Classifying handheld Augmented Reality: Three categories linked by spatial mappings

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(University of Grenoble, France)
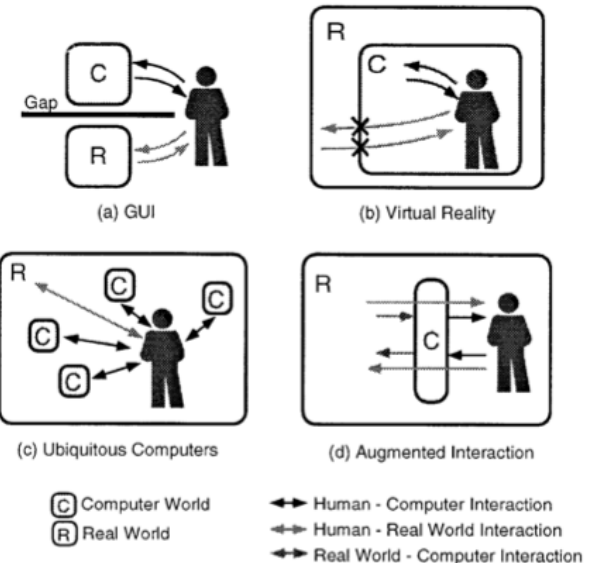Takeshi Kurata (AIST, Japan)

Plan

- Introduction and scope
- Framework
- Dynamicity
- Future work
- Conclusion

Introduction: Academic Definition

- Academic definition [Azuma 97]:
  - Combines real and virtual
  - Interactive in real time
  - Registered in 3D

[Rekimoto 95]

(a) GUI

(b) Virtual Reality

(c) Ubiquitous Computers

(d) Augmented Interaction

C Computer World
R Real World

←→ Human - Computer Interaction
←→ Human - Real World Interaction
←→ Real World - Computer Interaction

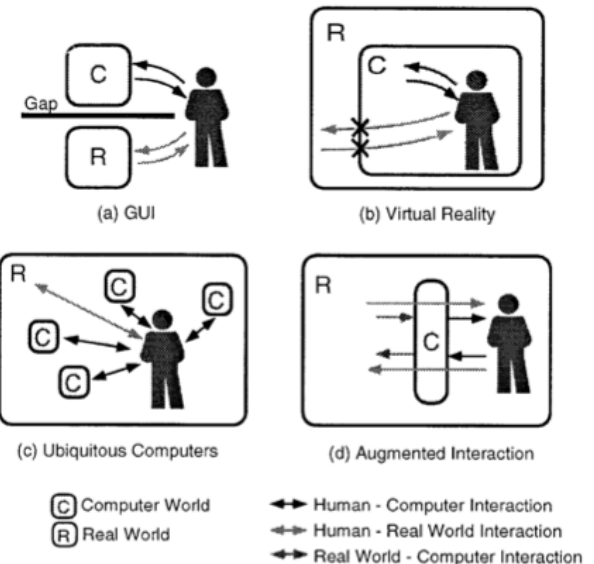# Introduction: Academic Definition

- Academic definition [Azuma 97]:
  - Combines real and virtual
  - Interactive in real time
  - Registered in 3D
- Specific to AR:
  - 'Real' AND 'Virtual'
  - Spatiotemporal relationship between the physical world and digital content.

[Rekimoto 95]

(a) GUI

(b) Virtual Reality

(c) Ubiquitous Computers

(d) Augmented Interaction

C Computer World
R Real World

◄► Human - Computer Interaction
◄► Human - Real World Interaction
◄► Real World - Computer Interaction

