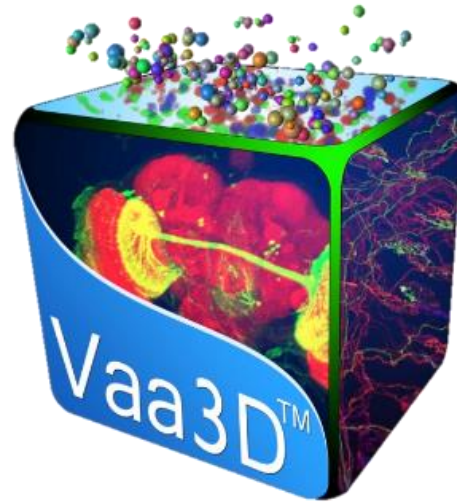


# Automated Neuron Tracing in Vaa3D

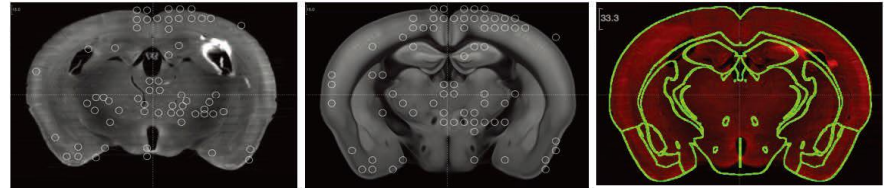
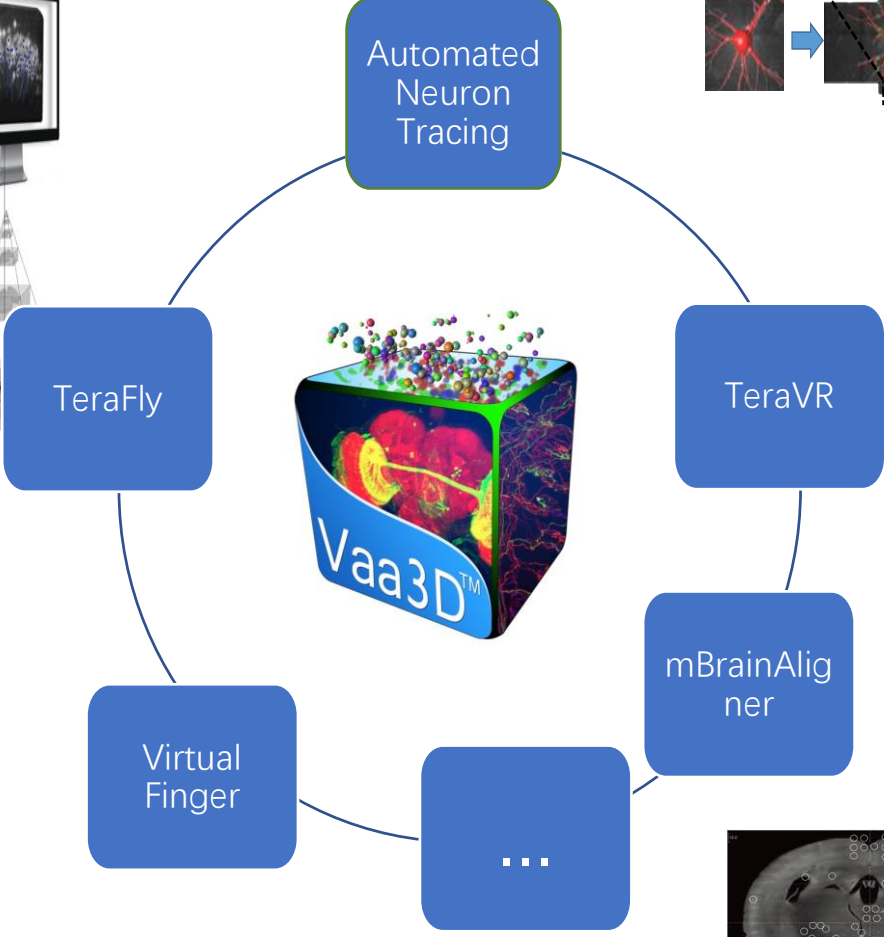
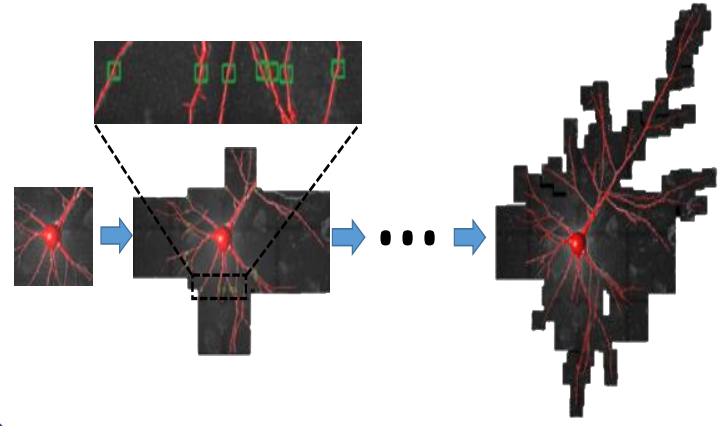
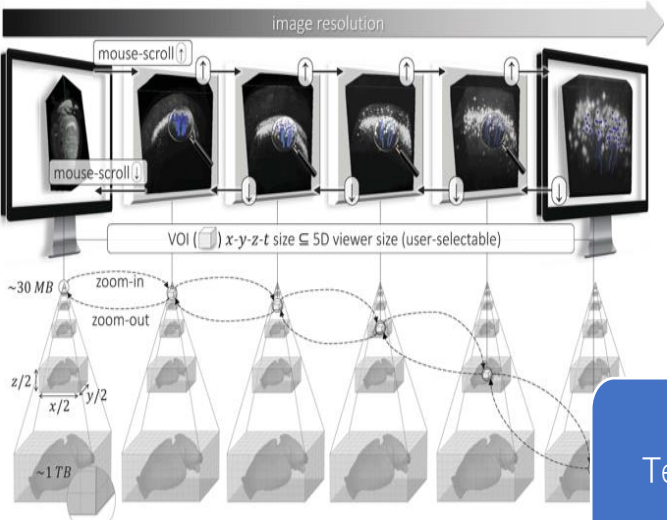


Presenter: Liya Ding

Institute for Brain and Intelligence

Southeast University

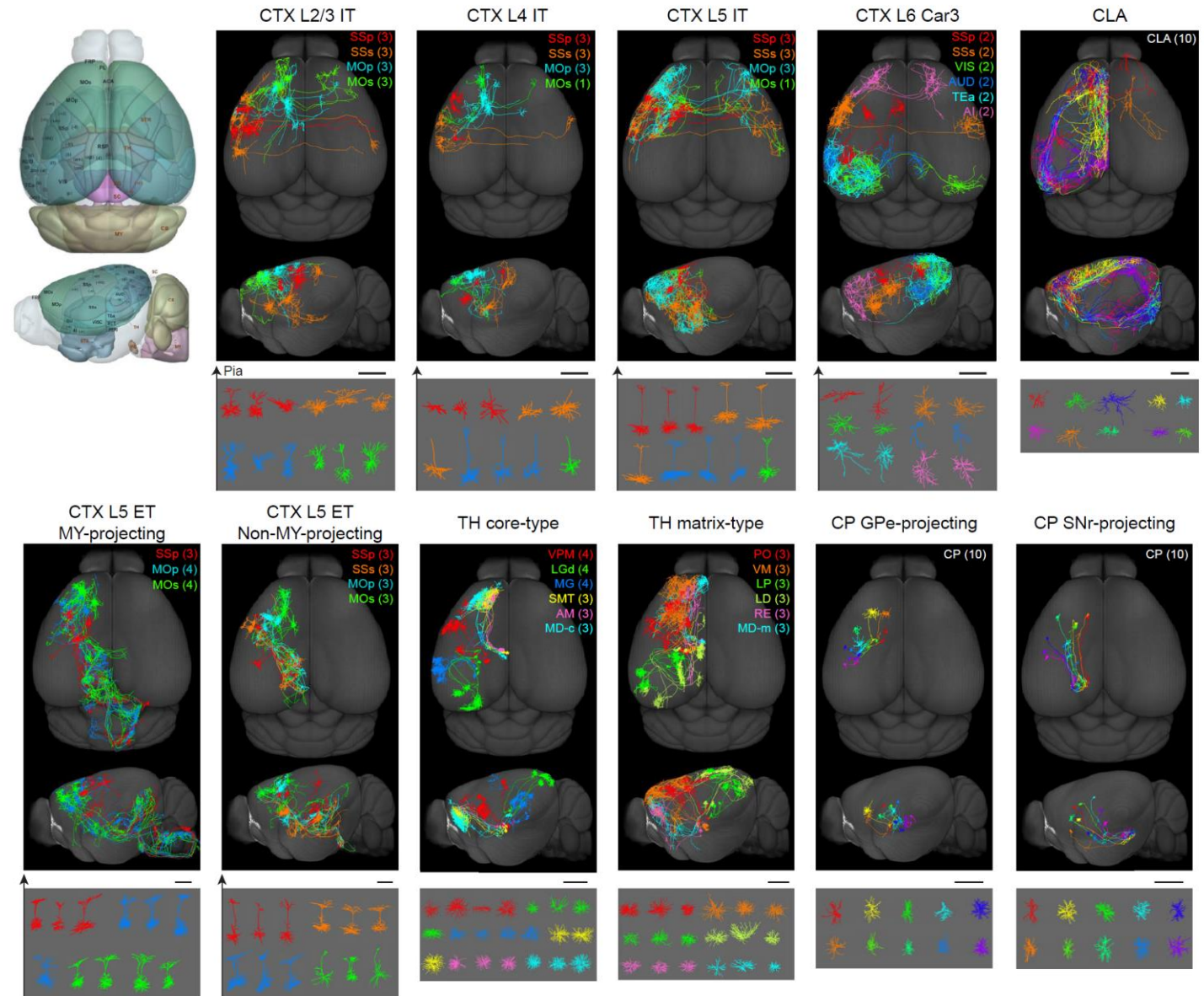
# Vaa3D platform

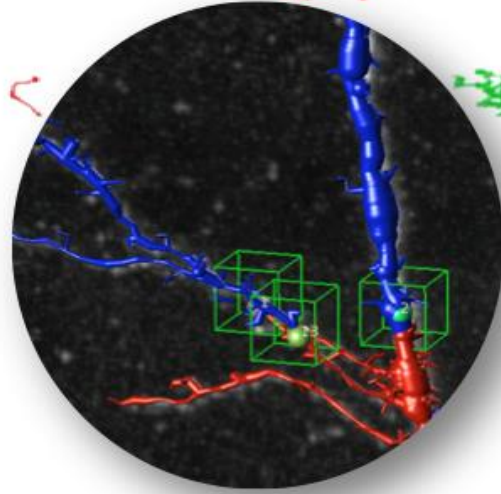
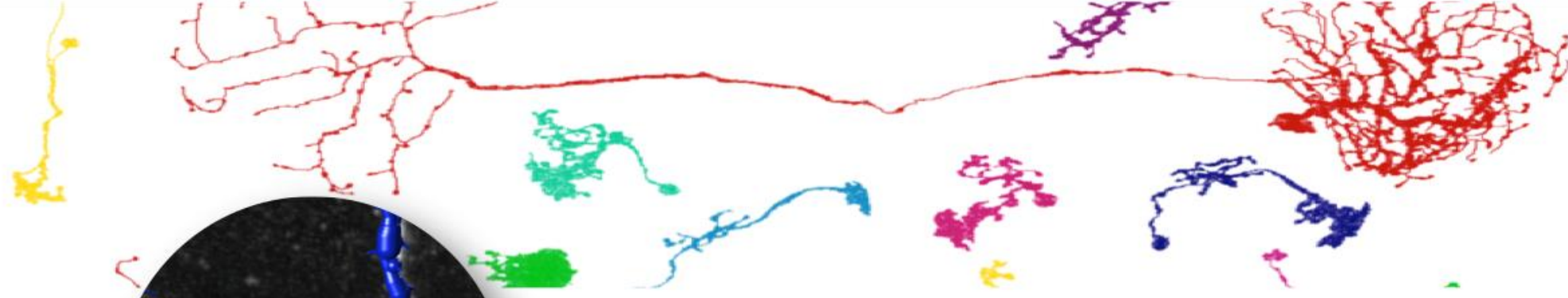


UltraTracer: Nature Methods, 2017  
 TeraFly: Nature Methods, 2016  
 Virtual Finger: Nature Communications, 2019  
 TeraVR: Nature Communications, 2019

# Neuron Morphology

- A defining feature of neuronal types
- Highly diverse and region specific
- Big number of reconstruction desired
- Automated reconstruction needed



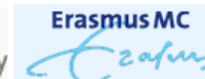
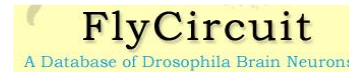


