Introduction to Haptics and VR

Domenico Prattichizzo

http://sirslab.dii.unisi.it
Dipartimento di Ingegneria dell’Informazione
Università di Siena

October 2007
what is *haptic*?

from Greek *haptesthai*: *to touch*
What about Haptic Display
Computer Haptics
Types of human haptic sensing

cutaneous / tactile:
  • heat, pressure, vibration, slip, pain
  • sensation arising from stimulus to the skin

kinesthesia / proprioception:
  • limb position, motion, force
  • end organs located in muscles, tendons, and joints
  • stimulated by bodily movements
Tactile Display or Devices

cutaneous / tactile:

• heat, pressure, vibration, slip, pain
Haptic Display or Devices

kinesthesia / proprioception:

- limb position, motion, force
The Phantom Desktop (sensible inc.)

- grounded interface (solidly connected to the ground)
- similar to a robot

Movie (Pai, James)
Ungrounded Haptic Interfaces

joint angles are measured and forces applied relative to mount point on the body

Cybergrasp by Immersion inc.
Visio-Haptic Interaction

Bidirectional flow

VR

Haptic Interface

Visual Interface
Haptics in Medicine

Medical Education

• Largely unchanged in last 100 years
• Apprenticeship model
• “See one, Do one, Teach one”

Education by Random Opportunity

New Technologies for Training …
Education: key concept

I Hear, I Forget
I See, I Remember
I Do, I Understand

Lao-Tsu
604-531BC

In the last 50 years, profound advancements have been in Biomedicine, Robotics and Computer Science
Medical Applications

• training & simulation, for:
  – diagnosis
  – tissue palpation
• Minimally Invasive Surgery (MIS)
  – training through simulation
  – the real thing: “fly by wire” to improve interaction
• telesurgery
demonstrated on a human in 2002
(at the EITS in Strasbourg from New York)
Telesurgery vs training

Haptic Interface

Visual Interface

training: ? = simulator (VR),

teleoperation: ? = real (remote) data

Video (Zeus)
Haptic Display

Degrees of Freedom (DoF)
Number of independent directions of a motion
Sensing DoF(input DoF) vs Actuation DoF(output DoF)

Common force-feedback haptic interfaces
2 DoF = 2D force feedback
3 DoF = 3D force feedback
6 DoF = 3D force feedback + 3D torque feedback
Haptic Display
Computer Haptics (as Computer Graphics)

Haptic attributes of objects and surfaces

Geometrical properties
- Size
- Shape

Material properties
- Stiffness and Hardness
- Texture and Roughness
- Friction and Stickiness
- Weight
- Curvature
Force Feedback Device

- Usually, Force command that a haptic rendering algorithm sends to the force-feedback device ≠ Force output that the force-feedback device produces and in turn a user feels

- Control of a force-feedback device
  - Minimize errors between force command and output = Maximize the transparency of a force-feedback device
  - Maximize the stability of device
The Visuo-Haptic Scheme

We split haptic rendering into three main blocks. **Collision-detection** algorithms provide information about contacts $S$ occurring between an avatar at position $X$ and objects in the virtual environment. **Force-response** algorithms return the ideal interaction force $F_d$ between avatar and virtual objects. **Control** algorithms return a force $F_r$ to the user approximating the ideal interaction force to the best of the device’s capabilities.
Real Time Simulation of Physics

Movie - NON Real Time

Interaction - Real Time
Psychophysics

- The sense of Touch
- Threshold analysis
- Detection Theory

The Human Operator

Haptic devices create a closed loop between user and haptic-rendering/simulation algorithms. \( x(t) \) and \( F(t) \) are continuous-time position and force signals exchanged between user and haptic device. \( x(K) \) and \( F(K) \) are discrete-time position and force signals exchanged between haptic device and virtual environment.

The Haptic System is IMPEDENCE TYPE: it reads positions (velocities) and send back forces.
Bibliography


EECE 700B. Introduction to Haptics Spring, 2007 Department of Computer Science and Engineering POSTECH, Seungmoon Choi