Comparison of Neuron Radius and Length Scaling Ratios from Angicart++ Image Reconstructions and Existing Morphological Reconstruction Data

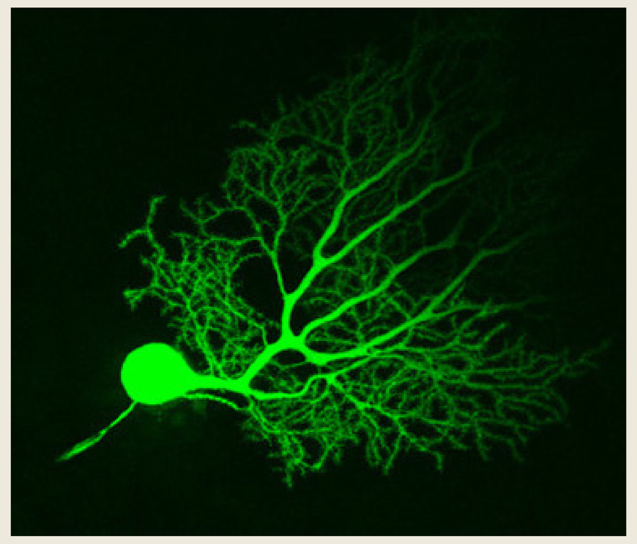
AUTHORS

Samhita Mallavarapu

AFFILIATIONS

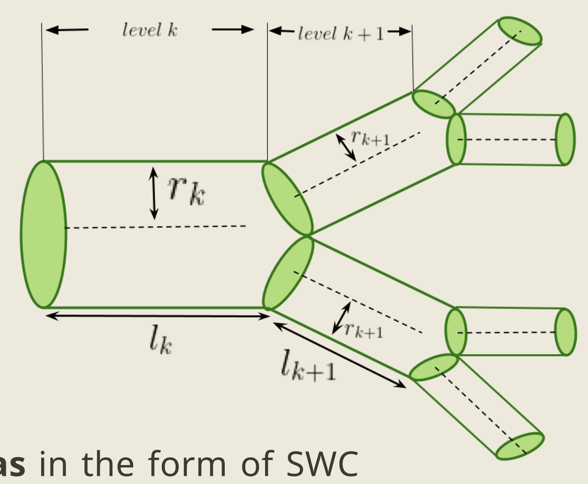
Principle Investigator: Dr. Van Savage
Mentor: Paheli Desai-Chowdhary
Department: UCLA Computational and Systems Biology

Introduction



- **Neurons**, connected through their networks of axons and dendrites, serve as the **primary messengers of information** throughout the brain and nervous system. This networks is what allows organisms to **relay information** and **respond to stimuli**.
- We can begin to understand the composition, structure, and function of the brain by looking at the **structure and function of neurons in relation to** the structure and function of **other neurons** .

- We built a **model** that takes into account the **theoretical biophysical properties** of the network that **utilizes cost functions and constraints** which we **solve for theoretical radius and length scaling ratios**. Then, we compared these models to other models constructed from the neuronal data to validate the use of this model.
- We use two different methods: **the SWC method** and the **Angicart++ method**.



- All the data utilized was sourced from the **Allen Brain Atlas** in the form of SWC data files (pixel-by-pixel data sets) and image stacks. We specifically looked at data from the **Middle Temporal Gyrus (MTG) layer 6**.

radius scaling ratio $\quad$ length scaling ratio

$$\frac{r_k+1}{r_k} \qquad \frac{l_k+1}{l_k}$$

Objective

To validate the use of Angicart++ as a tool to study the structure and function of neurons in order to further study the composition, structure, and function of the brain

Refrences

[1] Allen Institute for Brain Science. Allen Human Brain Atlas. 2010 [cited 2021 December 9]. Available from: http://celltypes.brain-map.org/experiment/morphology/613396614.

[2] Desai-Chowdhry P, Brummer A, Savage V. How Axon and Dendrite Branching Are Governed by Time, Energy, and Spatial Constraints . bioRxiv 2021.07.15.452445; doi: https://doi.org/10.1101/2021.07.15.452445.

[3] Newberry MG, Ennis DB, Savage S, Cox VM. Testing Foundations of Biological Scaling Theory Using Automated Measurements of Vascular Networks. PLoS Computational Biology. 2015; 11(8): e1004455.

