Touch-Enabled Interfaces

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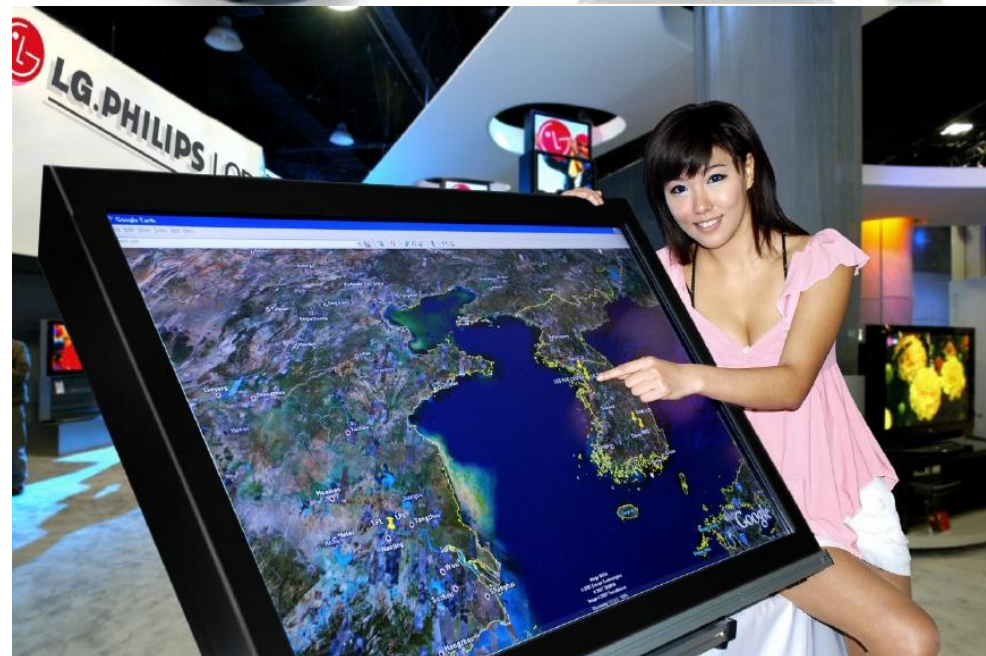http://www.cs.unc.edu/~lin

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Human Computer Interaction

Human Computer Interaction

- Visual (graphics, vision, etc)

- Auditory (sound)

- **Haptic (touch-enabled)**

- Others

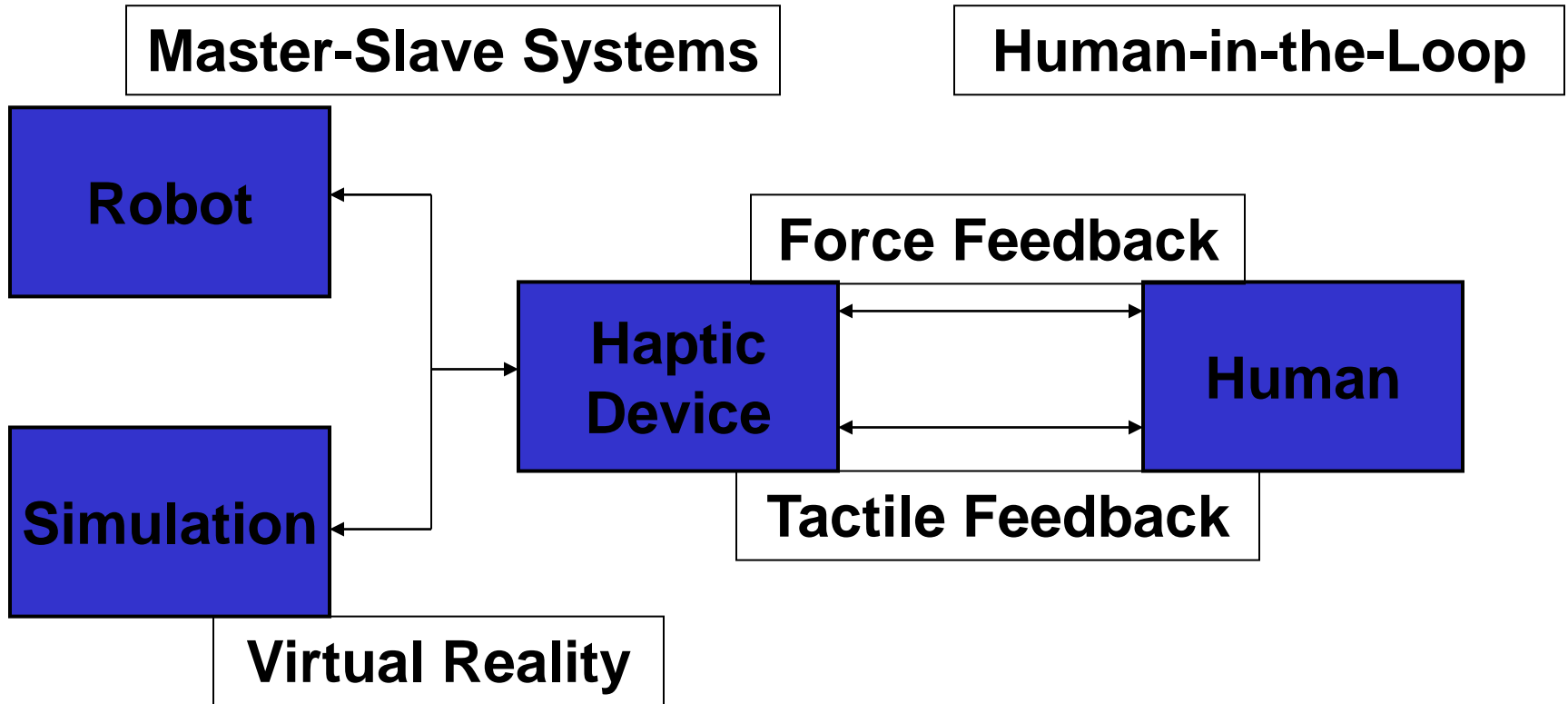# Common Touch-based Interfaces

Other Touch-based Interfaces

Benefits

- **Augment other senses**

- **Inherent 3D interfaces**

- **Physically-based interaction**

- **Assisted Technology**

- $\Rightarrow$ **Natural & Intuitive**

What Is Haptic Rendering?

Master-Slave Systems

Human-in-the-Loop

Robot

Simulation

Virtual Reality

Force Feedback

Haptic Device

Human

Tactile Feedback

Inter-disciplinary Research

| **Computer Science** | **Electrical Engineering** | **Mechanical Engineering** |

