

Graphical User Interface for Semi-Automated Tracing of Neuronal Processes

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Summary

- We aimed to build a tool for faster neuron tracing in neuromorphological research.
- Our hidden Markov modeling based approach incorporates a geometric prior and the image appearance likelihood.
- The globally optimal sequence of neuron fragments is computed efficiently with dynamic programming.
- *ViterBrain* outperforms state-of-the-art on a dataset of partial axons in a MouseLight brain image.
- Our algorithm is available as a napari plugin in our open-source Python package, brainlit.

Motivation

- A neuron's morphology determines how it integrates into brain circuits and contributes to overall brain function.
- Efforts to build brain-wide atlases of neuron morphology in the mouse rely on laborious manual tracing [1].
- Future work in human brains will exacerbate this bottleneck.

Data

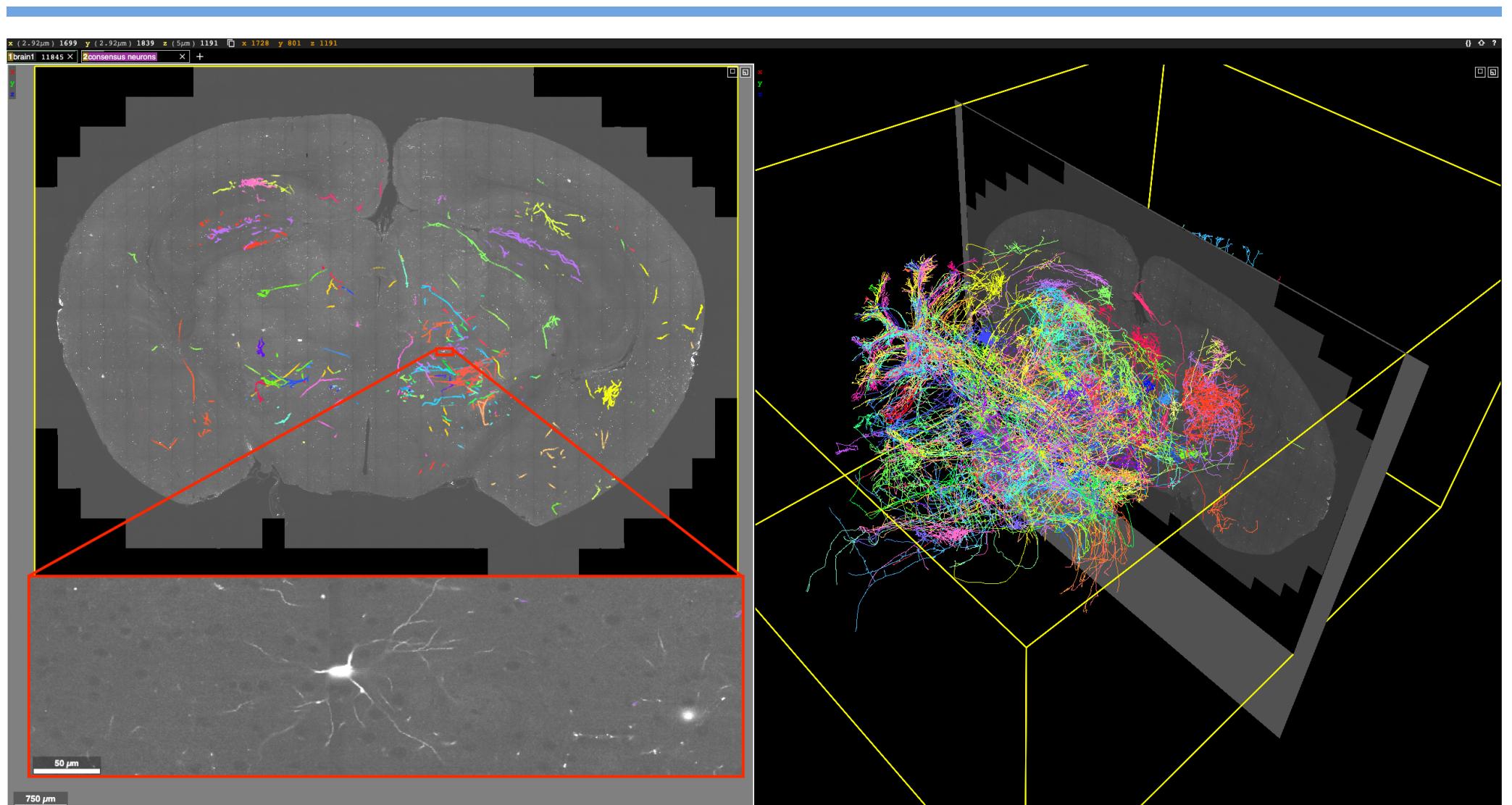


Fig 1: Sample from Janelia Mouselight project. Sparse labeling is achieved using a diluted AAV Syn-iCre and a Cre-dependent reporter. Images are acquired by serial two-photon tomography at $0.3 \times 0.3 \times 1.0 \mu\text{m}^3$ resolution.

