Human Brain Project:
Towards a European infrastructure for brain research

In March of this year, the Human Brain Project (HBP) [1] successfully released initial versions of its six Information and Communication Technology (ICT) Platforms to users outside the project [2]. The HBP Platforms are designed to help brain researchers advance faster and more efficiently, by sharing data and results, and exploiting advanced ICT capabilities. The release marked the end of the HBP's 2.5-year ramp-up phase and the start of the next phase, during which the HBP continues to build an open, community-driven infrastructure for brain research.

Fig. 1: A thin slice of human brain tissue, mounted for microscope imaging under polarized light, for the HBP Human Brain Atlas.

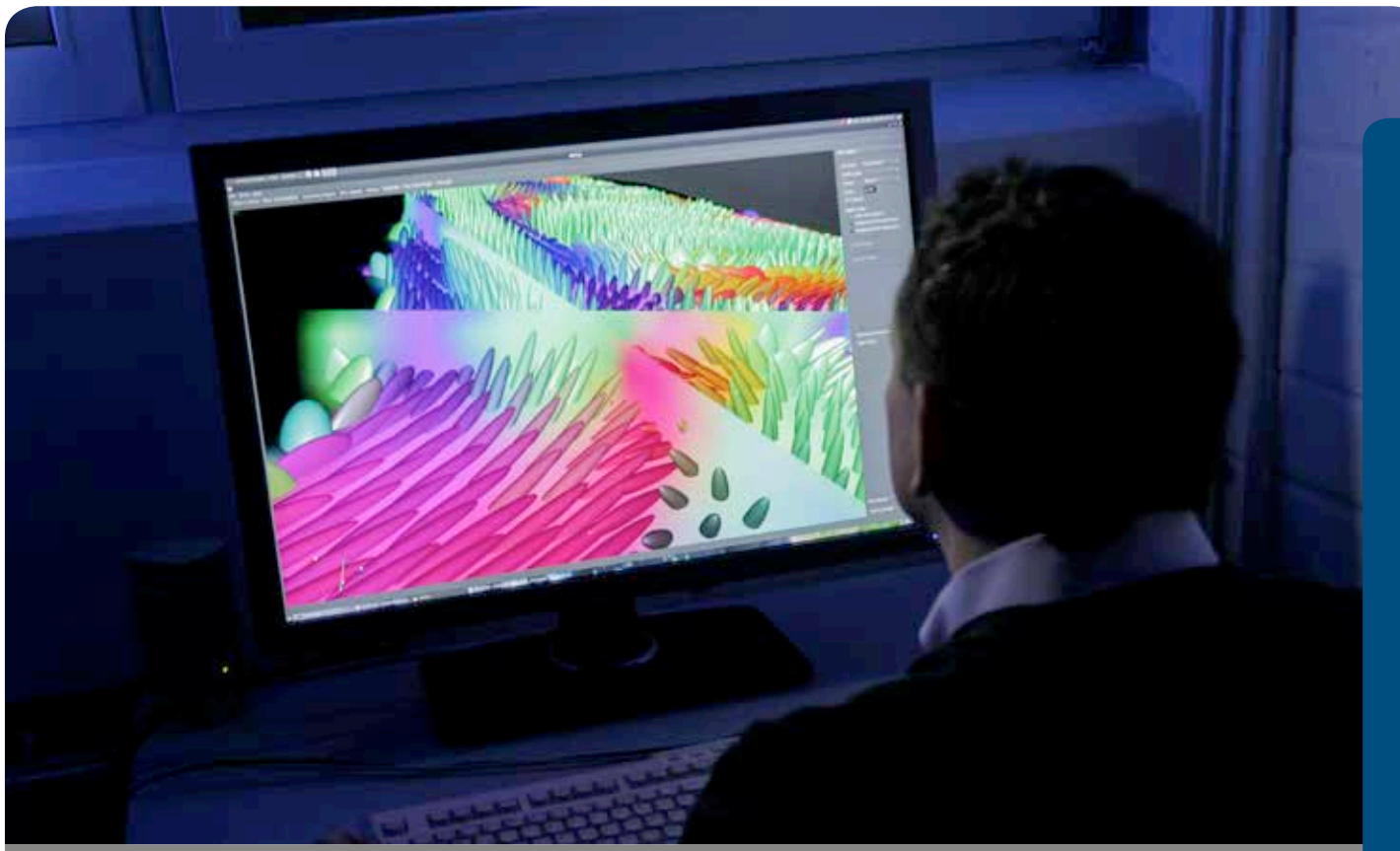

Fig. 2: HPAC Platform resources enable neuroscientists to reconstruct the orientations of nerve fiber tracts.

The HBP is a large-scale European project with over a hundred institutional partners from more than 20 countries in Europe and around the world. It is co-funded by the European Union (EU) within the EU's FET (Future and Emerging Technologies) Flagships Initiative [3]. Launched in October 2013 under the 7th Framework Programme, it is meanwhile governed by a Framework Partnership Agreement (FPA), which was signed in October 2015 [4]. The FPA describes the HBP's overall objectives, work plan and governance [5] for the remainder of its 10-year duration under Horizon2020 and beyond.

