Data-oriented Neuron Classification from Their Parts

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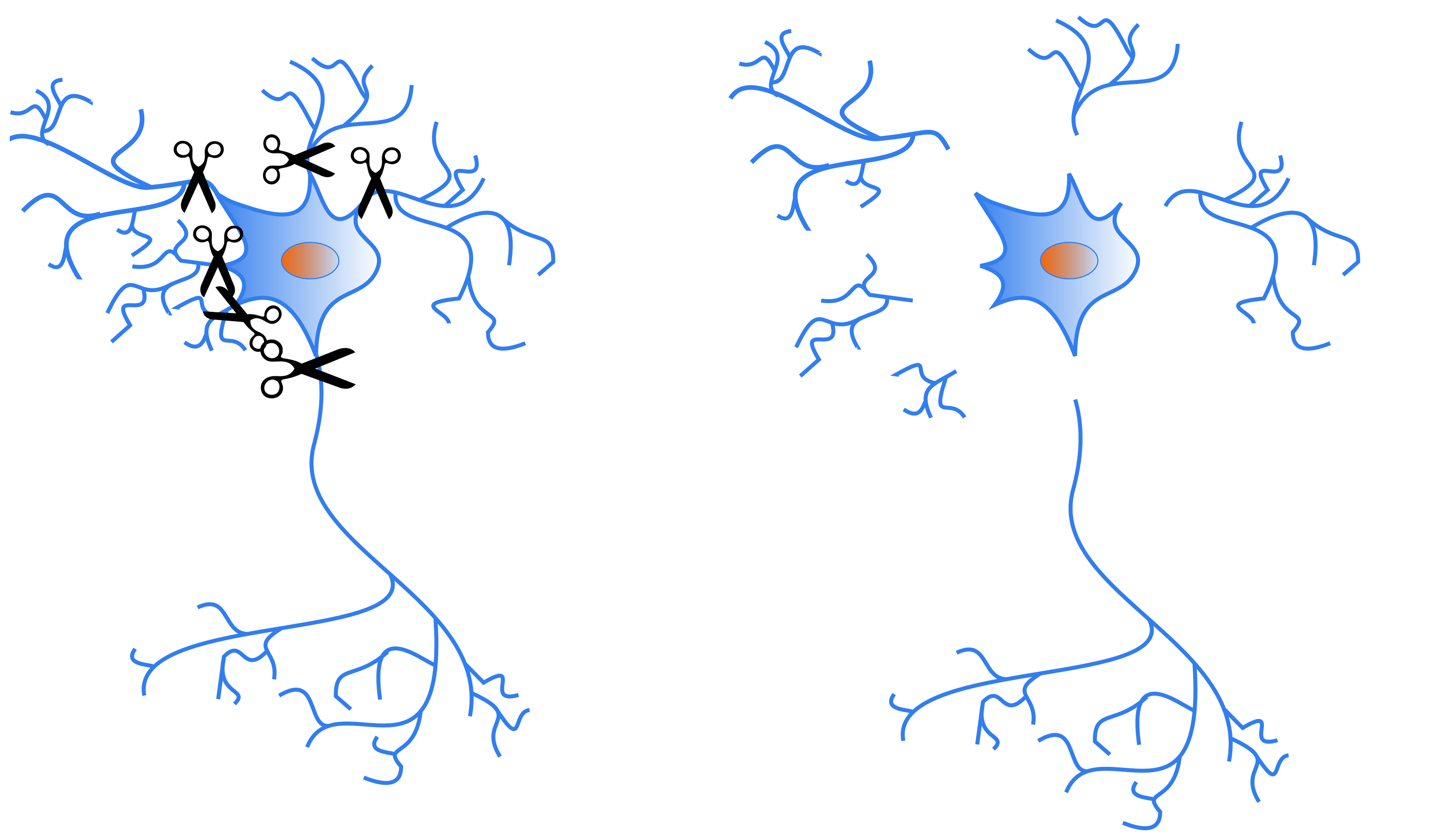
Abstract