# BigNeuron

*A community effort to find out what is exactly the state-of-the-art of single neuron reconstruction, standardize the protocols, and establish a Big Data resource for neuroscience.*



Human Brain Project



# Neuron tracer: APP2

## Step 1:

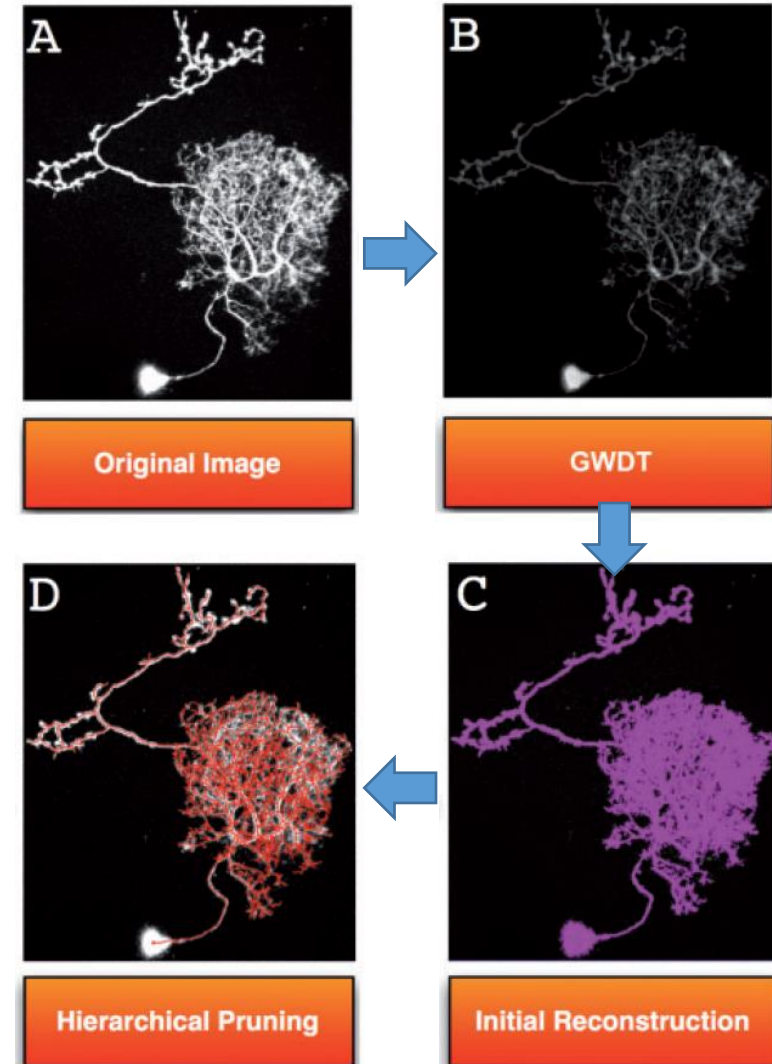
GWDT: gray-weighted image distance transform

## Step 2:

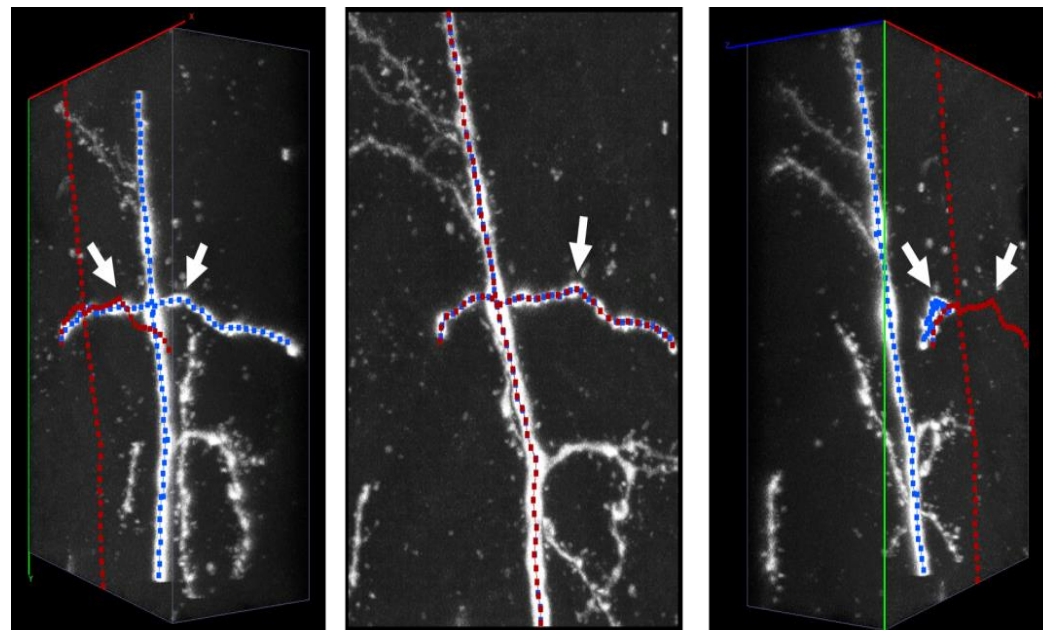
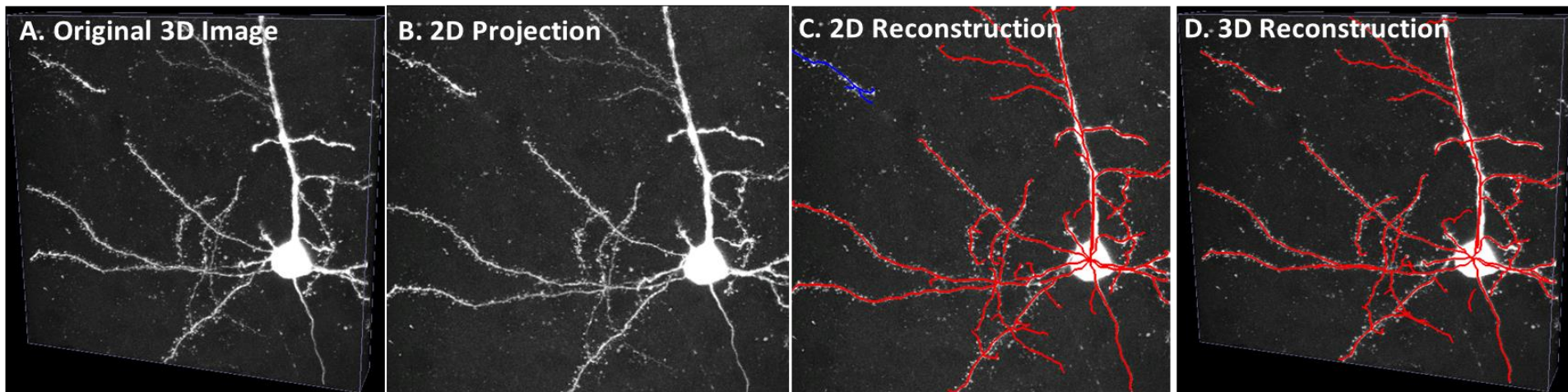
Initial neuron reconstruction

