Haptic Interaction

Prof. Emanuele Panizzi

DIPARTIMENTO
DI INFORMATICA
SAPIENZA
UNIVERSITÀ DI ROMA

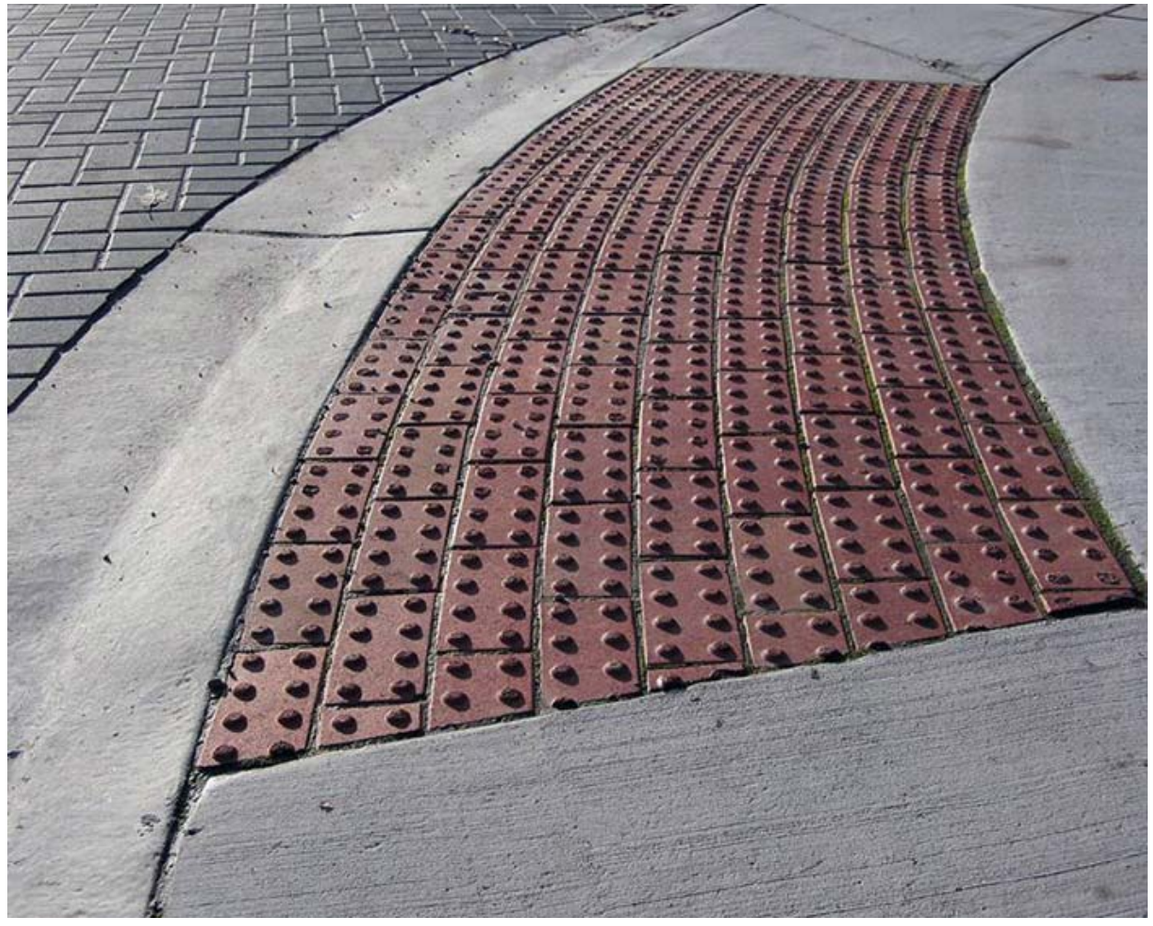
- Visual
- Auditory
- Haptic: combination of movement and touch

Why

- Manipulate physical and virtual objects
- Tactility to take action, visual feedback
- Visual interaction impractical or impossible:
  - Extraordinary needs, e.g. blind
  - Ordinary needs: e.g. eyes-free when driving, operating machinery, poor lighting

Doing vs receiving

- Take action
- Receive feedback



Retrieval and processing of information by the human body - two levels

- **Physical**: peripheral nervous system - gathering information of the different type of stimuli

- **Perceptual**: information conveyed to the brain and interpreted

Tactual perception

Senses

- Cutaneous sense: awareness of the stimulation of skin receptors
- Kinesthetic sense: awareness of the relative positioning of the body
- Tactual perception involve one or both these senses