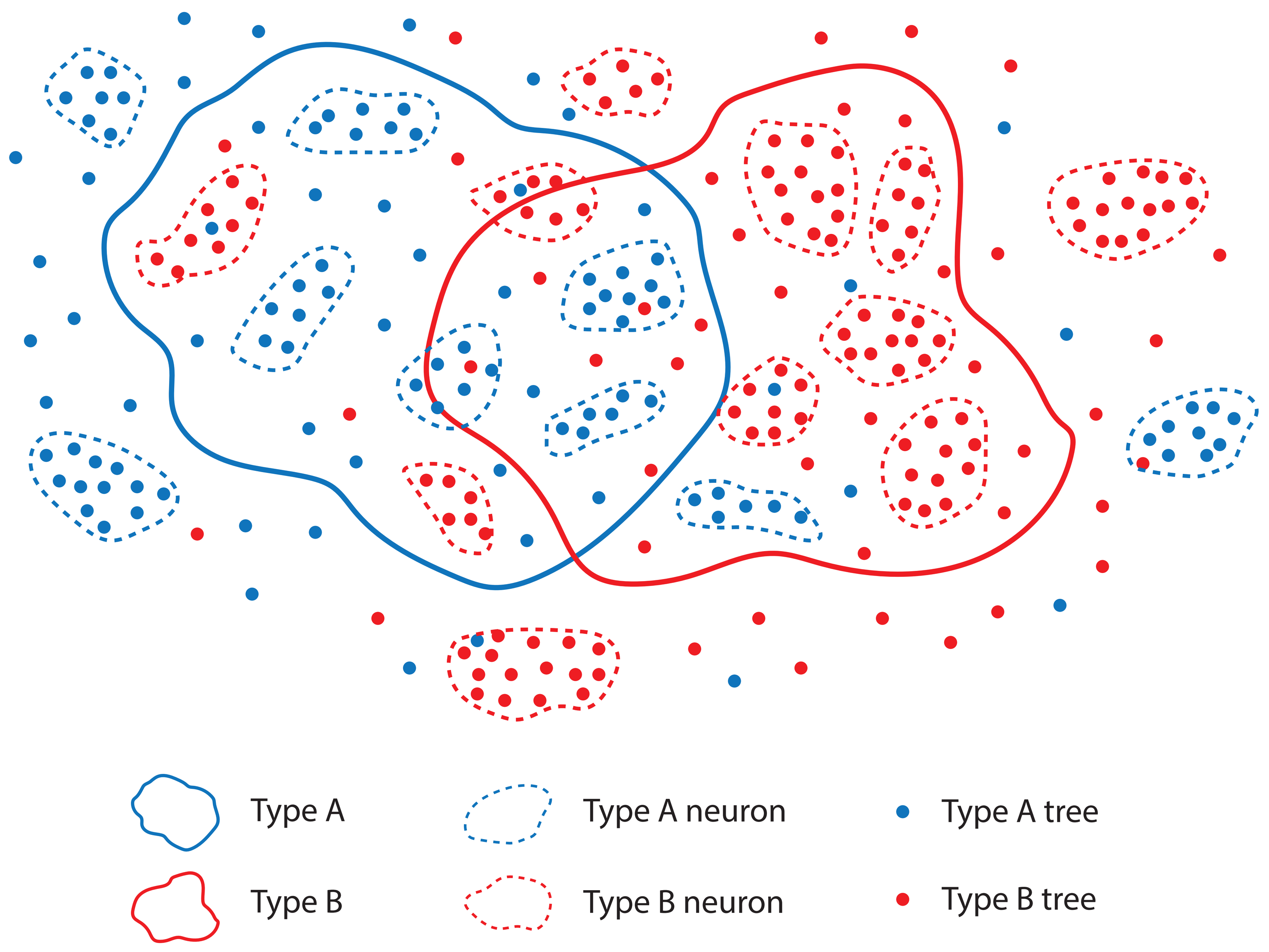
The shape of a neuron can reveal many interesting properties about its function. Therefore, organizing neuronal cells into appropriate classes according to their respective shape is a fundamental endeavor in neuroscience. Available online datasets allow new data-oriented approaches to solve such neuroscience problems. Here we analyze the feasibility of classifying neurons according not to their respective wholes, but to its constituent parts. Such a study may reveal interesting insights, including whether parts of the neuronal dendritic arborization preserve proper information about the morphology of the whole neuron. Experimental results using open datasets are reported, thus corroborating our approach.

Method

Current consideration of the neuronal morphology typically takes into account whole cells. It would be interesting to investigate whether the morphological properties distinguishing different types of neurons extend when the neuronal morphology is approached at more microscopic levels (e.g. branches, spines, channels, etc.).

