vancouver SIGGRAPH2014 NATURALLY DIGITAL

The 41st International Conference and Exhibition on Computer Graphics and Interactive Techniques

How Do People Edit Light Fields?

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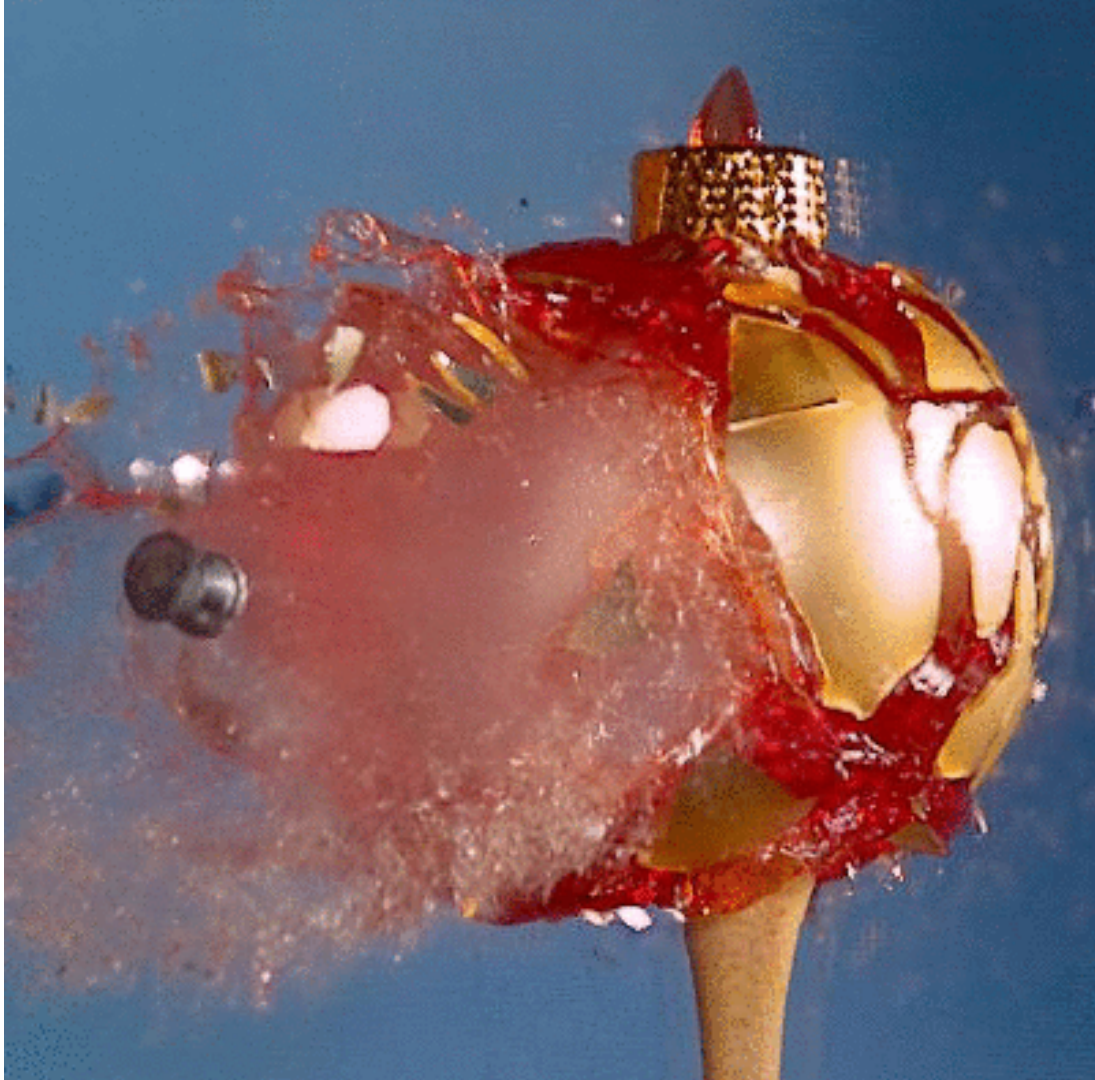
[1]Universidad de Zaragoza [2]Inria [3]Sapienza Università di Roma

A ‘*new kind*’ of pictures

A ‘*new kind*’ of pictures

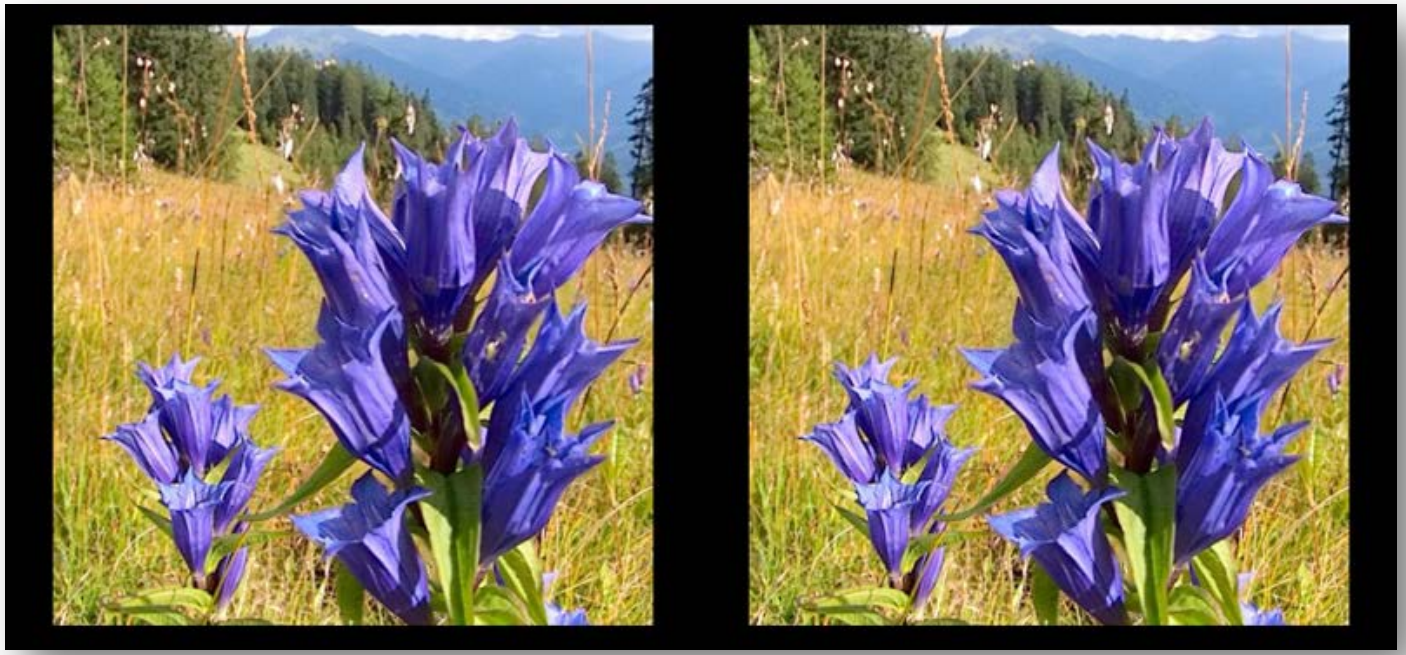


Not just view shifting…

Source: LightField Forum

Focus shifting

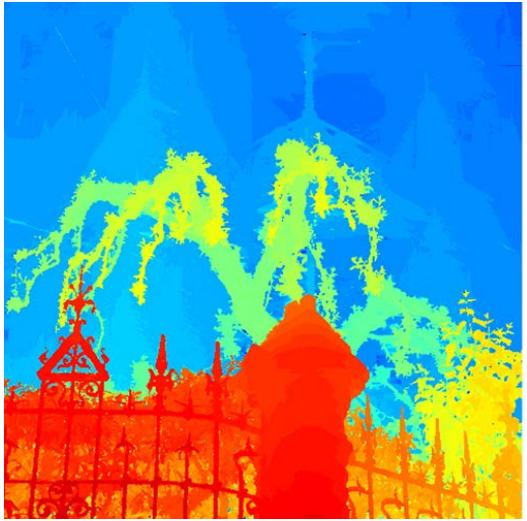
Not just view shifting…

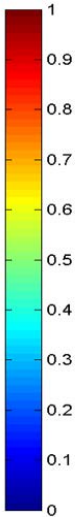


Source: LightField Forum

Stereo content creation

Not just view shifting…





[Kim et al. 2013]

