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Comparing data-driven architecture reconstructions of cortical microcircuits

Tuesday 18 June 2024 13:00 (20 minutes)

Microcircuits are the building blocks of the neocortex [1]. Single instances have been reconstructed experimentally (e.g., [2]), and their general dynamics and information processing capabilities have been investigated theoretically (e.g., [3,4]). Their connectivity is usually represented in connectivity maps consisting of probabilities that neurons establish connections. These maps reduce the complicated circuitry to simple relations between cell types, allowing for efficient instantiations of neural network models in parallel computers [5]. While higher-order features like connectivity motifs are neglected, they enable the discovery of how the underlying structural principles of local circuits are linked to their dynamics.

Recent years have seen significant advances in the application of electron microscopy (EM) for the reconstruction of local cortical networks through leveraging novel machine learning techniques ([6, 7]). These data allow for a more precise look into the architecture of local cortical circuits than was previously possible.

Here, we construct a layer-resolved, population-based connectivity map from a $1\ \mathrm{mm}^3$ EM reconstruction of mouse visual cortex [6]. We compare the obtained microcircuit connectivity based on EM data with a corresponding representation derived from light microscopy (LM) data [2]. The connectivity maps exhibit qualitative differences, e.g., in termination patterns of inter-laminar projections. Additionally, we find that the length scale of connectivity is consistently overestimated when using morphology-based approaches compared to the actual connectivity available from EM data. Finally, we simulate spiking neural networks constrained by the derived microcircuit architectures with NEST [8], investigating the extent to which simulated spiking activity is consistent with experimentally observed neural firing.

Acknowledgements

References

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Preferred form of presentation

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