Lecture 1: Introduction to haptics and Kinesthetic haptic devices

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today’s objectives

introduce you to the field of haptics (definition, why it is important, and why haptic technology is challenging)
give an overview of course content and policies
what is haptics?
haptic box

Pass it around. Feel inside.
Try to identify three objects.
Which sense is most valuable to you?

Which would you relinquish last?
**hap·tic** ('hap-tik)
adj. Of or relating to the sense of touch. [Greek *haptikos*, from *haptesthai*, to grasp, touch. (1890)]

- **Cutaneous**
  - Temperature
  - Texture
  - Slip
  - Vibration
  - Force

- **Kinesthesia**
  - Location/configuration
  - Motion
  - Force
  - Compliance

The haptic senses work together with the motor control system to:
- Coordinate movement
- Enable perception

Johansson and Westling
what would life be like without touch?

Cutaneous
https://www.youtube.com/watch?v=0LfJ3M3Kn80

Kinesthesia
http://www.youtube.com/watch?v=FKxyJfE83IQ
why do we have brains?
how does your computer/smartphone/iPad see you?
what if...

you could make any surface feel fuzzy, sticky, soft...?

you could touch priceless works of art?

there was a haptic holodeck?

haptics could teach you?
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<th>Retention</th>
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what about what one feels?

haptic box

what was in there?
how did you know?
tactual stereognosis

• Tactual = tactile = via the sense of touch

• Stereognosis = the mental perception of three-dimensionality by the senses, usually in reference to perceiving the form of solid objects by touch

• One study (Klatzky et al., 1985) showed that subjects could identify 100 common objects almost perfectly, taking about 2 seconds per object.

• People are very good at tactual stereognosis.
**Tactile Devices**
Stimulate skin to create contact sensations

**Hybrid Devices**
Attempt to combine tactile and kinesthetic feedback

**Kinesthetic Devices**
Apply forces to guide or inhibit body movement
existing applications of haptics

entertainment

education

human-computer interfaces
course overview
by the end of this course, you should:

- understand selected topics in haptics for virtual environments and teleoperation (see specific objectives on syllabus)
- improve your paper reading and presentation skills
- experience defining a design/research problem and investigating it
- be creative and have fun!
structure

Lectures by Allison and the CAs give way to lectures by you as the quarter progresses

grading

10% class participation
30% assignments
10% paper presentation
50% project
course content

Part 1  Design and control of kinesthetic interfaces
Part 2  Tactile devices
Part 3  Teleoperation
Part 4  Human haptics
Part 5  Haptic interface evaluation
Part 6  Student presentations
by the end of this course, you should be able to:

- Identify the primary mechanisms of human haptic sensing
- Understand a number of methods for sensing the position of and actuating haptic interfaces
- Describe the differences between grounded and ungrounded force feedback
- Identify salient features of a haptic device design
- List a variety of different types of haptic interfaces
- Implement controllers to render various dynamics (stiffness, damping, inertia)
- Describe and implement basic telemanipulation controllers
- Understand the causes of instability in virtual reality and teleoperation systems
- Design psychophysical and perceptual tests
- Describe applications of haptic devices
- Develop a new haptic device or application of a haptic device
- Read, evaluate, and critique research papers
- Design and deliver a research presentation
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fill out the survey
http://www.stanford.edu/class/me327/assignments/survey.pdf
(return to my office or in class by Thursday class time)

fill out when2meet poll
https://www.when2meet.com/?6566122-ccxKO (by Wednesday)

register on piazza
https://piazza.com/stanford/winter2018/me327/home

pay lab materials fee
($50 check made out to Stanford University)

get access to PRL if desired
(if necessary, sign up for training at http://productrealization.stanford.edu)
kinesthetic
(force-feedback)
device basics
**kinesthetic vs. tactile haptic devices**

**Kinesthetic haptic devices** display forces or motions through a tool

- Single, resolved force

**Tactile haptic devices** stimulate the skin

- Distributed forces/displacements
Kinesthetic vs. tactile haptic devices

Kinesthetic haptic devices are usually **grounded**

- Force is transmitted from ground to hand

Tactile haptic devices can more easily be **wearable**

- Vibration feedback element encased in glove

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ME 327: Design and Control of Haptic Systems  
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typical kinesthetic device configurations

- manipulandum
drawing by Jorge Cham

- grasp
drawing by Tricia Gibo

- exoskeleton
drawing by David Grow
manipulandums (expensive)

Omega
from Force Dimension
delta configuration
3 degrees of freedom

Phantom Premium 1.5
from SensAble/Geomagic
5-bar + rotation
3 degrees of freedom

Virtuose
from Haption
additional “wrist”
6 degrees of freedom

all images from Wikimedia Commons
manipulandums (cheaper)

Falcon from Novint
- delta configuration
- 3 degrees of freedom

Phantom Omni/Touch from SensAble/Geomagic
- 5-bar + rotation
- 3 degrees of freedom

Sidewinder from Microsoft
- spherical mechanism
- 2 degrees of freedom
Grip/grasp

Custom haptic gripper for Phantom Premium


Single-finger Cybergrasp from Cyberglove Systems

photograph courtesy Stanford Center for Design Research

da Vinci Surgical System from Intuitive Surgical, Inc. (no programmable force feedback on gripper)

photographed by Akiko Nabeshima
Exoskeletons

KINARM Exoskeleton from BKIN Technologies

Harvard

DARPA images from Wikimedia Commons
Hapkit
Hapkit
impedance-type kinesthetic devices

most force feedback devices are of the “impedance” type
"admittance"-type devices are not as common
mechatronics basics
a kinesthetic haptic system

- Human
- Haptic Device
  - Motion
  - Digital position
  - Mechatronics Interface
  - Force
  - Digital force
  - Computer
  - Teleoperated Robot?
a kinesthetic haptic system

- Human
- Haptic Device
- System dynamics
- Motion
- Digital position
- Mechatronics Interface
- Force
- Digital force
- Computer
- Rendering

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motion signals

handle (m) → drum or motor (rad) → position sensor → computer or board → virtual handle (m)

illustration by K. Kuchenbecker
force generation signals

virtual world (N) → D/A or PWM (counts) → amplifier (volts) → motor (current or voltage) → handle (N) (torque)

illustration by K. Kuchenbecker
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