Introduction

- Augmentation is mostly visual
- AR is influenced by hardware
- So handheld AR has some specificities:
  - Viewpoint is controlled by device pose
  - Direct Touch is the de facto standard input (1:1 mapping with the screen)
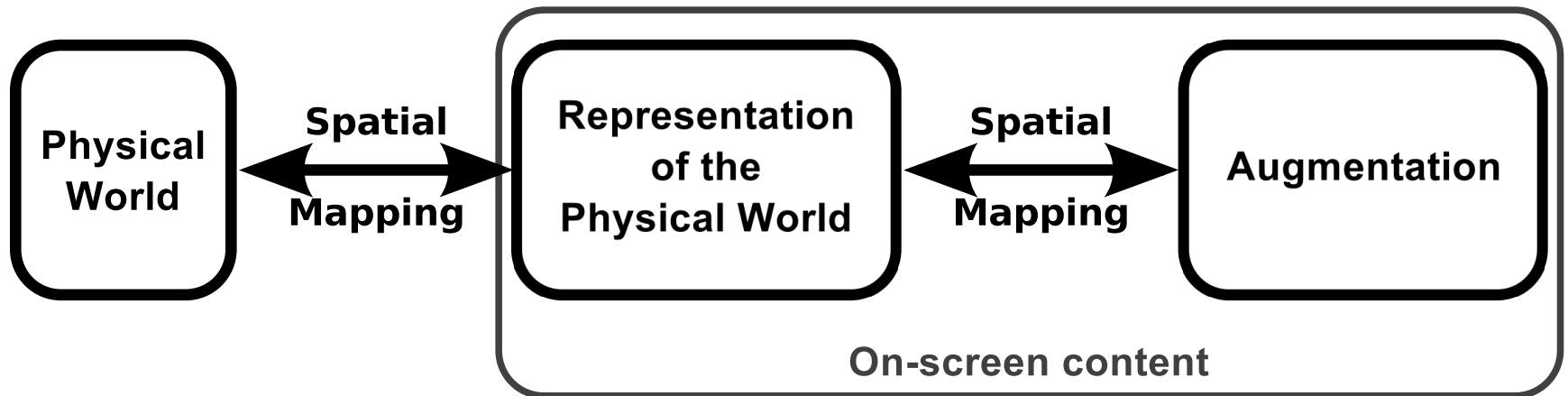- How to relax spatial constraint while keeping physical/digital colocation ?

Introduction

- Scope: Visual augmentation in handheld Augmented Reality

- Focus on spatial relations

- Goal: Organize design alternatives in a framework
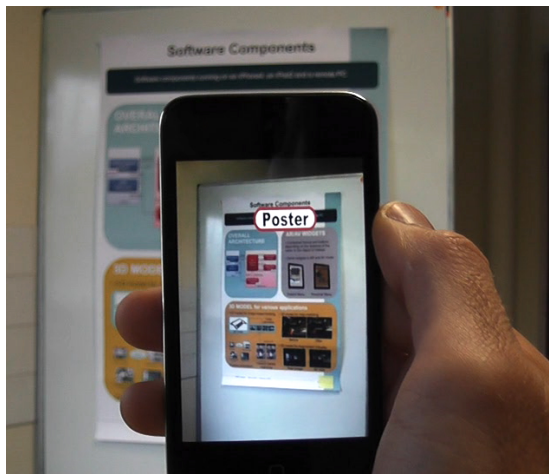
Framework Presentation

Framework organized around:

- 3 entities, 2 categories for on-screen content

- 2 spatial mappings

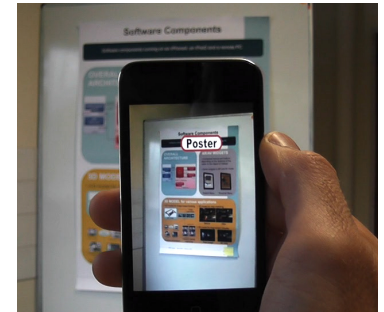# Representation of the Physical World

- On-screen content representing the physical surrounding

- Allows the user to map the viewpoint and digital augmentation in the physical world
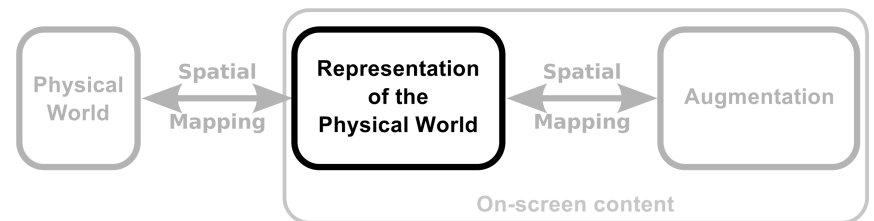
Representation of the Physical World

