Supplementary material for Phase retrieval for Fourier Ptychography under varying amount of measurements

Lokesh Boominathan[12]
boominathanlokesh@gmail.com
Mayug Maniparambil[1]
mayugmaniparambil@gmail.com
Honey Gupta[1]
hn.gpt1@gmail.com
Rahul Baburajan[1]
rahuledachali@gmail.com
Kaushik Mitra[1]
kmitra@ee.iitm.ac.in

[1] Computational Imaging Lab,
Indian Institute of Technology Madras,
Chennai, India
[2] Aindra Systems
Bengaluru, India

1 Fourier ptychography forward model

Fourier ptychography forward model involves the angular illumination of target using LEDs, interaction of light from target sample with the objective lens, and finally its acquisition using the camera. Below, we mathematically model each of these steps (refer Fig. 1), and use it for simulating the Fourier ptychography dataset.

- LED illumination: Let us consider the imaging of a thin target sample having transmission function given by $o(v) = A(v)e^{j\phi(v)}$, where v is the spatial vector, and $A(v)$ and $\phi(v)$ are the amplitude and phase attenuation respectively. If the target sample is illuminated using an LED that emits light with spatial frequency k, then light from the target sample that reaches the objective lens is $o(v)e^{j2\pi(v.k)}$. Therefore, if $O(\omega)$ is Fourier transform of the target sample under normal illumination, then the Fourier transform under angular illumination would be $O(\omega - k)$.

- Objective lens: Let $P(\omega)$ be the pupil function of the objective lens, then the light passing through it would be $O(\omega - k)P(\omega)$. Since under normal illumination $P(\omega)$ acts as a low pass filter with cut-off frequency given by its numerical aperture, under angular illumination it would behave as a band pass filter.

- Image acquisition: However, since camera sensors can capture only the intensity and not the phase of light coming from the objective lens, the captured image is given as $|\mathcal{F}^{-1}(O(\omega - k)P(\omega))|^2$, where $\mathcal{F}^{-1}$ is Fourier inverse. Multiple such images are taken using varying angles of illumination to capture different regions of the object's Fouier domain.

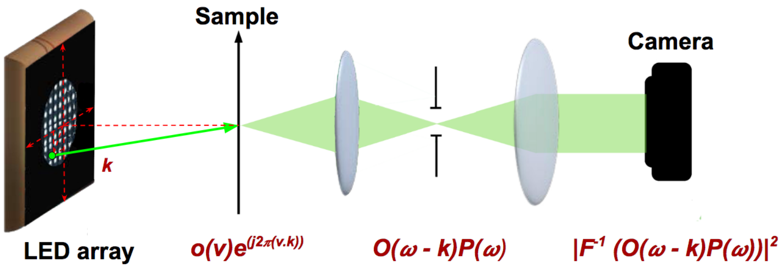

Figure 1: Schematic representation of Fourier ptychography forward model (a slightly modified version of Fig. 1 from [4])

2 Supplementary results

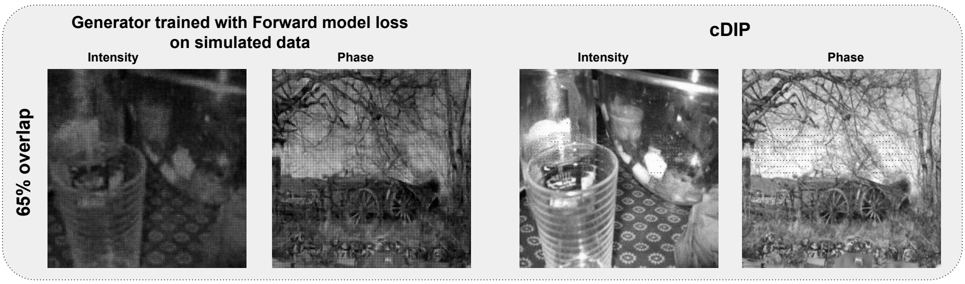

Figure 2: *Training for entire dataset vs optimizing for one test sample, for 65% overlap case:* The above figure is in reference to Section 4.2 in the main paper. On the left is the result obtained by training (on the simulated dataset) our auto-encoder based generator network using just forward model loss. On the right is the result obtained for the same generator network with forward model loss, but with weights optimized only for a given test sample. We observe that the generator finds it more difficult to reconstruct high resolution phase and amplitude, when trained for entire dataset, as compared to optimizing just for the one test sample.

