Synthetic Depth of Field Effect

Variable Synthetic Depth of Field with Stereo Cameras

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Introduction

Narrow depth of field effects are desirable in photography. However, mobile cameras with small apertures and short focal length cannot naturally achieve this. Instead, synthetic depth of field is achievable based on depth estimations.

Existing Work:

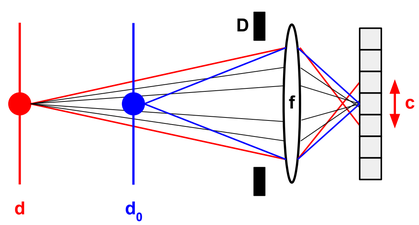
- Google: NN person segmentation + dual pixel disparity [1]
- DeepLens: pure NN depth estimation + upsampling [2]

Contributions:

- Implement a pipeline to generate depth of field effects with variable parameters such as focus distance, focal length, aperture size, and aperture shape.
- Attempt using stereo disparity to estimate depth.

Method

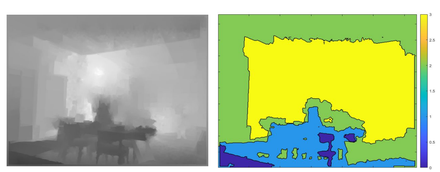
Background: Circle of Confusion



$$c(d) = D\left(\frac{f}{d_0 - f}\right)\left(\frac{|(d - d_0)|}{d}\right)$$

Defocus Radius Map

$$r_i = \lfloor \frac{c(d_i)}{2p} \rfloor = \lfloor \frac{c(d_i)}{2p_0 \frac{H_0}{H}} \rfloor$$

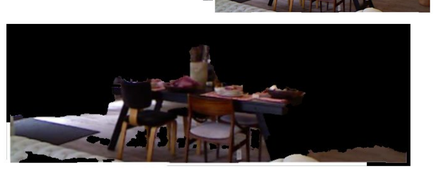


Blur Kernels

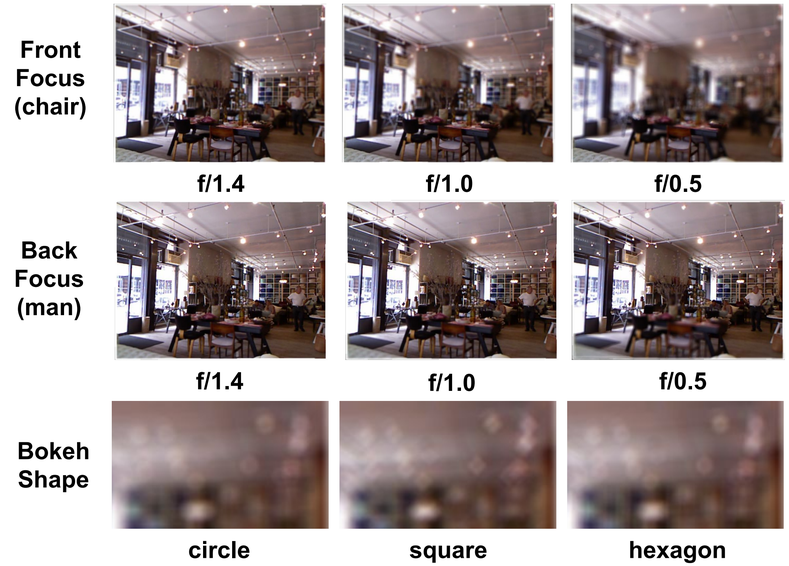
$$B_r \in R^{(2r+1)\times(2r+1)}$$

Merge Blurred Images

$$I_{out} = \sum_r (B_r * I)_{r_i = r}$$



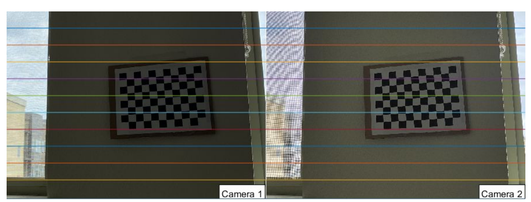
Variable Parameters



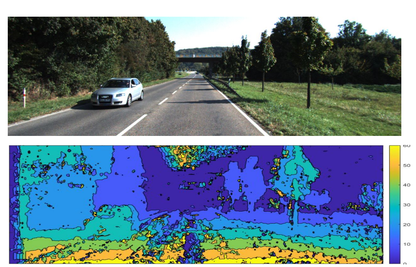
Experiments

Stereo Disparity

1. Calibrate & rectify.
2. Search matching tiles along rows. Compute match cost (SSD) for each disparity in a cost volume.
3. Filter cost volume conv2 with box filter (cost aggregation).
4. Choose disparity with lowest filtered cost.



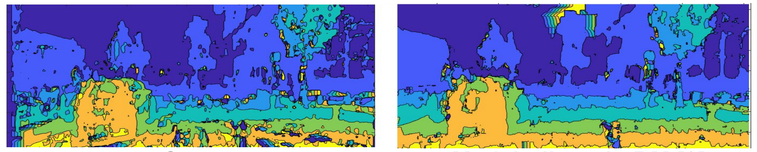
$$d = baseline \times \frac{f}{disparity}$$



Evaluation

NYU V2

KITTI Stereo



Ours | Matlab disparityBM [3]

iPhone Stereo

Ours | Matlab disparityBM [3]

Discussion

- Under ideal conditions, our method can achieve moderately acceptable depth of field blurring and bokeh.
- Segmentation mask is an important feature to improve the blurring around the target subject.
- Disparity matching algorithms need to be more robust for mobile stereo cameras, perhaps with bilateral smoothness and confidence constraints [4].

References

[1] Wadhwa, Neal, et al. "Synthetic Depth-of-Field with a Single-Camera Mobile Phone." ACM Transactions on Graphics, vol. 37, no. 4, July 2018, pp. 1–13. arXiv.org, doi:10.1145/3197517.3201329.
[2] Wang, Lijun, et al. "DeepLens: Shallow Depth Of Field From A Single Image." ArXiv:1810.08100 [Cs], Oct. 2018. arXiv.org, http://arxiv.org/abs/1810.08100.
[3] Compute Disparity Map Using Block Matching - MATLAB DisparityBM. https://www.mathworks.com/help/vision/ref/disparitybm.html. Accessed 11 Mar. 2020.
[4] Barron, Jonathan T., and Ben Poole. "The Fast Bilateral Solver." ArXiv:1511.03296 [Cs], July 2016. arXiv.org, http://arxiv.org/abs/1511.03296.