Cell Body Dry Mass Analysis

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Introduction

Neurons are incredibly important to our daily lives. The cells deliver sensory impulses or input in order for us to have proper motor and sensory functions. They send proteins from one neuron to another through the synapse in order to transmit protein signals. As a result, the cell body dry mass changes significantly. It is crucial that we study the connections between neurons and their cell body dry mass in order to analyze their state of functionality when in danger and in health.

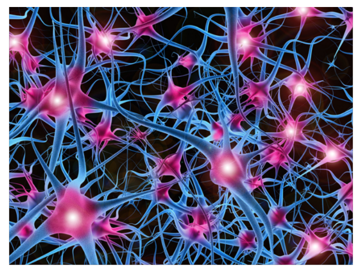


Fig1. Enhanced image of neurons that are all connected to one another.

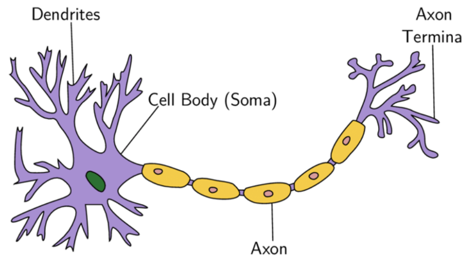


Fig2. A diagram of a neuron. The axon Terminal is used to send the signals.

Objective & Impact of Professor's Research

My Professor's lab is about using machine learning algorithms and mathematical models to analyze time series data, networks, and/or biological systems. This lab develops cyber physical systems through algorithms and mathematical models that are designed to analyze certain networks or models. Neurons act like networks as they are treated like nodes with edges used to support the body's main functions. Professor Bogdan's lab analyzes networks like these in order to produce results related to its functionality. Because neurons are essentially the fundamental units of the brain and the nervous system, researching and analyzing neurons and their connections to other neurons is very crucial in order to further understand MRI scans and other brain scans.

Acknowledgements

I would like to thank Professor Bogdan for giving me the opportunity to perform this research as well as my mentor Chenzhong Yin for guiding me through my project. Additionally, I would like to thank Emily Yamanaka, my Center Mentor, and Dr.Mills for supporting me through this research process especially during these hard times.

Research & Learning Process

Because pre-processing the neuron images requires intense algorithmic applications, I learned how to implement a KNN algorithm from scratch. I developed an algorithm that transformed an image into NumPy arrays and clustered the data points into 4 clusters, making the lines less blurry on the image.

Fig3. The raw image of the USC logo.

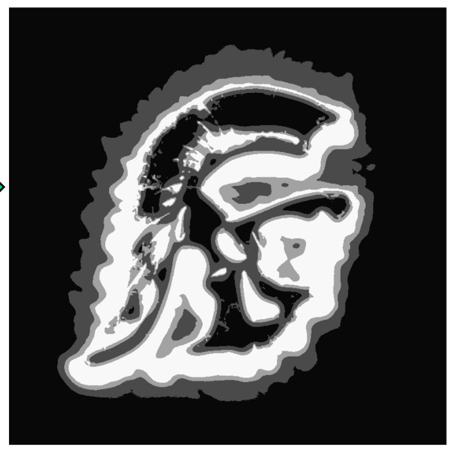
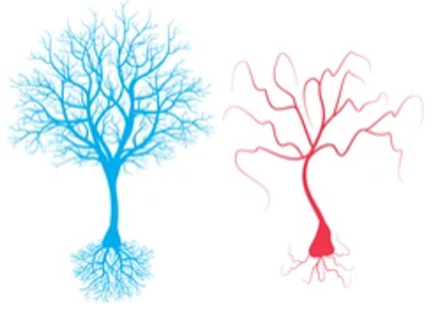


Fig4. The pre-processed image of the logo.

Then, I worked on my actual research, which was to analyze the Cell Body Dry Mass of a neuron. As a result of neurons transmitting proteins, the Cell Body Dry Mass often fluctuates and changes, informing us that the neuron is healthy and `functioning. However, TBI (Traumatic Brain Injury) Neurons are unhealthy and weak neurons. The unhealthy neurons can lead to severe motor and sensory loss and can even cause a patient to be brain dead.

Because I took AP Psychology and AP Computer Science A, I had great knowledge on the project in constructing the algorithms and how the structure of the neurons. I had to do some research on how the neurons would be affected after the brain had gone through severe brain tr



Fi healthy neuron (left) and a depleted, unhealthy neuron (right).

In the image above the red neuron has had severe damage as its dendrites and axons have lost its connections, destroying the network and damaging certain motor/sensory functions.

I had to learn how to analyze the different NumPy arrays that were derived from the images. This meant that I had to study the nodes matrix, adjacent matrix, and the mass matrix. The **nodes matrix** contains the different position of the neurons that is used to assign the corresponding mass of the neuron to another matrix. Additionally, the

Methods & Results

1. Use the NumPy array input to load the node and adjacency graph image of the set of TBI neurons at t = 0.

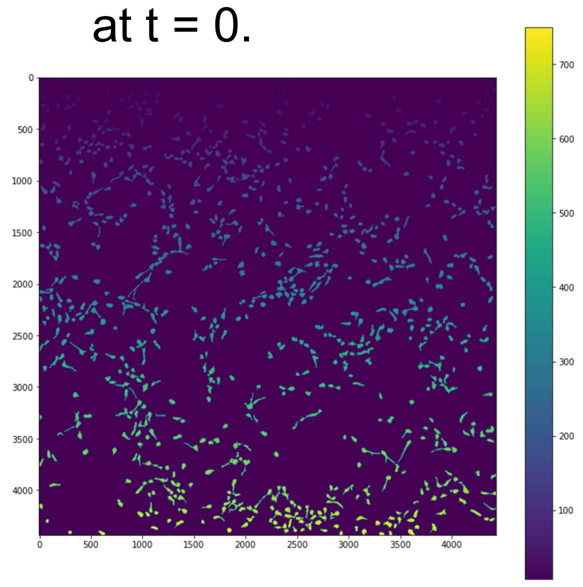


Fig6. The node neuron image at t = 0. The color of the neuron represents the range of the mass.