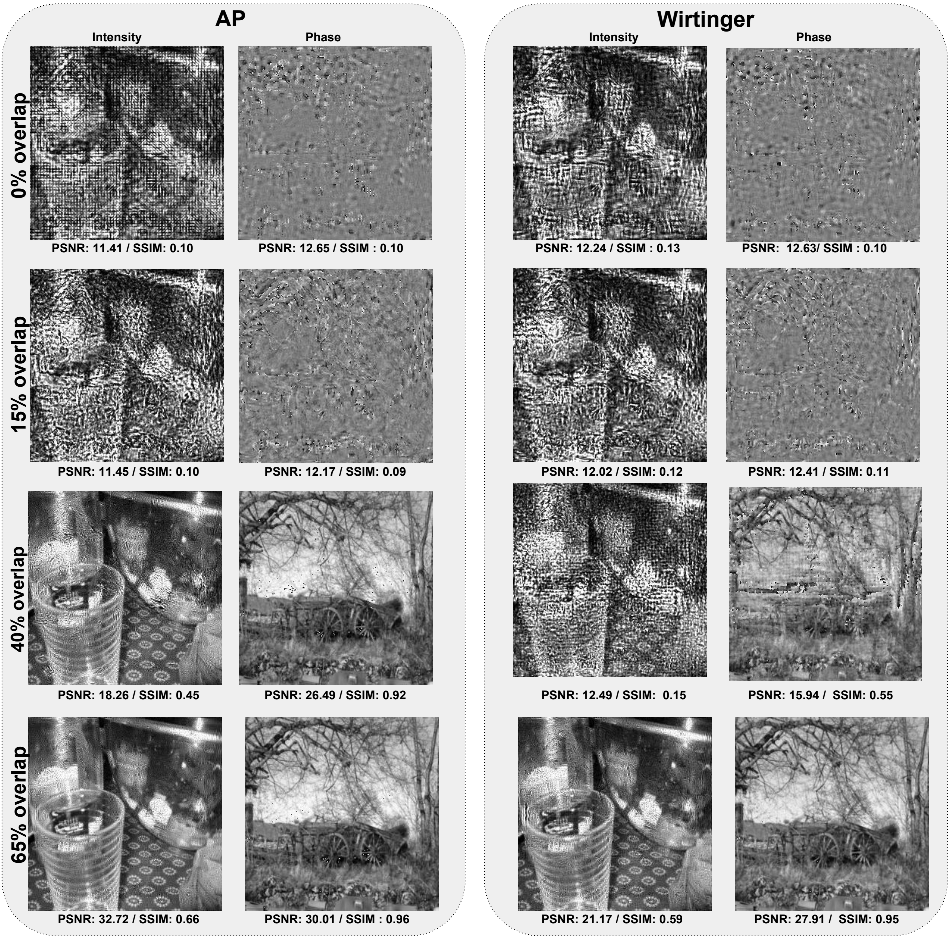

Figure 3: Comparison of results for Alternative Projection (AP)[3][2] and Wirtinger Flow [1]. We observe that AP's performance is better or at par with Wirtinger Flow in most cases

References

[1] Liheng Bian, Jinli Suo, Guoan Zheng, Kaikai Guo, Feng Chen, and Qionghai Dai. Fourier ptychographic reconstruction using wirtinger flow optimization. *Optics express*, 23 4:4856–66, 2015.

[2] James R Fienup. Reconstruction of an object from the modulus of its fourier transform. *Optics letters*, 3(1):27–29, 1978.

[3] RW Gerchberg. Super-resolution through error energy reduction. *Optica Acta: International Journal of Optics*, 21(9):709–720, 1974.

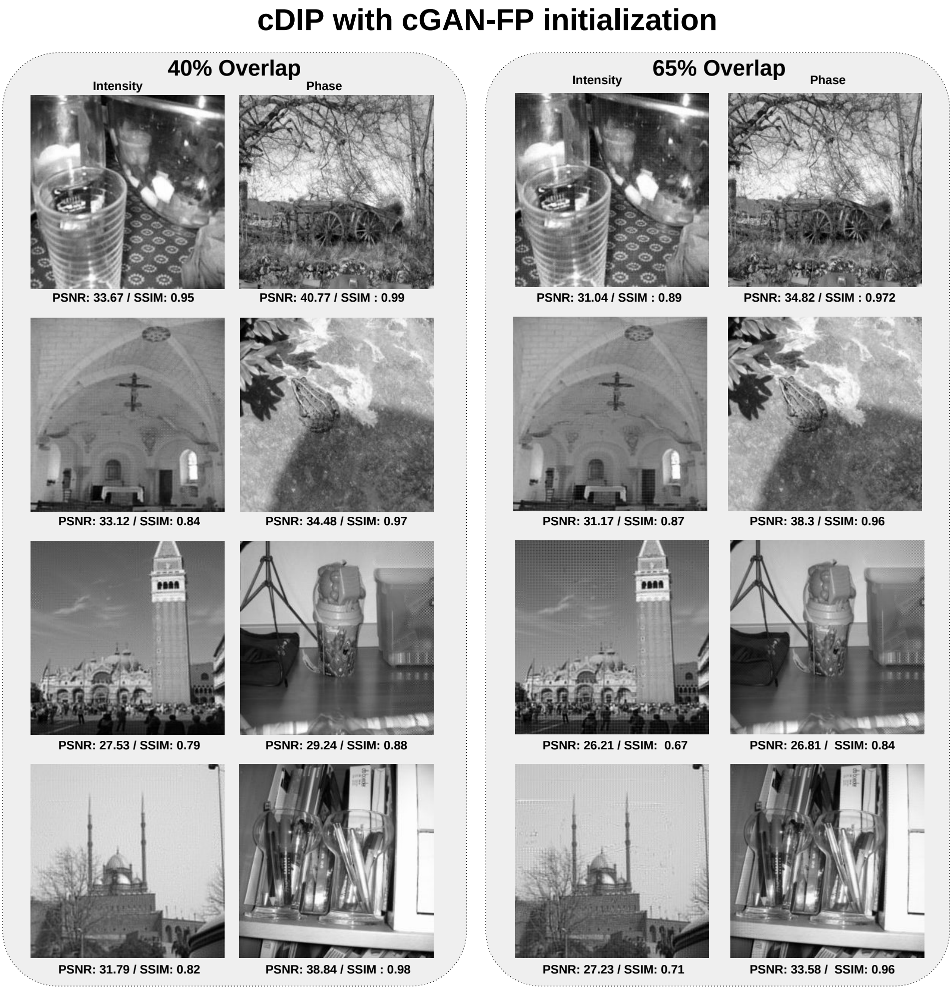

Figure 4: In the above figure, we show results of our algorithm for various test samples in the high overlap case.

[4] Lei Tian, Xiao Li, Kannan Ramchandran, and Laura Waller. Multiplexed coded illumination for fourier ptychography with an led array microscope. *Biomedical optics express*, 5(7):2376–2389, 2014.