Tactual perception

- Tactile perception: dependent on cutaneous sense only (body is not moving)

- Kinesthetic perception: dependent on the kinesthetic sense only (almost purely theoretical; in case of use of anaesthetics)

- Haptic perception: involves information from both senses

Tactual modes

1. Tactile perception - Cutaneous information alone.

2. Passive kinesthetic perception - Afferent kinesthesis.

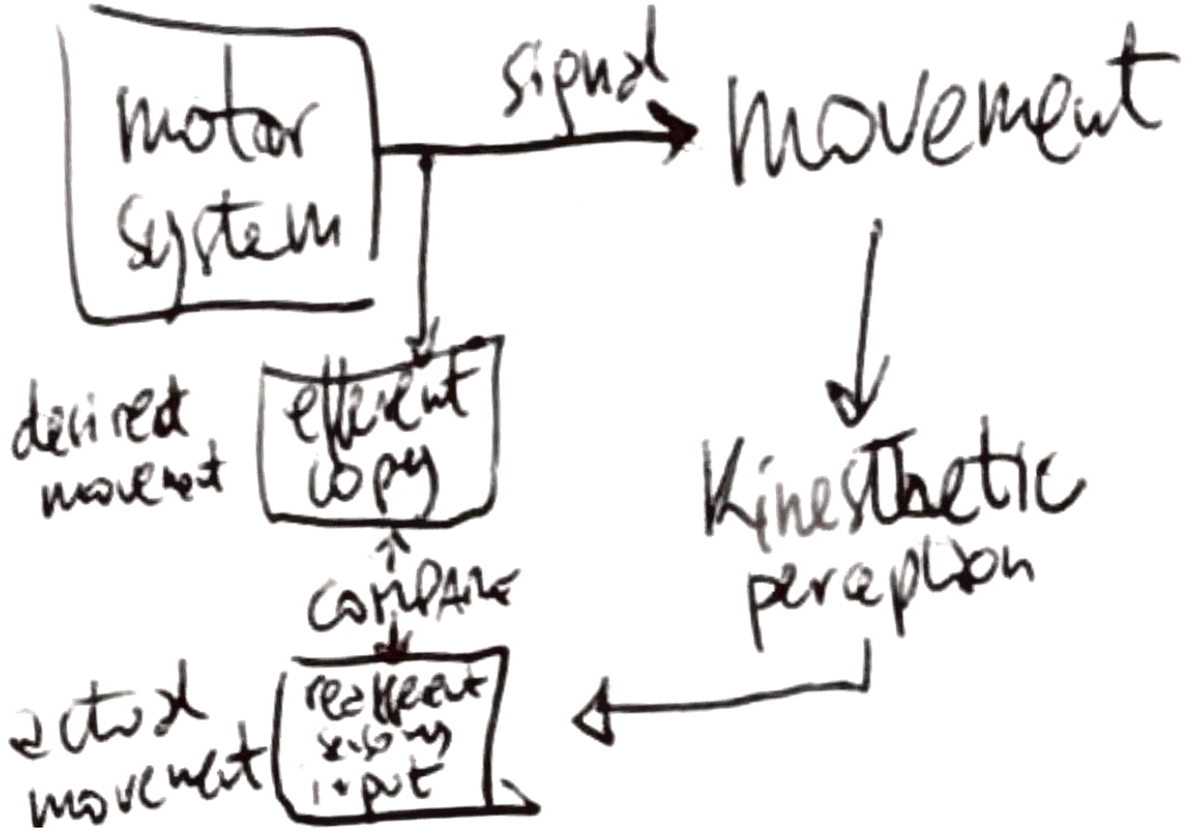
3. Passive haptic perception - Cutaneous information and afferent kinesthesis.

4. Active kinesthetic perception - Afferent kinesthesis and efference copy.

5. Active haptic perception - Cutaneous information, afferent kinesthesis and efference copy.

Efference copy

- Internal copy of an outflowing, movement-producing, signal
- Enables the brain to predict the effects of an action
- Shields perception from particular self-induced effects



Touch and sight

- No dominant sense in case of conflict
- Compromise between the two senses
- Highly individual
- Better suitability of one or the other sense in each different task

Touch and sight /2

	Haptic perception	Visual perception
Structural information	Slow Error prone	Fast
Substance dimensions (e.g. hardness, texture…)	Quick Reliable	—