## Step 3:

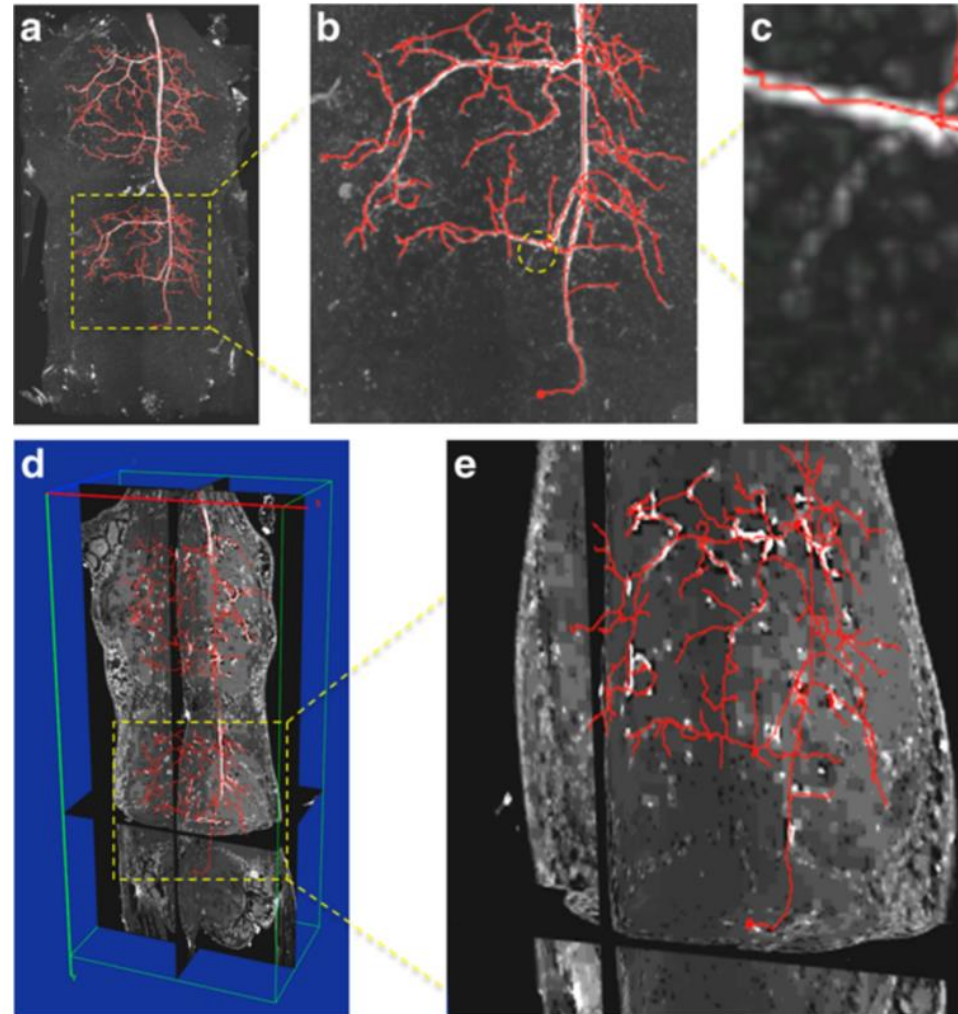
Hierarchical pruning



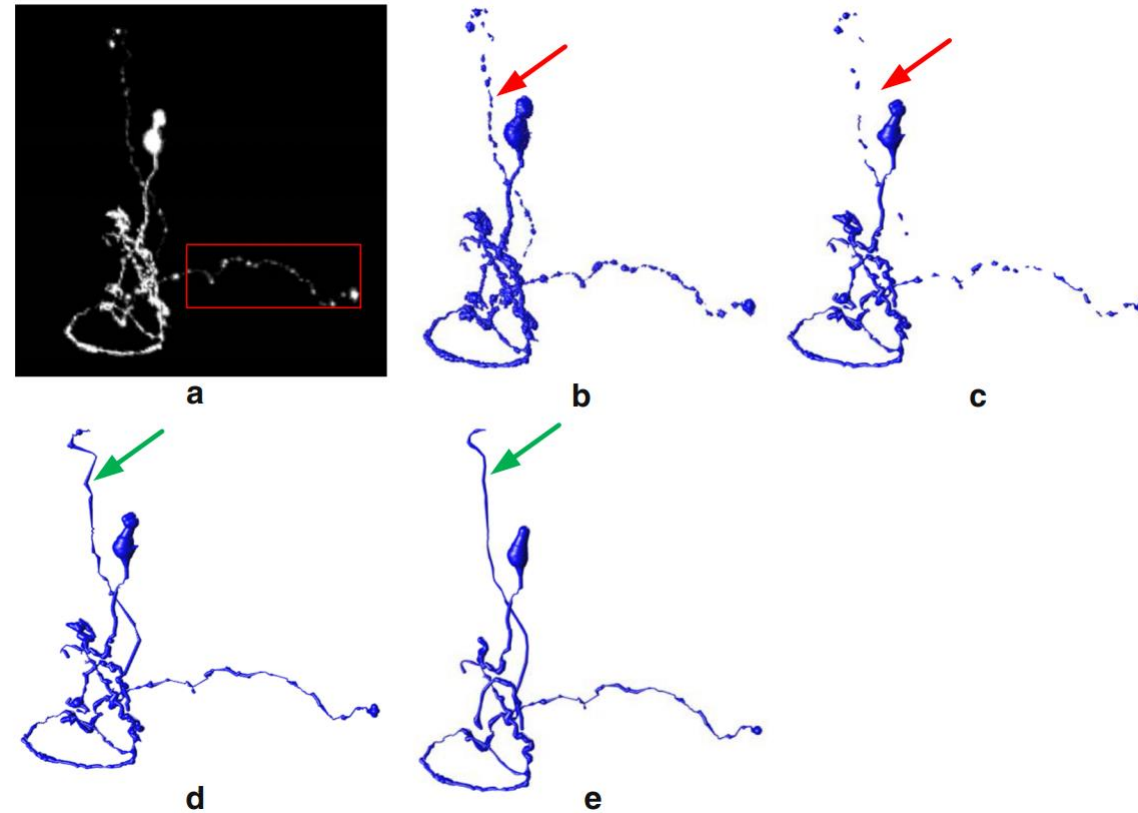
# Neuron tracer: TReMAP



# Neuron tracer: SimpleTracing(DF)

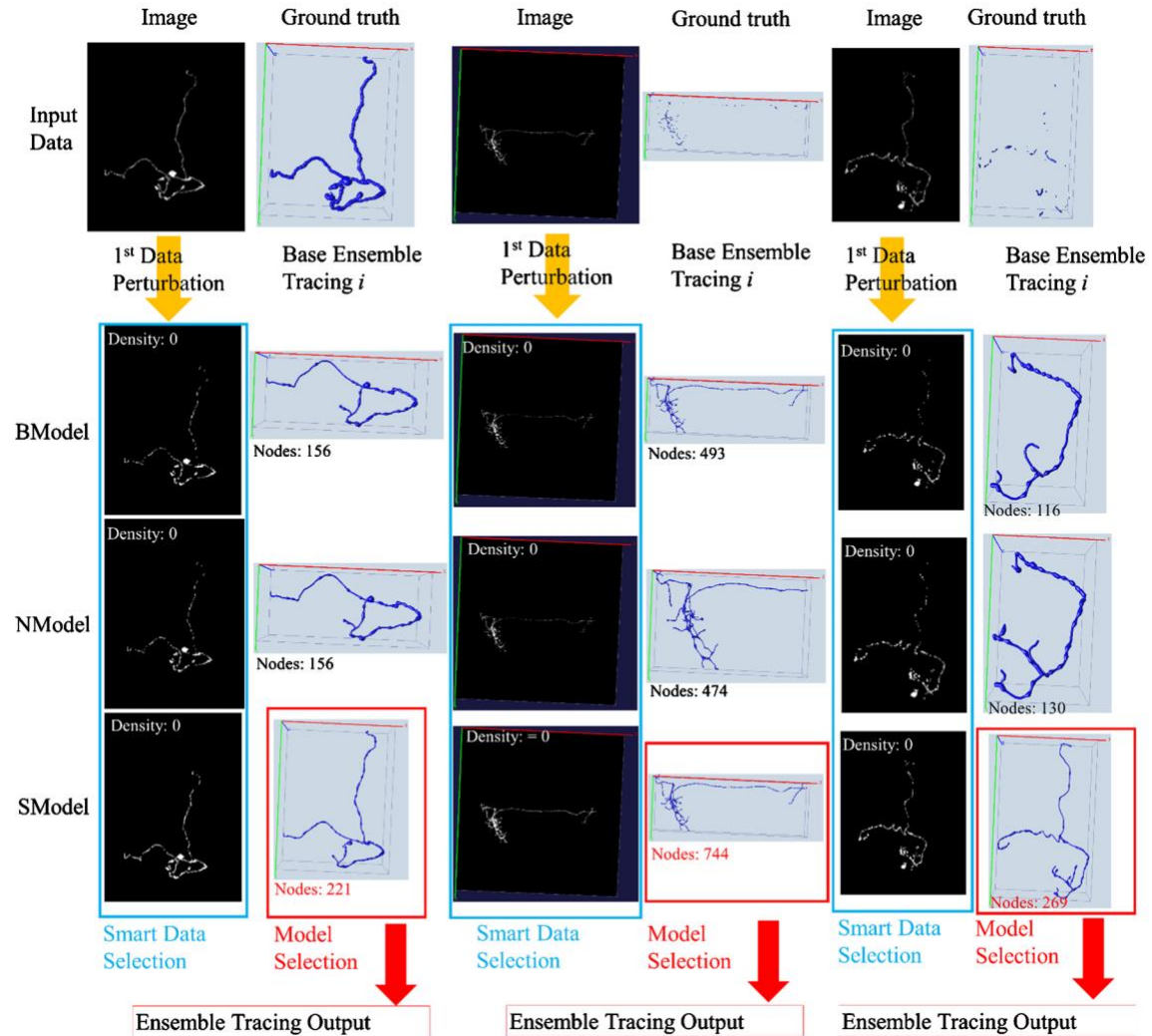


# Neuron tracer: FMST(Fast Marching and Minimum Spanning Tree)

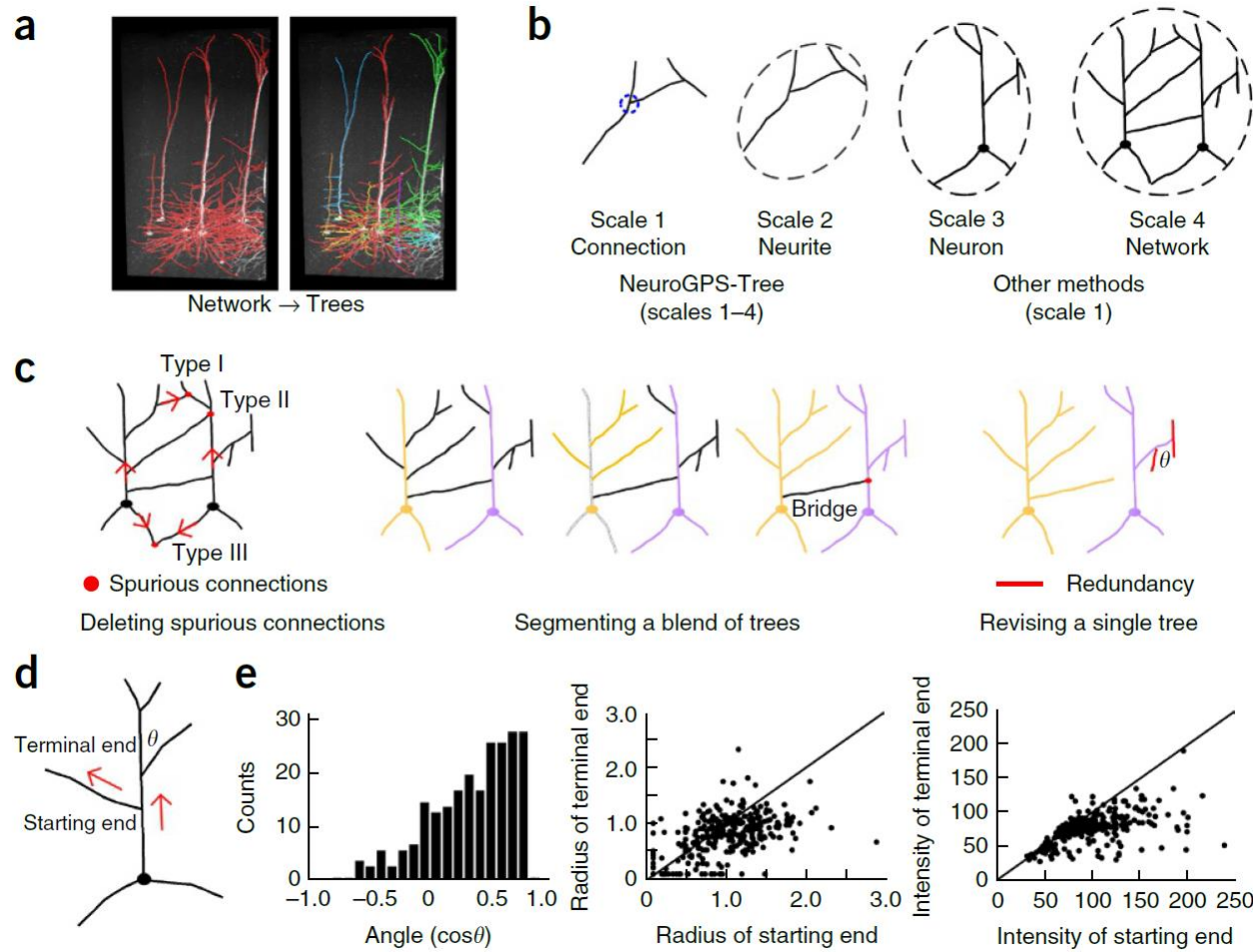




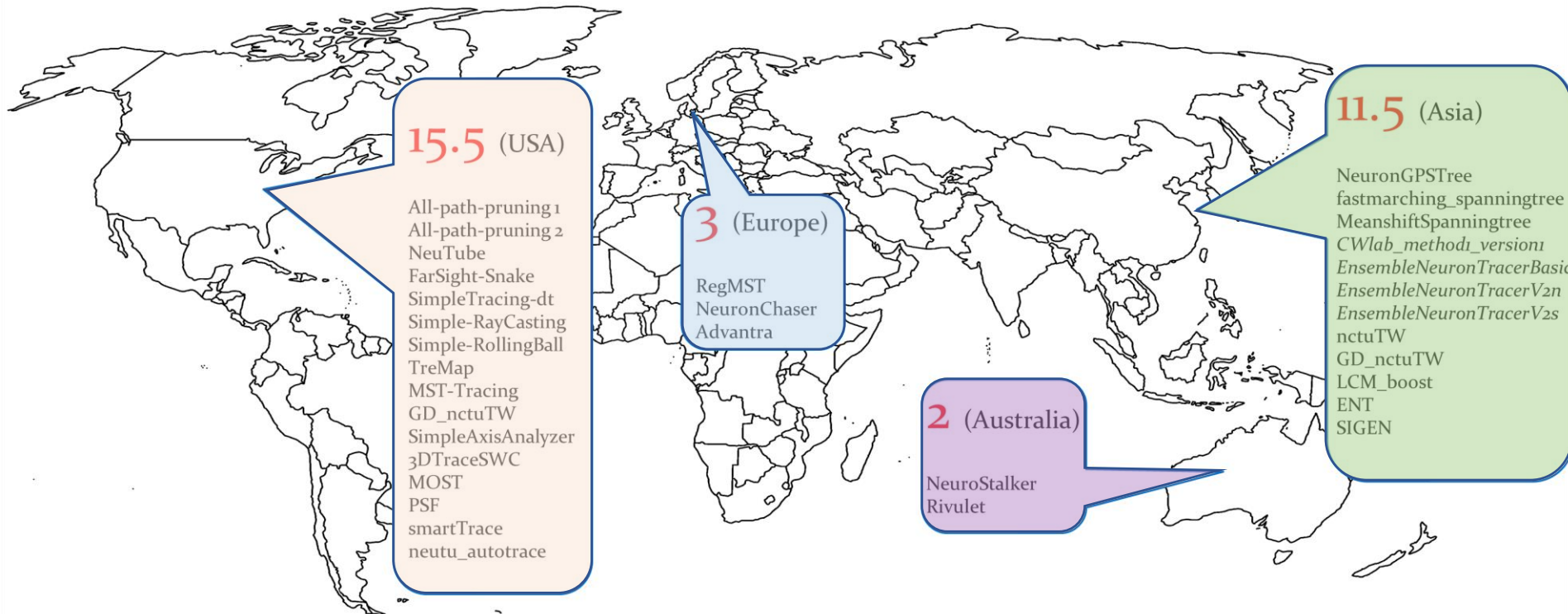
# Neuron tracer: Ensemble Neuron Tracer (ENT)



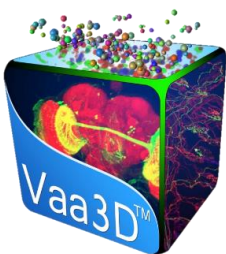
# Neuron tracer: NeuroGPS-Tree:

