HBP SCIENCE MARKET

THEORETICAL NEUROSCIENCE

SP4

What we do

Our researchers in Theoretical Neuroscience work to simulate and capture key biological processes using mathematical models in order to try help understanding the brain.
Theoretical Neuroscience is a link between experimentalists and technology. Brain mechanisms identified in the experimental HBP Subprojects are formalised into mathematical models, which are then made available to the HBP Platform Subprojects.
Theoretical Neuroscience is needed for linking scales, another fundamental aspect of brain exploration. Scientists investigate the brain at multiple levels, from the microscopic (synapses, neurons), through mesoscopic (brain circuits) to macroscopic scales (areas of the brain), and each method of investigation has its own specific scale, e.g. single-neuron recordings, imaging methods such as local field potential (LFP), up to large-scale imaging such as EEG, fMRI, etc. One needs theoreticians not only to understand how these signals are generated, but also how to link them together.
We also investigate key cognitive mechanisms, such as sensory processing (vision, auditory), learning and memory, spatial navigation or sensorimotor coordination through computational and mathematical models.
Our researchers use tools such as Python, Brian, NEST, etc., and ensure compatibility with the HBP Platforms. We use the same software environment, pyNN, as the one used on the Neuromorphic Computing Platform so that the program code of many of our models developed can be directly implemented to simulate neural networks. Many of our results obtained are open-access, and are at the core of the discussions held at the events of the European Institute for Theoretical Neuroscience .

How we are organised

WP4.1 BRIDGING SCALES. Aims to provide models linking different scales of investigation, including linking models over spatial scales, such as synapses (μm) single-cell (tens of μm), local network (mm) or whole brain region (cm), as well as linking between models of different levels of complexity (e.g. detailed vs. simplified neuron models). We also develop models of the different brain signals accessible experimentally, across different scales.
WP4.2 GENERIC MODELS OF BRAIN CIRCUITS.Aims to provide theoretical methods for large-scale simulations with generic network models. We will develop simplified large-scale models of specific brain areas and investigate the methodological aspects of model building.
WP4.3 LEARNING AND MEMORY. Aims to formulate synaptic plasticity algorithms from experimental data. We also aim to develop models of learning and reward, compatible with neuromorphic systems, and develop models of behavioural learning and long-term memory in the brain.
WP4.4 MODELS OF COGNITIVE PROCESSES. Aims to develop models of elementary cognitive processes that consider the different levels, from the biophysical level "network states" to sophisticated functions such as spatial navigation or decision-making. We aim to contribute to a multi-scale brain theory and develop large-scale models of cognitive functions that will bridge "high-level" behavioural and imaging data and detailed multilevel models of brain physiology.
WP4.5 LINKING MODEL ACTIVITY AND FUNCTION TO EXPERIMENTAL DATA. Aims to link theoretical models at different levels of description to create bridges between neuroscience and the models implemented in various HBP Platforms. This will involve mathematical principles and theoretical methods to integrate neuroscience data into models and compare the results with the existing data.
WP4.6 THE EUROPEAN INSTITUTE FOR THEORETICAL NEUROSCIENCE. Located in Paris area, the European Institute for Theoretical Neuroscience (EITN) aims to serve as an incubator of ideas and foster the exchange of ideas between theoreticians and experimentalists, and is open to researchers from the field worldwide, whether they are HBP Partners or not.
WP4.7 SCIENTIFIC COORDINATION. Coordinates and monitors the scientific activities of SP4, and the interactions with the other SPs.

SP LEADER Alain DESTEXHE
DEPUTY SP LEADERS Idan SEGEV
Viktor JIRSA
WORK PACKAGE LEADERS
- WP4.1 Bridging Scales: Alain DESTEXHE
- WP4.2 Generic Models of Brain Circuits: Markus DIESMANN
- WP4.3 Learning and Memory: Wulfram GERSTNER
- WP4.4 Models of Cognitive Processes: Gustavo DECO
- WP4.5 Linking Model Activity and Function to Experimental data: Sonja GRÜN AND Viktor JIRSA
- WP4.6 The European Institute for Theoretical Neuroscience: Alain DESTEXHE
- WP4.7 Scientific Coordination: Alain DESTEXHE

SP MANAGER Katherine FREGNAC

Publication highlights

Eyal G, London M, Globerson A, Ramaswamy S, Reimann M W, Muller E, Markram H, and Segev I. *Rich Cell-Type-Specific Network Topology in Neocortical Microcircuitry.* Nature Neuroscience. 2017, 20 (7): 1004–13. doi:10.1038/nn.4576.