HMM Based Reconstruction

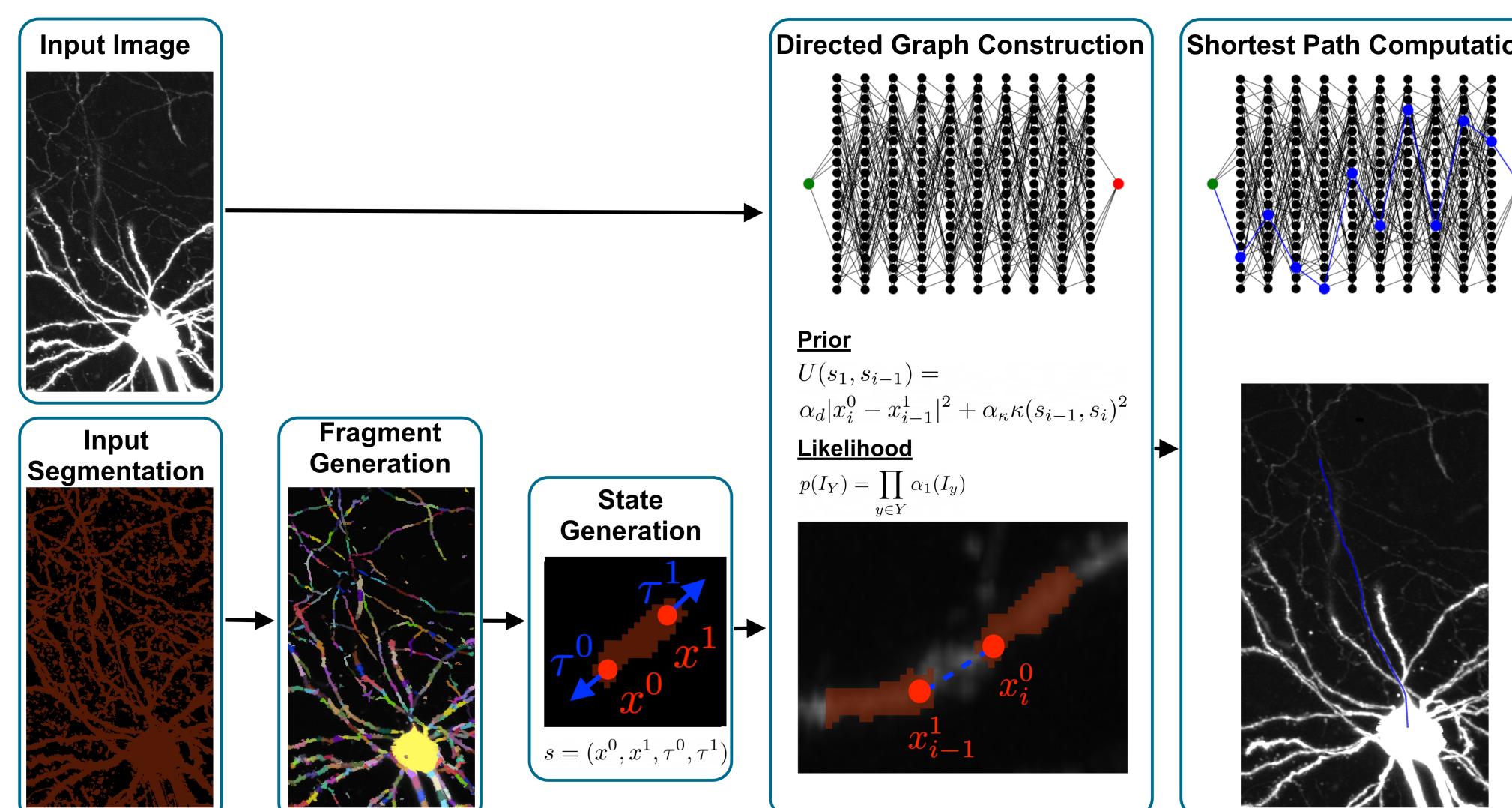


Fig 2: Overview of *ViterBrain* algorithm [2]. *ViterBrain* takes in an image and probability mask. The mask is processed into a set of fragments, whose endpoints and endpoint tangent vectors are estimated. Transition probabilities are computed according to image data and fragment geometry then the globally optimal fragment sequence is computed.

- Identify sequence of neuron fragments $\{f_i\}_{i=1}^n$ that follows neuronal path.
- Hidden Markov model incorporates:
 - i. Observed variable: Image data I
 - ii. Hidden variable: Neuron path $\{f_i\}_{i=1}^n$

Results and Conclusions

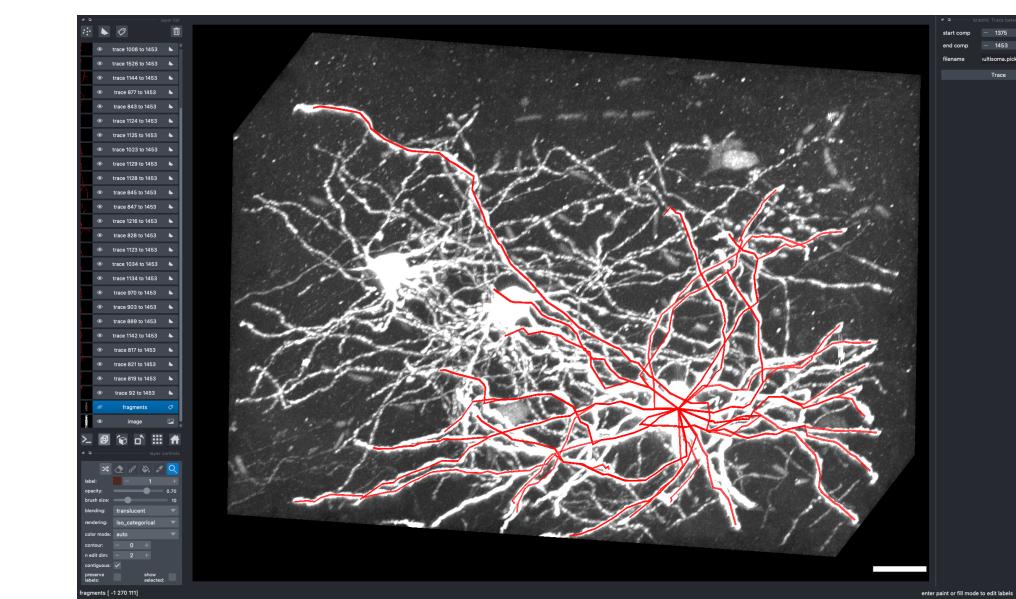


Fig 3: A neuron that was partially traced using the *ViterBrain* napari plugin. The plugin widget is on the right toolbar. The scale bar represents 20 microns.

- *ViterBrain* had a significantly higher success rate than state-of-the-art algorithms in a dataset of partial axons in a MouseLight brain sample [1].
- We built a plugin for napari, a popular multidimensional image viewer in Python, which can be used to accelerate neuron reconstruction workflows.

Limitations and extensions

- More work is needed to extend the algorithm to densely tangled neurons, and to whole-brain volumes.

Code

brainlit.neurodata.io



References

- [1] Winnubst J. et. al. Cell. 2019;179(1):268-281.
 [2] Athey T. L. et. al. arXiv. 2022;2106.02701.

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