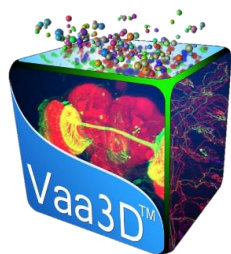
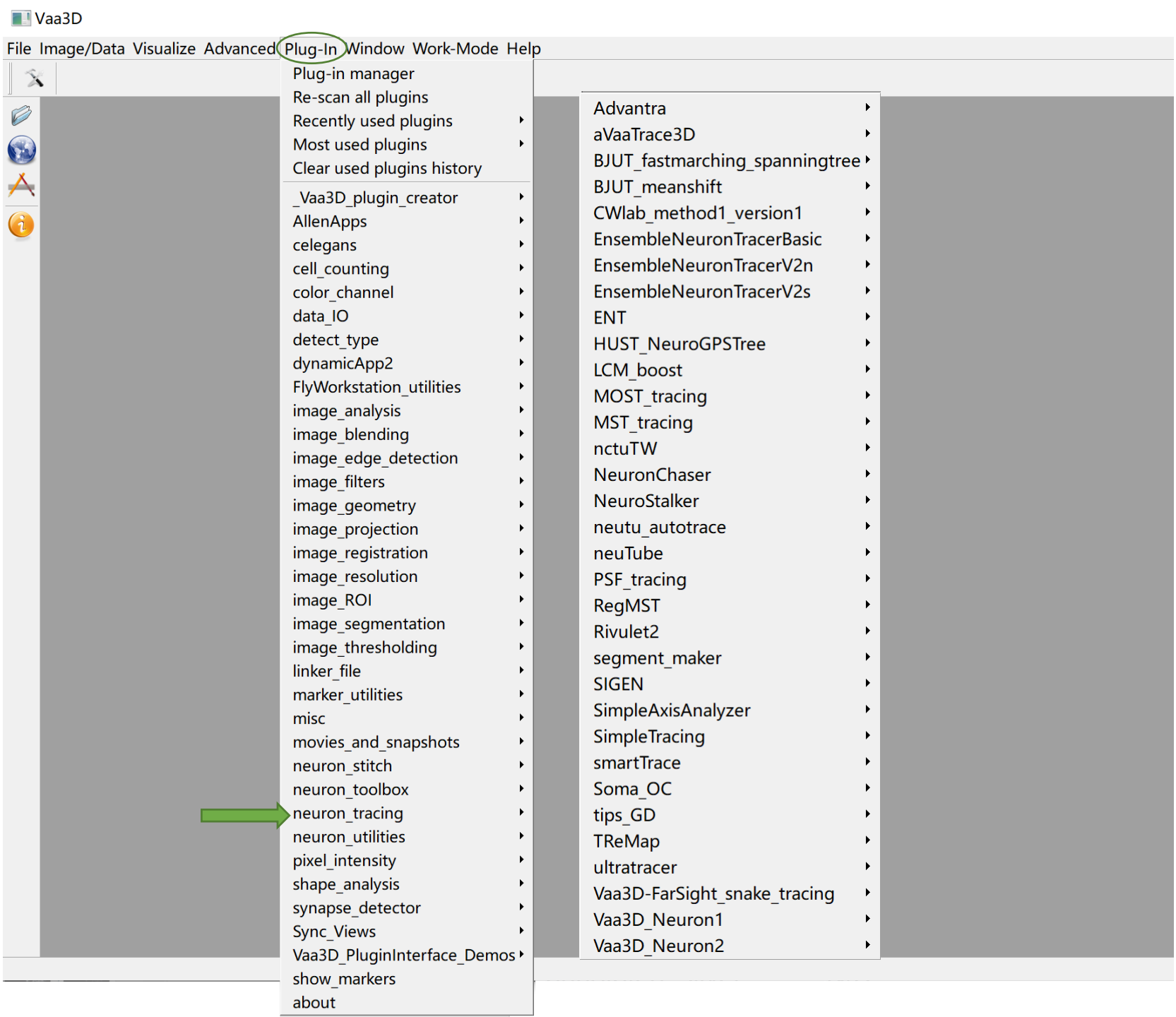


# Neuron Reconstruction Plugins(32+) in Vaa3D



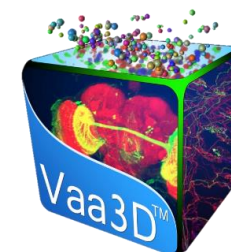
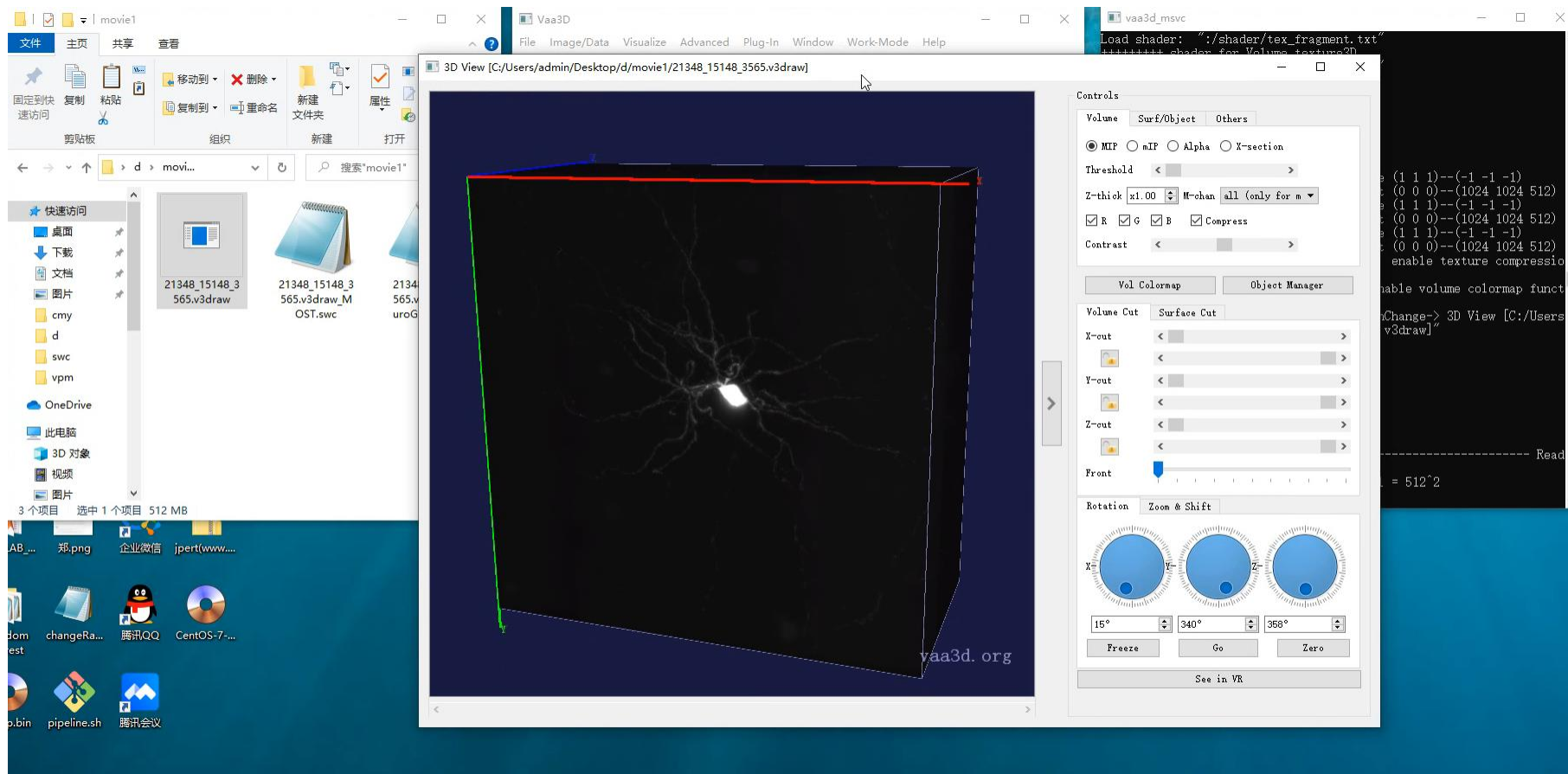
- pruning (*All-path-pruning 1, All-path-pruning 2*)
- fitting geometrical elements (*NeuTube*)
- ray casting (*Most-RayCasting, Simple-RayCasting, NeuronGPSTree*)
- spanning tree and shortest paths (*TreMap, SimpleTracing-dt, Simple-RollingBall*)
- deformable curves (*FarSight-Snake*)





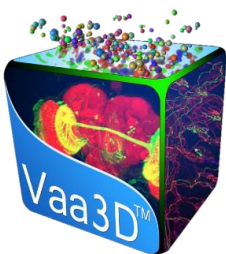
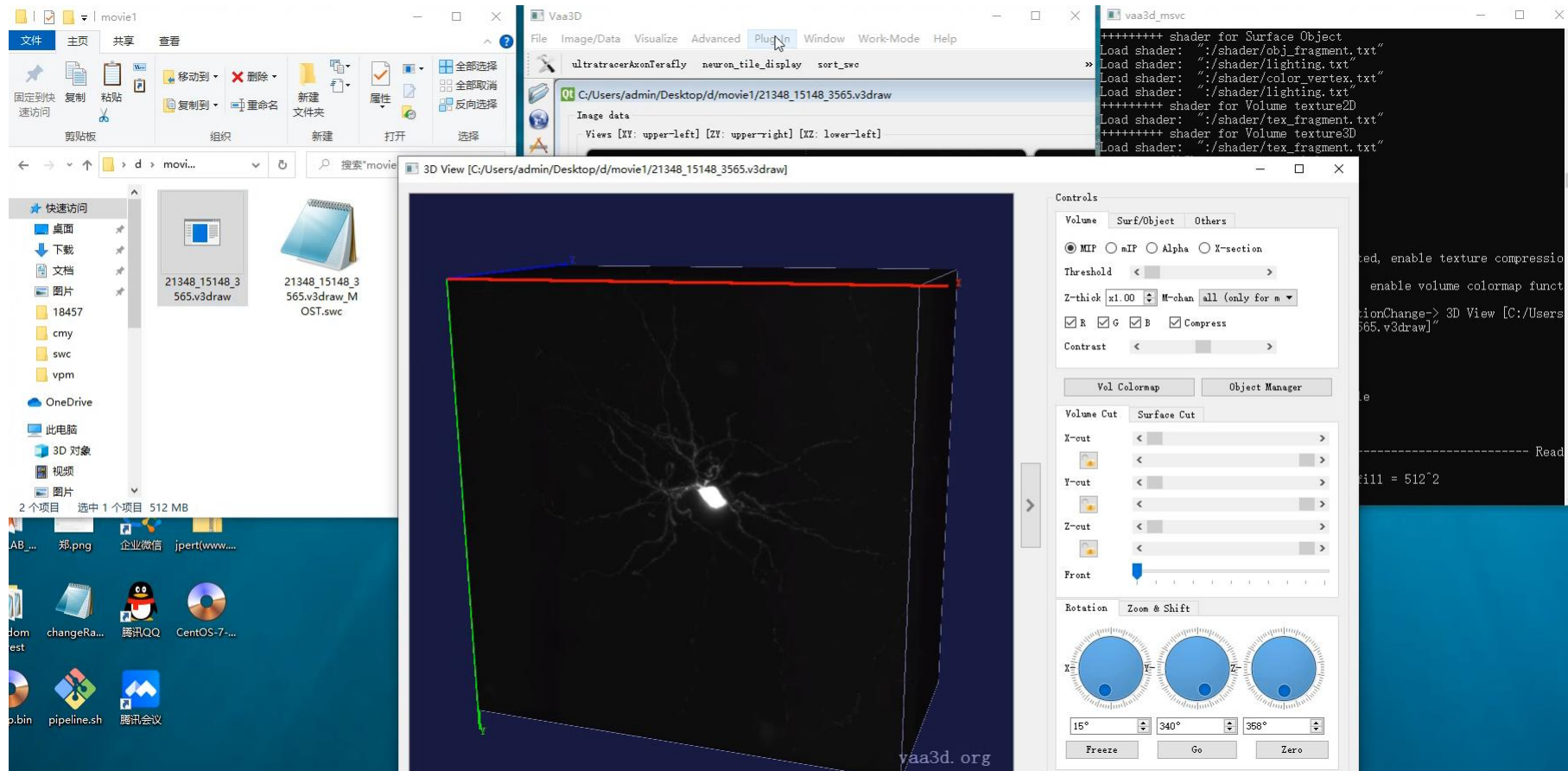
# Automatic Tracing Video Demos