Haptic Rendering   **Control and actuators**   **Mechanical design**

↓

Computation of the forces output by the device

Control of Haptic Devices
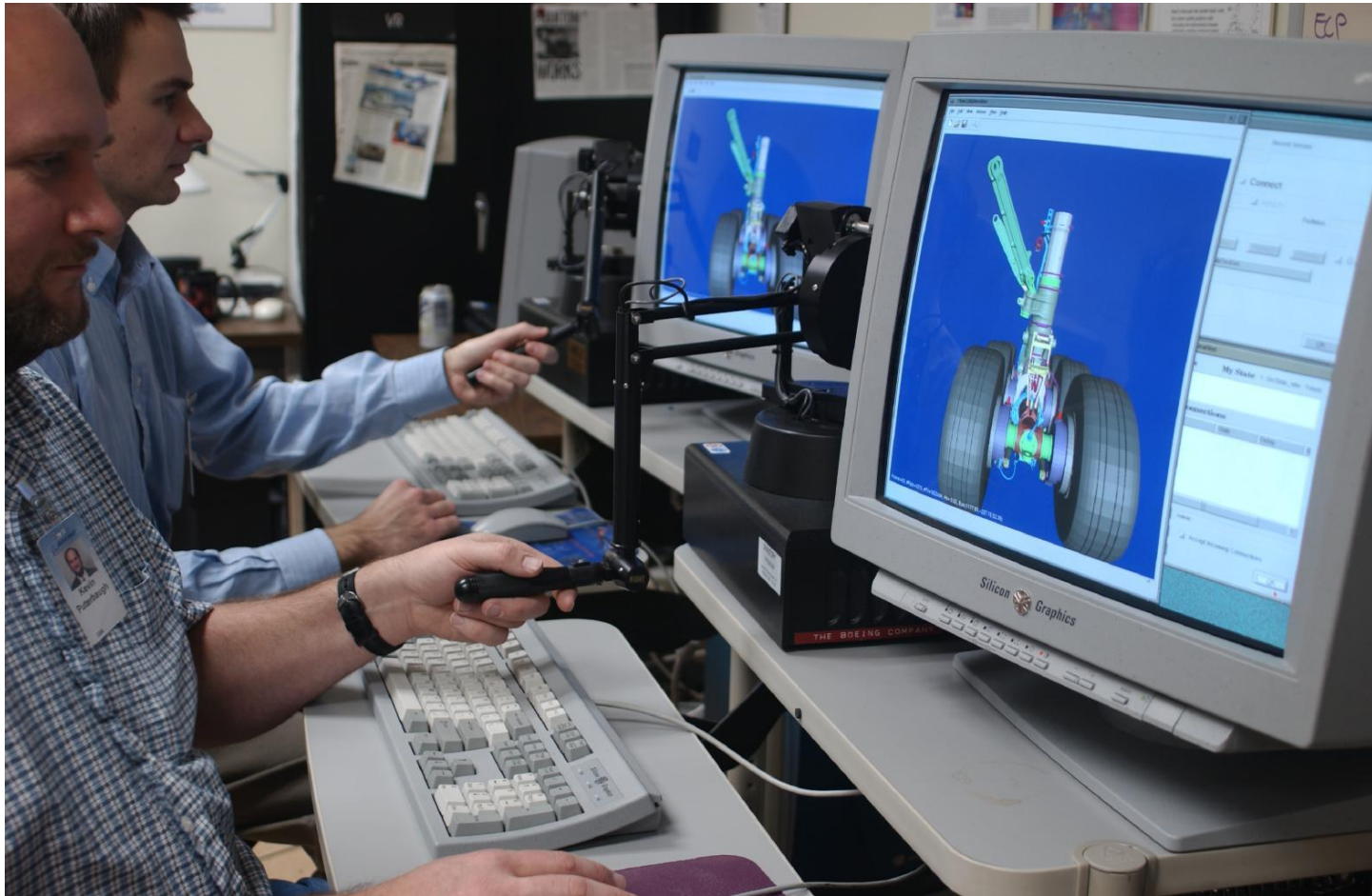
- **Impedance Devices**

- **Admittance devices**

6-DOF Phantom

COBOTs

Engine Close-Up

Boeing VPS System

# Collaborative Haptic Design Review

Other Examples

- A Haptic Hybrid Controller for Virtual Prototyping of Vehicle Mechanisms (Ford, BMW, etc)

- 3-DOF Cobot for Engineering Design

 (Northwestern University and Ford Automobile)

Medical Simulators

- **Endoscopy simulator** - Bronchoscopy and upper and lower gastrointestinal procedures on a single platform

- **Endovascular simulator** - Percutaneous coronary and peripheral interventions and cardiac rhythm management

- **Hysteroscopy simulator** - Skills assessment and myomectomy

- **Laparoscopy simulator** - Skills, cholecystectomy, sterilization, ectopic pregnancy, and myomectomy suturing

- **Vascular access simulator** - Adult, geriatric, and pediatric IV; PICC; phlebotomy; and skills assessment
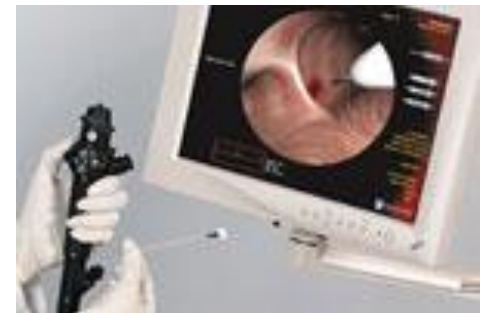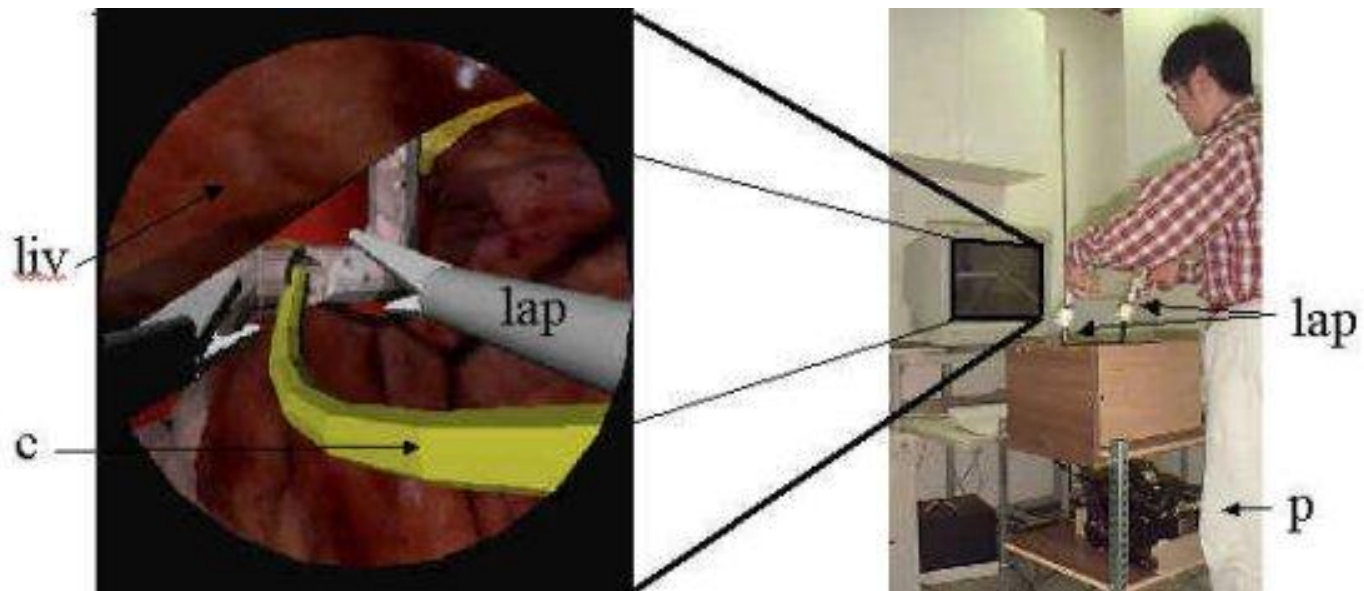
Virtual Endoscopic Surgery Training

