

# Augmented Reality

Theory and Practice of Tangible User  
Interfaces

Tuesday, Week 9

# Outline

- **Overview**
- Examples
- Theory
- Examples
- Supporting AR Designs
- Examples
- Theory



# Outline

- Overview
- **Examples**
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# First Down Line in Football Games



# Virtual Laser Keyboard



# Eye Toy [sony]



- [Eye Toy Demo](#)
- [Eye Toy Review](#)
- [Eye Toy Cups \[2:30\]](#)

# Outline

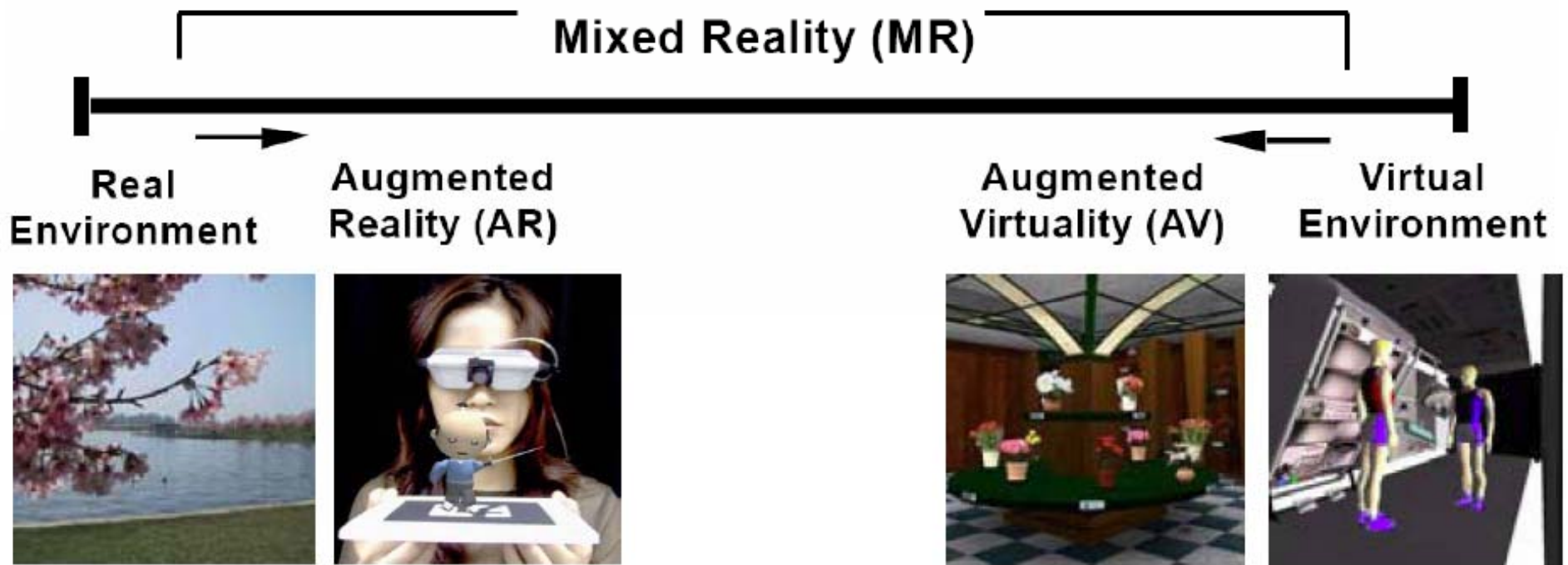
- Overview
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# Reality-Virtuality (RV) Continuum

[Milgram et al., 1994]

“Augmenting natural feedback to the operator with simulated cues” (Milgram et al., 1994)



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# Pacman and the RV Continuum

Yaw  
115.6300

Pitch  
0.7800

Roll  
3.8600

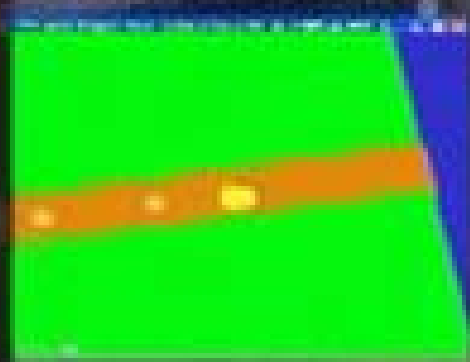
nearby  
Ingredient

nearby  
Ghost

Virtual Environment

Augmented Reality

Real Environment



**Pacman 2**  
Status: Normal  
Position: Lat -8.39 Lon -2.73

# Support Archeological Field Work

[Benko et al, 2005, Columbia]

[video]

The image shows an archaeological excavation site. In the foreground, there is a yellow toolbox containing various tools, a white bucket, and a black bucket. A shovel is leaning against a wheelbarrow. The ground is covered with a white tarp, and there are several wooden planks laid out on the ground. In the background, there is a white tent structure and a white chair. The overall scene is a typical archaeological field site.

# Overlay Assembly Instructions

[Feiner et al., 1993, Columbia]



# Overlay Assembly Instructions

[Zauner et al., 2003, Austria]



# Augmented Reality Kitchen

[Lee et al., 2005, MIT Media Lab]

[video]



# MARA: Mobile AR

[Nokia Research]





# Surface Drawing

[Schkolne and Keefe, 2001, Caltech]

[video]