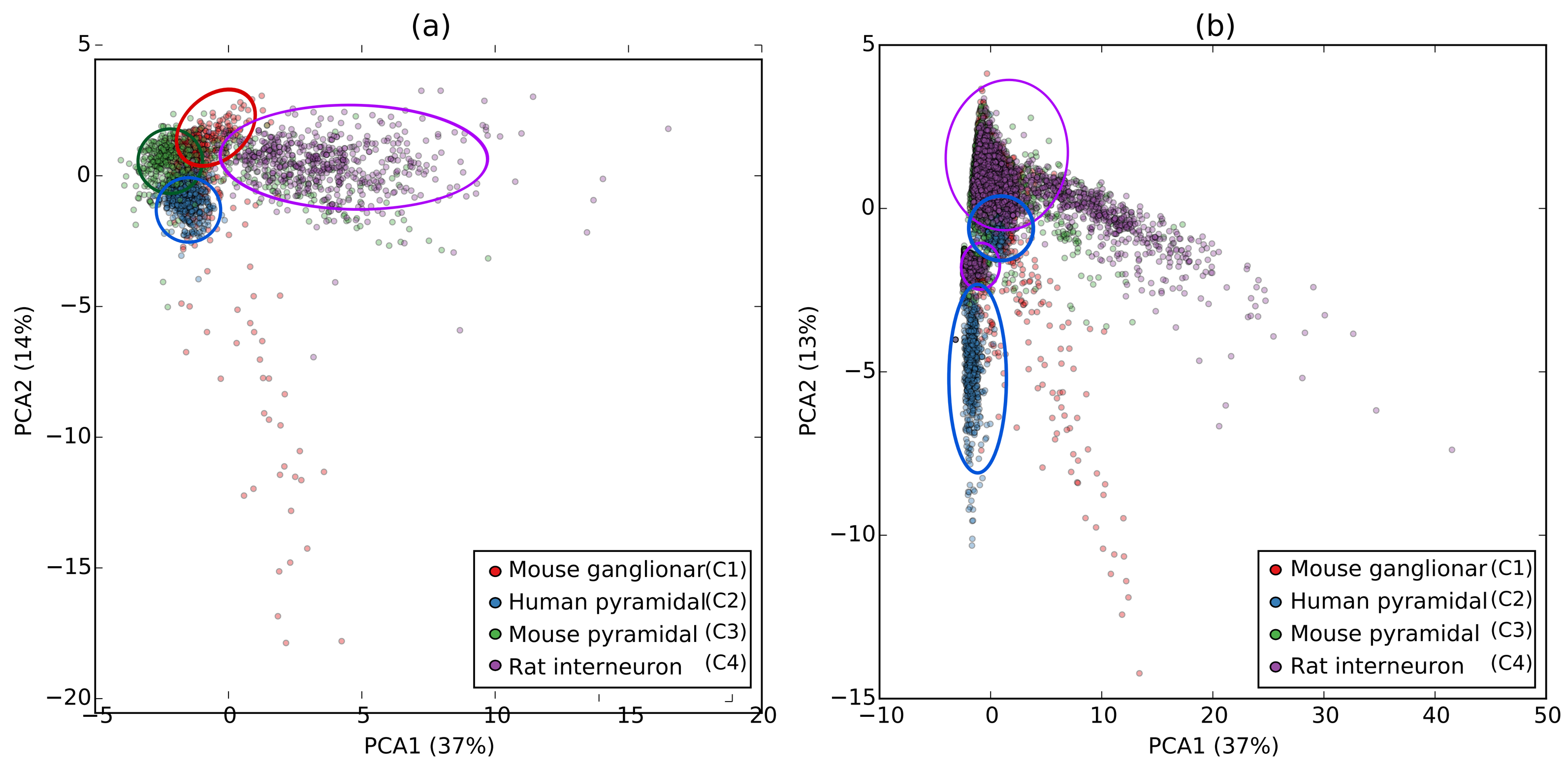


We consider two neuronal types, A and B. Such types are defined by a region in a feature space, which characterize the typical morphology of each type. Nevertheless, each distinct neuron, being it type A or B, belongs to different positions in such a space. Some neurons might even have characteristics that are not typical of their class, and therefore be located outside the class region. Furthermore, we consider that each neuron is in turn defined by a set of trees. We expect that trees from the same neuron will share similar properties. Yet, a given tree might not be typical of the neuron.

