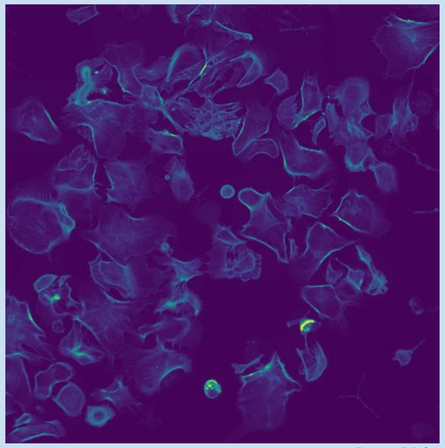
Deep Learning-based Segmentation and Deblurring of Microscopic Cell Images

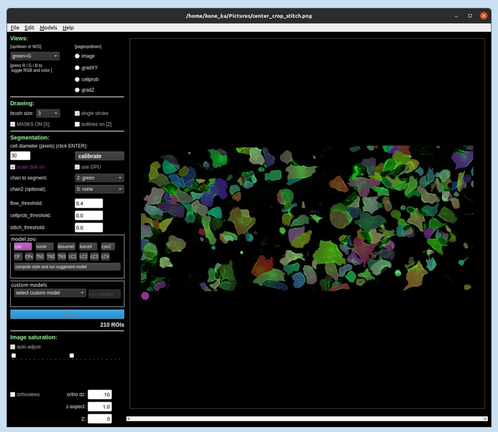
STED Microscope Image



From ME-BIO

Cellpose [1]

- Generalist algorithm for **cellular segmentation** (www.cellpose.org)
- **U-Net** architecture
- **Human-in-the-loop** training possible via GUI



Deblurring

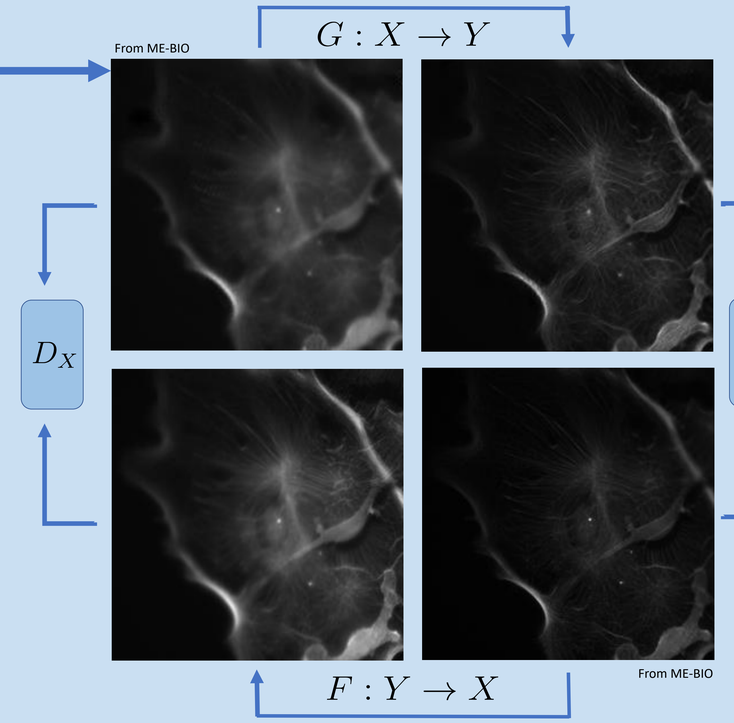
Motivation

- **Microscopic images** from fluorescence or STED microscopy can contain **blurry parts** due to diffraction barrier, astigmatism, defects and human error
- Tracing of **intracellular filamentous structures** not possible/difficult
- Use a **CycleGAN** to translate blurry images into sharp images

Method

- Using https://github.com/junyanz/pytorch-CycleGAN-and-pix2pix [2] implementation
- Results based on **103 paired images** with blurry (domain X) and sharp (domain Y) version
- Based on domain X/Y, G/F generates fake images in domain Y/X
- D_X/D_Y discriminates if image is from domain X/Y
- Adversarial loss: $\mathbb{E}_{y \sim p_{\text{data}}(y)}[\log D_Y(y)] + \mathbb{E}_{x \sim p_{\text{data}}(x)}[\log(1 - D_Y(G(x)))]$
- Cycle consistency loss: $\mathbb{E}_{x \sim p_{\text{data}}(x)}[\|F(G(x)) - x\|_1] + \mathbb{E}_{y \sim p_{\text{data}}(y)}[\|G(F(y)) - y\|_1]$

Results



Cell Filament Analysis

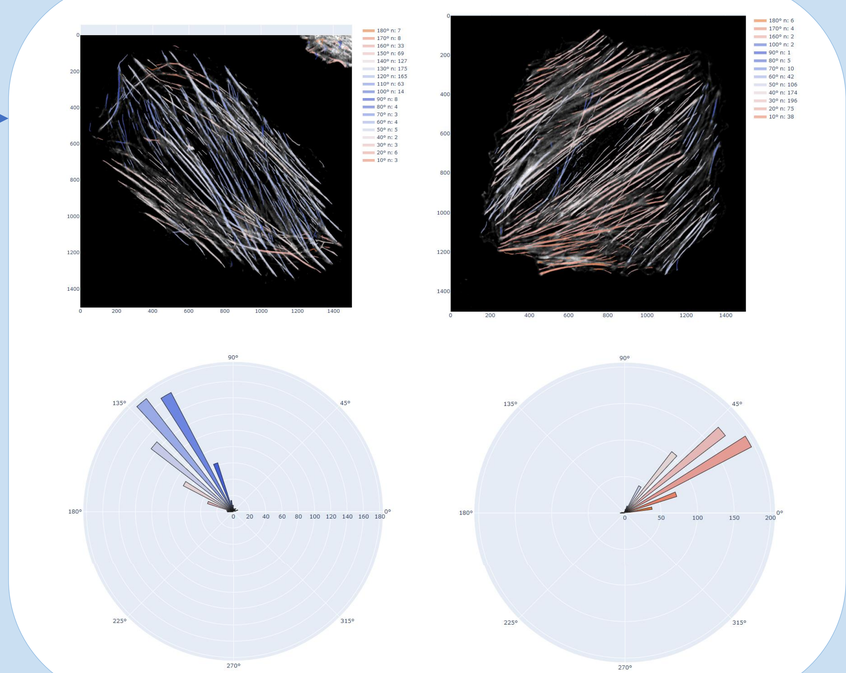
Motivation

- **Manual analysis** of the differences between actin fibers from cells grown under microgravity compared to cells grown under standard conditions entails an **extremely high workload**
- An **automated analysis** would benefit research areas that work with such filamentous cell data

Method

- **Ridge Detection** via first Eigen value of the **Hessian Matrix** of the cell image
- **Filtering** out **small filament** candidates
- Calculating the **orientation** of individual filaments via **PCA**

Results



[1] Stringer, C., Wang, T., Michaelos, M. et al. Cellpose: a generalist algorithm for cellular segmentation. Nat Methods 18, 100–106 (2021). https://doi.org/10.1038/s41592-020-01018-x

[2] Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks. Jun-Yan Zhu*, Taesung Park*, Phillip Isola, Alexei A. Efros. In ICCV 2017. (* equal contributions)

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in cooperation with DLR ME-BIO (Gravitational Biology)

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