VEST System *One* (VS*One*) Technology

- 3 haptic (force-feedback) devices as mock-up endoscopic instruments

- 1 virtual endoscopic camera

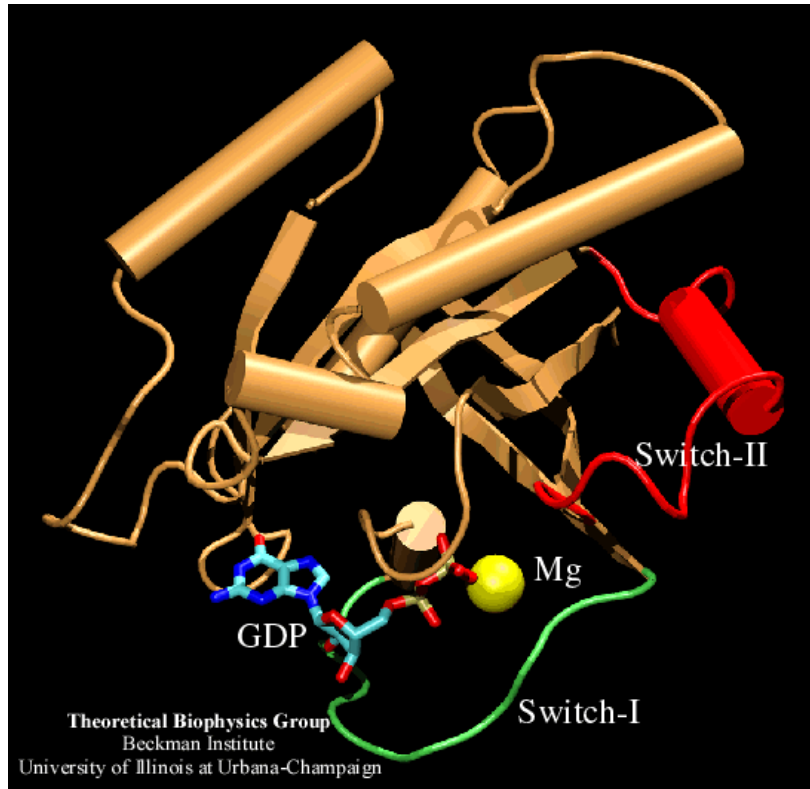- three new **Basic Task Training (BTT)** exercises - Find tubes/touch points/follow path
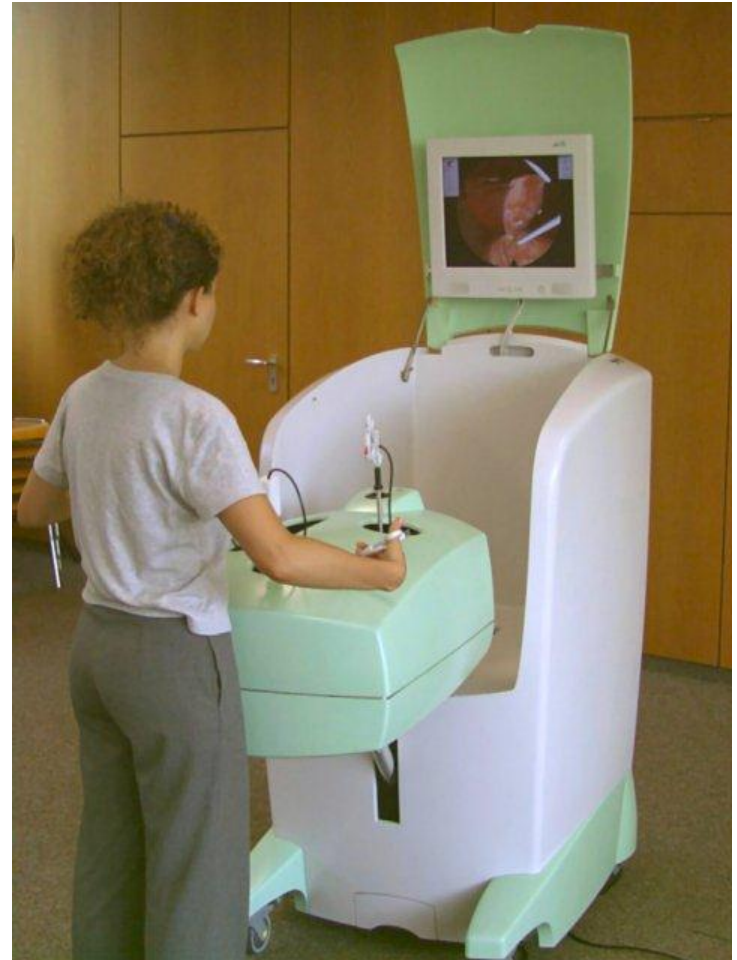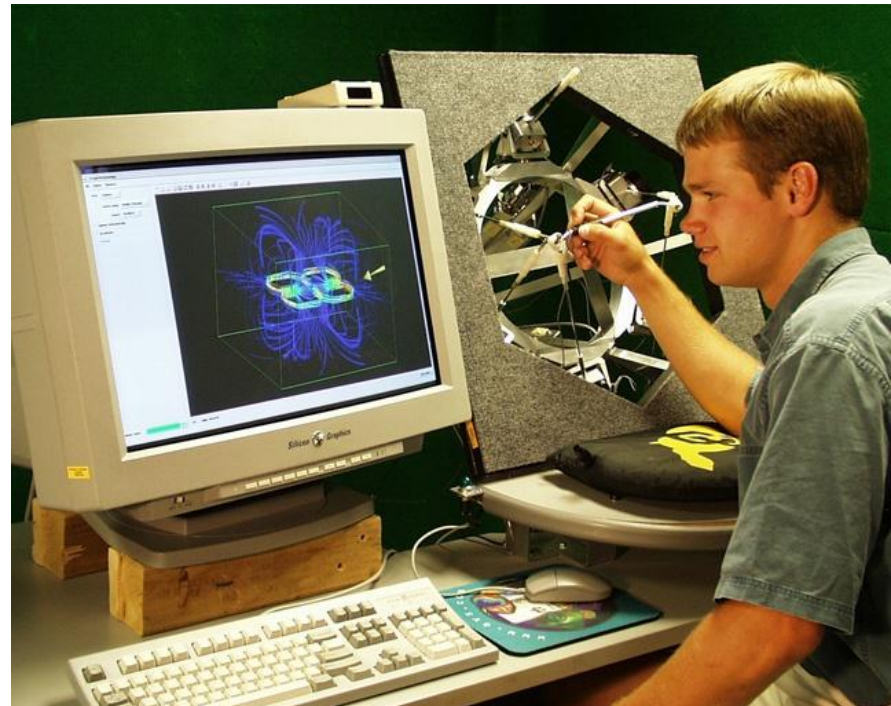
Laparoscopic Surgery

