MultiWienerNet for Computational Miniature Mesoscope (CM²) Measurement Reconstruction

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Introduction

- Fabrication processes and aberrations → **blurry measurements in low-cost miniaturized microscopy**
- Use **deconvolution techniques** for high-quality reconstruction
- Typical deconvolution algorithms assume **spatial invariance**
  - **Spatial Invariance:** neglects **variations in point spread functions (PSFs)** across **microscope field of view (FOV)** → common problem in practical use
- Prior approaches for spatial variance: **slow and computationally intensive**
- **MultiWienerNet:**
  - Integrates **Wiener filters** initialized with **spatially variant PSFs** and a **convolutional neural network (CNN)**,
- **Overall Goal:** Utilize the MultiWienerNet to reconstruct biological sample measurements taken by the Computational Miniature Mesoscope (CM²)
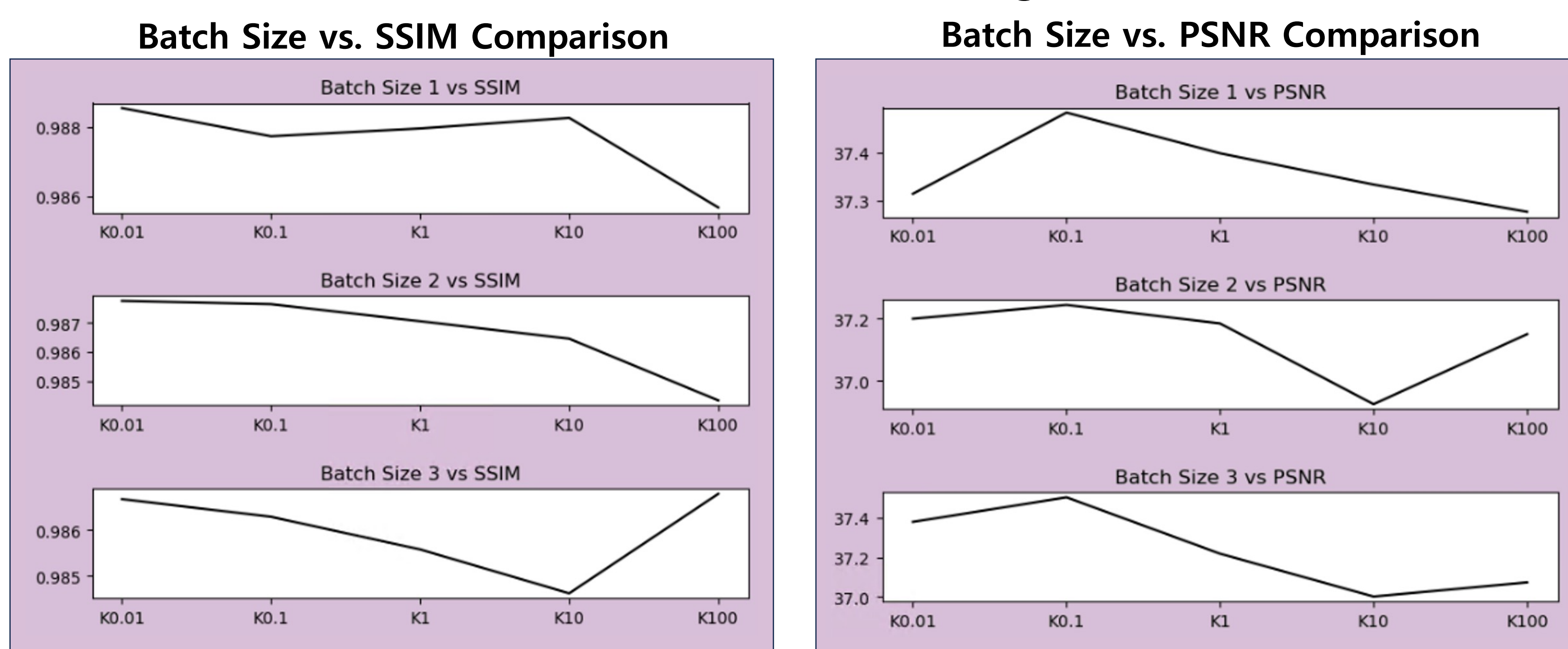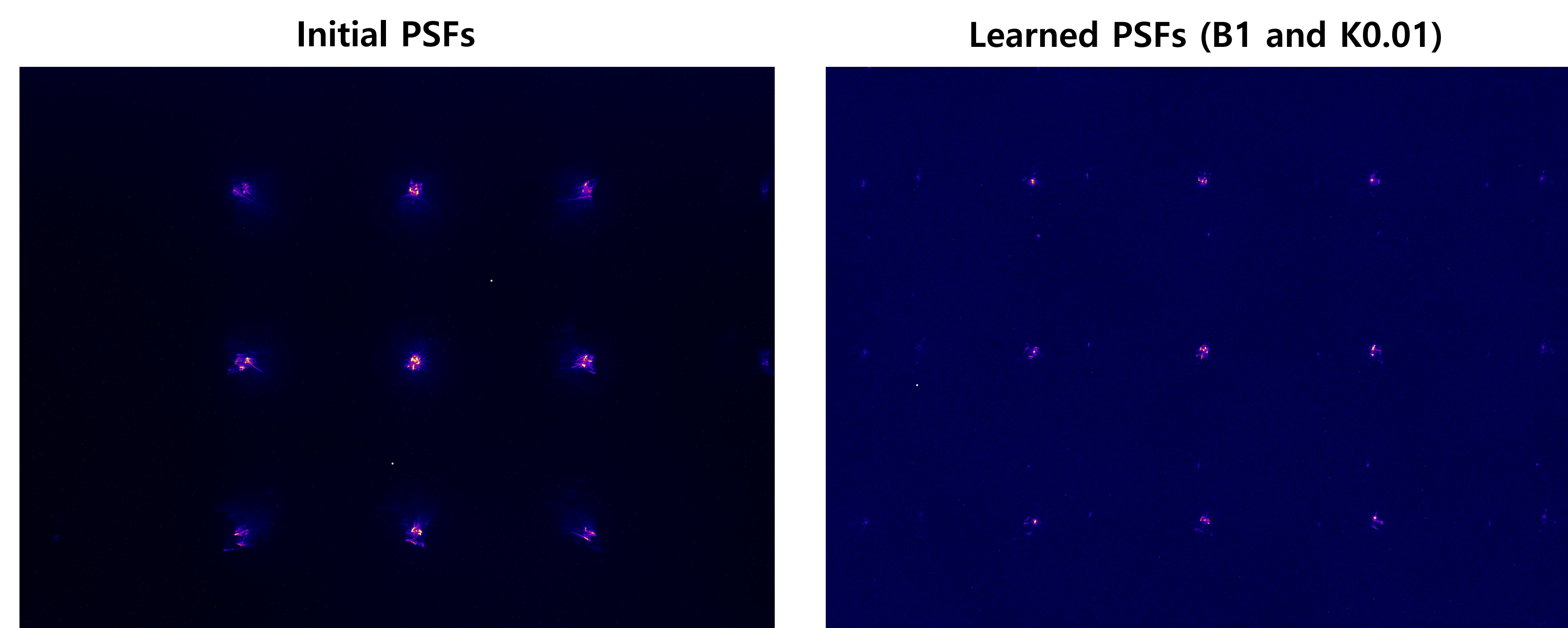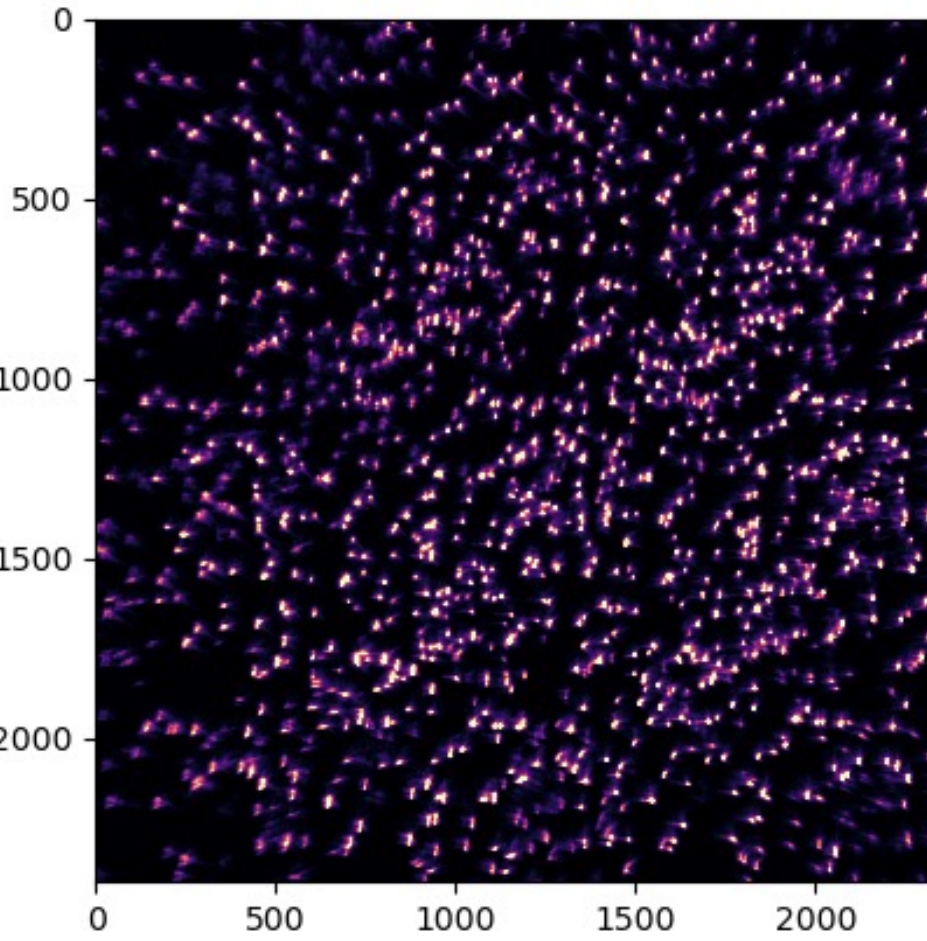
Methods

