Context-Driven Generation of Virtual Dendritic Morphologies Enables Complete Population-Level Construction and Analysis

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Dendritic morphology has been shown to have a dramatic impact on neuronal function, and there is an inherent variability in this morphology that is often overlooked when studying computation in neural networks. While detailed models for morphology and electrophysiology exist for many types of single neurons, the role of detailed single cell morphology in the population has not been studied in detail anatomically or computationally. Current techniques for the construction of morphological models largely ignore the structural location and context that the morphologies originate from, focusing on independent branching statistics. The current study instead uses the structural context of the neural tissue in which dendritic trees grow to drive the morphological generation process. Utilizing parallel computing, the complete population of the most numerous cell type in the hippocampus, the dentate gyrus granule cell, was generated within a realistic structural context, with a granule cell layer that contains all somata and a molecular layer that contains the dendritic trees. By growing dendrites within elliptical cones, which are characteristic of the dendritic field of dentate granule cells, in the realistic structural context of the volume of these neural layers, dendritic trees could be generated that were statistically and visually indistinguishable from experimental reconstructions. Branching statistics can now be linked to larger scale neuroanatomical features and the input organization of granule cells can be studied at the level of the population. This also provides a framework by which to populate network models with detailed single-cell morphological models and three-dimensional, intersection-based connectivity. This procedure can be repeated for other cell types within the dentate gyrus and for other brain regions, and represents a major advancement in the development of realistic large-scale neural network models.

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