Interactive Augmented Reality

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- Definitions

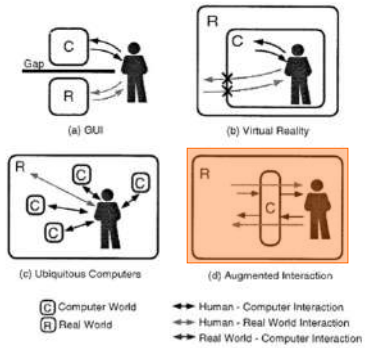
- Handheld AR/AV
  - Pointing at physical targets
  - Pointing at virtual targets
- HMD-based AR/AV
  - 3D pointing

Augmented Reality (AR)
Augmented Virtuality (AV)

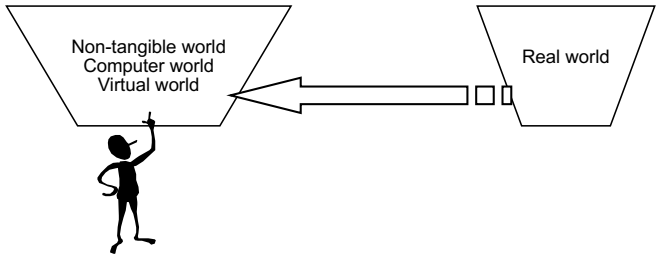
- Combination of the perception of physical and digital objects
- Mostly visual augmentation
  (even if other senses can be augmented)

Augmented Reality (AR)

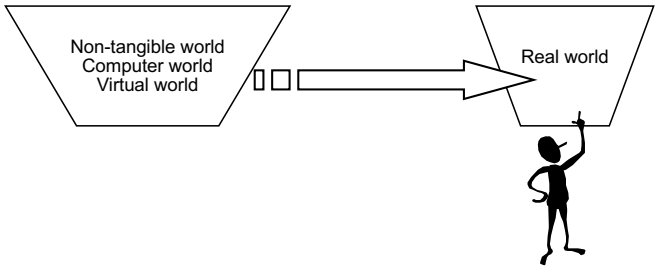
- [Azuma 97]
  - Combines real and virtual
  - Interactive in real time
  - Registered in 3D



Combining the real and virtual worlds



Combining the real and virtual worlds

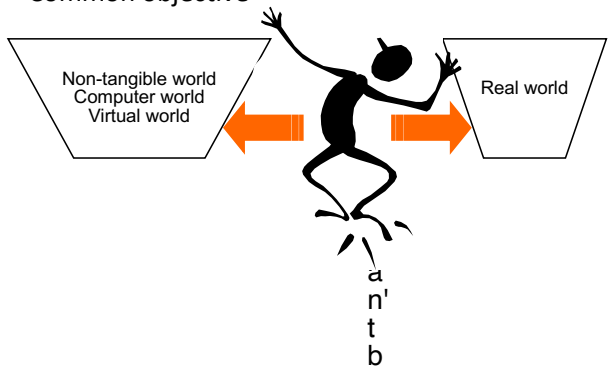


Combining the real and virtual worlds

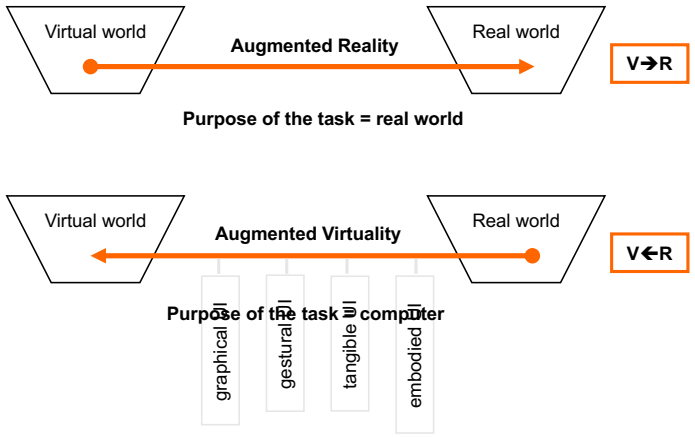
- Profusion of terms
  - Virtual reality
  - Bit / Atom
  - Computer Augmented Environment
  - Augmented Video
  - Augmented Interaction
  - Augmented Virtuality
  - Augmented Reality
  - …

Combining the real and virtual worlds

- Common objective



Augmented Reality / Augmented Virtuality



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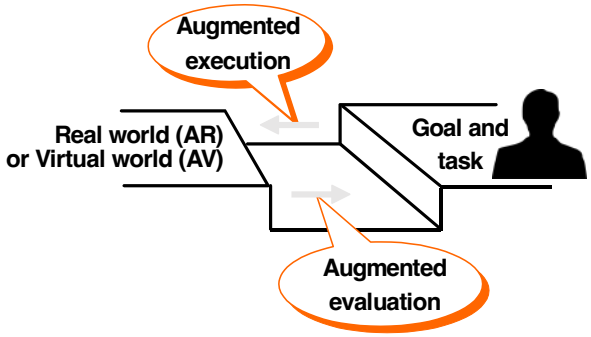
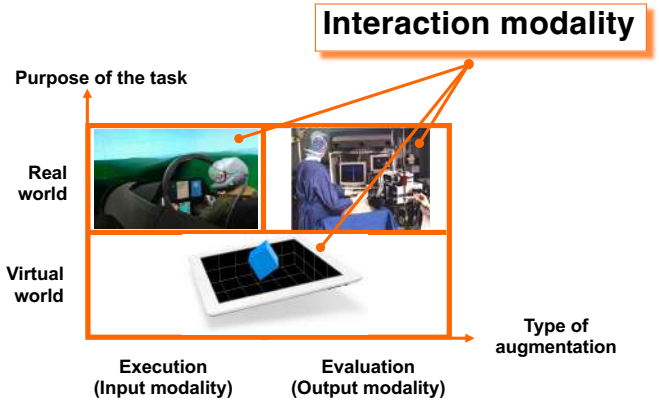


Augmented Reality / Augmented Virtuality



Augmented Reality/Virtuality (AR / AV)

- Projector-based Displays
- Handheld AR: Handheld devices used as physical 'magic lens'
- Head-Worn Displays

[Rekimoto 95]

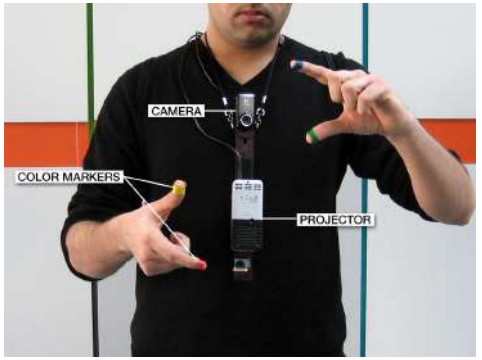
Mobile and projector-based interactive AR/AV: Sixth sense

- Sixth sense is a wearable gesture interface that augments the physical world around us with the digital world.
- It lets us use natural hand gestures to interact with the digital world.
- It comprises a pocket projector , a mirror and a camera. The hardware components are coupled in pendent like mobile wearable device.

http://www.123seminarsonly.com/Seminar-Reports/025/36074795-Sixth-Sense-Technology-Final.pptx

Sixth sense Components

Camera
Projector
Mirror
Colour markers



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APPLICATIONS

TAKE PICTURES

If you fashion your index fingers and thumbs into a square ("framing" gesture) we can take a snap.

After taking the photos, we can project them onto a surface, and use gestures to sort through the photos, and organize and resize them.

http://www.123seminarsonly.com/Seminar-Reports/025/36074795-Sixth-Sense-Technology-Final.pptx

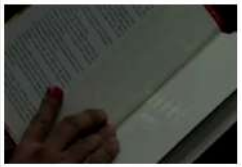
APPLICATIONS

ZOOMING FEATURES

We can arrange those pictures. The user can zoom in or zoom out by just using hand movements

GETS BOOK INFORMATION

The system can project Amazon ratings on that book, as well as reviews and all other relevant information



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APPLICATIONS

MAKE A CALL

You can use sixth sense to project a keypad onto your hand, then use the that key pad to make a call.

CREATES MULTIMEDIA READING EXPERIENCES

Sixth sense can be programmed to project related videos onto news paper articles you are reading.

