# FOURIER PTYCHOGRAPHY MICROSCOPY WITH INTEGRATED POSITIONAL MISALIGNMENT CORRECTION

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## BACKGROUND

- Fourier Ptychography Microscopy (FPM) reconstructs intensity and phase high-resolution images from multiple low-resolution captures under varying illumination directions using a matrix of LEDs [1].
- A physics-informed convolutional neural network (CNN) allows to iteratively optimize the reconstructed image of a sample to match the low-resolution captures [2].
- Pupil aberrations can be estimated during reconstruction [3].

## OBJECTIVE

Enhance reconstruction by integrating the correction of the LED positional misalignment, so reducing the need for precise manual calibration and improving reconstruction accuracy.

## METHODOLOGY

We integrate the LED matrix's position and orientation as learnable parameters of the reconstruction CNN. This involves:

- **Neural Network-based Self-calibration:** The CNN iteratively adjusts LED positions, correcting both shifts and rotations in the LED array.
- **Custom Pupil Layer:** We developed a custom ReLU-based layer to implement a differentiable pupil function for LED re-positioning.
- **Spectral Support Reset:** The reconstructed object is periodically reset to avoid residual frequencies artifacts after LED re-positioning.

## EXPERIMENTS

We compare reconstructions from FPM captures of the USAF test chart by Zheng *et al.* [4].

## REFERENCES


[1] G. Zheng *et al.*, "Wide field, high-resolution Fourier ptychographic microscopy", *Nature Photonics*, vol. 7, no. 9, pp. 739–745, 2013.

[2] S. Jiang *et al.*, "Solving Fourier ptychographic imaging problems via neural network modeling and TensorFlow", *Biomedical Optics Express*, vol. 9, no. 7, pp. 3306–3319, 2018.

[3] M. Sun *et al.*, "Neural network model combined with pupil recovery for Fourier ptychographic microscopy", *Optics Express*, vol. 27, no. 17, pp. 24161–24174, 2019.

[4] https://github.com/SmartImagingLabUConn/Fourier-Ptychography


## RESULTS

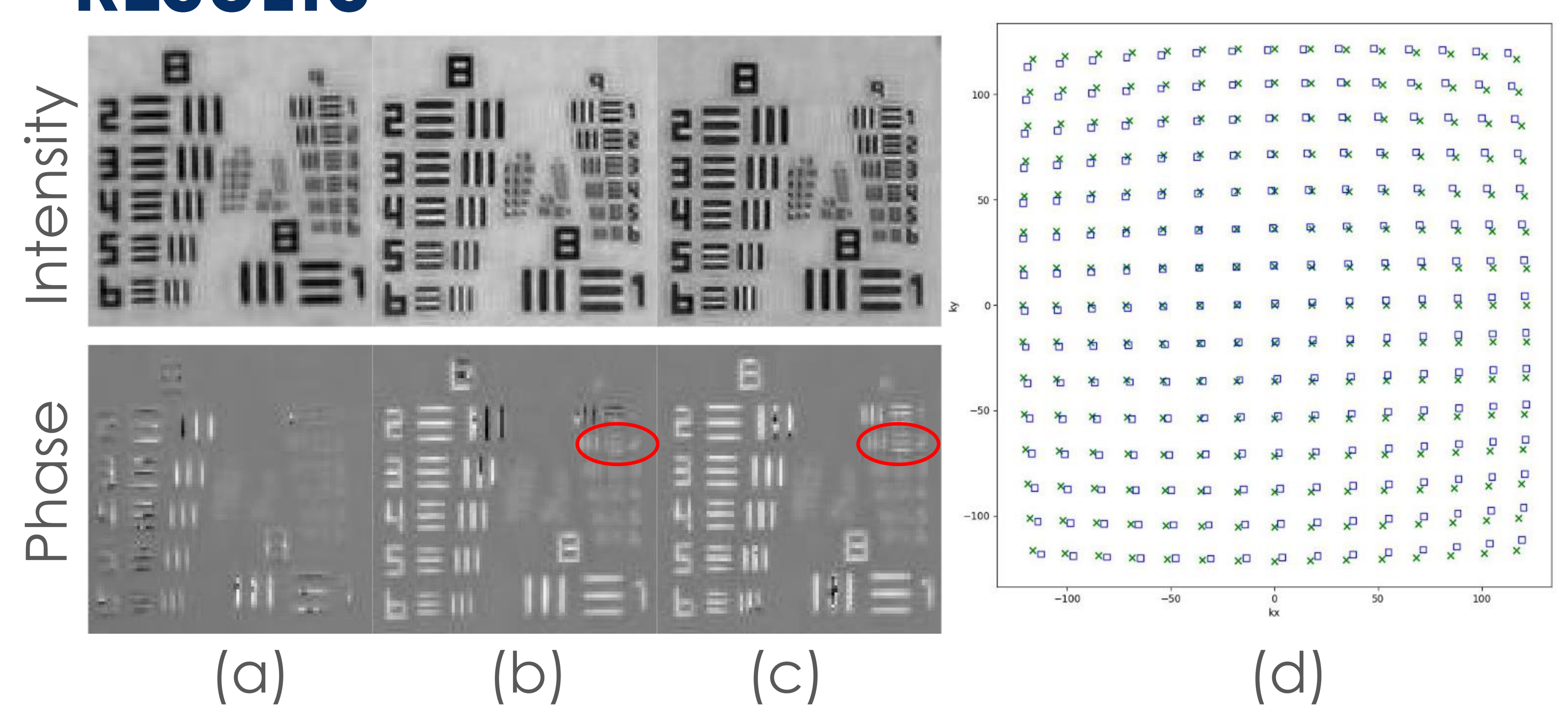


Fig. 1: FPM reconstructions comparison
(a) Reconstruction using Zheng *et al.*'s software [4].
(b) Reconstruction by our network using Zheng *et al.*'s original LED positions [4].
(c) Reconstruction by our network with LED self-calibration.
(d) Original and self-calibrated wave vectors for the matrix of LEDs (× are the original Zheng *et al.* positions, □ are the final self-calibrated positions).

