CAJAL BLUE BRAIN PROJECT

Volume 1, issue 2. December 2009

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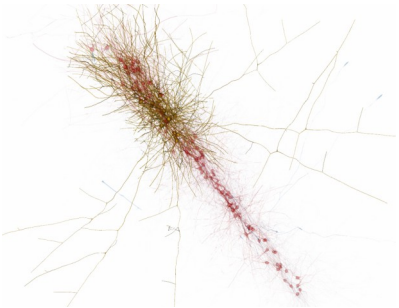
Special points of interest:

- Printed news generated by the project during 2009
- Relevant Publications
- Training within the project

First Year of the Project

On January 2009 Cajal Blue Brain Project (CajalBBP) was started on. The Cajal BBP is the Spanish representation within the International Blue Brain Project (BBP). On May 4 CajalBBP was officially launched in the Universidad Politécnica de Madrid (UPM). The international BBP represents the first comprehensive attempt to reverse-engineer the mammalian brain, in order to understand its operation and dysfunctions through detailed simulations.

The main strength of this project is that all participating laboratories are coordinated, so that, all efforts will be conducted towards achieving a specific objective by using common criteria of methodology. Thus, the generated data in a laboratory can be effectively used by other research groups.



2009 Hernando, BBP/EPFL

The Advanced Computation Group (ACG) from UPM, led by Prof.: J. M. Peña, is deeply involved in the objectives and visions of the BBP being engaged as one of the collaboration institutions close to the project core. Data analysis, optimization and visualization software of the BBP are researched in collaboration with ACG. The Neuronal Circuits Laboratory (NCL) from UPM-CSIC, leaded by Prof.: J. de Felipe (IC-CSIC) intensively collaborates in micro anatomical studies of neuronal cells, their morphology and function.

The Cajal Blue Brain Project is hosted by the Universidad Politécnica de Madrid (UPM) in the Montegancedo Campus, supported by two of its research centers, the Centro de Tecnología Biomédica (CTB) and the Centro de Supercomputación y Visualización de Madrid (CeSViMa).

At the beginning of 2009, ACG and NCL were moved to Montegancedo Campus and were established at the CeSViMa and CTB, respectively. Currently, both, ACG and NCL, are totally settled and fully operational.

Cajal Blue Brain Project in Media

Printed news

Headline: The 'worldmap' of all neural circuits: *Spain participates in an international project to create a model of the human brain with computer simulations*
Source: El Mundo Date: May 5, 2009

• Headline: Following the Cajal Trace.
Source: El Diario Médico. Date: May 5, 2009

• Headline: A simulator will allow for testing neuronal diseases
Source: El Diario de Cádiz. Date: May 5, 2009

• Headline: Seeking or Artificial Brain
Spain joins an international project to develop the most perfect simulator
Source: Público. Date: May 5, 2009

• Headline: A pioneering brain simulator will allow testing with neuronal diseases
Source: Sur. Date: May 5, 2009

• Headline: Unraveling the brain
Source: El Pais Date: December 13, 2009

On-line news

• Headline: The Blue Brain Project will help to know how the brain works
Source: SINC. Date: May 5, 2009

• Headline: Blue Brain: A journey through the neuronal human landscape
Source: Terceracultura Date: October 1, 2009

• Headline: Blue Brain Project: Model of human brain with supercomputers. Source: Barrapunto. Date: January 11, 2009

• Headline: A supercomputer unveil the mysteries of thought, perception and consciousness
Source: Terndencias Informáticas Date: January 13, 2009

Training Activities

Cerebral Microcircuits Course

During July 2009 a training course entitled 'Neuronal Microcircuits' was held at the Computer Sciences Faculty (UPM). The course was organized within the Cajal Blue Brain Project and was taught by Professor Rafael Yuste (Columbia University, New York) and Professor D. Javier de Felipe (Neural Circuits Laboratory- UPM/IC- CSIC). The total number of attendees was 30.
The programme of the course is described below.
Programme:
- Monday, July 6: Histology of the nervous system

-Wednesday, July 8 : Introduction to neural circuits (Chapters 1 and 2)
Monday, July 13 : Retina (Chapter 6)
- Wednesday, July 15: Olfactory bulb (Chapter 5)
- Monday, July 20: Cerebellum (Chapter 7)
- Wednesday, July 22: Hippocampus (Chapter 11)
- Monday, July 27: Cortex-1 (Chapter 12)
- Wednesday, July 29: Cortex-2 (Chapter 12)
- Friday, July 31: Delivery of final exams

Additional Information:
Detailed chapters in the previous Programme are referred to those of the book that was handed to each attendee at the beginning of the course. The reference of the book is the following: *Gordon M Shepherd, - The synaptic organization of the brain, 2004 - 4th edition. Oxford University Press*.