Deco G, and Kringelbach M L. *Hierarchy of Information Processing in the Brain: A Novel 'Intrinsic Ignition' Framework.* Neuron 2017. 94 (5). Elsevier Inc.: 961–68. doi:10.1016/j.neuron.2017.03.028.

Katkov M, Romani S, and Tsodyks M. *Memory Retrieval from First Principles.* Neuron 2017, 94 (5). Elsevier Inc.: 1027–32. doi:10.1016/j.neuron.2017.03.048.

Zerlaut Y , Destexhe A. *Enhanced Responsiveness and Low-Level Awareness in Stochastic Network States.* Neuron 2017, 94 (5). Elsevier Inc.: 1002–9. doi:10.1016/j.neuron.2017.04.001.

Contact

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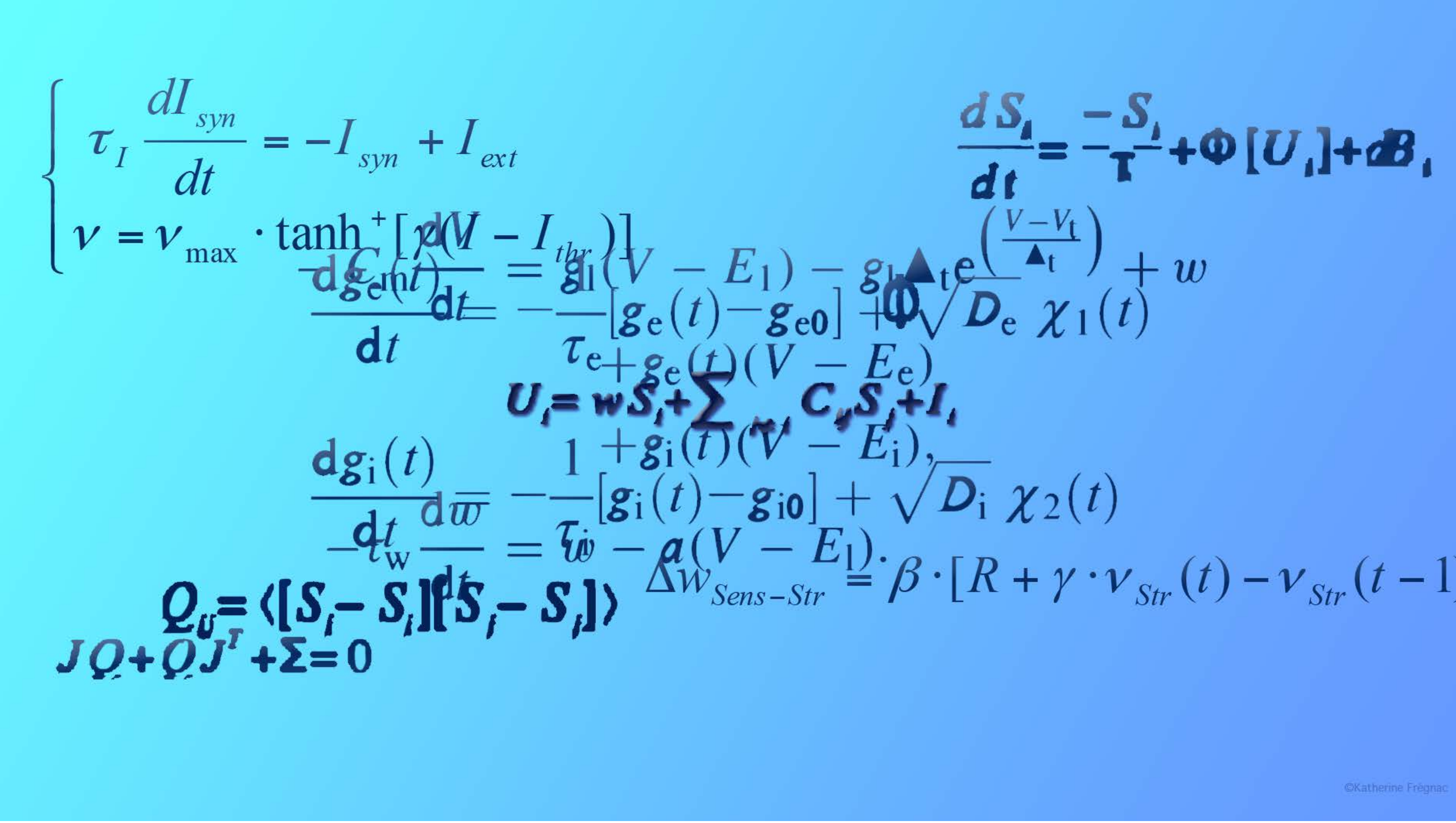
https://www.humanbrainproject.eu/en/about/project-structure/subprojects/



Human Brain Project

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