- Mode of representation:
  - Live video, snapshots
  - Non-photorealistic
  - Virtual Model

[Fischer 05]

| Physical World | Spatial Mapping | **Representation of the Physical World** | Spatial Mapping | Augmentation |
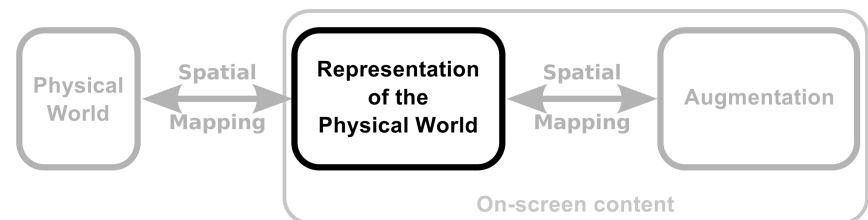
On-screen content

Digital Augmentation

- On-screen content that is not the representation of the physical world
- Provide extra information and interaction
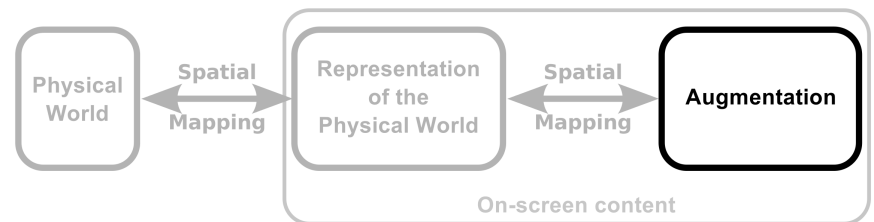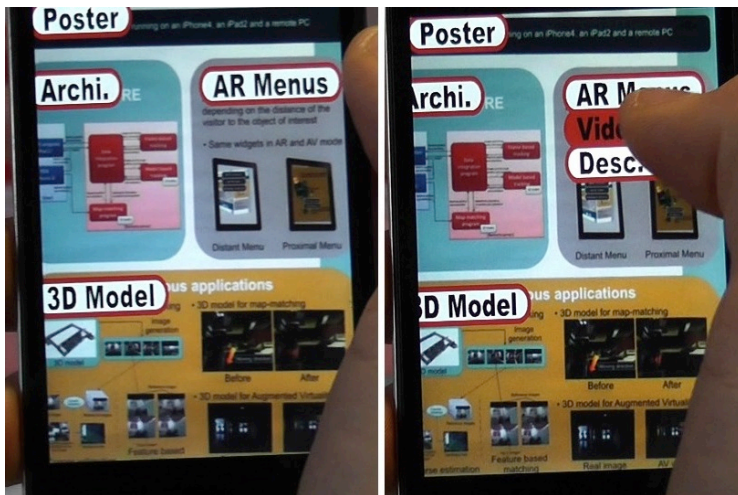
Digital Augmentation

