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Contractual Number and type:	SGA1 D6.5.3 (D36.2 D59) Report
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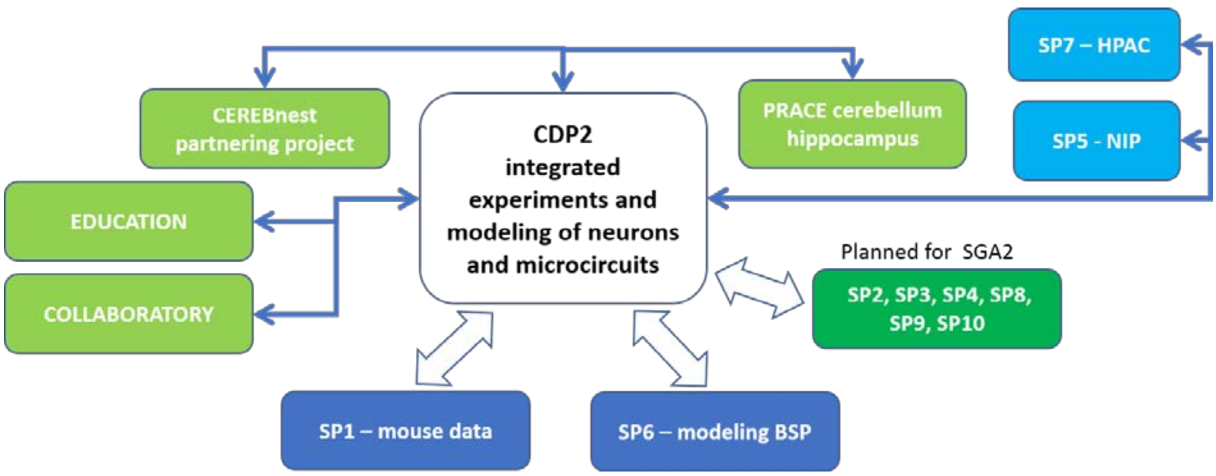
Abstract:	CDP2 bridges experimental work and modelling. At the end of the SGA1, the experimental work is carried out in SP1 and models are mostly developed in SP6. Moreover, models have been developed in connection with CDP1 to address large-scale networks applicable to robotic control in the virtual mouse. CDP2 is actively cooperating with SP5 and SP7 for data processing and HPAC and with SP12 for education. CDP2 has recruited a Partnering Project (cerebNEST) and takes part in the development of the Collaboratories on the Brain Simulation Platform. Based on SGA1 initial results, interesting new connections have been developed recently with SP2, SP3, SP4 and SP8 to address large-scale circuits in rodents and humans, with SP9 for neuromorphic hardware, and with SP10 for robotics.
Keywords:	Models, single cell, multi scale, microcircuits



CDP2 integration with other Human Brain Project activities

CDP2 collaborators during SGA1: Egidio D'ANGELO, Michele MIGLIORE, Henry MARKRAM, Felix SCHÜRMANN, Jean-Denis COURCOL, Eilif MULLER, Jeanette HELLGREN KOTALESKY, Sten GRILLNER, Szabolcs KALI, Armando ROMANI, Marc-Oliver GEWALTIG, Alessandra PEDROCCHI, Claudia CASELLATO, Alois SORIA, Jan BJAALIE, Thomas LIPPERT, Giuseppe FIAMENI, Bernd SCHULLER, Colin MCMURTRIE, Johannes HJORTH.

CDP2 collaborators who took part in work planning during the last phase of SGA1 and will become active in SGA2: Viktor JIRSA, Kim VANDUFFEL, Gustavo DECO, Marcello MASSIMINI, Cyriel PENNATZ, Philippe RYVLIN, Karlheinz MEYER, Alois KNOLL, Francesco PAVONE, Silvia TOLU, Eduardo ROS, Cecilia LASCHI.

Technical assistance by Simona TRITTO, Katrien VAN LOOK, (Daniel VARE), Suat SEVENCAN.

