라이트 필드 카메라를 이용한 완전 초점 영상 생성

위사루트 찬타라, 호요성
광주과학기술원 정보통신공학부
e-mail : {wisarut, hoyo}@gist.ac.kr

All-focused Image Generation using Light Field Camera

Wisarut Chantara, Yo-Sung Ho
School of Information and Communications
Gwangju Institute of Science and Technology (GIST)

Abstract

In digital photography, photographers should determine whether they focus on foreground or background objects. This means that objects apart from the focus range appear with blurring and ghosting effects. In order to solve this problem, we propose a method to generate all-focused image. In the proposed method, a raw image file taken by a light field camera is separated to differently-focused images that contain meta-data information. Afterwards, we apply the proposed all-focused method to integrate in-focused regions into the final image using the meta-data. With this process, we can reconstruct the all-focused image. Experiment results show that we successfully detect in-focused regions and generate the all-focused image.

1. Introduction

Nowadays, the current digital photography or the human vision can only focus on a single focal plane at a time. Then the objects which do not lie on that plane appear blurred. The focal plane is a flat plane orthogonal to the optical axis on which a lens is focused. Moreover, the depth of field, also called focus range or effective focus range, is the distance between the nearest and farthest objects in a scene that appears acceptably sharp in an image. However, the depth of field in photography is limited by the aperture size and focal length. The objects which lie on the area within the depth of field appear sharp, while the objects lie in front of and beyond the depth of field appear blurry. When we search the method that gives us extended the depth of field image under conditions in a single shot, the light field camera appeared. Based on the focused light field camera model, all-focused image algorithm provides a method for capturing images on multiple focal planes and transferring them to the single image in which all objects are in-focused.

In the past, several prior methods have been proposed to obtain all-focused image. Kodama et al. [1] proposed a focused image from two different focus by using a point spread function (PSF) which is approximated by a Gaussian function. Kim et al. [2] used a PSF to determine whether or not the input image is focused. Kubota et al. [3] presented an all-focused view from under-sampled light fields using multiple views at a given viewpoint and reconstructing the all-focused view by fusing the multiple views, while Shoa et al. [4] created all-focused images of micro-mechanical systems based on gradient operators. Alternative all-focused imaging techniques can be found in Refs. [5, 6].

This paper proposes an all-focused image algorithm by separating differently-focused images and combining in-focused regions to a complete image. The final image displays sharply an all-focused image and shows the depth of field can be extended greatly.

2. Proposed method

The following two steps are involved in the implementation of the proposed method. First, we split apart the jpeg images and meta-data encoded in the files from the raw files which are taken by a lytro light field camera [7]. After that, we assign the optimal depth for each region and combine the in-focused regions of those images into the final image. Therefore, the complete image displays all-focused image.

2.1 Image splitting

“lfpsplitter” is a command line tool, which can extract the following data from *.lfp* and *-stk.lfp* files into individual files: metadata, depth lookup table (plain-text list), and the raw image file (when extracting from the original *.lfp* file) or the different focal depth layers as JPGs (when extracting from a *stk.lfp* file). This application was proposed by Patel [8].

In this paper, we apply *-stk.lfp* file samples using lfpsplitter tool. The tool gives the images with different depths. Table 1 shows the information of lfpsplitter result files.

(Table 1) Lfpsplitter result files

Filename	Description
IMG0_00.jpg - IMG0_xx.jpg	The result of component jpeg image at different focal depths.
IMGxx_table.json	Metadata and lambda information for each jpeg component.
IMGxx_depth.txt	The depth information lookup table

(Table 2) Lambda information

Value	Description
Zero value	Original optical focusing
Negative value	Correspond to near refocusing
Positive value	Correspond to far refocusing

The *_table.json* provides a lot of information while the important data produces a map between the different depth image and its focal depth. We concentrate on lambda values because they present the different in-focused region between the optical focal plane of the main lenses at capture time and the virtual focal plane of the refocused images as shown in Table 2.

Fig. 1 shows the important information are extracted from the json file that presents the lambda information, width value and height value for each different focal depth image.

representation : jpeg
width : 1080
height : 1080
lambda : -6.8964385986328125

(Figure 1) The lambda information

2.2 All-focused imaging

In this subsection, we extract the in-focused regions of the different focal depth image files from the previous subsection. Then, the in-focused regions of those images are integrated into a final image.

We check the *_depth.txt* file and use the lambda information of each different focal image. The depth file is a flattened 20 x 20 array of depth values, while each different focal image sizes 1080 x 1080 pixels. This 20 x 20 array maps to the 1080 x1080 jpeg images. So each depth value in the array represents 54 x 54 pixels in the jpeg images. We compare the data between the lambda value of each image and the depth value. If the minimize absolute difference matches with which image, a region of this image is the closest focal depth. The in-focused region is the corresponding area of the image with the closest focal depth. The process is presented in Table 3 and is illustrated in Fig. 2.

