CAJAL BLUE BRAIN PROJECT

Volume 6, issue 12. December 2014

INSIDE THIS ISSUE:

2014 Project Structure	1
Dissemination activities	1
CBBP main achievements	2, 3
CBBP main contributions	3

Special points of interest:

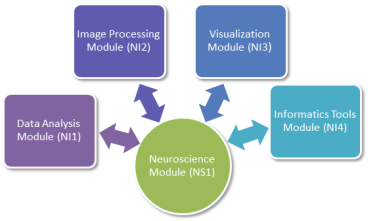
- ☐ 2014 Project main achievements and contributions

Cajal Blue Brain Brain Project

2014 Project Structure

The structure of the Project in 2014 has been as follows:

- Scientific Director
- Project Manager
- Scientific structures:
  - ◊ Neuroscience (NS):
    - * Module NS1: Neuroscience
  - ◊ Neuroinformatics (NI):
    - * Module NC1: Data Mining
    - * Module NC2: Image Processing
    - * Module NC3: Visualization
    - * Module NC4: Informatics Tools



General Scheme of the Core Project

In addition, the external collaborator groups were as follows:

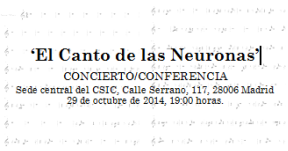
⇒ Cell Physiology Cajal's Laboratory (FCAN): research laboratory from Instituto Cajal (CSIC)

⇒ Modeling and Virtual Reality Group (GMRV): research group from Universidad Rey Juan Carlos, at the Mostoles Campus (most of the integrated members) and Computer Sciecnes School – UPM (see in Section 5 'Annexes': Annex 5.9)

⇒ University of Oxford: research laboratory from UOXF

⇒ CeSViMa: Centro de Supercomputación y Visualización de Madrid from UPM

'The Singing of Neurons and the Alzheimer's Disease'


'El Canto de las Neuronas'
CONCIERTO/CONFERENCIA
Sede central del CSIC, Calle Serrano, 117, 28006 Madrid
29 de octubre de 2014, 19:00 horas.

This event was held in October 2014 and was chaired by Her Majesty Queen Sofia. The musical intervention Quartet Almus, and lecture by Professor Javier DeFelipe, have been part of a program commemorating the 75th Anniversary of the CSIC.

To study the distribution and morphology of dendritic spines in the normal brain of patients with Alzheimer's disease, scientists from the CSIC and the UPM have recently developed an exploratory tool using musical notes. This form of analysis consists in that the most relevant features of spine morphology and spatial distribution in a given neuron is transformed into musical notes. In addition, in this pioneering research collaborates the as an integral part of an interdisciplinary approach to the study of normal brain and patients with neurodegenerative diseases.

Source: CIBERNED

Cajal Blue Brain Project

2014 Main Achivements

The sixth project year has closed and the project is well-placed to decode the synaptome or detailed map of the synaptic connections of the cortical column through 3D reconstructions in order to understand how the brain functions. Main achievements attained during the sixth project year are outlined below.

Main Achievements

Neuroscience

- Development and validation of software tools for 3D segmentation of cells of the complete cortical column in samples from the somatosensory neocortex
- Recognition of distribution patterns of different cell types using spatial distribution analyses
- Detection of the spatial distribution of synapses in the six cortical layers by means of spatial statistical tools
- Inyection of horizontal and coronal sections of pyramidal cell including layer IV. Implementation of3D reconstruction of these cells to analyze their architecture.
- Obtention of high resolution confocal microscopy stacks of images from layer IV pyramidal cells
- Target identification of cortical synapses to determine the proportion of synapses on dendritic spines and shafts
- Development of a computer method based on synaptic sizes to analysis the relationship between synaptic morphology and physiology
- Characterization of afferent and efferent connections in specific areas with tract-tracing experimets

Data Analysis

- Uni- and Multi-dimensional classification of GABAergic interneurons (Gardener); Identification of new subgroups; Building the NeuroClassificator: definition of new morphological variables, modeling experts' consensus with Bayesian networks and development of methodology for supervised clustering and data-streams
- Detection of common design principles that govern the geometry of dendritic branching angles of pyramidal cells in all cortical areas
- Analysis of 3D Spatial Distribution of Synapses in the Neocortex using Dual-Beam Electron Microscopy
- Identification of Random Positions of Dendritic Spines in Human Cerebral Cortex
- Edition of a Research Topic on "Bayesian networks in neuroscience" in Frontiers in Computational Neuroscience.

Image Processing

- Generation of algorithms for the segmentation of synapses and mitochondria in EM images

Visualization

- Development of new solutions for interactive exploratory analysis applicable to any kind of data from the neuroscience domain of knowledge (i.e., electron microscopy, confocal microscopy, or even electrophysiology data)
- Upgrading of the segmentation, data analysis and navigation tools

Neuroinformatics Tools

1) Tools for the segmentation and annotation of microscopy images

- Release of a new major revision of the EspINA software (v2.0)
- Development of a new tool for the automatic segmentation and counting of cell structures in light microscopy
- Neurite skeleton segmenter: development of a new assistant tool to support the identification of neurite processes (dendrites and axons) in EM stacks and to link them with PSD segmentations

2) Models for computational neuroscience.