Targeted users/readers	Researchers, community
Contributing Work-Package(s):	SGA1 WP 6.2, 6.4
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Summary of changes **14 Sep 2018**	1) The parts that have been changed are : a. 1. Introduction: last paragraph b. Several parts in 2 Results (e.g. list of CDP2 Products) c. 2.2 Key Result: Multi-scale validation: last two points d. 2.4 CDP2 products and all 2.4 subchapters e. 3. Overall Conclusion and Outlook f. Reference list 2) The collaborators list has been updated 3) All the LINKS have been updated, renamed for clarity when needed, and checked (all passed on September 13). Examples : links in 2. Results, links for components 946, 947, 994. 4) Please note that CDP2 does not produce models but rather it uses and refines SP6 models in order to generate complex products/use cases (e.g. simulations, pipelines etc). The Life Cycle, which is needed to manage model development in SP6, is not pertinent to CDP2 and this is the reason why it is not used in the report. 5) The description of the state of advancement of PRODUCTS has been restyled along with the addition of appropriate links, when needed. 6) Headings have been updated in order to better distinguish conclusions specific to each KR (2.1.4, 2.2.4, 2.3.4) from the Overall Conclusion (3).

Table of Contents

1. Introduction

The brain is a complex adaptive system and is probably the most complex structure in the Universe. Conceivably the understanding of the multiple dynamic interactions between elements and of their plastic changes is still incomplete. This is partly due to the lack of critical data but also, importantly, to the lack of appropriate models to simulate it. What we have now is information sufficient to start the reconstruction of brain functions in a model and the computational power required to simulate them. From the analysis of model spatiotemporal dynamics, we will formulate hypothesis on how the brain works.

CDP2 fully embraces and implements the concept of multiscale brain organisation and modelling through a bottom-up approach.

For the last 12 months, priority has been given to the following points.

- Completion of a full pilot pipeline for SP1-SP6-SP5 integration, including:
  1) data transfer from SP1 to SP5 repository and to SP6 Brain Simulation Platform (BSP)
  2) direct integration of template traces in the Single Cell Building workflow
  3) generation of optimised models
  4) transfer of these models back to appropriate repositories in SP5
- Running massive simulations for cerebellar and hippocampus circuit models on high performance computing (HPC) systems.
- Integration of a NEST network of simplified neurons into the robotic mouse of CDP1.
- Extension of the implementation of workflows and models on the BSP.
- Reaching a formal definition of the cerebellum Collaboratory and running its activity.
- Realisation of the new Erice course "From cell physiology and integrated signals to emerging brain functions." Details are given in section 2.2 and at http://www.erice-golgi.org/
- Realisation of the outreach event "Human Brain Project: the endeavour of neuroscience" in Pavia, Italy, 13 March 2018, with participation of all the Italian partners and at least 300 registered participants from a broad public including students, scientists, academics and journalists, with the aim of explaining HBP and attracting the community towards its aims. All the documentation is available at: https://hbp2018.weebly.com.

All these points have been completed. Many of the problems highlighted by the reviewers about the availability of resources and functionalities from SP5, SP7, and the Collaboratory, during the last part of SGA1, have been solved or are close to being solved. Intense collaboration with the teams of SP5 and SP7 have allowed to finalise the data transfer pipelines between SP1 and SP6 and to develop appropriate protocols for supercomputing applicable to large scale simulations. SP7 and SP5 are getting more and more involved in CDP2, and we are currently working within their planning constraints so that CDP2 work can smoothly initiate the activities planned for SGA2.

2. Results

The CDP2 key results are represented by the three CDP2 Use Cases.

- CDP2-UC-001 - Single cell modelling. This Use Case is completed, and a first release was presented at the 2017 Summit in Glasgow. It allows users to upload or select morphologies and electrical traces from the Neuroinformatics Platform (NIP) and use those in an easy-to-use neuron builder that produces a ready-to-run NEURON compatible simulation package available at this link on the BSP: Single cell building.
- CDP2-UC-002 - Multi-scale validation. This Use Case is almost completed, and a first release was presented at the 2017 Summit in Glasgow. It allows to validate the cellular level model behaviour against experiments at different scales, for example spiking behaviours at the single cell and microcircuit levels. This Use Case provides an important step for building the bridge to behaviour with simplified representations of microcircuit level models (Functional simulation with point neuron and Circuit Building).
- CDP2-UC-003 - *In silico* microcircuit experimentation. A first release of this Use Case is completed and has been made public on the BSP at the end of SGA1. It allows to configure, run and visualise simulation results for the hippocampal CA1 circuit (Single cell in silico experiments).

