

**The Interactive “Silk” Effect:  
Utilizing Semi-Transparency  
in Human Computer Interaction**

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# **Introduction: 3D Visual Interfaces**

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- **3D Graphics, Animation, CAD**
- **Information Visualization**
- **Virtual Environments**
- **Teleoperation / Telerobotics**

# Forms of 3D displays

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- Immersive, head mounted display - VR
- Desktop, monitor based, “fish tank” VR
- Large screen (or Table) projection system
- **Augmented Reality**
  - Merging virtual with real
  - Optical see-through
  - “wearable” computers
  - Stereovideo + Stereographics
  - System calibration
  - Perceptual calibration (cue conflict)

# 3D Cues and Technologies

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## Perceptual Cues

- Interposition
- Stereopsis
- Perspective
- Shadow
- Motion Parallax
- Active Movement
- *Semi-transparency?*

# 3D Cues and Technologies

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## Perceptual Cues

- Interposition
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- Motion Parallax
- Active Movement
- *Semi-transparency?*

## Interface Techniques

- ◆ Hidden surface removal
- ◆ Stereoscopic Shutters
- ◆ Perspective Projection
- ◆ Lighting Model
- ◆ Rotation, motion
- ◆ Head Tracking
- ◆ *Alpha blending*

# Research Questions

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- Does semi-transparency indeed provide depth cue?
- Can it be *utilized* in HCI?
- How much performance improvement?
- Relative strength

# Experimental Task

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- **Virtual Fishing**
- **3D dynamic target acquisition**
- **Essential element in  
3D interaction -  
Locating objects in depth**

# Experimental Task

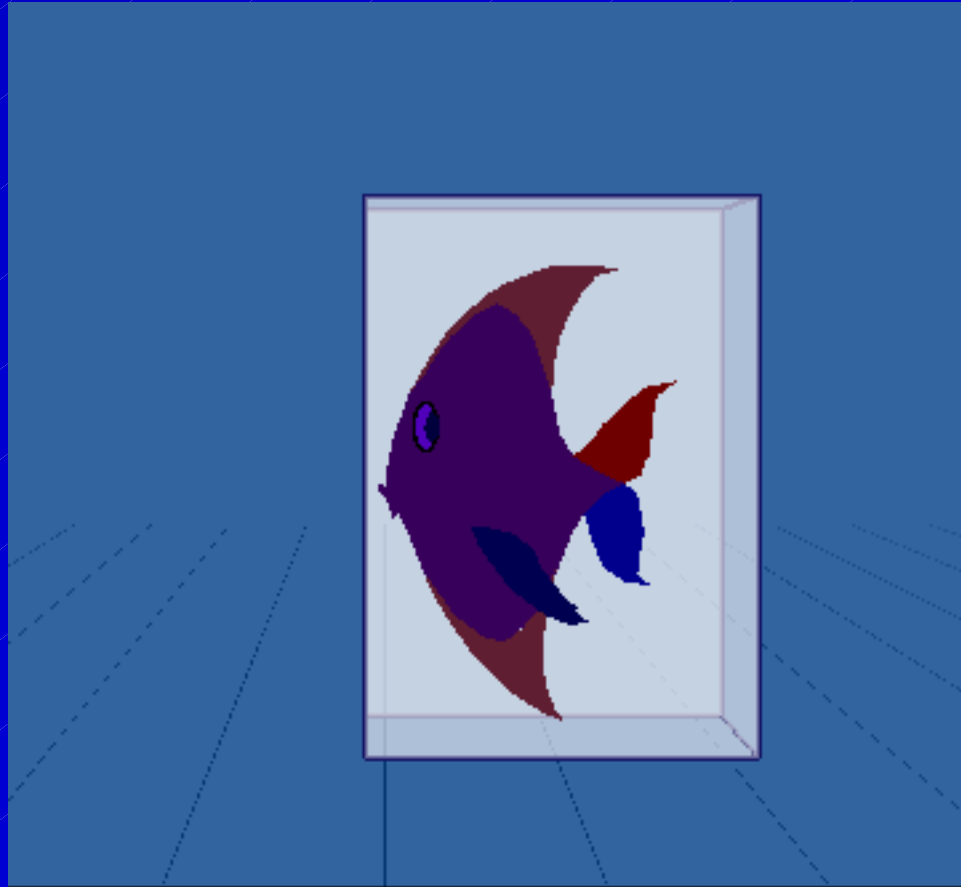
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- Input Device



# Experimental Task

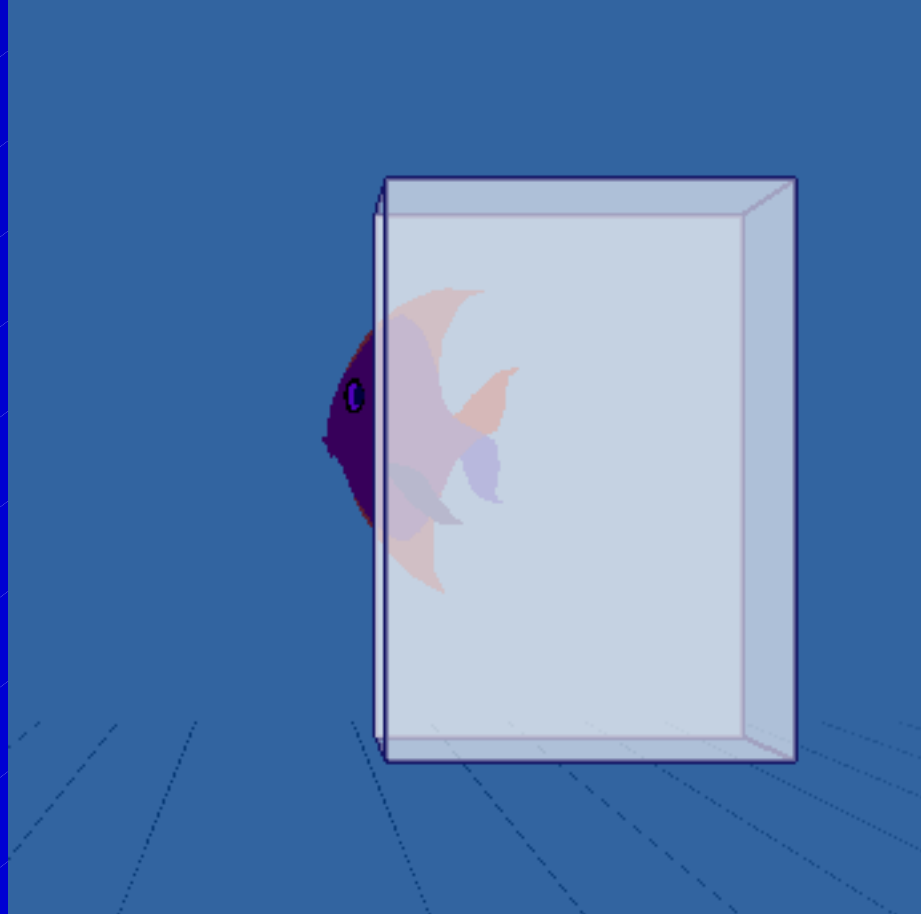
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- A fish in front of the silk cursor

