SloW-Dyn: Slow Wave Dynamics: from experiments, analysis and models to rhythm restoration

Main area: Theoretical and Mathematical Foundations of Neuroscience
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Abstract

Slow wave sleep and its underlying corticothalamocortical activity -slow oscillations- appears to be critical not only for memory but also for the maintenance of the brains structural and functional connectivity. At the same time, slow oscillations are an emergent pattern from the network, highly revealing of the underlying structure and dynamics of the system. In this project we plan to develop a data-constrained realistic model of the generation of slow oscillations. It will consist of a biophysically realistic model of adaptive exponential integrate-and-fire cells fully compatible with existing neuromorphic implementations in HBP. The model will go beyond state-of-art models by first describing mathematically and then fitting to real cortical data not only the first-order structure (mean), but also the second-order structure (variance and correlations) of the spatio-temporal organization of slow-wave oscillations. This model will be first developed and used to understand and document the cellular and network mechanisms slow wave oscillatory activity, and then to investigate the transformation of slow wave sleep with age and in two murine models of neurodegenerative disease associated to ageing. The model will be built and constrained using experimental data of cortical activity during slow oscillations obtained covering multiple scales. These data, together with a set of purpose-developed analytical methods, will reveal the causal contribution of genetically identified neurons to the slow wave dynamics, the 2D and 3D patterns of propagation of activity across different areas, an will go all the way to the very extensive data set of EEG obtained from large populations of humans during sleep through the SME in the project. A large emphasis will be on the analytical methods used at all levels, and the resulting tools will be useful for the scientific community. With this approach, we want to understand the underlying cortical system at multiple scales and reproduce it in silico. This will open up the possibilities for designing sensory stimulation patterns during sleep that restore young sleep in ageing individuals, an intervention expected to have a positive impact on cognition. This specific application will be directly accessible to society through the exploitation of the project led by the partner company.

Consortium

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