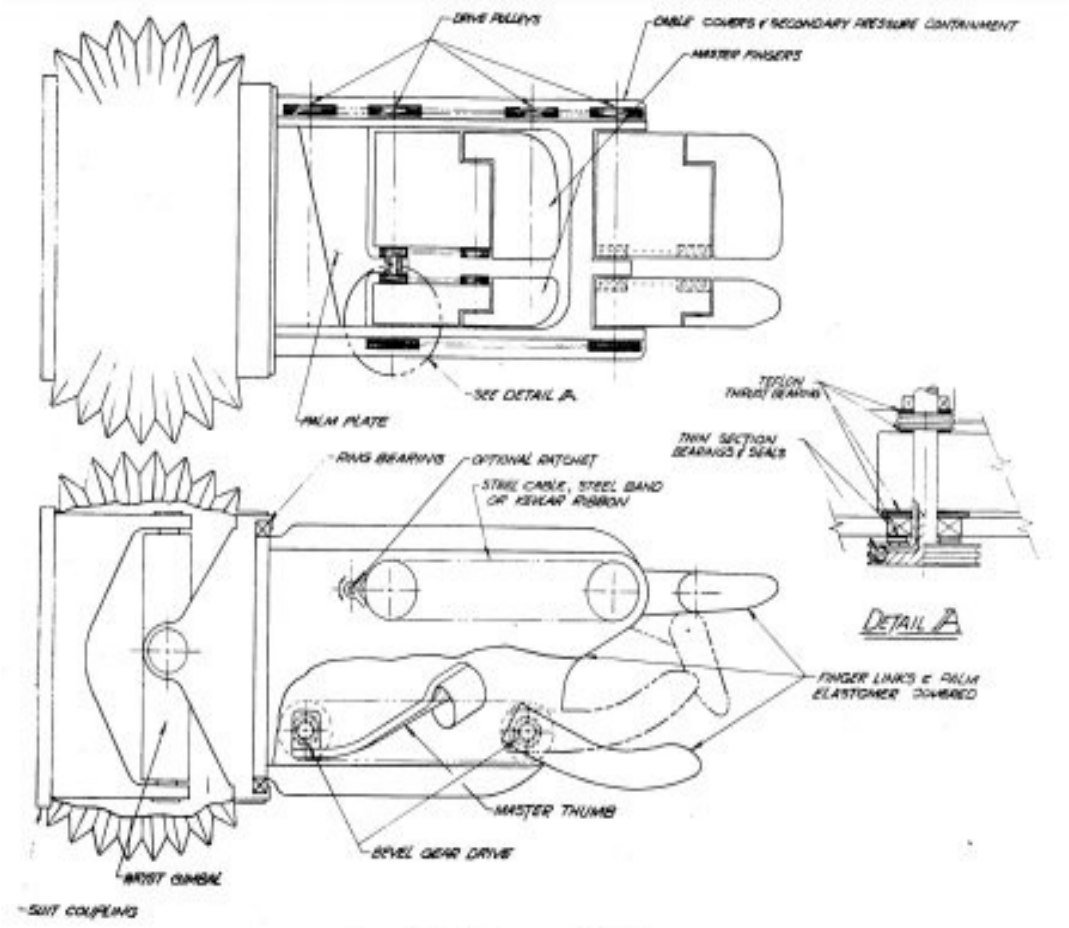
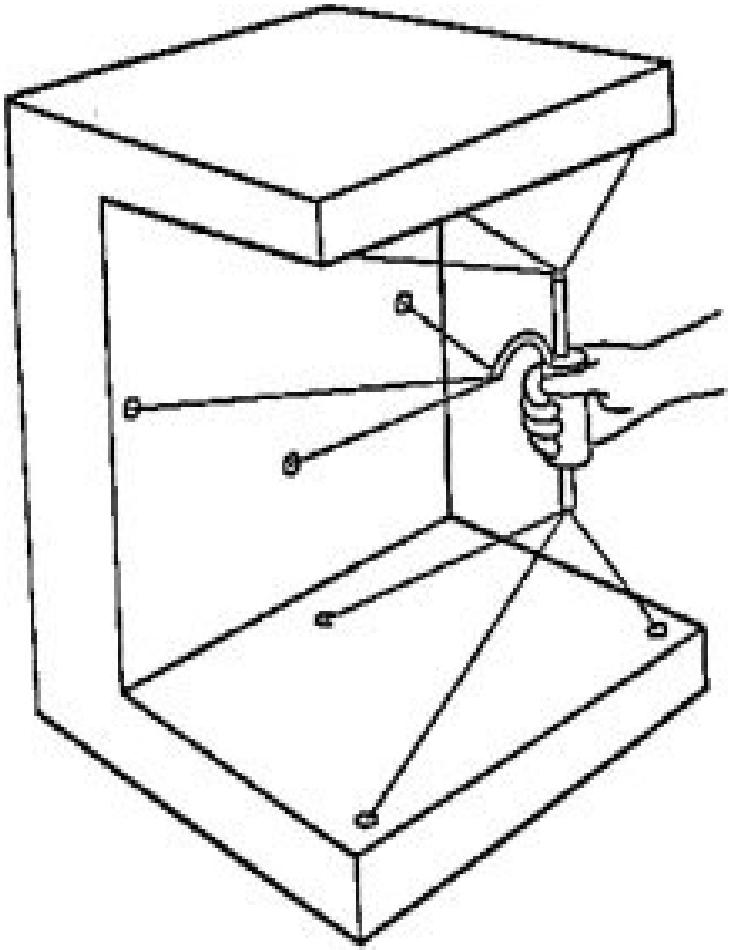