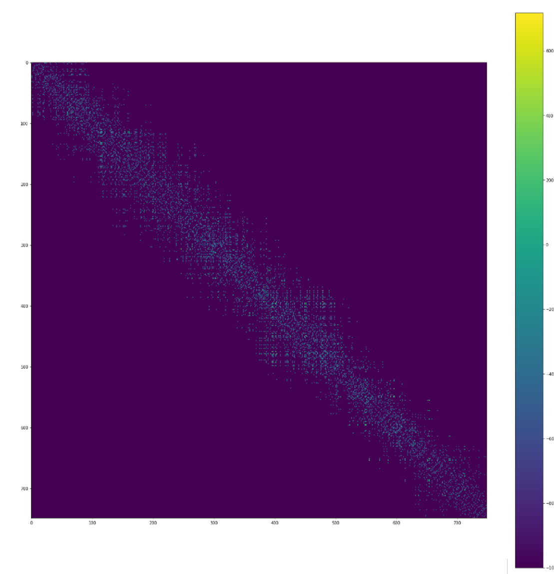


Fig7. The adjacency image at t = 0. The little dots represent each neuron and the color of the points represent the number of connections the neuron has.

1. I used the nodes matrix to retrieve the mass of each neuron. I iterated through the matrix and stored all the values where the mass was greater than zero in a list.
2. Use the adjacent matrix to determine the number of connections or neighbors each neuron has. I iterated through the adjacent matrix and found each connection in each column and stored the count in a list.
3. I later assigned the mass of each neuron to the number of connections that the neuron had in a 2D matrix. This will be the matrix that is graphed.
4. Develop an algorithm that will store the maximum, minimum, and mean mass value for each connection. I iterated through the matrix calculated in step 4 and found all the values.
5. Repeat the same steps for when t = 7 hours and t = 14 hours for comparison.
6. Plot the results in the same graph

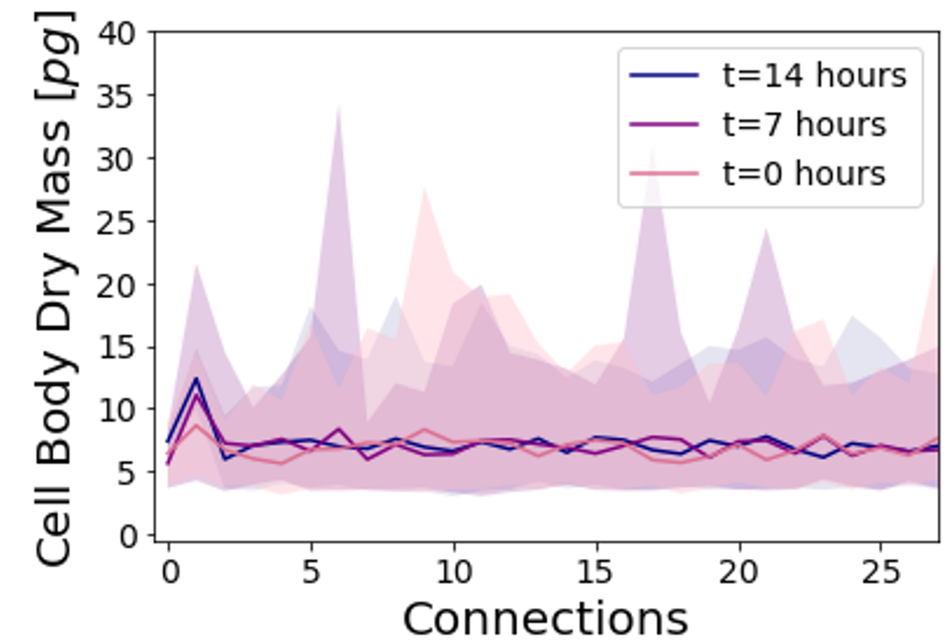


Fig8. The results graph of the Cell Body Dry Mass on the span of 14 hours.

Results Analysis

•The results show that there is a constant relationship between the number of connections and the Cell Body Dry Mass, indicating that the neurons have lost its functions due to the brain damage. If the neurons were healthy we would see that the dry mass would increase as the number of connections were increasing (positive correlation).
•Our work provides direct evidence of the hypothesis in the paper "Measuring physical properties of neuronal and glial cells with resonant microsensors" [3], that neurons have intrinsic growth potentials in terms of neuronal dry mass.

Next Steps for You

I hope to continue to work on using machine learning and mathematical models to analyze biological systems. I have watched documentaries where scientists have used machine learning to create an app that could scan skin blemishes to determine if it is a sign of skin cancer. Furthermore, I plan to learn more about neuron networks and how to use machine learning models to analyze images containing neurons and their nodes/connections.

Citations

[1] Yin, C., Xiao, X., Balaban, V. *et al.* Network science characteristics of brain-derived neuronal cultures deciphered from quantitative phase imaging data. *Sci Rep* **10,** 15078 (2020). https://doi.org/10.1038/s41598-020-72013-7
[2] Guo, Gongde & Wang, Hui & Bell, David & Bi, Yaxin. (2004). KNN Model-Based Approach in Classification.
[3 Corbin, Elise A., et al. "Measuring physical properties of neuronal and glial cells with resonant microsensors." Analytical chemistry 86.10 (2014): 4864-4872.