## 1.App2



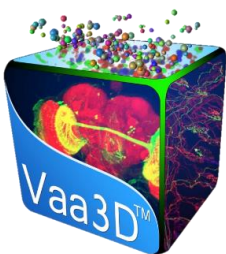
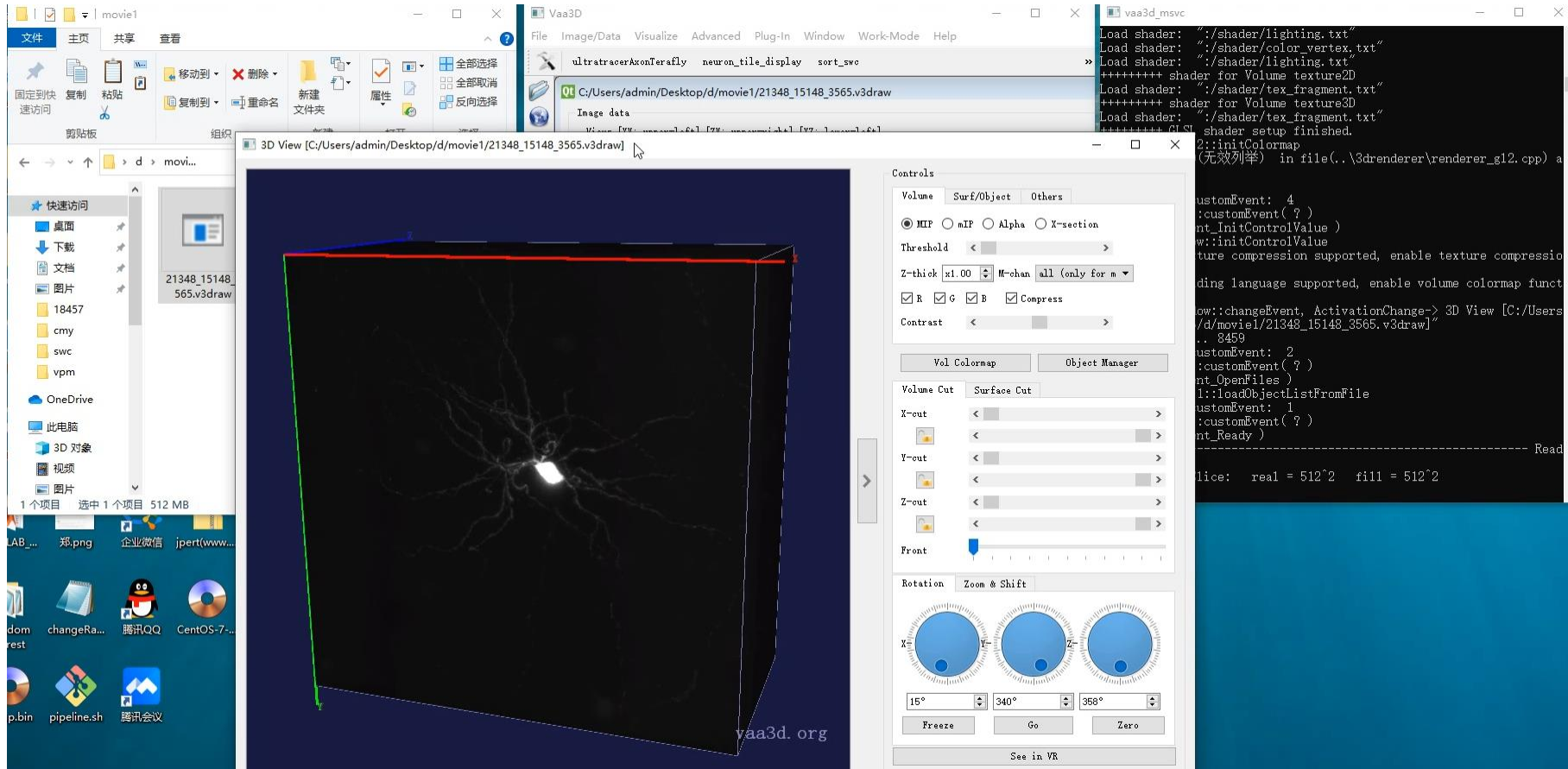
# Automatic Tracing Video Demos

