Beyond Visual: Shape, Haptics and Actuation in 3D UI

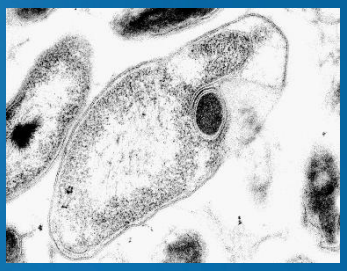
Ivan Poupyrev

▶Overview

- Virtual versus Physical interaction
  - virtual: mostly visual interaction
  - physical: visual, aural, smell, touch & kinesthesia
- Haptics: Feelings of touch & kinesthesia
  - touch: sensation from skin stimulation
  - kinesthesia: sensation resulted from bodily movements and tensions
- Interacting with physical objects
  - perception of shapes
  - perception of surface properties
  - adjustment and self-regulation of body motion, especially in 3D object manipulation
    - blind manipulation
  - sense of immersion and realism
    - ability to touch = really exist

▶Overview

- Sense of touch is the earliest feeling developed in living organisms
- Crucial to survival of species
  - Fish and birds: navigation in water and air streams
  - Single-cell organisms: rely only on touch to find food
  - Touch is the only common feeling between a human and bacteria
- Haptics –last frontier in user interface research and development
  - Significantly less explored, understood and applied to UI then vision
  - Exciting and challenging area of research
  - Key to create truly “realistic” UI



▶ Overview

- Two approaches to create realistic physical interfaces
  1. Simulate every perceivable aspect of the physical environment
  2. Dynamically modify the physical world itself to communicate information
     - Ivan Sutherland "Ultimate Display"
- Shape displays and kinetic interfaces
  - Influenced by robotics, haptics and tangible UI research
  - Presenting 3D information by directly by reconfiguring physical environment

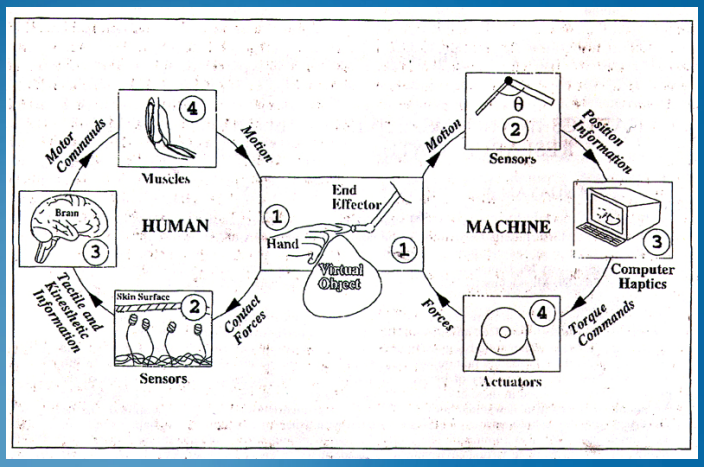
"Source"

▶Overview

In this lecture I overview:

1. Interfaces that produce feeling of interacting with 3D physical objects by stimulating sense of touch
    1. Force feedback devices
    2. Tactile user interfaces
2. Interfaces that use physical actuation and physical re-configurability to communicate information to users
3. Discuss relation to 3D user interfaces

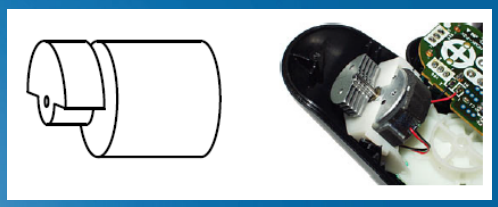
►Haptic Interfaces



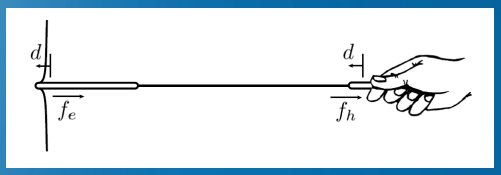
Haptic interaction between human and machine (Srinivasan, et al. 1997)