Scene reconstruction

Not just view shifting…

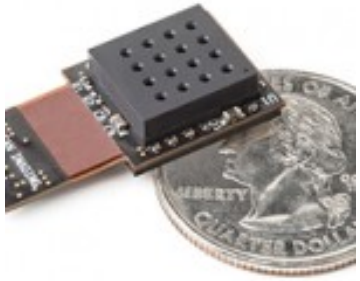
85-inch 8K autostereoscopic TV by Sharp

Content for
glasses-free 3D displays

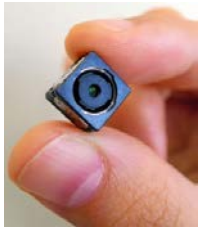
Light field cameras proliferate…

Raytrix™

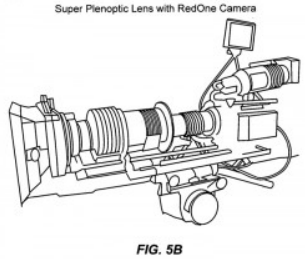
Lytro™



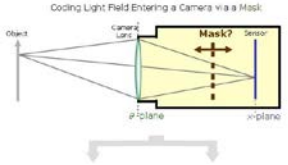
Pelican Imaging



Toshiba



Pixar



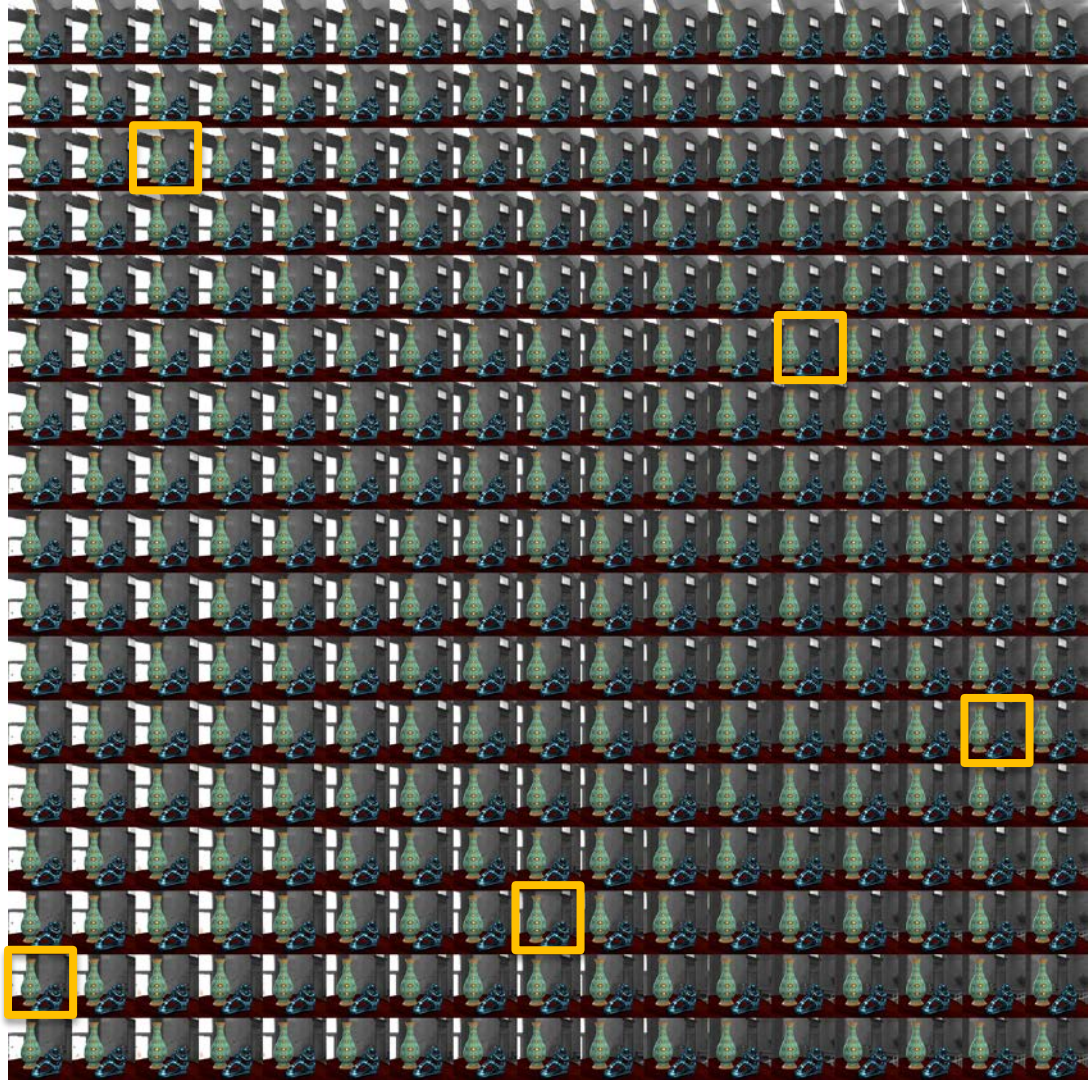
[Raskar et al. 2007]

Adobe

Cafadis

There is an increasing need for editing this new content

A 4D structure



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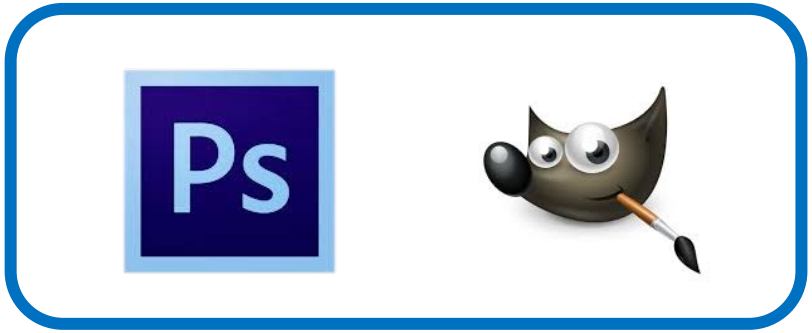

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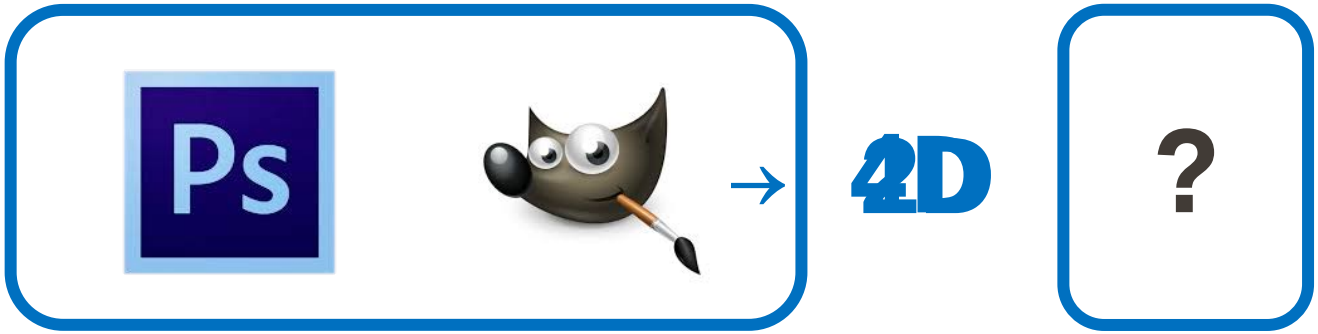
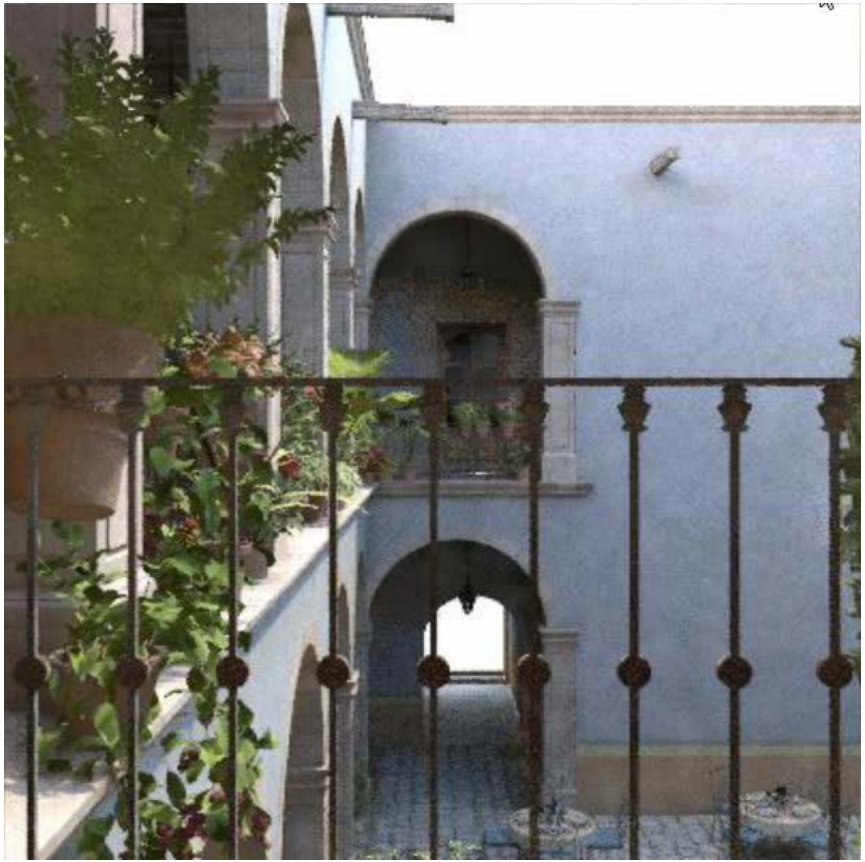


2D



4D

Using depth information?

It may be:

- Unavailable
- Inconvenient
- Imperfect

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Our goal: Explore users' preferences when navigating & editing a light field

There is an increasing need for editing this new content

(Distantly) Related Work

Morphing	[Zhang et al. 2002]
Painting, scissoring	[Seitz and Kutulakos 2002]
Pop-Up Light Field	[Shum et al. 2004]
Edit propagation	[
…	

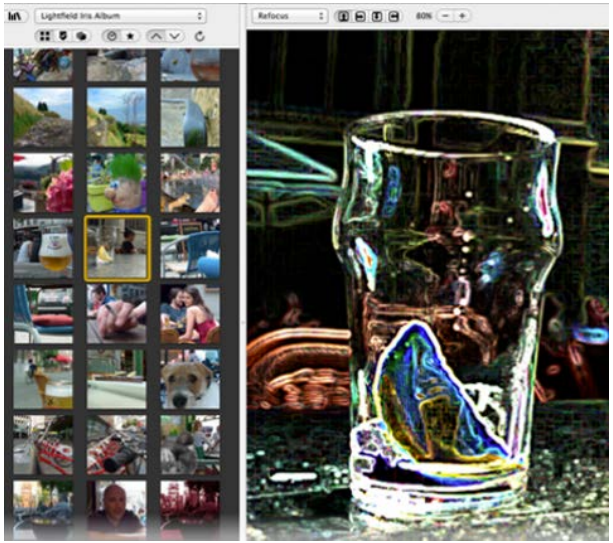
Pop up Light Field Rendering with 4 Layers

There is an increasing need for editing this new content

(More closely) Related Work

Lytro Filters [Lytro 2013]
Lightfield Iris [Vertical Horizon 2014]





Ps , , ...