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Augmented Reality/Virtuality (AR / AV)

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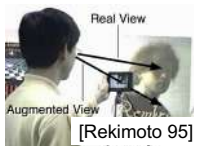
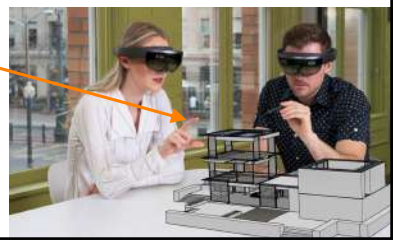


[Rekimoto 95]

Augmented Reality/Virtuality (AR/AV)

- Challenges
  - Tracking
  - Rendering
  - Interaction



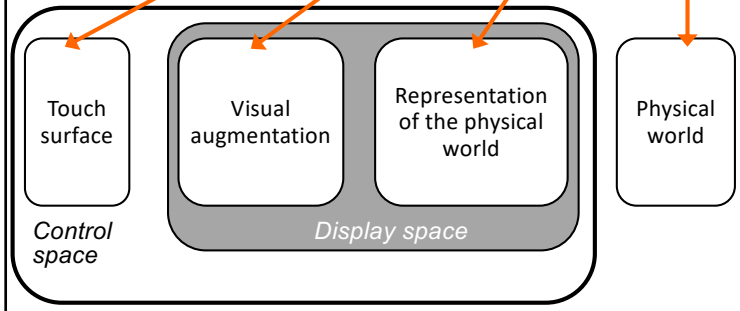
- Definitions
- Handheld AR/AV
  - Pointing at physical targets
  - Pointing at virtual targets
- HMD-based AR/AV
  - 3D pointing

Handheld AR/AV

- Specificities:
  - Viewpoint is controlled by the device pose
  - Direct Touch is the de facto standard input (1:1 mapping with the screen)
- Frame of reference for pointing?

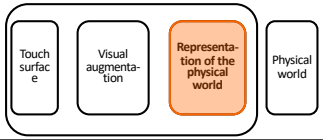
Framework

- 4 entities



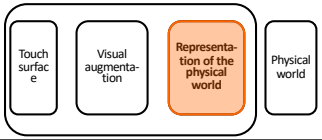
Representation of the Physical World

- On-screen content representing the physical surrounding
- It allows the user to map the viewpoint and digital augmentation in the physical world



Representation of the Physical World

- Visual aspect:
  - Live video, snapshots
  - Non-photorealistic
  - Virtual Model



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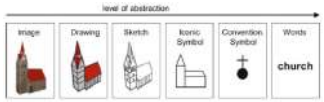
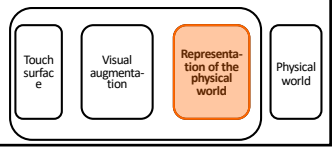
Representation of the Physical World

- Visual aspect:
  - Reproduction Fidelity axis

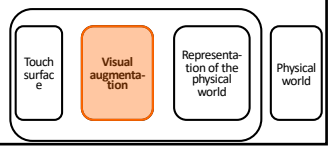
  - Level of abstraction





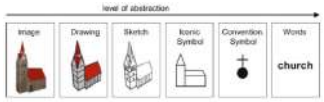
Visual Digital Augmentation

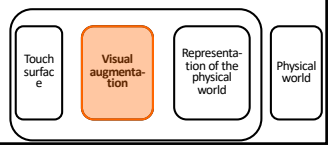
- On-screen content that is not the representation of the physical world
- Extra information and interaction



Visual Digital Augmentation

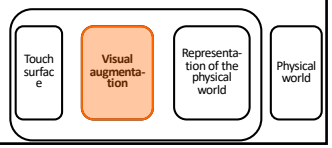
- Visual aspect:
  - Dimensionality 2D 3D
  - Level of abstraction





Visual Digital Augmentation

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



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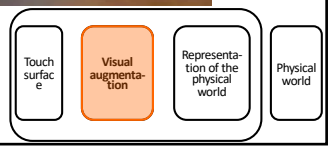
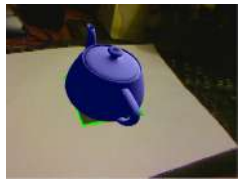
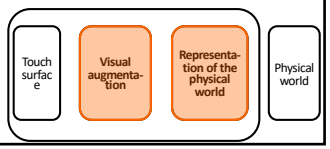
Visual Digital Augmentation



Distinction between Representation / Augmentation

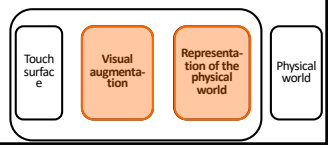




Distinction between Representation / Augmentation

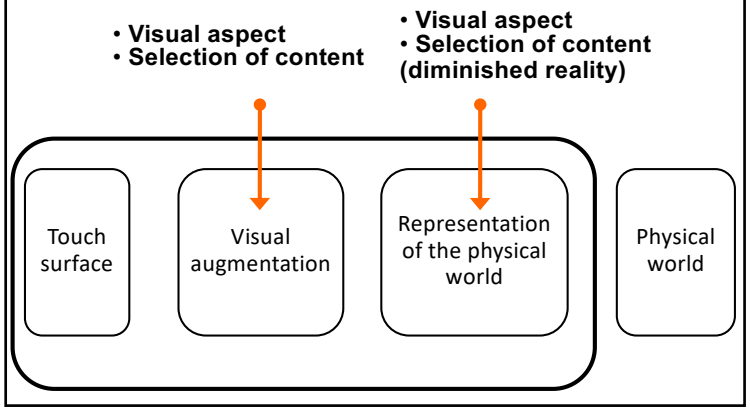
- ClayVision

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



Framework

- 4 entities: design elements



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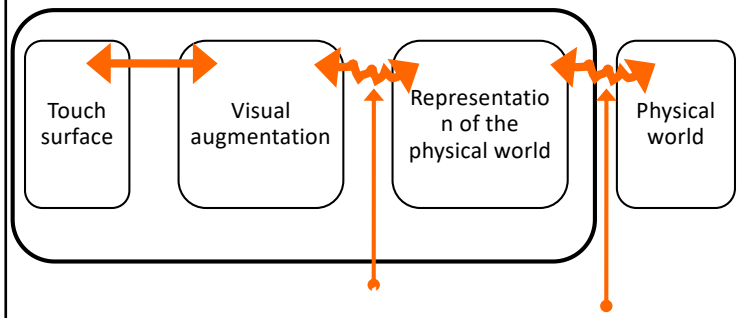
Framework

- 4 entities **linked by spatial relationships**



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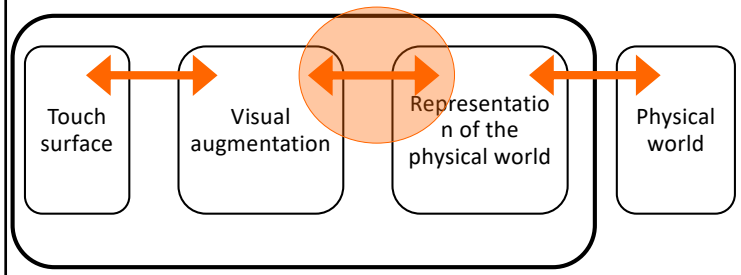
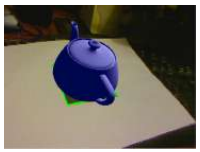
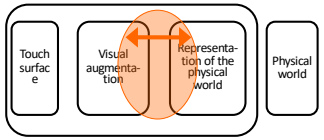


Spatial mapping between the Augmentation and the Representation

- Spatial coupling of the augmentation with the representation of the physical world





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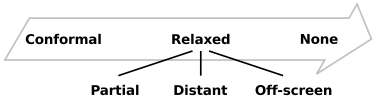

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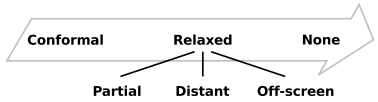
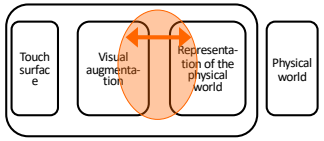
Spatial mapping between the Augmentation and the Representation