General Pipeline
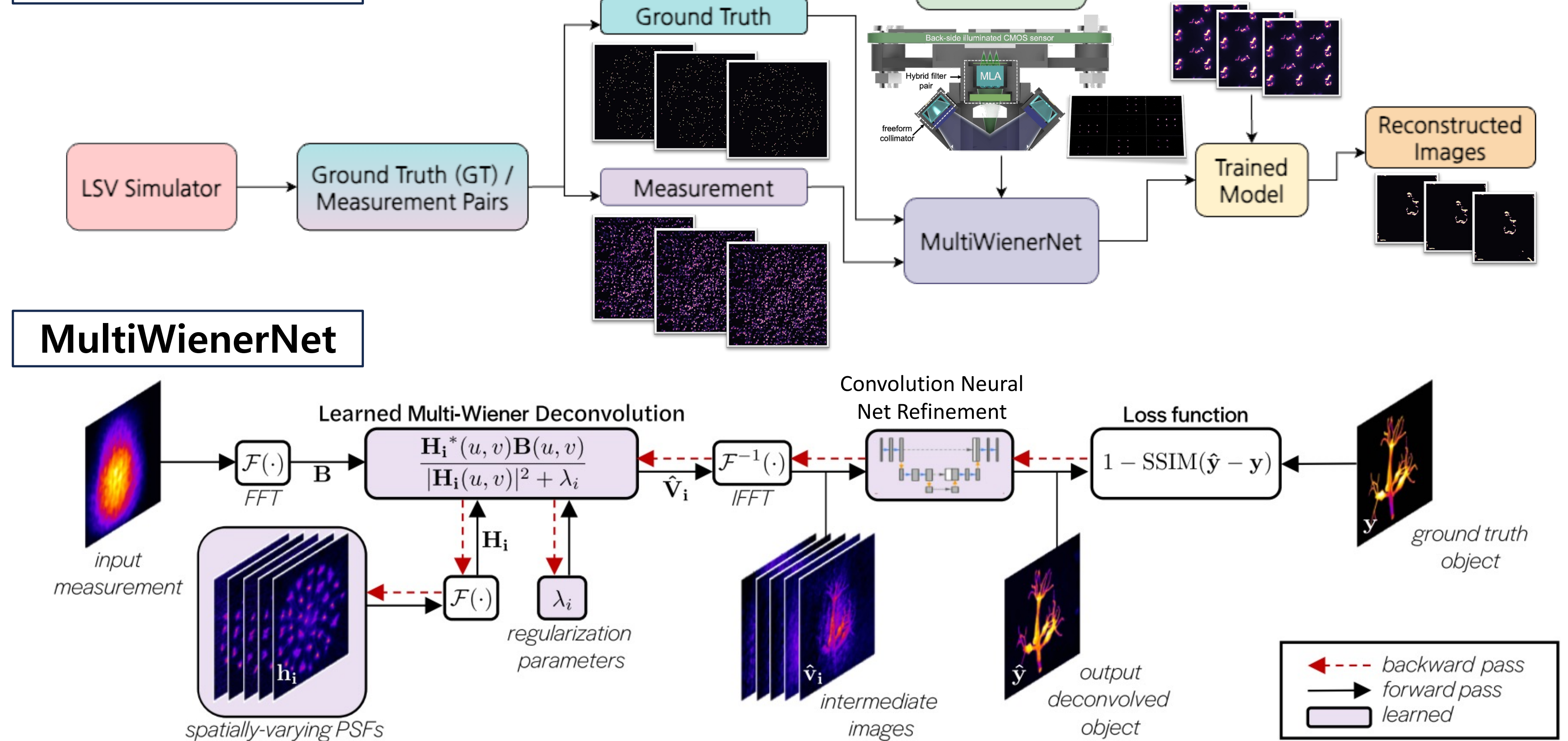
MultiWienerNet

Results

MultWienerNet Hyperparameter Tuning (Batch Size and K-Value) Testing Results