2D → 4D

?

Our goal: Explore users' preferences when navigating & editing a light field

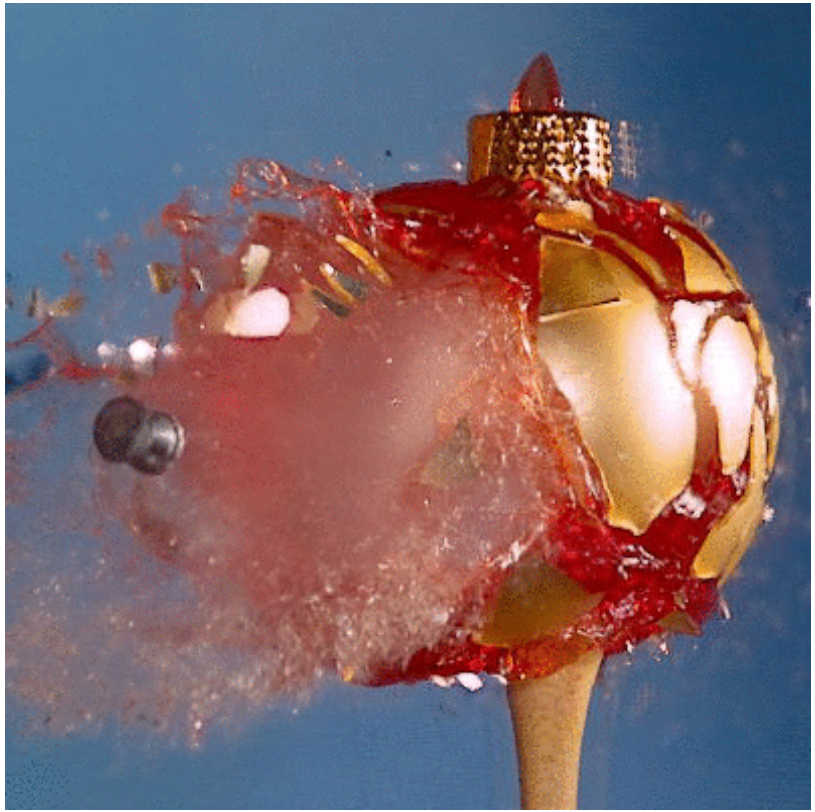
→ Analyze light field editing interaction paradigms

Interaction Paradigms

Two main paradigms:

- **Multiview** *[Zhang02, Wang05, Shum04]*

Interaction Paradigms - **Multiview**



Source: lytro.com

Interaction Paradigms

Two main paradigms:

- **Multiview** *[Zhang02, Wang05, Shum04]*
- **Focus** *[Isaksen02, Davis12]*

Interaction Paradigms - **Focus**

Source: T. Georgiev

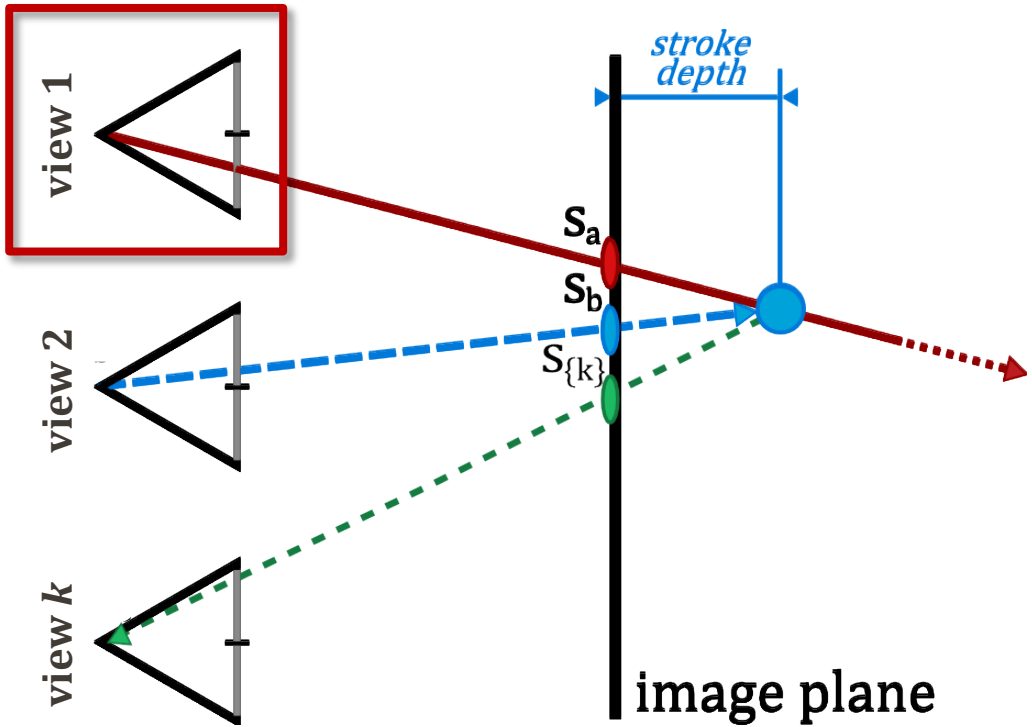
Interaction Paradigms

Two main paradigms (based on two depth cues):

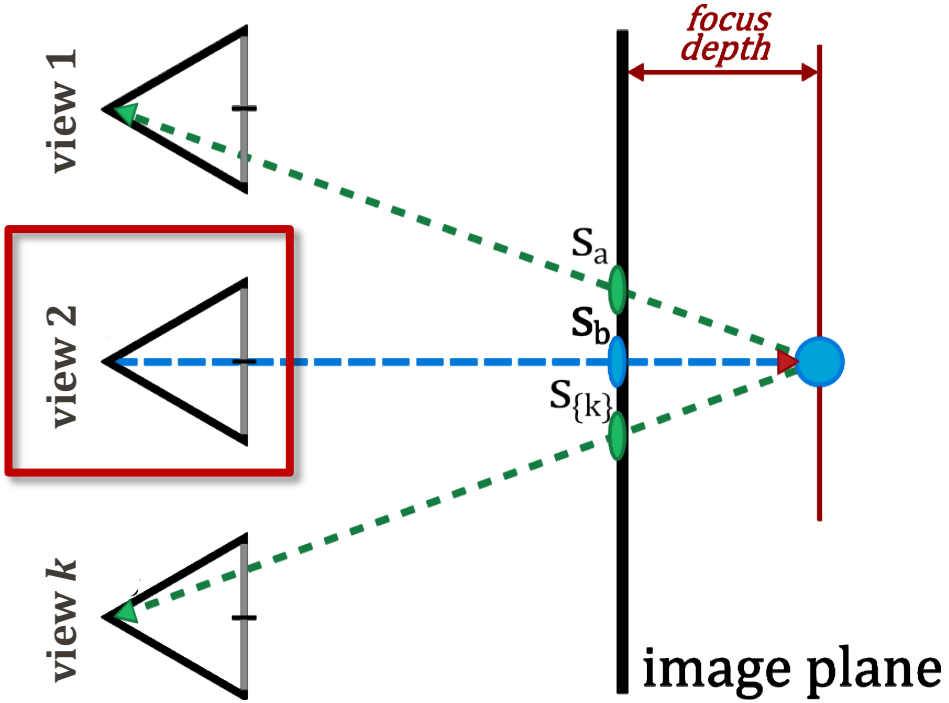
- **Multiview** *[Zhang02, Wang05, Shum04]*
  → Parallax

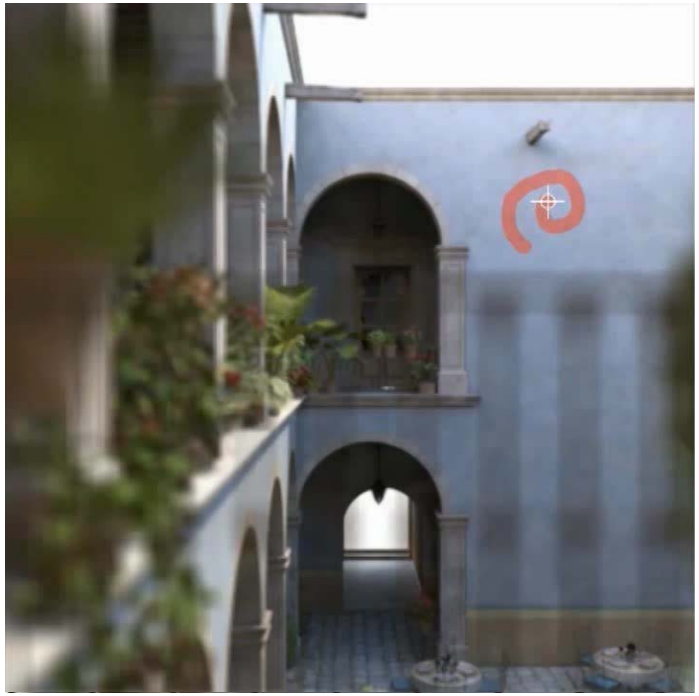
- **Focus** *[Isaksen02, Davis12]*
  → Defocus blur

Interaction Paradigms - **Multiview**



Interaction Paradigms - **Focus**





So…
how do people edit light fields?

