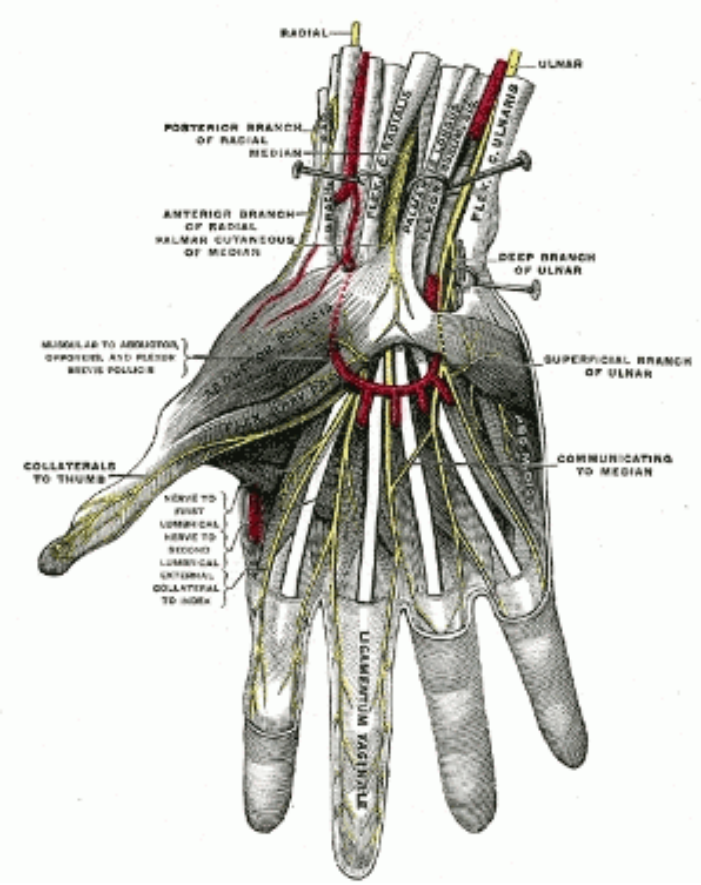
Multimodal Interfaces

lecture 03: Haptic Interaction



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++ lecture overview

+ definition of haptics

+ physiological background

+ haptic dimensions & perception

+ example: the reactable objects

+ kinesthetic/tactile actuators

+ haptic interface examples

partially based on Prof. A. Okamura's lecture notes

http://pegasus.me.jhu.edu/~allisono/courses/530.651/syllabus.html

++ definitions

1

++ haptics

+ origin

from the Greek word *haptesthai*: to touch

relating to the sense of touch

+ application fields

* human haptics
* haptic feedback, haptic interfaces
* machine haptics

++ types of sensing

+ kinesthesia

a sense mediated by end organs located in muscles, tendons, and joints.
stimulated by bodily movements.