# Experimental Task

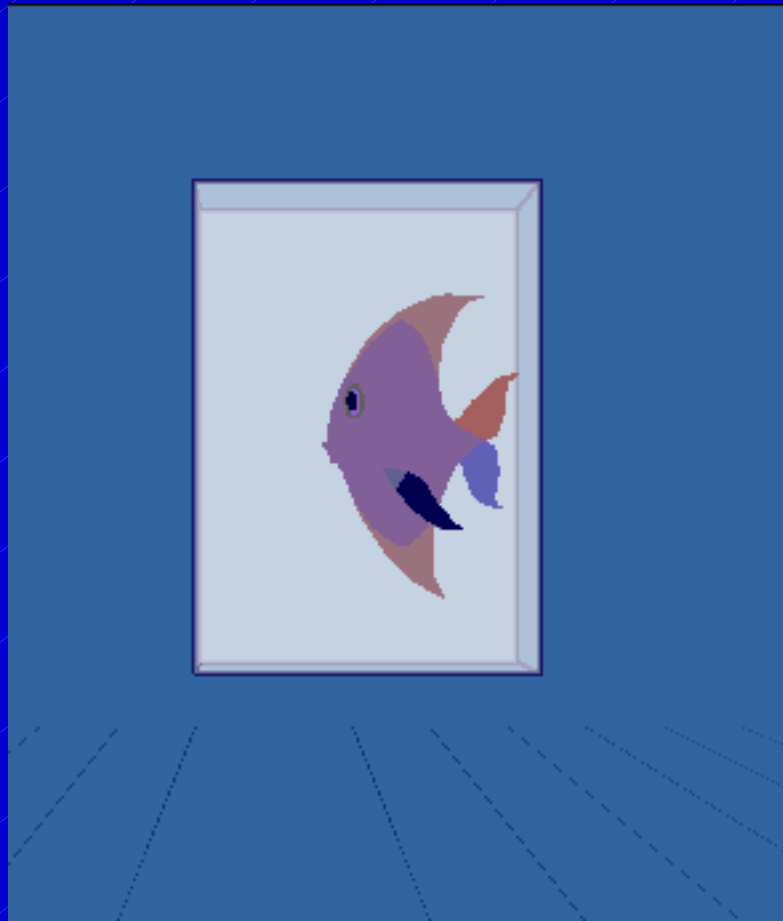
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- A fish behind the silk cursor

# Experimental Task

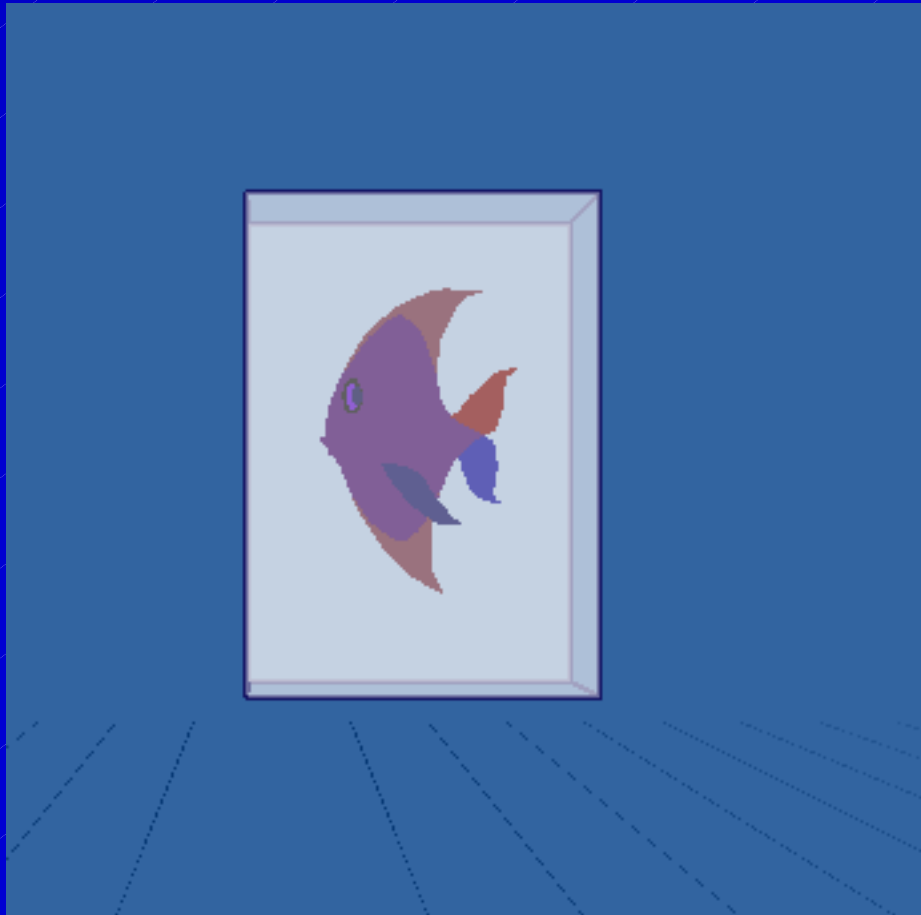
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- A fish partially inside of the silk cursor

# Experimental Task

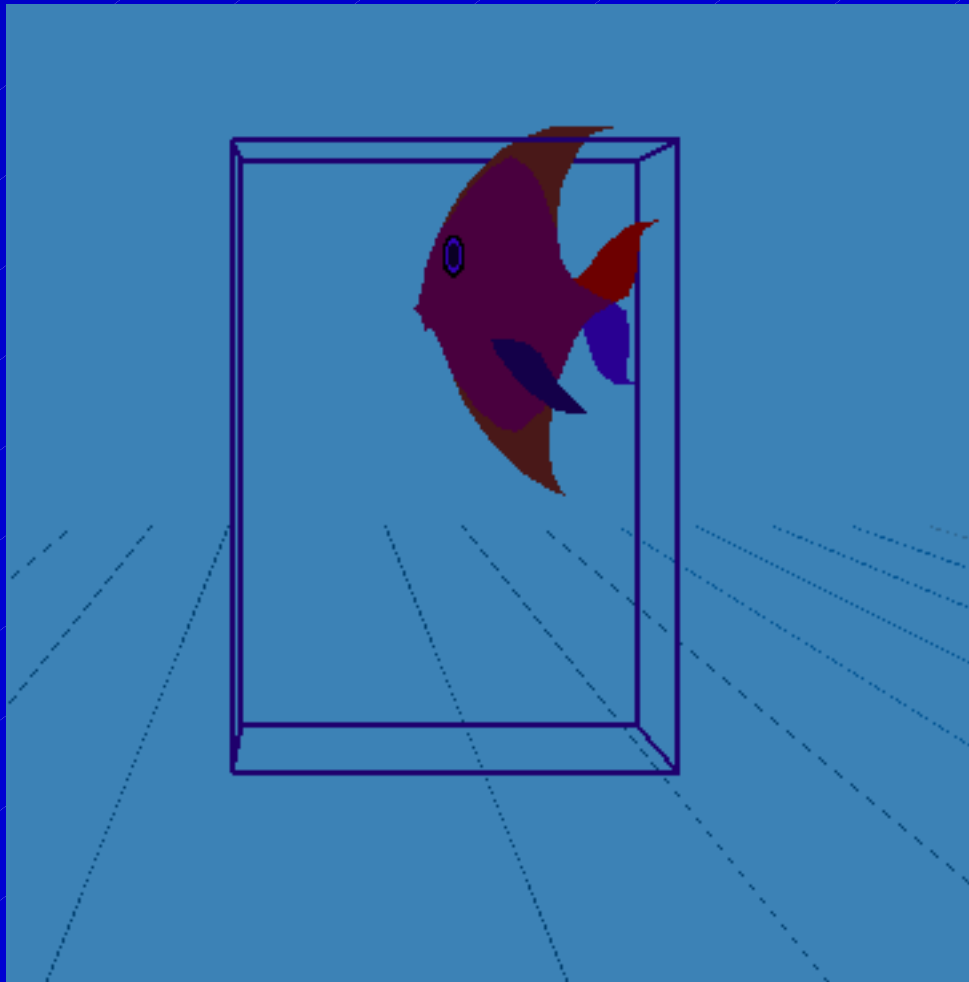
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- A fish completely inside of the cursor