- MIT Touch Lab

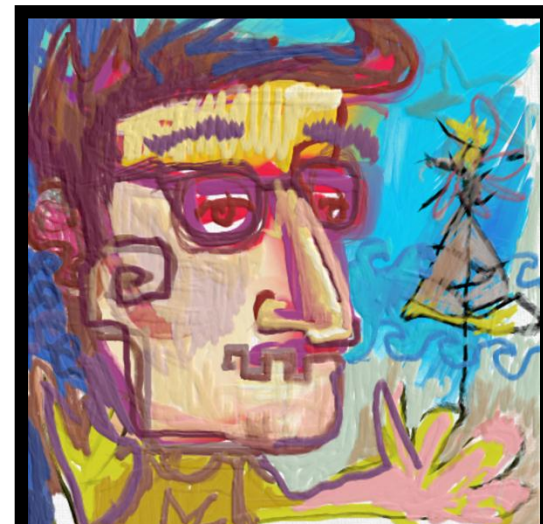# Molecular Dynamics

- VMD: Visual Molecular Dynamics

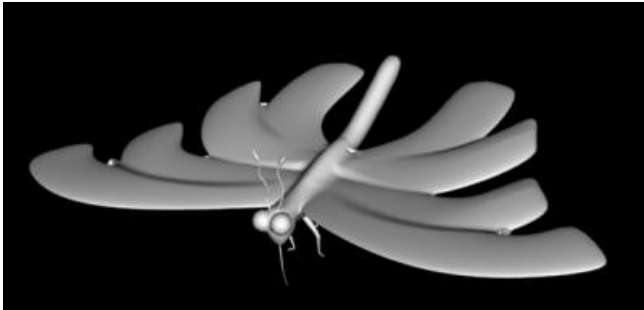**Humphrey, 1996**

Haptic Vector Field

- ## Lawrence, Lee, Pau, Roman, Novoselov
  - University of Colorado at Boulder

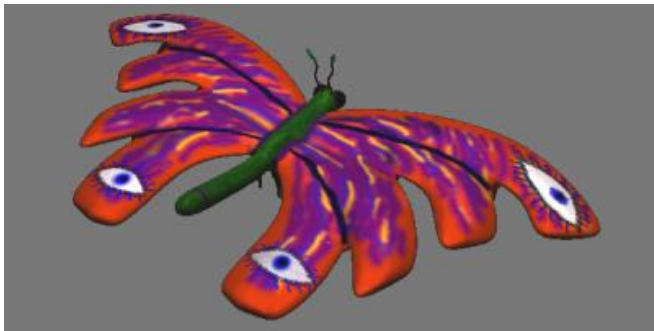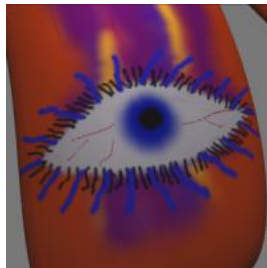- ## 5 D.O.F. in

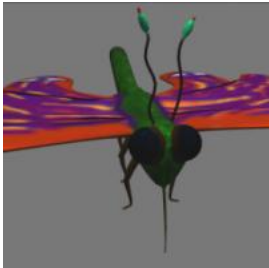- ## 5 D.O.F. out

Lawrence, 2000

dAb: Haptic Painting System

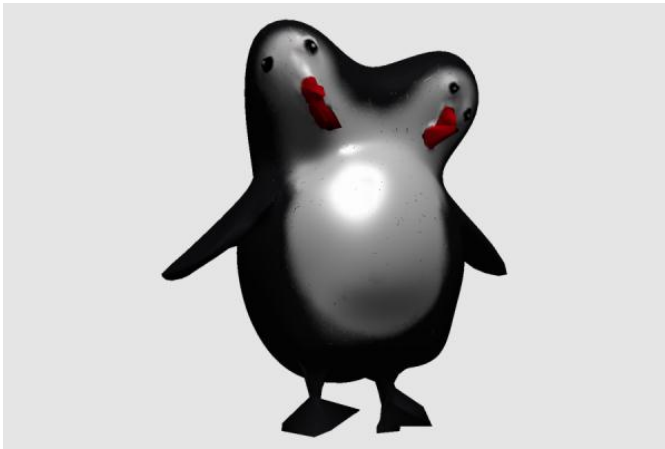# inTouch: 3D Haptic Painting

Painted Butterfly (~80k triangles)

inTouch: Multiresolution Modeling with Haptic Interface

ArtNova: Touch-Enabled 3D Model Design

- Interactive texture painting

- User-centric viewing

- Realistic force response

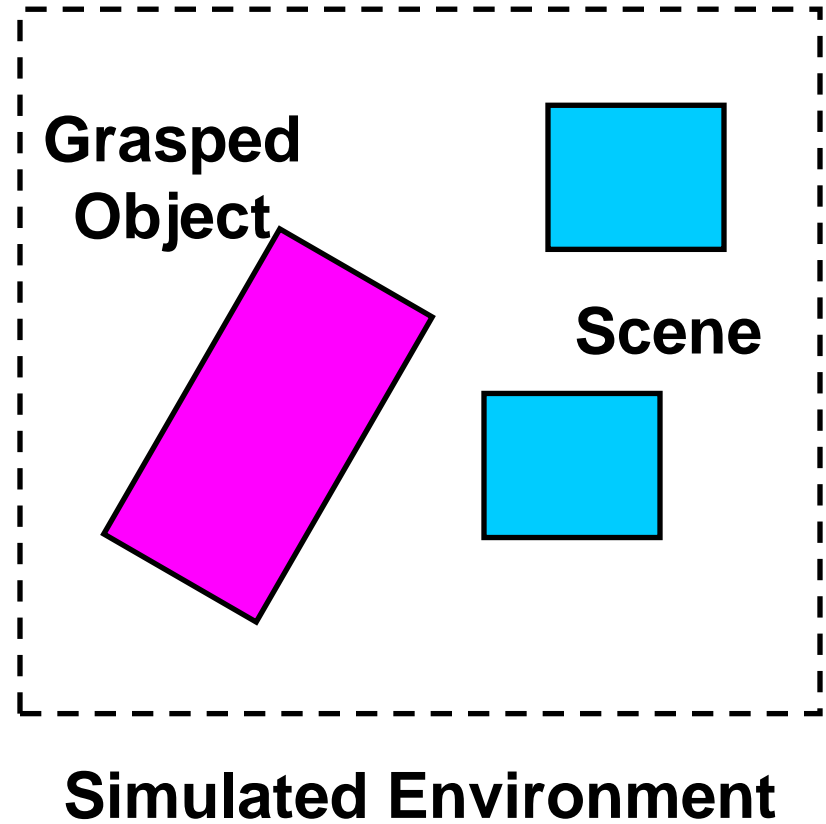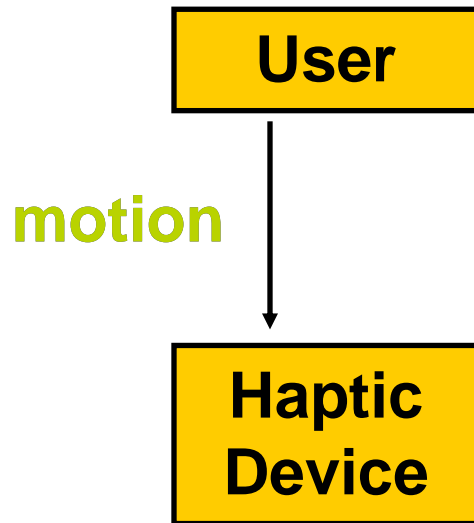**http://gamma.cs.unc.edu/ArtNova**