-> force feedback

+ tactile

related to the skin
mediated by receptors in the skin

-> tactile feedback

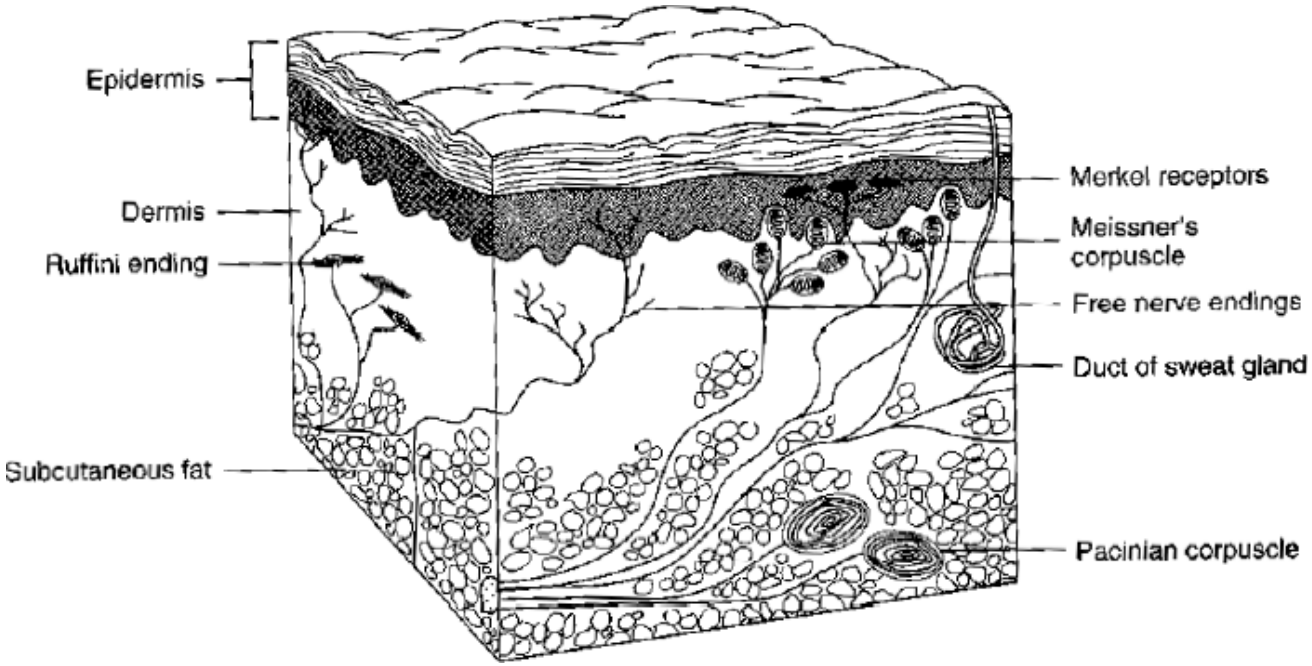
++ physiology

2

++ tactile (cuteneous) sensing

+ the skin

- the largest & heaviest human organ: $2m^2$
- provides information about various stimuli
- protects the human body



++ tactile receptors (sensors)

+ merkel receptor

disk-shaped pressure receptors between epidermis & dermis

+ meissner corpuscle

stack of flattened cells, with a nerve fiber winding its way through, detecting taps on the skin

+ ruffini cylinder

manybranched fibers inside a roughly cylindrical capsule: skin stretching, joint movement

+ pacinian corpuscle

layered capsule surrounding nerve fiber, sensitive to rapid vibrations

++ force (kinesthetic) sensing

+ kinesthesia

perception of limb movement & position, force

- some cutaneous information is used, especially in hairy skin (moving air)
- mechanoreceptors in muscles located in muscle spindles
- golgi tendon organ, at junction

+ force

resolution: 0,06N

grasping force: 400N

++ signal transmission

+ from the skin to the brain: nerve fibers
receptors -> dorsal root -> spinal cord -> thalamus

+ two pathways in spine
lemniscal (proprioception & touch)
spinothalamic (temperature & pain)

+ psychophysical/neural channels

++ perception

3

++ active / passive touch

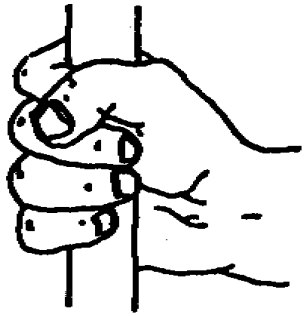
+ active touch
focus on the object

+ passive touch
focus on the sensation

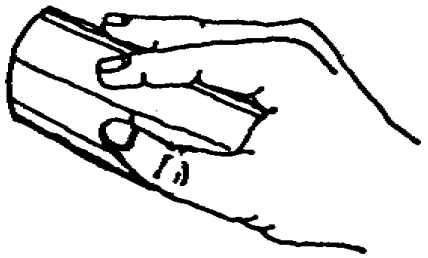
+ functionally equivalent
in performance

++ hand grip types

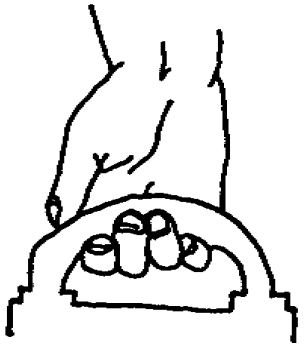
+ crush grip
object being gripped rests firmly against the palm and all fingers