The three Use Cases were broken down into the six CDP2 products:

- P1 Hodgkin-Huxley Neuron builder
- P2 Single Model Benchmark and Validation Suite
- P3 Community-based modelling strategy on the example of cellular-level Hippocampus model
- P4 Cellular level Basal Ganglia model
- P5 Cellular level Cerebellar model
- P6 *In silico* experimentation lab on the example of the cellular level neocortical model

A detailed description of the Key Results and Products is reported below.

2.1Key Result: Single Cell Model Builder

The Single Cell Model builder is one of the three use cases of CDP2. It allows a user to build, through the Collaboratory, a morphologically and biophysically accurate single neuron model. It builds on SP6 tools and software to implement a complete, self-consistent, robust and flexible pipeline. There are no similar tools available in the neuroscience field, and it can be effectively exploited by a wide range of potential users for several purposes, from students interested in learning modelling to experimentalists interested in building a realistic model of their own cell, to more experienced modellers interested to collaborate with HBP partners in using or building upon data and models already available in the HBP databases.

2.1.1 Achieved Impact

From 8th Sep 2017 to 16th March 2018:

Number of cloning: 82
Number of unique users (who cloned the web-app): 18
Number of times the app was added to an existing Collaboratory: 54
Number of times a new Collaboratory was created when cloning the app: 28

2.1.2 Component Dependencies

Component ID	Component Name	HBP Internal	Comment
946	SP6-T6.4.5-SGA1-Engineering support to build data-driven models	No	Essential
947	SP6-T6.4.5-SGA1-Support of open source tools for configuration of data-driven models	No	Essential
994	SP6-T6.4.6-SGA1-Web hosting, deployment, monitoring and updating of platform services for data-driven models	Yes	Essential

2.1.3 Component Details

The following is a list of the newly released internal Components for this deliverable.

2.1.3.1 SP6-T6.4.5-SGA1-Engineering support to build data-driven models

Field Name	Field Content	Additional Information
ID	946	
Component Type	Service	
Contact	MIGLIORE, Michele	
Component Description	This component provides a user-friendly interface to allow user an easy extraction of electrophysiological activity features, needed for data-driven model construction	
Latest Release	1.0.0 Feb.2018	
TRL	7	
Location	data hosted by task providing dataset, by collaboratory storage and by other non-HBP 3rd party	
Format	NA	
Curation Status	NA	

Validation - QC	Pass	QA Owner: Alexander Dietz, "Checkpoint Quality Assurance"
Validation – Users	Yes	Validation method: BSP analytics log Counts: 71 (43 external, 28 internal)
Validation – Publications	No	
Privacy Constraints	No privacy constraint	
Sharing	Public authenticated	
License	Apache v2.0	
Component Access URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/66850**Error! Hyperlink reference not valid.**	Trace analysis
Technical documentation URL	https://collab.humanbrainproject.eu/#/collab/19/nav/2108?state=software,Feature_Extraction_Graphical_User_Interface	Feature Extraction Graphical User Interface
Usage documentation URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/18580	BSP Guidebook
Component Dissemination Material URL		

2.1.3.2 SP6-T6.4.5-SGA1-Support of open source tools for configuration of data-driven models

Field Name	Field Content	Additional Information
ID	947	
Component Type	Service	
Contact	MIGLIORE, Michele	
Component Description	This component will provide a user-friendly interface to configure and launch optimisation processes on remote HPC systems	
Latest Release	1.0.0 Feb.2018	
TRL	7	

Location	data hosted by task providing dataset, by Collaboratory storage and by other non-HBP 3rd party	
Format	NA	
Curation Status	NA	
Validation - QC	Pass	QA Owner: Alexander Dietz, "Checkpoint Quality Assurance"
Validation – Users	Yes	Validation method: BSP analytics log Counts: 77 (28 external, 49 internal)
Validation – Publications	No	
Privacy Constraints	No privacy constraint	
Sharing	Public authenticated	
License	Apache v2.0	
Component Access URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/66898	Highly Integrated Workflows
Technical documentation URL	https://collab.humanbrainproject.eu/#/collab/19/nav/2108?state=software,Hodgkin_Huxley_Neuron_Builder_CDP2_P1	BSP Software Catalog
Usage documentation URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/18580	BSP Guidebook
Component Dissemination Material URL		