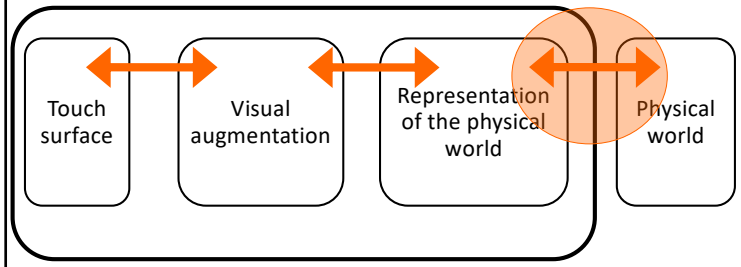


- Relaxing this coupling is useful to improve digital augmentation legibility



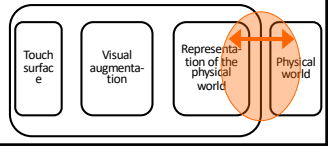
Framework

- 4 entities **linked by spatial relationships**



Spatial mapping between the physical world and its representation

- Spatial coupling of the viewpoint with the handheld device pose



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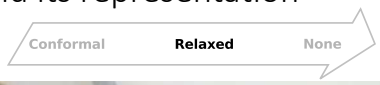

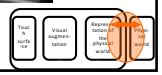

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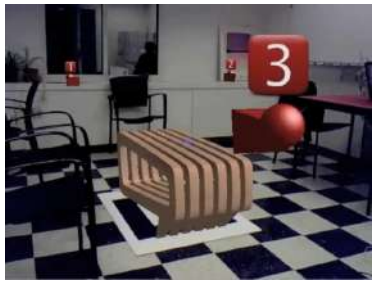
Spatial mapping between the physical world and its representation

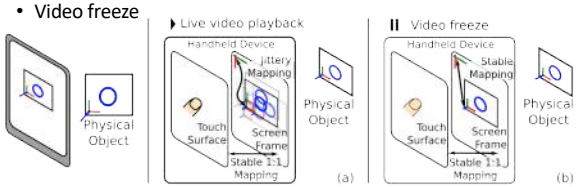
Conformal Relaxed **None**



Spatial mapping between the physical world and its representation

Conformal Relaxed **None**

- Spatial relationships temporality/partially broken for improving interaction
  - Video freeze



Spatial mapping between the physical world and its representation

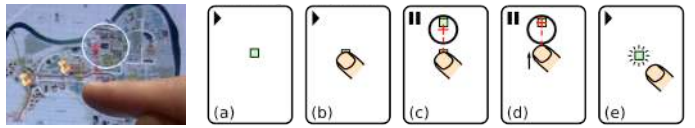
Conformal Relaxed **None**

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

Spatial mapping between the physical world and its representation

Conformal Relaxed **None**

- Adapt Shift with freeze-frame
  - Shift's callout and cursor overcome the 'fat finger' problem
  - Freeze-frame avoids viewpoint instability
  - On-demand precise quasi-mode



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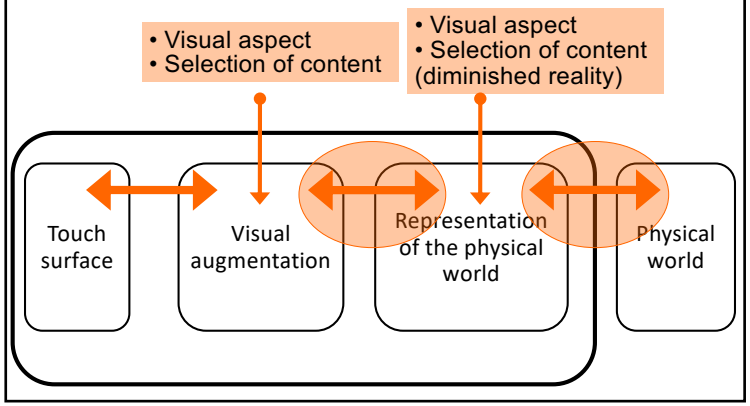
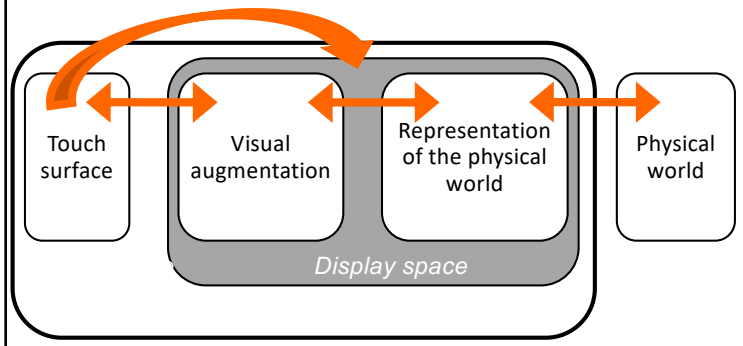
Framework

- 4 entities linked by spatial relationships

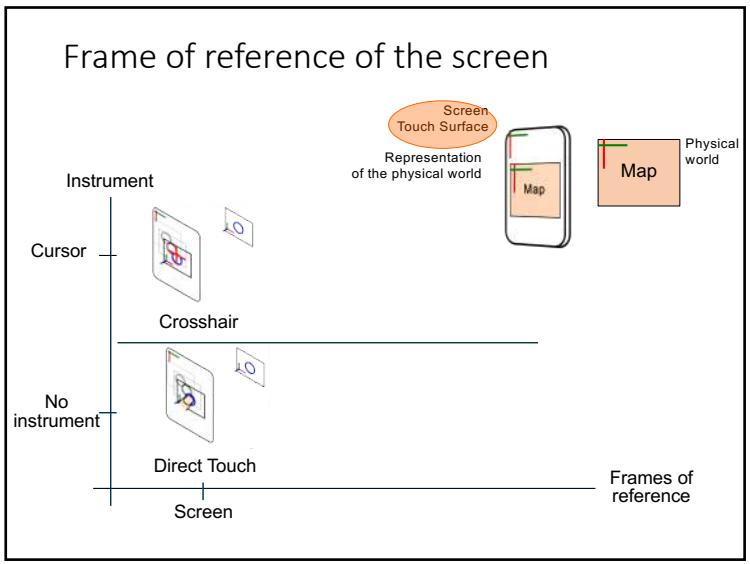


Framework

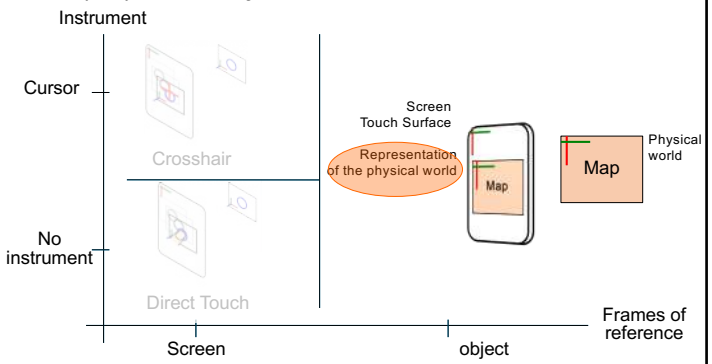
- Frames of reference for pointing



Frame of reference of the screen



Frame of reference of the physical object



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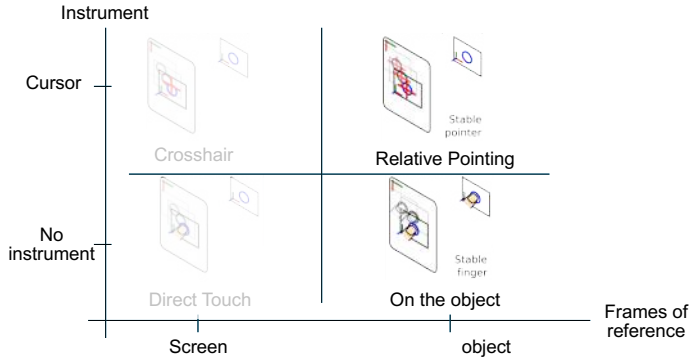
Frame of reference of the physical object



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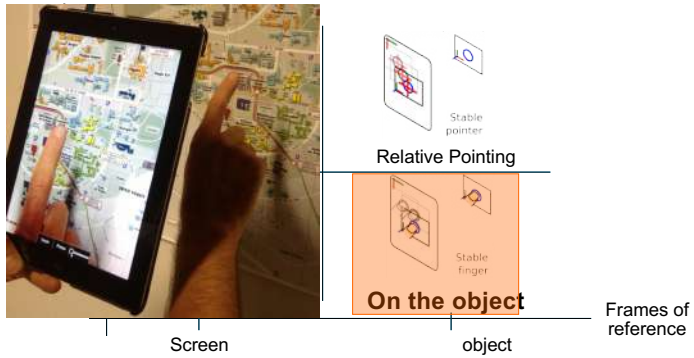

