A Deep Learning Framework for Light Field Reconstruction From Focus-Defocus Pair: A minimal hardware approach

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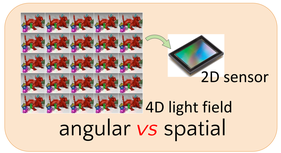
Resolution Trade-off with Light Field Imaging

- Due to bandwidth limitation, capturing 4D light field on a 2D sensor poses resolution trade-off

Solution: Multiplex or sub-sample angular rays and reconstruct back computationally

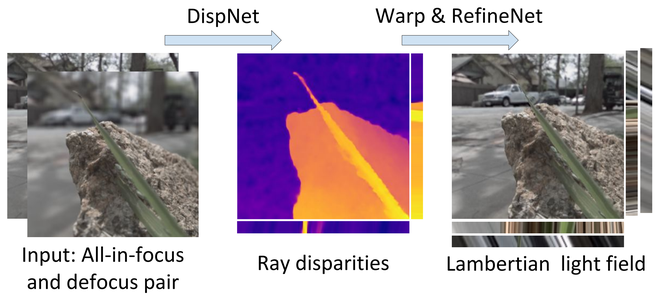
- Compressive light field, programmable aperture, view synthesis
- This often requires specific hardware requiremens



Our solution: Light field from focus-defocus pair
No additional hardware

Light Field Reconstruction Pipeline

- We breakdown the LF reconstruction from focus-defocus pair into two steps -



Lambertian Light Field Synthesis

$$\tilde{L}(x,q) = L(x + qD(x,q), 0)$$

Disparity EPI consistency

$$D(x,u) = D(x + kD(x,u), u + k)$$

Non-Lambertian Light Field Refinement

$$r = f(\tilde{L}, D, I_d)$$

$$L_r(x,u) = r(x,u) + \tilde{L}(x,u)$$

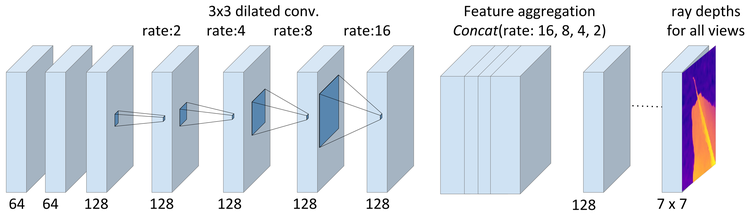
Overall Loss function

$$\mathcal{L}_{rec} + \mathcal{L}_{ref} + \lambda_{dc}\mathcal{L}_{dc} + \lambda_{tv}\mathcal{L}_{tv}$$

*This block is adapted from single image LF synthesis work [2]

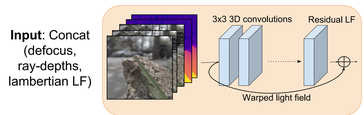
Proposed CNN Architectures

DispNet: Disparity from focus-defocus pair



RefineNet: non-lambertian LF

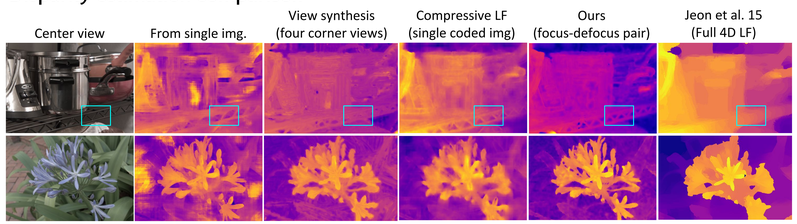
- Predicts non-lambertian LF and occluded pixels using a residual block [2]



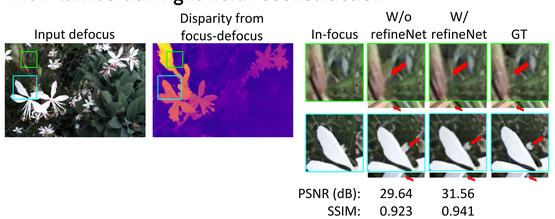
Challenges with disparity estimation

- Depth disambiguation from just focus-defocus pair
  - Variation of focal plane
- Textureless regions
  - Does not affect the lambertian LF reconstruction

Disparity estimation comparison

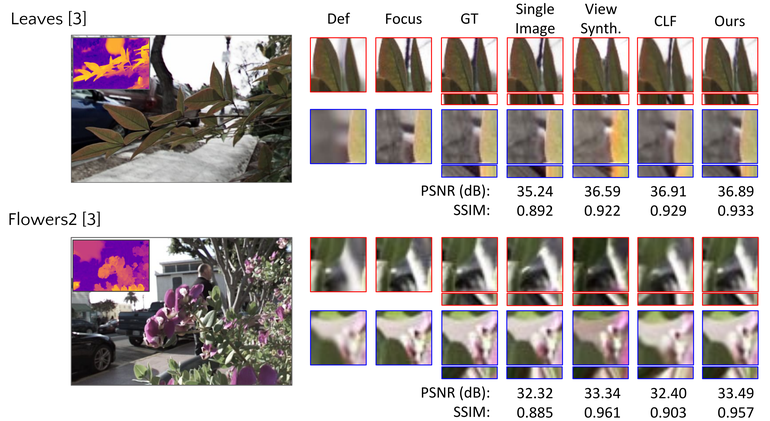


Non-lambertian light field reconstruction



Results

Approach	30 Test LFs [3]	Reflective_29	Occlusions (7, 25, 47)	Miscellaneous (1,2,21,22,29,43,56)
Single Image [2]	35.55 dB, 0.930	35.45 dB, 0.942	33.08dB, 0.855	35.03 dB, 0.927
View Synthesis [3]	**37.56 dB, 0.960**	37.47 dB, 0.974	34.74 dB, 0.924	35.85 dB, 0.951
Compressive LF [1]	37.29 dB, 0.951	37.67 dB, 0.972	33.95 dB, 0.911	36.22 dB, 0.944
Ours (Foc-Defocus)	37.41 dB, 0.955	**39.56 dB, 0.981**	**35.39 dB, 0.936**	**37.12 dB, 0.960**
Direct regression				



References

1. Vadathya, Anil Kumar, et al. "Learning light field reconstruction from a single coded image." In ACPR 2017.
2. Srinivasan, Pratul P., et al. "Learning to synthesize a 4d rgbd light field from a single image." In ICCV 2017.
3. Kalantari, Nima. K., et al. "Learning-based view synthesis for light field cameras". In SIGGRAPH ASIA, 2016.