Abstract: Tractography tool for processing ultra-high-resolution diffusion MRI data of terabytes size, Y1

Mapping the human connectome and exploring its characteristics is one of the most extensive endeavors in the neuroscience field. To this end, diffusion MRI fiber tracking has been used to map axonal trajectories of the white matter pathways as the structural connectome for the human and animal brains. Recently the diffusion MRI community has adopted "multi-shell acquisition" to achieve higher accuracy in tractography. The acquisition typically acquires hundreds or thousands of diffusion sampling at multiple b-values. This is in addition to a trend that major research institutes have installed more high-field MRI scanners to acquire ultra-high-resolution scans at 50 microns or even high resolutions. The resulting size of the diffusion MRI data can grow by 1000 times than conventional acquisition, creating a gigantic size of data at terabytes. The fiber tracking task thus will require terabytes size system memory and a tremendous amount of computation time.

Here we propose to remake a tractography tool "DSI Studio" to handle this challenging task on a supercomputer. The PI (PI: Fang-Cheng Yeh) has devoted 10-years of time developing DSI Studio using industrial standard C++ language that has the potential to process large sizes of data at high efficiency. We will upgrade the entire analysis pipeline by a list of coding strategies to enable efficient computation of large-sized data and integrate parallel processing packages that enable DSI Studio to maximize the usage of multi-core CPU computation, GPU computation, and ultimately, multi-node computation across multiple nodes on a supercomputer. Furthermore, we will implement a data concatenation routine that allows research groups to scan brain tissue in multiple blocks and merge image data afterward. These aims together will pave ways for processing ultra-high-resolution diffusion MRI scans, ultimately realizing the goal to map human brain connection at unprecedented details.