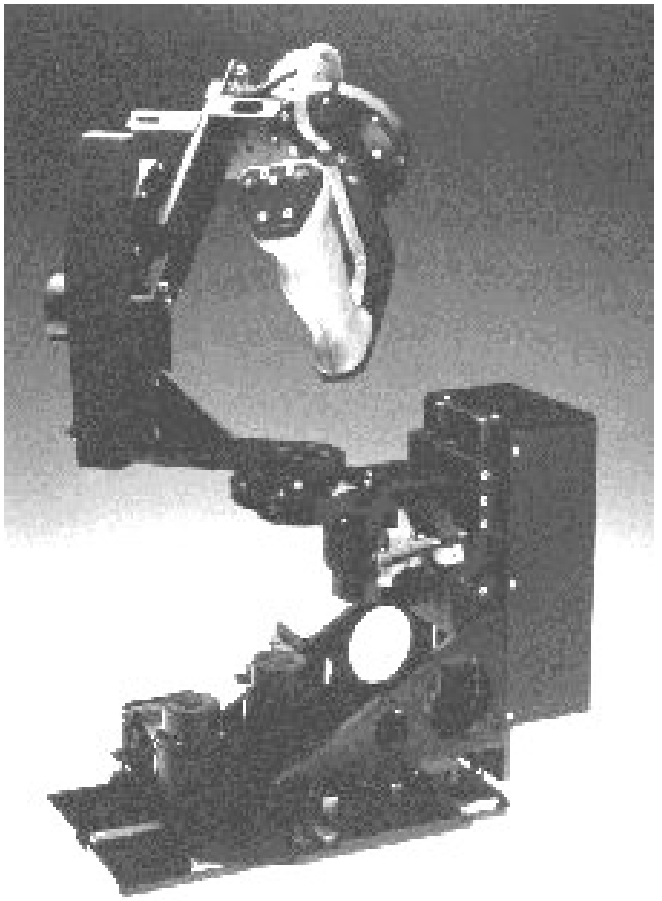