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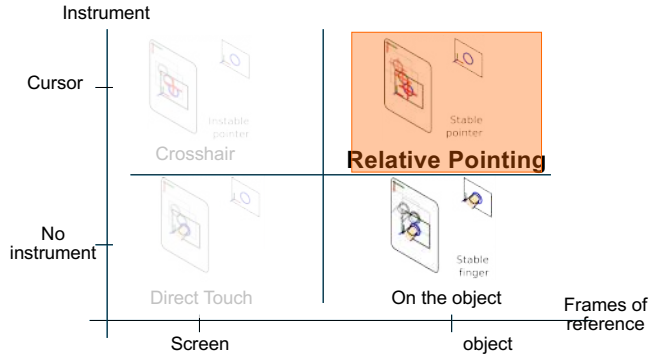
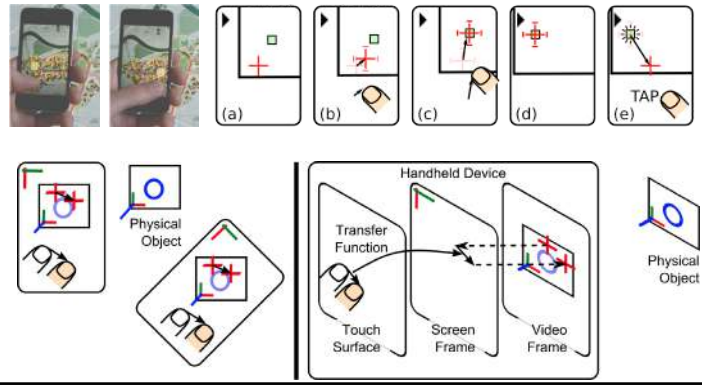


Frame of reference of the physical object

- Cursor stabilized in the physical object's frame



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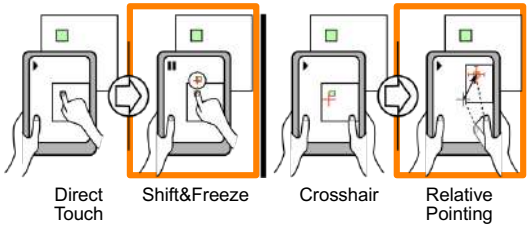
In-lab evaluations: Pointing

- User preference

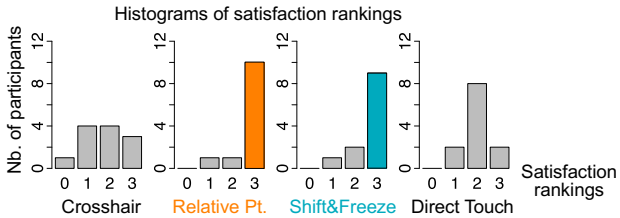


In-lab evaluations: User preference

- 'Realistic' pointing task: Placing marks on a wall map
- 12 participants
- Handheld tablet

In-lab evaluations: User preference

- Results
  - Shift&Freeze and Relative Pointing
    - Preferred over the baseline techniques
    - Precise mode used (73% of the time)



In-lab evaluations: User preference

- Results
  - Shift&Freeze and Relative Pointing
    - Preferred over the baseline techniques
    - Precise mode used (73% of the time)
  - Shift&Freeze
    - Participants used to Direct Touch
    - Freezing the frame during interaction: Not really disturbing in this context
  - Tablet form factor: Unsafe hold

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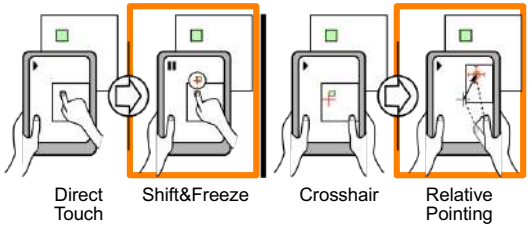
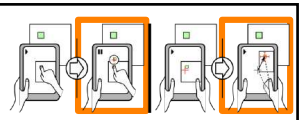
In-lab evaluations: Pointing

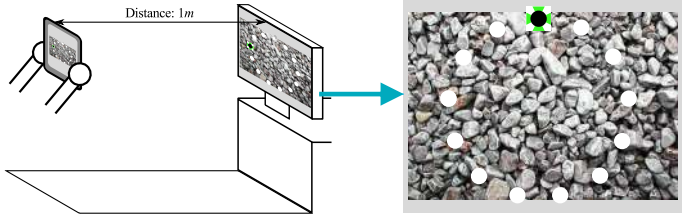
- User preference
- Comparing performance



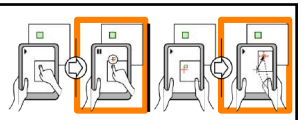
In-lab evaluations: Performance



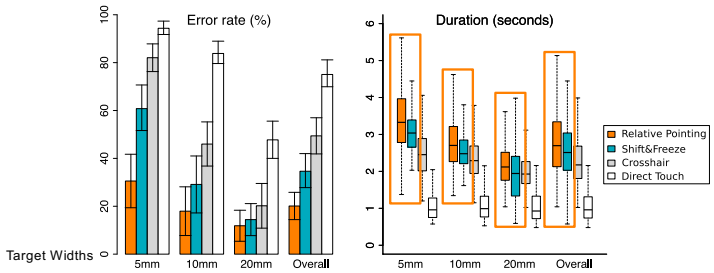
- Abstract pointing task
- 12 participants
- Handheld tablet
- Small targets: 0.5cm, 1cm, 2cm



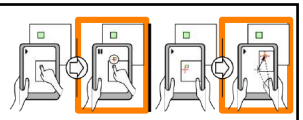
In-lab evaluations: Performance



- Results: Relative Pointing and Shift&Freeze
  - More precise that the baseline techniques
  - Relative Pointing less error prone
  - Comparable completion time



In-lab evaluations: Performance



- Results: Relative Pointing and Shift&Freeze
  - More precise that the baseline techniques
  - Relative Pointing less error prone
  - Comparable completion time
  - Precise modes used on purpose

Percentage of usage of the precise modes

Techniques	Overall	W=0.5cm	W=1cm	W=2cm
Shift&Freeze	83%	91%	91%	66%
Relative Pt.	78%	99%	83%	52%

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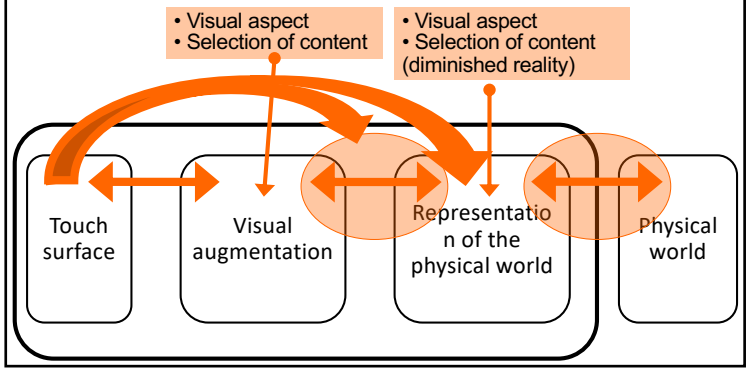
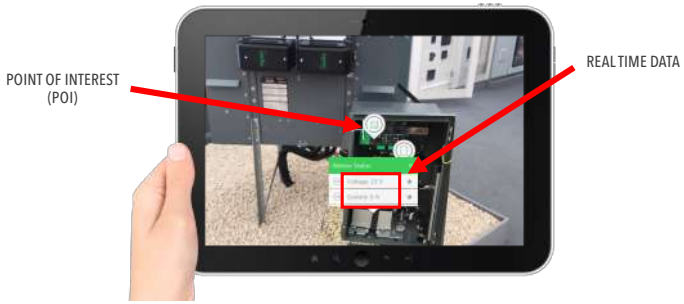
Design framework

- 4 entities linked by spatial relationships
- 2 frames of reference for pointing



- Definitions
- Handheld AR/AV
  - Pointing at physical targets
  - Pointing at virtual targets
- HMD-based AR/AV
  - 3D pointing

Pointing in handheld AR



Pointing in handheld AR

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Pointing in handheld AR

1. Limited screen' size
2. Digital targets anchored to physical world
3. Information contained inside digital targets

Pointing in handheld AR

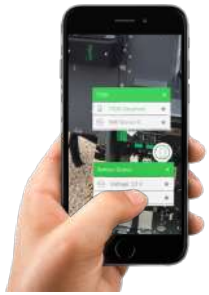
Limited intrusion on screen

Digital – physical link

Access AR information

Types of pointing

Direct pointing



Indirect pointing

Problems with direct pointing

- Target occultation
- Ambiguous selection area
- Unreachable screen areas
- Instability

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Solution

Indirect pointing

Solution

- No target occultation
- No ambiguous selection area
- No unreachable screen areas
- No instability

Indirect pointing

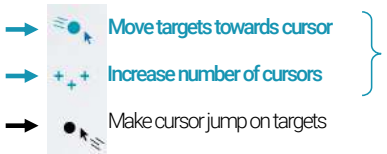
Solution

- No target occultation
- No ambiguous selection area
- No unreachable screen areas
- No instability

Indirect pointing

Cursor-targets distance

- Strategies



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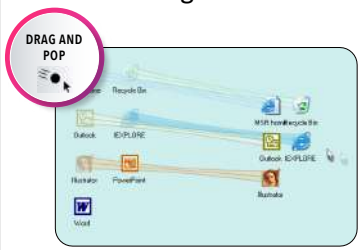
Cursor-targets distance

- Move targets towards cursor



Baudisch et al. 2003.