- Visual aspect:
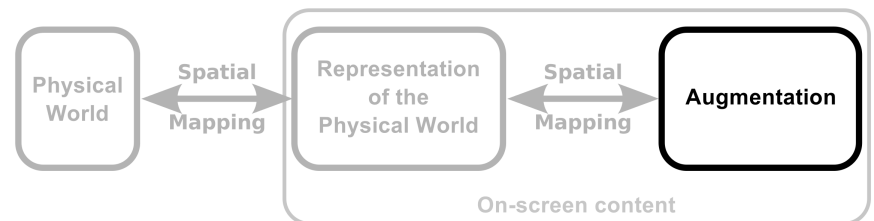 - Reproduction Fidelity axis [Milgram 1994]
  - Dimensionality [Tönnis 2011]
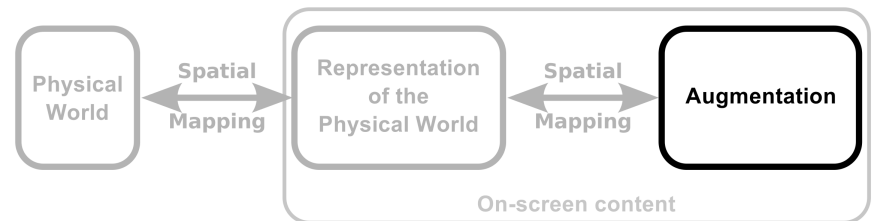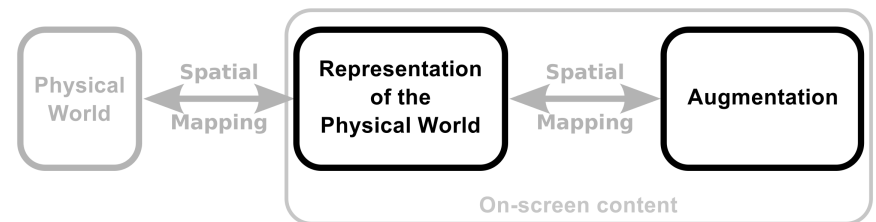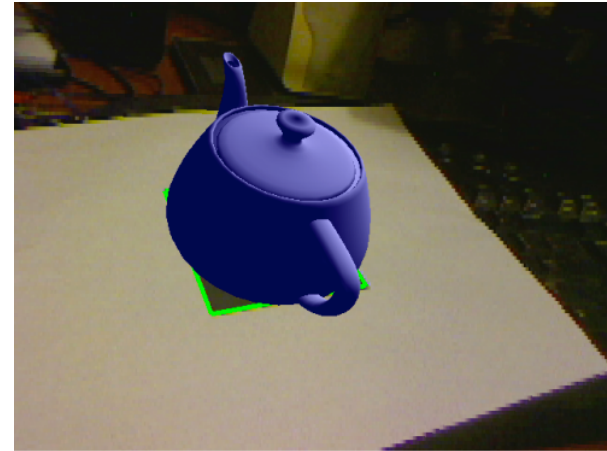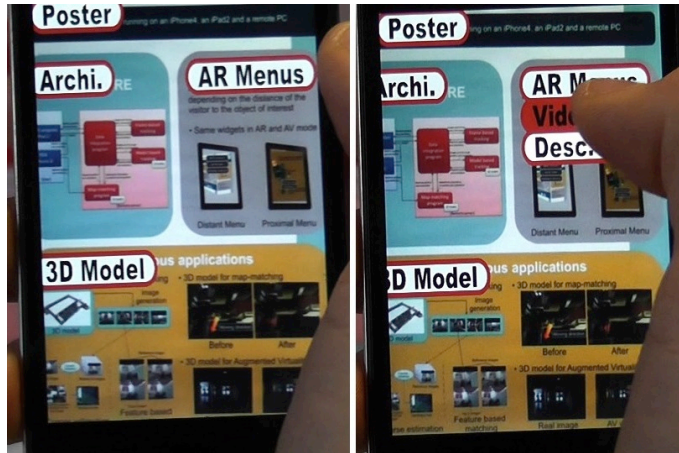
Digital Augmentation

- Content:
  - Selection of content beyond de facto viewport visibility
  - Information filtering [Julier 00]

LOD Interface [DiVerdi 04]

Distinction
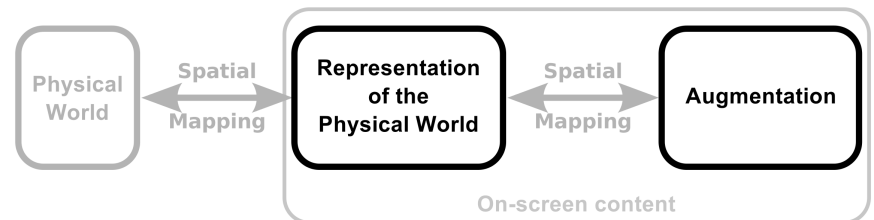# Representation / Augmentation

Distinction
Representation / Augmentation

- ClayVision [Takeushi 2012]

- Distinction on a per-characteristic rather than a per-object basis

Spatial mapping between the physical world and its representation

- Coupling of the viewpoint with the handheld device pose.