FIGURE 6.7 DISPLACED FINGERS

MIT! Advanced Robot Technology Project (Photo by ASAHIGRAPH)

Haptic Interfaces





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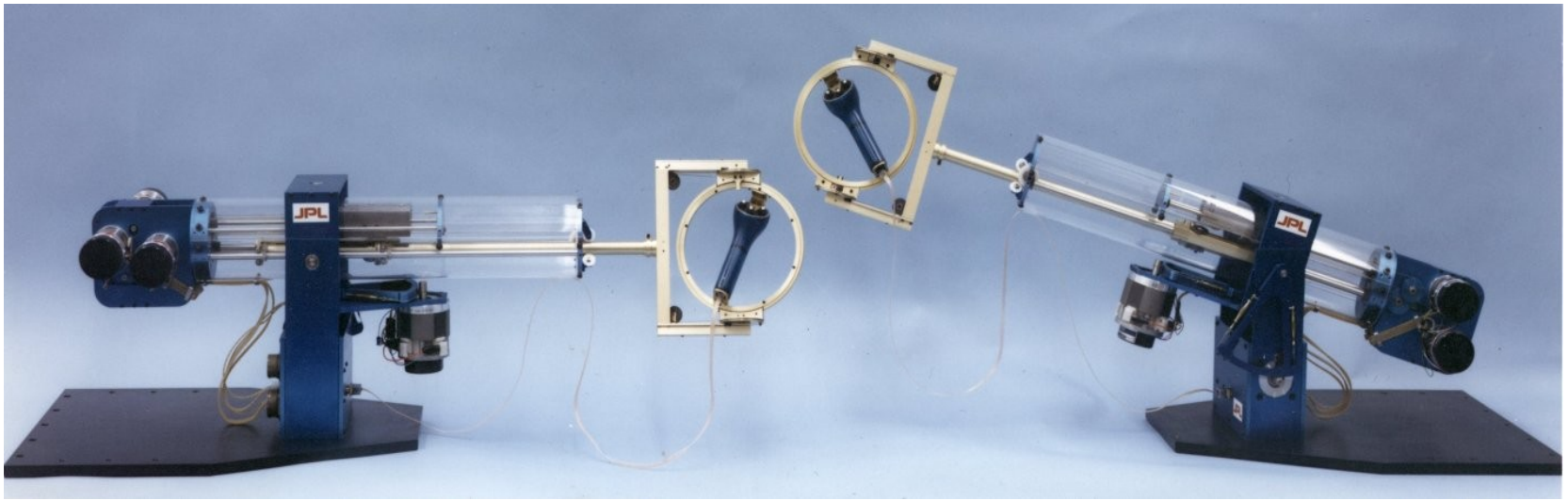

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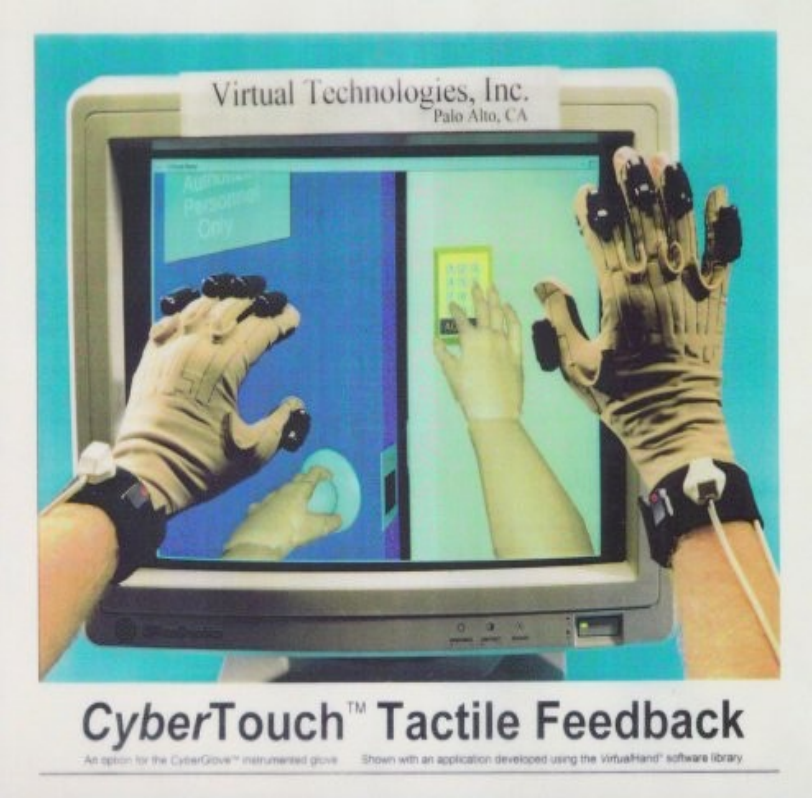