Our user studies

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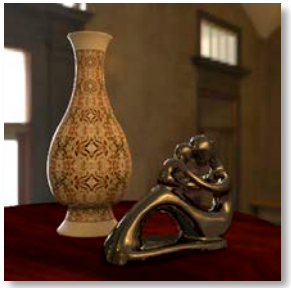
1. Baseline experiment
   - Users preferences on
   - Synthetic light fields





2. Experiment with real light fields
   - W
   - C





Our user studies – **Characteristics**

1. Task-based guided experiments

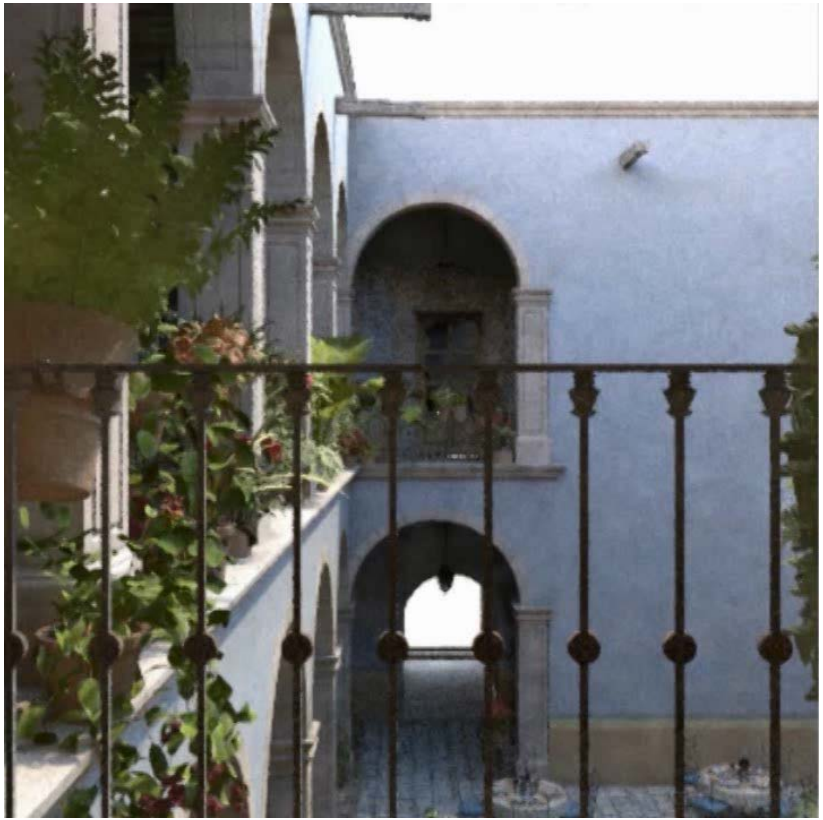
   - Users perform a specific edit on a given light field
   - Objective & subjective data is gathered

Our user studies – **Characteristics**

2. Depth information plugged into both paradigms (F, MV)

   - 4 interfaces (F, MV, F+D, MV+D)
   - Might not be always useful (e.g. imperfect depth, not editing on surfaces)
   - Similar to 3D editing

Our user studies – *Editing with Depth*



Our user studies – **Characteristics**

3. Point-based editing operations

- Most common editing tools
  - Color brush, dodge/burn, clone…
- Building block for non-local tools
  - Selection, coarse edit propagation, magic wand…

Our user studies

1. Baseline experiment
   - Users preferences on interfaces
   - Synthetic light fields

2. Experiment with real light fields
   - Workflows on realistic edits
   - Captured light fields

Experiment 1 – **Procedure**

SIGGRAPH2014

- 5 directed tasks in fixed order

Experiment 1 – **Procedure**

- 5 directed tasks in fixed order
- 4 interfaces (F, FD, M, MD) in random order
- Ground truth depth

Experiment 1 – **Findings**

- Task dependent
- *Focus* offers more sense of control, *Multiview* better for navigation
- Users prefer switching between interfaces

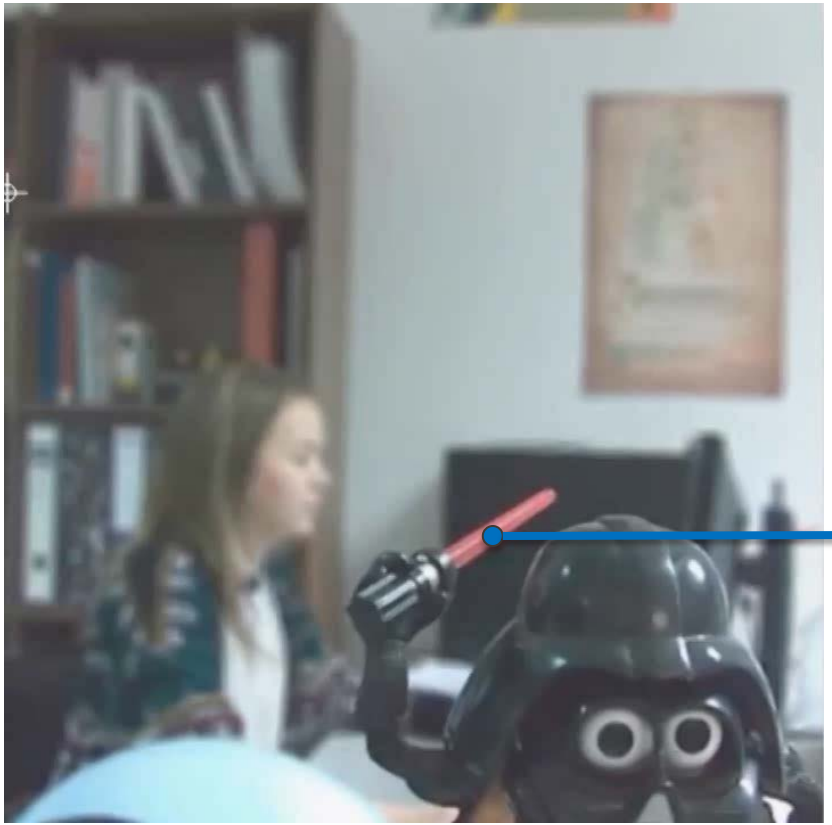
Hybrid Interface

Experiment 1 – **Findings**

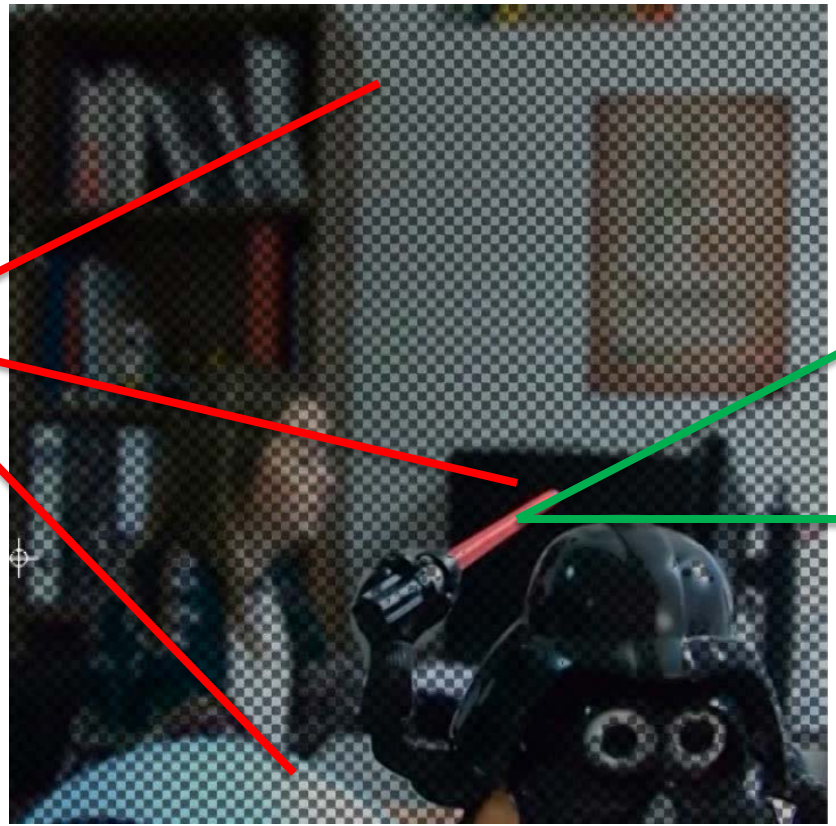
- Depth info is not always useful
- Handling occlusions is challenging with depth alone