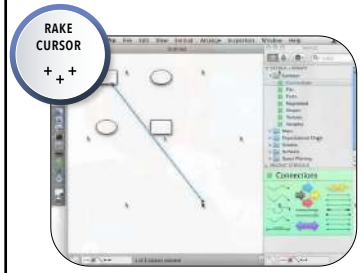
Visual link with new position of targets

Targets not anchored on the real world

AR information not considered

Cursor-targets distance

- Increase number of cursors



Blanch et al. 2009.

Not compatible with small screens

Targets anchored on the real world

AR information not considered

Summary

Summary

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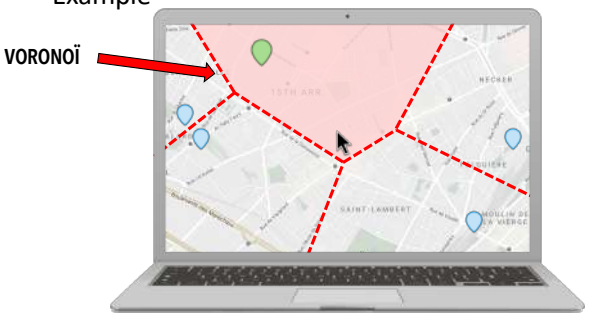
Increasing the size of targets

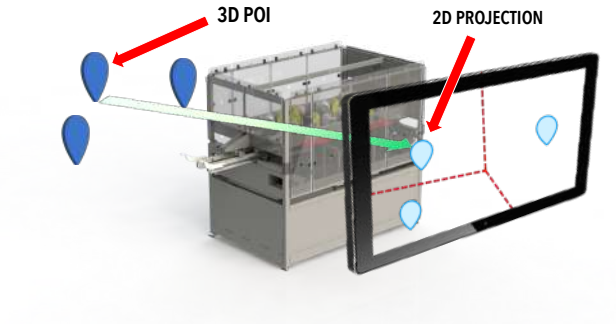
Target expansion

- Example



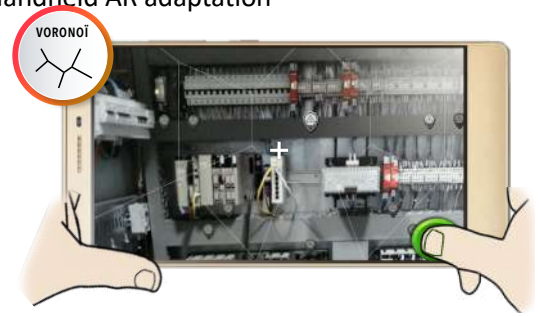
Target expansion

- Handheld AR adaptation



Target expansion

- Handheld AR adaptation



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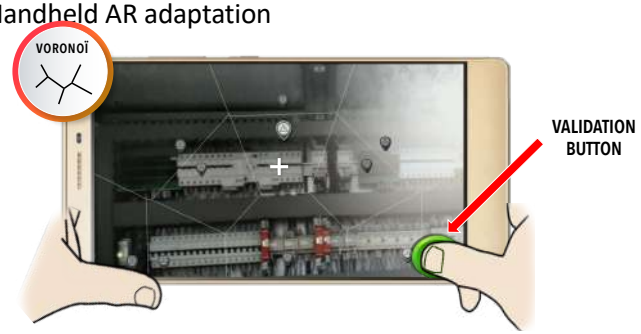
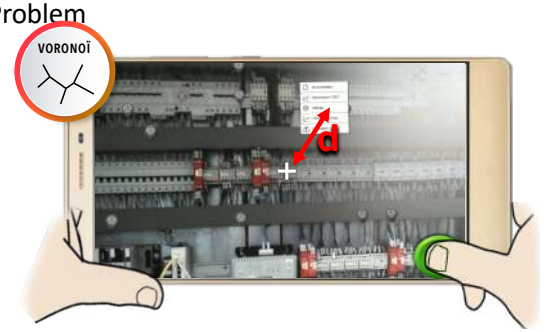
Target expansion

- Handheld AR adaptation



Digital information access

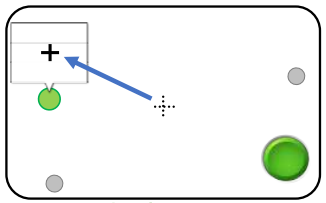
- Problem



Digital information access

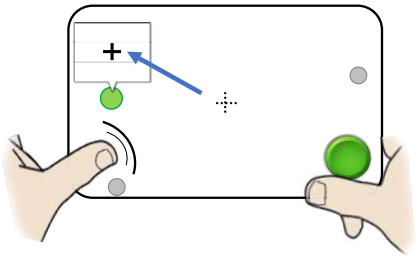
- Jumping cursor

1. How to make the cursor **jump** ?
2. How to **manipulate** the cursor?



Digital information access

- Jumping cursor



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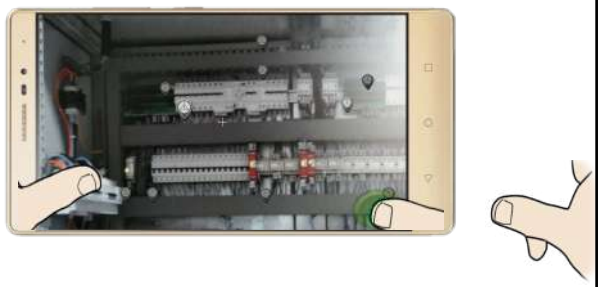
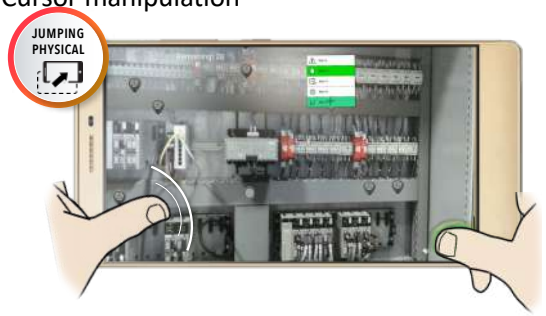
Digital information access

- Jumping cursor



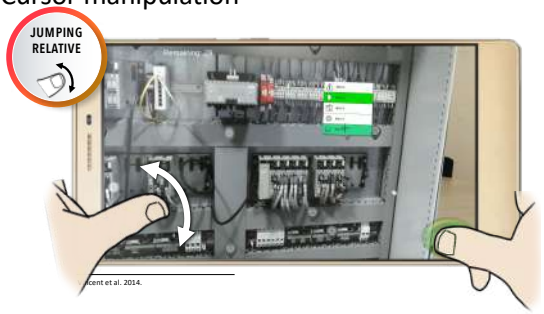
Digital information access

- Cursor manipulation



Digital information access

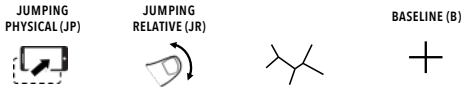
- Cursor manipulation



User study

- Access to information contained inside digital targets

4 Techniques



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User study

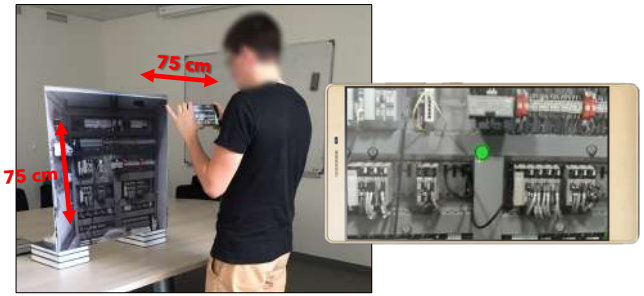
- Access to information contained inside digital targets 12 participants

