Analyzing Interfaces and Workflows for Light Field Editing

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ABSTRACT

With the increasing number of available consumer light field cameras, this new form of photography is progressively becoming more common. However, there are still very few tools for light field editing, and the interfaces to create those edits remain largely unexplored. We perform a state sequence analysis and hidden Markov-chain analysis based on the sequence of tools and interaction paradigms users employ while editing light fields. These insights can aid researchers and designers in creating new light field editing tools and interfaces, thus helping close the gap between 4D and 2D image editing.

CCS CONCEPTS

•**Computing methodologies** → **Image processing**; •**Human-centered computing** → *Interaction techniques*;

KEYWORDS

Light fields, editing interfaces, user study, editing workflow

1 INTRODUCTION

Light fields are 4D representations of a scene, where the two extra dimensions code angular information. While editing traditional 2D photographs is a well-understood process with established workflows, editing light fields still emains an open problem. Jarabo et al. [2014] recently proposed the first study on the topic, extended by Masia et al. [2014]: They evaluated a set of basic tools on the two most common light field interface paradigms (parallax-based and focus-based), and provided valuable insights on the suitability of interfaces. In this paper, we analyze the subjects' preferred *workflows* for a number of typical scenarios (editing of surfaces, editing in free space, occlusion handling, and editing of complex geometries). This provides a comprehensive description of subjects' choices and
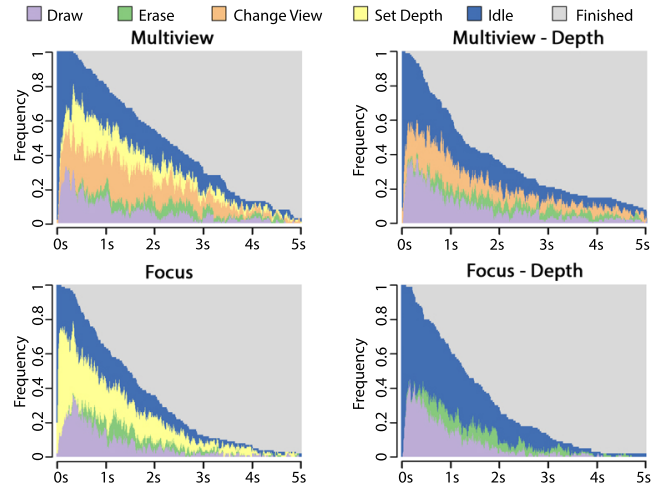
Figure 1: Tool usage distribution for five editing tasks (Experiment 1) grouped by interface showing the frequency of the use of each tool at each time interval.

preferences and a better understanding of the effort necessary to perform the different editing tasks. This combined knowledge is a valuable source of information for developing novel, user-friendly interfaces, as well as efficient and intuitive editing tools.

2 EDITING INTERFACES AND TOOLS

We make use of the editing interfaces proposed by Jarabo et al. [2014]; they are based on two interaction paradigms and feature a set of tools described below.

The key aspect that differenciates the **interaction paradigms** is the cue used to specify the position of the edit in 3D space while working on a conventional 2D screen. In *Multiview*, parallax is used to specify the depth at which an edit should be placed. To place a stroke, the user first draws it in one view, then switches between views to observe its resulting parallax, and moves the stroke to the desired position. In *Focus*, the depth at which the editing will be performed is specified by a plane of focus, while the rest of the light field is blurred accordingly.