2.1.3.3 SP6-T6.4.6-SGA1-Web hosting, deployment, monitoring and updating of platform services for data-driven models

Field Name	Field Content	Additional Information
ID	994	
Component Type	Service	
Contact	MIGLIORE, Michele	

Component Description	This component provides the services needed to deploy, monitor, update and host the web applications developed for support to data-driven models	
Latest Release	1.0.0 Feb.2018	
TRL	7	
Location	data hosted by task providing dataset, by HPC platform, by Collaboratory storage and by other non-HBP 3rd party	
Format	NA	
Curation Status	NA	
Validation - QC	Unchecked	
Validation – Users	Yes	Validation method: BSP analytics log Counts: 89 (external 51, internal 38) not available at this time
Validation – Publications	No	
Privacy Constraints	no privacy constraint	
Sharing	Public authenticated	
License	Apache v2.0	
Component Access URL	https://collab.humanbrainproject.eu/#/collab/19/nav/2108?state=software,Hodgkin_Huxley_Neuron_Builder_CDP2_P1	Hodgkin Huxley Neuron Builder (CDP2-P1)
Technical documentation URL	https://collab.humanbrainproject.eu/#/collab/19/nav/2108?state=software,Hodgkin_Huxley_Neuron_Builder_CDP2_P1	BSP Software Catalog
Usage documentation URL	NA	
Component Dissemination Material URL	NA	

2.1.4 Conclusion and Outlook for KR Single Cell Model Builder

All Use Cases use applications, tools, and functions co-developed by the Neuroinformatics Platform (NIP), the BSP and the High-Performance Computing and Analytics Platform (HPCAP) and independently available through the BSP.

The products and services of the Single Cell Modelling Use Case represent, to the best of our knowledge, the first set of tools through which the complete pipeline needed for building a realistic and data-driven single neuron model is provided to the user in a single, integrated and collaborative framework.

The framework is publicly available through the BSP of the Human Brain Project and relies on the HBP Collaboratory environment to share data and results among collaborators. Importantly, the users are provided with functionalities to access local (i.e. HBP) or remote datasets or provide their own data.

The Use Case represents an integrated workflow which involves the use of the NIP and HPCAP.

The framework built so far is fully functional, although at this time only a fraction of the data can be accessed from the NIP, and the only remote system used to carry out the cell model optimisation is the NeuroScience Gateway platform (which is not part of the HPAC Platform of the Human Brain Project). We plan to fully maximise its impact in the next 12 months, by adding full NIP integration and interaction with more HPC systems through the UNICORE framework.

2.2Key Result: Multi-scale validation

CDP2 has provided examples on how to validate the cellular level model behaviour against experiments at different scales, for example spiking behaviours at the single cell and microcircuit levels. From this point of view, CDP2 has started building the bridge to behaviour with simplified representations of the microcircuit level models. This target has been pursued through a series of actions in line with those anticipated in the CDP2 program:

A full pilot pipeline for integrating SP1 data into NIP-BSP has been set-up. (1) Data have been transferred from SP1 to NIP repositories and from there to BSP, (2) the data (typically current-clamp voltage traces of neuronal discharge) have been directly integrated as template traces in the Optimiser workflow, and (3) this has allowed optimised models to be generated. The transfer of model generated data back to appropriate repositories in NIP is under preparation.

- Massive simulations for cerebellar and hippocampal circuit models are running on HPC facilities (Juqueen, Jülich) through a dedicated PRACE project.
- A NEST network of simplified neurons has been integrated and tested and is now being prepared for integration in the robotic mouse of CDP1
- Modelling workflows have been implemented on the BSP. In particular, those of the granule cells, Purkinje cells and of the scaffold model of cerebellum.
- Modelling workflows for the hippocampus at the cellular and circuit level have been implemented on the BSP.
- A formal definition of the cerebellum collaboratory is on the way. A first action has been the formation of the Partnering Project cerebNEST, several collaborations are undergoing with groups outside HBP using the HBP cerebellum models.