1 POI selection

2 Menu item selection

User study

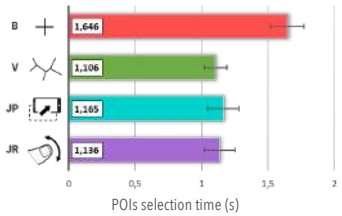
- Access to information contained inside digital targets



User study

- Results

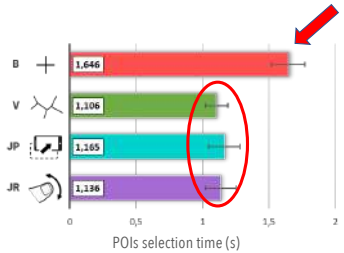
1 POIs selection



User study

- Results

1 POIs selection



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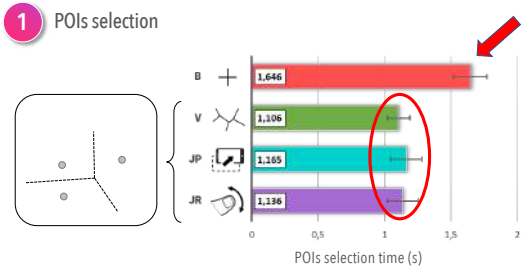
User study

- Results

1 POIs selection



User study

- Results

1 POIs selection

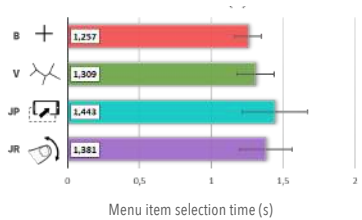
Target expansion techniques :

1. Make pointing tasks easier
2. Are suitable for handheld AR

User study

- Results

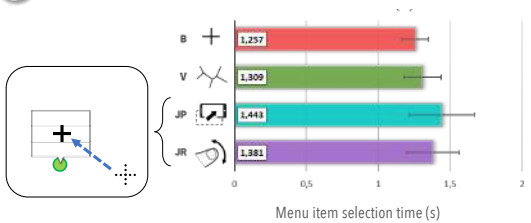
2 Menu item selection



User study

- Results

2 Menu item selection



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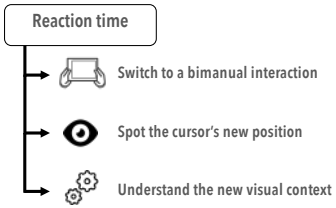
User study

- Results

2 Menu item selection



User study

- Results

3 Preferences

User study

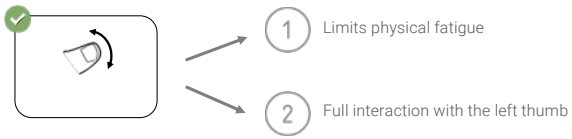
- Results

3 Preferences

User study

- Results

3 Preferences



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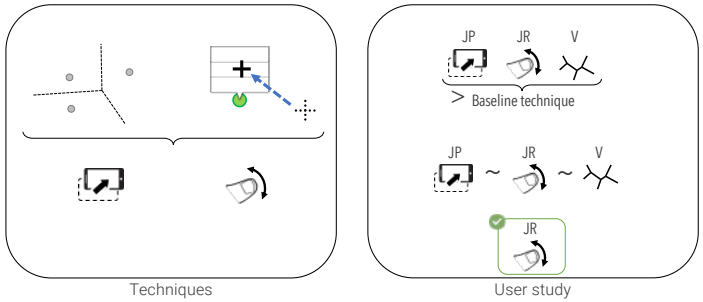
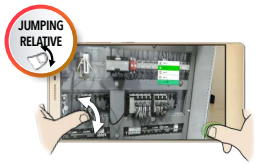
Techniques and experimental results

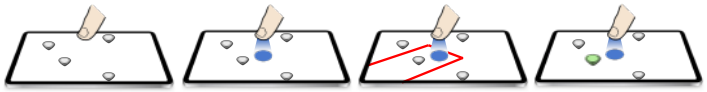


Extension

1. Test in a professional industrial context



2. Direct pointing and target expansion



Augmented Reality/Virtuality (AR/AV)

- Challenges
  - Tracking
  - Rendering
  - Interaction

- Definitions
- Handheld AR/AV
  - Pointing at physical targets
  - Pointing at virtual targets
- HMD-based AR/AV
  - 3D pointing

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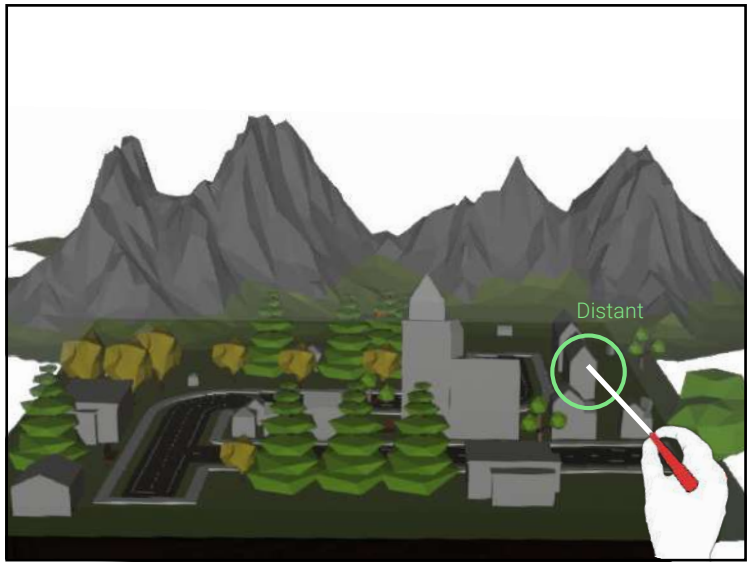
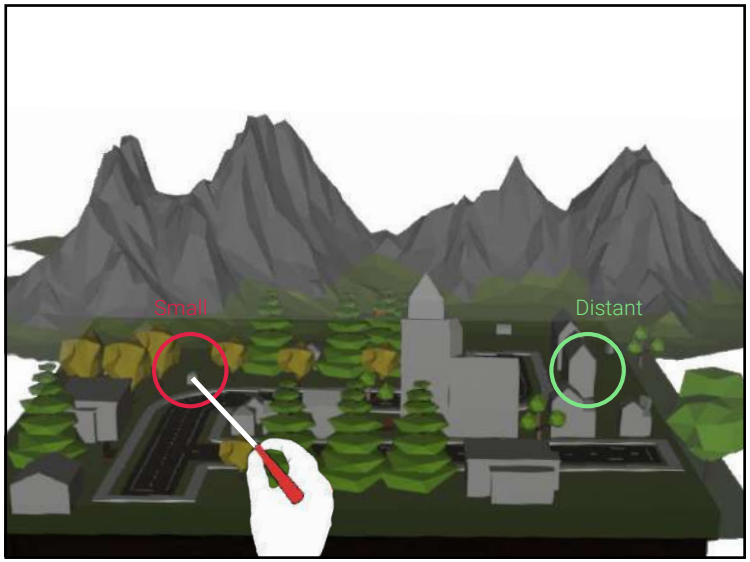
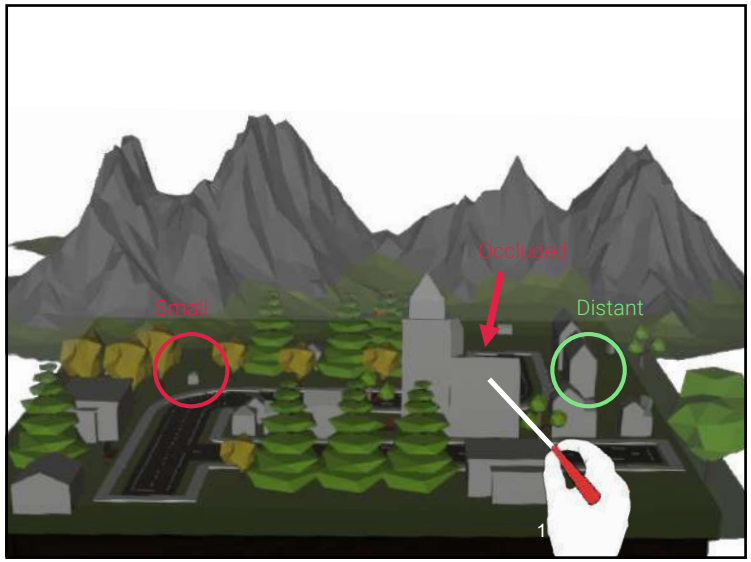
Augmented Reality/Virtuality (AR/AV)

