EVALUATION OF 12-DOF INPUT DEVICES FOR NAVIGATION AND MANIPULATION IN VIRTUAL ENVIRONMENTS

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Overview

• Navigation & Manipulation common tasks in VR environments
• 6-DOF input devices
• Alternative: 12-DOF devices

➢ New evaluation techniques
Devices – The Cubic Mouse

[Fröhlich & Plate, CHI 2000]

- Tracker – 6 DOF
- Rods – 3 x 2 DOF
- Position Control (isotonic)
  - clenching
- Full tactile coordinate system
- Regrasping (rods)
- Maximum 8 DOF simultaneously
Evaluation of 12-DOF Input Devices

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Devices – The YoYo

[Simon & Fröhlich, INTERACT 2003]

- 2 x 6 DOF
- Rate control (elastic)
- Unlimited range of control
- No coordinate system
- Grip change
- Maximum 6 DOF simultaneously
Evaluation of 12-DOF Input Devices

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Devices – The Square Bone

[New Prototype]

- 2 x 6 DOF
- Rate control (elastic)
- Unlimited range of control
- Tactile coordinate system
- Access to all 12 DOF
- Maximum 12 DOF simultaneously
  - DOF of both sides
The Extended Docking Task

- Evaluations of 6-DOF devices
  - docking tasks
  - tracking tasks

- Extended docking task
  - combines navigation and manipulation tasks
Evaluation of 12-DOF Input Devices

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**Experiment 1: Questions**

- **Device performance / comparison**
  - Cubic Mouse worse than others due to separate DOF for manipulation
  - Cubic Mouse better due to isotonic control [Zhai 1995]

- **How does learning affect device performance?**
  - Isometric control evokes higher learning progress [Zhai 1995]
Exp. 1: Methods

• Extended docking task
• Three devices:
  Cubic Mouse, YoYo, Square Bone
• 9 sessions within 5 weeks
• Details
  – 8 volunteers (23.6 year average)
  – all right-handed
  – previous experience with various input devices
  – 22” monitor with mono setup
  – average session duration: 45 min
  ➢ 2160 overall trials
Exp. 1: Task Completion Times

- Cubic Mouse outperformed
- Variability decrease
- Comparable learning
Exp. 1: Simultaneous Control

- Cubic Mouse
- YoYo
- Square Bone

\[ r = .13 \]
\[ p < .05 \]
Exp. 2: Effects of changing display systems?

- Methods equal to Exp1, except:
  - same monitor vs. Large projection screen (4 m x 3 m)
  - mono vs stereo
Exp. 2: TCTs, different Output and Display Conditions

![Graph showing TCTs for different output and display conditions.]

- Cubic Mouse
- Square Bone
- YoYo

Output Conditions: MONO, STEREO
Display Conditions: Monitor, Screen
Exp. 1 & 2: Subjective Data

Device Usability

![Bar chart showing device usability for Cubic Mouse, YoYo, and Square Bone. Cubic Mouse has good usability, YoYo has moderate usability, and Square Bone has poor usability.](chart.png)
Exp. 1 & 2: Subjective Data

Ease of Manipulation

- Cubic Mouse
- YoYo
- Square Bone

Ease of Usage

Levels:
- Easy
- Difficult

Values:
- 0
- 0.5
- 1
- 1.5
- 2
- 2.5
- 3
- 3.5
- 4

Devices
Exp. 1 & 2: Subjective Data

Ease of Navigation

- Cubic Mouse
- YoYo
- Square Bone

Ease of Usage

- Easy
- Difficult
Conclusions (1)

- Extended Docking Task produces reliable and valid results
- Cubic Mouse inferior vs. YoYo and Square Bone
  - high degree of DOF separation
  - only "city block" trajectories possible
- Navigation with Cubic Mouse very easy
  - isotonic input control
Conclusions (2)

- **Simultaneous control**
  - experienced users only (2% of time)
- **Effects of coordinate system?**
  - effects masked
  - Square Bone’s square handles uncomfortable
  - certain diagonal trajectories possibly avoided
Future Work

- Square Bone II
- Comparison with 6-DOF devices
  - Study additional tasks
  - Combine isotonic/ isometric input
  - Constrained interaction
  - … …
THANK YOU FOR YOUR ATTENTION!
References (1)

References (2)