Batch Size vs. SSIM Comparison

Batch Size vs. PSNR Comparison

Initial PSFs vs. Learned PSFs

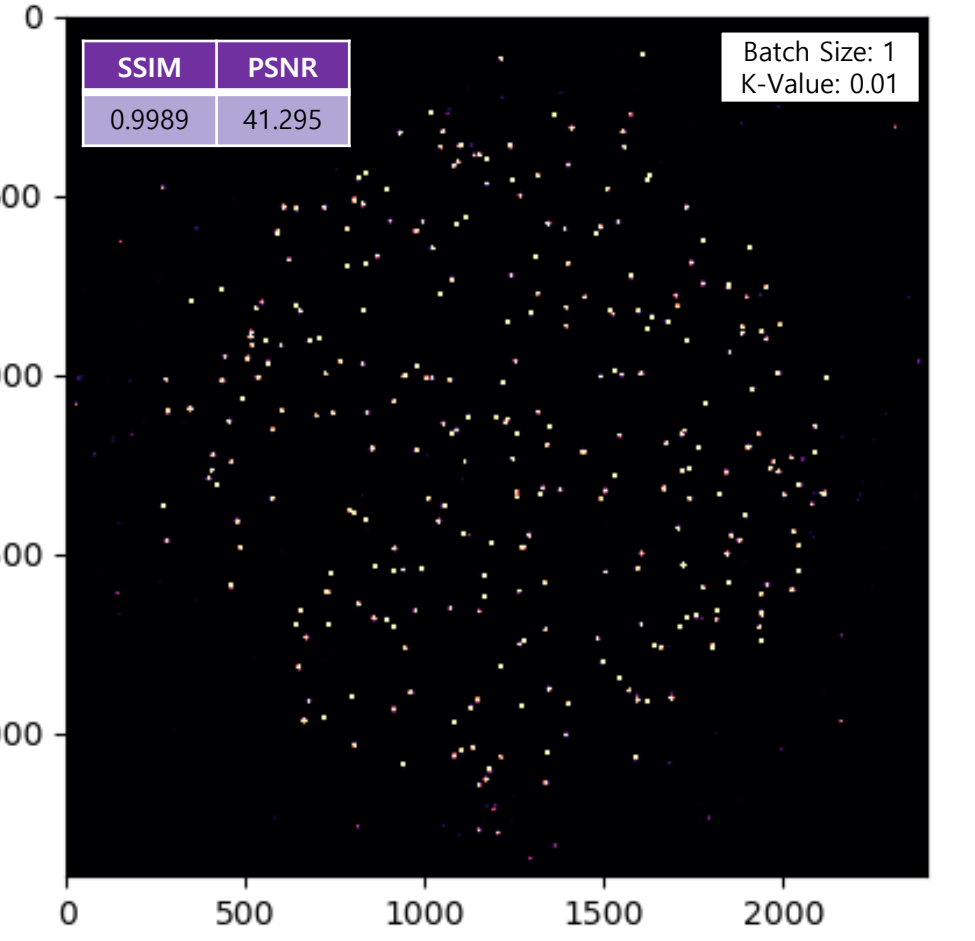**Initial PSFs**