Infrastructure co-design

The major goal of the HBP is the creation of a user-centric Research Infrastructure (RI) for neuroscience and brain-inspired research areas such as neuromorphic computing. This goal has become the main focus of the HBP following recommendations from reviewers [6] and a mediation addressing criticism of the project from parts of the neuroscience community [7].

The HBP RI will emerge from the HBP's six ICT Platforms, dedicated respectively to Neuroinformatics, Brain Simulation, High Performance

Fig. 3: The two pilot systems, developed by Cray (left) and IBM-NVIDIA (right), are designed to meet the specific requirements of neuroscience applications.

Analytics and Computing, Medical Informatics, Neuromorphic Computing, and Neurorobotics. The Platform versions released in March consist of a preliminary hardware infrastructure, software tools, databases and programming interfaces, all of which are now being further developed and expanded in a collaborative manner with users, and integrated within the framework of a European RI. All Platforms can be accessed via the HBP Collaboratory [8], a web portal where users can also find guidelines, tutorials and information on training seminars.

To ensure that the HBP RI meets the requirements of the user community, the HBP is promoting a co-design approach to technology development. There are currently six major HBP Co-Design Projects (CDPs) for this purpose, which are each co-led by a domain scientist and an infrastructure

expert. The HBP CDPs address challenging scientific problems that cannot be addressed with traditional methods in neuroscience, but which can possibly be solved with advanced technologies developed as part of the HBP RI [9].

Federated data infrastructure

A fundamental role in the HBP RI is played by the High Performance Analytics and Computing (HPAC) Platform, which is coordinated by the JSC at Forschungszentrum Jülich and CSCS, the Swiss National Supercomputing Centre in Lugano. The mission of the HPAC Platform is to provide the basic data and computing infrastructure that will enable scientists to deal with the huge amounts of data on the human brain. Specifically, enabling them to store the data, integrate it into models, use it in simulations, as well as analyze and visualize it. To this end, the participating data centers JSC, CSCS, Cineca and Barcelona Supercomputing Center are working closely together to develop a federated data infrastructure, codenamed FENIX. While strongly driven by HBP use cases, the scope of FENIX goes beyond neuroscience, as it should also benefit other research areas with similar requirements, such as materials science.

Pilot systems for interactive supercomputing

Regarding computing resources, the HPAC Platform currently federates existing HPC systems at the participating centers, including Europe's fastest supercomputer Piz Daint at CSCS and JUQUEEN at JSC. Two new pilot systems, which were installed at JSC over the summer, have just been integrated into the Platform. The two systems are cutting-edge demonstrators that have been developed by Cray and a consortium of IBM and NVIDIA, respectively, within a Pre-Commercial Procurement (PCP), carried out by Forschungszentrum Jülich on behalf of the HBP. The goal of the HBP PCP is to have suppliers of HPC technology competitively research, develop and integrate novel technologies in the areas of dense memory integration, scalable visualization and dynamic resource management in order to enable "interactive supercomputing", i.e., the interactive use of supercomputers for complex workflows comprising concurrent simulation, analysis and visualization workloads. The systems are currently used for testing and benchmarking, but are also already in productive use for neuroscience applications.

Outlook

The refocusing of the HBP on its infrastructure-building mission during the first phase of the project was accompanied by the introduction of a new governance structure, which is by now in place. The HBP remains open for new partners to join the Core Project through open calls for the next project phases, while Partnering Projects may use the HBP Platforms for their research and contribute to infrastructure development [10].

The HPAC Platform will continuously be improved and expanded to enable neuroscientists to address key challenges. These include the creation of high-resolution brain atlases and the processing of brain images using advanced data analytics methods. Another example is the study of synaptic plasticity as a basis for learning, by combining large-scale simulations on massively parallel HPC systems with ultra-fast simulations enabled by the Neuromorphic Computing Platform.

References

[1] **Human Brain Project:**
https://www.humanbrainproject.eu

[2] **Platform Release (press release):**
https://www.humanbrainproject.eu/en_GB/platform-release

[3] **ET Flagships:**
http://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-flagships

[4] **Framework Partnership Agreement – Signature (press release):**
https://www.humanbrainproject.eu/en_GB/fpa-signature

[5] **Governance:**
https://www.humanbrainproject.eu/en_GB/2016-governance

[6] **Main conclusions & recommendations from HBP 1st Technical Review:**
https://ec.europa.eu/digital-single-market/news/1st-technical-review-human-brain-project-hbp-main-conclusions-recommendations

[7] **HBP Mediation Report:**
http://www.fz-juelich.de/SharedDocs/Pressemitteilungen/UK/EN/2015/15-03-09hbp-mediation.html

[8] **HBP Collaboratory (registration required):**
https://collab.humanbrainproject.eu/

[9] **HBP Co-Design Projects:**
https://www.humanbrainproject.eu/en_GB/2016-co-design-projects

[10] **Partnering Projects:**
https://www.humanbrainproject.eu/en_GB/partnering-projects

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