Final Project Proposal: Using Machine Learning Algorithms to Classify Neurons by Morphological Traits

Jason Chen, Xuanyu Dong, Zhiran Xie

Department of Biological Science, University of California, San Diego

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Dr. Mikio Aoi

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Background:

Identification of neurons of different classes is crucial to modeling the brain structure relied on the electrophysiology and neural circuit. Current methods for classification have several limitations such as inefficiency, inaccuracy, and the unclear number of classes of neurons. In order to deal with an increasingly large number of neurons and provide more accurate identification, the improvement of tools for neuron classification is in urgent need of attention. The paper, *Morphological Neuron Classification Using Machine Learning*, introduced a developed and integrated pipeline based on existing algorithms that can be used to classify and quantify neurons with their morphological characteristics (Vasques, Vanel, Villette & Cif, 2016). The paper tried to classify 430 neurons from NeuroMorpho.org, which is a database that includes digitally reconstructed neurons and glia. Specifically, different supervised and unsupervised classification methods were tested with preprocessed normalized neuron data with all designed algorithms mentioned in the paper. After initiating the estimators, the data were fitted into the model and assigned to different classes. The developers then tested and compared the accuracy with the classification assessment.

Proposed work

We will use original data to validate the result of the paper. Besides that, we will test again with 200 neurons each for both mice and humans randomly chosen from the database to ensure that the algorithms are generalizable. For supervised machine learning, we choose to compare LDA with k-Nearest Neighbors, Support vector machines (SVM), Decision Trees (DT), and Neural Networks. We expect that among these algorithms, linear discriminant analysis (LDA) should provide the highest accuracy (around 0.9 for all categories of neurons in the original experiment data), as the paper mentioned. Meanwhile, unsupervised learning including K-means, Ward, and affinity propagation algorithms will be tested and compared. We expect that the affinity propagation and Ward will produce slightly better results than others. Based on that, we will try to optimize algorithms by altering weights or biases or using different traits to produce similar or better performances. Various morphological features may be included in the analysis such as myelination, structure, length, action potential, channel ratios, and synaptic plasticity. Besides, we will introduce data from other databases if needed since generally for machine learning algorithms larger datasets will produce better results. Using machine learning algorithms to classify neurons by morphological features is appropriate because the data we will acquire from the database are matrices, which are desirable formats for machine learning algorithms to perform classification tasks (since the nature of machine learning is the calculation of vectors and matrices). We expect that optimization of our method might have improvement on accuracy and efficiency in the classification of neuron classes with precise parameters. To demonstrate the successful implementation of our method, we will print the results and metrics for all the algorithms we test and compare them with the result from the original paper. Figures and tables will be plotted to help prove this.

Delegation of duty

Group members should collaborate and discuss steps during the project process. Respect and integrity should be obeyed by group members. We decided to collect data and write code together, and each of the group members should accomplish their assigned tasks such as testing code or editing bugs. Zhiran Xie is responsible for introducing data and parameters. XUanyu Dong and Jason Chen will be responsible for editing and running the code.

Github Link for Project: https://github.com/JasonC1217/BIPN-162-Project

References

Vasques, X., Vanel, L., Villette, G., & Cif, L. (2016). Morphological Neuron Classification Using Machine Learning. Frontiers In Neuroanatomy, 10. doi: 10.3389/fnana.2016.00102