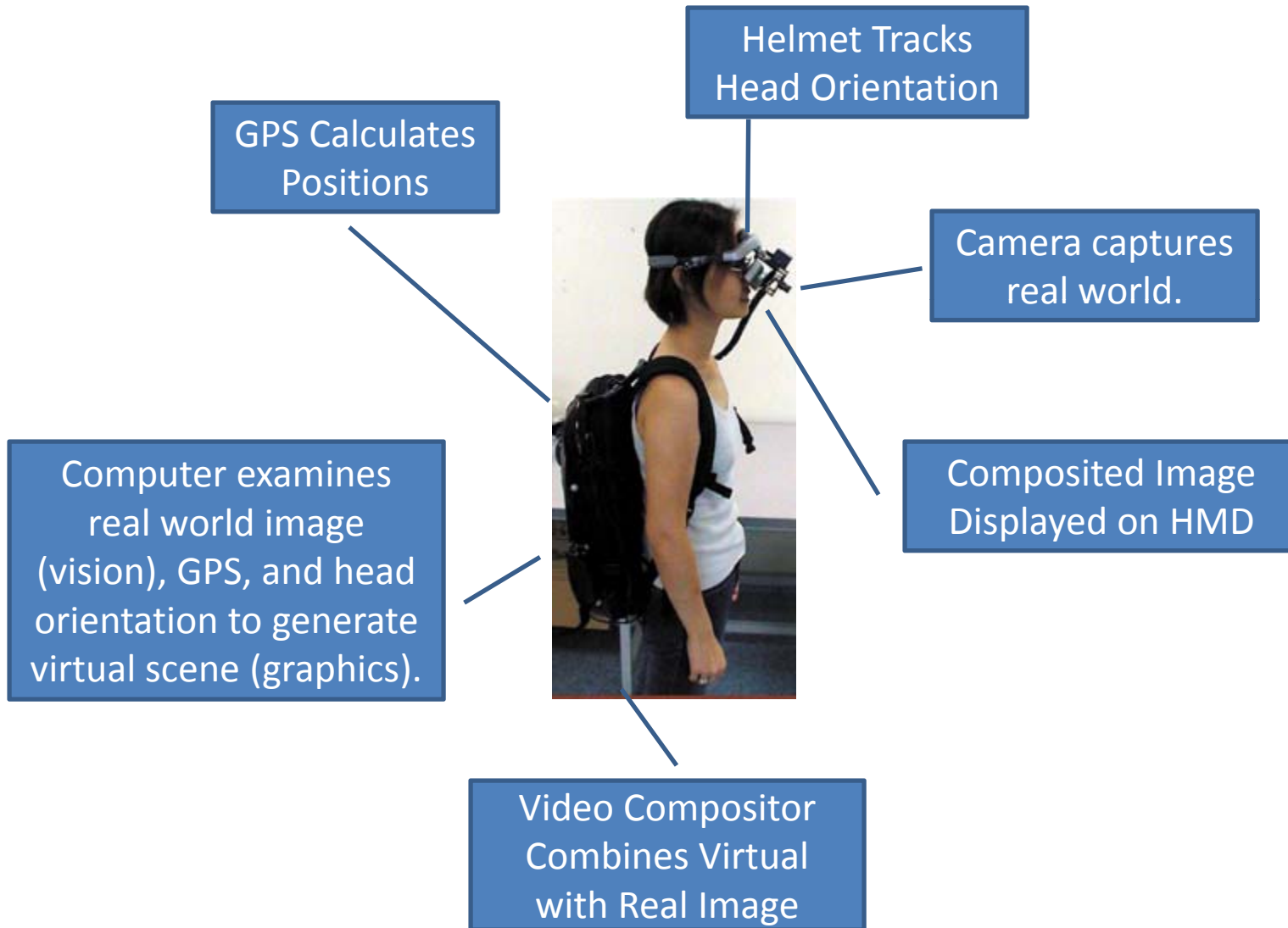
[video]



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- **Supporting AR Designs**
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# Building AR Systems is HARD



# Supporting AR Design

- Hardware
  - Use of advanced displays (head mounted, stereoscopic, novel projection)
  - Sensors to detect real environment actions
  - Actuators to affect the world
- Software Requirements
  - Computer Vision systems
  - 3D rendering systems
  - All in REAL-TIME
- Interaction Requirements
  - Complex domain of possible actions/reaction

