Immersive Neuron Tracing in Large-scale Microscopy Data

Will Usher, Pavol Klacansky, Frederick Federer, Peer-Timo Bremer, Aaron Knoll, Jeff Yarch, Alessandra Angelucci, Aniketh Venkat, Duong Hoang, Attila Gyulassy, Peer-Timo Bremer, Torin McDonald, Nate Morrical, Steve Petruzza, Valerio Pascucci
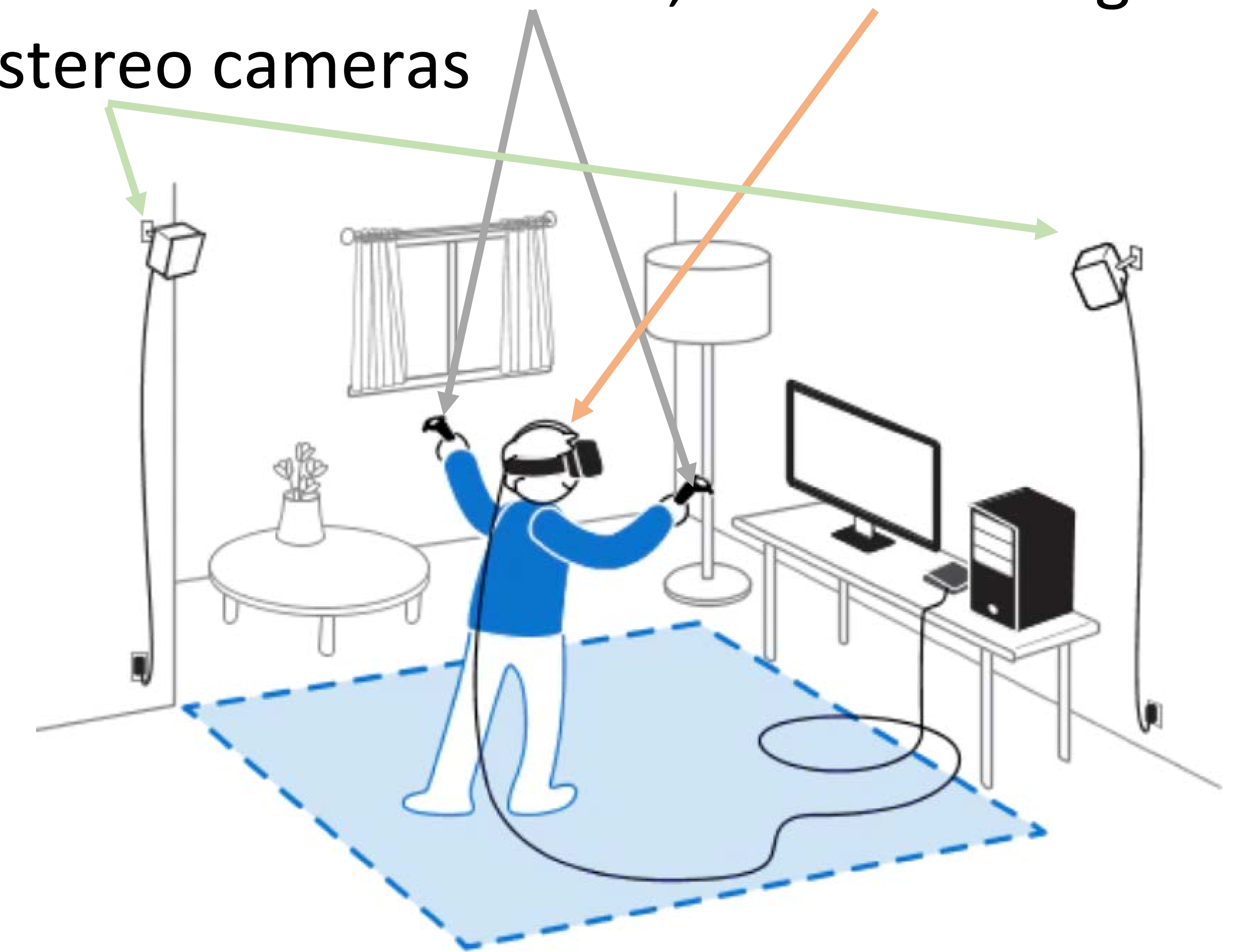The Center for Extreme Data Management Analysis and Visualization (CEDMAV)

Challenges of Neuron Tracing

The goal is to **establish a wiring diagram of the brain**, which is needed to understand how neural circuits in the brain process information and generate behavior.