# Experimental Task

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- Wireframe cursor

# Experimental Design

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- **Experimental Conditions**

<b>Cursor</b> <b>Display</b>	<b>Silk</b>	<b>Wireframe</b>
<b>Stereoscopic</b>	<b>StereoSilk</b>	<b>StereoWire</b>
<b>Monoscopic</b>	<b>MonoSilk</b>	<b>MonoWire</b>

- **Balanced within-subject**
- **12 subjects x 2 cursor types x 2 display modes  
x 5 tests x 15 trials**

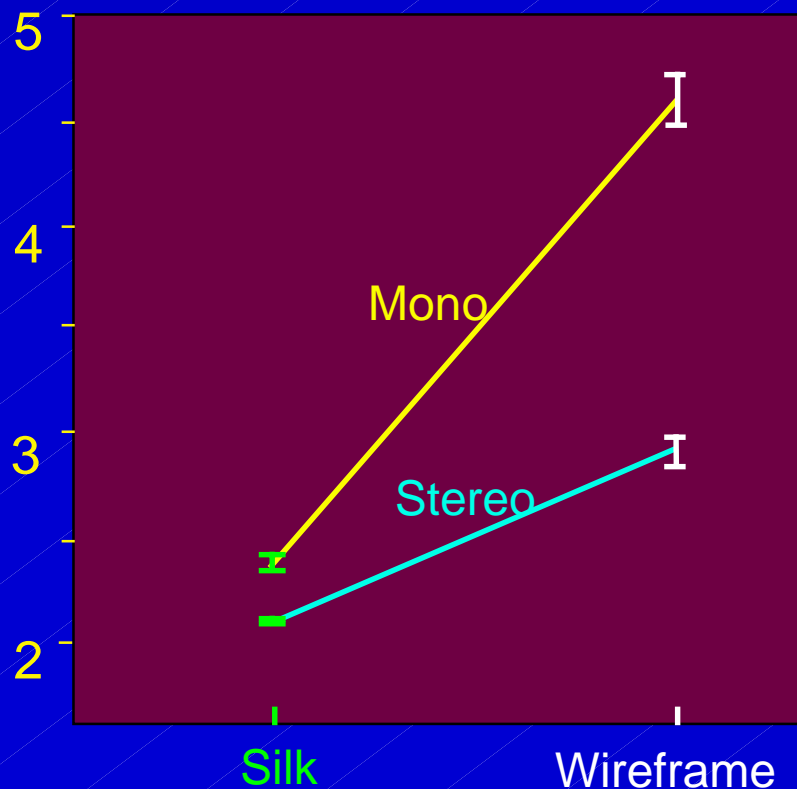
# Performance Measures

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- **Trial Completion Time**
- **Error Rate**
- **Error Magnitude**
- **Subjective Evaluation**

# Task Completion Time

Trial completion time (sec)



- **Significant factors:**

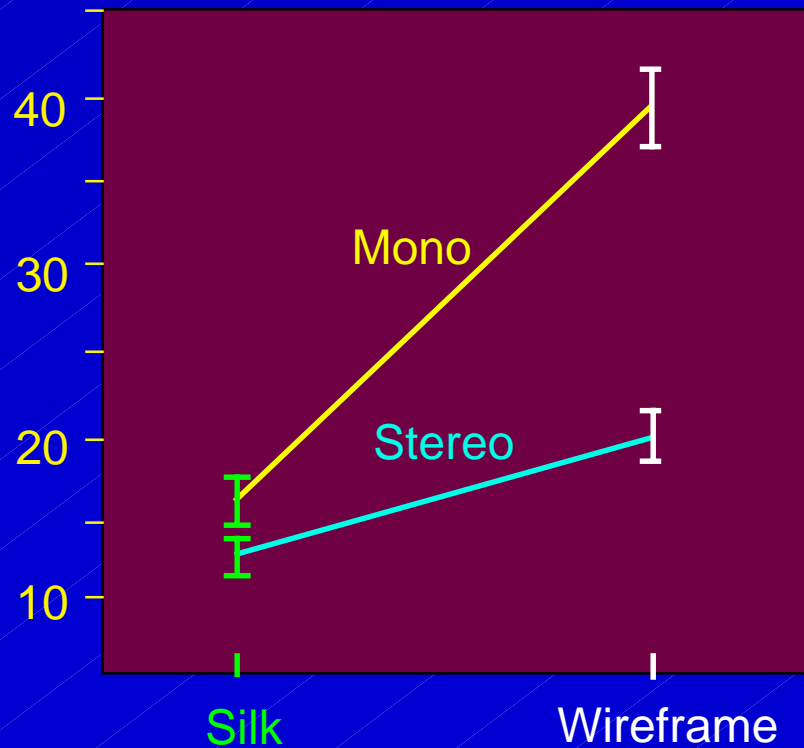
- Cursor type
- Display mode
- Cursor type and Display interaction

- **Ranking (best to worst):**

- StereoSilk
- MonoSilk
- StereoWire
- MonoWire

# Error Rate

Fish missed (%)



