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Project Number
38215

Project Title

New Visualization and Analysis Approaches Using 3D Electron Microscopy and 3D Printing Technologies

Abstract

Objectives/Goals

Serial block face scanning electron microscopy (SBEM) is a highly advanced technology to create 3D EM image stacks from 2D EM. Challenges of 3D EM have now shifted from how to capture the difficult-to-measure to what to do with all this big data. While the ability to acquire big 3D EM data is progressing rapidly, more advanced analysis tools and visualization methods are needed to assist in measuring precise 3D morphologies of micro-organelles.

Methods/Materials

In this project, manual, semi-automated, and auto-segmented 3D reconstruction methods were tested in the analysis of variable contrast SBEM datasets. Semi-automatic segmentation was performed with the #Interpolator plugin# from IMOD. Automatic segmentation was performed using modified tools in IMOD and ImageJ. Lastly, 3D printing is performed with programs Autodesk Meshmixer and Ultimaker Cura.

Results

IMOD and ImageJ combined automatic segmentation remarkably reduced annotation time and addressed the alteration and degeneration of the axon in the large brain cancer 3D EM dataset. Revealing the structure of the retinal neuron microcircuit can be accelerated using the alternative semi-automatic segmentation tool. Due to the limitations of printer technology, the delicate morphologies of retinal neurons pose the main technological challenge to constructing these 3D printouts. Reconstructed 3D retinal neuron model files were exported to OBJ or STL 3D model files and successfully produced the retinal microcircuit 3D printing model.

Conclusions/Discussion

Automatic segmentation is a strong tool to diagnose brain cancer illnesses in 3D EM datasets, which are relatively high contrast datasets. This technique should be extended to segment myelinated axon boundaries in brain images, where the axons do not follow the same direction and the staining is not limited to myelin sheaths. The IMOD Interpolator segmentation in 3D EM data is another advanced tool to accelerate the reconstruction of low contrast datasets. Types of retinal neurons and their synaptic interaction are able to be addressed in less time. Thus, these tools fill a critical need by allowing for the quantitative analysis of volumetric EM datasets at the nanoscale. The combination of the optimized annotation technique with 3D EM datasets and 3D printing can obtain high-resolution morphological data for microcircuits.

Summary Statement

Three segmentation tools were tested in SBEM datasets to reveal the advantages and limitations of software programs, and 3D EM and 3D printing visualization were combined to display these synapse-level models and their connectivity.

Help Received

Mrs. Gillum, Drs. Guy Perkins, Keunyoung Kim and Scott Mcavoy supervised me and helped me to analyze the datasets. UCSD provided equipments.