**Conformal**   **Relaxed**   **None**

- Projection:
  - Camera dependent, zoom
  - Distortion (e.g. Fish-eye)
  - Orthographic

Physical World   **Spatial Mapping**   Representation of the Physical World   Spatial Mapping   Augmentation

On-screen content
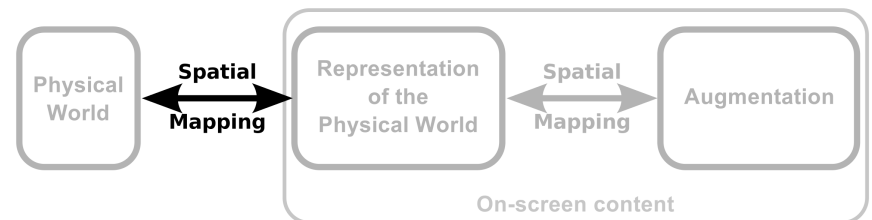
Spatial mapping between the Augmentation and the Representation

- Spatial coupling of the augmentation with the representation of the physical world
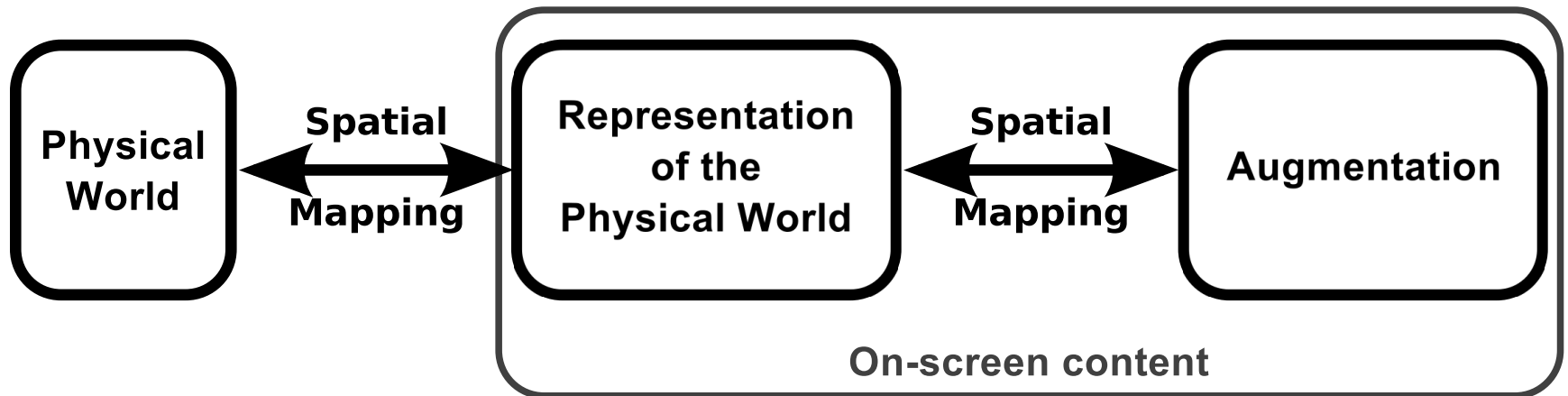
Conformal   **Relaxed**   **None**

Partial   **Distant**   **Off-screen**
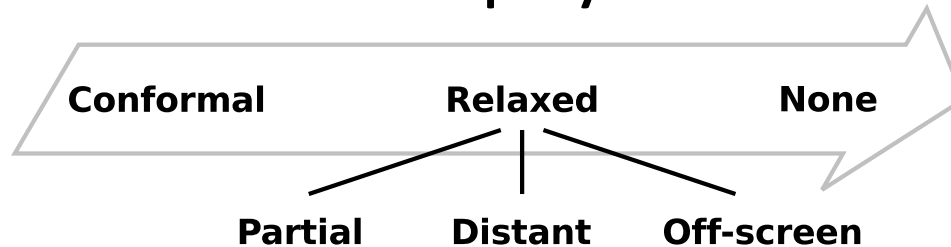
- Relaxing this coupling is useful to improve augmentation legibility

Physical World — **Spatial Mapping** — Representation of the Physical World — **Spatial Mapping** — Augmentation