# Standard Displays

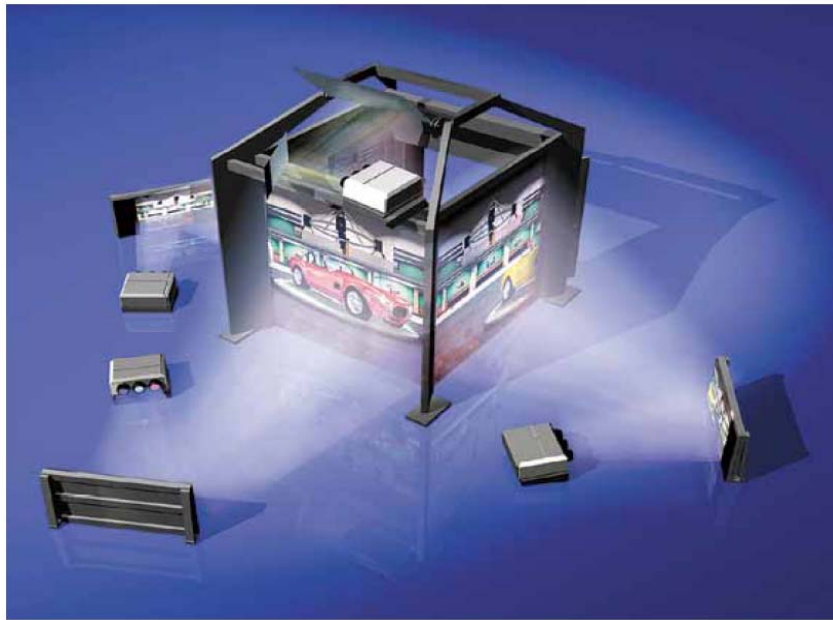


joe-ks.com

# Stereoscopic 3D Displays



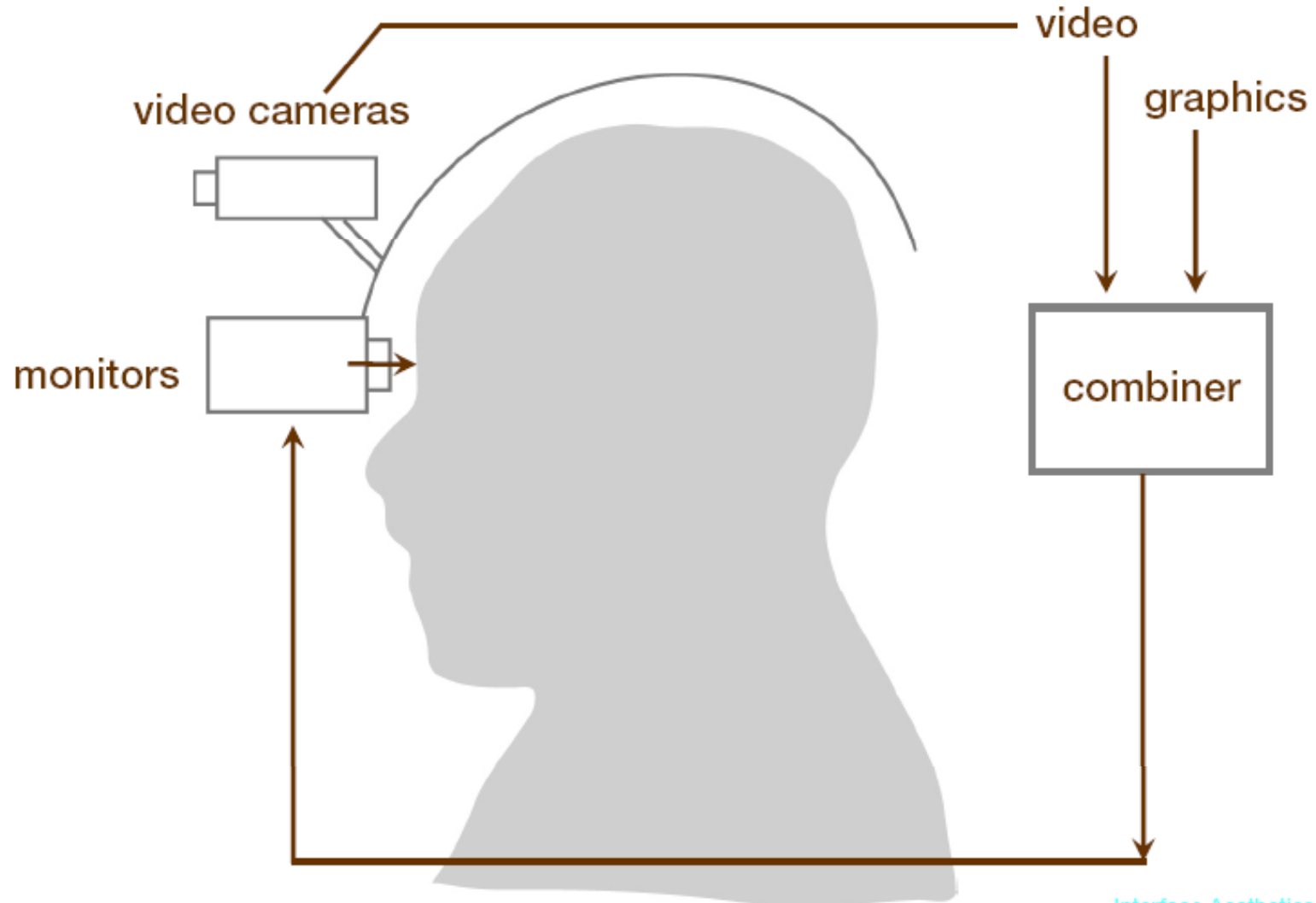
# Immersive Displays: CAVEs



AUGMENTED REALITY

# Video see through HMD

[adopted from Billinghurst & Ollila]





AUGMENTED REALITY

# Video see through HMD

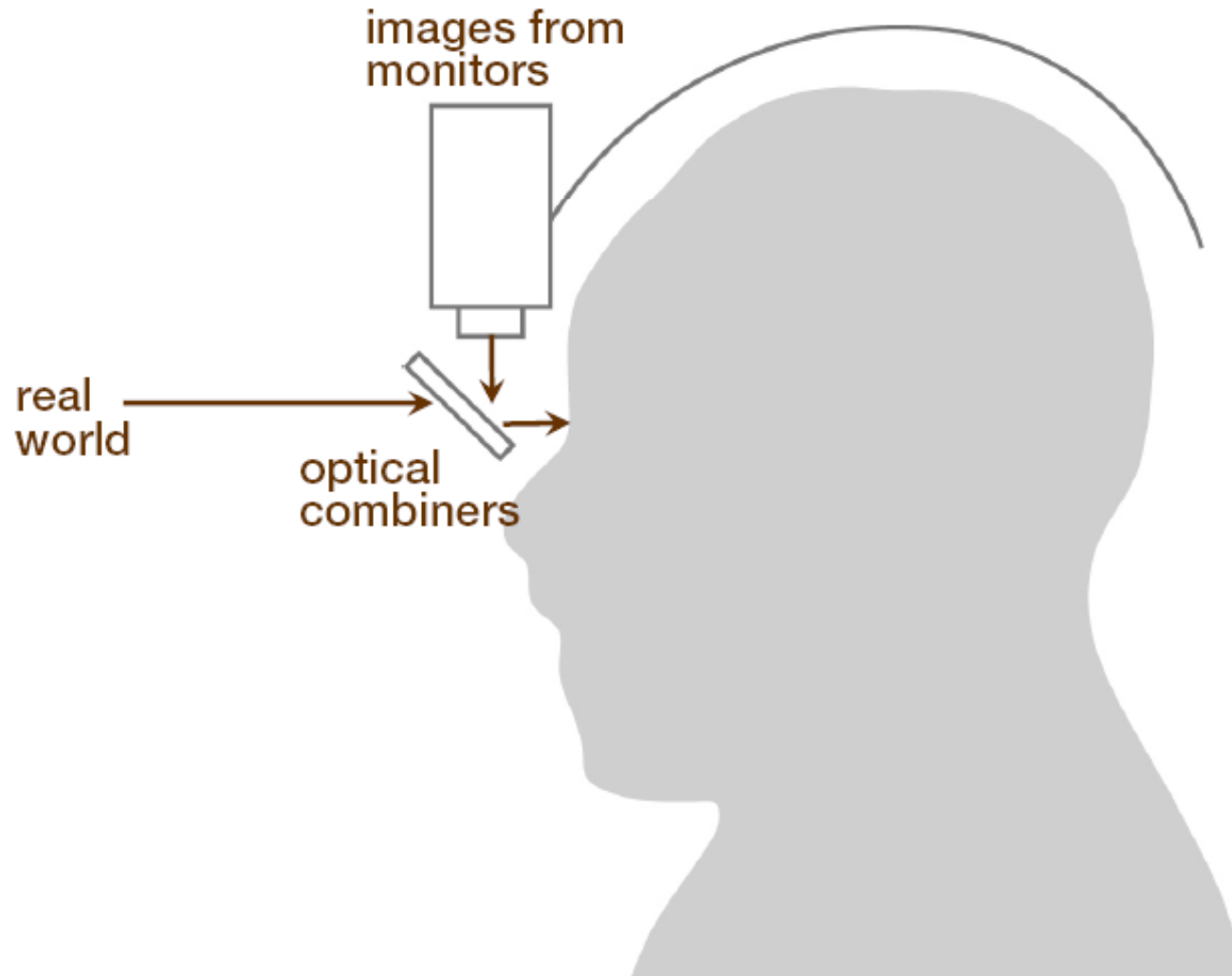
Sony Glasstron HMD with video camera and head tracker [courtesy of Piekarski]