- Challenges
  - Tracking
  - Rendering
  - Interaction







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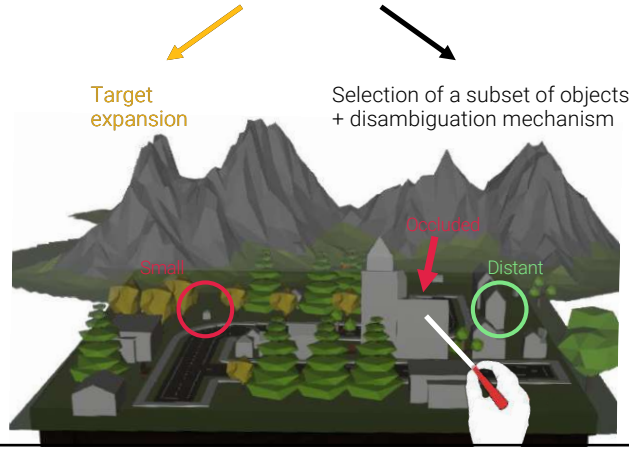
Extensions of raycasting

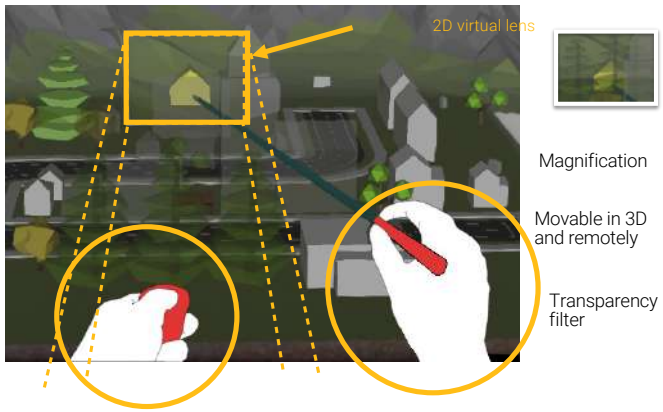


Limitation of existing works

	Small targets	Occluded targets	⚠
Target expansion	✔	✔	Density
Quad menu + progressive refinement	✔	✔	Density Loss of context Loss of links between objects
Zoom	✔	✖	Loss of context
Spatial rearrangement	✔	✔	Loss of links between objects

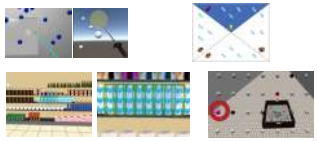
What about magnification lenses?

RayLens



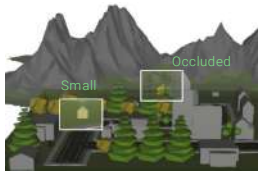
RayLens: advantages

Previous works



⚠
- Impact of the density
- Loss of link between objects
- Loss of context

Magnification lens



✔
- Independent of the density
- Maintains links between objects
- Maintains the context

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Experimental study

Performant?

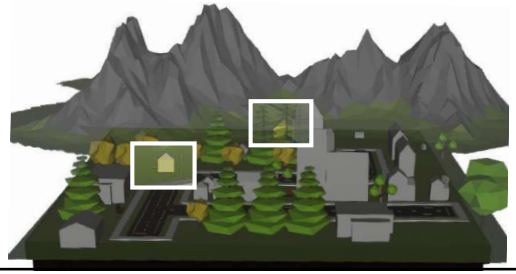
Speed

Accuracy

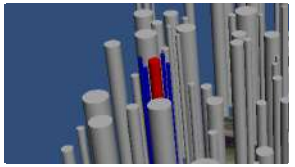
3D movement of the lens?

Ease

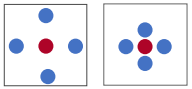
Fatigue



Evaluation of RayLens performance Task



3 target sizes



Sparse

Dense

2 density spacing

Evaluation of RayLens performance Techniques

RayLens

RayCasting

RaySlider

Evaluation of RayLens performance Experiment & Measures

12 participants

RayLens

RayCasting

RaySlider

Quantitative evaluation

Speed

Accuracy

Qualitative evaluation

Workload

Users preferences

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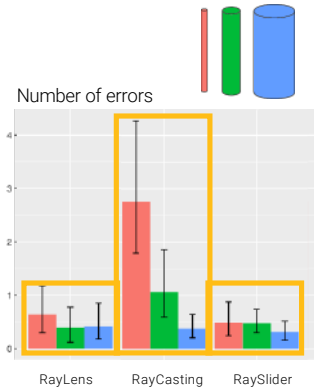
Results: accuracy

The 3 techniques are equivalents on average

RayCasting impacted by the target size

RayLens and **RaySlider** more accurate

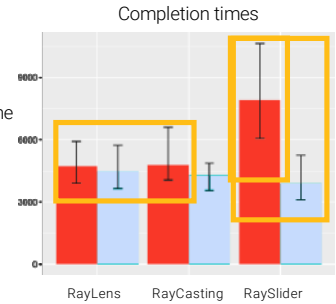


Results: speed

RaySlider impacted by the density

3 techniques equivalents in time

RayLens 1.6x faster than **RaySlider**

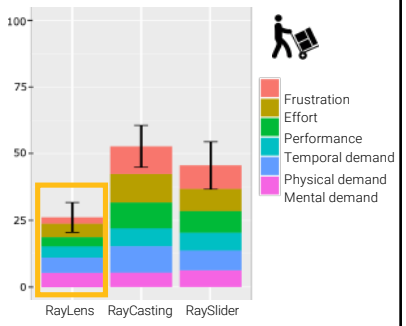


Qualitative results

The lowest workload with **RayLens**

RayLens is easy-to-learn and easy-to-use

RayLens is preferred by all participants

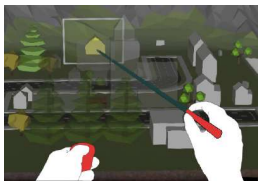


RayLens: extension of raycasting

Performant?

Speed

Accuracy



- Magnified target
- 3D task reduced to a 2D task
- Shorter distance to the target
- Smaller number of distractors

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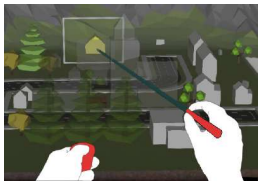
RayLens: extension of raycasting

3D movement of the lens?

Ease

Fatigue



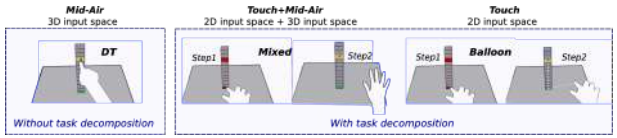
- Simple, intuitive
- The lowest workload
- The least physically and mentally tiring
- Preferred

Augmented Reality/Virtuality (AR/AV)

- Challenges
  - Tracking
  - Rendering
  - Interaction

3D object selection in Tabletop AR

Experimental study



- Comparison of 3 interaction techniques

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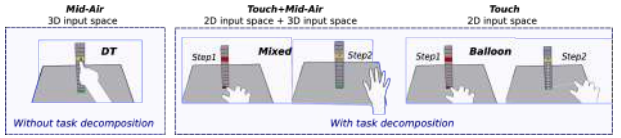
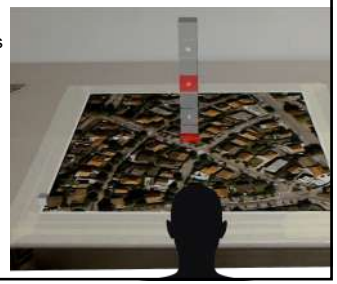
Experimental study

