Abstract for 6th Chinese Computational and Cognitive Neuroscience Conference (CCCN 2024) (July 3-5, 2024)

Data-Based Large-Scale Models Provide a Window into the Organization of Cortical Computations

Guozhang Chen, Franz Scheer, Wolfgang Maass

School of computer science, Peking University, P. R. China

Institute of theoretical computer science, Graz University of Technology, Austria

Email: guozhang.chen@pku.edu.cn

The neocortex of the brain is one of the most powerful computing devices that exists, but it remains largely open how its computations are organized. Since the neocortex is a 2D tapestry consisting of repeating stereotypical local cortical microcircuits, a key step for solving this problem is to understand how cortical microcircuits compute. We know by now a lot about their connectivity structure and their neuron types, but we are lacking tools for elucidating causal relations between this structure and their computational function. We present a new tool for elucidating this relation: We train large-scale models of cortical microcircuits, which integrate most current knowledge about their structure, for carrying out similar computational tasks as in the brain. We show that the trained model achieves a similar computational performance as the brain, and that it reproduces experimentally found traits of cortical computation and coding that do not appear in neural network models from AI. Furthermore, we reverse-engineer how computations are organized in the model, thereby producing specific hypotheses that can be tested in experimental neuroscience. Altogether we show that cortical microcircuits provide a distinct new neural network paradigm that is of particular interest for neuromorphic engineering because it computes with highly energy-efficient sparse activity.