Symbols for haptic interaction

Line symbols

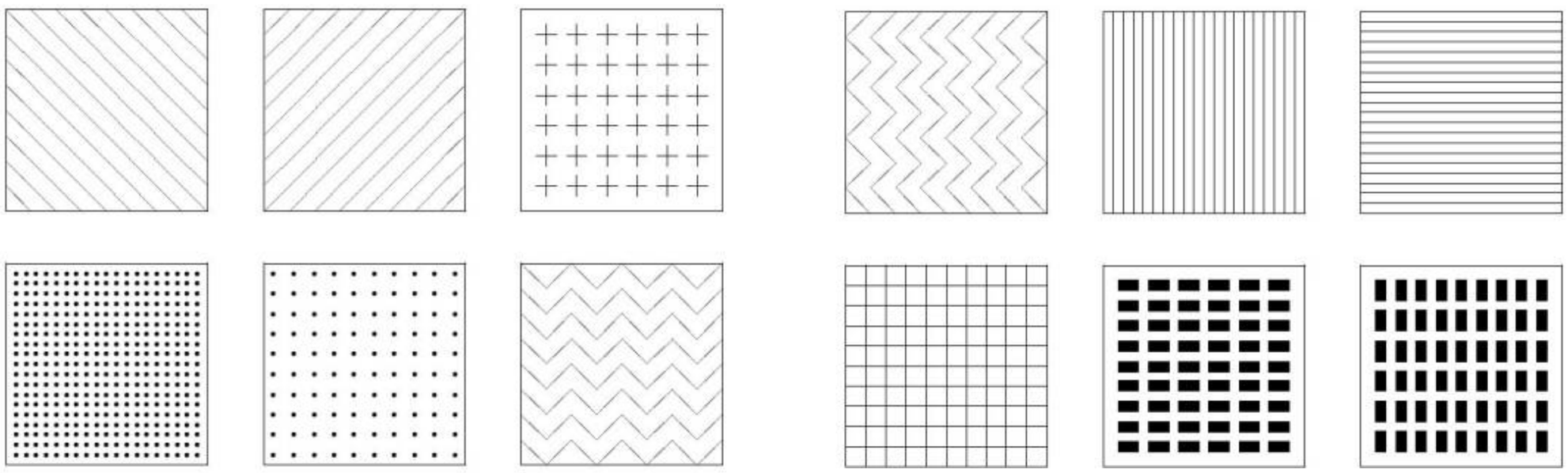
- Raised lines as tactile substitutes for visual ones
- Issues with:
  - Traceability: how easy can they be traced
  - Thickness distinguishability
  - Trace lines despite of intersections
  - Smooth vs rough (e.g. dotted) lines tracking performance
- If line il thicker than finger (both sides not perceived), performances drop
- More than 8 -10 linear symbols: similarity errors occur (Nolan, Morris 1971; Gill 1975)

Point symbols

- Explore with minimal movement of fingertip
- Not only dots (e.g. different shapes)
- Issues
  - How well perceived in contrast with background (figure-ground problem)
  - Raised vs incised symbols — raised easier to recognize
  - Legibility and meaningfulness — learning necessary

Areal symbols

- Use of texture or tactile pattern to provide information
- Factors:
  - Size vs spacing
  - Applied force affects roughness perception
  - Speed



Limitations of tactile perception

- **Spatial resolution:** the distance at which two points are perceived as one (blurring effect; density, size, and sensitivity of receptors; number of neurons in the cortical projection area)