AUGMENTED REALITY

# Optical see through HMD

[adopted from Billinghurst & Ollila]





# Toshiba Head-Dome Display



- “Ludicrous Speed, Go!”
- “I have seen the future, and it is lame”
- “about as glamorous as wearing an old-style TV set on your head” -USA Today

# Head Mounted Displays

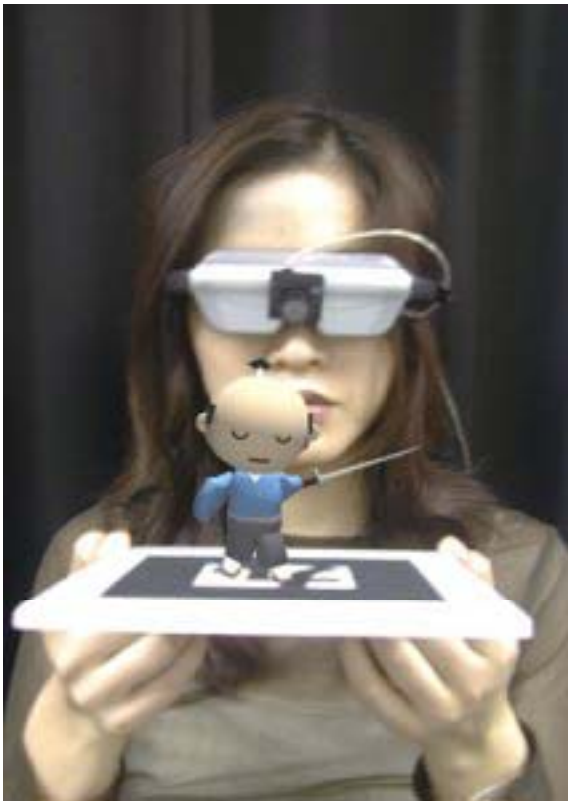


# Corporate Support: Total Immersion

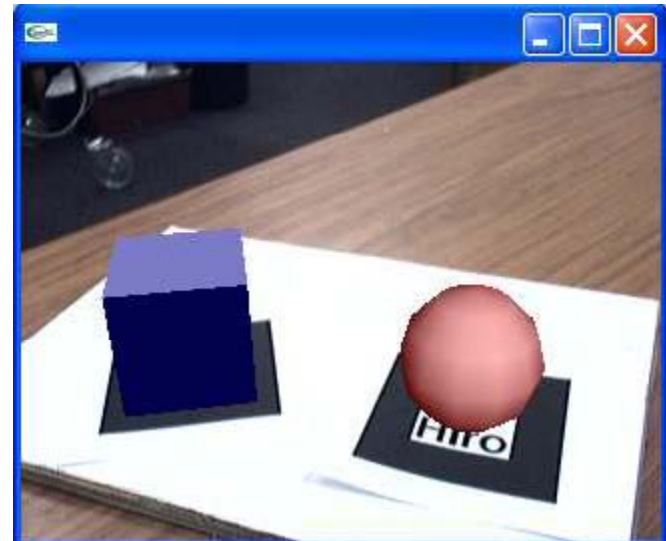
[video]

# Software Support: ARToolkit

(HIT Lab, Washington and New Zealand)



- Everything you need to draw stuff on cards (fiducials markers)



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# Collaboration: Magic Meeting

[Shared-Reality, Germany]

[video]



# 3D Popup Book

[HIT Lab, New Zealand]

[video]

A photograph showing two men in dark suits and blue ties seated at a wooden table. They are looking at a red 3D popup book that is partially open. The book is resting on a white sheet of paper. The background is a plain, light-colored wall. A central text box with a black background and white text reads "[video]".

# Support Botanical Field Work

[video]

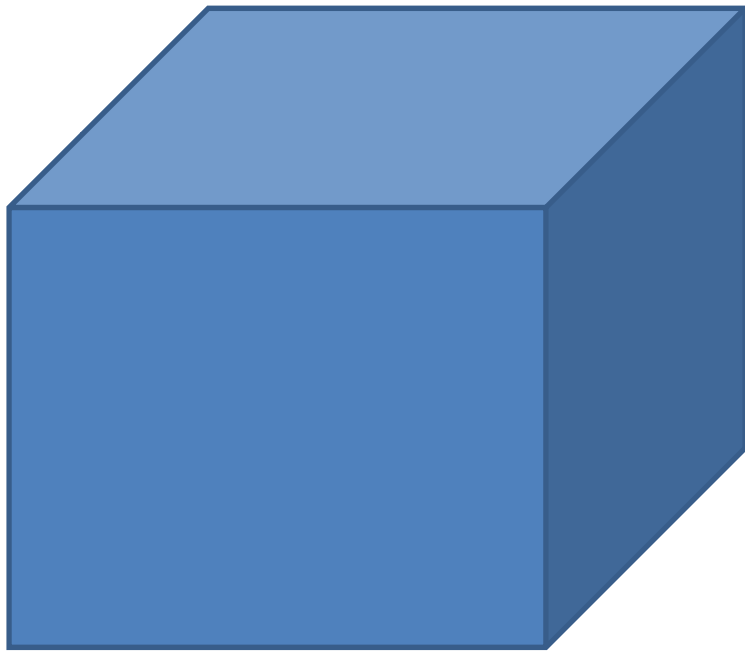


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# Taxonomy of Mixed Reality Systems

[Milgram et al., 1994]

