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Topology of the microconnectome

The Blue Brain Project team recently provided the network graph for a neocortical microcircuit comprising 8 million connections between 31,000 neurons. Since traditional graph-theoretical methods may not be sufficient to understand the immense complexity of such a biological network, we explored whether methods from algebraic topology could provide a new perspective on its structural and functional organization. Structural topological analysis revealed that directed graphs representing connectivity among neurons in the microcircuit deviated significantly from different varieties of randomized graph. In particular, the directed graphs contained on the order of \(10^7\) simplices (groups of neurons with all-to-all directed connectivity). Some of these simplices contained up to eight neurons, making them the most extreme neuronal clustering motif ever reported. Functional topological analysis of simulated neuronal activity in the microcircuit revealed novel spatio-temporal metrics that provide an effective classification of functional responses to qualitatively different stimuli. This study represents the first algebraic topological analysis of structural connectomics and connectomics-based spatio-temporal activity in a biologically realistic neural microcircuit. The methods used in the study show promise for more general applications in network science. (Joint work with P. Dlotko, R. Levi, H. Markram, E. Muller, M. Nolte, M. Scolamiero, K. Turner)

4:00 p.m.
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