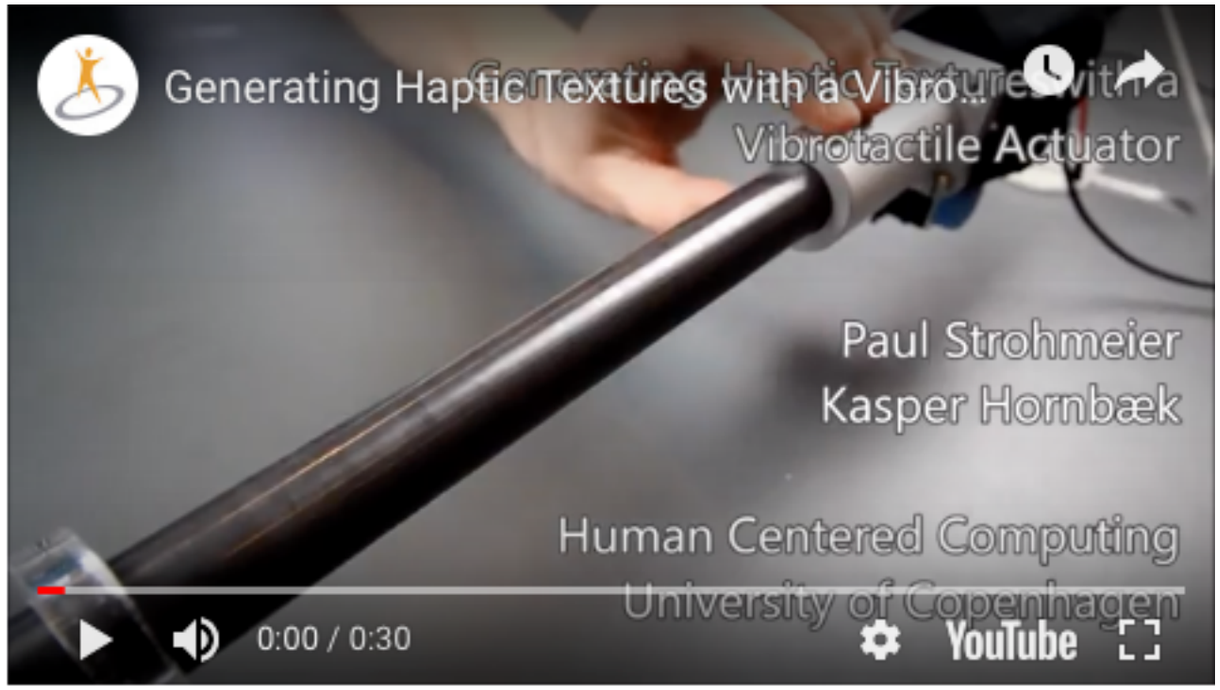
- **Temporal resolution** (dynamic stimuli) 2-40ms

- **Interactions between widely spaced stimuli** (e.g. phantom dot in the middle if dots presented to both hands)

- **Perceptual integration** (information may fail to be recognized)

- **Limited attention** (not capable of focusing attention when information exceeds)

- Up to 8 tactile patterns can be recognized if used together
- Height can be used as a filtering method


Generating Haptic Textures with a Vibro...
Vibrotactile Actuator
Paul Strohmeier
Kasper Hornbæk
Human Centered Computing
University of Copenhagen
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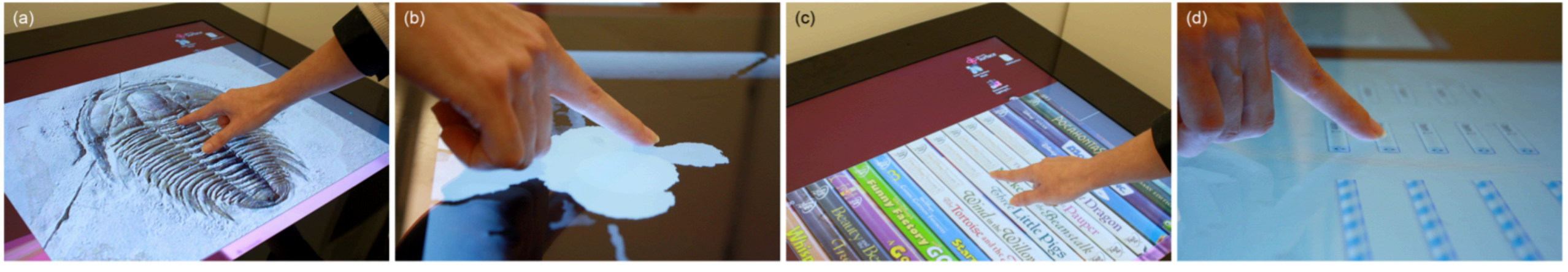
YouTube


(a)
(b)
(c)
(d)

Methods for tactile stimulation

- Skin deformation
- Vibration
- Electric stimulation
- Skin stretch
- Friction (micro skin-stretch)
- Temperature

Technologies for tactile interfaces

- uta.fi

Tactile feedback in apps

- https://developer.apple.com/design/human-interface-guidelines/ios/user-interaction/feedback/

Haptic feedback

Force feedback interfaces

- measure the positions and contact forces of the user's hand (and/or other body parts)