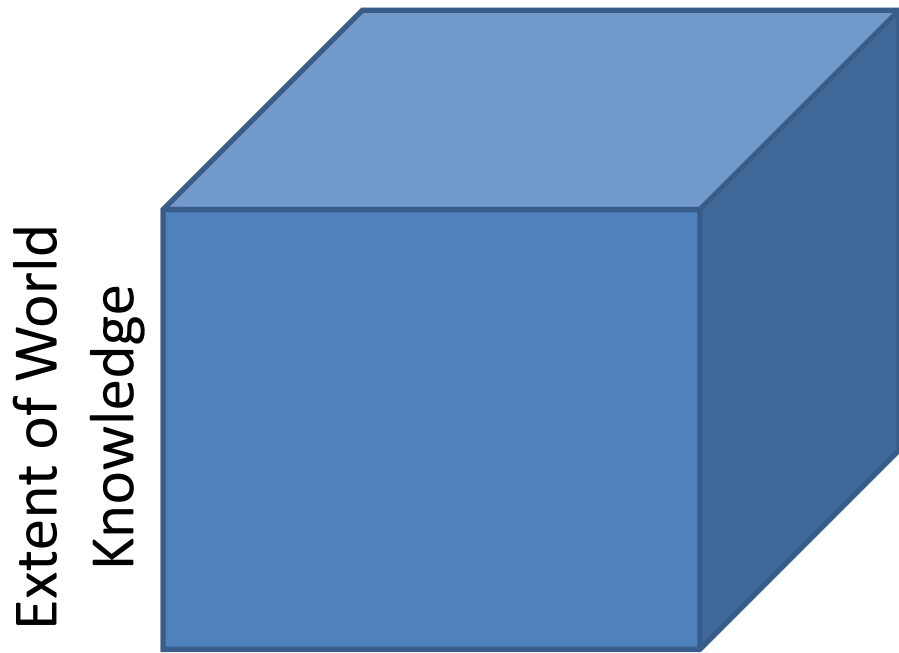


Extent of Presence  
Metaphor

**Extent of Presence Metaphor**  
The extent to which the observer is intended to feel “present” within the displayed scene.

# Taxonomy of Mixed Reality Systems

[Milgram et al., 1994]



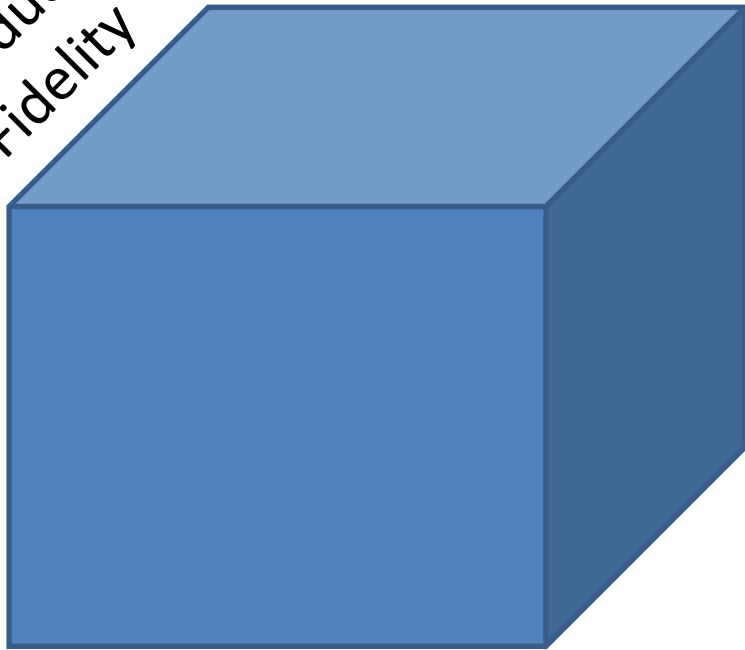
## **Extent of World Knowledge**

How much we [the computer] actually know about the objects and the world in which they are displayed.

# Taxonomy of Mixed Reality Systems

[Milgram et al., 1994]

Reproduction  
Fidelity

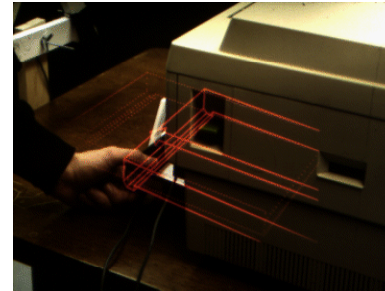
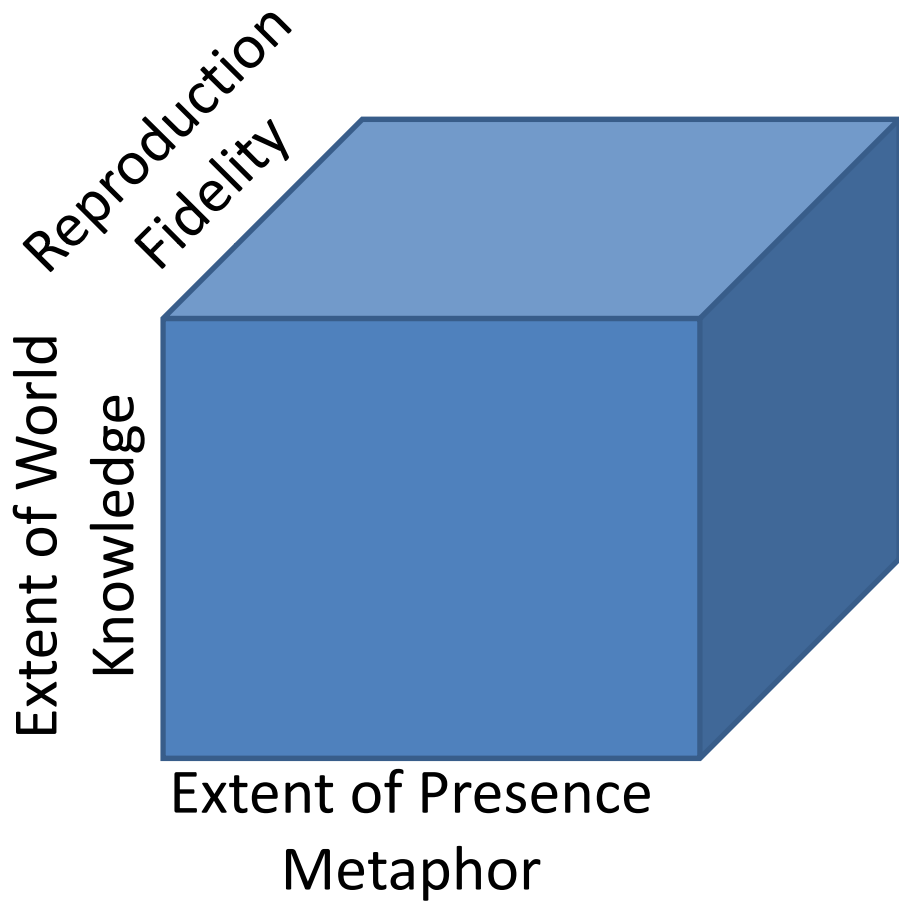


## **Reproduction Fidelity**

The relative quality with which the synthesizing display is able to reproduce the actual or intended images of the objects being displayed.