+ pinch grip
the fingers are on one side of an object, the thumb is on the other

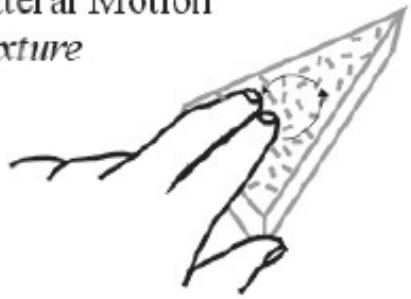


+ support grip
typically involves holding an object such as the handle of a bucket

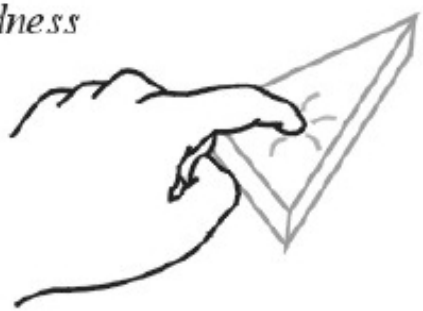


++ haptic exploratory procedures

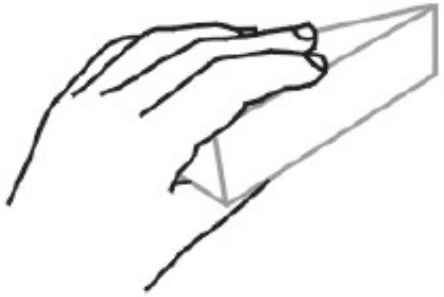
Lateral Motion
Texture



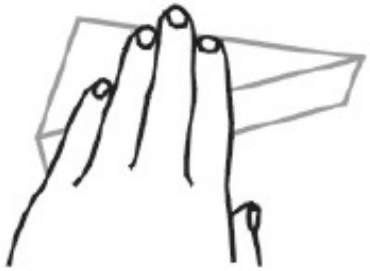
Pressure
Hardness



Enclosure
Global shape/Volume

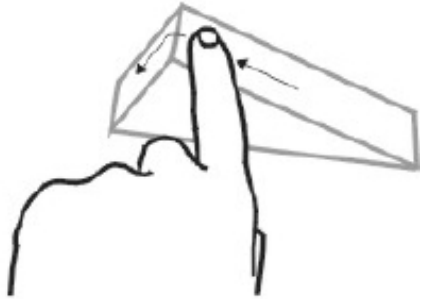


Static Contact
Temperature



Unsupported Holding
Weight

Contour Following
Shape



++ haptic dimensions

+ shape
perceived by contour following or hand enclosure

+ size/volume
hand enclosure

+ weight
perceived by unsupported holding

+ density/hardness
perceived by pressure

++ haptic dimensions

+ texture
lateral motion

+ temperature / thermal conductivity
static contact

+ friction, inertia
movement, kinesthetic resistance

+ others
stickiness, humidity, ...

++ discrimination

+ shape

complex shapes require contour following -> time
shape is generally recognized worse than texture

+ tactile discrimination

rough/smooth, soft/hard
big/small, heavy/light

+ visual/haptic performance

haptics: detecting substance
visual: detecting shape

+ material identification

combination of texture, temperature signature and density/weight

++ haptic encoding scheme

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++ current object design

+ passive objects

no electronics inside, no sensors, no actuators

defined by their physical properties only

no active (computer controlled) haptic feedback

+ abstract vs. symbolic

only abstract geometric objects

no everyday objects (mobile phones, rubber duck, …)