On-screen content
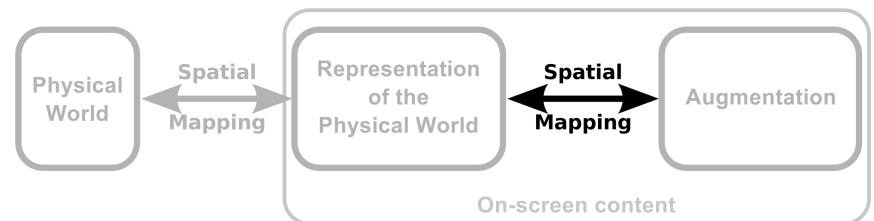
Framework: Summary

- A snapshot at a given time
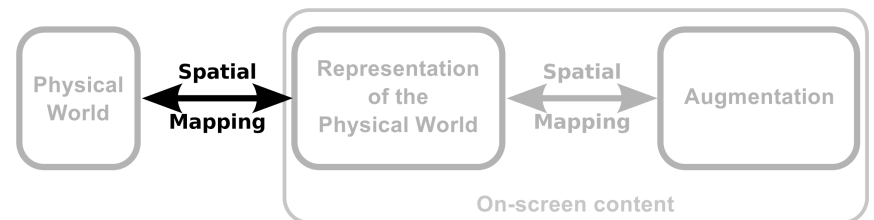- Need for description of dynamicity and transitions

Dynamicity of the spatial mappings

- Initiative:
  - Explicit
  - Implicit
  - Automatic
- Sustainability:
  - Transient
  - Sustained

Dynamicity of the spatial mappings

- Spatial mapping between the physical world and its representation:

 - Freeze-frame implemented as explicit and sustained

Sample technique: AR TapTap

- Adapt TapTap [Roudaut 08] to AR
  - Explicit and transient freeze rather than sustained
  - 2 views: one with freeze, the other with live video

Dynamicity of the spatial mappings

- Spatial mapping between the physical world and its representation:
  - Touch Projector: implicit and transient zooming
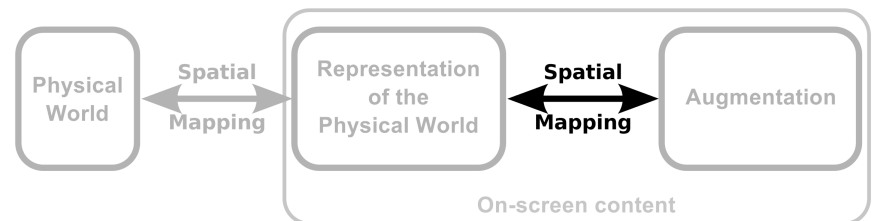

[Boring 10]
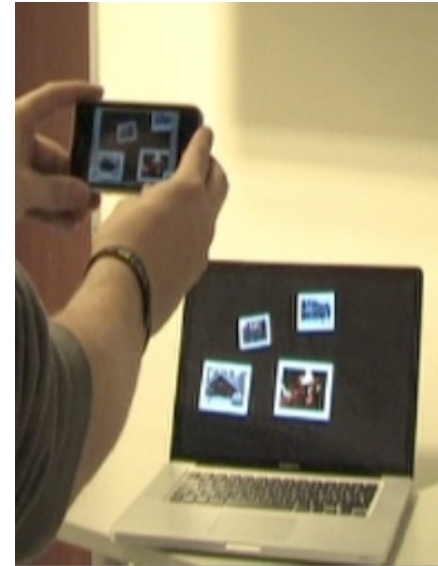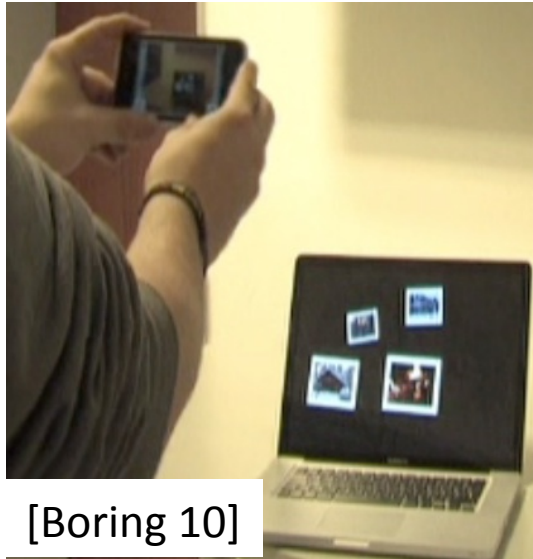
Dynamicity of the spatial mappings