# Taxonomy of Mixed Reality Systems

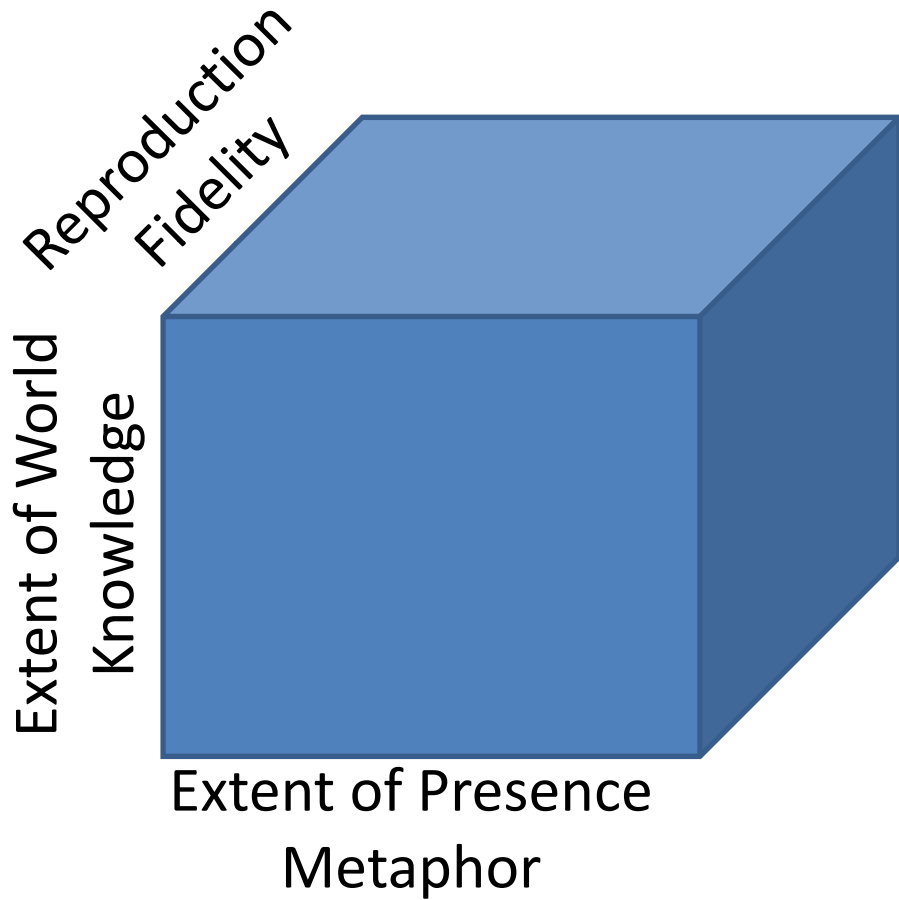
[Milgram et al., 1994]





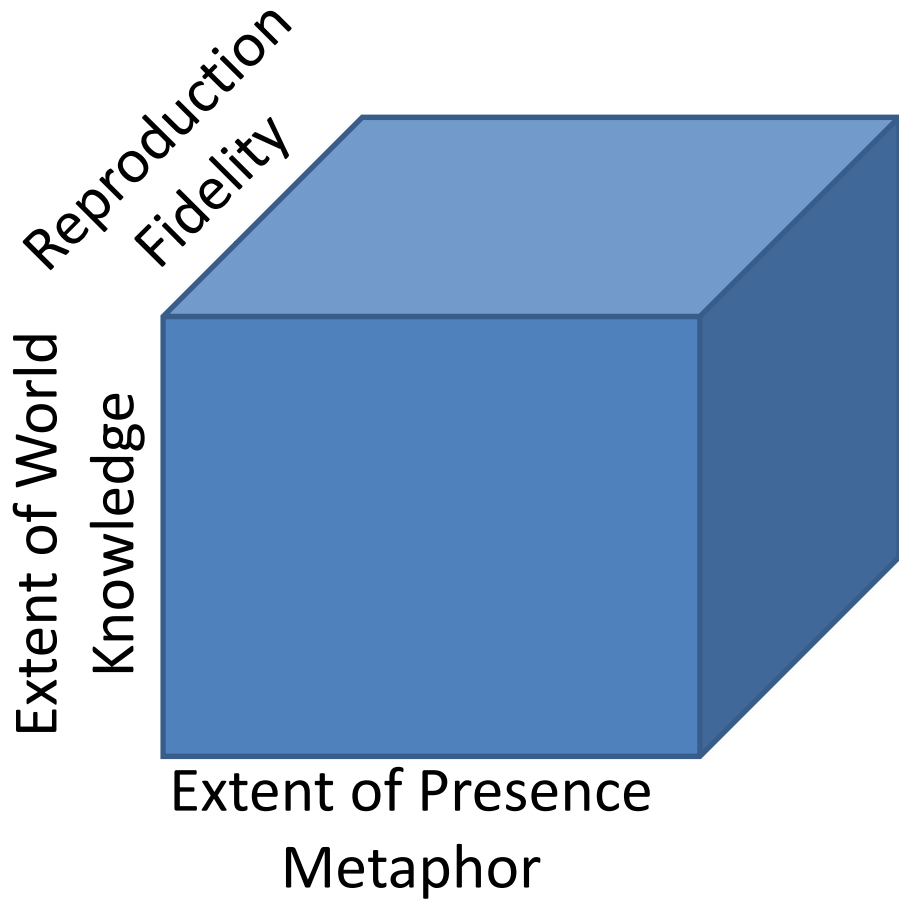
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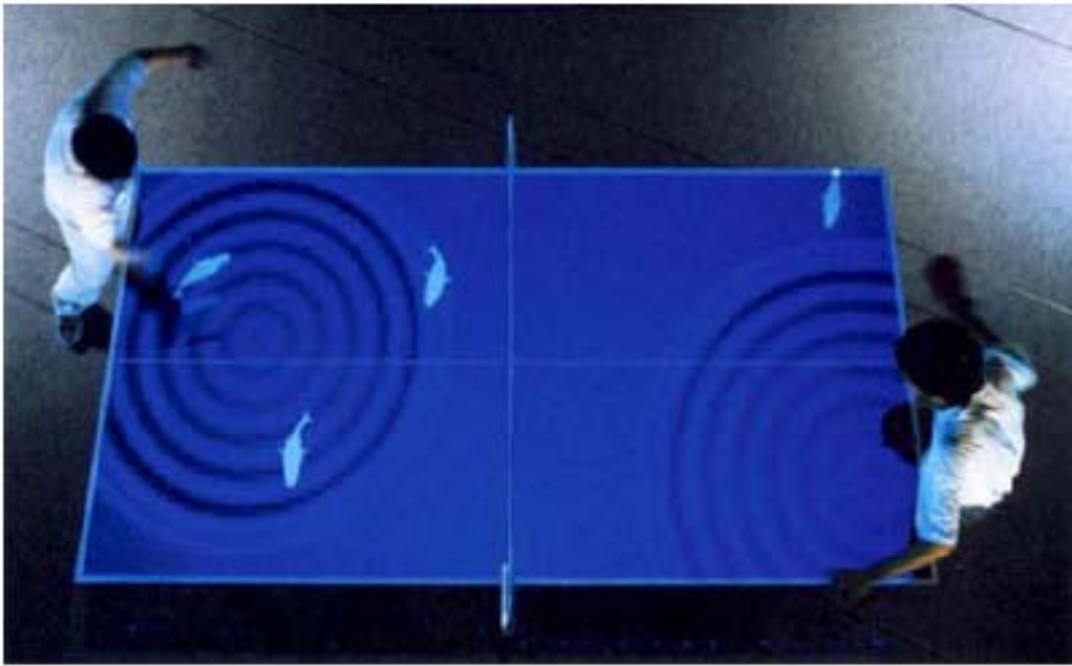
[Milgram et al., 1994]