Learned PSFs (B1 and K0.01)
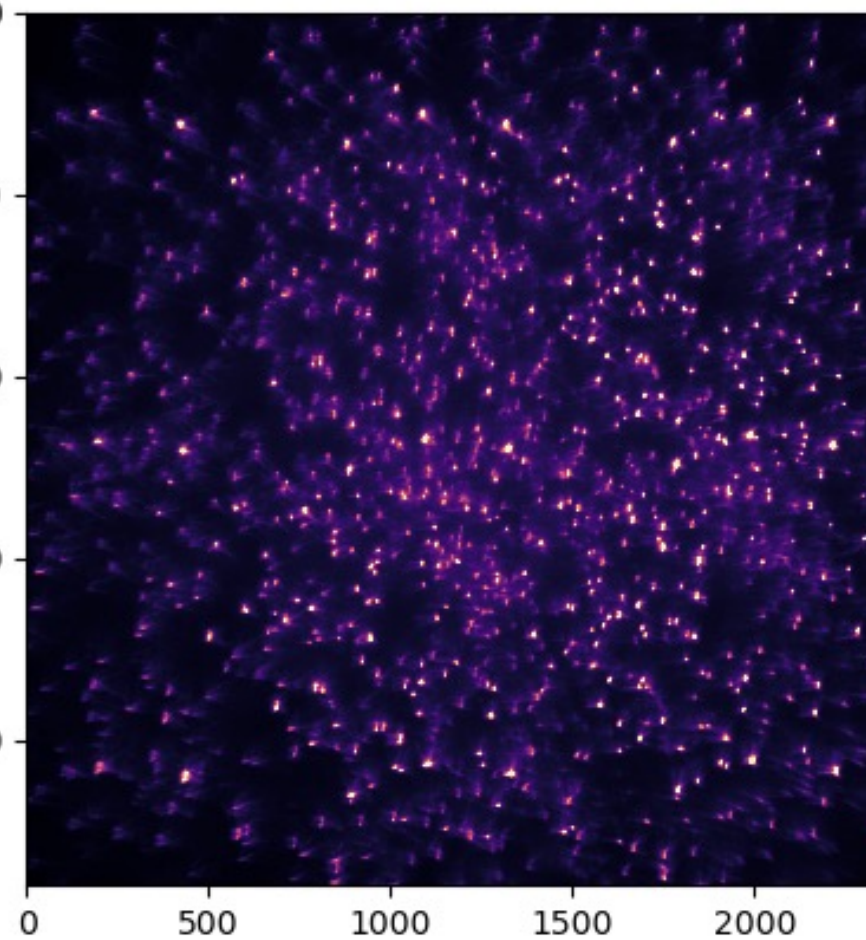

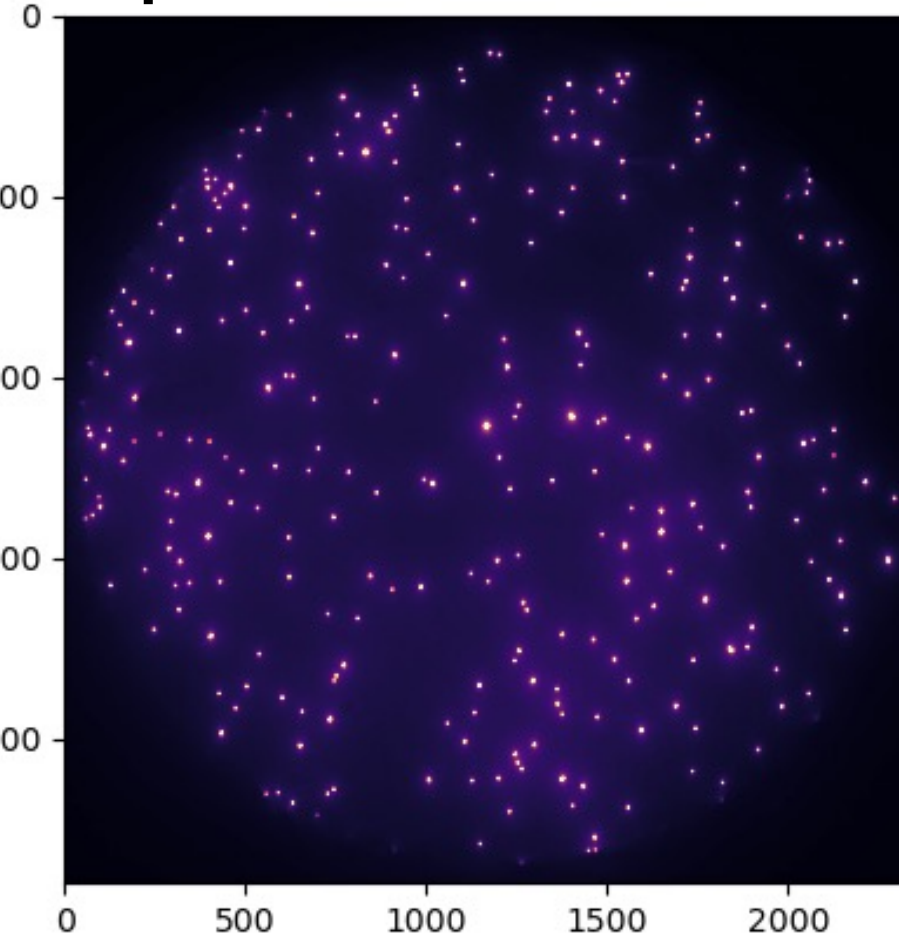**Simulated Beads Measurement**

Simulated Beads Ground Truth