(Table 3) All-focus algorithm

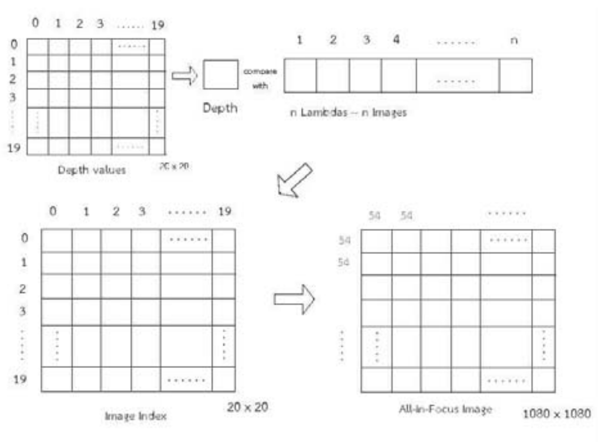
Process	Method's description
Step 1	Consider the depth value and the lambda value of each image.
Step 2	Compute: for K = 1, 2, …N where N= number of images delta K = | Lamba - Depth K | closest depth = min (delta1, delta2, … , deltaN)
Step 3	The closest focal depth represents an in-focused region.
Step 4	Map in-focused image to the corresponding area of the final image.
Step 5	Consider next depth value.
Step 6	Repeat Step 1 through Step 5 until end of depth data value.
Step 7	The final image is the all-focused image.

Condition:

Image size: 1080 ×1080 pixels

Depth file: 20 × 20 array of depth values

Ratio: each depth value 54× 54 corresponding pixels



(Figure 2) All-focused process

3. Experiment results

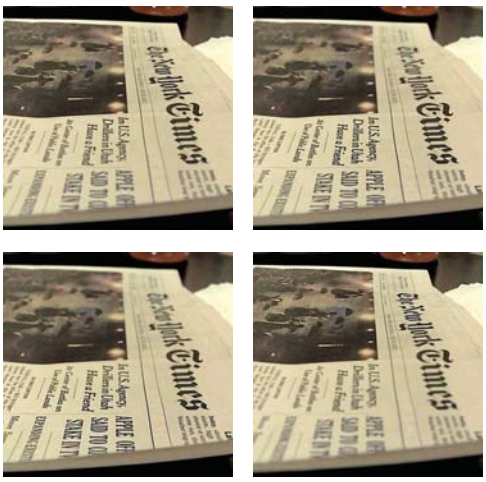
In this section, we show the outcomes of the proposed method with different image samples. We conducted the experiments on 1080 × 1080 sample images, while the size of depth data information from the meta-data is 20 × 20 array.

(Figure 3) Experiment sample images

The experiment samples consist of three source images. These samples contain different illuminations as shown in Fig. 3. The next subsection shows the outcomes of the proposed technique.

3.1 Image splitting results

Fig. 4 to Fig. 6 show the result of component jpeg images at different focal depths. Each image displays the same position in which images become in-focused images of different focal planes.



(Figure 4) The difference focal depth layers as JPGs

(Figure 5) The difference focal depth layers as JPGs

(Figure 6) The difference focal depth layers as JPGs

3.2 All-focus image results

From Fig. 7 to Fig. 9, we compare the results of the proposed method with all-focused images which are generated by a lytro desktop software [7] and the average-focused images. The experiment results show that the proposed method provides more effective and sharper the all-focused image results than other methods. The results also show that the depth of field can be extended significantly.

(a) Average-focused image (b) Lytro all-focused image

(c) The proposed all-focused image

(Figure 7) Experiment image results

(a) Average-focused image

(b) Lytro all-focused image

(c) The proposed all-focused image

(Figure 8) Experiment image results

4. Conclusion

In this paper, we proposed a method for reconstructing an all-focused image through the raw light field data which are taken by a lytro light field camera. We separate the raw data to the differently-focused images by a light field picture splitter and merge the in-focused regions of those images into the final image using the meta-data information. Experiment results revealed that our proposed method reconstructed the all-focused image with different focal images successfully. The outcomes present the efficiency of the proposed method and show that the depth of field can be extended greatly.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (No. 2011-0030079).

(a) Average-focused image

(b) Lytro all-focused image

(c) The proposed all-focused image

(Figure 9) Experiment image results

Reference

[1] K. Kodama, K. Aizawa, and M. Hatori, “Iterative Reconstruction of an All-Focused Image by Using Multiple Differently Focused Images,” IEEE Proceeding of International Conference on Image Processing, vol. 3, pp. 551-554, 1996.

[2] S. K. Kim, S. R. Part, and J. K. Paik, “Simultaneous Out-of-focus Blur Estimation and Restoration for Digital Auto-focusing System,” IEEE Transactions on Consumer Electronics, vol. 44(3), pp. 1071-1075, 1998.

[3] A. Kubota, K. Takahashi, K. Aizawa, and T. Chen, “All-focused Light Field Rendering,” Eurographics Symposium on Rendering (EGSR), pp.235-242, 2004.

[4] T. Shoa, G. Thomas, C. Shafai, and A. Shoa, “Extracting a Focused Image from Several Out-of-focus Micromechanical Structure Images,” Acoustics, Speech, and Signal Processing, Proceedings, vol. 3, pp. 505-508, 2004.

[5] F. P. Nava and J. P. Luke, “Simultaneous Estimation of Super-resolved Depth and All-in-focus Images from a Plenoptic Camera,” 3DTV Conference: The True Vision - Capture, Transmission and Display of 3D Video, pp. 1-4, 2009.

[6] Y. S. Jeon and H. W. Park, “Fast All-in-focus Light Field Rendering using Dynamic Block-based Focusing Technique,” 3DTV Conference: The True Vision - Capture, Transmission and Display of 3D Video, pp. 1-4, 2011.

[7] Lytro, “The lytro camera,” https://www.lytro.com/

[8] N. Patel, “lfptools,”http://github.com/nrpatel/lfptools/