## 2. NeuronGPSTree



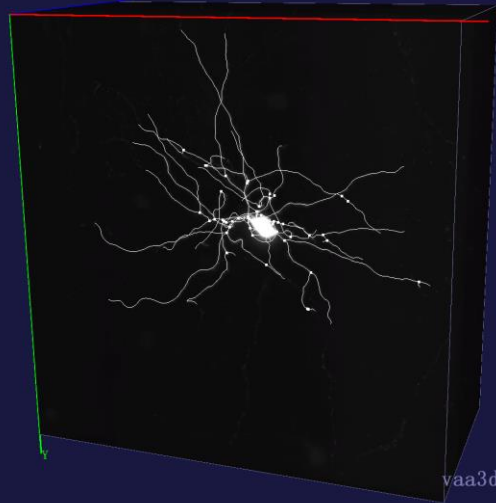
# Automatic Tracing Video Demos

## 3. Most

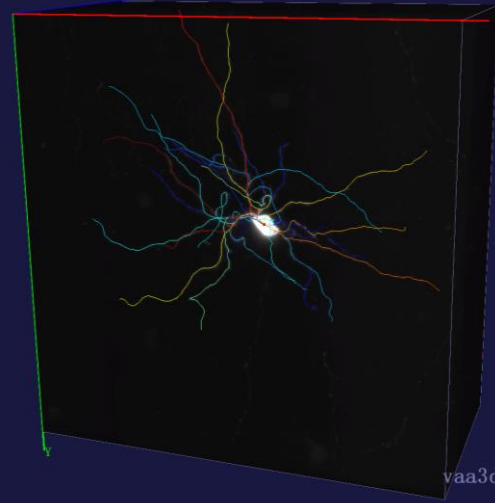


# Automatic Tracing Examples

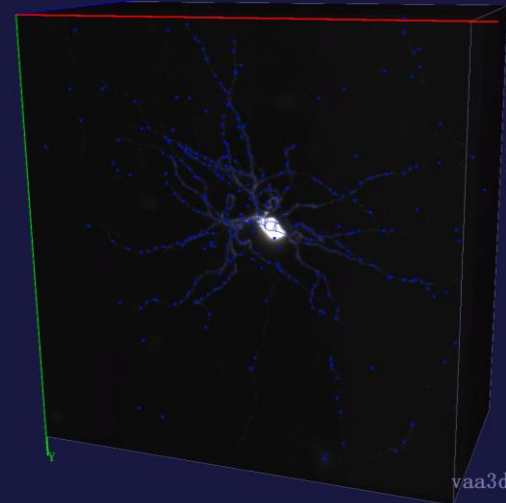
NeuroGPSTree



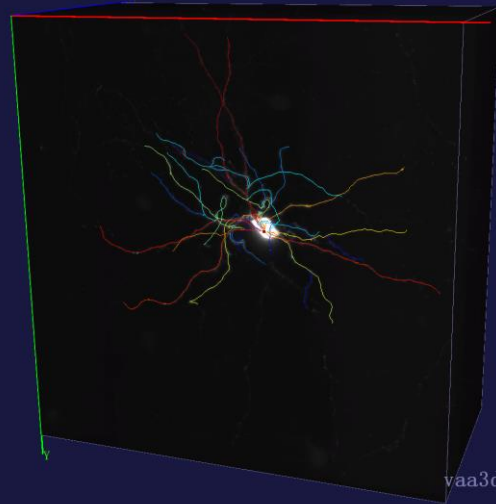
App2



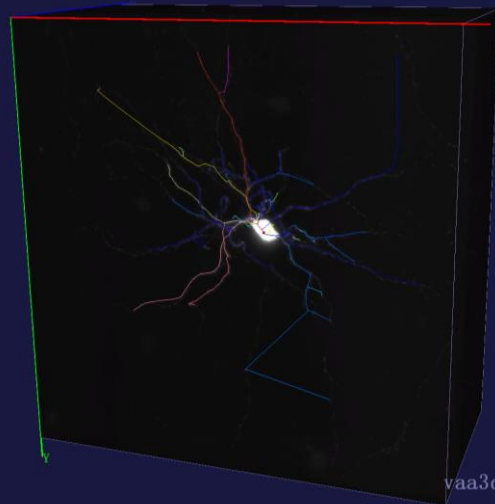
MOST



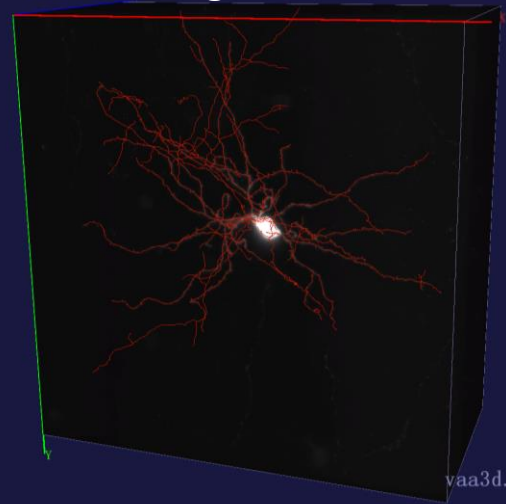
ENT



FMST

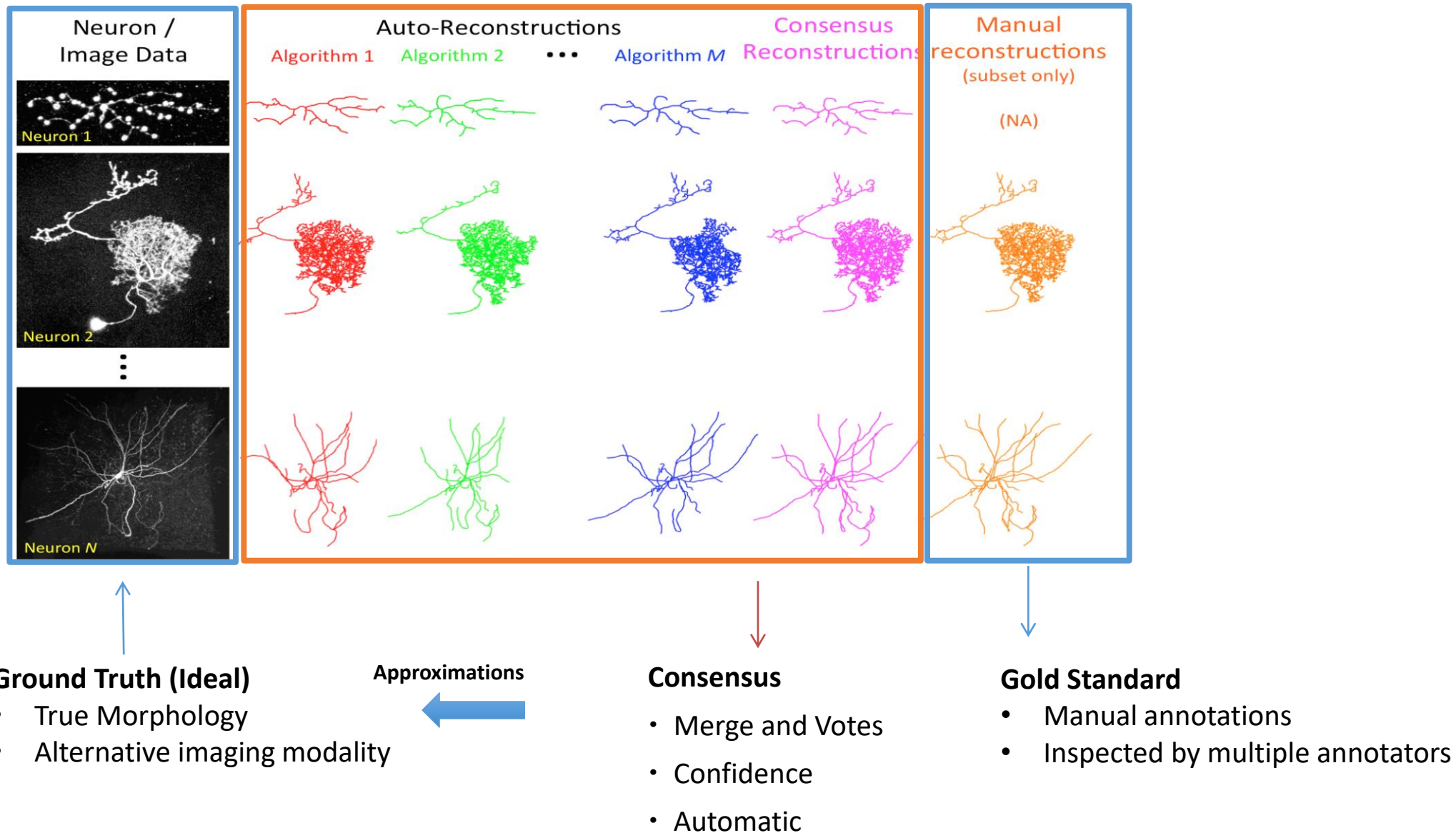


SmartTracing



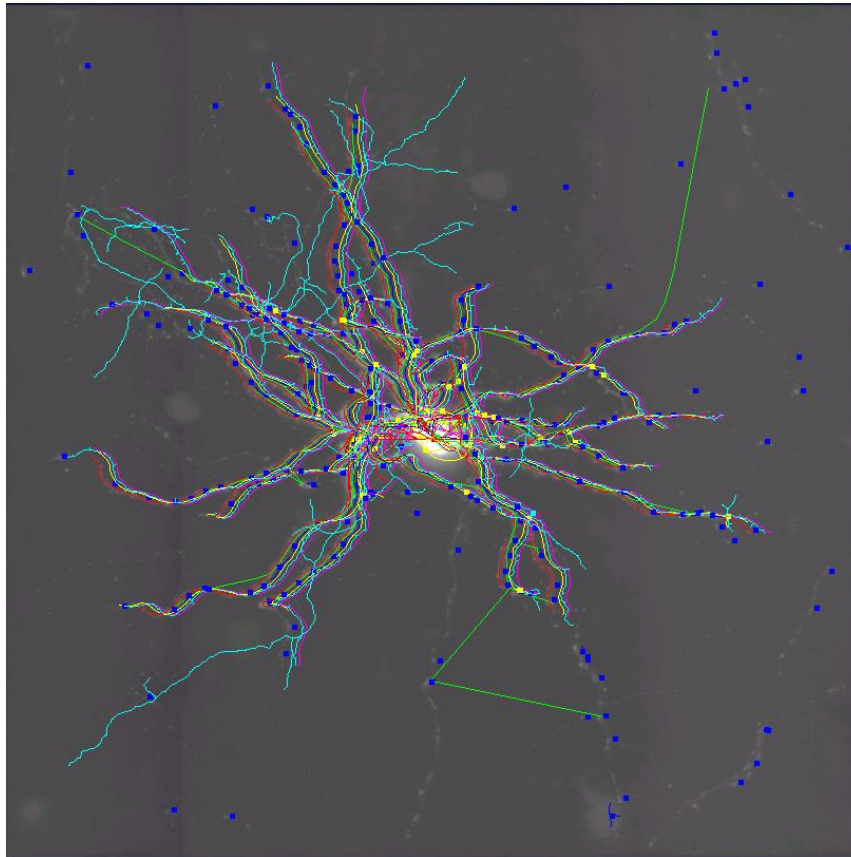


# Neuron Reconstruction Results Evaluation

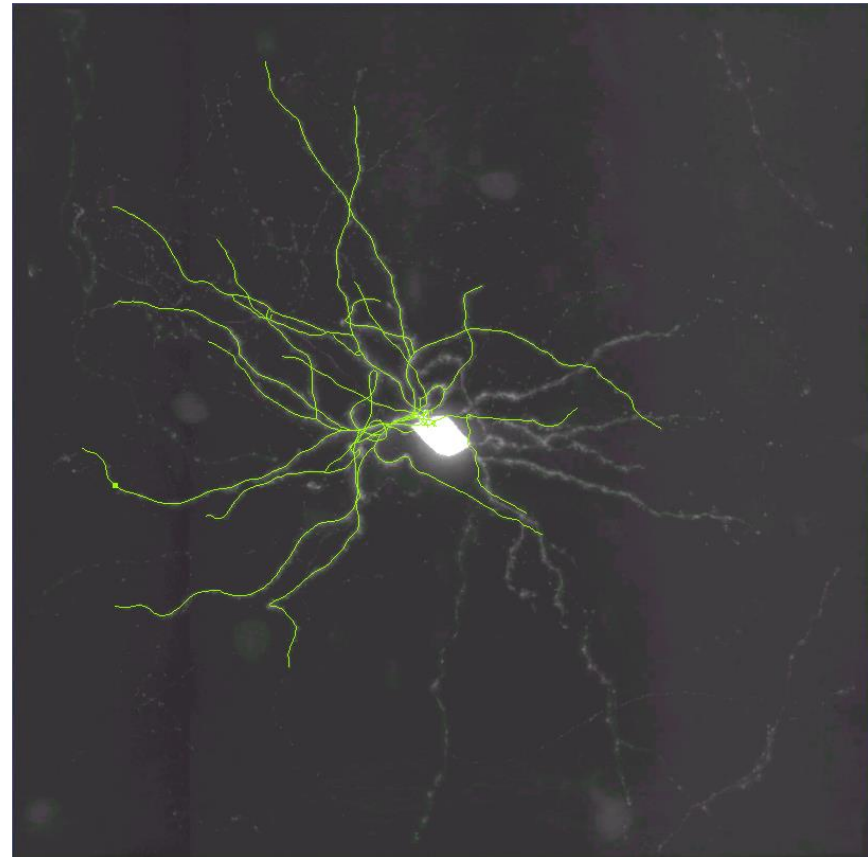


# Automatic Tracing Consensus Example

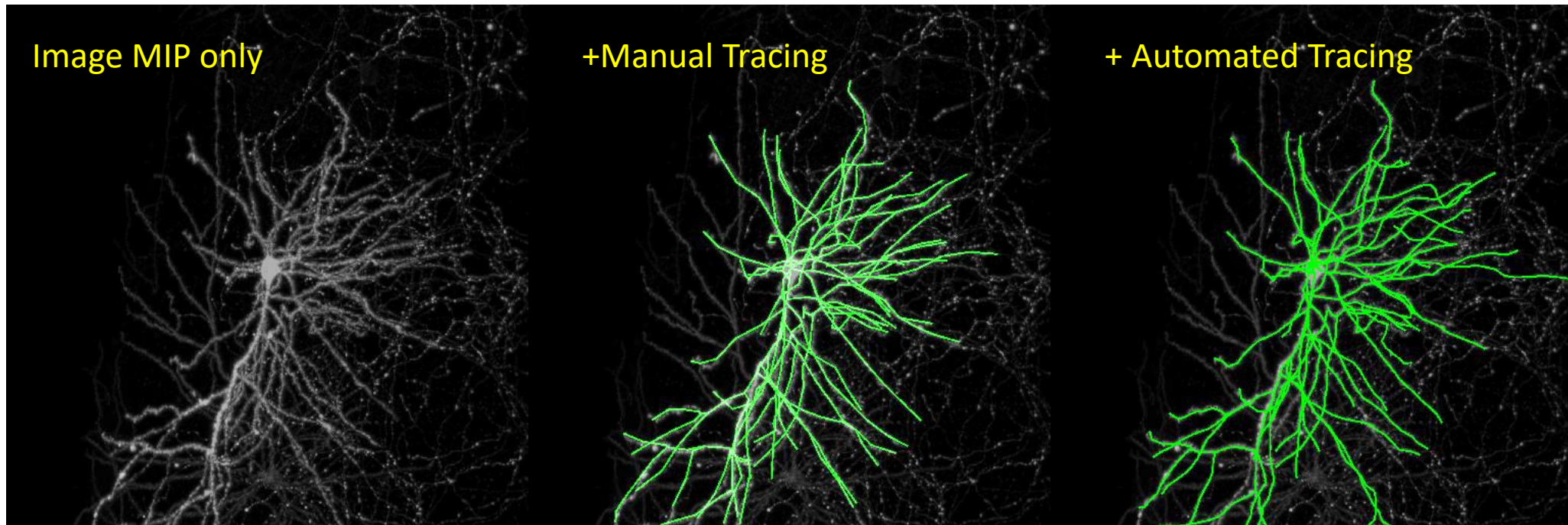
Tracing results



Consensus



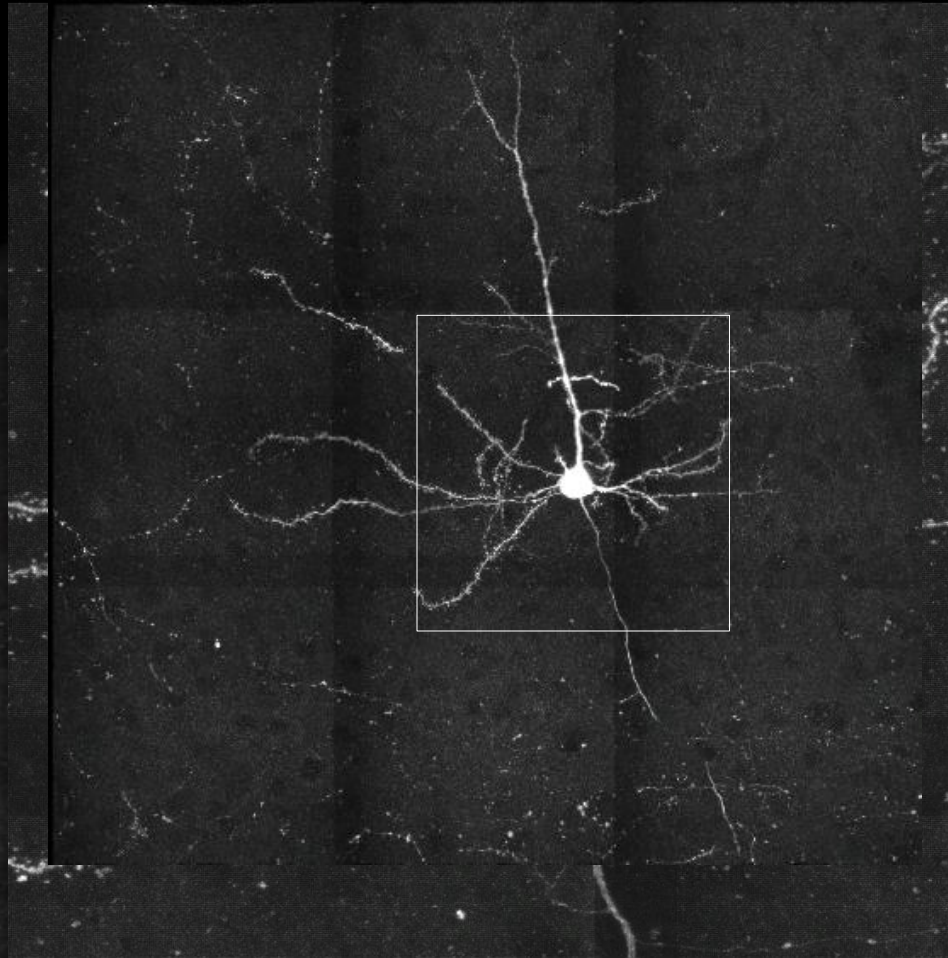
# Automatic Tracing Examples

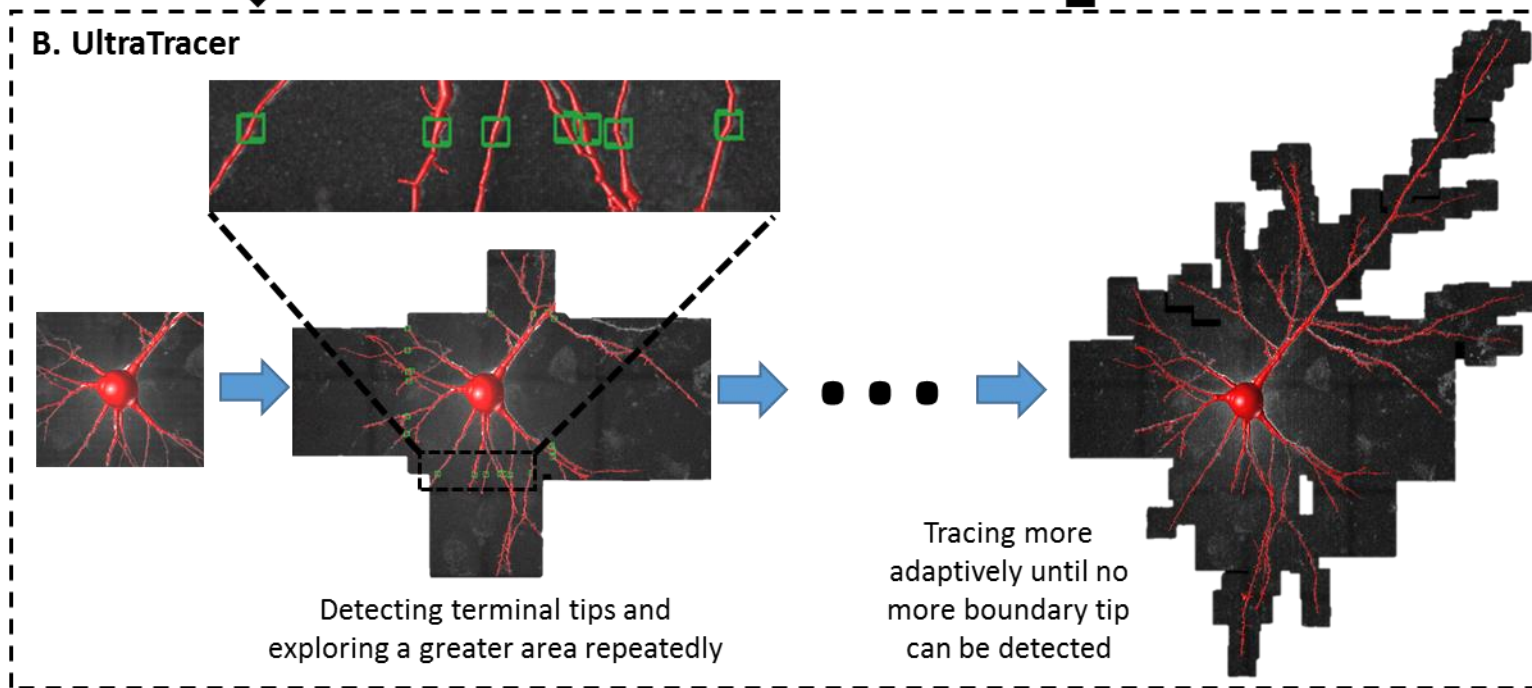
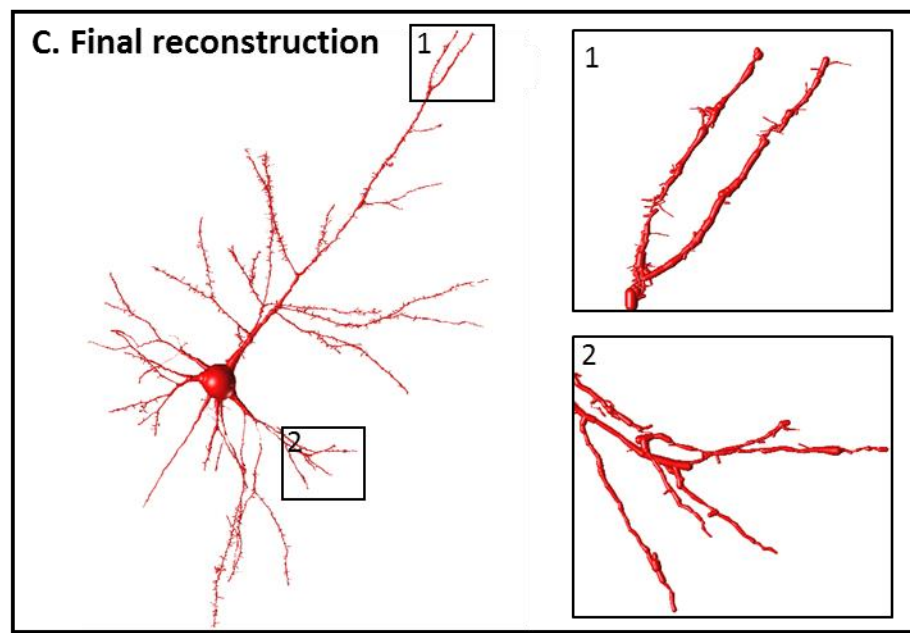
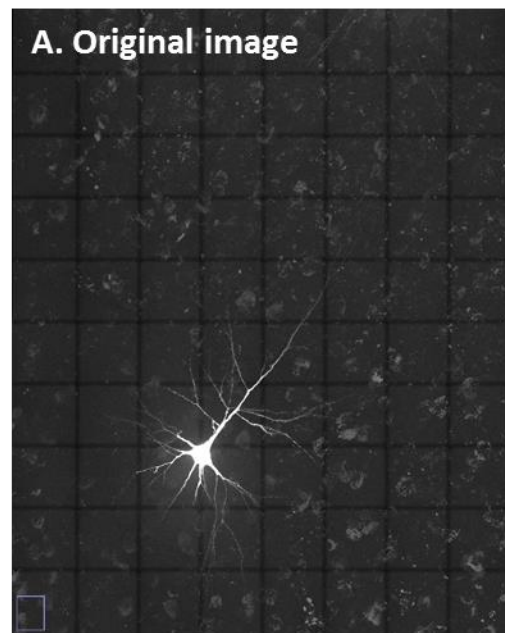