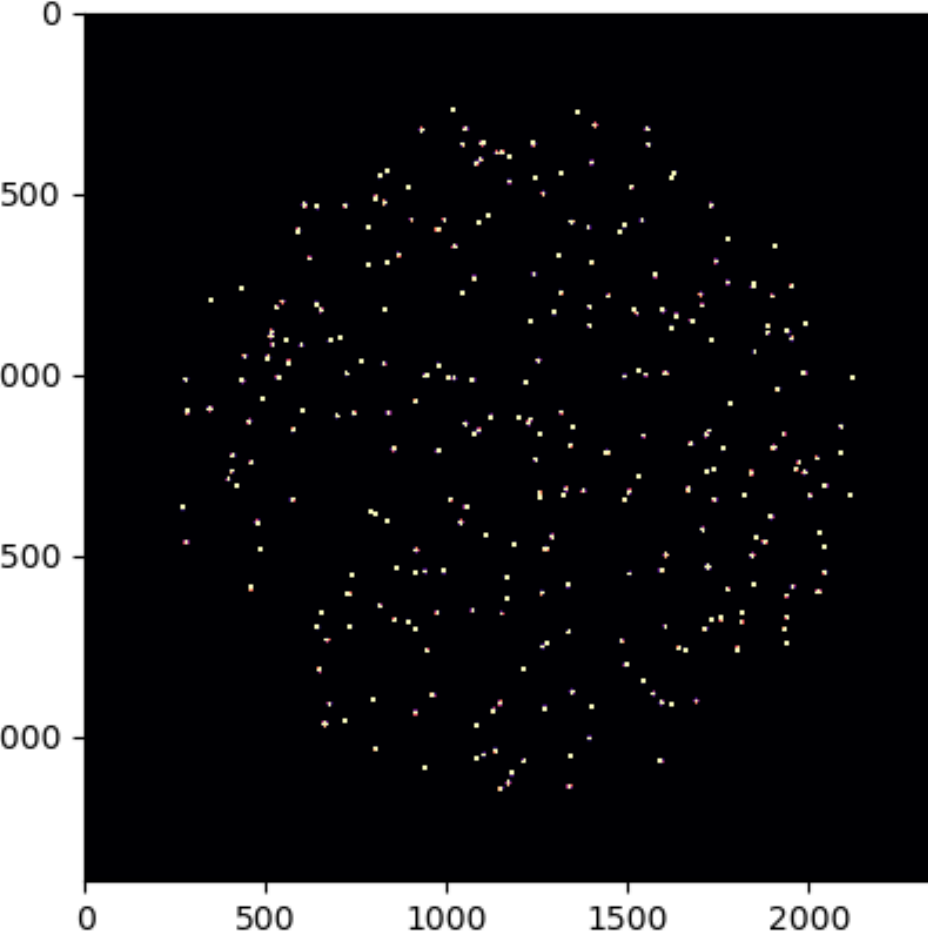
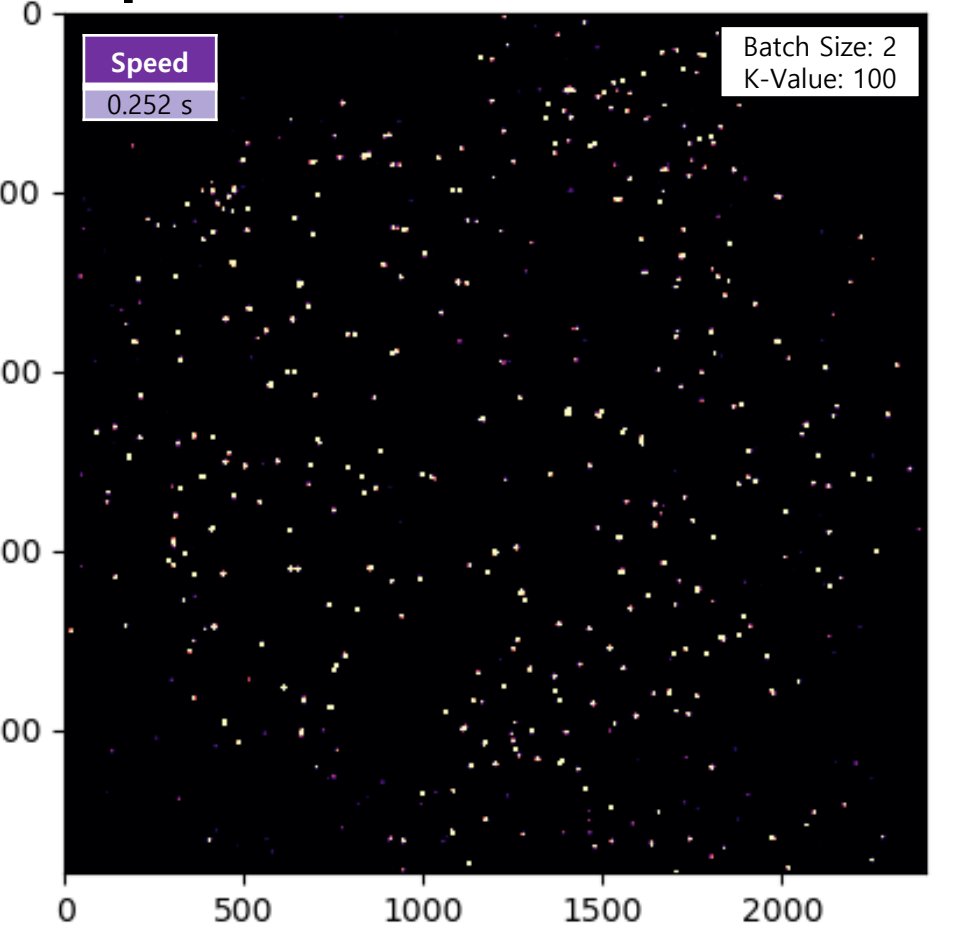**Simulated Beads Reconstruction**
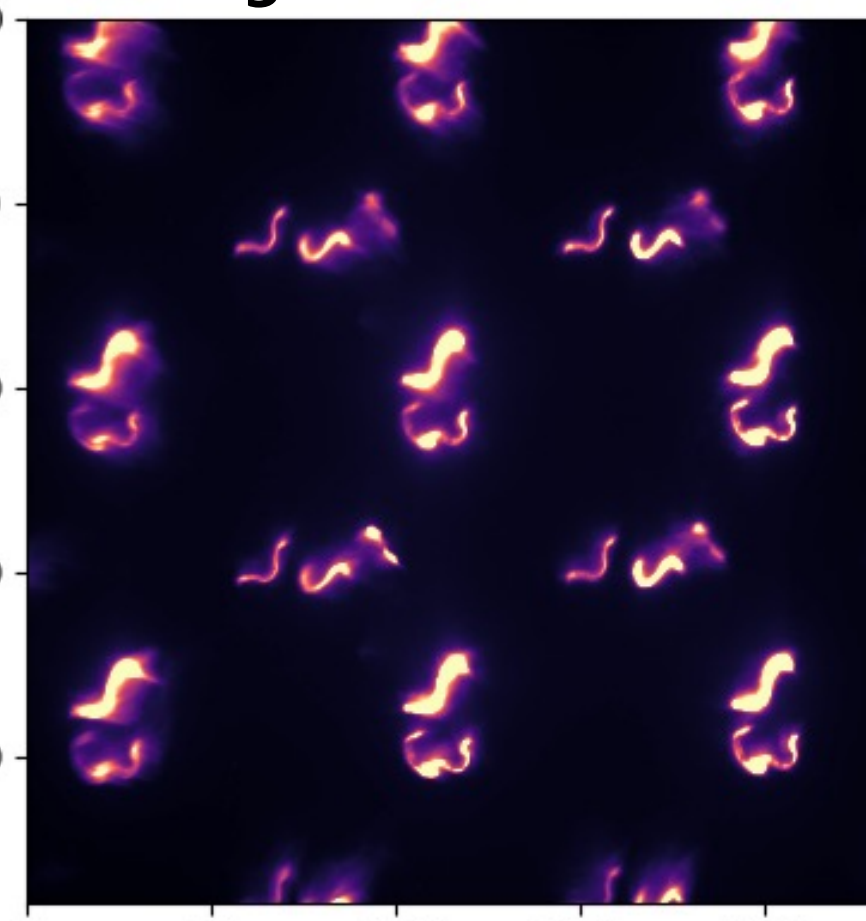

