Introduction to Haptic Interfaces and Its Applications

Prof. Jee-Hwan Ryu
School of Mechanical Engineering
Korea University of Technology and Education

What is Haptic?

- **hap·tic** (‘hap-tik)
  adj.
  Of or relating to the sense of touch; tactile.
  [Greek haptikos, from haptesthai, *to grasp, touch*. (1890)]

- Anything relating to the sense of touch
  - Human haptic
  - Haptic feedback/haptic interfaces
  - Machine haptics

- Haptic vs. Optic
Haptic Exploratory Procedures

- Lateral Motion
  - Texture
- Pressure
  - Hardness
- Enclosure
  - Global shape/Volume
- Static Contact
  - Temperature
- Unsupported Holding
  - Weight
- Contour Following
  - Shape


Types of Sensing

- Kinesthesia inspires Force
- Cutaneous inspires Tactile
What is Haptic Interfaces?

- "Mechatronic (computer and mechanical) systems to allow humans to feel and physically manipulate virtual or remote environments” — Blake Hannaford
From Nuclear Teleoperator

Ray Goertz 1940’s

Molecular Docking

- Fred Brooks 1970’s
- User feels interaction force between molecules
Computer Controlled Telerobot

JPL ~ 1987

The Entrepreneurial Era 1990’s

SensAble Technologies

Immersion
Current Needs and Activities

- Teleoperation
  - Exploration
  - Tele-surgery
  - Micro/Nano Manipulation

- Interaction with Computer
  - Training
  - Education
  - Entertainment
  - 3D Interaction

Exploration of Hazardous Environments

- Underwater Robot
- Space Robot
Tele-surgery

One of the biggest challenges of nanotechnology is the manipulation of the nano-sized materials. It is impossible to observe the manipulation through an optical microscope. Haptic can improve dramatically the efficiency of nanomanipulations.

Micro/Nano Manipulation

- One of the biggest challenges of nanotechnology is the manipulation of the Nano-sized materials.
- It is impossible to observe the manipulation through an optical microscope.
- Haptic can improve dramatically the efficiency of nanomanipulations.
Training

- Medical simulators

Education

- Haptic involves active and intentional action
- Combination of kinesthetics and sensory perception creates particularly strong neural pathways in the brain, Druyan (1997)
- Students are able to feel nano-sized materials such as viruses that are imaged under an atomic force microscope
Entertainments

Virtual Reality
Technical Issues of Haptic Interfaces

- Advanced mechanism designs
  - Low mass, high stiffness, high dexterity, kinematics, actuators with high T/M ratio and high resolution sensors
- Control engineering
  - Stability
  - Quality of force feedback
- Computation
  - Rendering
  - Collision detection
- Human factor (Performance measure)
  - Psychophysics
  - Ergonomics

Mechanism

- Friction and inertia force from the mechanism distort force
Stability

Performance

- Effective way to imitate physical behavior
- Multimodal (Haptic + Sound + Visual)
Rendering Issues

- Collision detection
- Computation burden

Haptic Interaction with Linear Elastic Models
Doug L. James
Dinesh K. Pai
Univ. British Columbia
April 2000

Human Factors

It was Realistic!
No way
### History of Haptic Interfaces, and What will be the Next?

<table>
<thead>
<tr>
<th>1st Generation</th>
<th>2nd Generation</th>
<th>3rd Generation</th>
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**Ubiquitous World (UW) in Near Future**

Numerous useful digital information will be available
How can we Handle Those Information?

Shift some of the load information feedback to the driver from visual sense to the tactile sense.

BMW iDrive
Haptic Information for the Disabled

H-M/C vs. H-I Haptic Interaction

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<tr>
<th></th>
<th>H-M/C Interaction</th>
<th>H-I Interaction</th>
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<tbody>
<tr>
<td><strong>Type of Device</strong></td>
<td>Desktop, Robot</td>
<td>Wearable ?</td>
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<tr>
<td><strong>Rendering Method</strong></td>
<td>Based on Physics</td>
<td>?</td>
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<tr>
<td><strong>Performance Measure</strong></td>
<td>P/F matching, Psychophysical research</td>
<td>Emotion ?</td>
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