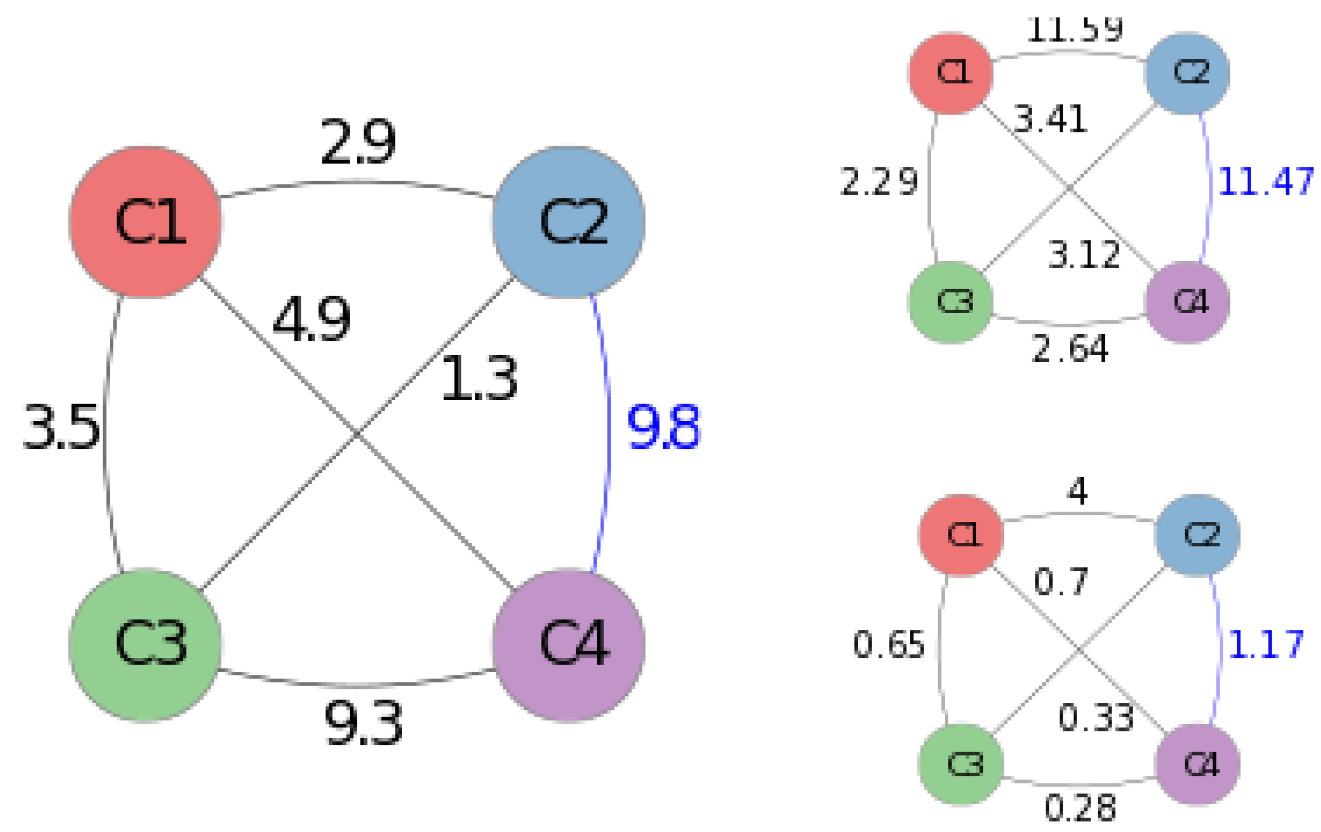


Results

Visualization of the first two principal components, found by the PCA algorithm, of the neuron dataset considered in the current study. The percentage of variance associated with each axis is indicated in the respective label of the axis. The principal components were calculated for features applied to the (a) whole neuron and (b) neuronal trees.



The PCA results indicate that the classes described by neuronal trees tend to be less separated in the feature space than when considering the whole cells. In order to better understand this effect, we estimated the scatter distances between each pair of neuron classes. It is clear that the two approaches result in widely distinct values for some class pairs. But at dendritic trees level there are features that still allow to distinguish classes.



Conclusions

- We present a method to characterize neurons using their dendritic trees instead of the respective whole cells.
- The results obtained indicate that the features characterizing the neuronal morphology extend from the whole cells to the smaller spatial scale of the respective neuronal trees, suggesting that the relevant differentiating characteristics are already found at this level.
- This preservation of discriminability was not identical for all the four classes.
- Future works: dismantle the neuronal cells not at the soma level, but along the hierarchy of the trees.

Acknowledgments