iSphere:
A Proximity-based 3D Input Interface

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CAAD Futures 2005
Vienna, Austria
Background

• Why we need CAD tools?
• Freehand sketching
  – direct
  – Interactive
• CAD tools -> Design Media

(What’s 3D modeling?...)
Background

- What’s 3D modeling?
  - Visualizing, re-visualizing and acting
  - Bottom-up construction
  - Mode switching machinery
  - Trivial, disruptive, and low-level steps

(Problems of 3D modeling...)
Problems of 3D modeling

• Modeling 3D is not an intuitive task.
• There is a gap between mapping design concepts to shapes.
• Designers usually plan and build 3D scenes.
• To model 3D is to execute a series of low-level commands.
• Thinking and modeling simultaneously is hard.
Learning from the past

• Intuitive ways to interpret and evaluate spatial qualities of a design [Aish, ’79]
• Haptic Feedback [Murakami, ’94]
• Tangible User Interfaces [Ishii, ’97]
• Human motor systems, 6 DOF controller, DataGlove [Zhai, ’96,’98,’99]
• Gesture Modeling [Gross, ’01]
• Capacitive Skin [Rekimoto, ’02]
• Two 6DOF tokens can deform a sphere into any shape [Llamas, ’03]

(What do we need?...)

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The Goal

We need a 3D input device which can...
• be learned and shape 3D easily.
• Reduce redundant mental loads of 3D modeling.
• Enable fast-switching mental activities for designing and modeling tasks.
• Make us think and evaluate shapes more intensively.
• Provide less interruptions from manipulating commands.
• Make us focus to what’s in our mind, not the menus or commands.

(We suggest iSphere which is...)
iSphere as a free-hand 3D modeling tool

- 24 DOF input device
- Interactive Techniques
  - Realistic Interaction
  - Play and Build
- Pilot experiments
- History of iSphere
- Implementation

(iSphere demo video)
Interactive Technique

• Proactive 24 (12 x 2) DOF input device
• iSphere as a human / hand gesture detector
  – Hand gesture
  – Body position
  – Head position
• Realistic Interaction
• Play and Build
Realistic Interaction

- Spatial mapping for 3D inputs
- Analog (proximity) inputs (4 bits resolution)
- Physical manipulation
- Hand movements as metaphors (push / pull)
- Familiar gestures
- Two modes for modeling and inspecting

- Hard to interpret hand actions precisely
Realistic Interaction

Pull

Touch

Push

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Realistic Interaction

Squeezing

Pushing

Zoom-Out

Zoom-in

Rotating Viewpoints by approaching
Play and Build

• Traditional 3D modeling is bottom-up and plan-and-build process.
• Top-down modeling concepts
• Play-and-build and playback

• Neither efficient nor effective, but fun.
Pilot Experiment

• New interface
  – Command-based machinery
  – Concept-based activities
• Experiment setup
• Simple tasks (iSphere vs Mouse)
  – Pull-up action
  – Expending action
  – Modeling an apple
  – Making anything
• Pilot study video
• GOMS & Think-aloud
GOMS & Think-aloud Studies

- **GOMS keystroke analysis**
  - Analyze knowledge of how to do each task
  - **Goals, Operators, Methods, and Selection rules**
    - Mentally prepare 1.35 s
    - Move cursor 1.10 s
    - Click mouse button 0.2 s
    - Press/release mouse button 0.1 s
  - 3 novices using iSphere: 1) Pull-up 8.6 s, 2) Expend 12.5 s
  - GOMS: 1) Pull-up 20 s, 2) Expend 25 s

- **Think-aloud study**
  - Subject has to explain each action
  - Time consumption between designing and modeling
  - How to make an apple in 3D?
# History of iSphere

<table>
<thead>
<tr>
<th>C# program</th>
<th>Rhino</th>
<th>3DS MAX</th>
<th>Maya</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best performance</td>
<td>Poor performance</td>
<td>Good performance</td>
<td>Good performance</td>
</tr>
<tr>
<td>&gt; 30 fps</td>
<td>&lt; 1 fps</td>
<td>&gt; 12 fps</td>
<td>&gt; 12 fps</td>
</tr>
<tr>
<td>OpenGL (C#)</td>
<td>Rhinoscript</td>
<td>3DSMAX API</td>
<td>Maya API</td>
</tr>
<tr>
<td>Best Stability</td>
<td>Poor Stability</td>
<td>Poor Stability</td>
<td>Good Stability</td>
</tr>
<tr>
<td>Non-interchangeable</td>
<td>Good Capability</td>
<td>Good Capability</td>
<td>Best Capability</td>
</tr>
<tr>
<td>Loading mode</td>
<td>Loading mode</td>
<td>Transmit mode</td>
<td>Transmit mode + Foam</td>
</tr>
</tbody>
</table>

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Implementation

• Physical:
  – Acrylic dodecahedron

• Sensory:
  – Capacitive sensing (Transmit mode)

• Hardware:
  – PIC microcontroller

• Software:
  – Alias Maya 6.0 API
Software Architecture

Microsoft Windows XP Professional

Alias Maya 6.0

iSphere Plug-in (C++ API)  MEL Hypergraph

Serial Interface  Meta-sphere  Edit / View / Animation  3D Model
Conclusion

• iSphere is a 24 DOF 3D input device.
• iSphere exhibits a top-down approach for 3D modeling in a conceptual stage.
• iSphere can reduce mental load of command-based machinery.
• Subjects spent more time on thinking what they want, not how to build.

• Limitations
  – Fidelity (4 bits -> 16 bits)
  – Feedback (visual, tactile)
  – Fatigue problem (supports for wrists)
  – Fast mode-switching
Future work

• Improving the 4 Fs
  – fidelity, feedback, fatigue, and fast mode switching
• Applying constraints or rules to generate form
• Understanding why making a conceptual 3D input device is hard
• Proving using command-based 3D input system never satisfies conceptual design processes

• Ultimate modeling tools
  – Crafting the physical space directly (without drawing and modeling 3D)
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