►Haptic interfaces

- Two classes of haptic displays
  - Tactile displays
    - The feel of virtual 3D objects contacting the skin is simulated
    - Vibrotactile stimulation
  - Net force displays
    - The interaction with 3D objects is simulated through the tool
    - Force-feedback
  - Can be used in combination



- Vibrotactile feedback Hayward, McLean (2008)

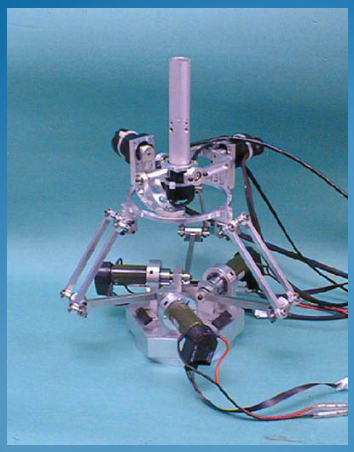


►Haptic interfaces

- Net force displays
  - active force feedback or haptic breaks
  - has been extensively developed and relatively successful
    - requires just net single force and net torque computed
    - product released e.g. Phantom by Sensible
  - response matches some of the basic properties of human sensor-motor performance
- Underlying technology
  - motors, pneumatic actuators, magnetic break particles

- Phantom force feedback device

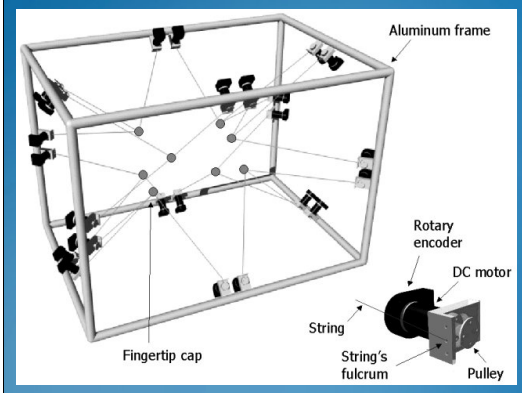
▶Haptic interfaces

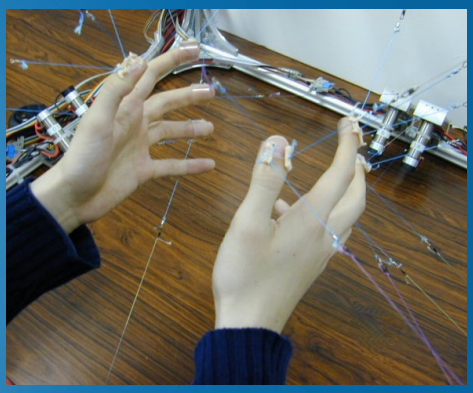


- Space machine laboratory, Tohoku University

- Falcon by Novint Inc.

▶Haptic Interfaces

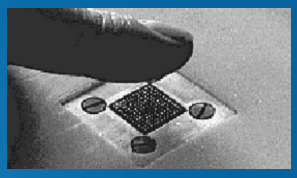




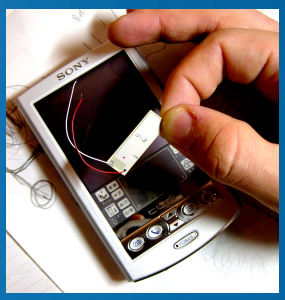
- Spider, Tokyo Institute of Technology

►Tactile interfaces

- Tactile displays
  - very challenging
  - requires distribution of forces and torques on skin over the touch area
    - single point simulation are often presented with vibrotactile feedback
    - multipoint simulation use actuator arrays
- Underlying technologies
  - piezo-actuators, SMA, micro-motors

