Data-intelligence for microscopy data

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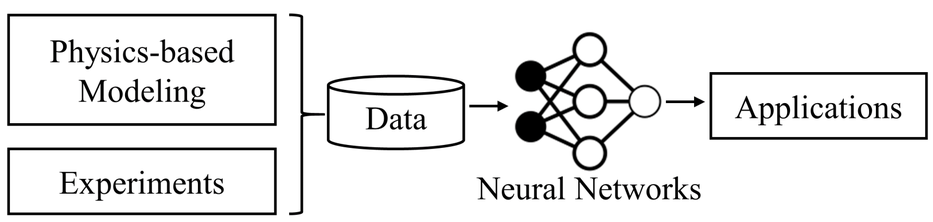
1. Introduction

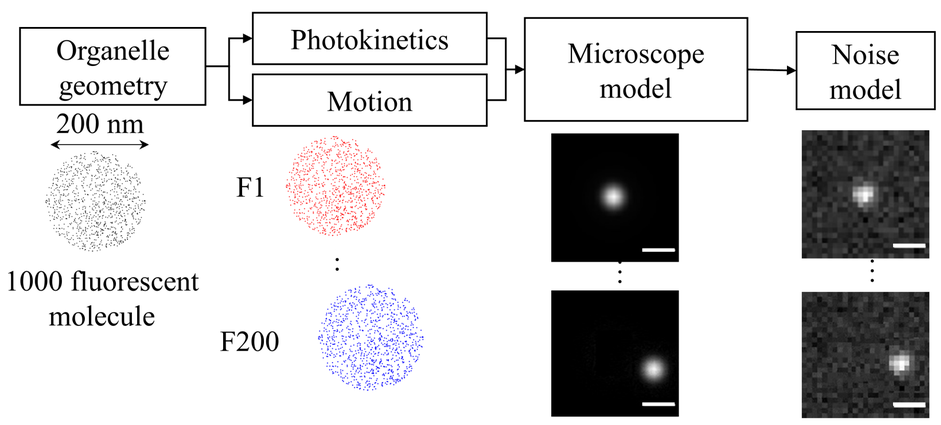
The application of artificial intelligence (AI) is relatively new in microscopy. Advances in microscopes and AI are greatly expanding the possibilities for microscopy image analysis and interpretation, which is of special importance to researchers in biology. It has been noted earlier that the state-of-the-art AI methods generally perform poorly due to (a) the complex nature of microscopy images, (b) large amount of noise in microscopy images in comparison to other conventional image datasets, and (c) the lack of suitably annotated data. Here, we propose data intelligence solutions for some problems in microscopy data analysis by utilizing physics-based simulation and designing suitable AI architectures.

2. Methodology

Data-intelligence can be achieved by combining (a) collection of suitable experimental data, (b) simulation and generation of large volume data similar to the experimental data, and (c) design of suitable intelligent neural networks for the task.

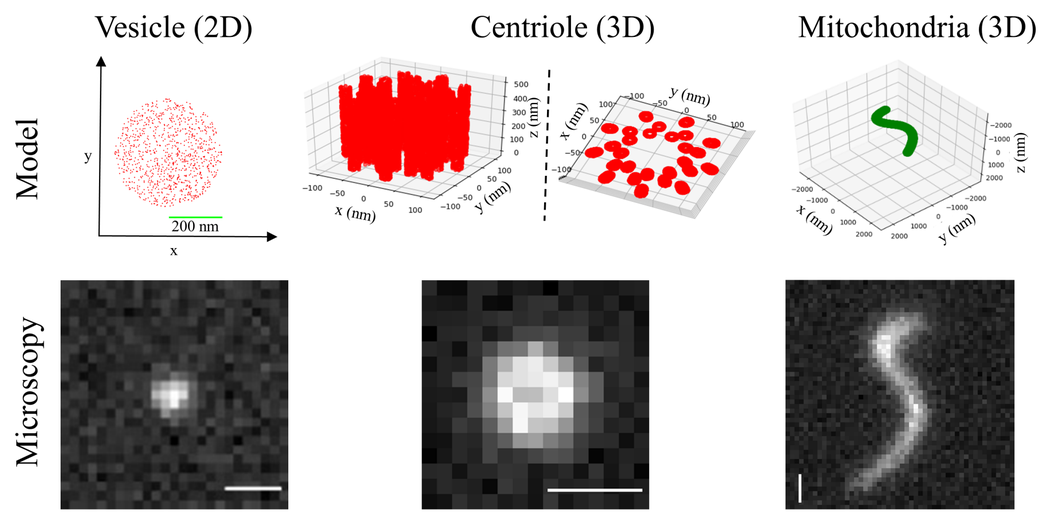


The simulation module consists of (a) geometry of organelle, (b) different possible movement patterns, (c) photokinetics, (d) microscopy parameters, and (e) noise.