We study two **interfaces** derived from the interaction paradigms described above: *Multiview* and *Focus*. We also leverage recent advances in scene reconstruction from light fields that allow to infer depth maps (e.g. [Kim et al. 2013]) to include two additional
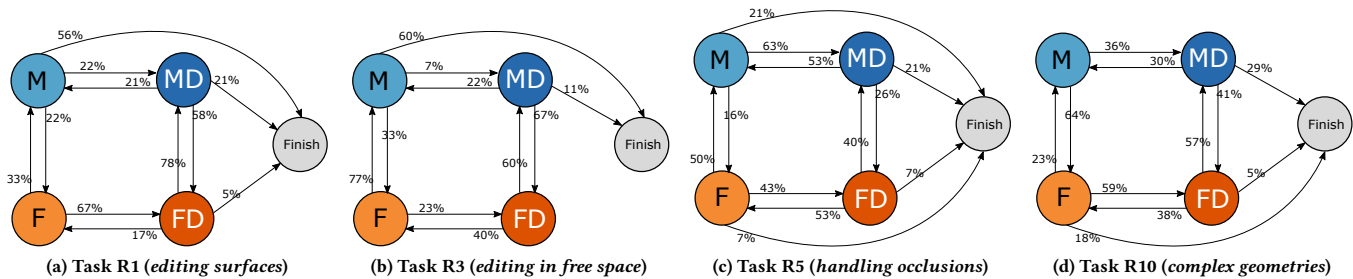
Figure 2: Effective interface transition probabilities for Tasks R1, R3, R5, and R10, one pertaining to each of the four categories or use case scenarios (editing surfaces, editing in free space, handling occlusions, and editing complex geometries). Self-loop transitions have been removed.

interfaces: *Multiview With Depth* and *Focus With Depth*. For both, the strokes drawn will now snap to the nearest surface below them.

For each interface, we provide the following set of basic **editing tools**: draw, erase, change view, and set depth.

3 WORKFLOW ANALYSIS

In Experiment 1, 20 subjects performed five editing tasks (S1 to S5) with synthetic light fields, using the four interfaces for each task in random order. In Experiment 2, 10 subjects performed 10 different edits in real light fields, choosing freely among the four interfaces.

3.1 Tool Sequence Analysis (Experiment 1)

We assume that the tools used in the editing process correspond to different states: *draw*, *erase*, *change view*, and *set depth*, and also include states *idle* and *finished*. Editing workflows are grouped by interface since users could not switch among them freely and analyzed with the TraMineR library [Gabadinho et al. 2011].

Figure 1 shows the **tool usage distribution**, i.e. how the use of different tools is distributed along time. While using the Multiview interface, users constantly change the view to check the appearance of the edits, which indicates that they are very aware of the high dimensional nature of the light field. The use of change view is even more extensive when depth is not present, since it has to be used to place edits at a correct depth. Similarly, the time spent setting the depth is consistently longer in the Focus interface because it is used first to choose the plane to edit. Users spend more time in idle state in the Focus with depth interface, probably because they are moving the cursor on the screen observing how the focus changes. There seems to be no clear or preferred order of states in any of the interfaces. i. e., the distribution of the non-finished people among the available states remains constant throughout time.

We also obtain the most common **tool sequences** by extracting the hidden Markov chains (MC) up to order five. For Multiview, the most common workflow consists of looping between setting the edits' depth and navigating through the light field views to check its correctness. The limited navigation capabilities of Focus simplifies the workflows: in general, users loop between setting the depth and drawing. When depth is available, users focus mostly on surface editing: drawing, and then erasing for refining. With all the interfaces, users navigate through the light field to check the correctness of the edits before finishing the task.

3.2 Interface Sequence Analysis (Experiment 2)

We now consider four states corresponding to the four studied interfaces, and include a *finished* state.

Figure 2 depicts the **effective interface transitions**, i.e. the probability of transitioning from one interface to another. In Task R1 (Figure 2a), toggling between Multiview with depth and Focus with depth is very common. This points out that users prefer the use of depth, and change between Multiview and Focus to find the most suitable interface to perform their edits and check results. In Task R3 (Figure 2b) users always finish their editing in Multiview, which indicates that this is the preferred interface to examine the results. For Tasks R5 (Figure 2c) and R10 (Figure 2d), which involve dealing with occlusions and complex geometries, participants switch among interfaces looking for what feels more comfortable without any clear patterns on the choice of interface.

4 CONCLUSIONS

We have tested a set of interfaces and tools for light field editing and performed state sequence analysis and hidden Markov-chain analysis. We have noticed that users quickly understand the high dimensionality of light field images and work on a constant iteration of drawing or erasing and checking the results by navigating across light field views or adjusting the depth. We have also discovered that users prefer to use depth information while editing, and generally switch to the Multiview paradigm to review their work before finishing the editing task.

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