Depth from Defocus for Mobile Cameras

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Summary

Depth from Defocus (DFD) is a technique in which a depth image of a scene is reconstructed from multiple images with varying camera parameters from a single camera [1]. Parameters that affect defocus characteristics of an image are; distance to the focus plane, the focal length, and the depth of field which is controlled by the aperture size.

I would like to explore and implement DFD methods on smartphones [2]. My aim is to display a captured scene with a some kind of 3D technique, i.e. parallax mapping. A use for this could be simple capturing of 3D photos of people or of sculptured art.

Technical Details

In the first stage I will implement a DFD method in MATLAB with image stacks taken by a stationary DSLR camera, i.e. no translation or parallax between images. This will give me a solid understanding of the mathematics behind the optics and the algorithms.

In the second stage I will extend the above method to handle camera shake and alignment of images [3] in MATLAB and subsequently test the implementation with images taken by my iPhone.

In the third stage I will implement the above method on my iPhone using OpenCV for iOS. I will experiment with the iOS Camera API to manually set the focus distance of the camera.

If there is enough time I will implement an iPhone viewer for the image and its reconstructed depth map. Further work could be to investigate methods of improving the accuracy of the depth map by including shading information from the scene [4].

References

[1] J. Ens and P. Lawrence. An investigation of methods for determining depth from focus. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 15(2):97–108, Feb 1993.

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[3] R. Ben-Ari. A unified approach for registration and depth in depth from defocus. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 36(6):1041–1055, June 2014.

[4] C. Li, S. Su, Y. Matsushita, K. Zhou, and S. Lin. Bayesian depth-from-defocus with shading constraints. *IEEE Transactions on Image Processing*, 25(2):589–600, Feb 2016.