5µm Beads Measurement
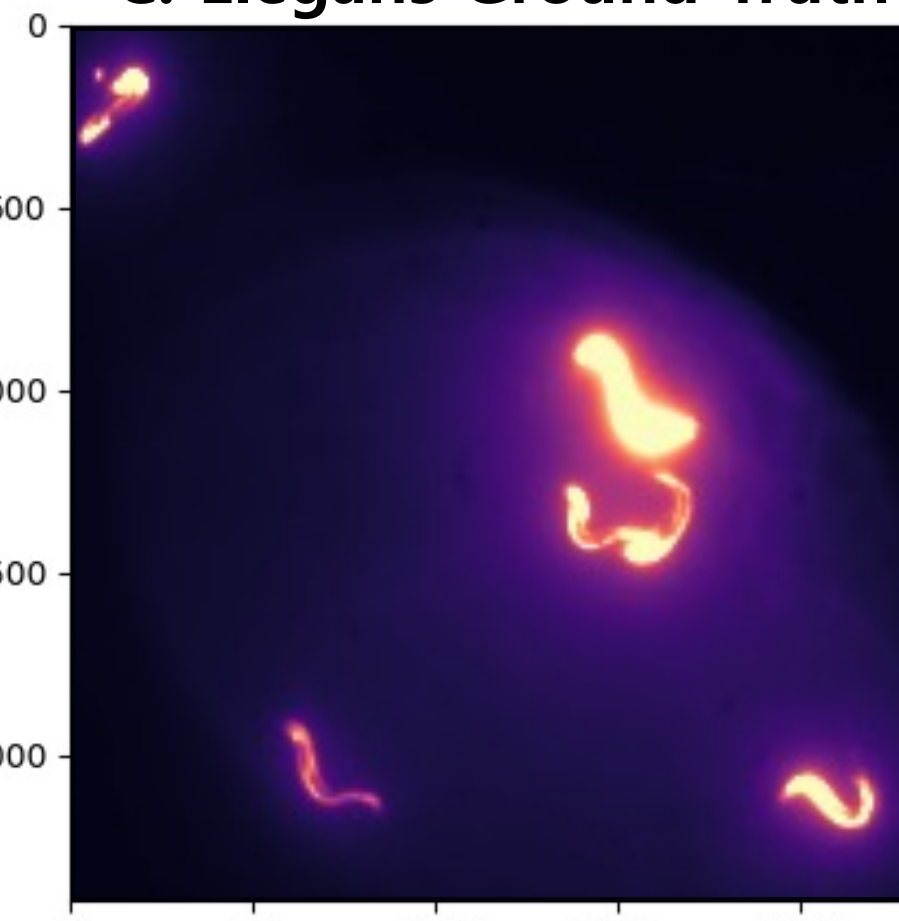
5µm Beads Ground Truth