- display contact forces and positions to the user

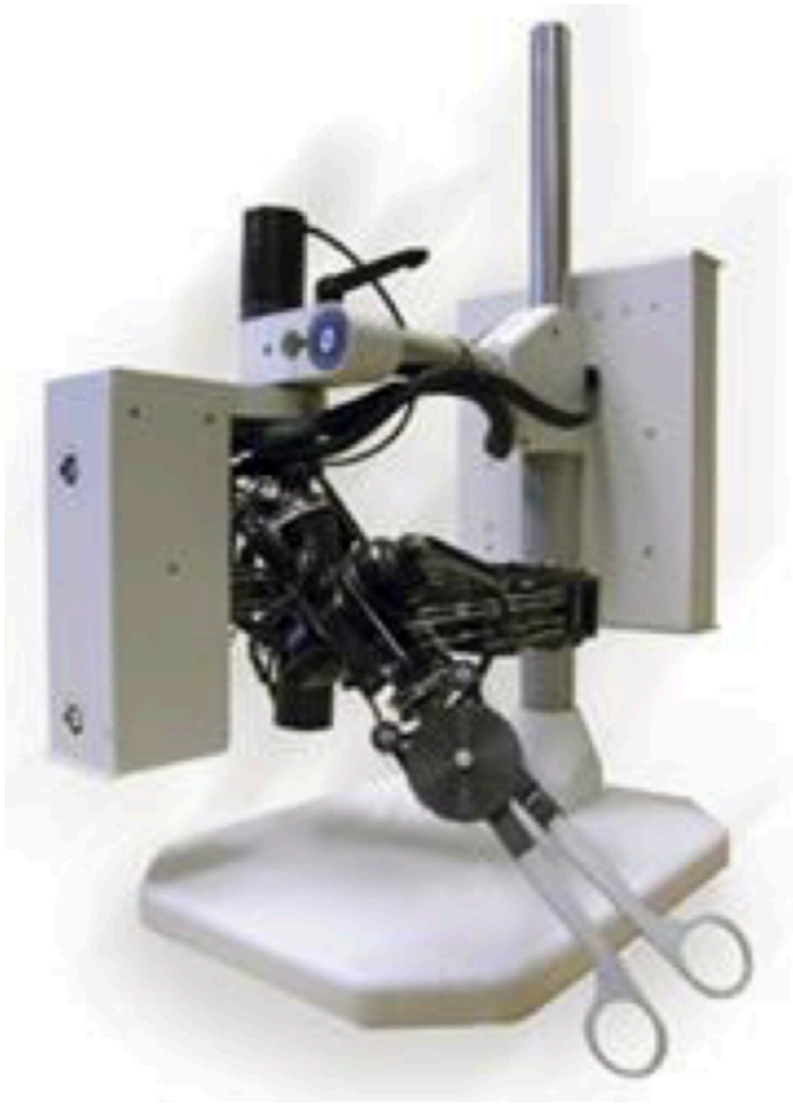
1

2

3

4

1DOF - 3DOF (degree of freedom)



6DOF 7DOF

Haptic rendering

- computing and generating forces
- in response to interactions with virtual objects
- based on the position of the device

Haptic rendering /2

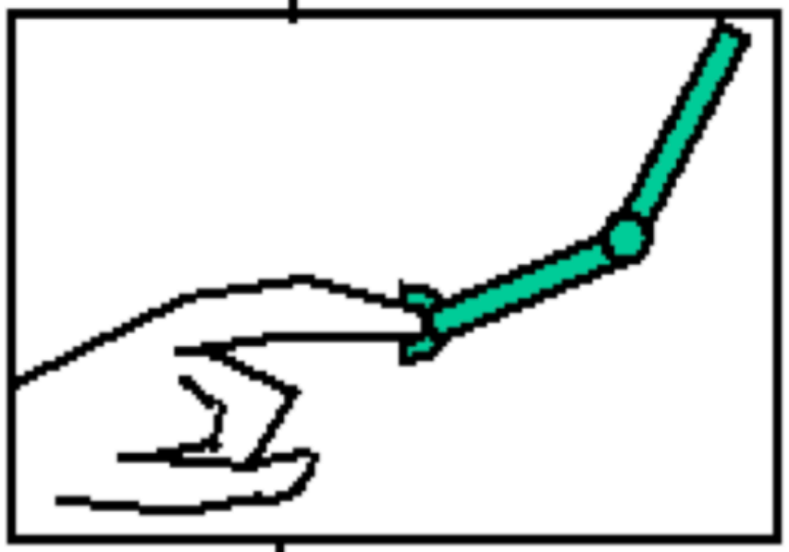
- Haptic rendering of an object can be seen as pushing the device out of the object whenever it tries to move inside it

