How Do People Edit Light Fields?

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A ‘new kind’ of pictures
A ‘new kind’ of pictures
Not just view shifting...

Focus shifting

Source: LightField Forum
Not just view shifting…

Stereo content creation
Not just view shifting...

Scene reconstruction

[Kim et al. 2013]
Not just view shifting...

Content for glasses-free 3D displays

85-inch 8K autostereoscopic TV by Sharp
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
There is an increasing need for editing this new content
There is an increasing need for editing this new content
How Do People Edit Light Fields?

4D

• Unavailable
• Inconvenient
• Imperfect

Using depth information?

It may be:
There is an increasing need for editing this new content.

**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
Painting, scissoring
Pop-Up Light Field
Edit propagation

...
There is an increasing need for editing this new content

(More closely) Related Work

Lytro Filters [Lytro 2013]
Lightfield Iris [Vertical Horizon 2014]
There is a need for editing and manipulating this new content. 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
Interaction Paradigms

Two main paradigms:

- **Multiview** \([\text{Zhang02, Wang05, Shum04}]\)

- **Focus** \([\text{Isaksen02, Davis12}]\)
Interaction Paradigms

Two main paradigms (based on two depth cues):

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

- **Focus** [Isaksen02, Davis12]
  → Defocus blur
Interaction Paradigms - Multiview

stroke depth

image plane
Interaction Paradigms - **Focus**

![Diagram showing interaction paradigms with focus and depth](image_url)

- view 1
- view 2
- view k

**Focus** depth

**image plane**
So...
how do people edit light fields?
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
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
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**

- 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

Masked Out → Selected
Edit on selected areas
Depth Selection tool

Allows handling occlusions
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

1. Hybrid Interface
2. Depth Selection tool
Experiment 2 – Procedure

- 10 directed tasks; random order
- Hybrid interface
- Reconstructed depth info available
  ➢ What impact does imperfect depth have?
Experiment 2 - Tasks
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

Subjective Data

- Ratings in post-task questions
Experiment 2 – Analysis

Subjective Data

- Ratings in post-task questions
- Ratings & rankings in final questions
Experiment 2 – Analysis

Objective Data

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

- Times of use of the different features and workflows

Full analysis in the paper and supplementary material
Conclusions

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

2. Users leverage the extra angular information in the 4D light field
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
• LF and 3D models owners
• Projects Verve, Golem, TAMA, Tropic, Intel Corp, Adobe, NVIDIA
Interface, Code & Data online:

http://giga.cps.unizar.es/~ajarabo/pubs/lfeiSIG14/
Multiview Interface, Depth Off, Task 2

Instructions
Using the brush (and the erase tool if necessary), paint on the pattern of the vase as shown in the sample image to change the color of that part of the vase. Do not worry about the color of the brush.

Time: 5 mins.
How Do People Edit Light Fields?

**Interfaces - Focus**

*Focus Interface, Depth Off, Task 2*

**Interface in use**

**Instructions**

Using the brush (and the erase tool if necessary), paint on the pattern of the vase as shown in the sample image to change the color of that part of the vase. Do not worry about the color of the brush.

Time: 5 mins.

Time Elapsed: 02:49