- **Significant factors:**

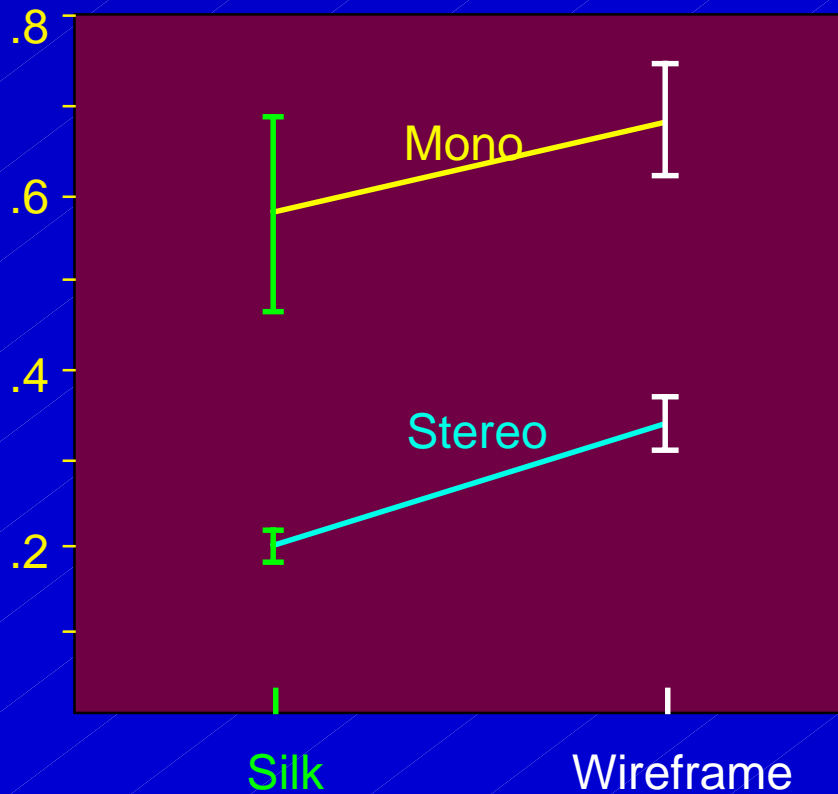
- Cursor type
- Display mode
- Cursor type and Display interaction

- **Ranking (best to worst):**

- StereoSilk
- MonoSilk
- StereoWire
- MonoWire

# Error Magnitude

Error magnitude



- **Significant factors**

- Cursor type
- Display mode

- **Ranking (best to worst):**

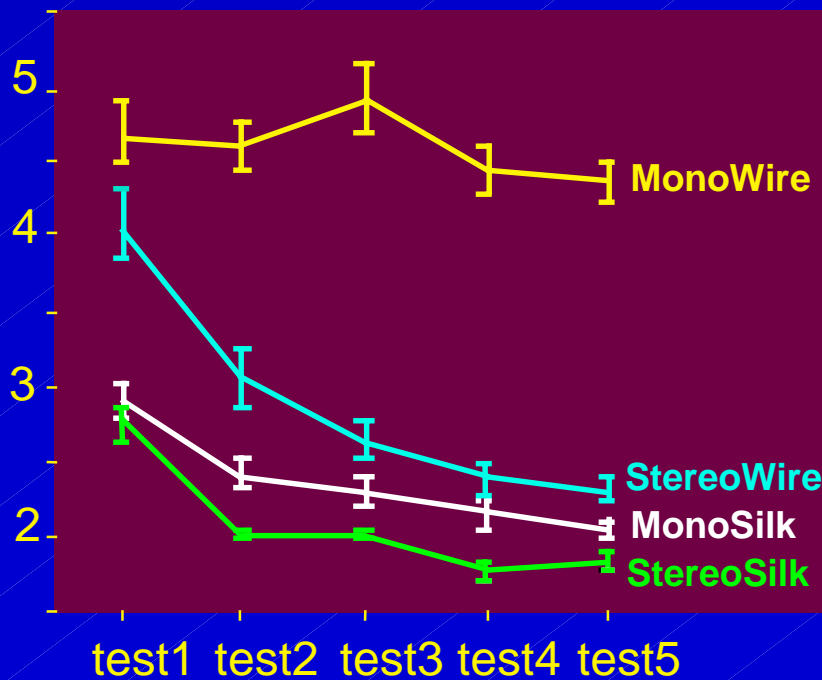
- StereoSilk
- StereoWire
- MonoSilk
- MonoWire

- **Post hoc analysis:**

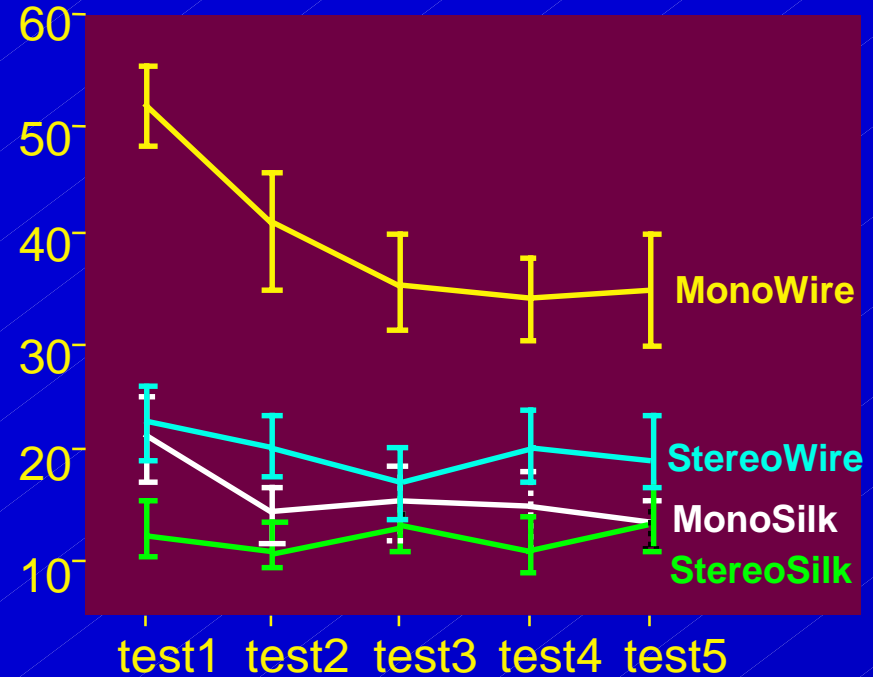
- MonoSilk vs. StereoWire:  $p = 0.16$
- Other pairs significant

# Learning Effects

Completion Time (Sec)



Error Rate (%)



- Speed accuracy trade-off w.r.t learning

# Subjective Preference

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	Very Low	Low	OK	High	Very High
StereoSilk				3	9
MonoSilk			4	4	4
StereoWire		2	7	3	
MonoWire	8	3	1		

(Number of subjects in cells)

- **Consistent with performance measures:  
StereoSilk - MonoSilk - StereoWire - MonoWire**