- The new Erice course "From cell physiology and integrated signals to emerging brain functions" was successfully held with attendees coming from all over the world. The course dealt with multiscale brain experimental analysis and modelling, highlighting high-level functions and fMRI signals.
- A NEST network of simplified neurons has been constructed and tested and is going to be integrated in the robotic mouse of CDP1. The initial delays in this operation were due to several factors independent from CDP2, i.e. (1) the level of development of the robotic mouse and its ability to host the cerebellar network (CDP1/SP10, now fixed), (2) the interfacing of the Neurorobotic Platform with the Allen Brain Atlas for the import of neuronal distribution data (CDP1/SP10, now fixed), (3) the development of the Cerebellum Scaffold (SP6, now available), (4) the development of simplified cerebellar neurons (SP6, now available). The integration of the NEST network in the robotic mouse, which is the first example of this procedure and paves the way to further implementation of neuronal circuits, is going to be completed in SGA2.
- The Cerebellum Collaboratory is building upon the functionalities of the Brain Simulation Platform, the participation to the Erice Courses and on several direct collaborations with groups outside HBP that are using the HBP cerebellum models. These other groups include the Erasmus MC (Rotterdam, Holland - Chris DE ZEEUW), the Ecole Normale Supérieure (Paris, France - Boris BARBOUR), the University College London (London, UK - Michael HAUSSER), the University of Texas (San Antonio, USA - Fidel Santamaria), the Amrita University (Amritapuri, India - Shyam DIWAKAR). A first successful integration of an external group has been the affiliation of the Partnering Project cerebNEST (Milano, Italy - Alessandra PEDROCCHI), that is actively exploiting and refining the HBP cerebellar models for motor control in robotic settings. The Collaboratory is going to be extended during SGA2 with the proposal and incorporation of new Partnering Projects.

2.2.1 Achieved Impact

The Use Case has had a relevant impact on the coordination of activities in HBP through different researches.

- Realistic models constructed in the BSP have been used and validated in CDP2. The used models include all the main cerebellar neurons as well as hippocampus CA1 pyramidal cells and interneurons. This CDP2 activity has allowed implementing specific pipelines to test the models, to give feed-back to BSP developers, and to diffuse the knowledge in the scientific community.
  - Hippocampus CA1 single cell models (Migliore *et al.*, under review).
  - Hippocampus CA1 circuit (Romani *et al.*, in preparation).
  - Stellate cell model (Rizza, Locatelli, Masoli, Munoz, D'Angelo, *in preparation*).
  - Golgi cell model (Rizza, Locatelli, Masoli, Munoz, D'Angelo, *in preparation*).
  - Purkinje cell model. This model has been uploaded on modelDB and is being used by the main centres operating in cerebellar models outside HBP, including UCL (University College London), ENS (École Normale Supérieure) and UTSA (University San Antonio, Texas).
- In CDP2, simplified cerebellar models elaborated by the Partnering Project CEREBNEST have been validated and tested in closed-loop robotic simulations:
  - Spiking neural network embedded in a closed-loop control system to model cerebellar pathologies.
  - A paper on the philosophy and strategy of multiscale brain modelling, with specific examples from the cerebellar work in CDP2.
- The Erice Course on multiscale brain modelling has been successfully carried out in December 2017, with more than 60 students and 20 speakers, 6 of them being members

of HBP. The School of Brain Cells and Circuits has organised courses since 2014 and is coordinated with the HBP Education Programme. The 2017 course was dedicated to the relationship between bottom-up models derived from cellular biophysics and top-down models derived from non-invasive brain measurements (mostly fMRI). This course addressed the integration micro-, meso and macro-scale brain phenomena and applied all of this to neurodegenerative, vascular and neuroinflammatory brain diseases. This event is one of a series gathering large sectors of the scientific community around the HBP targets. The abstracts are going to be published in a Research topic of Frontiers Neuroscience.

- A partnering Project (cerebNEST) has been recruited as a tangible evidence of the expansion of the Collaboratory. cerebNEST is exactly working in the directions expected for the multiscale validation aims of CDP2
- The generating of a pipeline for data and modelling transfer between SP1, NIP and BSP is providing a tangible example of activities and platform integration.