Do you think this is a useful  
taxonomy for interaction design?

# Ping Pong Plus

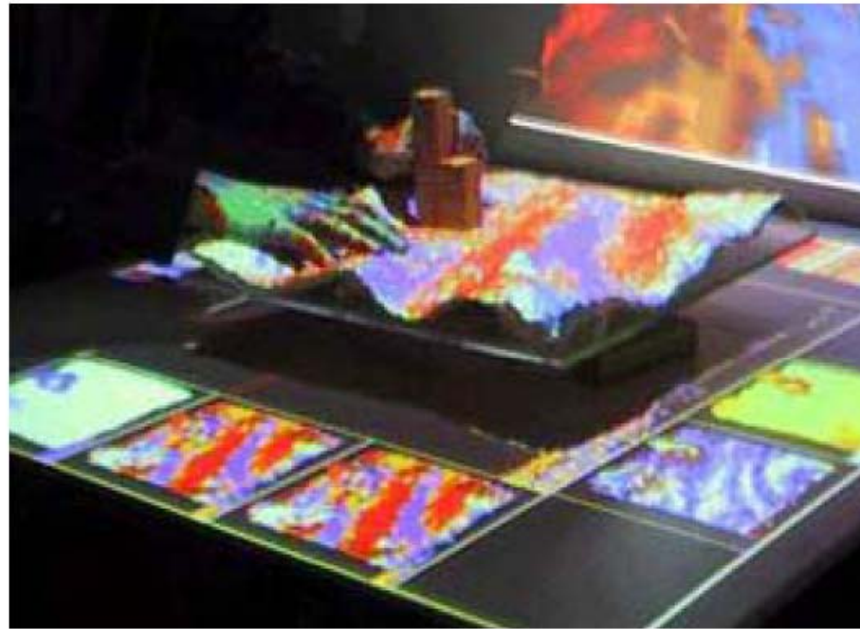
[Ishii et al., 1999, MIT Media Lab]



**Ping Pong Plus**

# Illuminating Clay

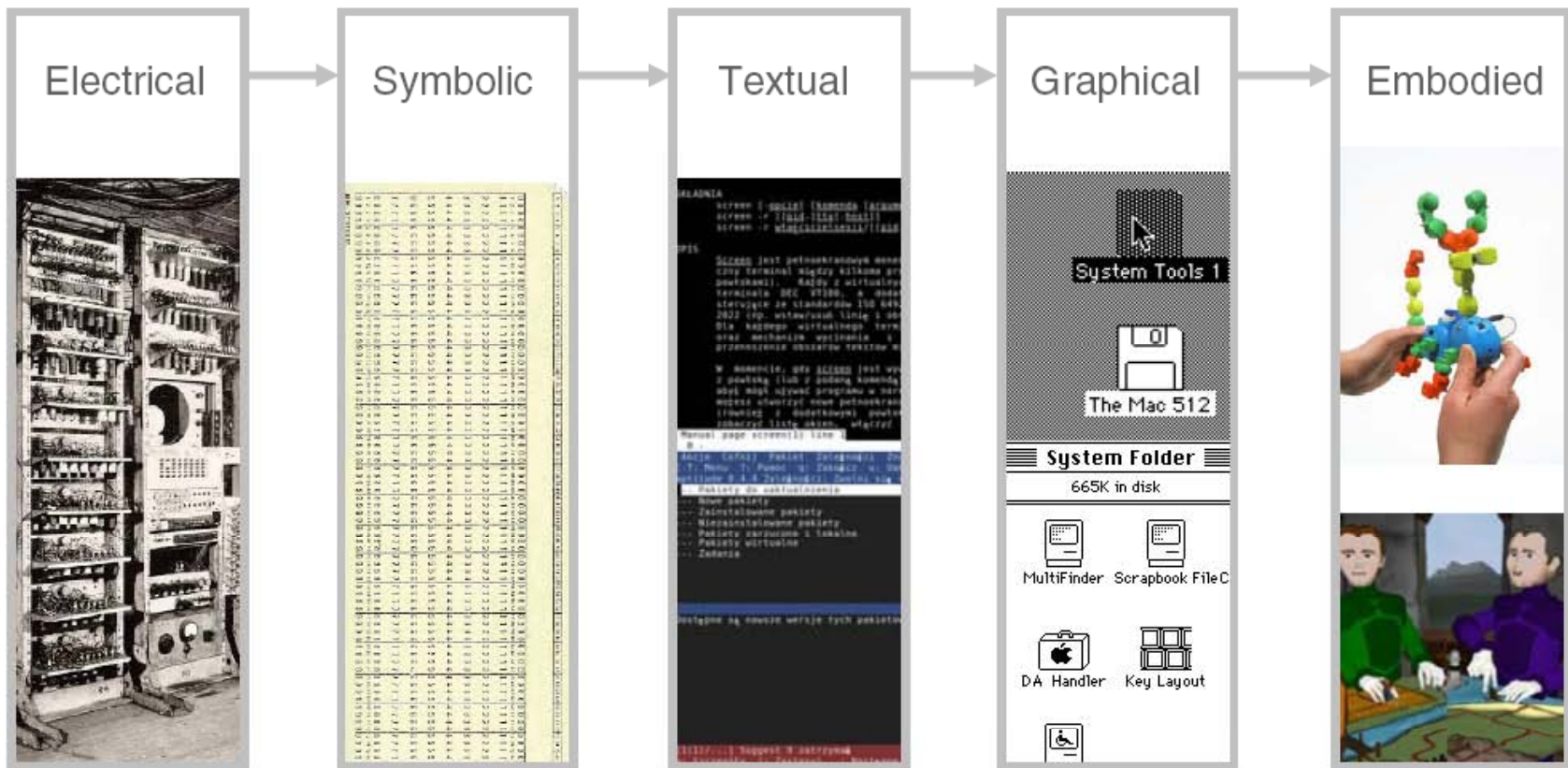
[Piper et al., 2002, MIT Media Lab]