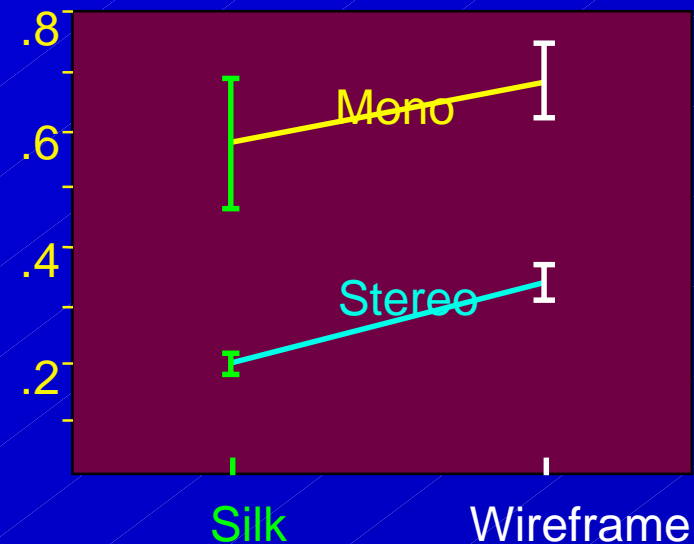
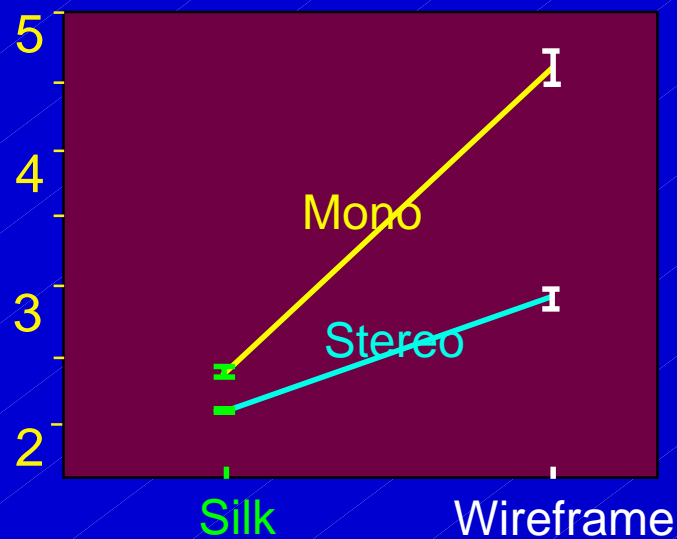
# Partial Occlusion Depth Cue

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- Semi-transparency does not obscure objects,
- Semi-transparency as qualitative/relational depth cue.
- Quantitative/continuous information can be enhanced through *interaction* (moving through object).

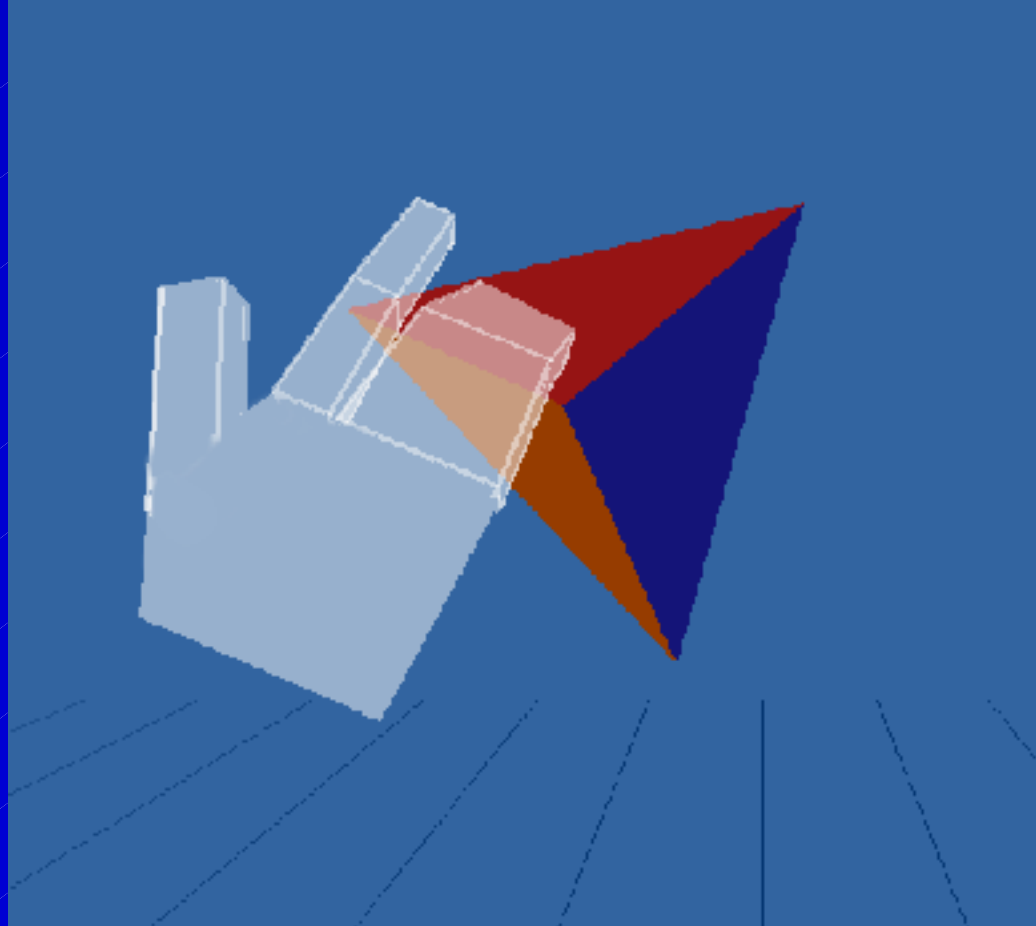
# Models of 3D Performance

- Combining multiple sources of information
- Additive model (Bruno and Cutting, 1988)
- Multiplicative model (Sollenberger and Milgram 1993)
- This experiment:
  - ◆ Time and Error: Multiplicative  
- dominance of semi-transparency.
  - ◆ Error magnitude: Additive