2.2.2 Component Dependencies

Component ID	Component Name	HBP Internal	Comment
721	SP6-T6.4.4-SGA1-Model Validation Service (service)	Yes	Essential

2.2.3 Component Details

The following is a list of the newly released internal Components for this deliverable.

2.2.3.1 SP6-T6.4.4-SGA1-Model Validation Service (service)

Field Name	Field Content	Additional Information
ID	721	
Component Type	Service	
Contact	DAVISON, Andrew	
Component Description	The Model Validation Service REST API allows modellers to find validation tests that are suitable for the species, structure (single cell, brain region, etc.) and spatial/temporal scale being modelled. It also allows modellers to define and upload new validation test definitions. It provides a database of validation experiment results, and a web-services API for querying the database and uploading new results.	
Latest Release	v1.0	31/03/2018
TRL	6	

Location	Data hosted by other non HBP 3rd party	Commercial cloud provider (EU based)
Format	Web API	
Curation Status	Not applicable	
Validation - QC		Agile Quality Assurance
Validation – Users	Yes	Sara Saray, Alexander Kozlov, Armando Romani, Luca Bologna, Alexander Dietz
Validation – Publications	No	
Privacy Constraints	No privacy constraint	
Sharing		
License		
Component Access URL	https://collab.humanbrainproject.eu/#/collab/8123/nav/61654	Model validation test suites
Technical documentation URL	https://collab.humanbrainproject.eu/#/collab/8123/nav/61654	Model validation suites
Usage documentation URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/18580	BSP Guidebook
Component Dissemination Material URL		

2.2.4 Conclusion and Outlook for KR Multi-scale validation

This Use Case has substantially contributed to expand HBP activities, to coordinate experimental research with modelling, to implement modelling and data-processing pipelines, and to gather the interest of the scientific community around the HBP targets.

2.3Key Result: *In silico* microcircuit experimentation

The *in silico* microcircuit experimentation is one of the three Use Cases of CDP2. Its aim is to allow an average user to build through the Collaboratory, an experiment against a biophysically detailed model of a microcircuit of the hippocampus. The process involves the following steps: 1) setting up the location and the definition of the stimuli for the experiment 2) setting up the location and the definition of the report variable for the experiment 3) defining the HPC job configuration and submitting the job 4) selecting analysis and defining their parameter 5) configuring the HPC job and submitting it for the analysis 6) studying the analysis figures produced. The use case hides the complexity of setting up a simulation environment, configuring the proper files, transferring files between sites and configuring HPC job.

2.3.1 Achieved Impact

The main key points achieved through the *in silico* microcircuit experimentation Use Case are 1) the design and implementation of a Collaboratory integrated application on the example of the hippocampus circuit, 2) the design and implementation of a multiple step pipeline, and 3) the integration with the HPC Unicore systems to execute jobs and transfer file between sites therefore providing smooth access to remote HPC systems. Since this platform application has just been finished, the impact has mainly been on the construction side until now, waiting for exploitation in the next project phases.

2.3.2 Component Dependencies

Component ID	Component Name	HBP Internal	Comment
213	Js Simulation Configuration (software)	Yes	Essential
946	SP6-T6.4.5-SGA1-Engineering support to build data-driven models	No	Essential
947	SP6-T6.4.5-SGA1-Support of open source tools for configuration of data-driven models	No	Essential
994	SP6-T6.4.6-SGA1-Web hosting, deployment, monitoring and updating of platform services for data-driven models	Yes	Essential

2.3.3 Component Details

The following is a list of the newly released internal Components for this deliverable.

