

## High Performance Computing for Human Brain Imaging

The objective of this international workshop is to create an international task force targeting the computer technologies required for the huge mass of data that will be generated by the Asia-Pacific brain imaging initiative "SYNAPSE" (Synchrotron for Neuroscience: Asia-Pacific Strategic Enterprise). With an international collaboration strategy and a clear roadmap on high performance computing (HPC) for brain imaging emerging from this meeting, the task force will master this computing enterprise, with a strong and very positive impact on its scientific and technological image, specifically as far as huge-data management is concerned.

This workshop will be opened with presentations of the imaging methods and the data handling issues encountered by the experimental teams in SYNAPSE. Presentations from the HPC partner facilities and experts with previous experience working on the brain imaging data will facilitate the following discussions .

## Background

The exploration of animal and human brains presents challenges and offer an excellent opportunity for high performance computation. In particular, the SYNAPSE project will generate an unprecedented amount of data, exceeding 1 exabyte from one human brain and thousands of mouse brains, and the corresponding 3-dimensional (3D) microscopic maps of neural networks. This mass of data challenges the current HPC technologies in computation, storage and database management.

Similar endeavors in brain science, such as the European Human Brain Project (HBP) and the US BRAIN Initiative, will generate comparable amounts of data, with multibillion USD investments. However, the features of SYNAPSE are unique. In particular, it generates data by experimental measurements on real brains, whereas HBP is mostly based on computer simulation. The price to pay is an orders-of-magnitude increase in the complexity of the storage, security and processing of the mass of data. This challenge is further

enhanced by another recent development: SYNAPSE involves at present six Asia-Pacific facilities and the number is expected to grow with the inauguration of the project.

Data management will also profit from the SYNAPSE international umbrella: currently, NSCC commits to provide sufficient computing power and network speed to serve as a data hub of the processed data, but a multi-national facility enterprise is still required for the implementation of overall HPC infrastructure for SYNAPSE. The six synchrotrons and the associated HPC facilities of SYNAPSE will thus complement the NSCC network, contributing with their experience to the development and use of essential new huge-data technologies.

The workshop will launch this alliance, discussing all the facets and challenges related to full animal brain imaging. The participating institutions will share their capabilities and views on dealing with these topics as well as with hurdles that may hinder the execution.

International Workshop on

# High Performance Computing for Human Brain Imaging

January 16

National Supercomputing Centre

## Organizing committee

Chair – Chian-Ming LOW

Co Chair – Mark BREESE

Eng-Soon TOK

Alvin TEO

International Advisory Committee

## Workshop objectives

- (1) To launch an international task force targeting the development of the necessary HPC technologies to manage the data generated by the SYNAPSE initiative.
- (2) To establish a roadmap for future development within the international computational coalition for SYNAPSE.

The international partners of SYNAPSE from Asia-Pacific regions of Taiwan, Japan, Korea, China and Australia will gather in Singapore to discuss these issues and agree on a roadmap towards the solution of all present and future challenges. This is an essential task for SYNAPSE, but its impact will go well beyond its boundaries. In fact, other kinds of HPC applications to brain imaging - such as data storage and processing for magnetic resonance imaging (MRI) and super-resolution optical microscopy - will also benefit from the discussions and developments.

We specifically propose the following key subjects for the workshop:

1. Image processing - neural/deep learning, algorithms, pattern recognition, etc.
2. Data pipeline and throughput coordination
3. Database management
4. Data access and security

The SYNAPSE project will generate imaging data at a speed exceeding 200 GB/sec. This is made possible by the use of state-of-the-art x-ray tomography at multiple synchrotron facilities operating in a coordinated fashion. Beyond data taking, key factors of a successful platform are high-speed and reliable data transfer, large data storage and data compression, data safety and image reconstruction/analysis. The workshop will plan the formation of a high-performance large data storage and globally accessible repository of unique datasets for all SYNAPSE partners.

On the day before the HPC workshop, we will host a symposium on the synchrotron technologies that now capable of full human brain imaging with sub-cellular resolution. This will be concluded by the public announcement of the creation of SYNAPSE and by the signature of international agreements. A press conference will then present SYNAPSE as a concerted Asia-Pacific effort to map for the first time the human brain neural network.

In perspective, this concrete example will also facilitate broader research collaborations between different partner countries on cloud and grid computing, artificial Intelligence and machine learning, as well as on neuromorphic computing. These potential outcomes will be highly beneficial to basic and applied research.

## DAY 1

(15<sup>th</sup> January; Wednesday) – Shaw Foundation Alumni House Auditorium (NUS)

Inaugurating SYNAPSE

## DAY 2

Workshop for High Performance Computation for Brain Imaging 16<sup>th</sup> January; Thursday – NSCC (Charles Babbage room), Connexis South Building, 1 Fusionopolis Way

08:30 Arrival at Ground level of Fusionopolis Connexis South Building (Security Check Point)

08:50 Welcome speech by Chief Executive, NSCC (Tin-Wee TAN)

09:00 Planning and structuring the SYNAPSE computation (Ting Kuo LEE)

09:20 Data management capabilities in NSRRC/NCHC

09:35 Distributed Collaboration Infrastructure in ASGC(Taiwan)

09:50 Data management capabilities of RIKEN

10:05 Data management capabilities of DGIST (Korea)

10:20 Data management capabilities of NSCC (Singapore)

10:35 Coffee Break

11:10 Current methods – tomography reconstruction: current methods and possible developments (Yeukuang HWU)

11:25 Current methods - segmentation, skeletonization and visualization algorithms (Nan-Yow CHEN)

11:40 Machine learning in processing the brain imaging (Yu-Tai CHING)

11:55 Database management: FlyCircuit as an example (Chi-Tin SHIH)

12:10 Automation in CT data collection and processing at beamline 6C of the Pohang Light Source-II (Jae-Hong LIM)

12:25 Lunch Break

13:30 Breakout Sessions (six 10-minute presentations on each session)  
Image processing – Room 1  
Data pipeline and throughput – Room 2  
Data compression, storage and security – Room 3

15:30 Tea Break

15:50 Image processing session representative sharing

16:05 Data pipeline and throughput session representative sharing

16:20 Data compression, storage and security session representative sharing

16:35 Summary; Moving Forward; Next Meeting (Year/Country)

17:00 Meeting Closed