- Multiscale modeling of neurotransmitter reléase
- Development of couple mechanical-electrophysiological new models in collaboration with the University of Oxford

Cajal Blue Brain Project

2014 Main Achivements

Cell Physiology Cajal's Laboratory (IC-CSIC)

- Analysis of the modulation of neuronal activity and synaptic transmission and plasticity in the primary somatosensory cortex induced by stimulation of astrocytes
- Spatial extension characterization of the astrocyte-induced synaptic regulation

Modeling and Virtual Reality Group, GMRV, URJC

- A new multimodal technique for the interactive exploration of distributions of spines based on the synthesis of music and using particular visual codings
- Development of a haptic-assisted tool to improve automatic segmentation
- Development of a haptic-assisted visualization method, completion of a visualization prototype and implementation of a new procedure for massive neuron populations
- Development of method for the labelling and retrieval of dendritic spines

2014 Main Contributions

Main Contributions

Cross-publications between modules and/or groups:

Bielza C, Benavides-Piccione R, López-Cruz P, Larrañaga P, DeFelipe J (2014). Branching angles of pyramidal cell dendrites follow common geometrical design principles in different cortical areas. Sci. Rep. 4, 5909; DOI: 10.1038/srep05909.

Morales J*, Ruth Benavides-Piccione* R, Dar M, Fernaud I, Rodríguez A, Anton-Sanchez L, Bielza C, Larrañaga P, DeFelipe J, Yuste R (2014). Random Positioning of Dendritic Spines in the Human Cerebral Cortex. J Neurosci. 34:10078-10084. doi: 10.1523/JNEUROSCI.1085-14.2014. *both authors contributed equally

Anton-Sanchez L, Bielza C, Merchán-Pérez A, Rodríguez J-R, DeFelipe J and Larrañaga P (2014). Three-dimensional distribution of cortical synapses: a replicated point pattern-based analysis. Front.Neuroanat. 8:85. doi:10.3389/fnana.2014.00085. Trends Neurosci. 2014 Oct; 37(10):525-7. doi: 10.1016/j.tins.2014.08.002.

Mihaljević B, Bielza C, Benavides-Piccione R, DeFelipe J, Larrañaga P (2014) Multi-dimensional classification of GABAergic interneurons with Bayesian network-modeled label uncertainty. Front Comput Neurosci. 2014 Nov 25; 8:150. Doi: 10.3389/fncom.2014.00150.

Mihaljević B, Benavides-Piccione R, Bielza C, DeFelipe J, Larrañaga P (2014) Bayesian Network Classifiers for Categorizing Cortical GABAergic Interneurons. Neuroinformatics. 2014 Nov 25. [Epub ahead of print]

Jérusalem, A., García-Grajales, J.A., Merchán-Pérez, A., & Peña, J.M. (2014). A computational model coupling mechanics and electrophysiology in spinal cord injury. Biomechanics and Modeling in Mechanobiology (13):4 pp. 883-896

Pablo Toharia, Juan Morales, Octavio de Juan, Isabel Fernaud-Espinosa, Angel Rodríguez, Javier DeFelipe. "Musical representation of dendritic spine distribution: a new exploratory tool" Neuroinformatics Springer Verlag. ISSN 1539-2791 DOI: 10.1007/s12021-013-9195-0 12(2): 341-353 Apr. 2014

Loic Corenthy, Marcos García, Sofía Bayona Beriso, Andrea Santuy, Jose San Martin, Ruth Benavides-Piccione, Javier DeFelipe, Luis Pastor: Haptically Assisted Connection Procedure for the Reconstruction of Dendritic Spines. IEEE T. Haptics (TOH) 7(4):486-498 (2014)

Lopez-Cruz, P.L., Larrañaga, P., J. DeFelipe, & Bielza, C. (2014). Bayesian network modeling of the consensus between experts: An application to neuron classification. International Journal of Approximate Reasoning, 55(1), 3-22.

Merchán-Pérez, A., Rodríguez, R., González, S., Robles, V., DeFelipe, J., Larrañaga, P. & Bielza, C. (2014). Three-dimensional spatial distribution of synapses in the neocortex: A dual-beam electron microscopy study. Cerebral Cortex, 24, 1579-1588*.

Mihaljevic, B., Benavides-Piccione, R., Guerra, L., DeFelipe, J., Larrañaga, P. & Bielza, C. (2014c). Classifying GABAergic interneurons with semi-supervised projected model-based clustering. Artificial Intelligence in Medicine, (in press).

CONTACT DETAILS

Cajal Cortical Circuits Laboratory
Center for Biomedical Technology (CTB)
Parque Científico UPM
Campus de Montegancedo s/n
28223 Pozuelo de Alarcón
Madrid. Spain
E-mail: info@cajalbbp.com

CTB

The Cajal Blue Brain Project is hosted by the Universidad Politécnica de Madrid (UPM) in the Scientific and Technological Park of Montegancedo Campus. Computational needs and support infrastructure required by CajalBBP are provided by two of the Research Centers of the Park, the Centro de Tecnología Biomédica (CTB) and the Centro de Supercomputación y Visualización de Madrid, CeSViMa, which is focused on the massive storage of information, high-performance computing and advanced interactive visualization.

More information: www.ctb.upm.es

Sponsorship