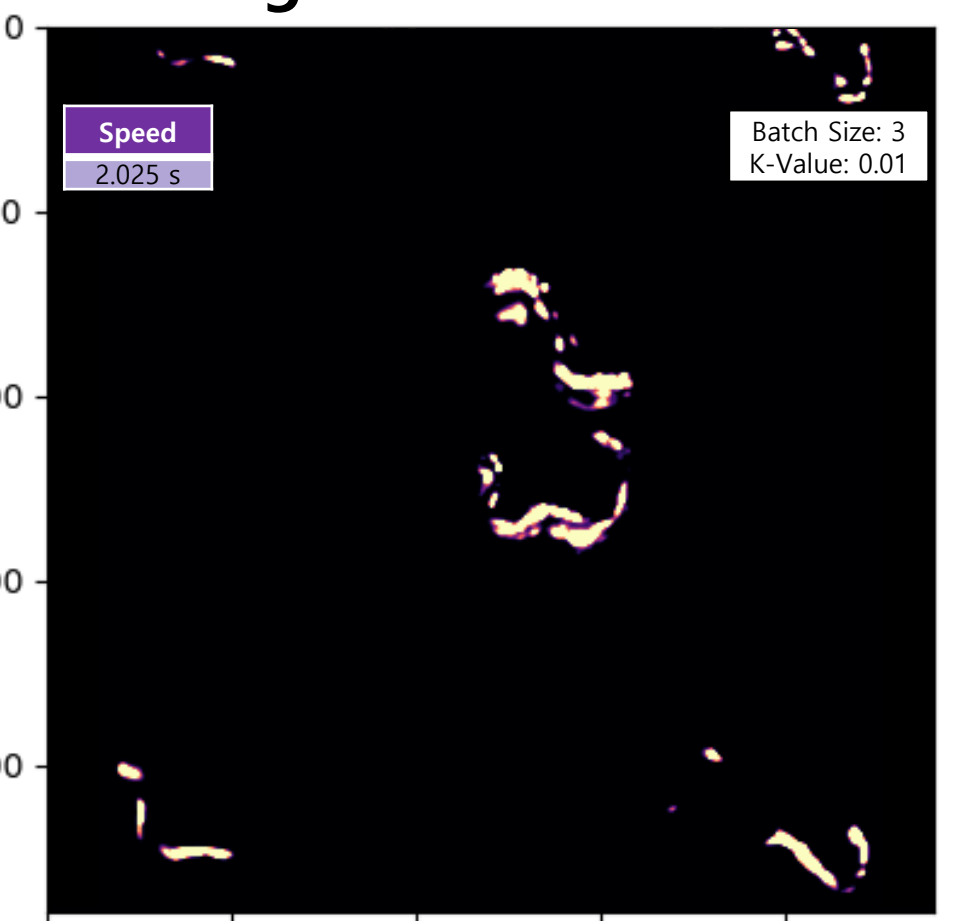**5µm Beads Reconstruction**

C. Elegans Measurement

C. Elegans Ground Truth

C. Elegans Reconstruction

Conclusion

- **Hyperparameter Tuning shows:**
  - The reconstruction result relies on the initialization and batch size
  - Different samples with **distinct features** require **different initialization conditions**
- Mostly generalizes to experimental data (experimental testing beads and C. Elegans measurements)
  - Able to **capture general trends**, but **not reconstruct continuous points**
  - Initial results show MultiWienerNet's potential for practical application on real biological samples
- **Future work:**
  - Test different model structures & parameters (Ex. Change CNN and # of PSFs)
  - Test model on a variety of biological samples to determine practical applications

References

1. Sroubek F.; Kamenicky J.; Lu Y. M.; *Decomposition of Space-Variant Blur in Image Deconvolution*. IEEE Signal Processing Letters **2016**, 23 (3), 346-350.
2. Xue, Y.; Yang, Q.; Hu, G.; Guo, K.; Tian, L.; *Deep Learning-Augmented Computational Miniature Mesoscope*. Optica **2022**.
3. Yanny, K.; Monakhova, K.; Shuai, R. W.; Waller, L. *Deep Learning for Fast Spatially Varying Deconvolution*. Optica **2022**, 9 (1), 96

Acknowledgements