FreeForm Design

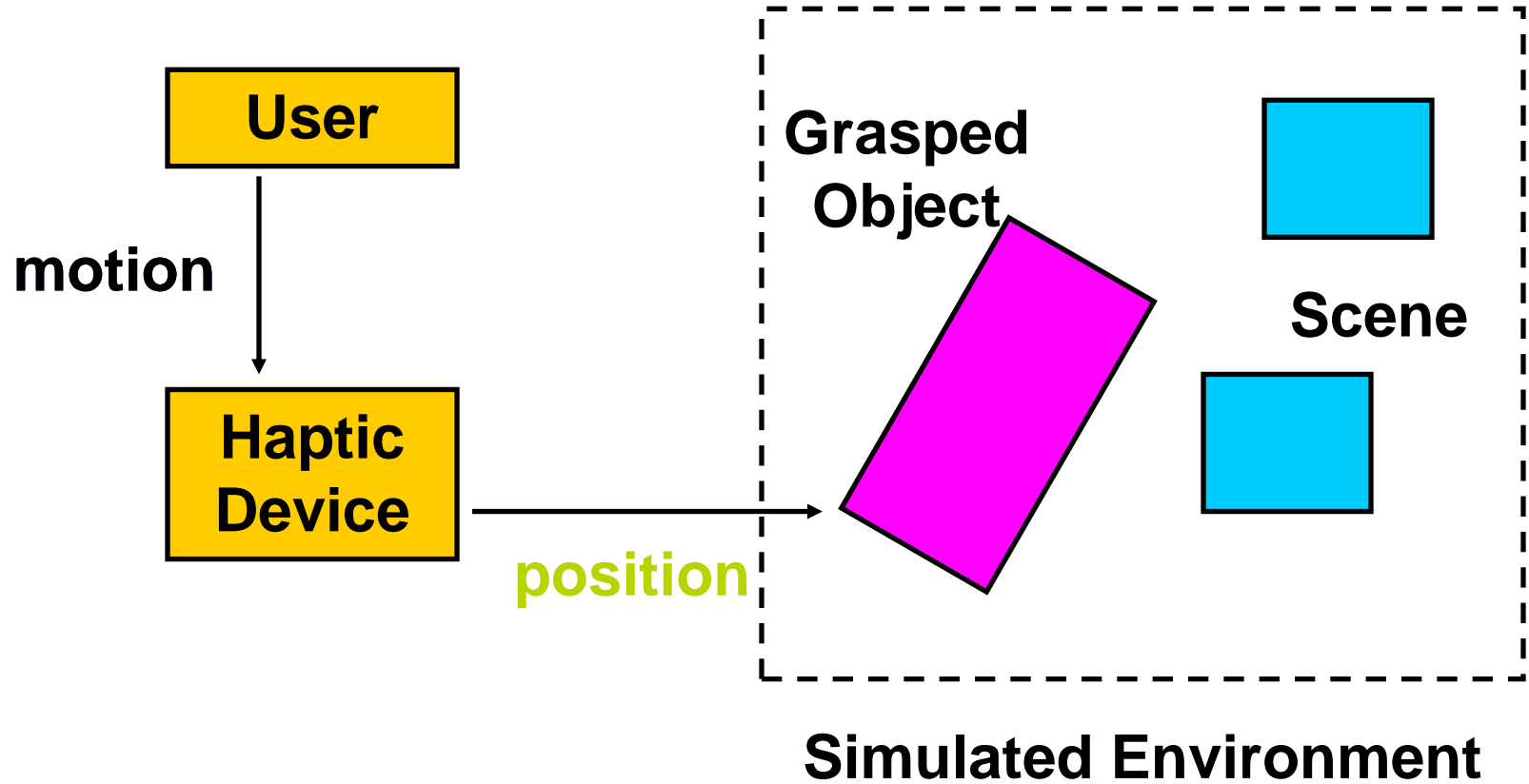**Model Gallery**
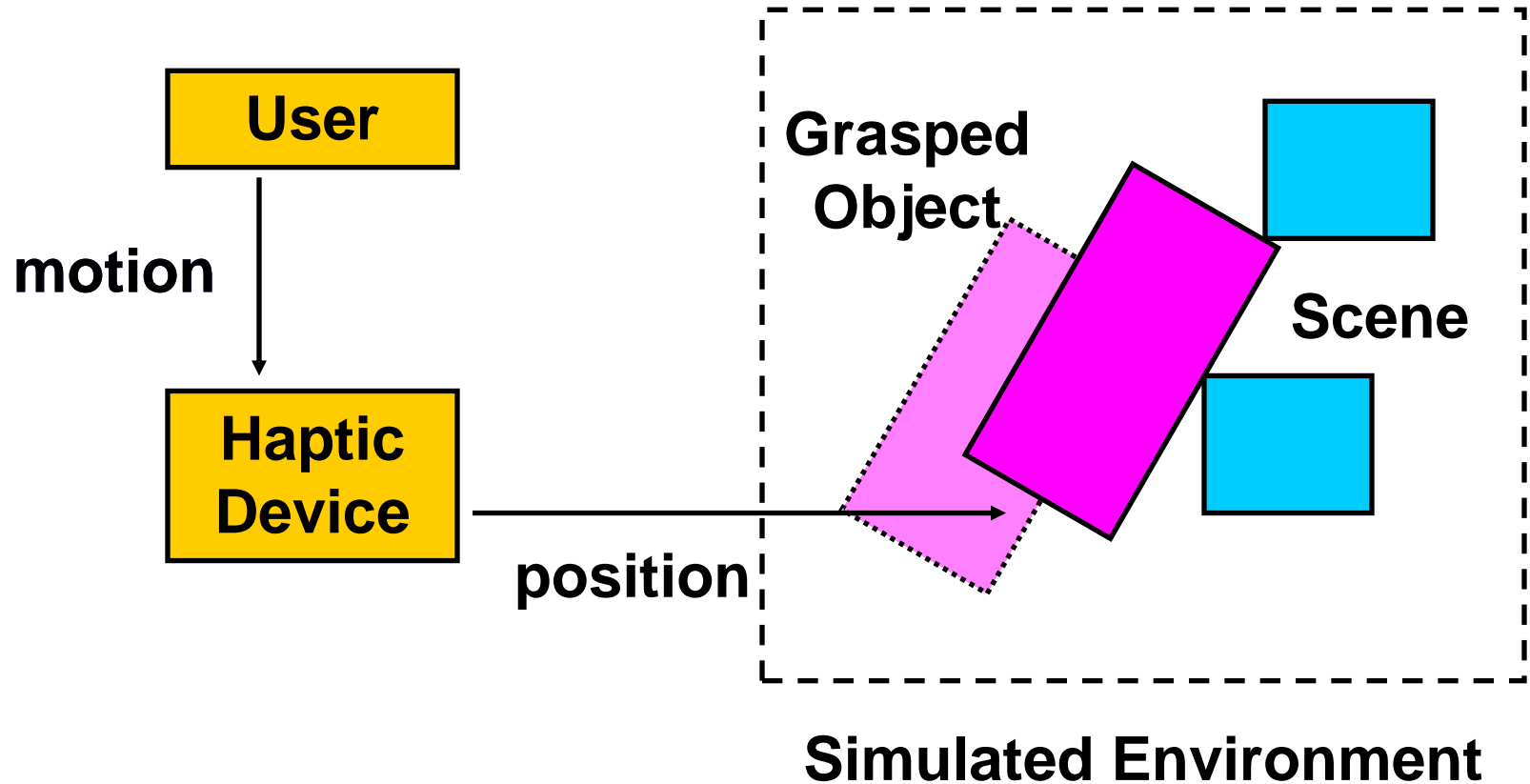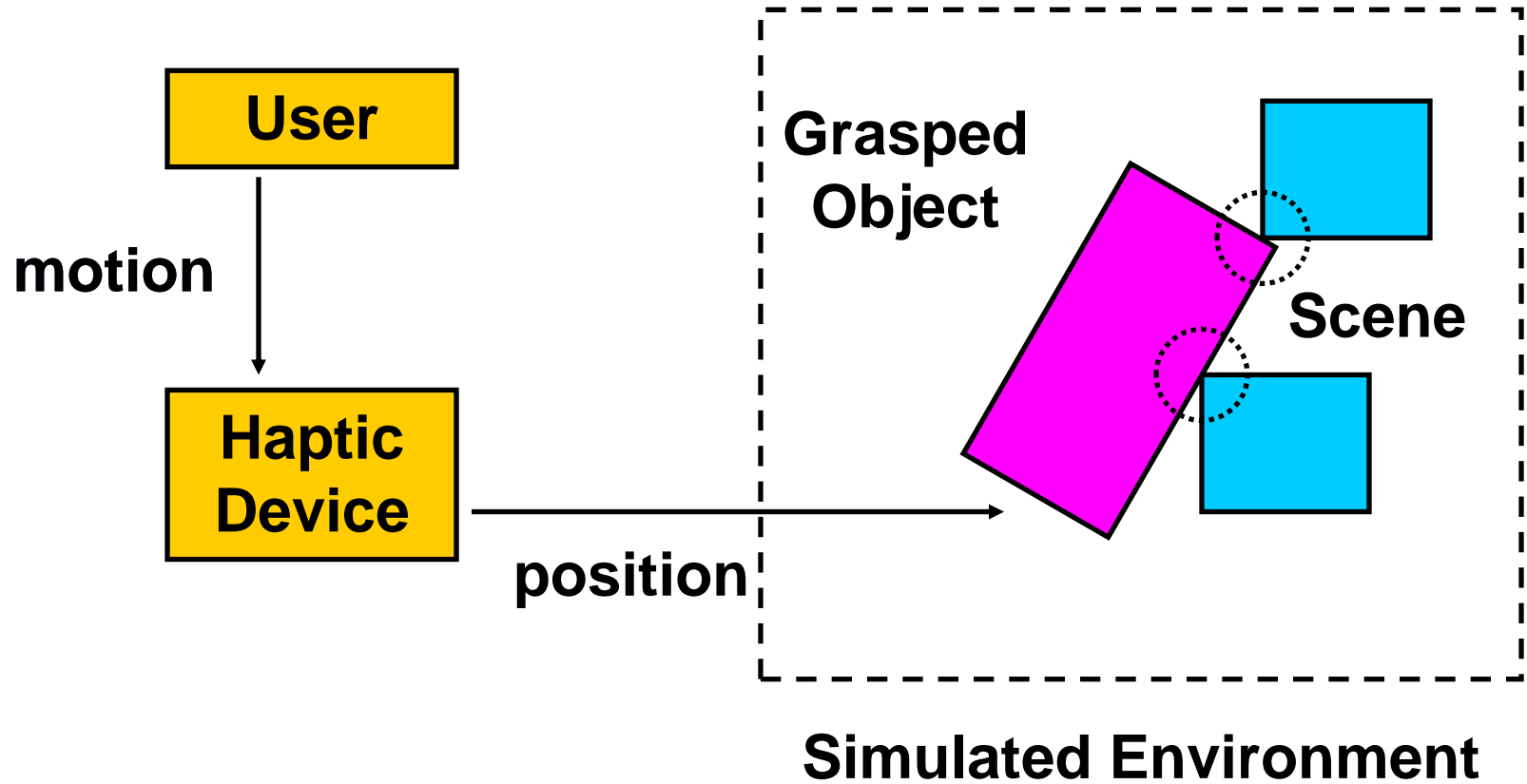