# Applications

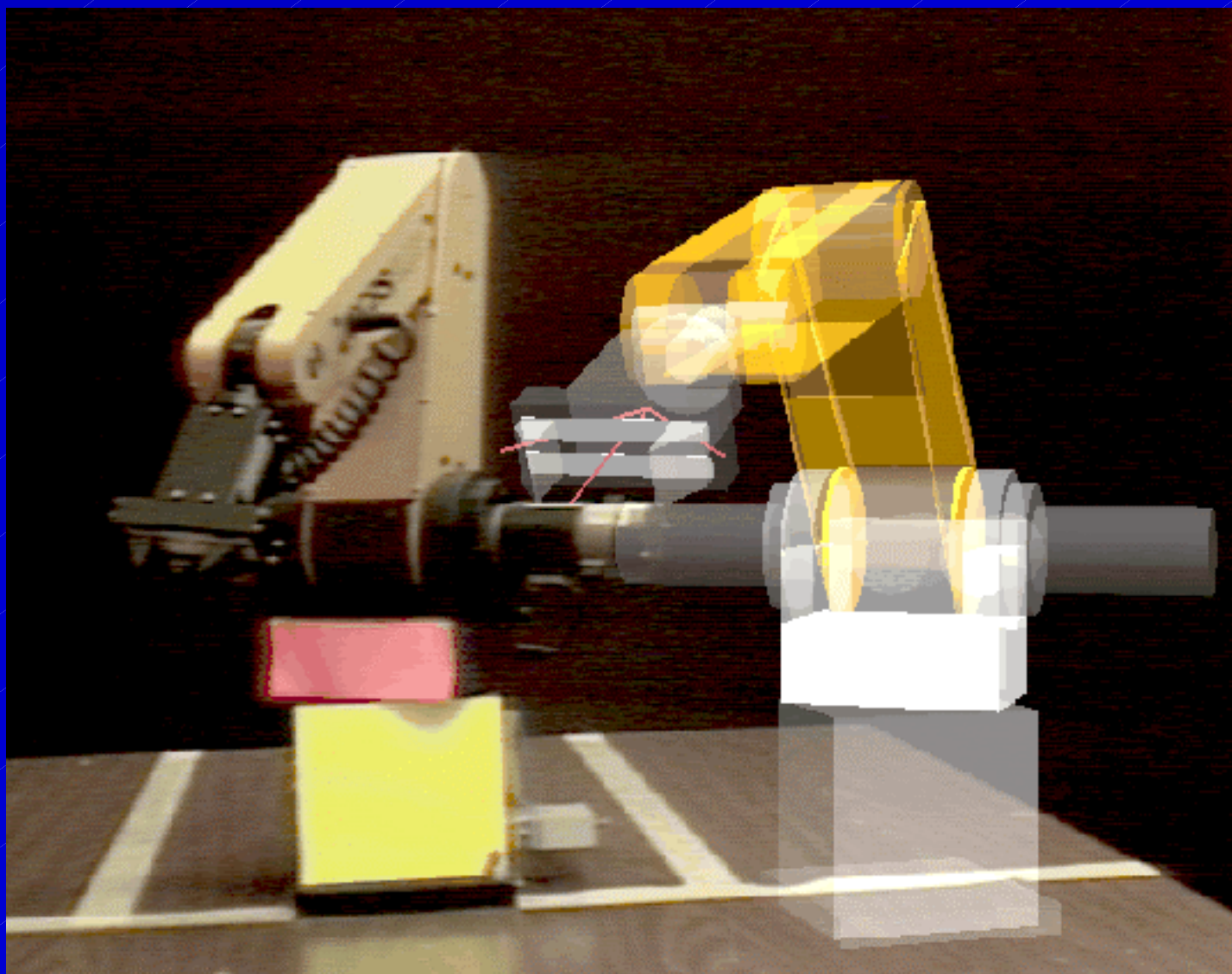
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- “Silk Hand”

# Telerobotics

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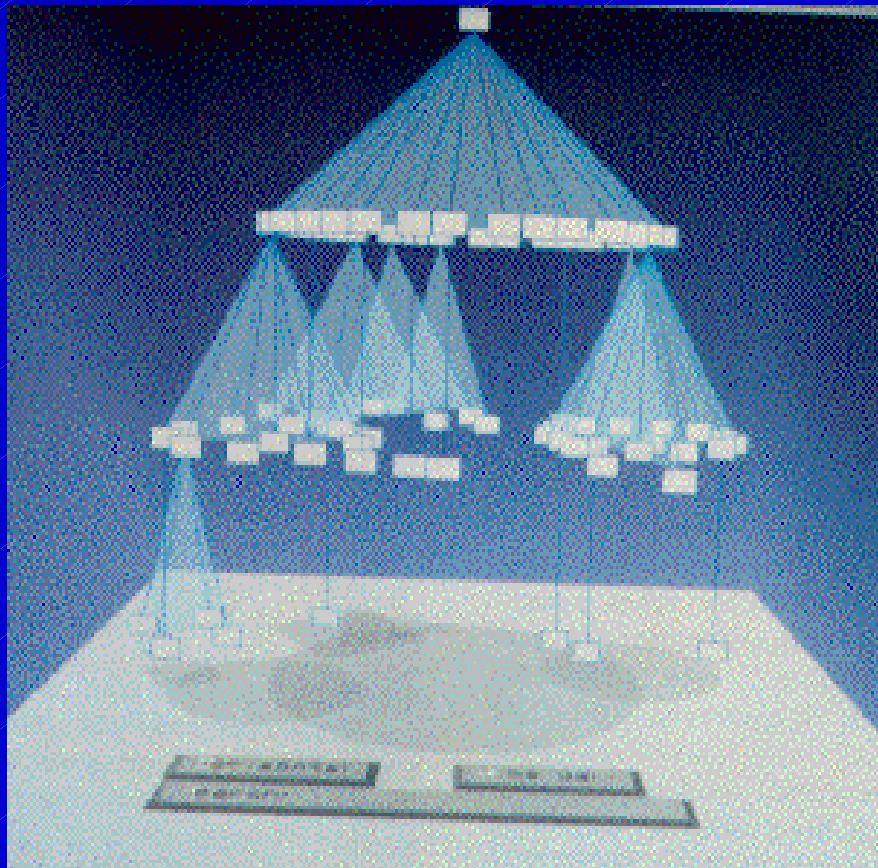
## - Movie and Video

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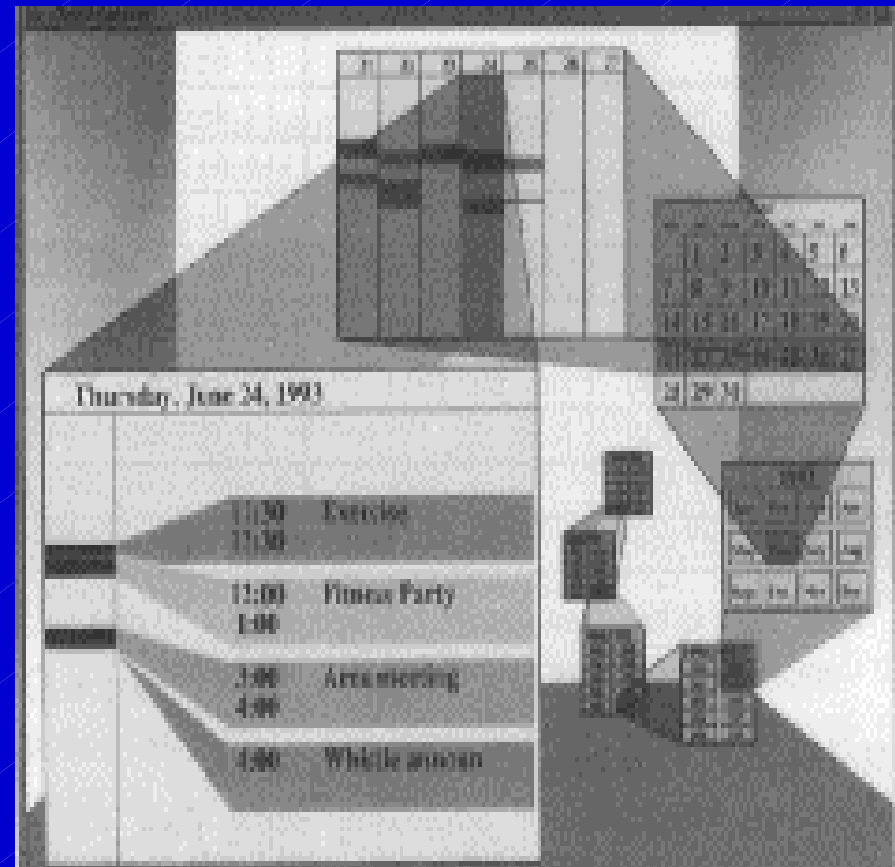


