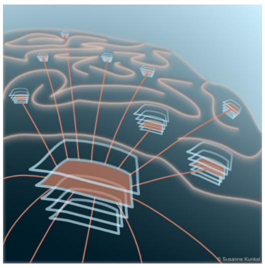

Institute of Neuroscience and Medicine (INM-6) *Computational and Systems Neuroscience* & Institute for Advanced Simulation (IAS-6) Theoretical Neuroscience & JARA Brain Institute I

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Preprint

Identifying anatomical origins of coexisting oscillations in the cortical microcircuit
Bos Hannah, Diesmann Markus, Helias Moritz (2015)
arXiv:1510.00642

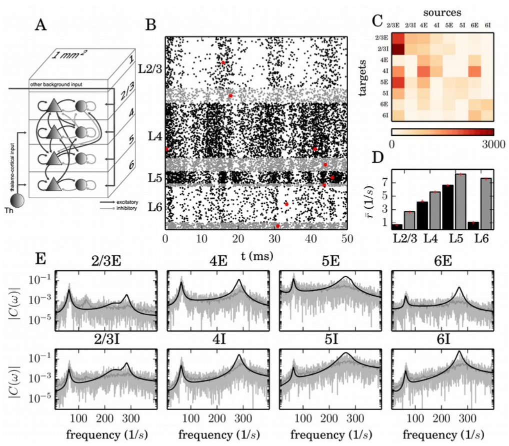

Figure 1: Activity in the microcircuit model
© Hannah Bos

Oscillations are omnipresent in neural population signals, like multi-unit recordings, EEG/MEG, and the local field potential. They have been linked to the population firing rate of neurons, with individual neurons firing in a close-to-irregular fashion at low rates. Using mean-field theory we predict the spectra generated in a layered microcircuit model of V1, composed of leaky integrate-and-fire neurons and based on connectivity compiled from anatomical and electrophysiological studies. The model exhibits low- and high-gamma oscillations visible in all populations. Since locally generated frequencies are imposed onto other populations, the origin of the oscillations cannot be deduced from the spectra. We develop a universally applicable systematic approach that identifies the anatomical circuits underlying the generation of oscillations in a given network. Based on a mean-field reduction, we derive a sensitivity measure resulting in a frequency-dependent connectivity map that reveals connections crucial for the peak amplitude and frequency of the observed oscillations and identifies the minimal circuit generating a given frequency.

Publications

Modulated escape from a metastable state driven by colored noise
Schuecker Jannis, Diesmann Markus, and Helias Moritz (2015), Phys. Rev. E 92, 052119
doi:10.1103/PhysRevE.92.052119

Many phenomena in nature are described by excitable systems driven by colored noise. The temporal correlations in the fluctuations hinder an analytical treatment. We here present a general method of reduction to a white-noise system, capturing the color of the noise by effective and time-dependent boundary conditions. We apply the formalism to a model of the excitability of neuronal membranes, the leaky integrate-and-fire neuron model, revealing an analytical expression for the linear response of the system valid up to moderate frequencies.

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The closed form analytical expression enables the characterization of the response properties of such excitable units and the assessment of oscillations emerging in networks thereof.

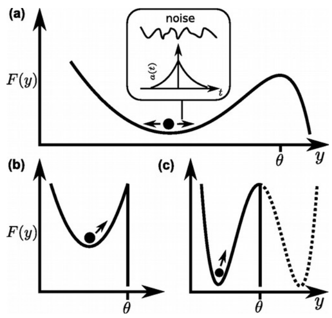

Figure 2: Escape from a metastable state
© Jannis Schuecker

Scalability of Asynchronous Networks Is Limited by One-to-One Mapping between Effective Connectivity and Correlations.

van Albada SJ, Helias M, Diesmann M (2015), PLoS Comput Biol 11(9): e1004490.
doi: 10.1371/journal.pcbi.1004490

Neural networks have two basic components: their structural elements (neurons and synapses), and the dynamics of these constituents. The so-called effective connectivity combines both components to yield a measure of the actual influence of physical connections.

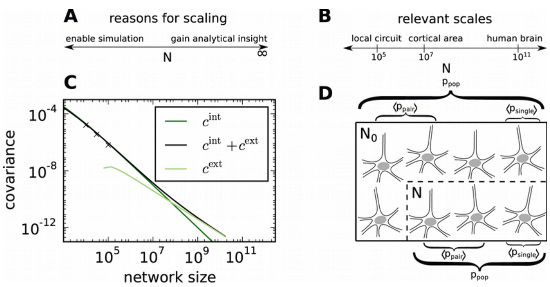

Figure 3: Framework for neural network scaling,
© SJ van Albada

Previous work showed effective connectivity to determine correlations, which quantify the co-activation of different neurons. Conversely, methods for estimating network structure from correlations have been developed. We here extend the range of networks for which the mapping between effective connectivity and correlations can be shown to be one-to-one, and clarify the conditions under which this equivalence holds. These findings apply to a class of networks that is often used, with some variations, to model the activity of cerebral cortex. Since the numbers of neurons and synapses in real mammalian brains are vast, such models tend to be reduced in size for simulation purposes. However, our findings imply that if we wish to retain the original dynamics including correlations, effective connectivity needs to be unchanged, from which we derive scaling laws for synaptic strengths and external inputs, and fundamental limits on the reducibility of network size. The work points to the importance of considering networks with realistic numbers of neurons and synapses.

Activities

NESTML Community Workshop
7-8 Dec 2015, Aachen

Figure 4: NEST Logo

During the workshop, a general introduction to model creation for NEST and an in-depth introduction to the concepts and application of NESTML were given.

Simulation of Biological Neuronal Networks
30 November - 11 December 2015, Freiburg
The yearly course took place in Freiburg.

… and many more. See:
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