Using Zheng *et al.*'s precise initial LED positions [4], self-calibration slightly improves the reconstructed phase image.

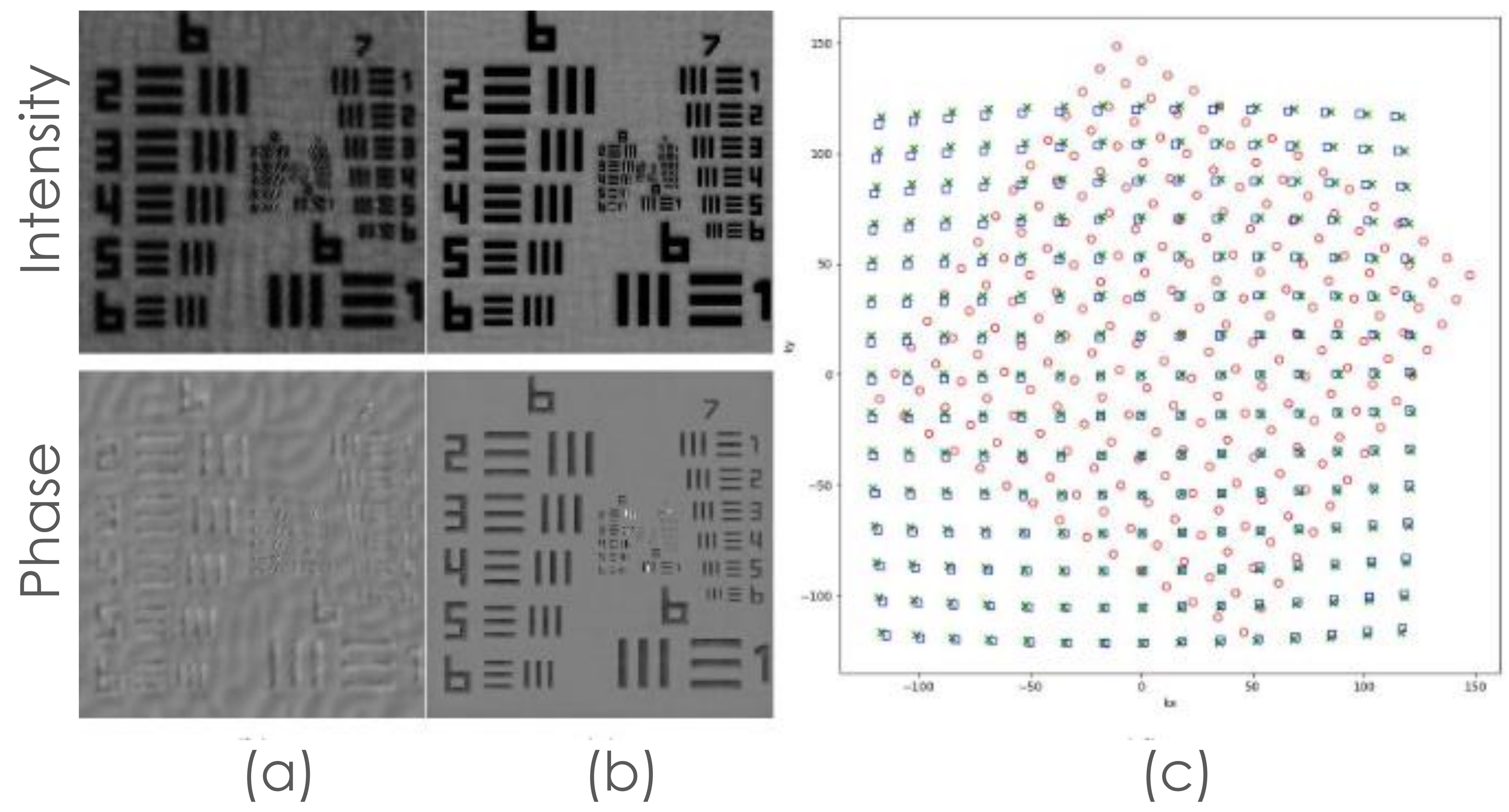


Fig. 2 : FPM reconstruction from simulated captures with a large initial LEDs positioning error:
(a) Reconstruction without positioning correction.
(b) Reconstruction with self-calibrated the LEDs geometry.
(c) The calibrated (optimized) wave vectors for the matrix of LEDs (× are the original Zheng *et al.* positions, O are the perturbated initial positions and □ are the final self-calibrated positions).

Self-calibration can cope with large initial position errors.

## CONCLUSION

We propose a self-calibrating FPM reconstruction with LEDs position correction, that:

- improves reconstruction, especially the phase image,
- works both for precisely hand-calibrated captures, and coarse misalignments,
- alleviates the need for precise calibration of the LED setup.

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