http://www.sensable.com/freeform-models.htm
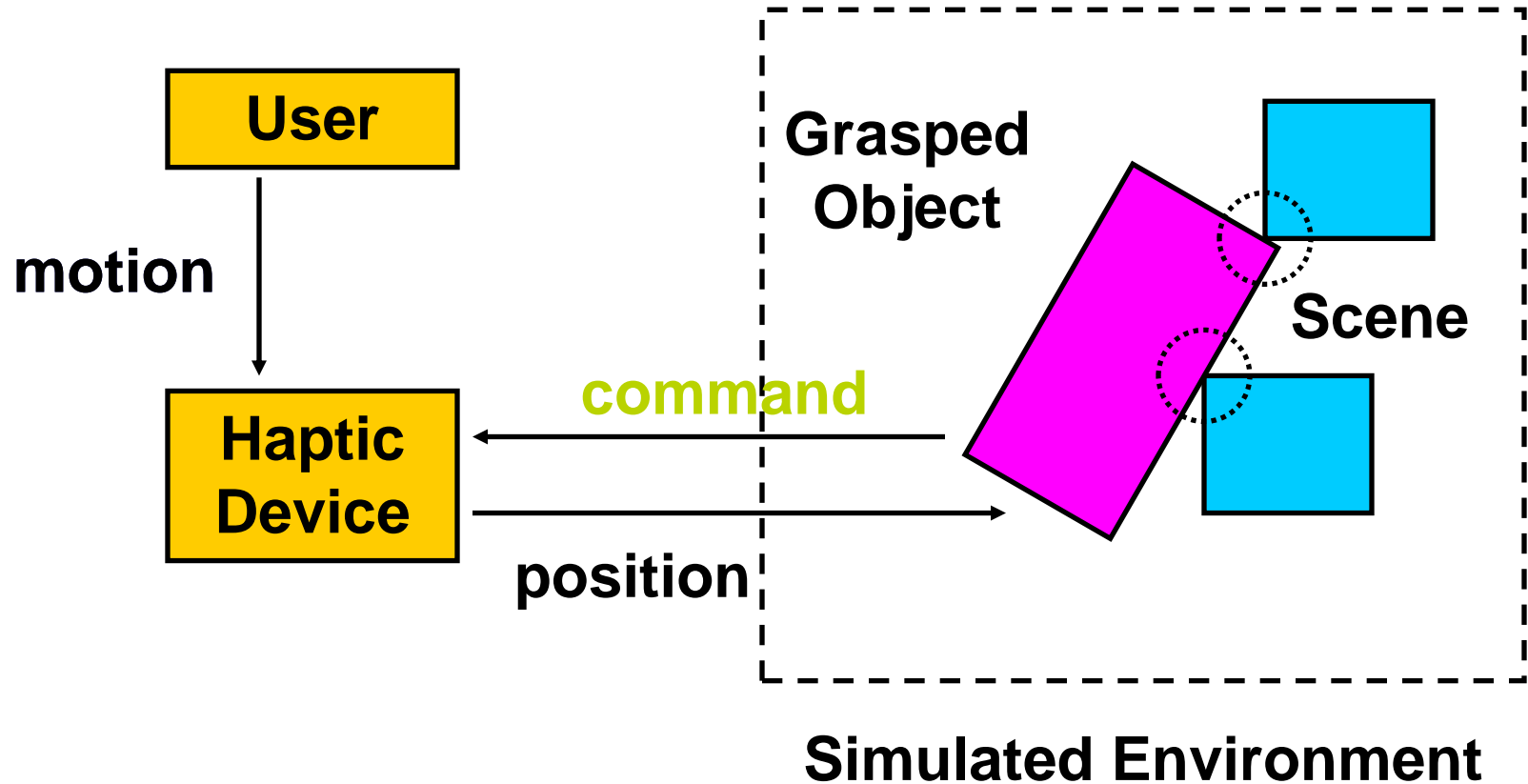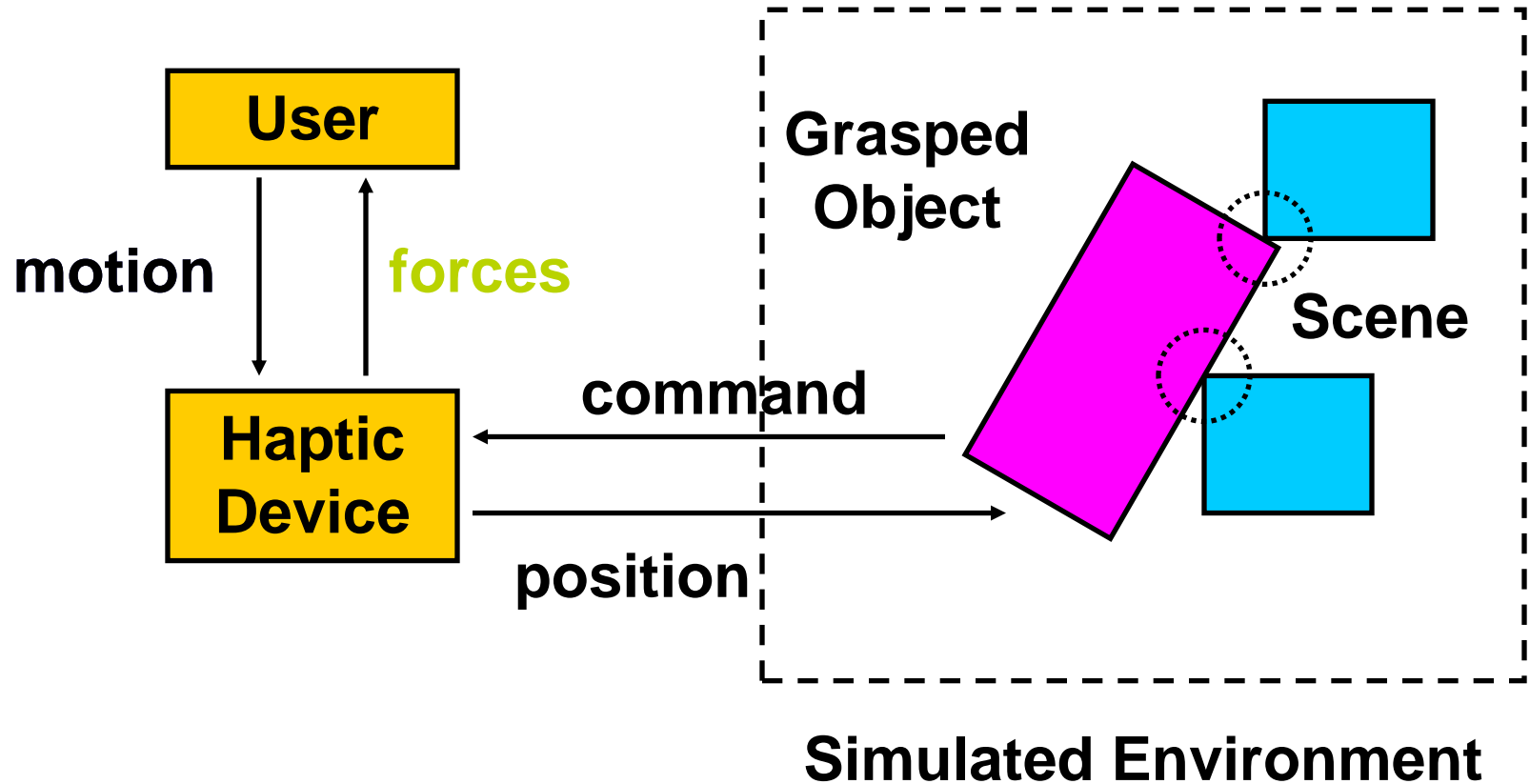
Manipulating Gears