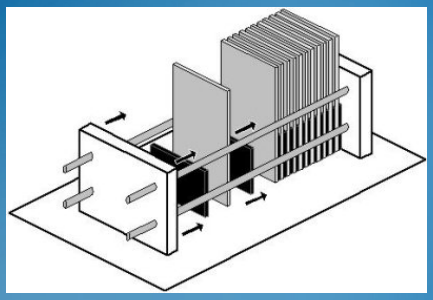


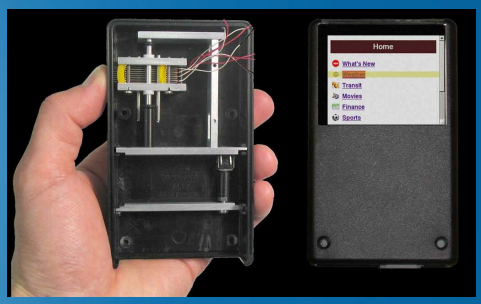
Pin matrix actuator



Piezo actuator for touch screens

►Tactile Interfaces

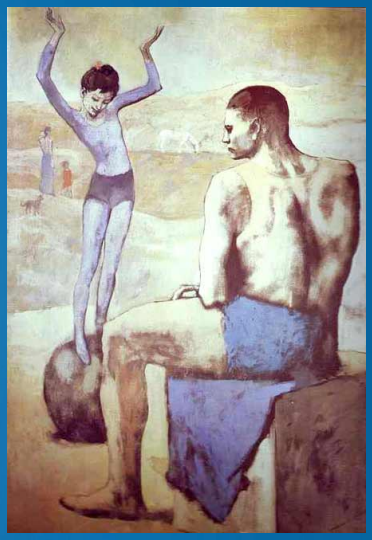




- Lateral tactile displays (McGill University)

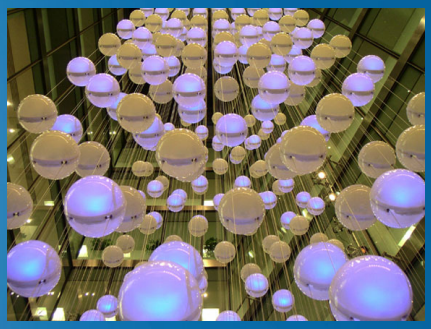
►Haptic displays

- Haptic displays in 3D UI
  - Physical, hasptic properties are essential element of 3D experience.
  - Simulation of objects physical properties, e.g. stiffness, weight
    - application in medical simulators
  - Simulation of surface properties, e.g. texture, roughness, etc.
  - Guiding the user through haptic feedback
    - e.g. desktop haptics
  - Alerting, simulation of impact
    - e.g. games
- Effect on user performance
  - Faster and more precise manipulation
  - Immersion and higher believability



►Shape and actuated displays

- Direct shape creation and interaction through physical motion of the device
  - creating 3D structures dynamically
  - creating 3D relief structures with or without visual overlay
    - different scales from building to hand-held device
    - touchable and not touchable
  - creating creature-like structures
    - entertainment robots



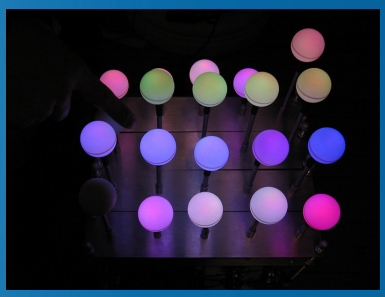
Source by Greyworld

▶Shape and actuated displays

- Lumen by Poupyrev
- Snoil by Frey

►Shape and actuated displays

- Aegis Hyposyrface
- Glowbits



►Shape and actuated displays

- Outerspace

▶Shape and actuated displays

Actuated spaces

▶Conclusions

- 3D interaction is more then just visual information, its also force and tactile feedback and tactile feedback
  - improve understanding and interaction with 3D virtual environments
  - Increase, realism, immersion and enjoyment
- The physicality of interaction can be achieved by two different means
  - simulating forces and sensations communicated to the user
  - create actuated physical devices that directly simulate some properties of the virtual world
    - shape displays can be considered very primitive “Ultimate Display”
- Current research barely scratches the surface more interesting work is going to appear.