Depth Estimation using Light-Field Camera

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Motivation

Light-field cameras have enabled applications that are not feasible with traditional cameras because they capture not only the projected 2D images but also the directions of light beams. This additional information allows us to perform various tasks, including depth estimation, which is a long-existing problem within the field of computational photography. For example, by leveraging the defocus in the reconstructed 2D images using light field information, we may compute the relative depth of each pixel as we did in homework 5. Nevertheless, since following the homework instructions does not produce high-quality depth maps, we are interested in reproducing and possibly improving advanced methods that generate better results.

Related Work

Researchers have explored depth estimation using light field information for a long time. For example, Adelson and Wang compute depth estimates using the displacement of the object's image on the sensor plane [1]. Tao et al. compute depth maps using both defocus and correspondence depth cues in light fields [2]. Wang et al. later develop an occlusion-aware algorithm that makes sharp depth estimates at boundaries [3]. In this project, we are interested in reproducing Jeon et al.'s algorithm [4], which achieves state-of-the-art performance when their paper was published. We will briefly explain their approach in the following section.

Project Overview

One key challenge for depth estimation using light-field cameras lies in the narrow baseline between sub-aperture images captured by a light field camera. In other words, minor pixel disparity will introduce significant errors in depth estimates. Following the algorithm proposed in [4], we will address this issue in four steps.

1. Implement the algorithm using the phase shift theorem in the Fourier domain to estimate the sub-pixel shifts of sub-aperture images.
2. Use a weighted median filter and reliable disparity labels to reduce image noise and optimize weak texture regions, respectively.
3. Refine the estimated depth map by employing quadratic polynomial interpolation iteratively.
4. Use a low order approach to correct the distortion in the depth map estimation.

Once we finish reproducing the algorithm, we also hope to improve it by any chance. However, since there remains more uncertainty about whether we have enough knowledge and time for improvement, we will leave this part as an optional bonus for our project.

Source Code

One thing we would like to bring up into discussion with the teaching team is that we have found the source code released by the author of the paper. In this case, we are not sure whether reproducing the algorithm alone is sufficient enough to be a great final project. One alternative is that we could re-implement the algorithm using Python because the released source code is written in Matlab. We would also love to discuss with the teaching team about other available options for the project.

Milestones, Timeline, Goals

Week	Date	Progress
6	2/14	Discuss with the teaching team and read the paper thoroughly
7	2/21	Implement the first version of the algorithm
8	2/28	Debug or improvement the algorithm
9	3/06	Write up the report and make the poster
10	3/13	Project report and code due

References

(1) E. H. Adelson and J. Y. A. Wang, "Single lens stereo with a plenoptic camera," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 14, no. 2, pp. 99-106, Feb. 1992.

(2) M. W. Tao, S. Hadap, J. Malik and R. Ramamoorthi, "Depth from Combining Defocus and Correspondence Using Light-Field Cameras," 2013 IEEE International Conference on Computer Vision (ICCV), Sydney, 2013, pp. 673-680.

(3) T. Wang, A. A. Efros and R. Ramamoorthi, "Occlusion-Aware Depth Estimation Using Light-Field Cameras," 2015 IEEE International Conference on Computer Vision (ICCV), Santiago, 2015, pp. 3487-3495.

(4) H. Jeon, J. Park, G. Choe, J. Park, Y. Bok, Y. W. Tai and I. S. Kweon, "Accurate depth map estimation from a lenslet light field camera," 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Boston, MA, 2015, pp. 1547-1555.