[4] OpenCV Documentation. OpenCV Open Source Computer Vision. [cited 2021 December 9]. Available from: https://docs.opencv.org/4.x/d1/dfb/intro.html.

[5] Savage VM, Deeds EJ, Fontana W. Sizing up Allometric Scaling Theory. PLoS Computational Biology. 2008; 4(9):e1000171.

Methodology

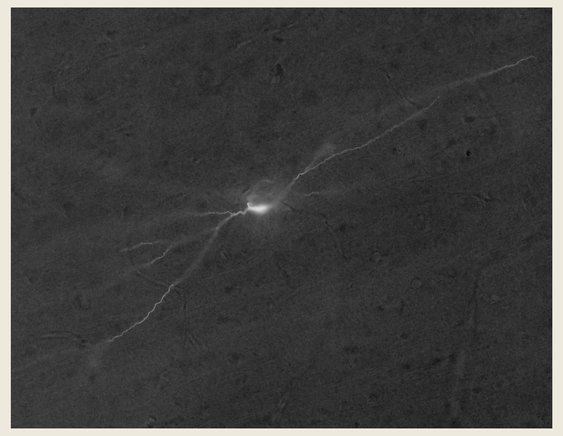
SWC File Method

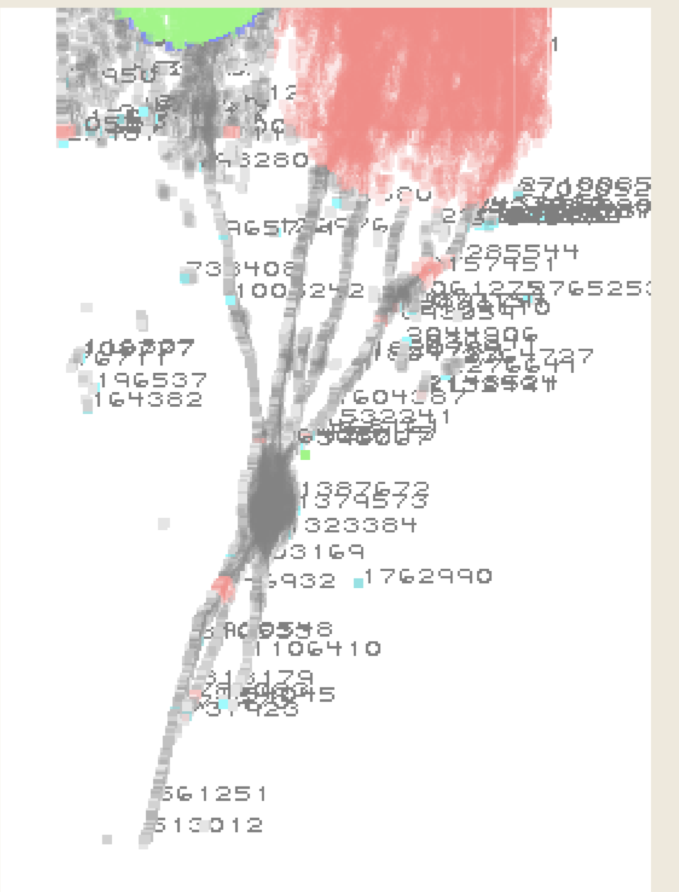
- Download SWC Files from Allen Brain Atlas
- Organize the data branch by branch
- Extract average radius and length of each branch
- Loop through the data to get scaling ratios
- Create histograms and compare to other method
- Create another set of data by combining the data of 3 SWC files and repeat the previous procedures

Angicart++ Method

- Download image stacks from Allen Brain Atlas
- Invert, downsample, and adjust range of the images
- Run images through Angicart++ software to extract radius and length of the branches
- Loop through the data to get scaling ratios
- Run the threshold analysis
- Create histograms and compare to other method