+ physical representation

each physical objects corresponds directly to a synthesizer component

-> allows direct physical manipulation

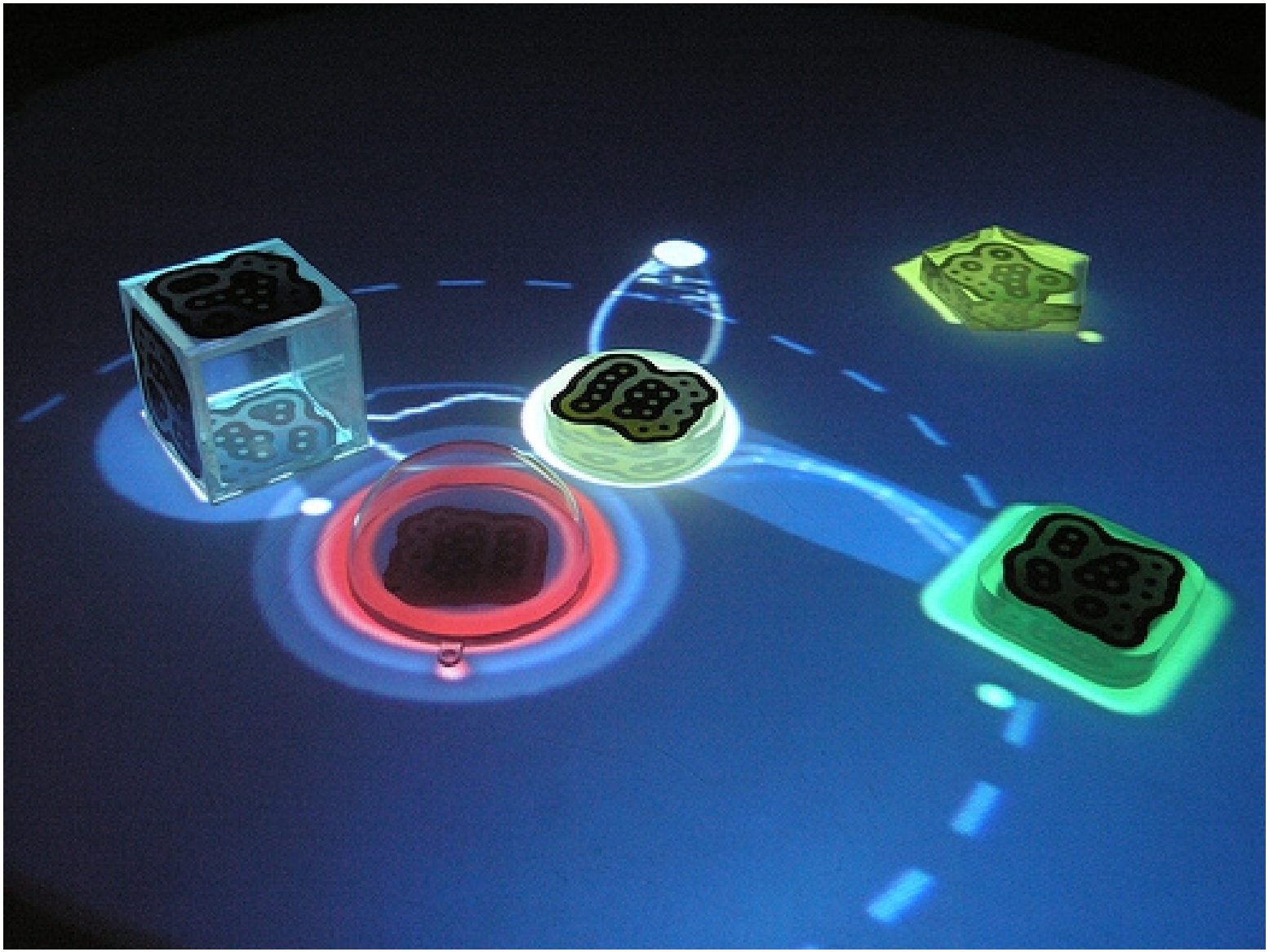
+ current solution

set of plexi-glass object of various simple geometric shapes

shape: defines generic object classes

graphical symbol: defines specific object class

++ current object design



++ object design issues

+ current design pros

easily and cheaply to manufacture

aesthetically pleasing appearance

+ current design cons

hard to recognize in low light conditions

similar symbols for different object types

limited primary colour coding space

++ earlier object design

++ reactable object dimensions

+ shape

simple shapes are both visually and haptically accessible and provides a suitable encoding for the abstract object types simple geometric shapes can be identif ed with a grasp or hand enclosure, more complex shapes require a contour following and cannot be identif ed completely.