# - Information Visualization

“Cone Tree”



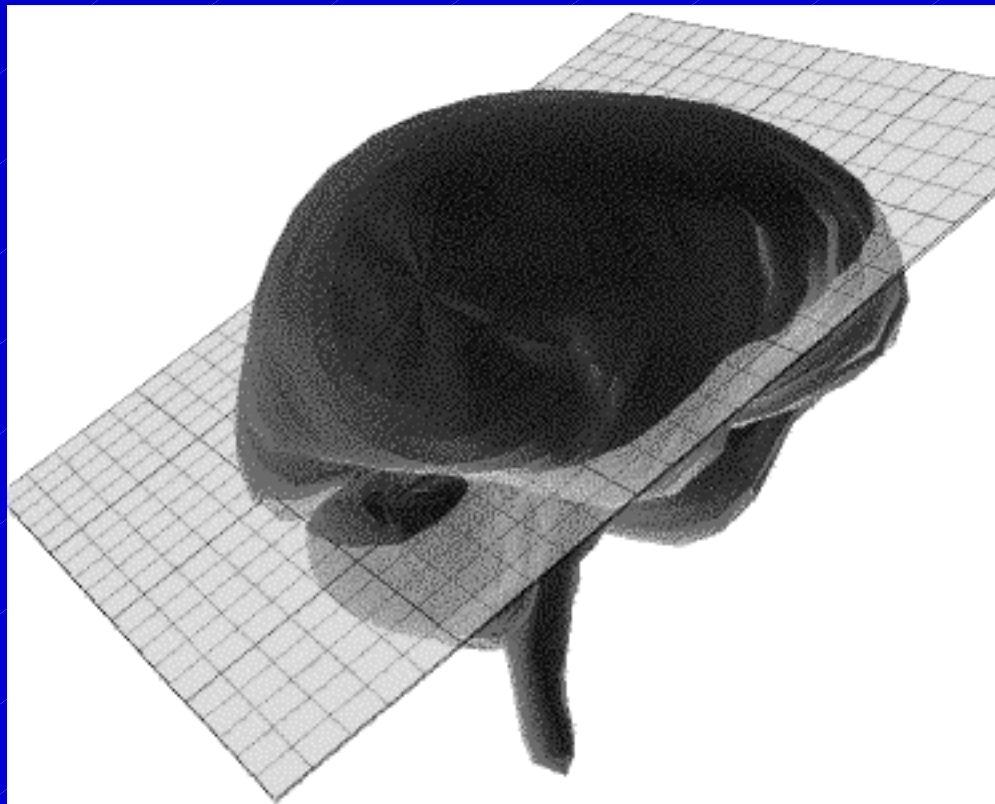
“Spiral Calendar”



(Card, Robertson, Mackinlay, Pirolli, 1991, 1994)

# - Surgical Visualisation

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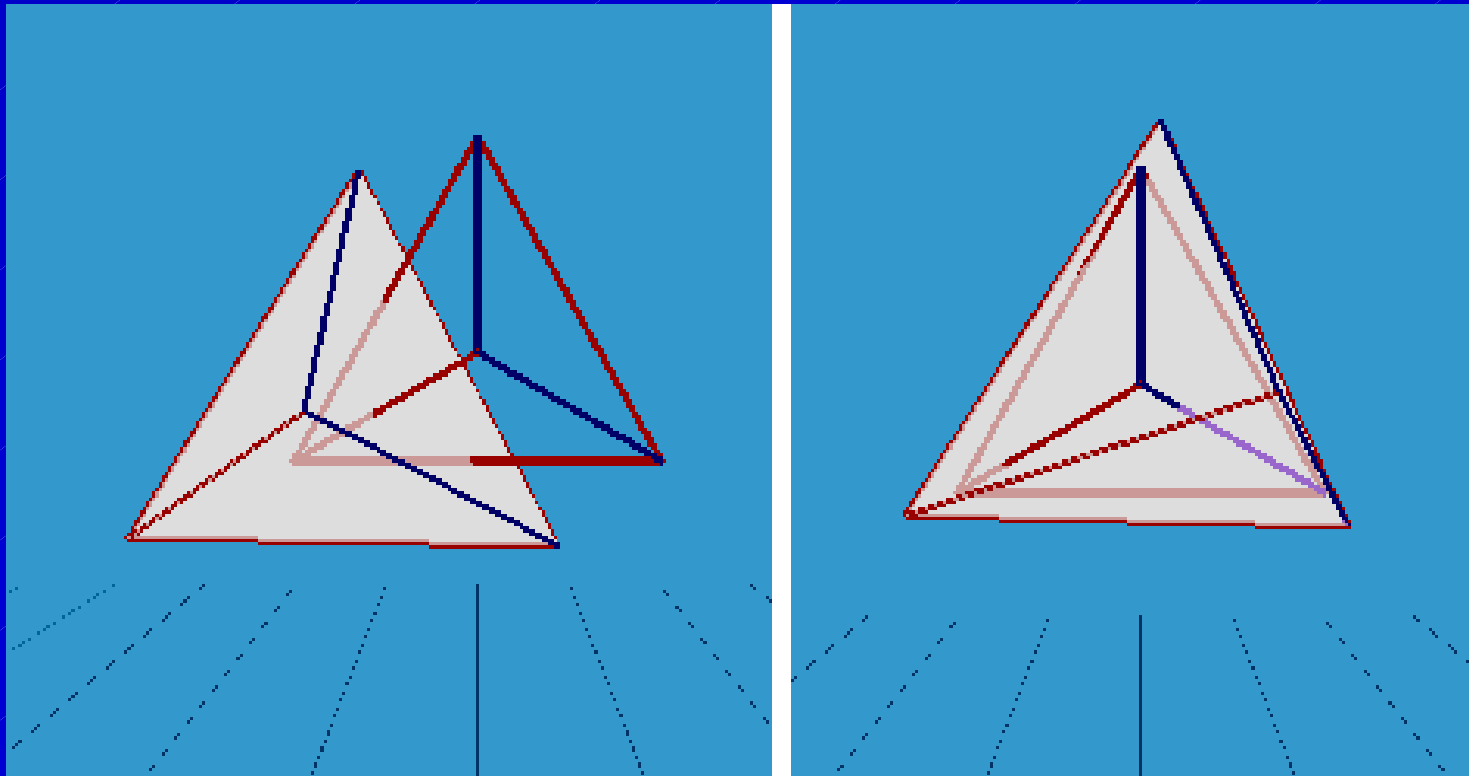