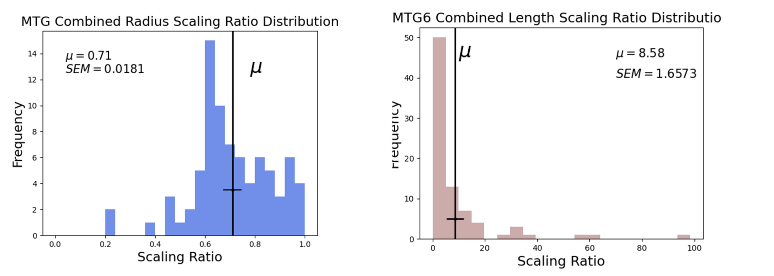
Images



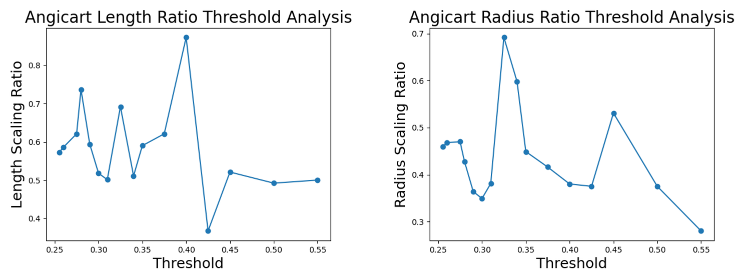


Results

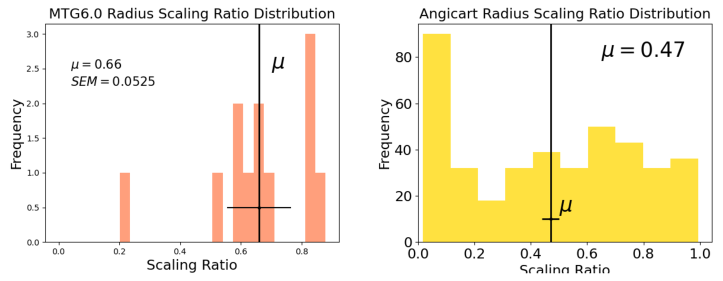
Combined SWC Files Radius and Length Comparison



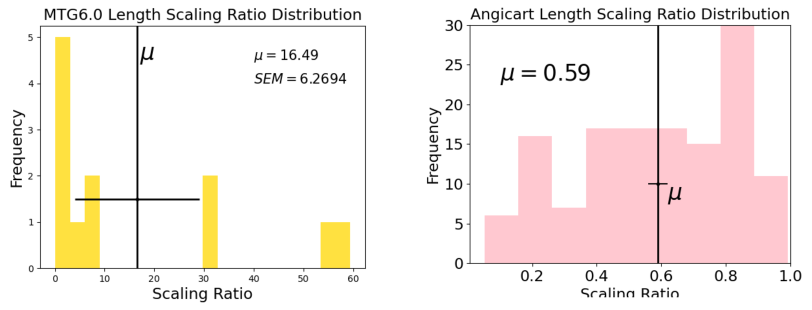
Angicart++ Threshold Analysis



Radius Comparison



Length Comparison



Conclusion and Future Directions

- Using a **combination of three SWC files** resulted in a **smaller error than a singular SWC file**.
- The distribution of the **radius scaling ratio** is **uni-modal and slightly skewed to the right with few outliers** while the distribution of the **length scaling ratio** is **uni-modal and noticeably right skewed with many outliers**. This could be because the radius of a parent and daughter branch of a neuron has a lower variance than the length. Additionally, as branching occurs, the radius gets smaller but this is not necessarily the same with the length.
- The **0.26 threshold** is optimal to conduct comparisons.
- There are **significant differences** between the SWC and Angicart++ distributions.
- The distribution of the **SWC File radius histogram** is **left skewed and contains gaps**. The distribution of the **Angicart++ radius histogram** is **right skewed and more continuous**. The **mean of the SWC file radius data** is **higher** with a **larger error**.
- The distribution of the **SWC File length histogram** is **right skewed and contains gaps**. The distribution of the Angicart++ radius histogram is **left skewed and more continuous**. The **error of the SWC file length data is larger**. The **means appear to be on an entirely different scale**.
- Discrepancies could be because **SWC files have less data** and that **Angicart++ analysis is based on a specific set of images**, not the whole stack.
- For future studies, we will use a **larger sample size** in order to get a better understanding of how the SWC outputs compare to the Angicart++ outputs. Once we can tailor and validate Angicart++ to work with this type of data, we will be able to answer the question of why different neuron types have a different branching networks.