- The further inside the object you move, the greater the force pushing you out

- This makes the surface feel solid

- The human sense of touch is sensitive enough to require a processing speed of at least 1000 Hz in terms of haptic rendering

Position
Orientation



Collision
Detection

Contact
Information

Collision
Response

Force
Torque

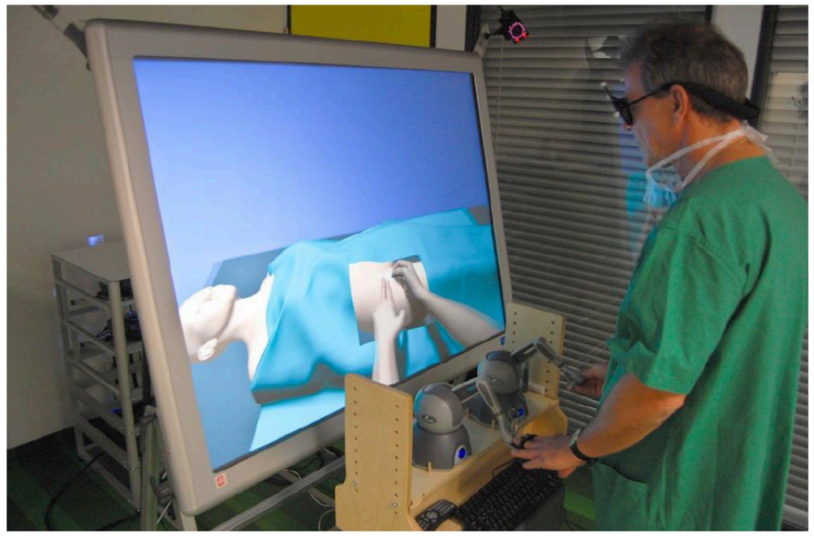
Object
Database

Geometry

Material

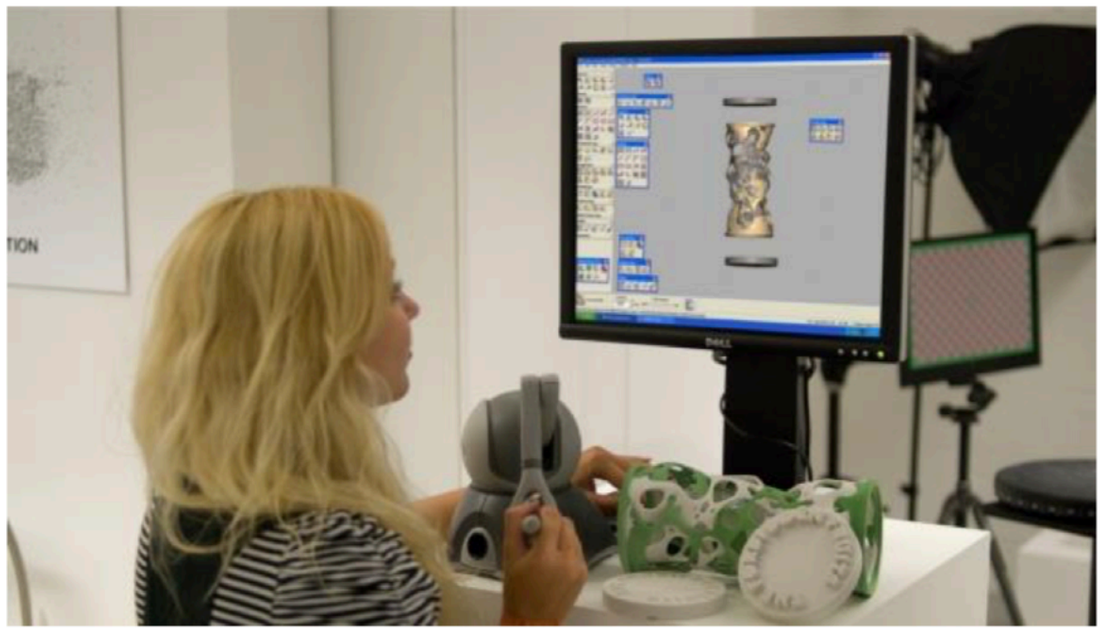
Haptic interaction applications

- Medical:
  - tissue modeling and visualization
  - training
  - remote surgeries
  - rehabilitation



Haptic interaction applications /2

- Three-dimensional modeling
  - virtual prototyping
  - virtual sculpting of 3D objects (the object surface can be felt already during modeling)



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