Augmented Reality & Handheld AR Interactions
In AV and VE/VR the surrounding environment is virtual; In AR the surrounding environment is real

[Milgram & Kishino, 1994]
How to show it?

Where to show it?
How to show it?

• Show virtual objects overlaying the real world in 3D space

• Display technologies
  • Head mounted
  • Handheld
Where to show it?

- To register virtual objects in 3D space and track user input
- Tracking (and registration) technologies track the
  - (a) Scene
  - (b) The user’s 6DOF viewpoint (head and/or eyes, device)
  - (c) The user’s hands/body for input
  - (d) Input devices
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Perceptual Issues in Handheld AR

- Dual View
Perceptual Issues in Handheld AR

- Dual View
- Viewing angle offset
Perceptual Issues in Handheld AR

- Dual View
  - Viewing angle offset
- Field of view

[Kruijff et al., 2010]
Perceptual Issues in Handheld AR

- Dual View
  - Viewing angle offset
  - Field of view
- No stereoscopy
Take out your phone

Open your camera app

Only looking through the camera, touch your spacebar
Interacting in Handheld AR
Viewport Manipulation
Essential Interaction Tasks

Selection  Translation  Rotation  Scaling
Selection

- Direct Touch
- Shift & Freeze
- Crosshair
- Relative Pointing

[Vincent et al., 2013]
3D Input: Six Degrees of Freedom

Translation (3 DoF)

Rotation (3 DoF)
Mid-Air Object Manipulation

3D Touch

HOMER-S

[Mossel et al., 2013]
Tracking of the Pen

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How to select a virtual object?
Selection Techniques: Task
1/5: Without Highlighting
2/5: With Highlighting
3/5: One-handed
4/5: Two-handed
5/5: PenRay
Selection Techniques: Results

15 participants

2.9%
Selection Techniques: Results

<table>
<thead>
<tr>
<th>Technique</th>
<th>Success</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>PenRay</td>
<td>87%</td>
<td>2.6s</td>
</tr>
<tr>
<td>Highlight</td>
<td>82%</td>
<td>7.4s</td>
</tr>
<tr>
<td>2-handed</td>
<td>79%</td>
<td>1.9s</td>
</tr>
<tr>
<td>1-handed</td>
<td>70%</td>
<td>2.3s</td>
</tr>
</tbody>
</table>

15 participants
Selection Techniques: Ranking

- **without highlight**
- **with highlight**
- **one-handed**
- **two-handed**
- **pen ray**
How to pick up and move a virtual object?
Translation Techniques: Task
1/5: Pen Drag & Drop
2/5: Pen Ray Pickup
3/5: One-handed
4/5: Two-handed

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5/5: Touch&Pen
Translation Techniques: Task Time

- Drag & Drop: 8.9s
- Touch & Pen: 6.9s
- 1-Handed: 6.8s
- 2-Handed: 6.5s
- PenRay: 5.9s

15 participants
Translation Techniques: Ranking

1. pen drag&drop
2. pen ray pickup
3. one-handed
4. two-handed
5. touch&pen

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Essential Interaction Tasks

Selection
Translation
Rotation
Scaling
Depth Visualization Techniques
1/5: MinVis

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MinVis

Bubble

DepthRay

...
2/5: DepthRay

MinVis

Bubble

DepthRay

Shadow
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4/5: Bubble

MinVis
Bubble
DepthRay
5/5: Heatmap
Depth Visualization Techniques

MinVis  DepthRay  Shadow  Bubble  Heatmap

10 participants
Depth Visualization Techniques: Ranking

- minVis
- depth ray
- bubble
- shadow
- heatmap

1. minVis: 7, depth ray: 2, bubble: 1, shadow: 0, heatmap: 0
2. minVis: 6, depth ray: 3, bubble: 1, shadow: 0, heatmap: 0
3. minVis: 5, depth ray: 4, bubble: 1, shadow: 0, heatmap: 0
4. minVis: 4, depth ray: 3, bubble: 2, shadow: 0, heatmap: 0
5. minVis: 3, depth ray: 4, bubble: 2, shadow: 0, heatmap: 0
Menus in Handheld AR

[Wacker et al., 2020b]
Interaction Methods

1. Screen: Scene Aligned
2. Screen: Screen Fixed
3. Pen: Mid-Air
4. Pen: On Surface
5. Device: Movement
1/5: Two-Handed Touch
2/5: Mid-Air Pen
3/5: One-Handed Touch
4/5: DevicePointer
5/5: Surface
Menu Techniques

2-Handed

Mid-Air

1-Handed

DeviceP

Surface

15 participants
Menu Techniques: Ranking

mid-air pen  | one-handed  | device pointer | surface | two-handed
---|---|---|---|---
1  | 5  | 3  | 2  | 1
2  | 5  | 2  | 2  | 1
3  | 4  | 3  | 2  | 1
4  | 3  | 3  | 2  | 1
5  | 1  | 1  | 3  | 1

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