- We maintain manual user control because **fully automated** techniques often **fail**
- Connectomics researchers may spend **weeks or months manually** tracing using 2D image stacks: we need to increase performance without quality compromises.

## New VR System for Neuron Tracing in Large-scale Microscopy Data

We design a new virtual reality (VR) system in collaboration with trained neuroanatomists to trace neurons in microscope scans of the visual cortex of primates.
Our results are demonstrated:

- with off-the-shelf **consumer-grade** VR technology (the HTC Vive)
- with a **fast** process that generates **accurate** results
- in a system that handles **order-of-magnitude larger** data than existing solutions

Virtual Reality(VR) for Visualization

Why: enhancing 3D data understanding
How: with controllers, Head tracking and stereo cameras
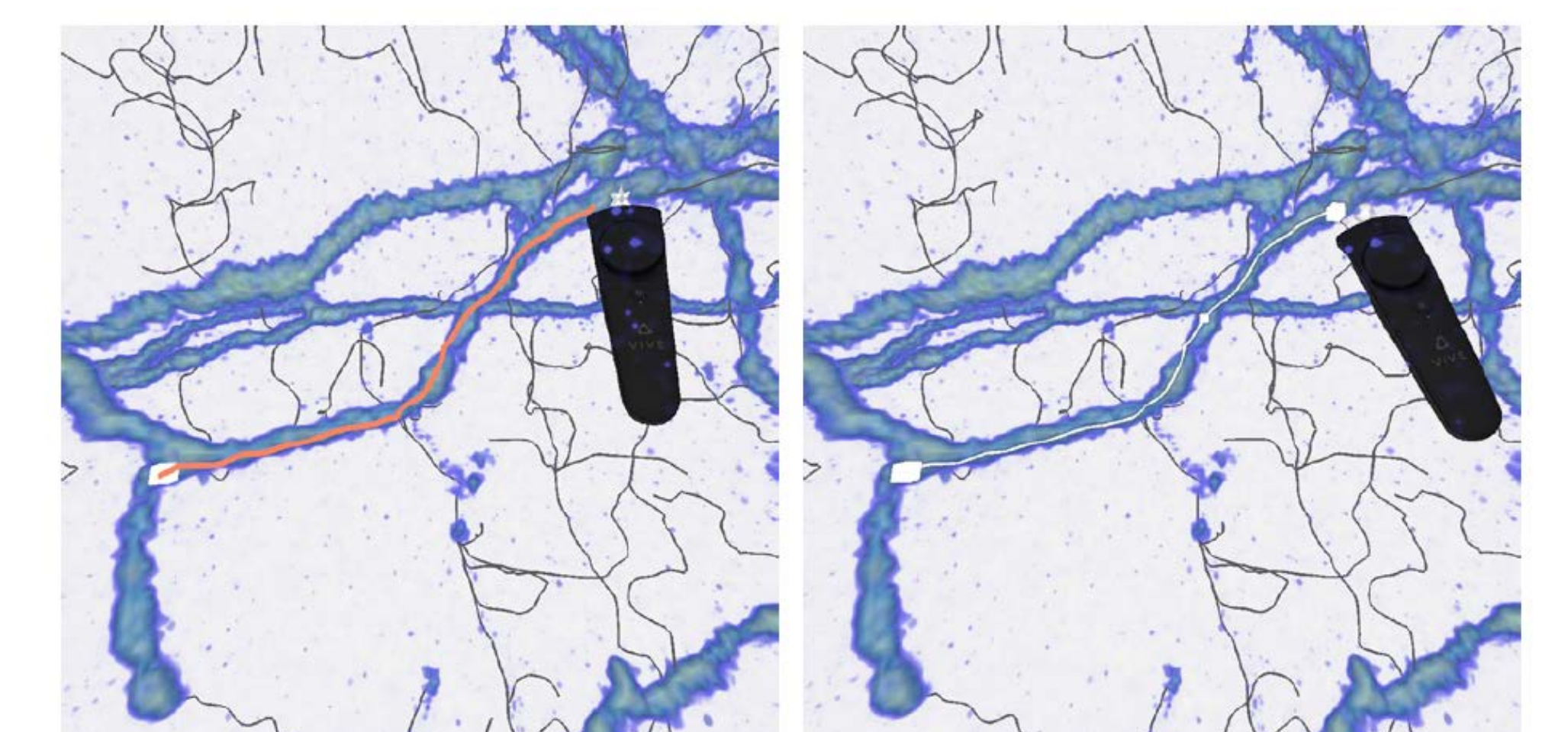
Real-world Usability Improvements
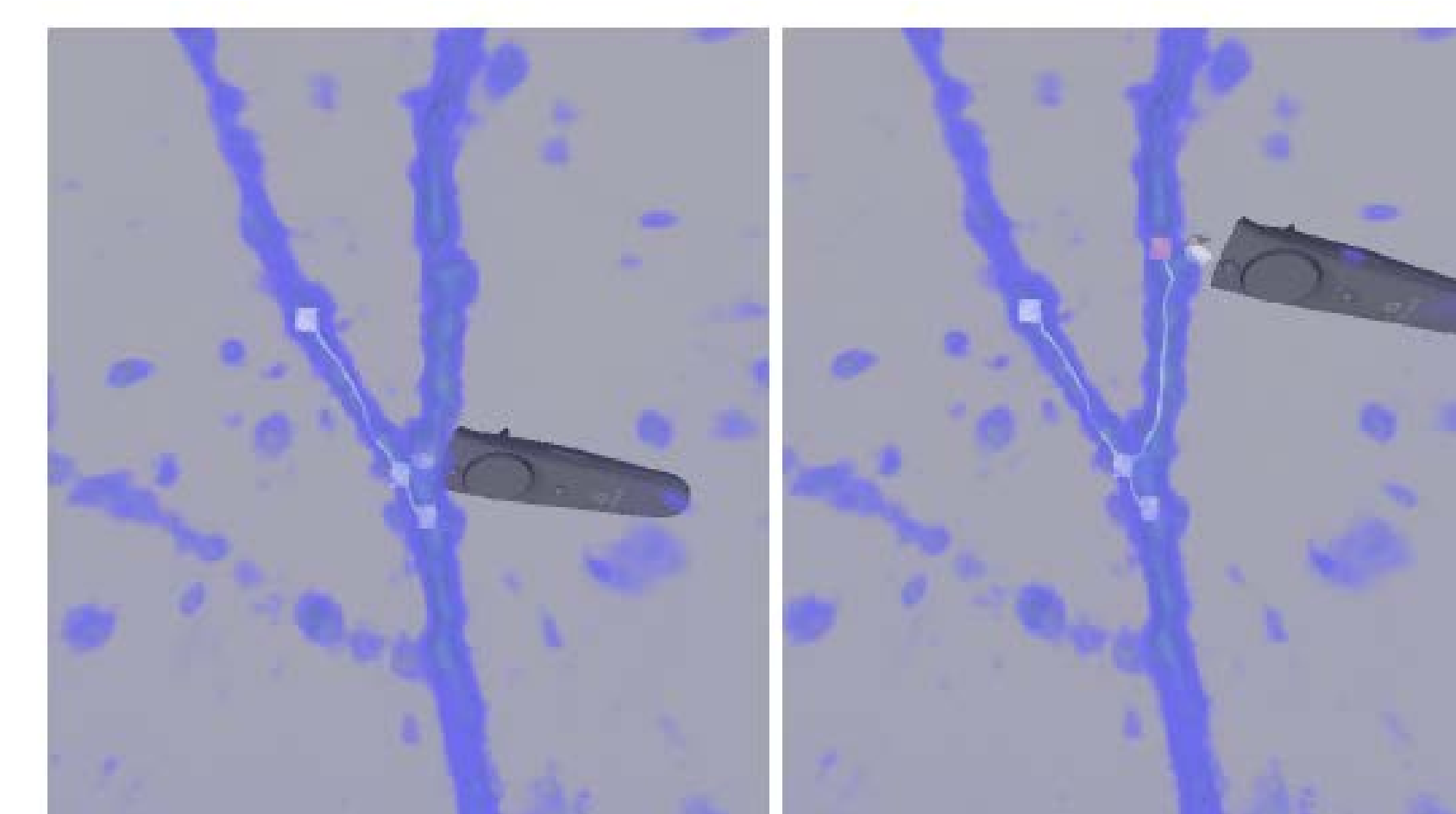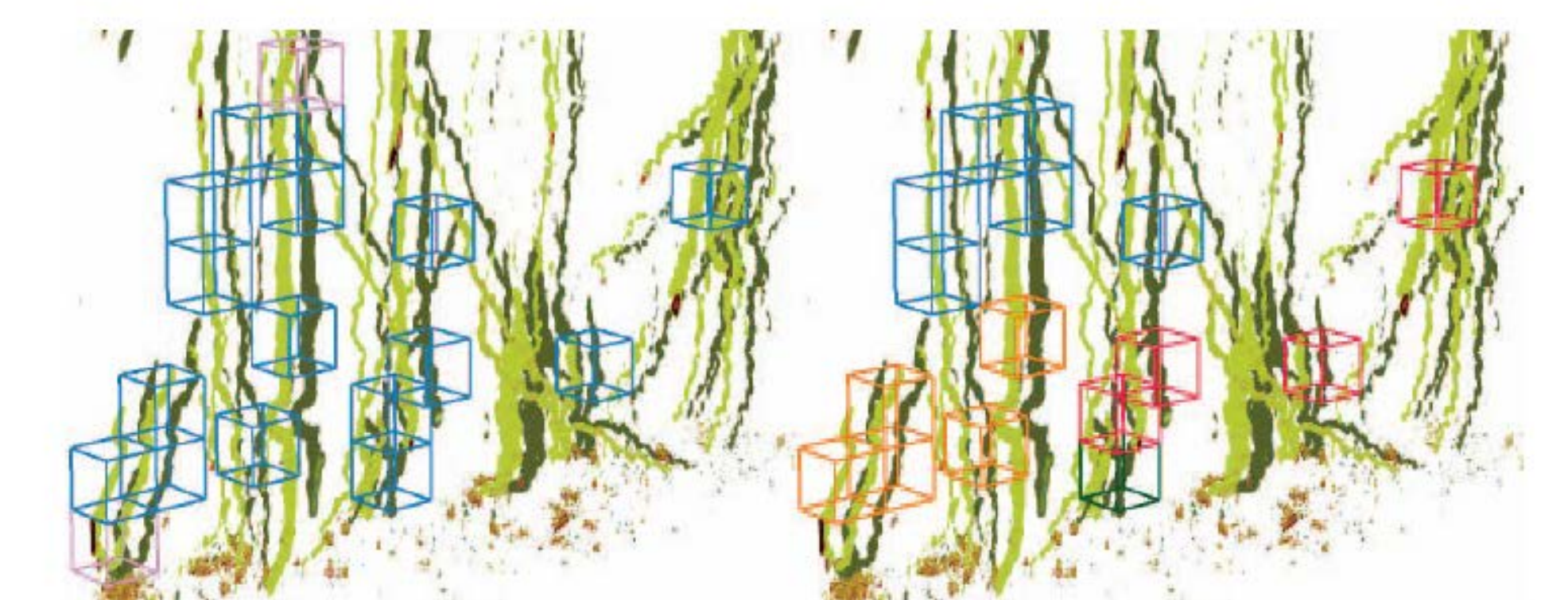
(a) Branching from an existing line
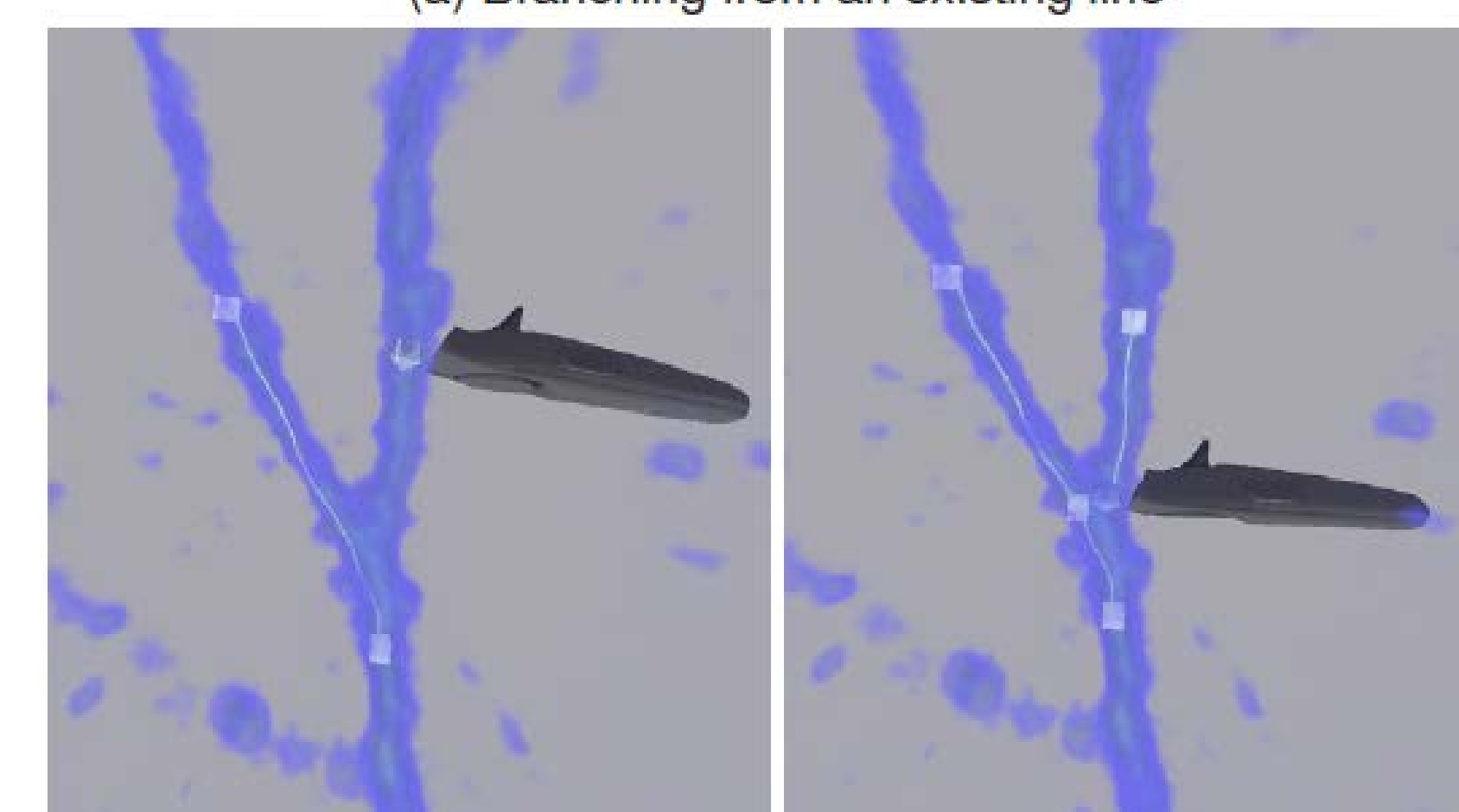
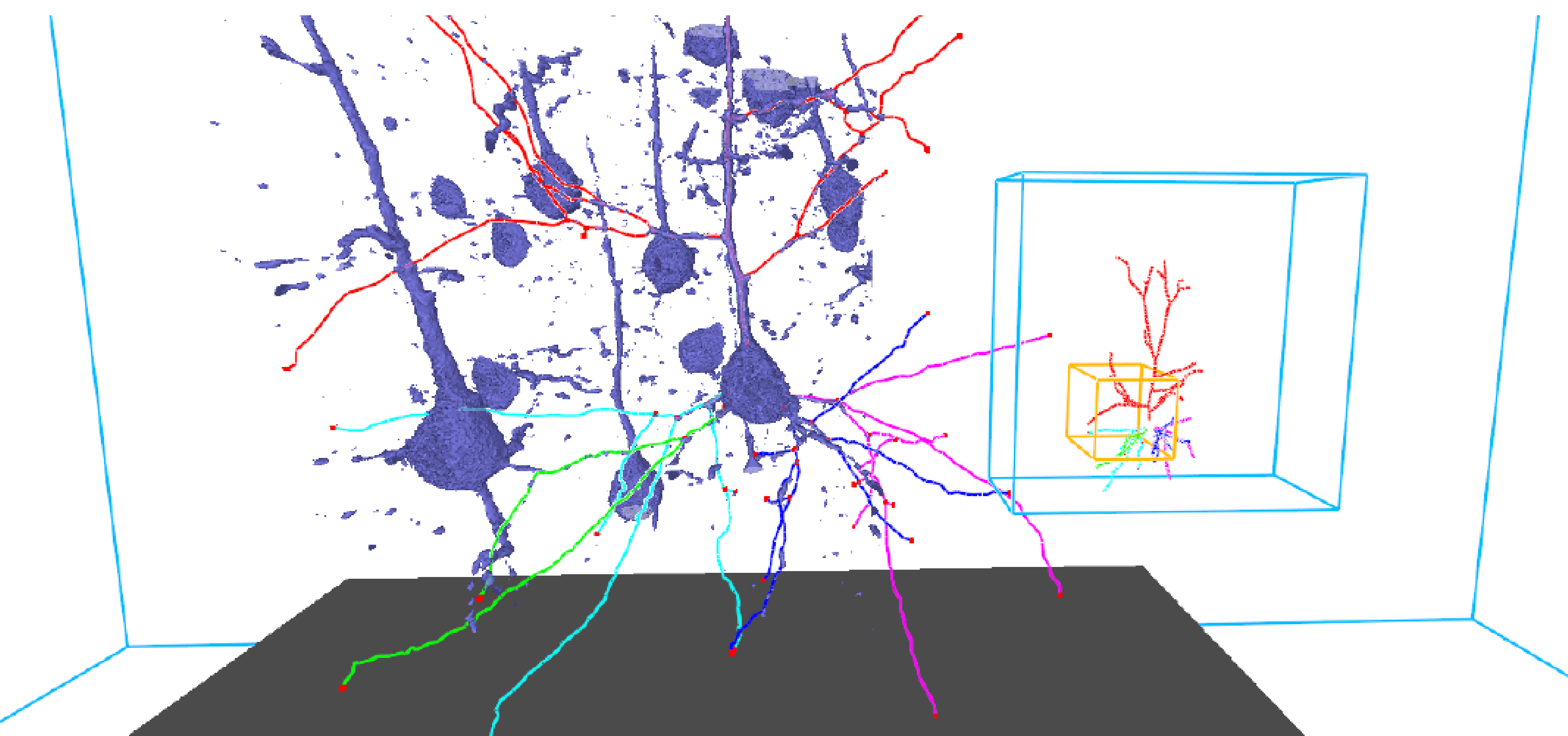(b) Connecting a branch back to the parent tree

Tracing and merging

Topology-elements guided tracing

Progressive auto-alignment

- W. Usher *et al.*, "A Virtual Reality Visualization Tool for Neuron Tracing," in *IEEE Transactions on Visualization and Computer Graphics*, vol. 24, no. 1, pp. 994-1003, Jan. 2018, doi: 10.1109/TVCG.2017.2744079.
- A. Venkat *et al.*, "High-Quality Progressive Alignment of Large 3D Microscopy Data," *2022 IEEE 12th Symposium on Large Data Analysis and Visualization (LDAV)*, Oklahoma City, OK, USA, 2022, pp. 1-10, doi: 10.1109/LDAV57265.2022.9966406.
- McDonald T, Usher W, Morrical N, Gyulassy A, Petruzza S, Federer F, Angelucci A, Pascucci V. Improving the Usability of Virtual Reality Neuron Tracing with Topological Elements. IEEE Trans Vis Comput Graph. 2021 Feb;27(2):744-754. doi: 10.1109/TVCG.2020.3030363.

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