Usage Report for Fiscal Year 2024

Project Title:

3D reconstruction of volumetric electron microscope images of the marmoset brain

Name:
○Nilton Liuji Kamiji (1)
Laboratory at RIKEN:
(1) Center for Brain Science, Research Resources Division, Support Unit for Electron Microscopy Techniques

1. Background and purpose of the project, relationship of the project with other projects

The prefrontal cortex (PFC) is dramatically expanded in primates and is considered to play a crucial role in higher cognitive functions. A recent study by Watakabe and colleagues (Watakabe et al., Neuron. 2023; 111(14):2258-2273) in RIKEN CBS suggested the existence of columnar structures in PFC and their reciprocal connections. However, their analysis was mesoscale, leaving the synaptic-level structure unexplored. In order to elucidate the cortical microcircuitry of the marmoset PFC at the synapse level, we obtained large volume electron microscope images from over 1,000 serial ultrathin sections. For each section we imaged an area of about 1.7 mm x 1.1 mm, which was composed of over 15,000 image tiles (6,000 x 6,000 pixels each tile). This resulted in over 400 TB of image data. The aim of this project was to generate a 3D reconstruction of the marmoset brain from the obtained electron microscope image.

2. Specific usage status of the system and calculation method

We did not use the system this time, but the method is briefly introduced below. To generate a 3D reconstruction from large volume electron microscope images, we used the open source tool feabas (https://github.com/YuelongWu/feabas) developed at Jeff Lichtman Lab (Harvard University). This tool uses finite element for image registration in 2D (stitching) and 3D (alignment). This tool is written in python, and can use distributed computing to process different sections independently for stitching, as well as for finding the matching points between image pairs for alignment process.

3. Result

We first started by processing part of the data composed of 729 tiles (27 x 27 tiles; roughly about 300 um x 300 um) for each section. For this initial process we used our local workstation. Several trials were necessary until obtaining a good 3D reconstruction.

4. Conclusion

We were able to generate a 3D reconstruction of a volume of about 300 um x 300 um x 50 um, which is being manually segmented to elucidate the cortical microcircuitry of the marmoset PFC.

5. Schedule and prospect for the future

We aim at fine tune the procedure, and to develop a pipeline for AI assisted automated dense segmentation of neuronal elements.

6. If no job was executed, specify the reason.

No job was executed as we processed the data on our local workstation with a smaller dataset for proof of concept. We are fine tuning the process so that we can reliably run on a supercomputer cluster.