2.3.3.1 JS Simulation Configuration

Field Name	Field Content	Additional Information
ID	213	
Component Type	Software component	
Contact	COURCOL, Jean-Denis	
Component Description	A Web component to configure simulation on detailed circuit model using Neuron.	
Latest Release	1.0.0	Feb 2018
TRL	7	
Location	Data hosted by HPC platform	
Format	NA	
Curation Status	NA	
Validation - QC	Pass	QA Owner: Alexander Dietz
Validation – Users	Yes	Internal Users: Michele Migliore, Stefano Antonel
Validation – Publications	No	
Privacy Constraints	No privacy constraint	
Sharing	public authenticated	
License		
Component Access URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/66856	Brain Area Circuit In Silico Experiments (cerebellum)
Technical documentation URL		

Usage documentation URL	https://collab.humanbrainproject.eu/#/collab/1655/nav/18580	BSP Guidebook
Component Dissemination Material URL		

2.3.4 Conclusion and Outlook for KR In silico microcircuit experimentation

The products and services implemented during this period for the *in silico* microcircuit experimentation Use Case is a first step towards an easy to use solution for non-experts to experiment with the microcircuit delivered by SP6.

The application leverages the HBP UNICORE web services to abstract the HPC system and therefore can be extended to HPC systems where UNICORE is installed.

Setting up the simulator and the HPC interaction was a laborious task during development and this application will help users to skip that step and go directly to science.

We are planning to have a MOOC that will use the developed application. The students will learn how to experiment with an *in-silico* circuit in the actual Brain Simulation Platform. This will give them a gentle introduction and real-life exercises. This will maximise the impact of the tool by giving an educational environment to the community.

The web application is generic and can support any new micro circuit developed by the brain simulation platform as soon as we think they are ready for end users to experiment with.

Our next steps are to enable the connection with interactive visualisation through the web browser. Progresses have been made in that direction, but this requires development of the HPC system to allow a visualisation system running on compute nodes to be easily visible and reachable through the Internet.

A second step is to have the output of the simulation being registered in the NIP for sharing.

2.4 CDP2 products

2.4.1 CDP2-P1 Hodgkin-Huxley neuron builder

The neuron builder has been released and is accessible to internal and external users on the Brain Simulation Platform. Achieved. Hodgkin-Huxley neuron builder.

2.4.2 CDP2-P2 Single model benchmark and validation suite

A prototype web service (REST API) providing a model catalog, validation test library and validation results database was released to the consortium in Month 15. This was accompanied by a web interface and a Python client and enabled automated running of validation tests with registration of results in the database. Based on experience with the prototype, an improved version of the web service is in development, together with a number of Collaboratory apps targeted at different classes of users (modellers, experimentalists, etc.). A number of test suites, based on the SciUnit framework, are under development for different classes of validation tests, e.g. tests of hippocampal neuron models, cerebellum neuron models, network model structure, network model activity, sub-cellular models. Achieved. Model validation suite .

2.4.3 CDP2-P3 community-based modelling strategy through the example of the cellular-level hippocampus model

Product 3 aimed to establish a community-based modelling strategy through the example of the cellular-level hippocampus model. This strategy involved, first of all, direct engagement of the relevant experimental and theoretical scientific communities to identify their needs, priorities, and possible concerns regarding data-driven collaborative modelling, and also to educate them about the opportunities provided by HBP in general and the Brain Simulation Platform in particular. An important vehicle for such interactions has been a series of HBP sponsored community workshops, the latest instalment of which (Hippocamp 2017) took place at the EITN during SGA1. In addition, an initial list of potential external collaborators was constructed (partly as an outcome of the Hippocamp workshops), which included scientists who were interested either in providing data and model components for the hippocampal community model, or in using the community model to answer their scientific questions. These collaborations were then further developed through detailed discussions via personal contacts. Another critical component of the community engagement strategy is showcasing the capabilities of the HBP Platforms. This involves the development of initial scaffold models of single neurons and circuits by a core team within HBP, and then making both the models and the model building and validation process itself accessible through intuitive interfaces in the BSP. Important examples released during SGA1 included the BSP Use Cases demonstrating the construction and validation of hippocampal neurons, *in silico* experimentation, circuit construction and simulation (see links below). Finally, substantial efforts have been devoted to the design and implementation of massive open online courses (MOOCs) to guide interested users through the Use Cases, operation, power and benefits of the BSP, and a course involving simulations using the HBP hippocampal circuit model is currently under development. Achieved.