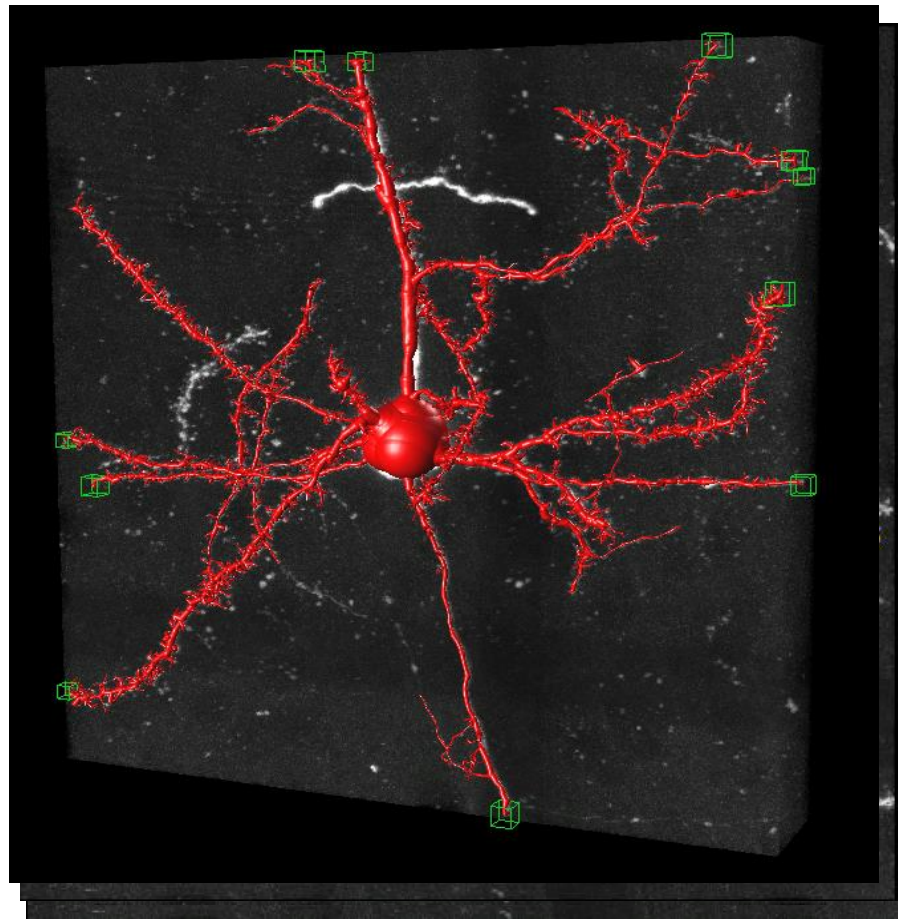
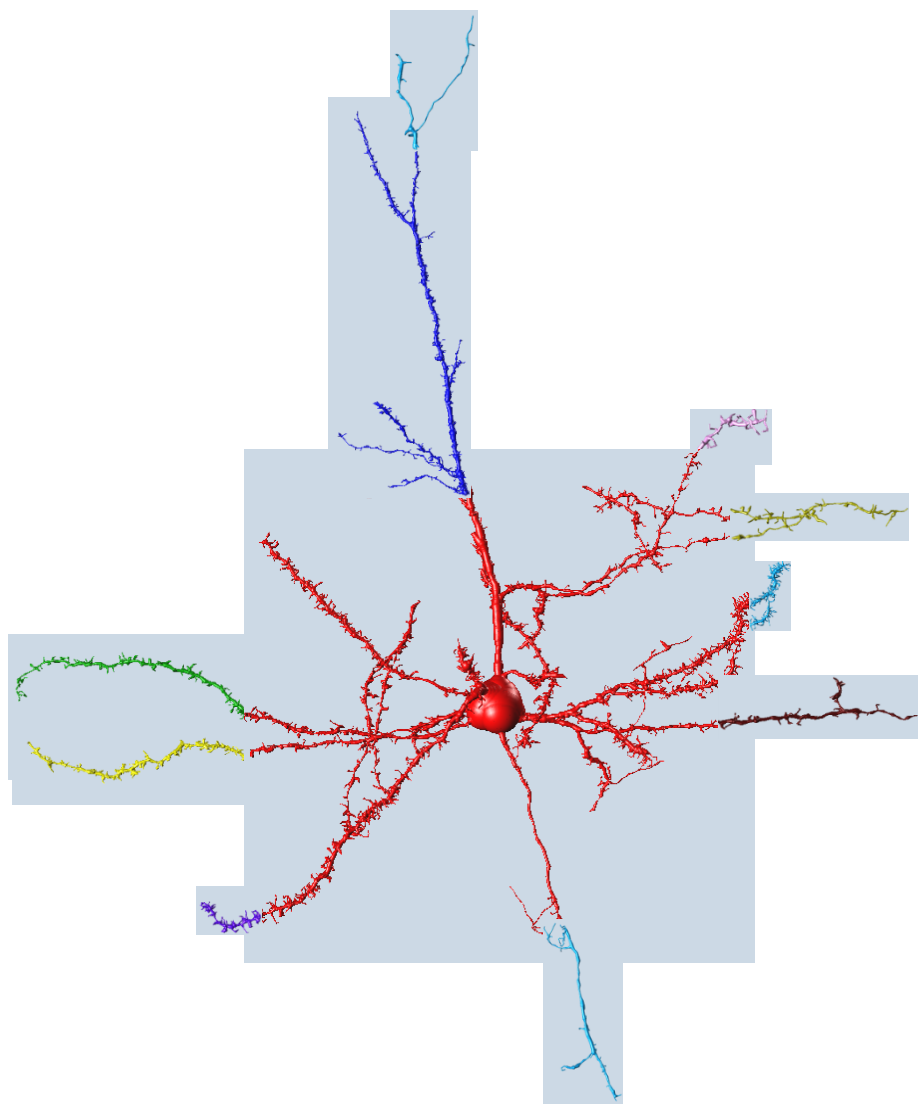
# UltraTracer

-- for full morphology in ultra-volumes of neuronal images

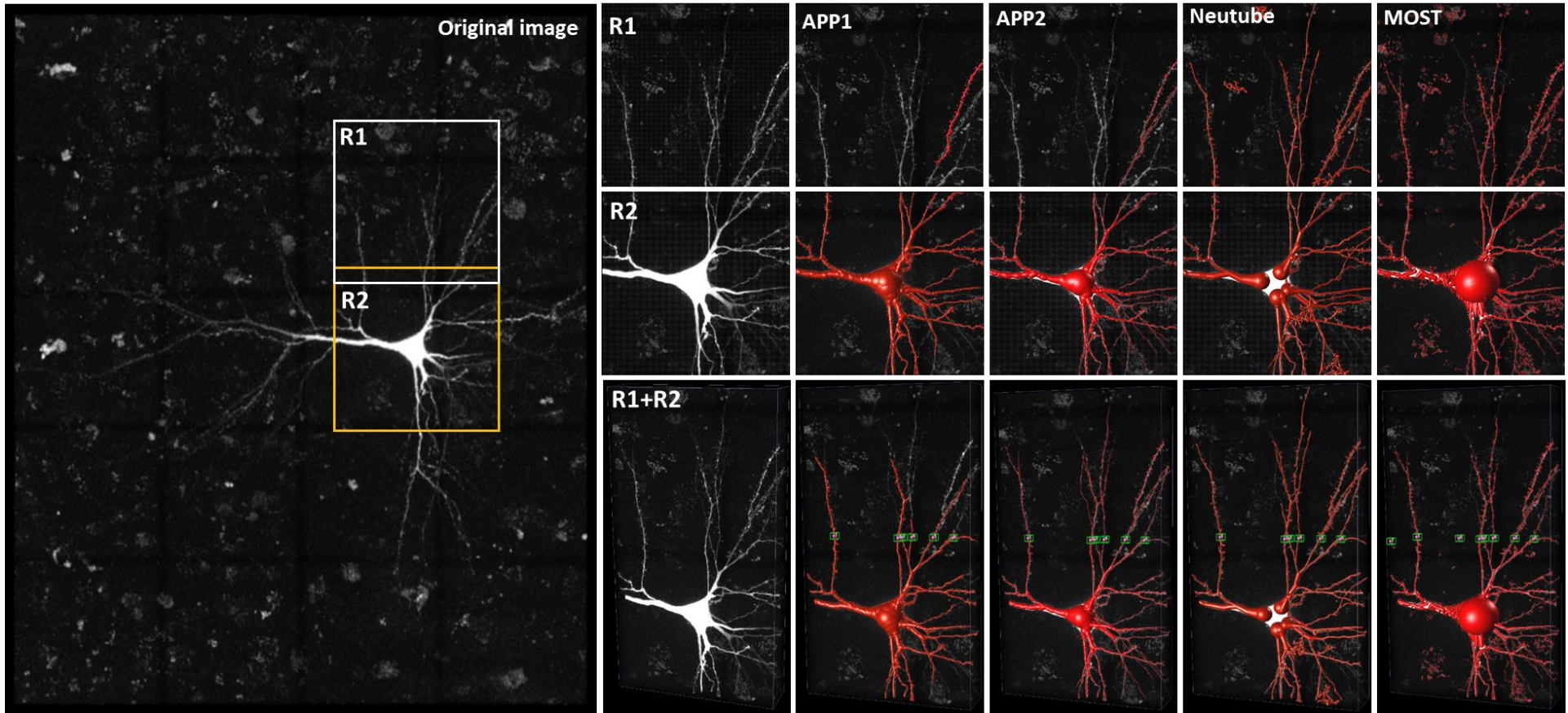
- Mouse RV-GFP-layer4\_Slide1.3, Imaging with a 63x, 1.4 NA objective.
- Voxel size: 143 nm x 143 nm x 280 nm.
- 126 tiles: 1024 x 1024 x 159.
- 29.9 GB.