Depth Selection Tool

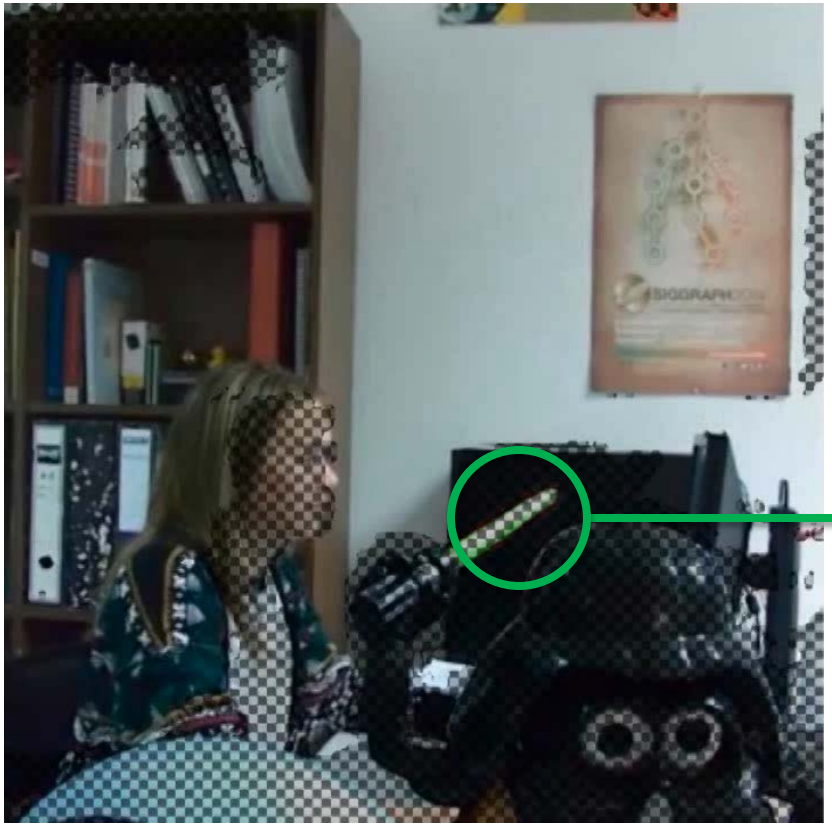
Depth Selection tool



Depth Selection tool



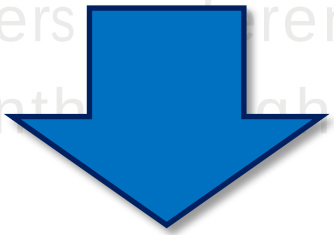
Depth Selection tool



Allows handling occlussions

Our user studies

1. Baseline experiment
   - Users' preferences on interfaces
   - Synthetic light fields



   1. **Hybrid** Interface
   2. **Depth Selection** tool

2. Experiment with real light fields
   - Workflows on realistic edits
   - Captured light fields

Experiment 2 – **Procedure**

- 10 directed tasks; random order
- Hybrid interface
- Reconstructed depth info available
  - What impact does imperfect depth have?

Experiment 2 – **Tasks**

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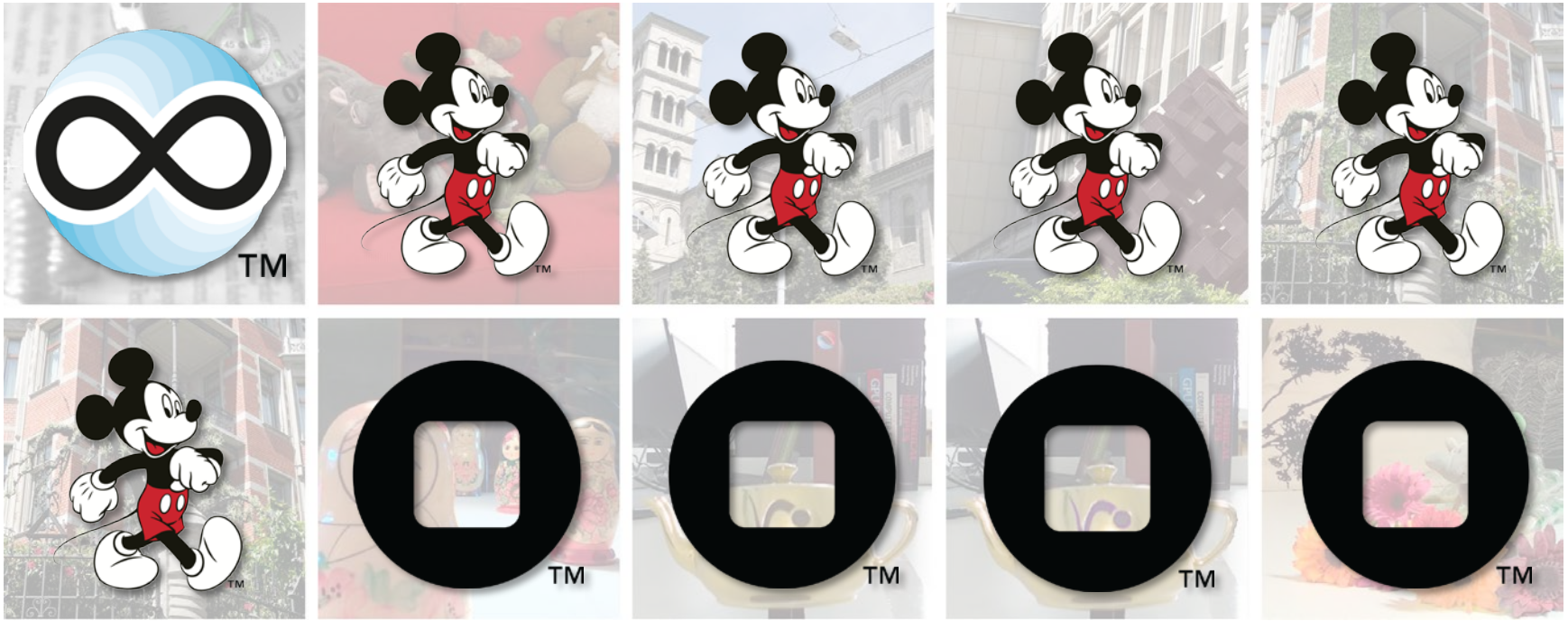
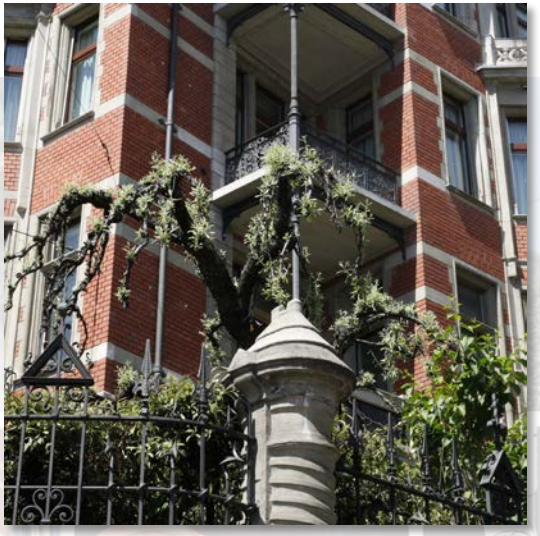


