RUHR-UNIVERSITÄT BOCHUM

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INSTITUT FÜR
KOGNITIVE
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Colloquium

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Tuesday, 25. September 2012, 18:00 s.t., GA 04/187

Host: Prof. Sen Cheng
Website: www.rub.de/cns
All interested students, scientists, and scholars are cordially invited to this talk of the IKN colloquium.

A topological approach to neuronal space representation

Our ability to navigate our environments relies on our ability to form a mental representation of them. The hippocampus plays a central role in this mental map, and it has been assumed that hippocampal place cells encode geometric information (distances, angles). But how is this information encoded—and how is it decoded? We reasoned that because downstream brain regions must be able to translate place cell spiking patterns into reasonable information about the environment, the temporal pattern of neuronal co-firing must be crucial for decoding spatial information. Furthermore, since co-firing implies spatial overlap of place fields, a map encoded by co-firing will be based on connectivity and adjacency rather than distances and angles, i.e., it will be a topological map. We tested this topological hypothesis with a simple model of hippocampal activity, varying several parameters in computer simulations of rat trajectories in distinct test environments. Using a computational algorithm based on recently developed tools from Persistent Homology theory in the field of algebraic topology, we find that the patterns of neuronal co-firing can, in fact, convey topological information about the environment in a biologically realistic length of time. Notably, our simulations reveal a “learning region” that highlights the interplay between parameters in producing hippocampal states that are more or less adept at map formation. For example, within the learning region a smaller number of neurons firing can be compensated by adjustments in firing rate or place field size, but beyond a certain point map formation begins to fail. We propose that this learning region provides a coherent theoretical lens through which to view conditions that impair spatial learning by altering place cell firing rates or spatial specificity.

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