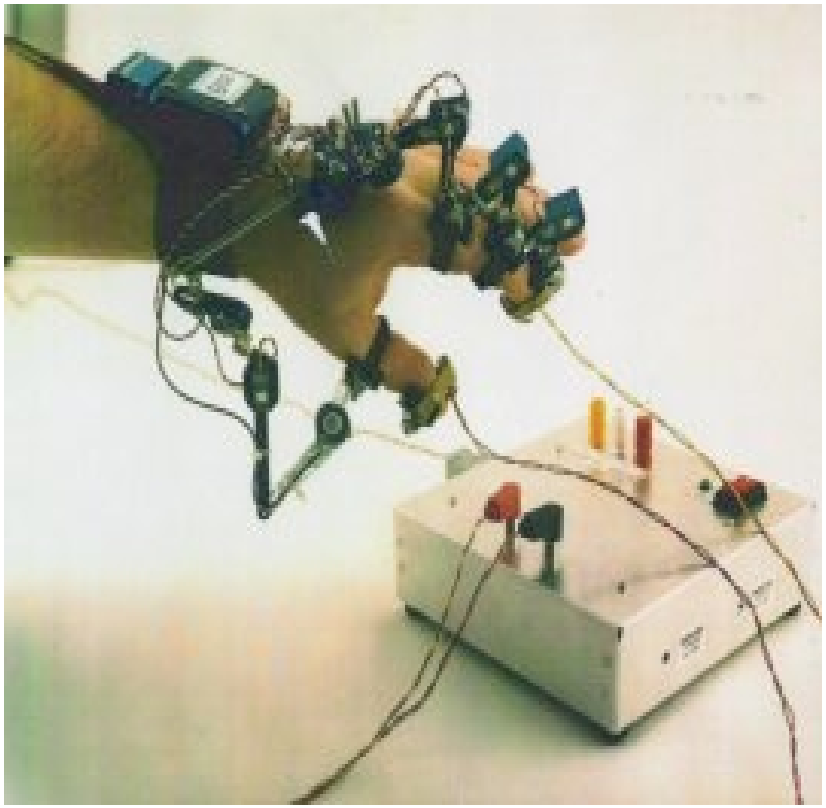

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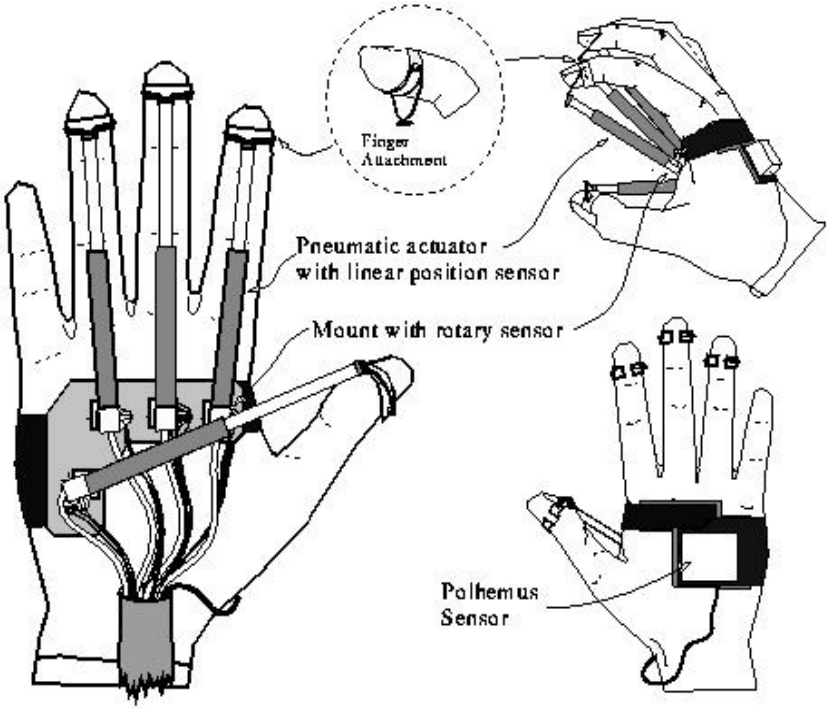
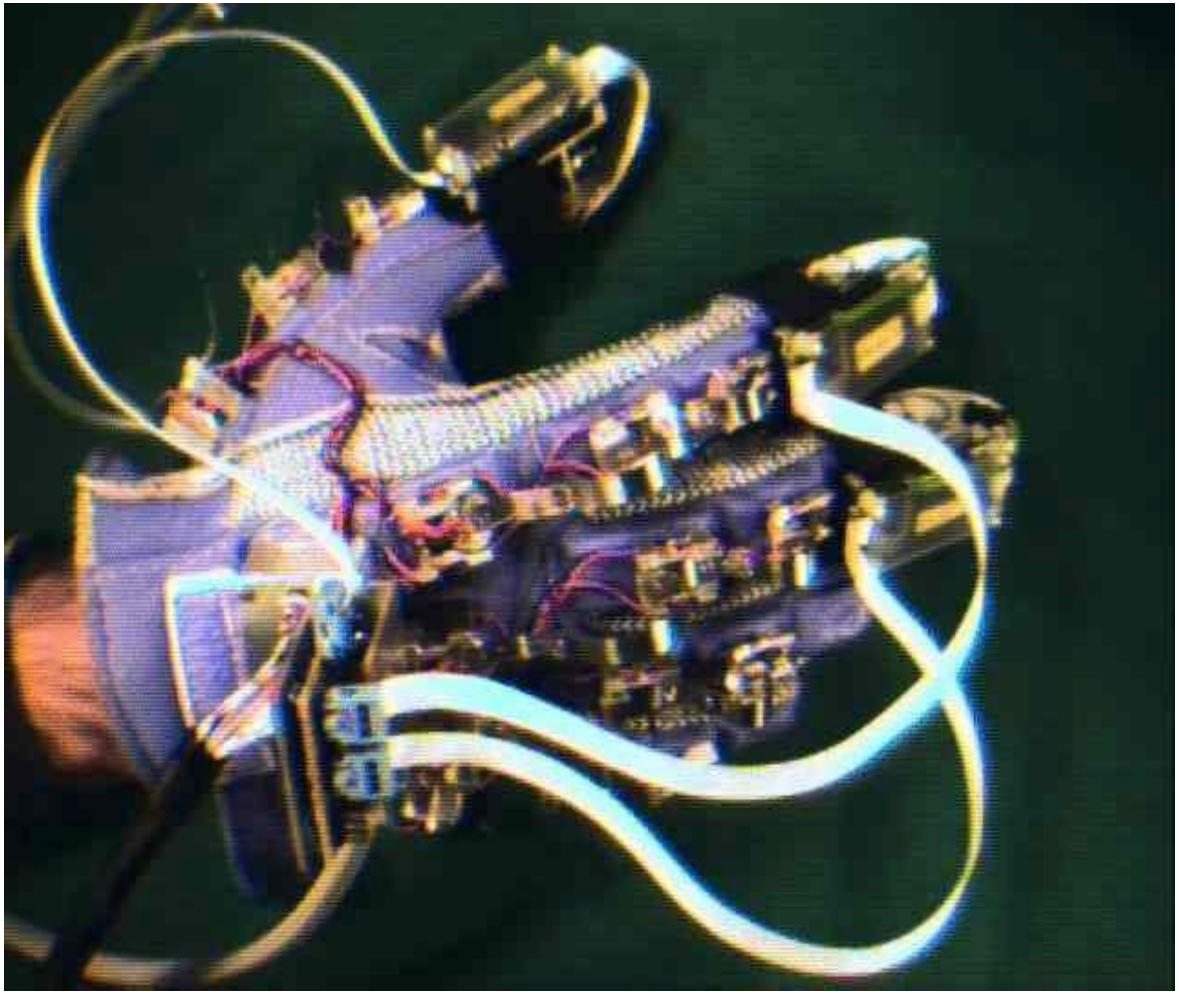


Haptic Interfaces

Other Stimulation Modalities

- Vibration and tactile arrays (Howe, Harvard)
- Thermal stimulation (Ottensmeyer, MIT)
- Tactile and Thermal Glove (Scuola Superiore S.Anna. Italy)
- Electrical (Bach-y-Rita)
- Tangential Stimulation, Haptic Flow (Hayward, Bicchi)

Other Stimulation Modalities



Other Stimulation Modalities