Experiment 2 – Tasks

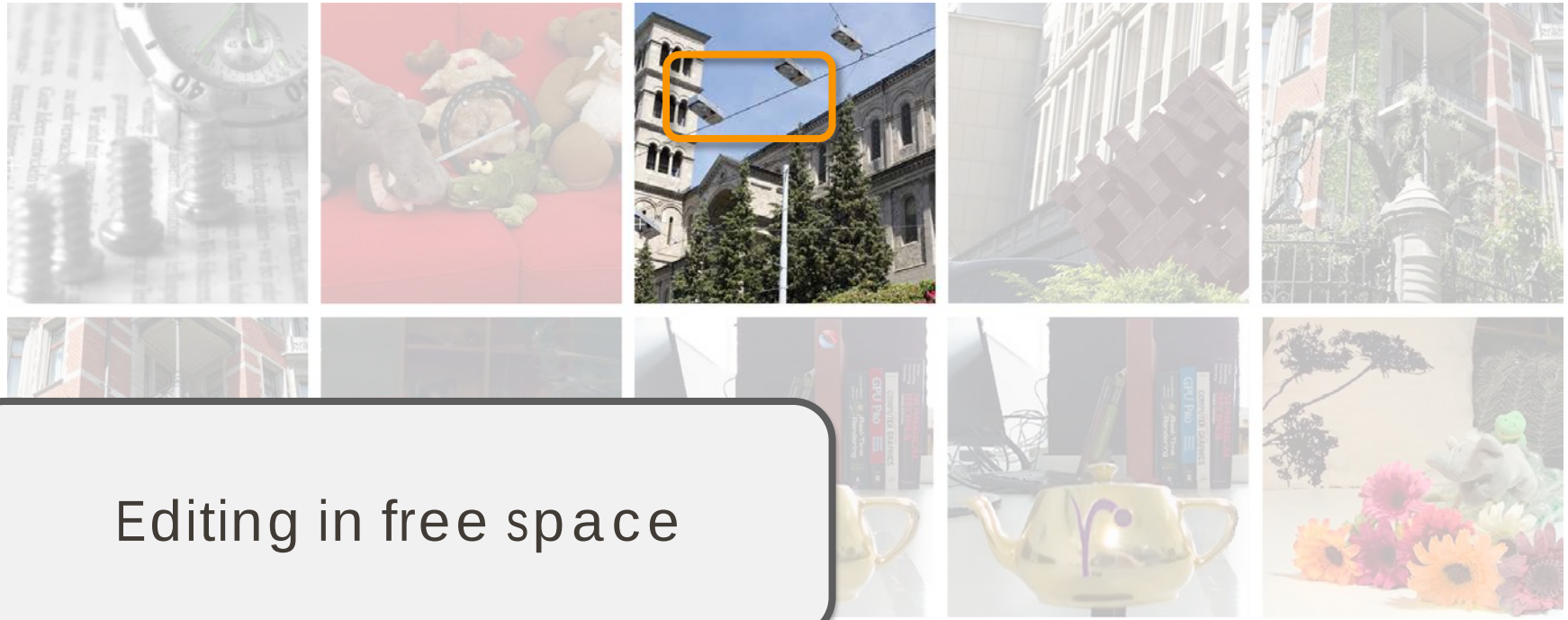
Handling occlusions

Experiment 2 – Tasks



Handling occlusions

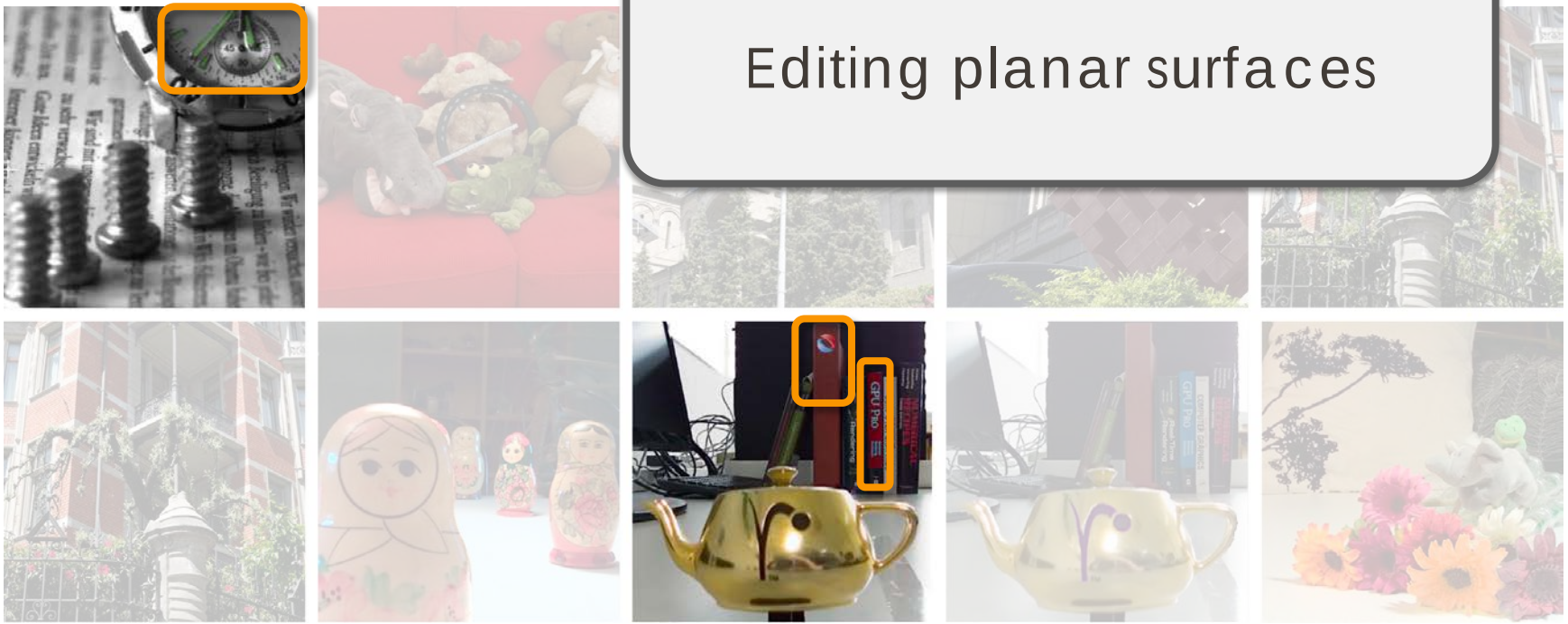
Experiment 2 – Tasks



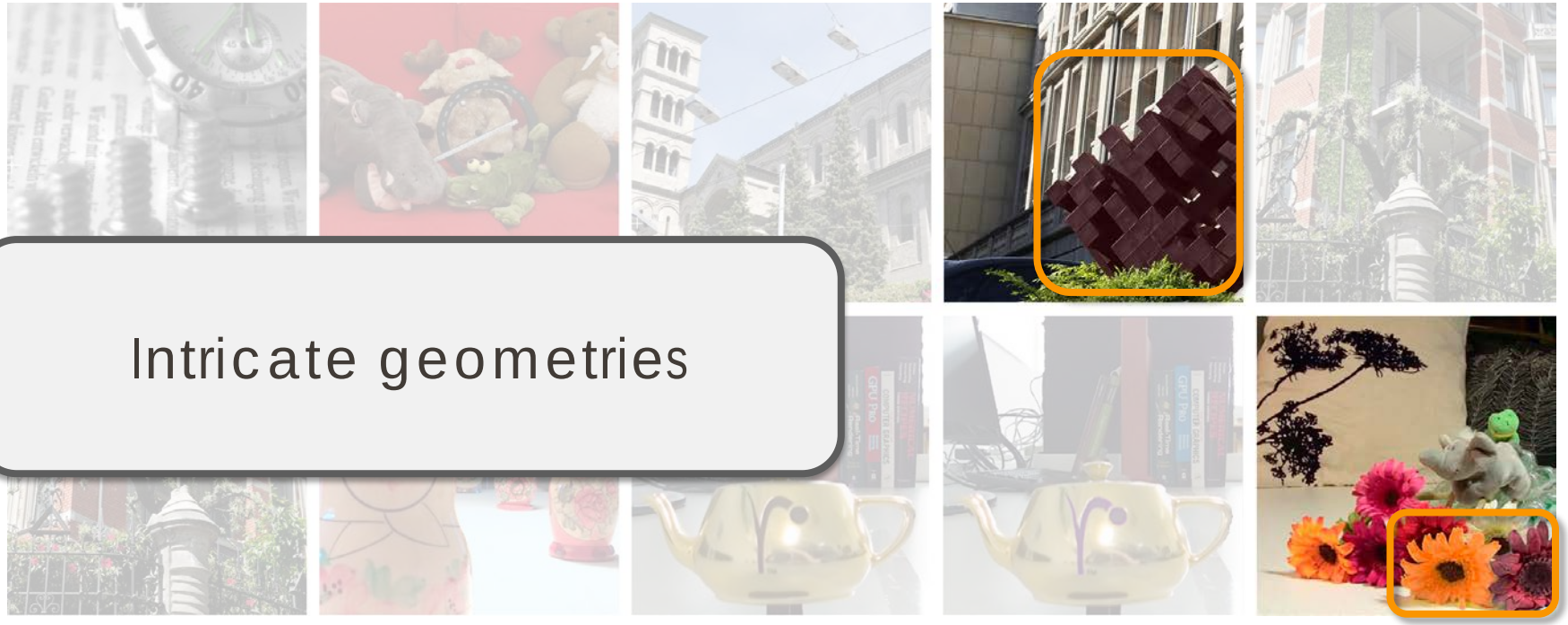
Editing in free space

Experiment 2 – Tasks

Editing planar surfaces

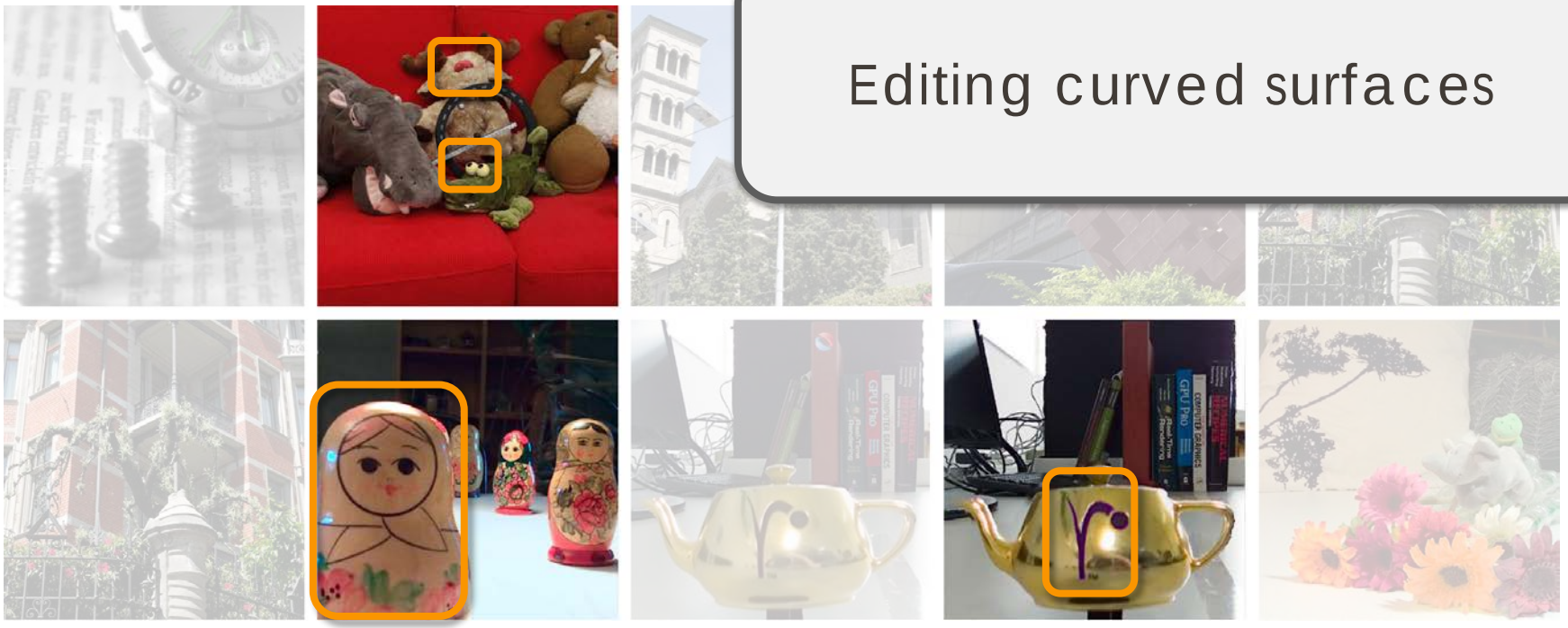


Experiment 2 – Tasks



Intricate geometries

Experiment 2 – Tasks



Editing curved surfaces

Experiment 2 – Analysis

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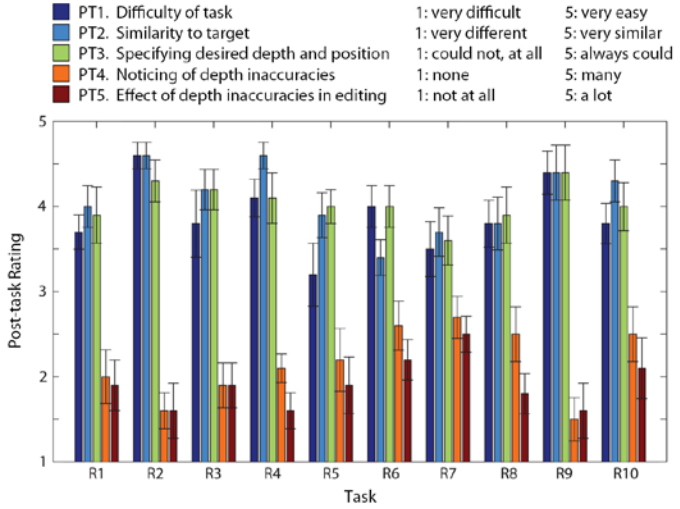
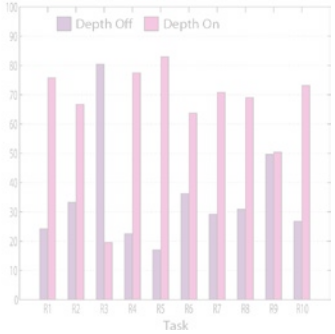
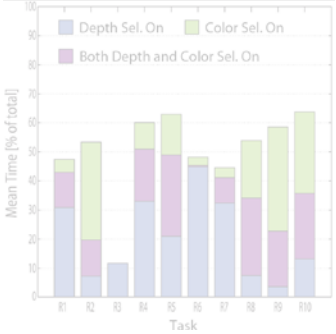
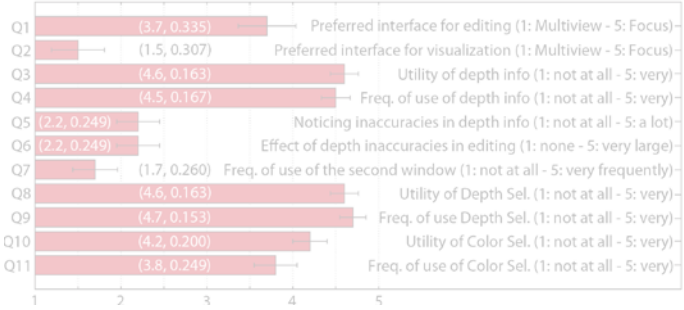
Subjective Data

- Ratings in post-task questions