Basic Pipeline

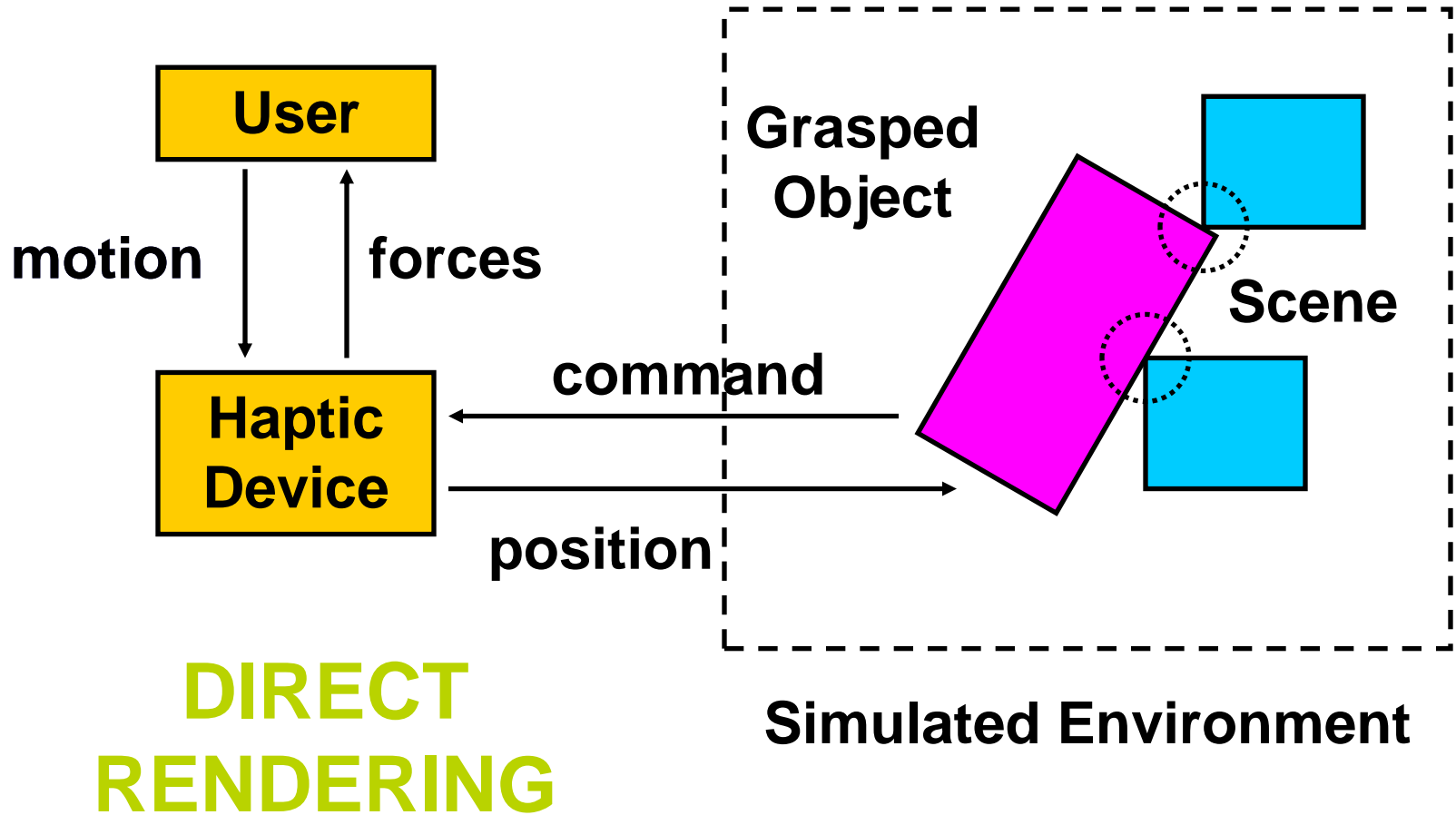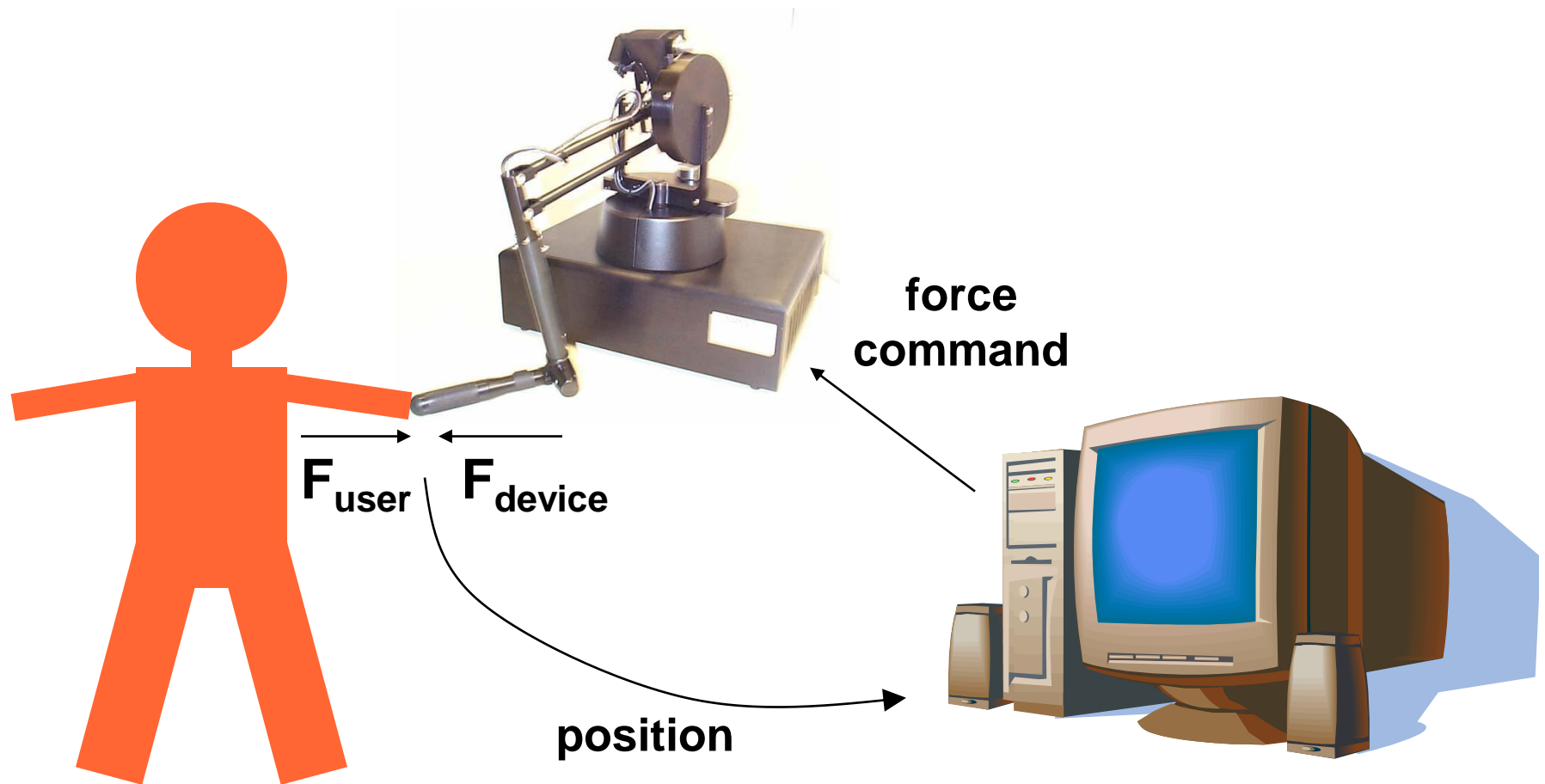# Basic Pipeline

