The Telescience Portal for Advanced Tomography Applications

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Abstract

Electron tomography is a powerful tool for deriving 3D structural information about biological systems within the spatial scale spanning 1 nm^3 and 10 μm^3. With this technique, it is possible to derive detailed models of subcellular components such as organelles and synaptic complexes and to resolve the 3D distribution of their protein constituents in situ. While there continues to be progress towards the integration of high performance computing technologies with traditional electron tomography processes, there is a significant need for more transparent integration with applications and to minimize the administrative overhead and complexity (resource administration, authentication, scheduling, data delivery) passed on to the non-computer scientist end-user. Here we present the "Telescience Portal" (https://gridport.npaci.edu/Telescience) as an example of a fully integrated, web-based solution for performing end-to-end electron tomography. More than just a collection of individual applications, the Portal provides a transparent workflow, where simple intuitive interfaces for grid-enabled parallel computation, resource scheduling, remote instrumentation, advanced image processing and visualization, access to distributed/federated databases, and network enabled data management and archival are tightly coupled within a secure environment which promotes increased collaboration between researchers. This tightly integrated Telescience system is a test-bed application for using grid resources to accelerate the throughput of data acquisition and processing, increase access to scarce and/or expensive instrumentation, and improve the accuracy of derived data products.

The application of electron tomography to cell biology has led to important insights into the 3D fine structure of subcellular processes and organelles. Tomography has been particularly useful for studying relatively large, multi-component structures such as the Golgi apparatus, mitochondria and synaptic complexes. When combined with very powerful high voltage electron microscopes, tomography has also provided high-resolution quantitative views of extended structures such as neuronal dendrites in very thick sections (4 μm) at electron microscopic resolution. The utility of tomography is twofold: first, it provides 3D examination of subcellular structure without the need for serial section analysis; second, because the computed slices through the tomographic volumes can be much thinner than is possible to produce by physical sectioning, it reveals structural detail in the range of 5-30 nm that tends to be obscured in conventional thin sections. Tomographic analysis has forced re-assessment of long-standing views of organelles such as mitochondria and the Golgi apparatus and as the technique advances, additional insights are likely forthcoming.[1]

Electron tomography is an expensive technique, both in terms of the instruments used and the computational resources required. The three major high voltage electron microscope resources in the United States, San Diego, Boulder and Albany, are all actively engaged in

tomographic research and offer this important technology to the scientific community at large. However, travel can be a major impediment for many researchers due to the expense and time away from the laboratory. At the National Center for Microscopy and Imaging Research (NCMIR), along with our research program on electron tomography, we are working to increase access to tomographic resources through the Internet.

We have demonstrated previously that it is possible to control our JEOL 4000EX intermediate voltage electron microscope (IVEM) through a web-based system (Figure 1.) written in Java that provides interactive and collaborative video guided remote control and data acquisition from a web browser.[2] This system is routinely used by remote users to select areas appropriate for tomography.[3] Telemicroscopy is currently being incorporated into a more ambitious effort, entitled Telescience, which is creating a set of tools to allow researchers to go seamlessly through the end-to-end process to create tomographic images using the IVEM, from acquisition to analysis. Central to this effort will be the creation of a Telescience web portal.

The Telescience Portal represents a conglomeration of tools necessary for a biologist to perform a complete tomographic reconstruction from any Internet capable location. More than just a collection of individual applications, the Portal provides transparent workflow and data management, simple intuitive interfaces to grid enabled computation and data distribution, remote instrumentation via Telemicroscopy, as well as utilities that allow for increased collaboration between researchers. Telescience tools are evolving to make data management and computationally related tasks, transparent to the user.

Collaboration tools, originally designed for the Telemicroscopy system, are being generalized for the Telescience Portal. The "Image Whiteboard", for example, allows several users to jointly annotate and share images. Images for the whiteboard can be acquired by the microscope or downloaded from The Storage Resource Broker. Additional discussion regarding shared data is facilitated through the use of an interactive "chat" panel. Using the data grid services of The Storage Resource Broker, we have developed tools to allow the direct sharing of data via the Telescience Portal. For example, researchers can tag data for "sharing" by single or group collaborations without the explicit need to "copy" or "transfer" data between physical locations.

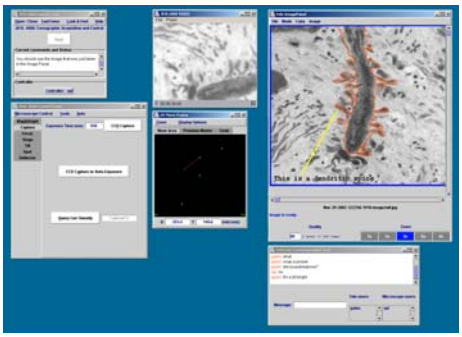

Figure 1: Web-based Telemicroscopy Interface (VidCon2) featuring the shared "whiteboard" collaboration tool.

References

[1] Perkins, G. and Frey, T. (2000) Micron, 31, 97-111.
[2] Hadida-Hassan, M., et al. (1999) J. Struct. Biol. 125, 235-245.
[3] Lenzi, D., et al. (1999) J. Neurosci. 19, 119-132.
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