- Comparison of 3 interaction techniques

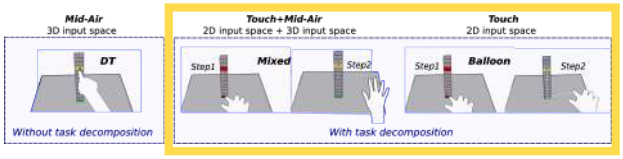
Experimental study

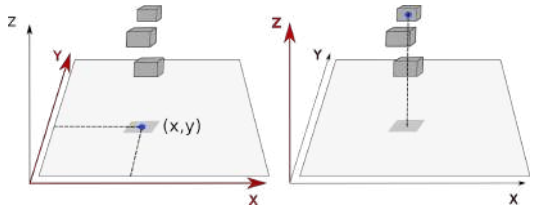


- Comparison of 3 interaction techniques
- Selection of a 3D box in a stack of 3D boxes placed on the table



The 3 compared techniques

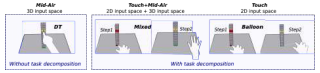




Design

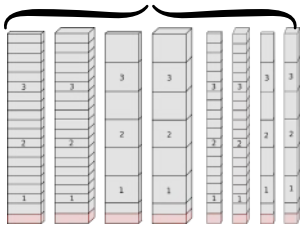
- Quantitative Evaluation: completion time & accuracy

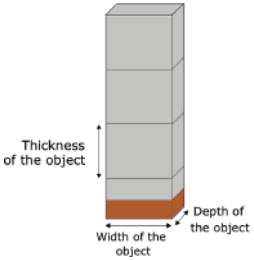
TECHNIQUE



SHAPE

8 different shapes





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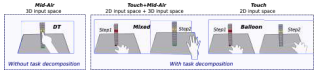
Design

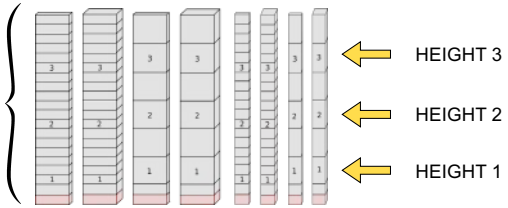
• Quantitative Evaluation: completion time & accuracy

TECHNIQUE



SHAPE

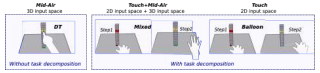
HEIGHT



Design

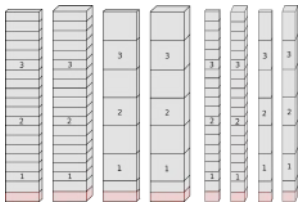
• Quantitative Evaluation: completion time & accuracy

TECHNIQUE



SHAPE

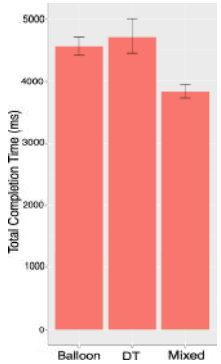
HEIGHT



• Qualitative Evaluation: NASA-TLX & users' preferences

Results: speed

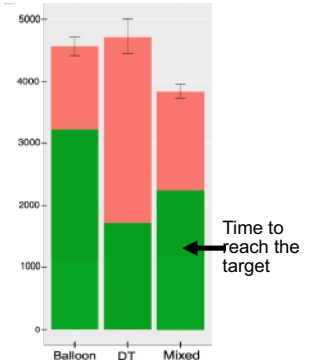
1. *Mixed, a* fast selection technique on average



Results: speed

1. *Mixed* a fast selection technique on average

2. Similar completion times to reach the targets for the first time with *DirectTouch* and *Mixed*



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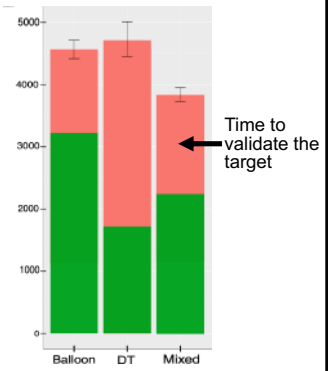
Results: accuracy

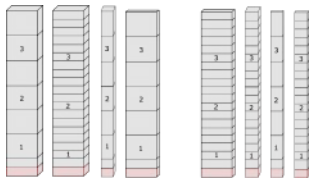
DirectTouch less accurate than others

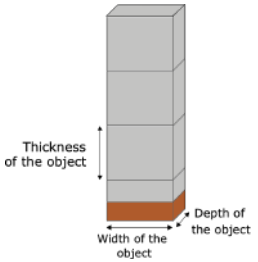


Time to validate the target

Results: SHAPE effect

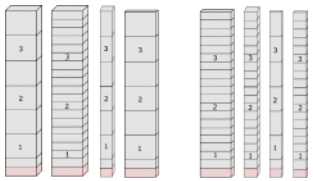
Grouping the shapes according to the numbers of small dimensions

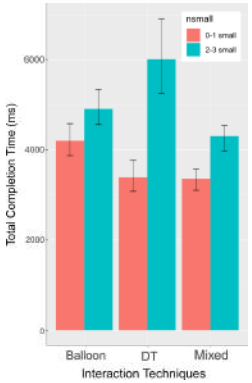




Results: SHAPE effect

Grouping the shapes according to the numbers of small dimensions

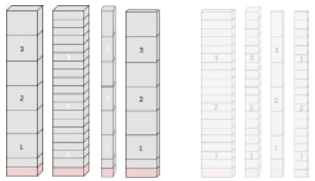


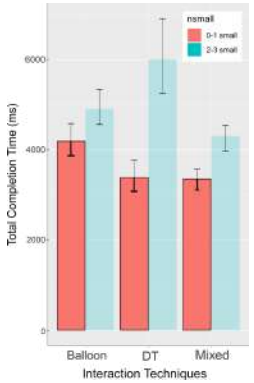


Results: SHAPE effect

- For shapes with at most 1 small dimension:

Mixed and *DirectTouch* are faster than *Balloon*





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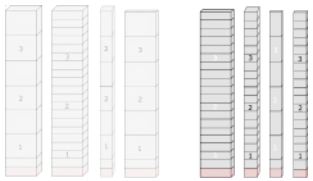
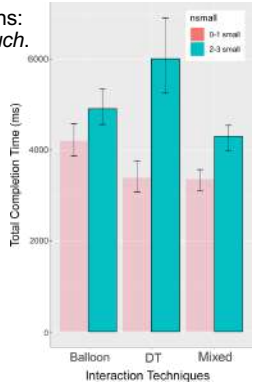
Results: SHAPE effect

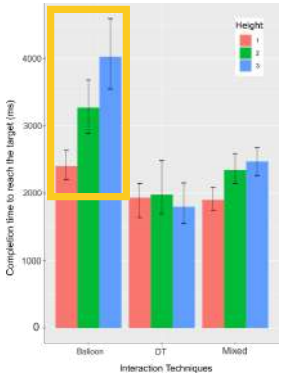
• For shapes with at least 2 small dimensions: *Mixed* and *Balloon* outperformed *DirectTouch*.





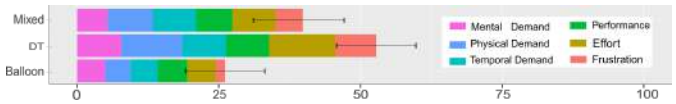
Results: HEIGHT effect

Time to reach the target with *Balloon* strongly impacted by the height of the target in the stack



Results: Qualitative evaluation

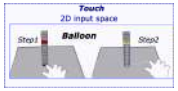
- *Mixed* and especially *Balloon* are largely preferred over *DirectTouch*
- They also required a lower workload than *DirectTouch*



Lessons learned

- Intuitive
- Fast to reach the target regardless of its height

- Least accurate
- Frustration
- Fatigue



- Most accurate
- Low fatigue
- Most preferred
- Feeling of control

- Slowest to reach the target
- Slower for high targets

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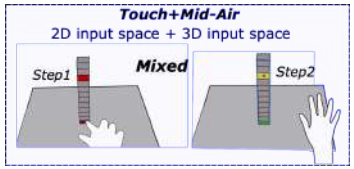
Lessons learned



- The fastest technique on average
- Efficiency of the task decomposition with a fast height adjustment in mid-air, little impacted by the height of the target
- Unifying 2D and 3D spaces:
  good compromise for fast and accurate selections

Augmented Reality/Virtuality (AR/AV)

- Challenges
  - Tracking
  - Rendering
  - Interaction

- Definitions
- Handheld AR/AV
  - Pointing at physical targets
  - Pointing at virtual targets
- HMD-based AR/AV
  - 3D pointing
- Perspectives

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Perspective

+ Unlimited viewing space
- Interaction techniques : fatigue and precision

Perspective

+ Unlimited viewing space
+ 3D stereoscopic view
- Interaction techniques : unifying 2D and 3D desktop