4 차원 Light Field 영상에서의 일관된 각도-공간적 편집 전파

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Spatio-Angular Consistent Edit Propagation for 4D Light Field Image

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요 약

In this paper, we present a consistent and efficient edit propagation method that is applied for light field data. Unlike conventional sparse edit propagation, the coherency between light field sub-aperture images is fully considered by utilizing light field consistency in the optimization framework. Instead of directly solving the optimization function on all light field sub-aperture images, the proposed optimization framework performs sparse edit propagation in the extended focus image domain. The extended focus image is the representative image that contains implicit depth information and the well-focused region of all sub-aperture images. The edit results in the extended focus image are then propagated back to each light field sub-aperture image. Experimental results on test images captured by a Lytro off-the-shelf light field camera confirm that the proposed method provides robust and consistent results of edited light field sub-aperture images.

1. Introduction

Over the last decade, light field processing has become an active research topic that has attracted many researchers in computer vision and computer graphics communities. Various algorithms and applications for consumer light field image, such as depth estimation, saliency detection, and calibration, have been presented in the recent academic conference. In particular, the study of editing algorithms on light field gains the public interest [2, 3] for the past few years. Nonetheless, recent works on single image edit propagation cannot be applied directly to light field because they do not preserve the angular coherency. In addition, direct implementation of those causes inefficiency due to the massive redundancy and immense size of light field. Though there is study about light field editing interfaces or tools [3], yet it is still limited to point-and-click operation. On the other hand, recent sparse edit propagation on light field [2] is restricted to synthetic data and requires accurate depth information.

In this paper, we propose a sparse edit propagation method for light field images that preserves the coherency in the angular domain. Our key observation is that, since light field contains high redundancy, the propagation could be done on a cluster image to increase the efficiency. Figure 1 presents the overview of the proposed framework.

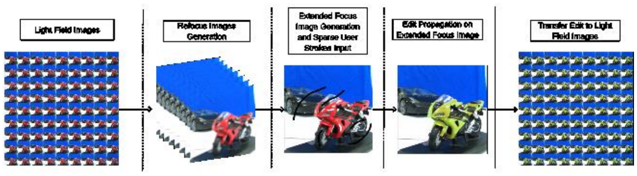

Figure 1 Pipeline of the proposed algorithm.

2. Proposed method

We improve the original formulation in [2] to account for the coherency between sub-aperture images, as given by:

$$E=\sum_{i,j} w_j z_{ij}\left(e_i-g_j\right)^2+\lambda\sum_{i,j} z_{ij}\left(e_i-e_j\right)^2+\sum_{i}\sum_{k\in D(i)}\left(e_i-e_k\right)^2$$

where k is a pixel from the corresponding pixels $D(i)$. The novel term forces the zero constraint between pixel i and its corresponding pixels $D(i)$. Instead of the angular position proximity, we only utilize the appearance similarity and spatial location proximity as an affinity weight, which is described in

$$z_{ij}=`exp\left(-\frac{\left\|a_i-a_j\right\|^2}{\sigma_a}-\frac{\left\|s_i-s_j\right\|^2}{\sigma_s}\right).$$

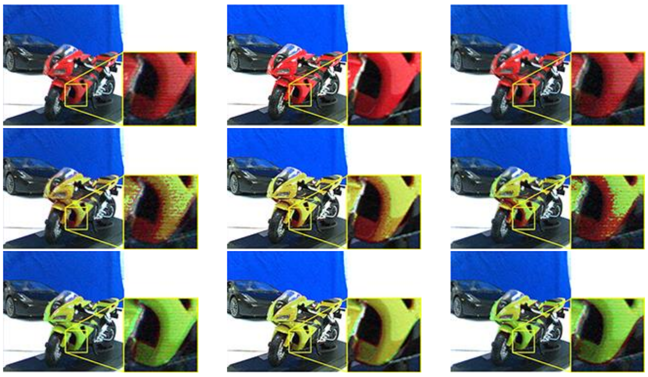

Figure 2 Zoom version of *Motor* data. (First row) Input light field images; (Second row) Edit results of Jarabo's method [2]; (Third row) Edit results of the proposed method;

Instead of solving the optimization function directly, we perform edit propagation in the extended focus image domain which is the informative representation of immense light field data. To generate the extended focus image, we must compute the set of refocus images based on various depth values. Then, we estimate the depth based on those images by utilizing the depth estimation algorithm for a consumer light field camera [3]. Lastly, the extended focus image is synthesized by combining infocus pixels from the refocus images.

The extended focus image forces the third term to be automatically minimized. Hence, the final optimization function can be easily solved by the general editing propagation algorithm. In this paper, we utilize the approximated solver from An and Pellacini [1] to solve the optimization function and obtain the edit result in the extended focus image domain. The edit value should be propagated to the original sub-aperture images, which store the 4D light field data. Each pixel in the extended focus image has its corresponding pixels in all sub-aperture images. Therefore, we transfer the edit value so that corresponding pixels have similar edit value (as obtained in the extended focus image.

3. Experimental Results

Figure 2 depicts the zoom version of the sub-aperture images at (1,1), (5,5), and (9,9) of *Motor* dataset for easy comparison. It is clearly shown that the proposed method preserves the coherency between sub-aperture images much better than [2]. The conventional approach only considers obtaining similar results for images with similar angular position. Therefore, it produces color bleeding artifact in many pixels, which becomes even worse for the sub-aperture images far from the center image. On the other hand, the proposed method does not have such an artifact in all sub-aperture images. Figure 3 shows the edit results for *Sign1*, *Sign2*, and *Pole* datasets with various edit colors.

(a) (b) (c)

Figure 3 Additional edit results. (a) Extended focus image with user input; (b)~(c) Edited extended focus images

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4. Conclusion

In this paper, we proposed a consistent and efficient sparse stroke propagation method that is applied for 4D light field. We proposed the propagation of sparse user edits in the efficient representative image of immense light field data. The experimental results showed that the proposed method achieved satisfactory results for both color and alpha edit operators.

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