**Illuminating Clay**

Wait a minute. What's going on here?

# Historical Development of UI



# “Computer reaching out”

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The scope of human-computer interaction is expanding to include larger-scale, longer-term phenomena of computer use. Interaction moves from being directly focused on the physical machine to incorporating more and more of the user’s world and the social setting in which the user is embedded. (Dourish, 2004)

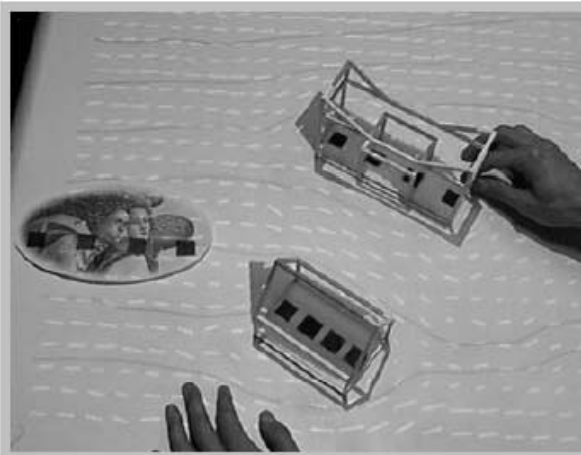


## Historical Development of HCI

# Tangible Interaction



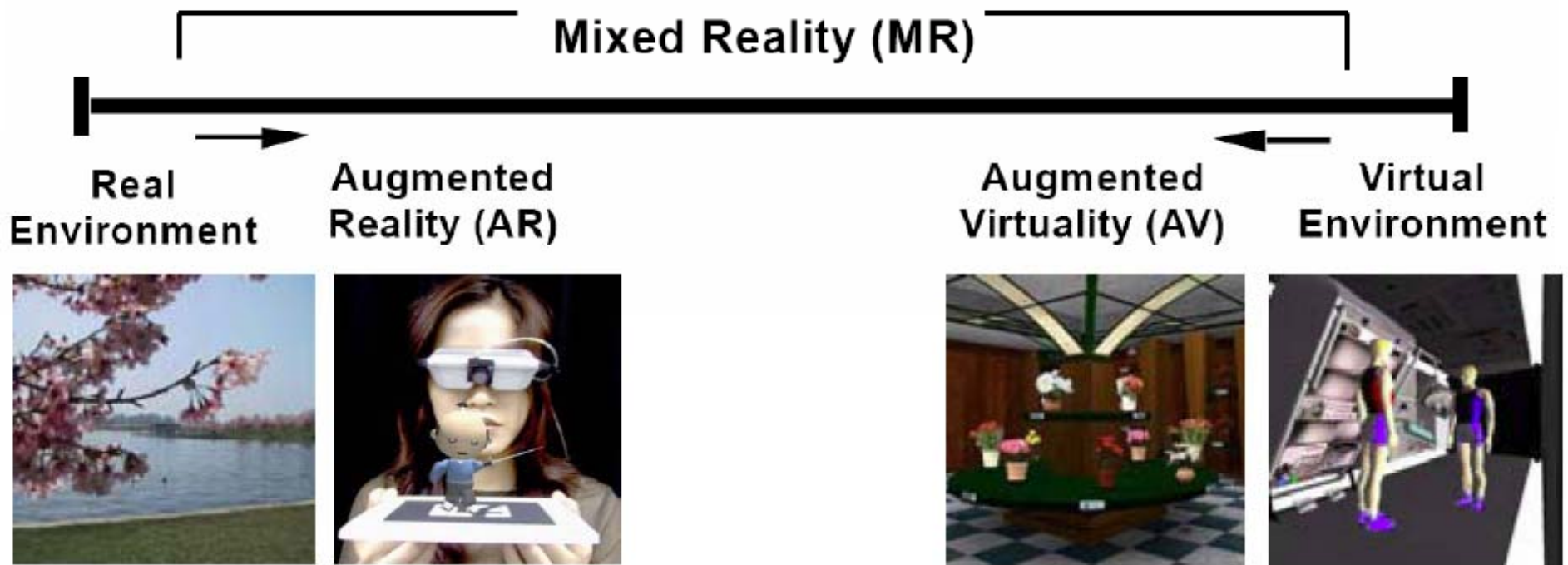
- Computation that moves beyond desktop
- Interaction is incorporated more richly in our daily experience of the physical world



# Reality-Virtuality (RV) Continuum

[Milgram et al., 1994]

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TUI vs. AR: Is there a difference?  
What is it?

# Difference

[nguyen, today, tui Class]

Both Tangible User Interface (TUI) and Augmented Reality (AR) designs seek to move computation beyond the desktop. The primary difference between the two lies in the approach. TUI seeks to **inject** computation **into** the physical world while AR seeks to **overlay** computation **onto** the physical world. However, the two approaches are not orthogonal.