+ size

size has not be chosen as an encoding dimension so far, because in traditional instruments size often correlates to pitch (tuba, f ute). nevertheless we evaluated three different sizes: 4,6 and 9 cm diameter which can be held and manipulated with three, four or f ve f ngers

++ reactable object dimensions

+ space

both 2D (**f** at) and 3D (cubic) objects are used
e.g. sample cube provides six sides for different sample sounds

+ surface texture

natural or treated object surface (rough, polished, ….)
or laser engraving to encode abstract haptic surfaces

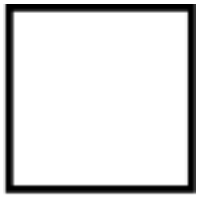
+ material

natural and synthetic materials with different weight, density, thermal and texture properties.
objects can be fully made of a material or a diffent material can be glued to the object surface to change its surface structure while maintaining the density and weight if the carrier

++ shape: generic object classes

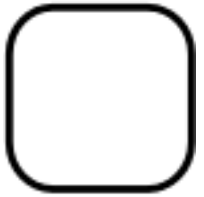
+ sound generators: squares, cubes

oscillators, sound fonts, samples, phys. models



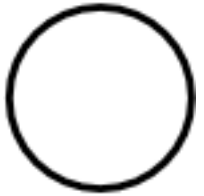
+ sound effects: rounded squares

filter and effects (band pass, delay, distortion ...)

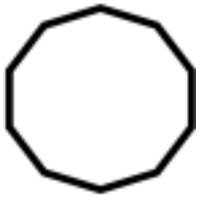


+ control generators: round disks

LFOs, melody generator, random



+ step sequencer: round polygons



+ global objects: star shape

tempo, tonality, volume

++ secondary object class ideas ….

+ plain materials:

wood = sample player

plastic = oscillators

metal = physical bell model

+ engraved surface structure:

flat = sine oscillator

rippled = sawtooth oscillator

rough = noise generator

+ attached surface material:

sand paper = granulator effect

sponge = flanger effect

++ haptic actuators & displays

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++ force actuators

+ electric motors

rotating *armature* with coil windings is caused to rotate relative to a permanent magnet

+ pneumatic actuators

compressed air pressure is used to transfer energy from the power source to haptic interface

++ tactile actuators

+ pneumatic stimulation

air jets, air rings (cuffs), air pockets (bellows)

+ vibro-tactile display

voice-coil motors,
basically mini-loudspeakers

+ micro-pin actuators

can produce highly localized forces
may cause pain

++ tactile actuators

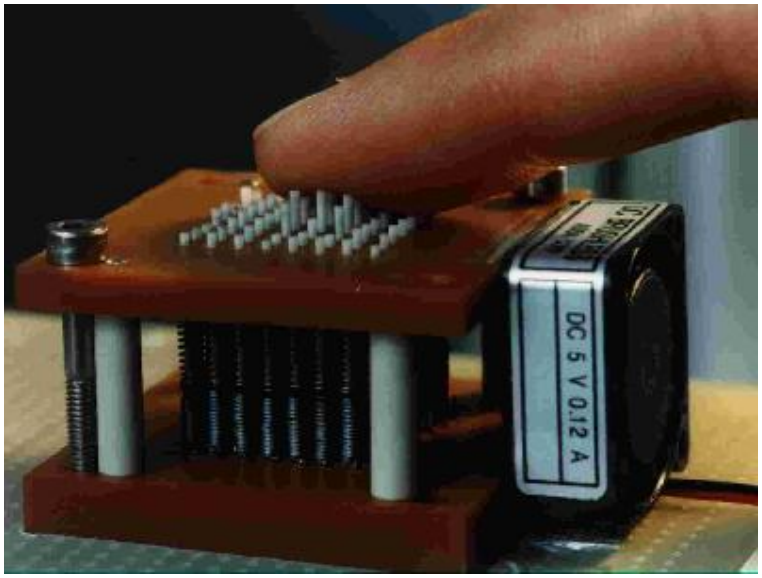
+ peltier pump, thermoelectric heat pump