Seminars

1º) **Connectomics**: from reconstruction of neuronal circuits to the beginning of the organization. Professor Gonzalo Polavieja. April 2009.

2º) **Constitutive Modeling of Neuronal Cells**: Mechanical Characterization of Neuron Damage under Blast Loading

December 2009, Dr. Antoine Jérusalem, from IMDEA Materials / MIT.

Conference Contributions

'*Machine Learning and Neuroscience*' Coference October 2009
Participants of the Cajal Blue Brain Project, Dr. Concha Bielza and Dr. Pedro Larrañaga, have given a conference entitled 'Machine Learning and Neuroscience' at the University of Aveiro (Portugal) on October 6. The conference addressed issues of machine learning and optimization focused on neuroscience. Both, Dr. Concha Bielza and Dr. Pedro Larrañaga, are participants of the Cajal Blue Brain Project.

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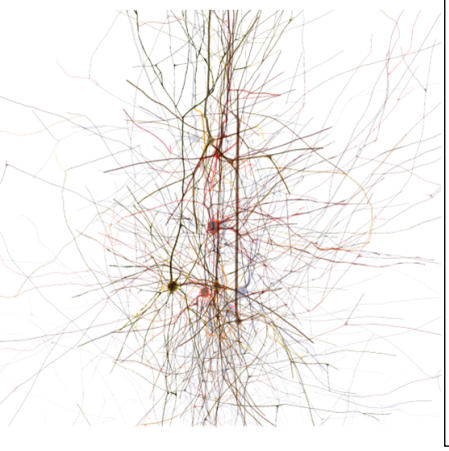
"*Computational Intelligence for Neuroscience*" Conference, October 2009
Participants of the Blue Brain Project, Dr. Concha Bielza and Dr. Pedro Larrañaga, have given a tutorial entitled "Computational Intelligence for Neuroscience" at the Discovery Science 2009 Conference which was held in Porto, October 2009.
Abstract
Reverse-engineer the human brain has been identified by the National Academy of Engineering in 2009 as one of the 14 challenges that will influence science and technology for the next decade This calls engineers and neuroscientists to work together. As participants of the Blue Brain international project (http://bluebrain.epfl.ch/), in this tutorial a number of interesting problems is described where Machine Learning and Neuroscience can collaborate.



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Special Session *IEA-AIE 2010*
Participants of the Cajal Blue Brain Project, together with other collaborators, contribute with a Special Session in *The Twenty Third International Conference on Industrial, Engineering & Other Applications of Applied Intelligent Systems2010 (IEA-AIE 2010),* which is going to be held on June 2010 in Córdoba, Spain (http://www.ieaaie2010.org/).
The Special Session is entitled *New Frontiers in Data Analysis, Optimization and Visualization for Bioinfomatics and Neuroscience,* and its main aim is to bring together researchers working on different topics from data analysis, optimization and visualization that develop their ideas in the fields of bioinformatics or neuroscience.

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Computer assisted identification, segmentation and quantification of synapses in the cerebral cortex.
Juan Morales, Lidia Alonso-Nanclares, José Rodrigo Rodríguez, Ángel Merchán Pérez Javier De Felipe, and Ángel Rodríguez
Abstract.
Synapses are key elements in the organization of nervous circuits. The application of combined focused ion beam milling and scanning electron microscopy allows the automated serial section and image acquisition from large samples of nervous tissue. However, the identification, 3D reconstruction and quantification of synapses within these samples are labor intensive procedures that require continuous user intervention. We have developed a software tool that performs the automated segmentation of synapses present in a reconstructed 3D volume of the cerebral cortex and thus greatly facilitates and accelerates these processes. The tool is interactive, allowing the user to supervise the process of segmentation, modify the appropriate parameters and validate the results. It is also modular to permit the implementation of new functionalities as needed. We have also focused on usability, through a friendly user interface, and portability, to make it accessible to a wide range of potential users.

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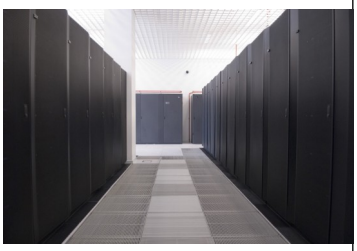
AmiLabContours : A tool for image structure segmentation
Luis Alvarez and Pedro Henriquez

Abstract.
We present AmiLabContours, an image processing tool for segmenting complex image structures. AmiLabContours has a friendly user interface which allow creating and modify 2D/3D contours. Contours can be modi_ed by hand or using active contours. Most of the contour operations are performed on the contour associated level set (the set inside the contour). In this paper we present an overview of AmiLabContours and we explore its application to electron microscopy image structure segmentation



Cajal Blue Brain publishing in PNAS

Cortical Explorer Award

Relevant Publications of the Project

Proximity of excitatory and inhibitory axon terminals adjacent to pyramidal cell bodies provides a putative basis for nonsynaptic interactions.