Basic Pipeline

Basic Pipeline

Basic Pipeline

Basic Pipeline

Basic Pipeline

User

motion ↓ ↑ forces

Haptic Device

command ←

position →

DIRECT RENDERING

Grasped Object

Scene

Simulated Environment

Haptic Rendering Loop

force command

F_{user} F_{device}

position

Problem of Haptic Rendering

1. The user becomes part of the simulation loop.

2. 1KHz is necessary so that the whole system doesn't suffer from disturbing oscillations.

   - Think of the analogy with numerical integration of a system with spring, mass and damper, where the frequency of the haptic loop sets the integration step.

3. The Phantom haptic devices run their control loop at 1KHz.

4. Consequence: we are very limited on the amount of computation that we can do.

Haptic Rendering Loop
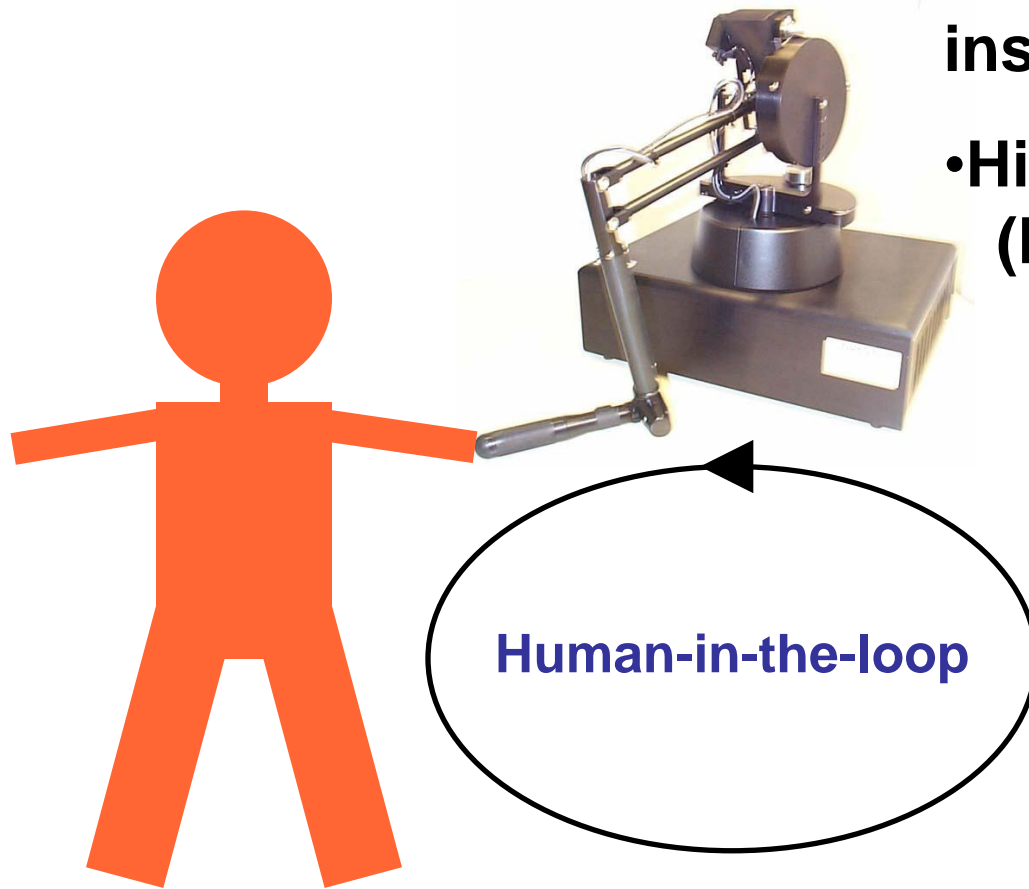
- **High sensitivity to instabilities!!**

- **High update rates required!! (kHz for high stiffness)**

Human-in-the-loop
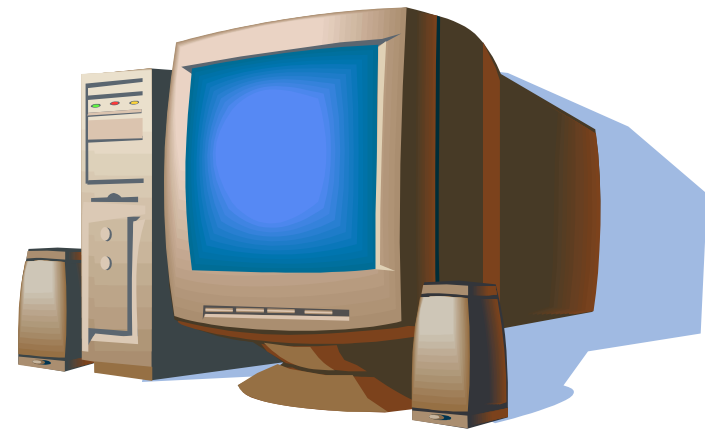
Key Challenges

- Collision Detection

  – Choice of representation and algorithm

- Interaction Paradigm

  – Penalty forces vs. ***constraint-based optimization***

  – Virtual coupling vs. direct rendering

  – Newtonian dynamics / Quasi-static approximation

  – Single user *vs.* collaboration

Additional Issues

- Decouple haptic and simulation loops?

  – Use intermediate representations?

- Force type and quality

  – How hard does hard contact feel?

  – How free does free-space feel?

    - Repulsive forces?

    - Force artifacts / stability considerations