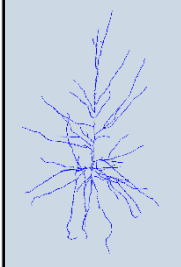
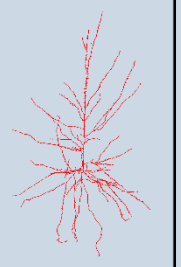
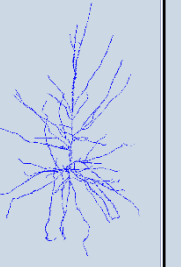
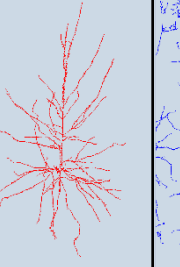
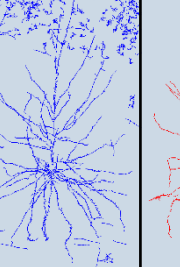
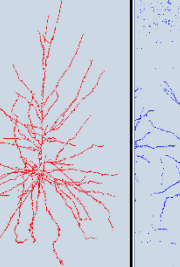
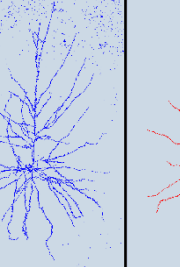
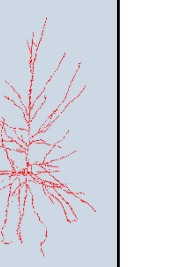


# Tip-queue based Neuron Growth Algorithm





# Comparison Results

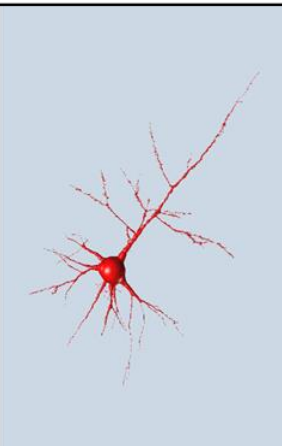
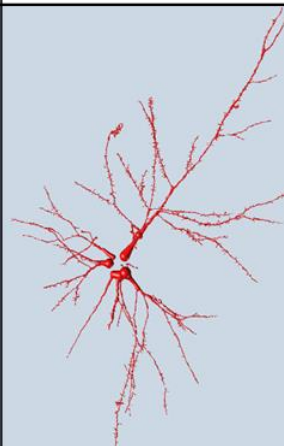
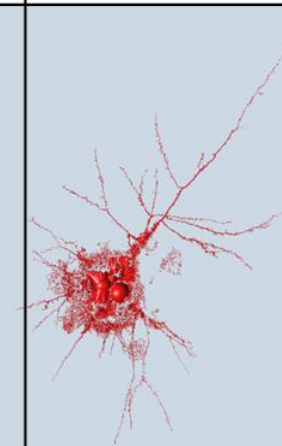
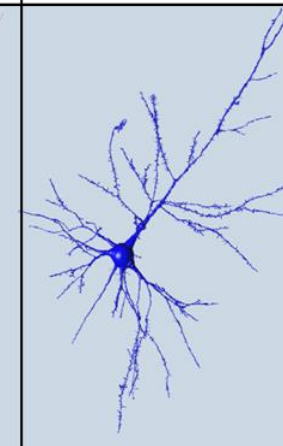
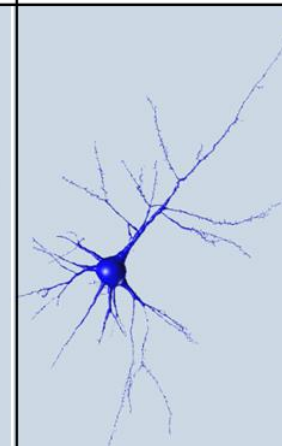
Algorithm	APP1		APP2		Neutube		MOST	
Tracing Method	TR	UT	TR	UT	TR	UT	TR	UT
Morphology Reconstruction								
BASDM (voxels) (against 2 ind. manual tracings)	1.83, 2.35	1.99, 2.50	2.30, 3.17	2.78, 3.57	179.72, 173.71	5.17, 5.42	39.83, 38.83	3.01, 3.42
Peak Memory (GB)	77.18	14.21	31.23	2.82	27.9	1.92	4.61	0.64
Tracing Time (s)	956.94	1132.82	69.95	115.67	1322.50	3317.86	22.43	29.65
Total Cost (PM x TT)	73856.63	16097.37	2184.54	326.19	36897.75	6370.29	103.40	18.98
Performance Gain (UT/TR)	3.59		5.70		4.79		4.45	

BASDM (BASD score compared to a pure human manual reconstruction);

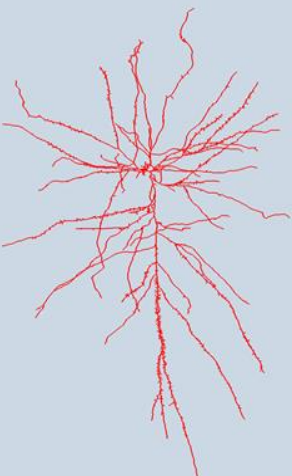
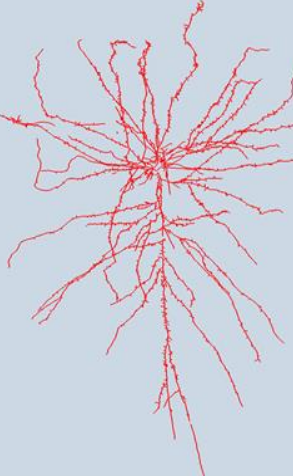
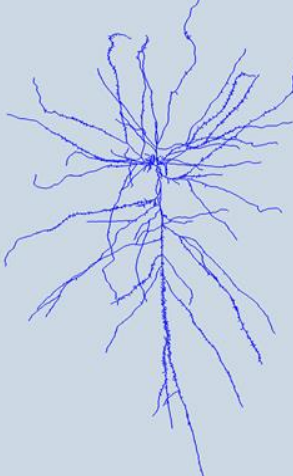
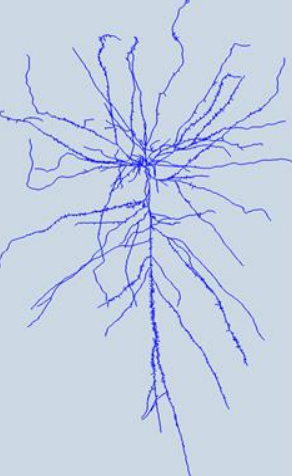
BASD: Best Average Spatial Distance.

**BASD score between two pure human manual reconstructions is 3.56.**

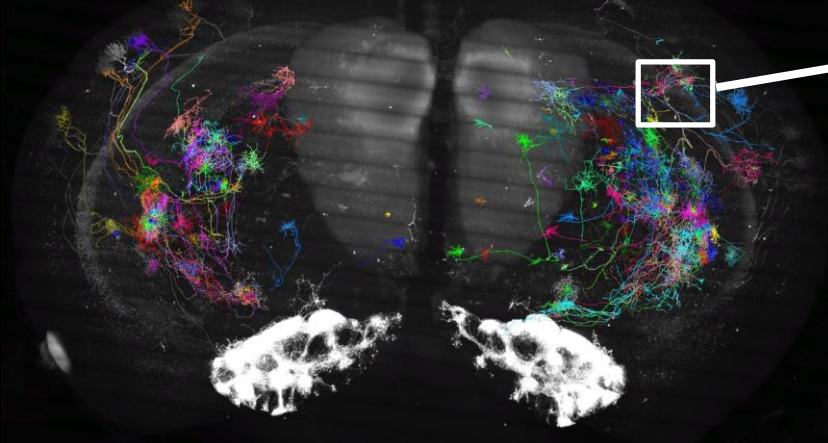
# Combination Scheme 1

Algorithm	APP2	Neutube	MOST	APP2+Neutube	APP2+MOST
Morphology Reconstruction					
Total Scanned Areas (billion voxels)	0.94	2.80	1.90	2.80	1.90
Tracing time (s)	40.63	2250.73	408.91	2158.69	89.18

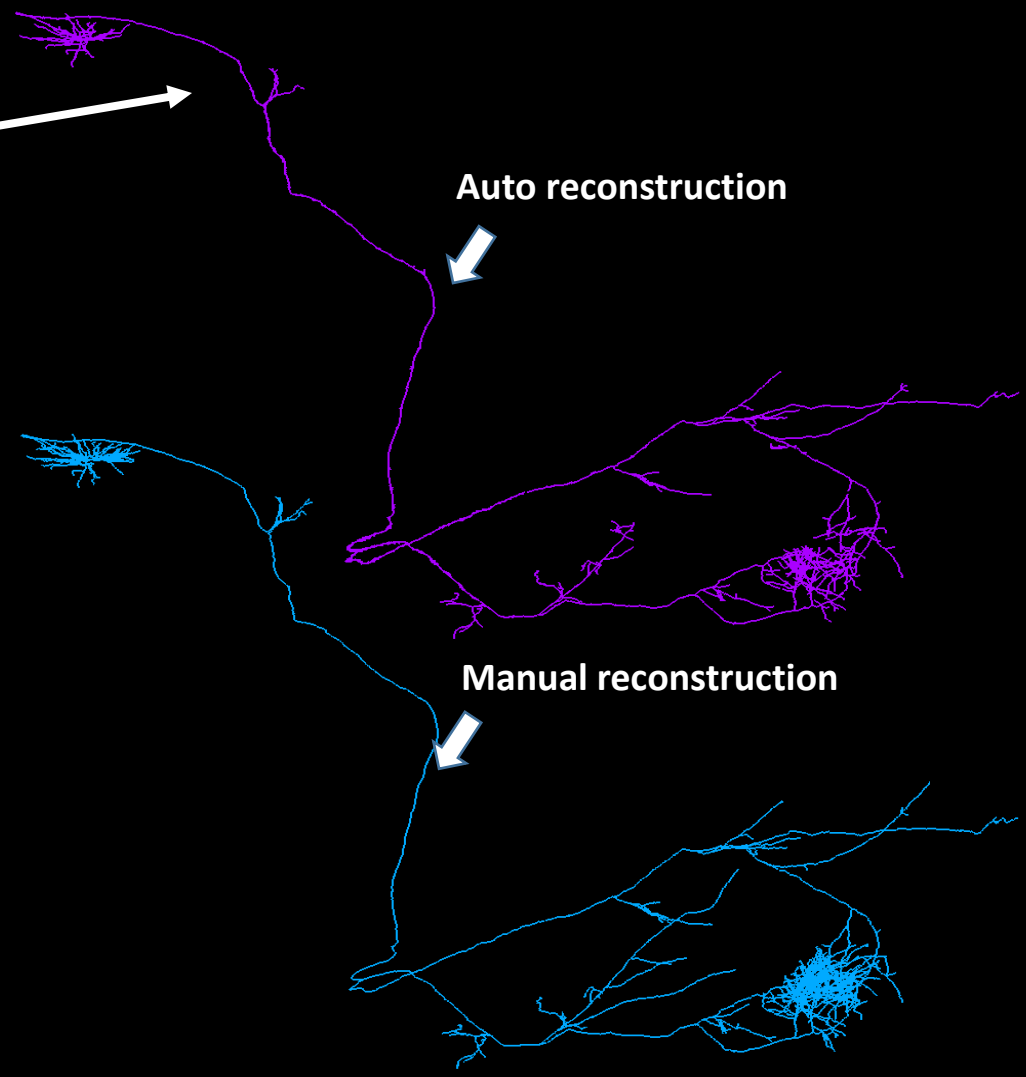
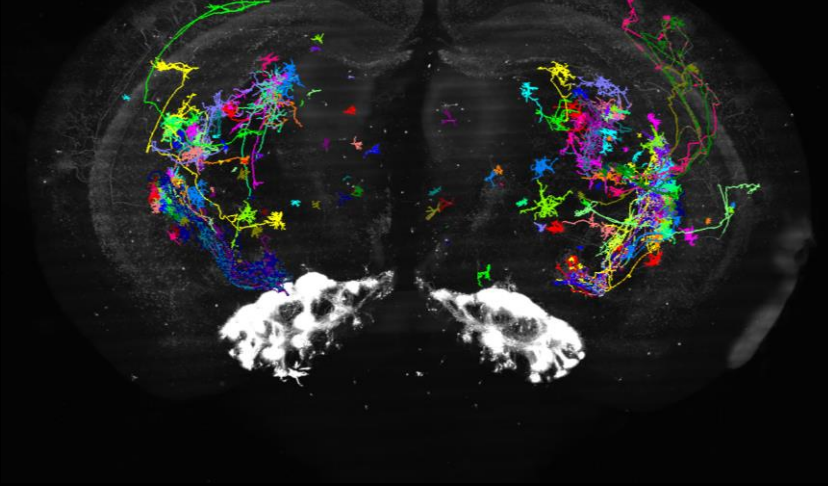
# Combination Scheme 2

Algorithm	APP2	Neutube	Real-time selection	
			Best candidate	Consensus
Morphology Reconstruction				
BASDM (voxels) (against 2 ind. Manual tracings)	2.78, 3.57	5.17, 5.42	2.62, 3.42	3.73, 4.18
Tracing time (s)	115.67	3317.86	3565.69	3204.97

124 Auto reconstructions on brain 17302



174 Auto reconstructions on brain 17545



***Thank you***