Ángel Merchán-Pérez, José-Rodrigo Rodriguez, Charles E. Ribak, and Javier DeFelipe

Abstract:
Although pyramidal cells are the main excitatory neurons in the cerebral cortex, it has recently been reported that they can evoke inhibitory postsynaptic currents in neighboring pyramidal neurons. These inhibitory effects were proposed to be mediated by putative axo-axonic excitatory synapses between the axon terminals of pyramidal cells and perisomatic inhibitory axon terminals [Ren M, Yoshimura Y, Takada N, Horibe S, Komatsu Y (2007) *Science* 316:758–761]. However, the existence of this type of axo-axonic synapse was not found using serial section electron microscopy. Instead, we observed that inhibitory axon terminals synapsing on pyramidal cell bodies were frequently apposed by terminals that established excitatory synapses with neighbouring dendrites. We propose that a spillover of glutamate from these excitatory synapses can activate the adjacent inhibitory axo-somatic terminals.

Reference: *9878–9883 PNAS June 16, 2009 vol. 106 no. 24*

Learning Hybridization Strategies in Evolutionary Algorithms

Antonio LaTorre, José María Peña and Santiago Muelas and Alex A. Freitas

Abstract
Evolutionary Algorithms are powerful optimization techniques which have been applied to many different problems, from complex mathematical functions to real-world applications. Some studies report performance improvements through the combination of different evolutionary approaches within the same hybrid algorithm. However, the mechanisms used to control this combination of evolutionary approaches are not as satisfactory as would be desirable. In most cases, there is no feedback from the algorithm nor any regulatory component that modifies the participation of each evolutionary approach in the overall search process. In some cases, the algorithm makes use of some information for an on-line adaptation of the participation of each algorithm. In this paper, the use of Reinforcement Learning (RL) is proposed as a mechanism to control how the different evolutionary approaches contribute to the overall search process. In particular, three learning policies based on one of the state-of-the-art RL algorithms, Q-Learning, have been considered and used to control the participation of each algorithm by learning the best-response mixed strategy.
To test this approach, a benchmark made up of six large-scale (500 dimensions) continuous optimization functions has been considered. The experimentation carried out has proved that RL control mechanisms successfully learn optimal patterns for the combination of evolutionary algorithms in most of the proposed functions, being able to improve the performance of both individual and non RL hybrid algorithms.

Reference: *Intelligent Data Analysis* 14 (3), 2010

Tripartite synapses: astrocytes process and control synaptic information

Gertrudis Perea, Marta Navarrete and Alfonso Araque

The term 'tripartite synapse' refers to a concept in synaptic physiology based on the demonstration of the existence of bidirectional communication between astrocytes and neurons. Consistent with this concept, in addition to the classic 'bipartite' information flow between the pre- and postsynaptic neurons, astrocytes exchange information with the synaptic neuronal elements, responding to synaptic activity and, in turn, regulating synaptic transmission. Because recent evidence has demonstrated that astrocytes integrate and process synaptic information and control synaptic transmission and plasticity, astrocytes, being active partners in synaptic function, are cellular elements involved in the processing, transfer and storage of information by the nervous system. Consequently, in contrast to the classically accepted paradigm that brain function results exclusively from neuronal activity, there is an emerging view, which we review herein, in which brain function actually arises from the coordinated activity of a network comprising both neurons and glia.

Reference: *Trends in Neurosciences Vol.32 No.8*

AWARDS

A member of the Cajal Blue Brain Project is announced as the winner of the 2009 Cortical Explorer Award.

Ruth Benavides Piccione, PhD, member of the Cajal Blue Brain Project, has been announced as the winner of the 2009 Krieg Cortical Kudos award (Cortical Explorer) for developmental neurobiology. The prize is awarded by the Cajal Club which is an organization of neuroscientists.

Each year, the Cajal Club presents Krieg Cortical Kudos Awards to neuroscientists at senior, intermediate, and beginning stages in their careers for outstanding research on the cerebral cortex. The award was made during the annual meeting of the Society for Neuroscience in Chicago, Illinois, at the Cajal Club Social on Sunday, October17. The Club now meets every year at the annual meeting of the Society for Neuroscience. The goals of the Cajal Club are to 1) revere Cajal, 2) provide an opportunity for neuroscientists with special interests in the structure and function of the nervous system to confraternize, and 3) contribute to the welfare of neuroanatomy and neuroanatomists

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More information: www.cesvima.upm.es

Sponsorship