Experiment 2 – Analysis

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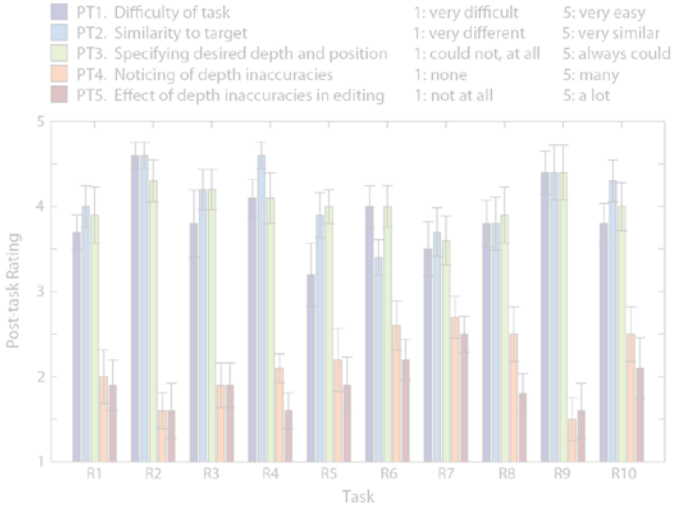
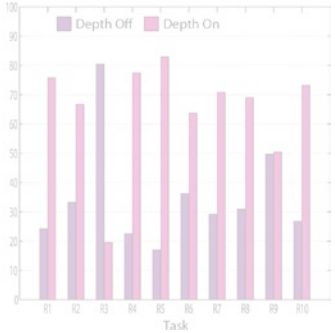
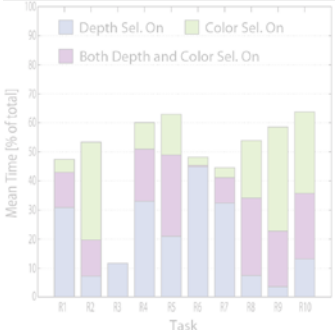
Subjective Data

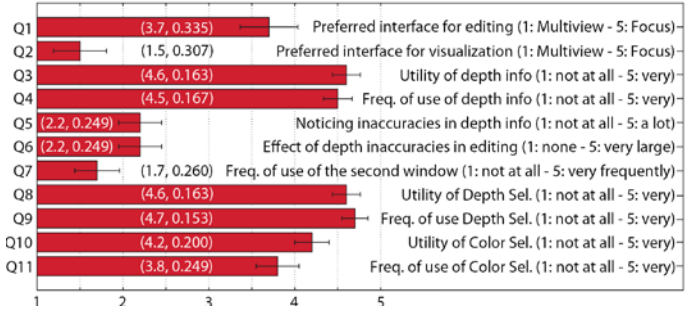
- Ratings in post-task questions

- Ratings & rankings in final questions









Experiment 2 – Analysis

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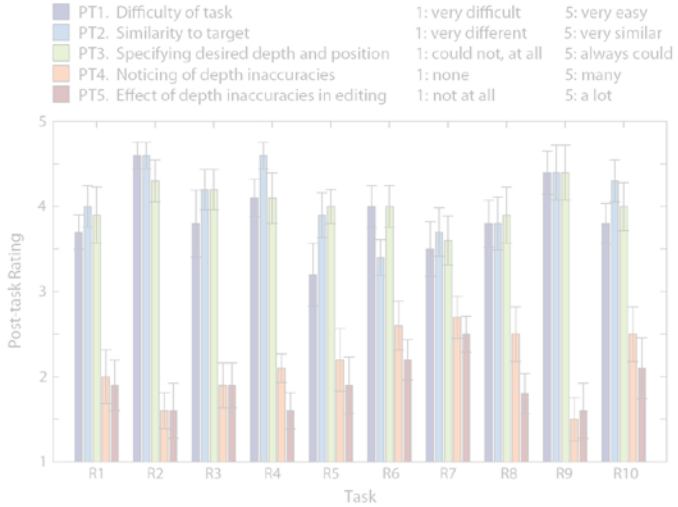
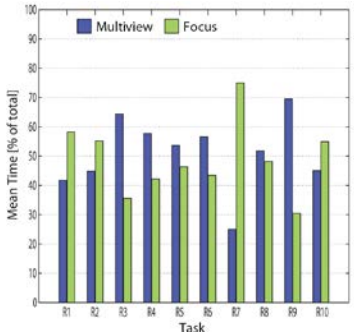
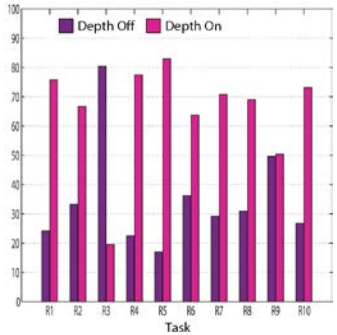
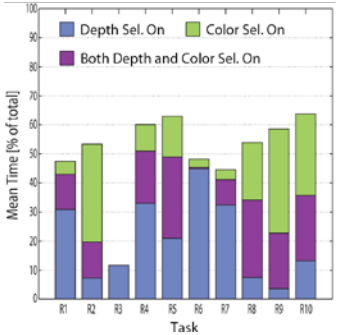
Objective Data

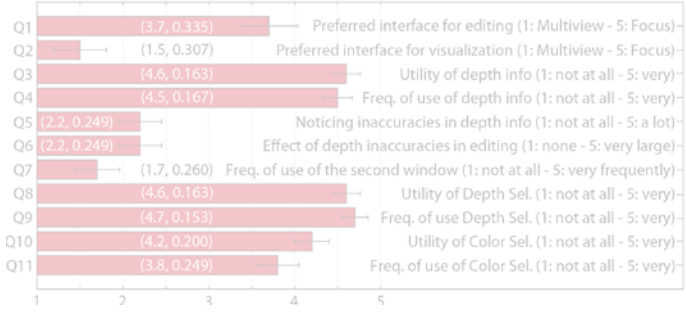
- Times of use of the different features and tools → workflows