- Spatial mapping between the representation and the augmentation:
  - Implicit

View Management [Bell 01]

Dynamicity of the spatial mappings

- Transient transitions interesting to best fit current user's task

- Implicit transitions interesting as no extra user's action is necessary

- To avoid discontinuity, transitions needs an assistance such as animation
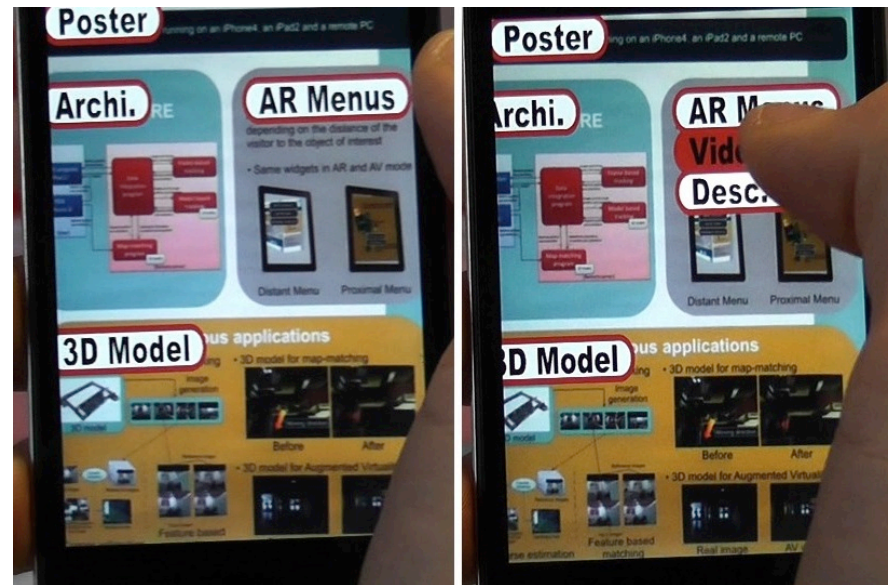
Ongoing Work

- Validation and refinement:
  - Existing classifications
  - Existing interaction techniques and systems
  - Own experience

Ongoing Work

- Input modalities and spaces
  - Relaxed viewpoint control
 - Interaction with augmented scene

Future Work

- Generalization to other AR settings

Display device	Physical World	Representation Physical World	Augmentation
HMD - Video		✓	✓
- Video Miniat.	✓	✓	✓
- Optical	✓		✓
Projection-based	✓		✓
Handheld device	✓	✓	✓

Conclusion

- Framework:
  - 3 entities, 2 categories for on-screen content
  - 2 spatial mappings
  - Dynamicity of spatial mappings: Initiative, sustainability
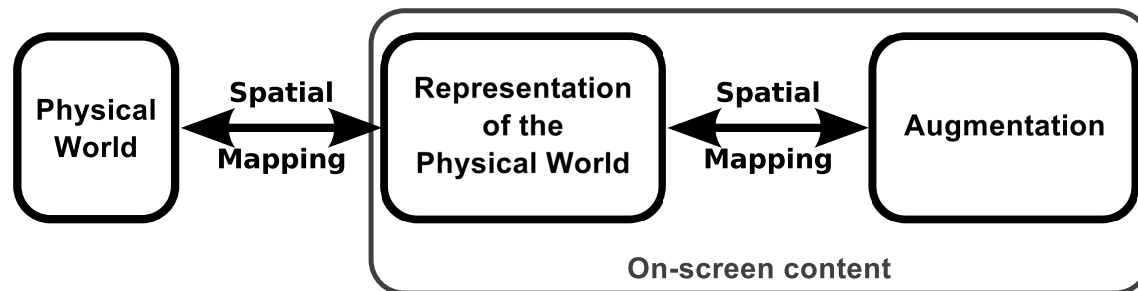
Thank you for your attention

Questions ?