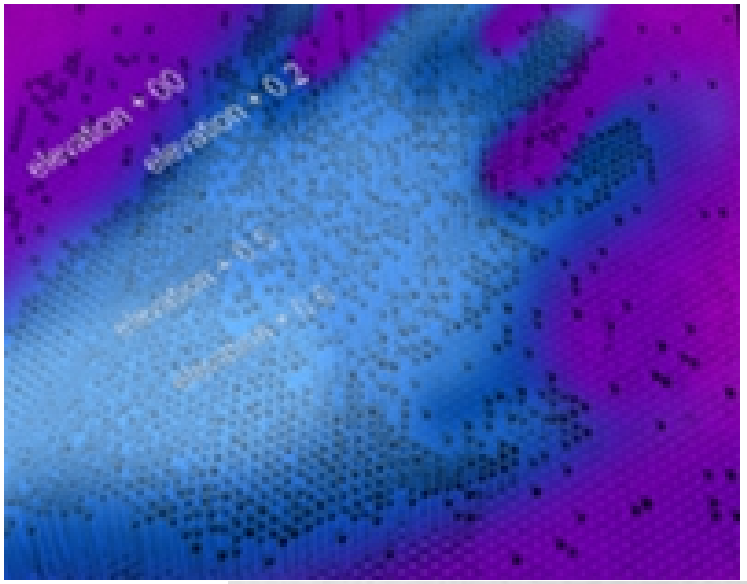
applying current to two materials in contact
creates a temperature differential
can be used to control surface temperature

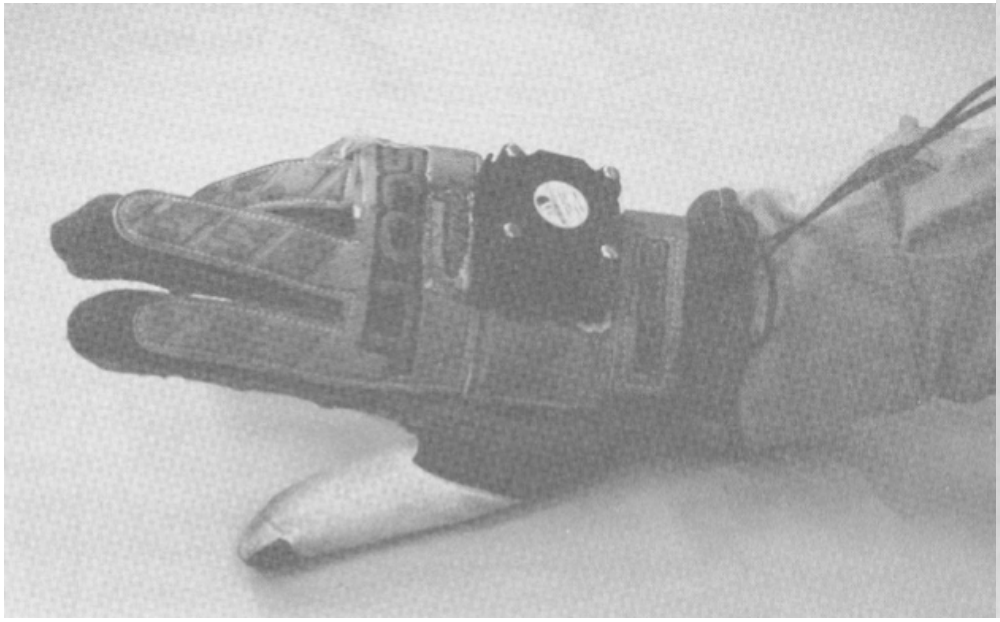
+ electro-tactile stimulation

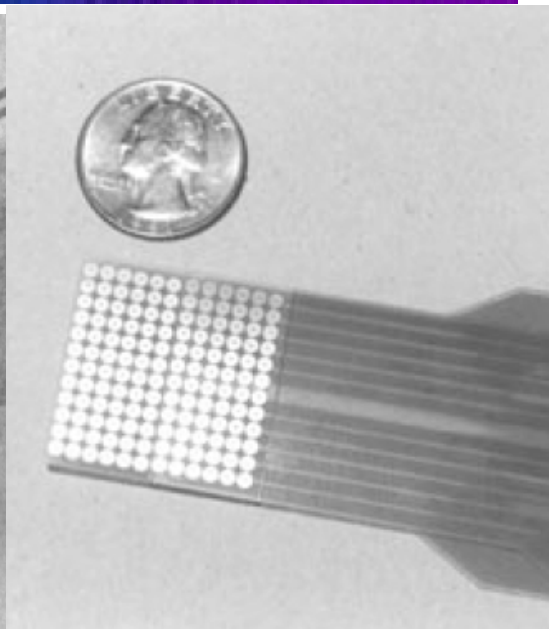
uses very small currents passing through electrodes
placed on the skin