(Hinckley, Pausch, Goble, Kassel 1994)

## - 6 DOF Tracking

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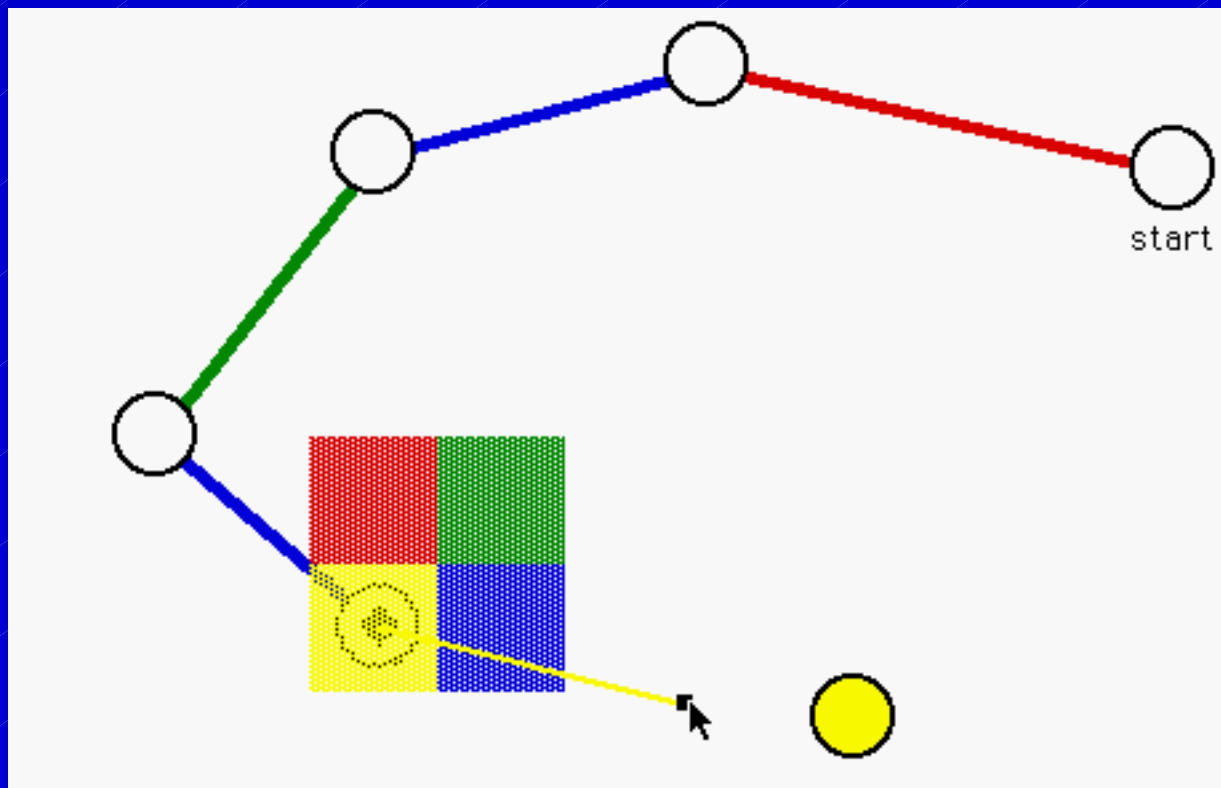
- Tracking with six degree-of-freedom (Zhai, Milgram 1993)



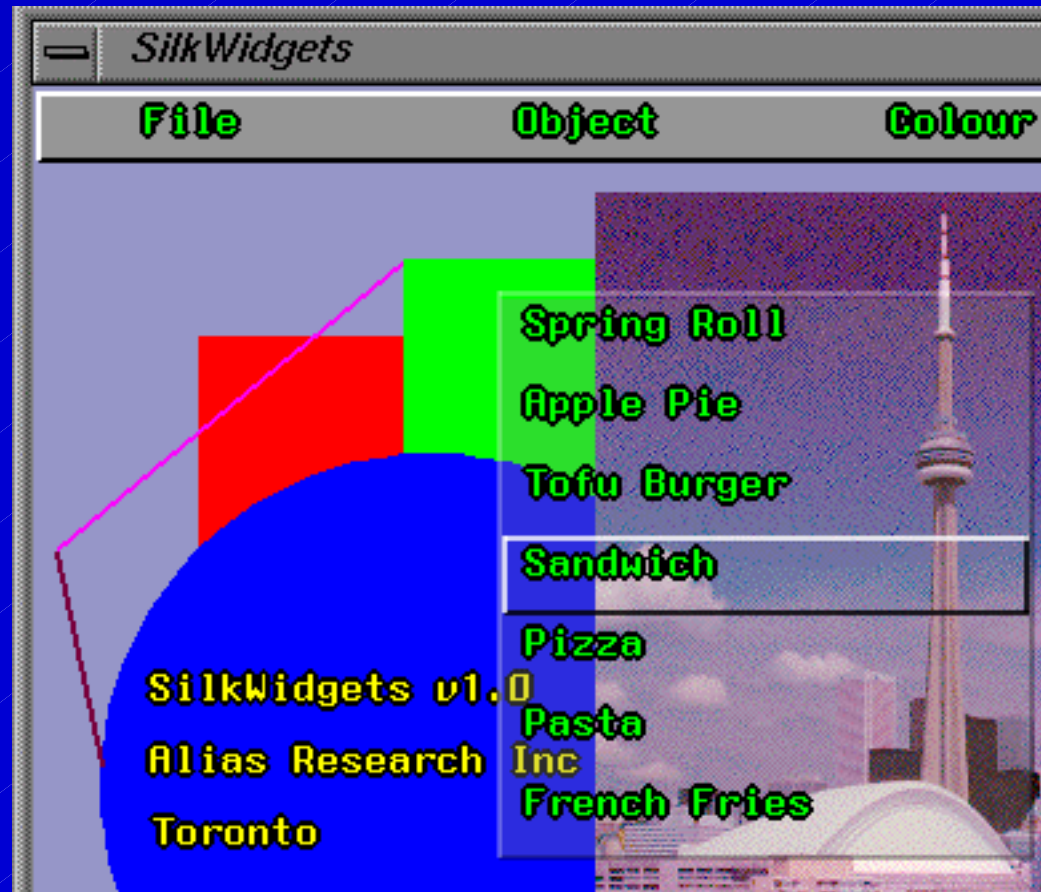
## - 2.5 Interfaces

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- “Tool glass and magic lenses



## - 2.5 Interfaces



- "SilkWidgets"

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# Reading

Zhai, Buxton, Milgram:

“The Partial Occlusion Effect: Utilizing Semi-transparency in  
3D Human Computer Interaction”

*ACM Transactions on Computer Human Interaction* , Vol. 3,  
No.3, September 1996, p254-284.

[http://vered.rose.toronto.edu/people/shumin\\_dir/SILK/silk.html](http://vered.rose.toronto.edu/people/shumin_dir/SILK/silk.html)