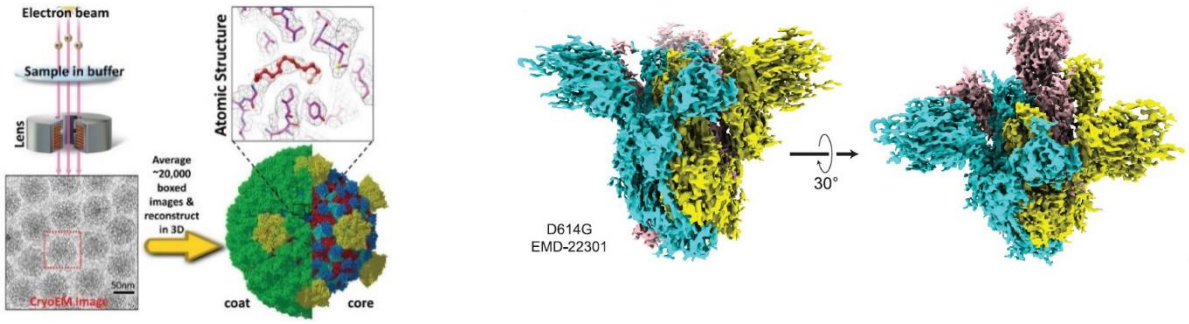
Student Project:

Increasing the Throughput of Electron Microscopy with AI-powered Image Analysis

Introduction

Thanks to a revolution of 3D resolution in the field of structural biology, the past decade has been one of the most productive eras in the history of drug discovery. Single Particle Analysis (SPA) using Transmission Electron Microscopy (TEM) is the leading technology in this field. A typical SPA workflow consists of illuminating the sample at many target locations using an electron beam and deducing the 3D structure of the imaged protein from thousands of such two-dimensional projections. This technology has been awarded the Nobel prize in 2017. It keeps expanding the frontier of human understanding to fight disease.



Left: Typical SPA workflow. Courtesy of Prof. Z. Zhou.

*Right: D614G SARS-CoV-2 Spike Protein envelope from the three-dimensional SPA reconstruction, which helps understand the virus causing **COVID-19**. Courtesy of Prof. J. Luban.*

Problem Statement

In TEM, to image the sample and derive useful data, one first must direct the electron beam to pass through the area of interest. However, due to limited targeting accuracy, operators are forced to carry out a large number of mechanical position corrections. This adds unnecessary acquisition time overhead to the SPA workflow and reduces overall throughput.

To remove this bottleneck and assist a faster drug discovery, this project aims to design and implement an image-based feedback algorithm for the acquisition workflow. This will be integrated as a prototype in the Thermo Fisher Scientific microscope product, with the goal to on-the-fly adjust the beam positioning using information derived from already acquired data.

Student project

The project includes the following activities for the student:

- Learn the general concept of TEM. Study literature on deep-learning-based image segmentation techniques and identify a network architecture suitable for the problem at hand.

- Implement and train a neural network to segment/recognize distinct features on SPA images.
- Assisted by the project lead scientists in Thermo Fisher Scientific, implement the beam control feedback to improve targeting accuracy.
- Compare the performance of the segmentation solutions, e.g., U-net or generative models, with classical baseline algorithms.
- Evaluate the performance in tilted SPA acquisition, which is widely used in development studies for vaccines, e.g. against COVID-19.

Student profile

- Affinity with deep learning and image processing
- Experience with Python programming for deep learning
- Creative, enthusiastic, communicative

What you will learn

- Work with a team of experts with diverse backgrounds in one of the world-leading scientific companies.
- Get hands-on experience with high-end electron microscopes.
- Interact with an industry-leading microscopy product and enable a new workflow.

About Thermo Fisher Scientific

Thermo Fisher Scientific is the world leader in serving science, with revenues of more than $20 billion and approximately 70,000 employees globally. Our mission is to enable our customers to make the world healthier, cleaner and safer. We help our customers accelerate life sciences research, solve complex analytical challenges, improve patient diagnostics, deliver medicines to market and increase laboratory productivity. Through our premier brands – Thermo Scientific, Applied Biosystems, Invitrogen, Fisher Scientific and Unity Lab Services – we offer an unmatched combination of innovative technologies, purchasing convenience and comprehensive services.

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