++ tactile displays

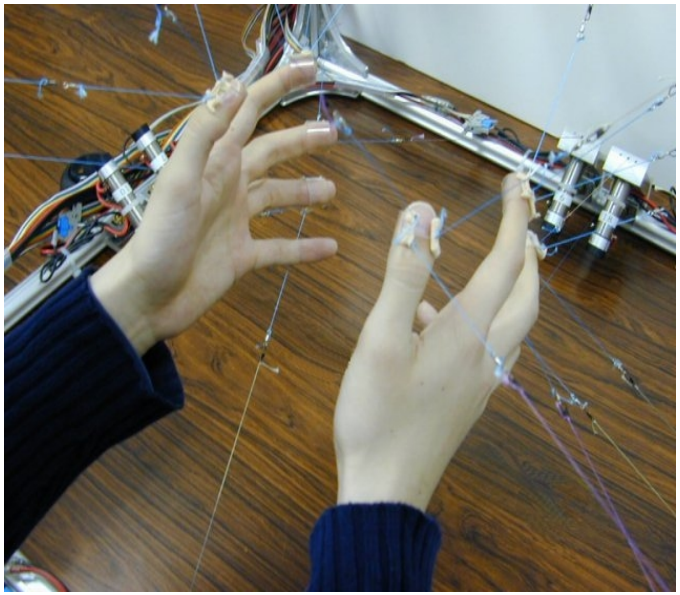


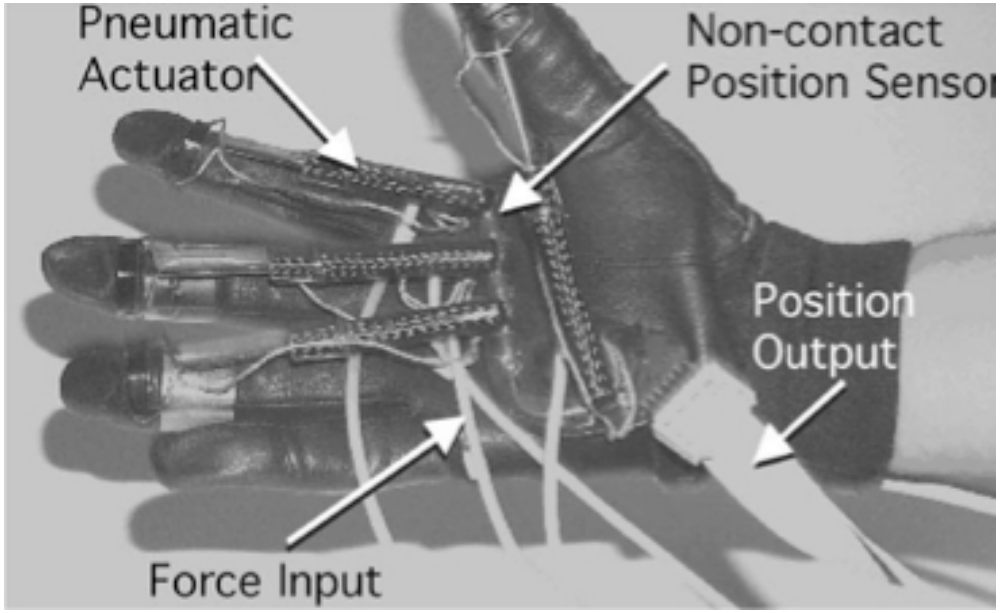






++ kinesthetic displays





++ haptic interface examples

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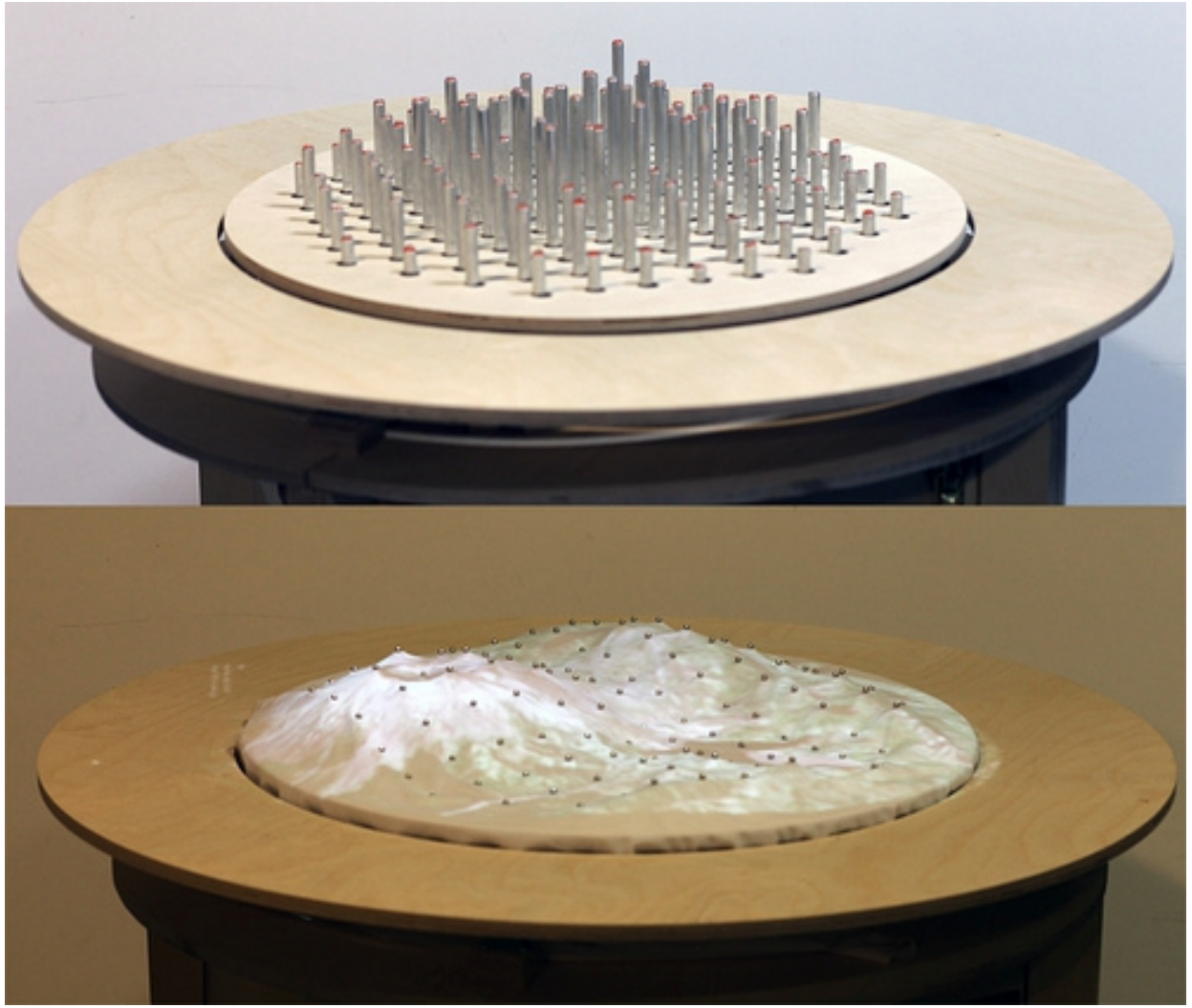
++ force feedback controller - falcon

++ Lumen

Ivan Popyrev, Sony CSL

http://www.sonycsl.co.jp/person/poup/projects/lumen.html

++ Relief



Daniel Leithinger, Tangible Media Group, MIT
http://tangible.media.mit.edu/project.php?recid=132

++ Touch TV

Sile O'Modhrain, Media Lab Europe

http://www.sarc.qub.ac.uk/~somodhrain/palpable/projects.html#touchtv

++ Haptic Sex Toys

Kyle Machulis, Polynomial Labs

Http://slashdong.org/