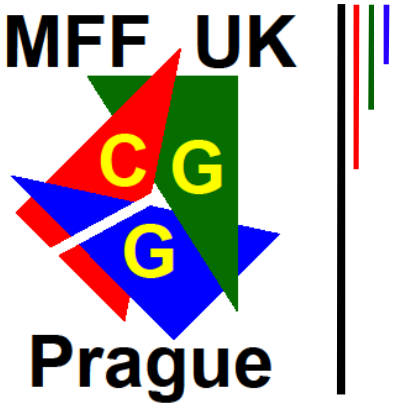

Haptics – Don't Lose Touch with Virtual Reality

Petr Kmoch
Computer Graphics Group
MFF UK
http://cgg.ms.mff.cuni.cz/~kmoch/

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What is “Haptics”?

- Touch-based computer interface involving force
- Haptic ≠ tactile
  - Force × pressure
- Broad sense: force feedback controllers
  - Steering wheels, Nintendo Rumble Pak, Nintendo Wii, Sony DUALSHOCK, …
- Narrow sense: force I/O devices
  - PHANTOM, omega, CyberGrasp, Freedom, …

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Presentation

- User's view
  - Practical notes, overview
  - No claim of completeness
- Outline
  - Introduction to haptics
  - Device overview
  - chai3d
  - Live demo

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Introduction to Haptics

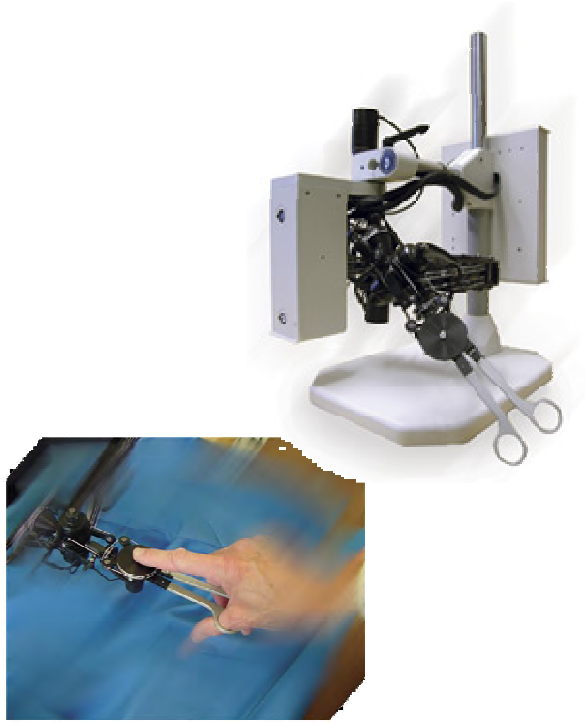
- Another scene modality

  Sight Hearing Touch

- Haptics = force-based
  - Sensing and applying forces (I/O)
  - 3D shape
- Tactile = pressure-based
  - (Fine) texture

Why Bother?

- Realistic haptic rendering
  - 3D perception
  - Material differentiation
- Non-realistic haptic rendering
  - Helps visualization
  - Potential fields, flow, …
- Professional training
- Visually impaired users



MPB F7S device
Images © MPB Technologies Inc.

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Technical Issues

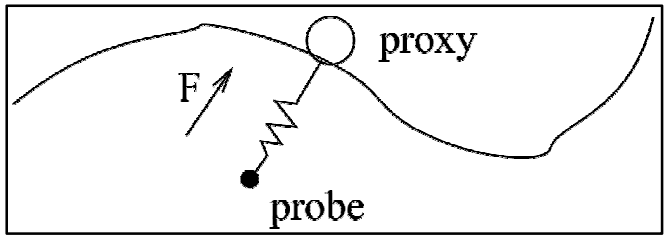
- Rendering frequency
  - Visual: 25-30Hz
  - Haptic: 1kHz
- Device costs
  - Typically n×€10,000
- Device APIs
  - Manufacturer-specific
  - Some multi-device alternatives

Haptic Rendering (what)

- High level
  - Surface properties
    - Friction (static, dynamic)
    - Stiffness
  - Force fields
    - Function of device position
- Low level
  - Forces, torques

Haptic Proxy

- Common force computing mechanism
- Proxy object in scene
  - Device (probe): copies physical position
  - Proxy: blocked by virtual scene
- Collisions tested for proxy
- Force applied towards proxy
  - Typically spring-like
  - Depends on surface properties



Haptic Rendering (how)

- Haptic thread
  - *Push* approach
  - Custom thread running at 1kHz
    - Reading position
    - Writing forces & torques
- Callbacks
  - *Pull* approach
  - Haptic thread is in driver (or device)

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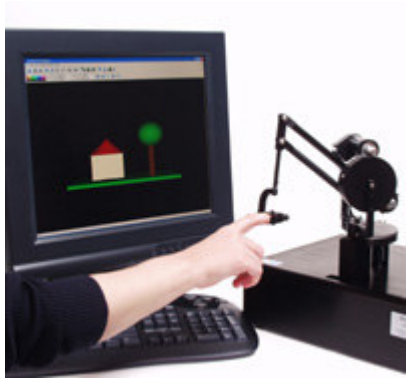
Device Classification

- Input degrees of freedom
  - 3DOF: position
  - 6DOF: position & rotation
  - 7DOF: 6DOF + extra (grip, scissors, …)
- Output degrees of freedom
  - 3DOF: forces
  - 6DOF: forces & torques

Technical Parameters

- Workspace dimensions
- Angular range
- Force range
- Sensitivity
- Force compensation

