NEURAL NETWORKS FOR FOURIER PYTCHOGRAPHY MICROSCOPY AND APPLICATION TO MALARIA

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OBJECTIVES

- Fourier Ptychography reconstruction [1] of high-resolution intensity and phase wide fields from multiple low-resolution microscope images under varying illuminations using a neural network approach
- Self-calibration of the imaging system
- Detection of malaria parasites in red blood cells (RBC).

APPROACH

Reconstruction:

Given an initial estimation of the illumination directions and aberration-free microscope pupil, iterate:

- Reconstruct the complex image of the wide field using a neural network [2].
- Calibrate the pupil aberration (weighted sum of 10 Zernike polynomials), then the illumination directions by minimizing the difference between the actual low-resolution captures and captures re-synthesized from the reconstructed image.

Classification:

- Earlier work: Preliminary results on classifying healthy and malaria infected RBC from low-resolution intensity images [3].
- Instead, taking advantage of captures with multiple illumination directions, we reconstruct high-resolution intensity and phase images of individual cells. Then we classify cells using transfer learning and ResNet-152.

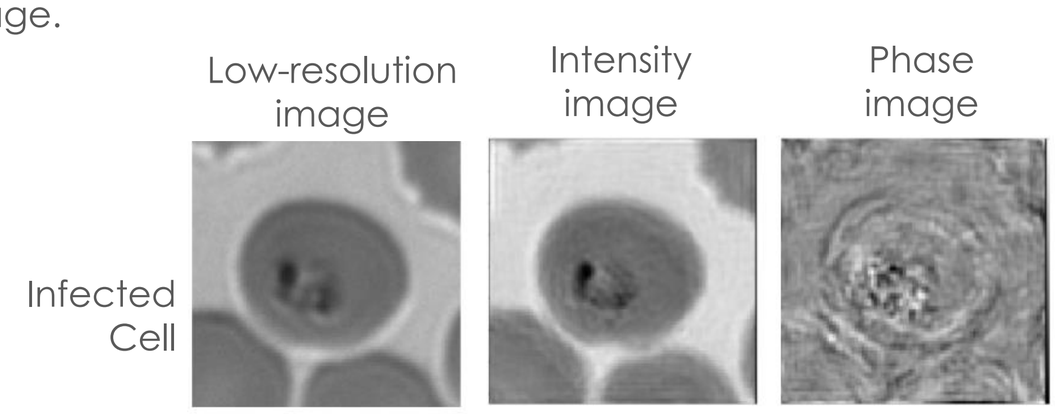

Image 1: Original image obtained by plain microscopy and reconstructed intensity and phase image images.

RESULTS

- We use a set of 10 slices from a patient (so far), each slice being captured with 35 illumination directions, from which 13743 cells have been segmented and labelled by a biologist as infected (3.4 %) or healthy.
- Individual cells are reconstructed by FPM. We compare the classification accuracy using plain microscopy and FPM reconstructed images captured from the same microscope in Table 1.

Case	True negative	False negative	True positive	False Negative	Acuracy	Loss
Low-resolution image	99,36%	0,64%	99,89%	0,11%	99.62%	0.3469
FPM Reconstruced high-resolution intensity	98,56%	1,44%	99,87%	0,13%	99.19%	0.0346
FPM Reconstruced high-resolution intensity + phase	99,55%	0,45%	99,92%	0,08%	99.72%	0.0

Table 1: Comparison between low resolution images and reconstructed images

CONCLUSION

We have demonstrated:

- FPM using self-calibration of the physical parameters.
- Improved detection of malaria parasite using both the intensity and phase images reconstructed by FPM.

REFERENCES

[1] Zheng, G., Horstmeyer, R., & Yang, C. (2013). Wide-field, high-resolution Fourier ptychographic microscopy. [doi:10.1038/nphoton.2013.187].

[2] S. Jiang, K. Guo, J. Liao, and G. Zheng (2018). Solving Fourier ptychographic imaging problems via neural network modeling and TensorFlow [doi:10.1364/BOE.9.003306].

[3] Pattanaik, P. A., Wang, Z., & Horain, P. (2019). Deep CNN frameworks comparison for malaria diagnosis [hal-02280412].

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