Single cell building (Rebuilt an existing single hippocampal cell model and Build your own single hippocampal cell model using HBP data)

Model Validation- Hippocampus Single cell BluePyOpt optimized model validation

Single Cell in Silico Experiments- Single cell in silico experiments under current clamp

Circuit Building- Rat Hippocampus CA1

Brain Area Circuit In Silico Experiments

Mooc Initialization

2.4.4 CDP2-P4 Cellular-level basal ganglia model: generalisation strategies

We have a first scaffold model of the striatum incorporating the principal MS D1 and D2 neurons, as well as FS and ChIN. A scaled downed version runs in a Jupyter notebook on the Collab." Achieved. Circuit Building- Striatum microcircuitry (>connectome>striatum)

2.4.5 CDP2-P5 Cellular-level cerebellar model: generalisation strategies and integration in robotic systems

We have started to integrate a simplified cerebellar network in closed-loop cerebellar-driven tasks; simplified learning rules drive motor adaptation. The translation of the model in PyNEST is now being implemented in synergy with partnering project cerebNEST. The pointneuron network will be enhanced in terms of embedding realistic connectivity schemes and in terms of neuronal microcircuit dynamics. Achieved. Functional Simulation with point neuron (>functional simulation)

2.4.6 CDP2-P6 In silico experimentation lab on the example of the cellular-level neocortical model

An *in silico* experiment builder for brain area regions has been developed. It provides a web graphic user interface that enables the following workflow.

- Configuration of an experiment. The configuration of the experiment enables the end user to define various types of stimuli on a set of pre-defined targets (or group of neurons) for a certain duration. It enables the end user to report on variables on a set of pre-defined targets.
- Execution of the experiment on a super computer. The graphical user interface connects to Unicore REST API to configure, launch and monitor the job. The end user can see a list of queued jobs, jobs in progress and finished jobs, and get more details (logs, configuration details etc.).
- Execution of a pre-defined analysis on the report generated by the experiment. The service can move the data from a super computer to a more appropriate cluster using the Unicore REST API. A set of predefined analyses is executed and the generated images are visible through the graphical user interface.
- Interactive visualisation of the experiment. A web service can be launched to interactively visualise the experiment. The circuit and the report are visible, the end user can control the camera and the replay. This GUI is currently provided for the hippocampus model and is generic so that it will be made available once the neocortex model will be available. The end user is now able to extract a neuron from the circuit model and experiment on the single cell model with the synapses defined from the “circuit building pipeline", this is available in the Use Cases "Single cell *in silico* experiments under current clamp" and "Configure and run a small circuit using preconfigured HBP model and data".

The end user will be able to extract a neuron from the circuit model and experiment on the single cell model with the synapses defined from the “circuit building pipeline”. Achieved. Small Circuit in silico Experiments

3. Overall Conclusion and Outlook

As a whole, CDP2 has substantially contributed to expand HBP activities, to coordinate experimental research with modelling, to implement modelling and data-processing pipelines, and to gather the interest of the scientific community around the HBP targets. CDP2 has been working as an effective and needed connection project between SP1, SP6, SP5, projecting its activity toward SP2, SP3, SP4, SP8, SP9, SP10 and CDP1 to mention those that have already been engaged for future SGA2 activities. CDP2 has been bridging science and technology providing substantial feedback from models toward experimental data sampling. CDP2 has gathered the scientific community around core themes like multiscale modelling by developing specific courses and meetings. CDP2 has given substantial support and feedback for platform implementation and refinement, especially for the Brain Simulation Platform. Through these actions, CDP2 has substantially contributed to put the seeds for future developments of HBP activities, in SGA2 and beyond.

The SGA2 planning, that took place in the last phase of SGA1, further characterised CDP2 as a key component to verify the usefulness of HBP Platforms. In this perspective, CDP2 will extend the validity of the HBP Modelling/Simulation approach for empowering neuroscience research and technological development (see SGA2 Grant Agreement). This will require a continued coordination of data production in SP1 and modelling in SP6 to fuel single neuron and *in silico* microcircuit experimentation integrated on the Brain Simulation Platform, the Neuroinfornatic Platform (SP5) and HPC Unicore (SP7). Moreover, CDP2 will extend its interaction with the external community through dissemination, outreach initiatives and collaboratories. CDP2 will therefore continue to implement and extend the concept of multiscale brain organisation and modelling through a bottom-up approach further extending its implications in large-scale brain simulations, neurorobotics and neuromorphic computing.

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