Experiment 2 – Analysis

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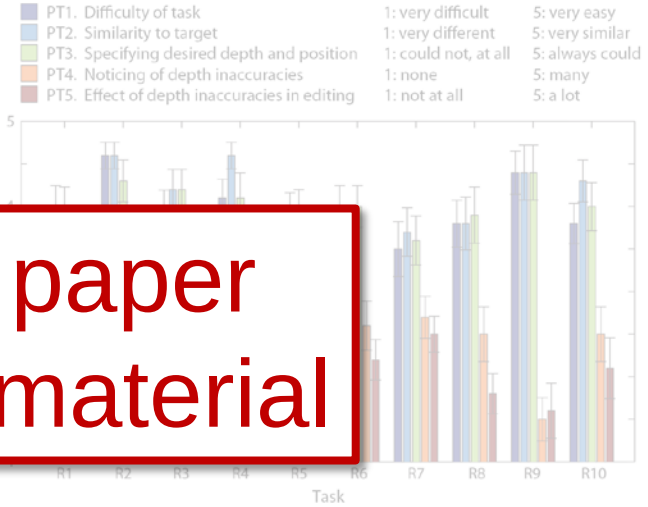
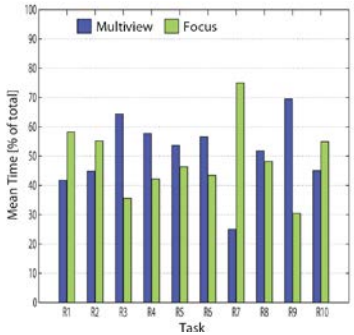
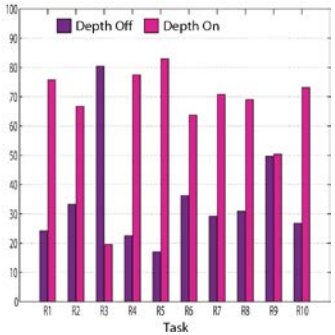
Objective Data

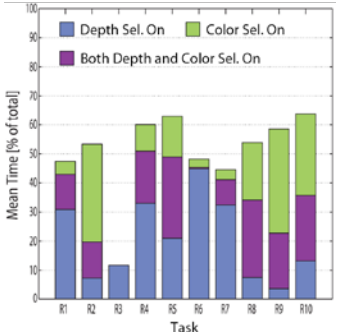
- Times of use of the different features

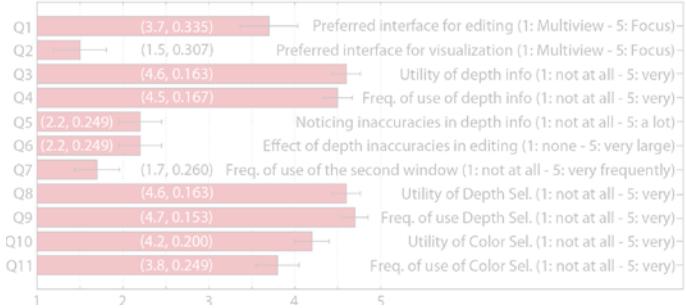
Full analysis in the paper and supplementary material





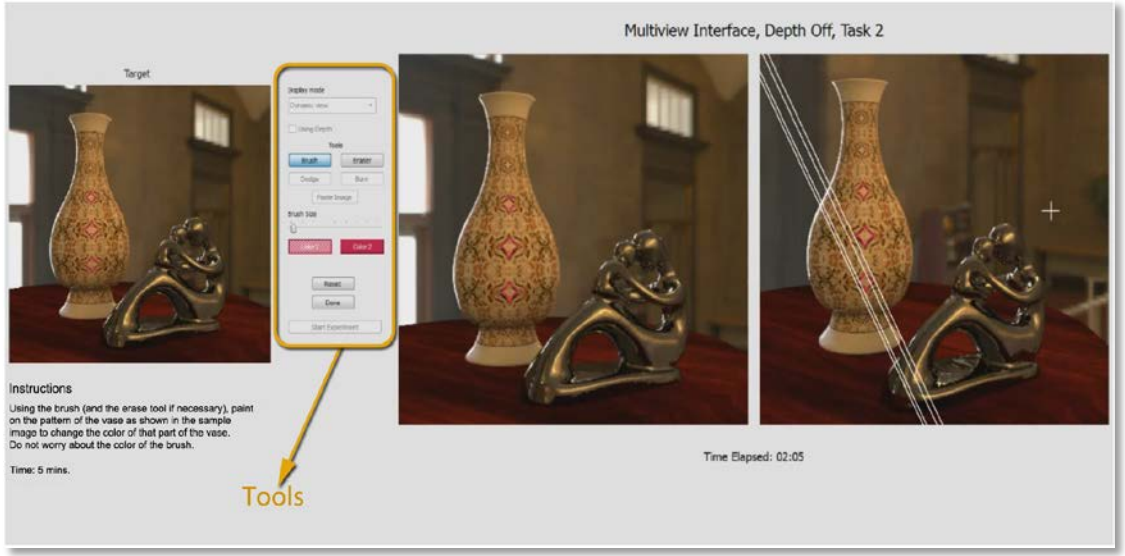






Conclusions

1. A usable interface that allows performing common edits on a light field



Editing results

Conclusions

2. Users leverage the extra angular information in the 4D light field

Conclusions

3. Occlusions and complex geometries can be handled with the Depth Selection tool
   - Utility of Depth Selection: 4.6/5
   - Freq. of use Depth Selection: 4.7/5

1: not at all – 5 very

Sample editing session

Conclusions

4. Depth inaccuracies do not significantly affect editing
   - Effect of depth inaccuracies in editing: 2.2/5
   - Noticing inaccuracies in depth info: 2.2/5

1: none – 5 a lot

Conclusions

5. A LF Edit Interface would benefit from the easy navigation of multiview and the degree of control of focus

Thanks!

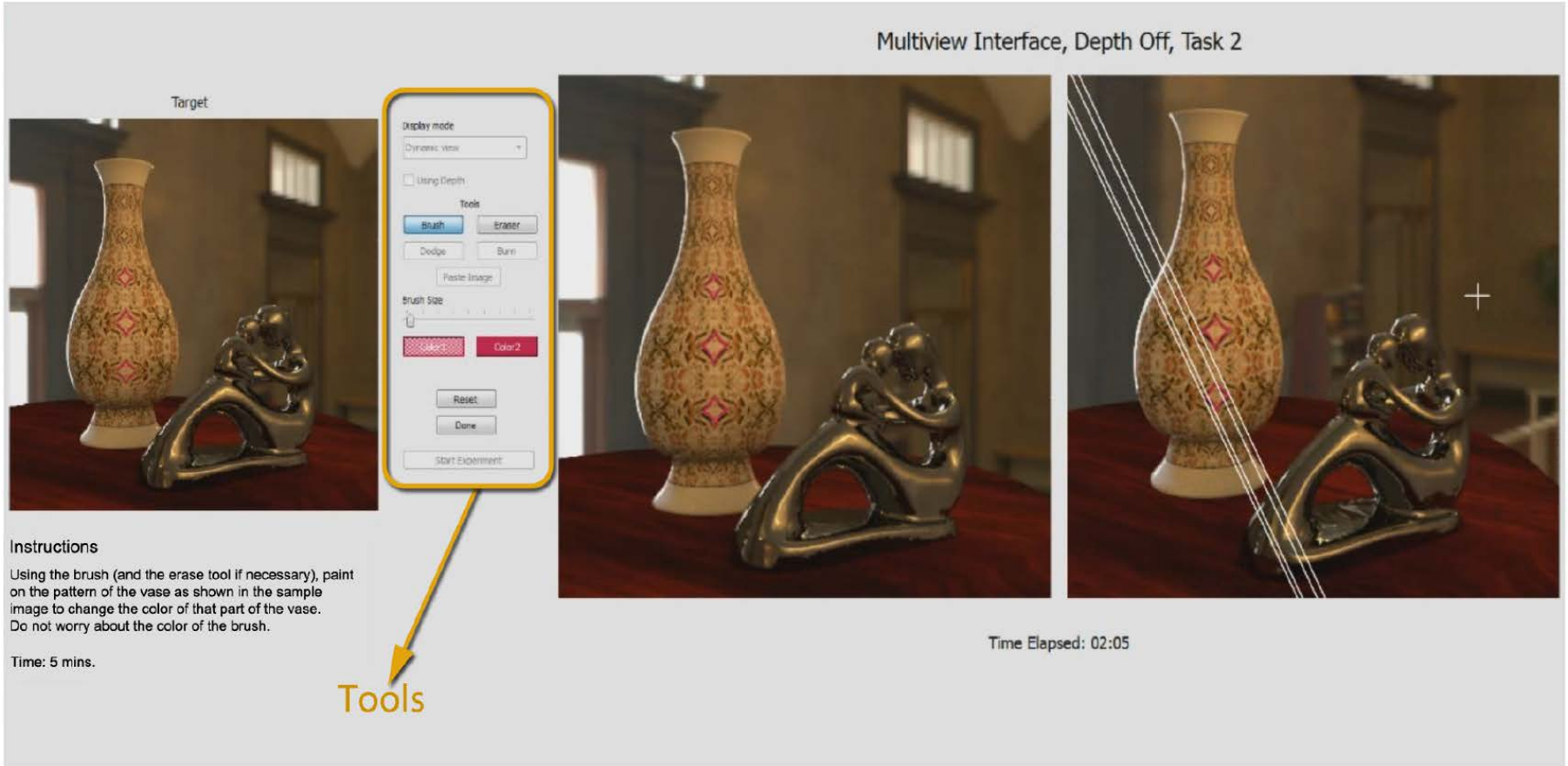
- Anonymous Reviewers
- Participants of the experiments
- P. Moosebrugger, S. López, J. I. Echevarría, C. A. Aliaga, R. Buisan, J. Marco, P. Hernando, L. Serra, C. K. Liang
- LF and 3D models owners
- Projects Verve, Golem, TAMA, Tropic, Intel Corp, Adobe, NVIDIA

Thanks!

Interface, Code & Data online:

http://giga.cps.unizar.es/~ajarabo/pubs/lfeiSIG14/

Interfaces - **Multiview**



Interfaces - **Focus**