3-DOF Devices

omega.3	Cubic3	PHANTOM Premium	Falcon
			
Force Dimension	MPB	SensAble	Novint

6/3-DOF Devices

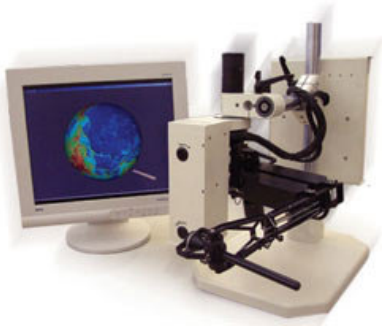
omega.6	PHANTOM Omni	PHANTOM Premium	Virtuose 3D15-25
			
Force Dimension	SensAble	SensAble	Haption

6-DOF Devices

delta.6

Force Dimension

Freedom S6



MPB

PHANTOM Premium 6DOF

SensAble

Virtuose 6D35-45

Haption

Special Devices

omega.7	Freedom 7S	CyberGrasp	Falcon
			
Force Dimension	MPB	Immersion	Novint
Grasping	Medical	Glove add-on	Cheap :-)

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chai3d

- Open-source library (GPL)
- C++, OpenGL
- Windows, beta Linux
- Multi-device
  - PHANTOM, delta/omega, Freedom, Falcon
  - Virtual device
- Scene graph

Feature Overview

- Graphic display
  - Viewport
- Scene graph
  - Mesh, camera, material, light, tool, shader, …
- Collision detection
  - AABBs, spheres
- Force algorithms
  - Point contact, potential field
- Devices
  - Single-device, virtual device, meta-device
- Utilities
  - Loaders, algebra, text labels, timers, arrows, …

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Setup

- Create scene graph (world)
  - Lights, meshes, potential fields
  - Camera, tool
- Create collision detectors
- Initialize haptic device
  - Setup force algorithms
- Run

Scene Graph

- All nodes derived from `cGenericObject`
  - Transformation matrix
  - Global/local coordinates
  - Collision detector
- Visualization options
  - Bounding box
  - Coordinate frame
  - Scene graph tree

Mesh Node

- `cMesh` (sub)class
  - Colors, textures
  - Material
    - Graphics (A/D/S color, shininess, transparency)
    - Haptics (stiffness, friction)
- Visualization options
  - Normals
  - Wireframe

Potential Field Node

- `cGenericPotentialField` subclass
  - Force based on probe position
  - No common properties
- Two sample classes provided
  - Sphere
  - Torus
  - Properties set via material

Haptic Tool Node

- `cGenericTool,cGeneric3dofPointer`
  - Workspace size, proxy
  - Device position and velocity
  - Force algorithms
  - Device access (`cGenericDevice`)
  - Stores computed forces
- Visualization options
  - Proxy, device

Force Algorithms

- `cGenericPointForceAlgo` subclasses
- `cProxyPointForceAlgo`
  - Renders meshes
  - Spherical proxy
  - Manages contact state
  - Moving object support
- `cPotentialFieldForceAlgo`
  - Renders potential fields

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Other Nodes

- `cGenericShader`
  - Shader applies to node's descendants
- `cBitmap`
  - Uses `glDrawPixels`
- `cCamera`
  - Projection, 2D foreground
- `cLight`
  - OpenGL light properties

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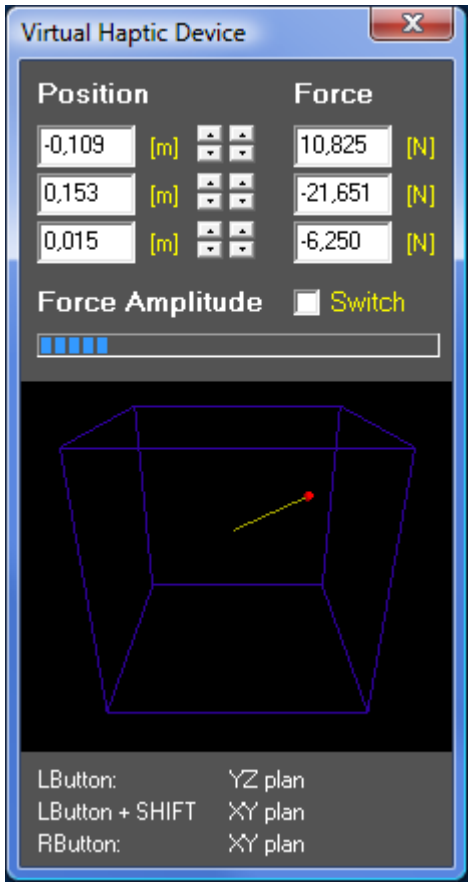
Haptic Rendering

- Haptic thread
  - Continuous or timer-based
  - Haptic call sequence:
    - `tool->updatePose()`
    - `tool->computeForces()`
    - `tool->applyForces()`
- Callbacks
  - If device supports them (now just PHANTOM)

Virtual Device

- Software “device”
  - Stand-alone .exe
  - 3DOF
  - Mouse-controlled
- Last resort for meta-device
- Can start automatically
  - In theory



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chai3d Summary

- High-level scene graph
  - Also access to low-level force computing
- Multiple devices
  - Force Dimension, MPB, Novint, SensAble
  - Run-time automatic selection possible
- Virtual device
- Extensible – virtual method mechanism
- Implementation a bit messy

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Alternatives

- Device manufacturers' SDKs
  - Device dependent, optimized, closed-source
  - Level varies
- H3D
  - Open-source, high-level
- HAPI
  - Open-source, low-level
  - Used in H3D

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Haptics Summary

- Another scene modality
  - Touch
- Haptic ≠ tactile
  - Force based
- Expensive devices
  - Falcon an exception
- chai3d, H3D multi-device APIs
- **Rendering frequency 1kHz**

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