Interneuron morphology representations for cell type discrimination: A systematic review.

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Editorial

In order to make individual morphologies accessible to normal statistics tools and machine learning algorithms, quantitative study of neuronal morphologies often begins with the selection of a specific feature representation. Many various feature representations, ranging from density maps to intersection profiles, have been proposed in the literature, but they have never been compared side by side. In this study, we conducted a thorough evaluation of different representations, assessing how well they captured the distinction between recognised morphological cell types. We employed multiple curated data sets of mouse retinal bipolar cells and cortical inhibitory neurons for our benchmarking attempt. The highest performing feature representations were discovered to be two-dimensional density maps, two-dimensional persistence pictures, and morphometric statistics, which performed well even when neurons were only partially traced. Combining these feature representations resulted in additional performance gains, indicating that they captured non-redundant information. The same representations performed well in an unsupervised scenario, indicating that they may be useful for dimensionality reduction or grouping. The advancement of experimental tools for high-throughput single cell RNA sequencing and large-scale functional imaging has sparked a renewed interest in finding the brain's building blocks-neural cell types.

Specialized quantitative methods are used to evaluate both data modalities. and provide data sets that may be analysed statistically, such as cell type identification by clustering. Simultaneously, the architecture of a neuron has been regarded the distinguishing characteristic of a neuronal cell type since the study of Santiago Ramón y Cajal (1899). Anatomical data sets have become much more accessible in recent years, thanks to improvements in light and electron microscopy, as well as accompanying technologies for increasingly automated reconstruction, much as they have in genetics and physiology. However, reliable quantitative representations of neuron morphologies are required for anatomical study of neuronal cell types based on these reconstructions. While numerous alternative representations have been produced in the literature, their ability to identify distinct cell types has seldom been thoroughly compared. Density maps and morphometric statistics are two prominent examples of such representations, representing opposite ends of the spectrum: density maps ignore all fine details of morphology, simply measuring the density of neurites; morphometric statistics, on the other hand, quantify the complex branching of axons and dendrites in a set of single-valued summary statistics. In this study, we compared how well different representations of neural morphologies captured the differences between known morphological types of interneurons. We used anatomical data from three studies that included over 500 retinal and cortical interneurons with complete axonal and dendritic reconstructions and expert annotated cell type labels. We utilised a supervised learning framework to provide a well-defined performance measure: given the expert labels, we questioned which morphological representations were best suited for cell type classification. We investigated how well various representations conveyed complementary information about cell shapes by merging them. Furthermore, we explored how resilient these representations are when only portions of a neuron are rebuilt, as well as how beneficial they are in an unsupervised situation.

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