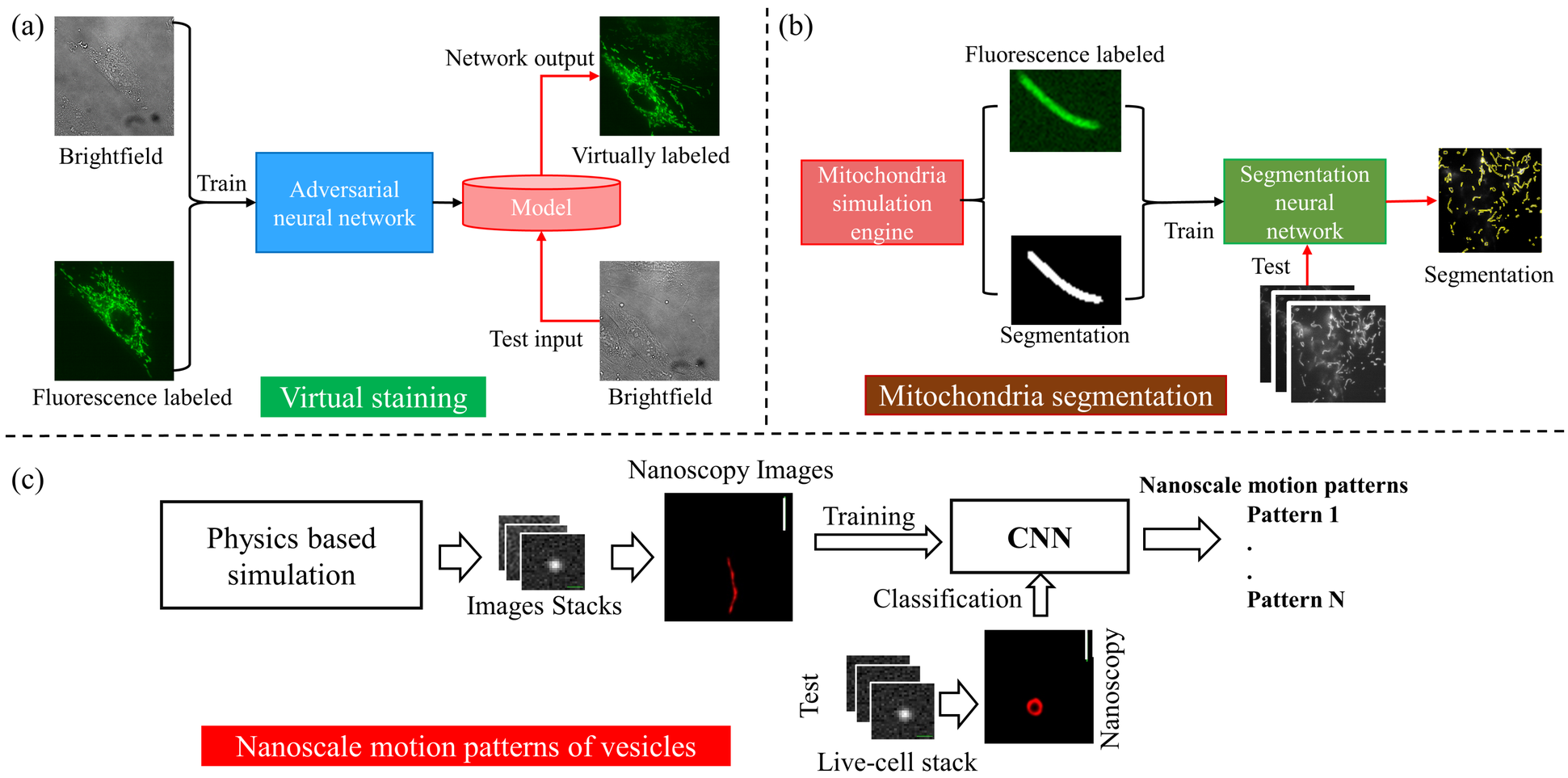
3. Simulation examples

We have simulated (a) vesicles in 2D (diameters 30 nm to 1 um) and having different motions such as circular, random walk, flow, etc. (b) mitochondria having length 100 nm to 4 um in 3D, and (c) centriole in 3D having spinning motion. The scale bars in the images below are 500 nm.



4. Applications

We are working on three applications of data-intelligence methods: (a) digital staining, where brightfield and fluorescence labeled images are used together to train a neural network such that the trained model can produce artificially labeled images from the brightfield input image. (b) mitochondria segmentation, where mitochondria in fluorescence microscopy images can be segmented accurately by neural network trained using a dataset of simulated images. (c) vesicle motion classification, where a simulated image stack is used to generate nanoscopy images using the Multiple Signal Classification Algorithm (MUSICAL) [1] and dataset of such images is used to train a neural network for classifying different nanoscale movement patterns of vesicles.



5.References

[1] K. Agarwal and R. Macháň. Multiple signal classification algorithm for super-resolution fluorescence microscopy. *Nature communications*, 7(1):1–9, 2016.

Acknowledgement

Special thanks to Ida Sundvor Opstad, Åsa Birna Birgisdottir, and Sebastián Andrés Acuña Maldonado.