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Human Brain Project

Overview of Visualization Tools in the HBP

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Outline

- Why visualization?
- Visualization approach for the HBP
- Overview of visualization tools in the HBP
- Coordinated views from multiple tools
- Remote Rendering

Visualization

Visualization is any technique for creating images, diagrams or animations to effectively, accurately as well as meaningfully communicating information

- Not only produce beautiful images, but **aid the understanding of data**
- Represent data in a way that humans are able to gain insight and understand its structure “*easily*”
- Visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data

From data to wisdom- Ackoff 1989

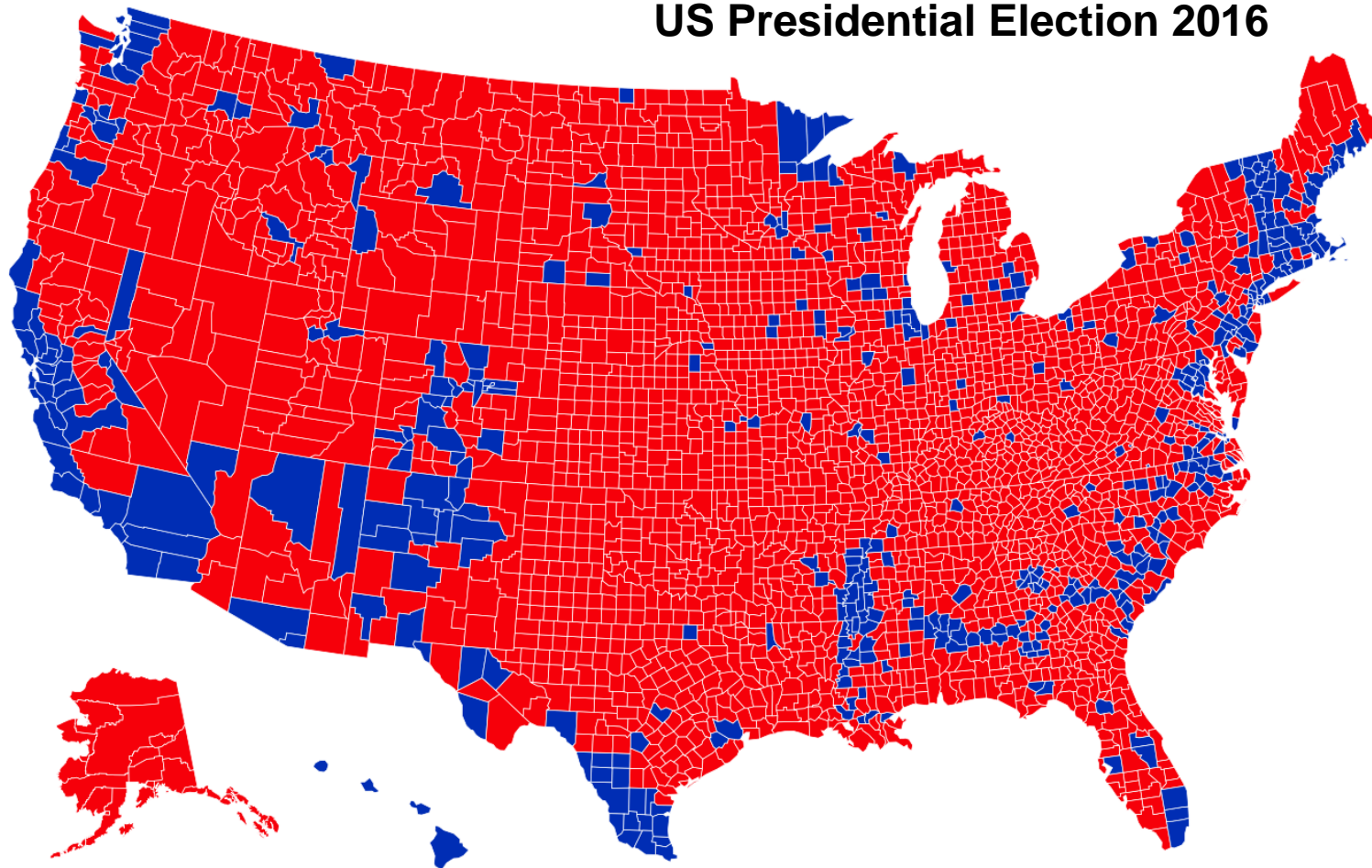
Harry Beck's Tube Map



<https://tfl.gov.uk/corporate/about-tfl/culture-and-heritage/art-and-design/harry-becks-tube-map>

Visualization

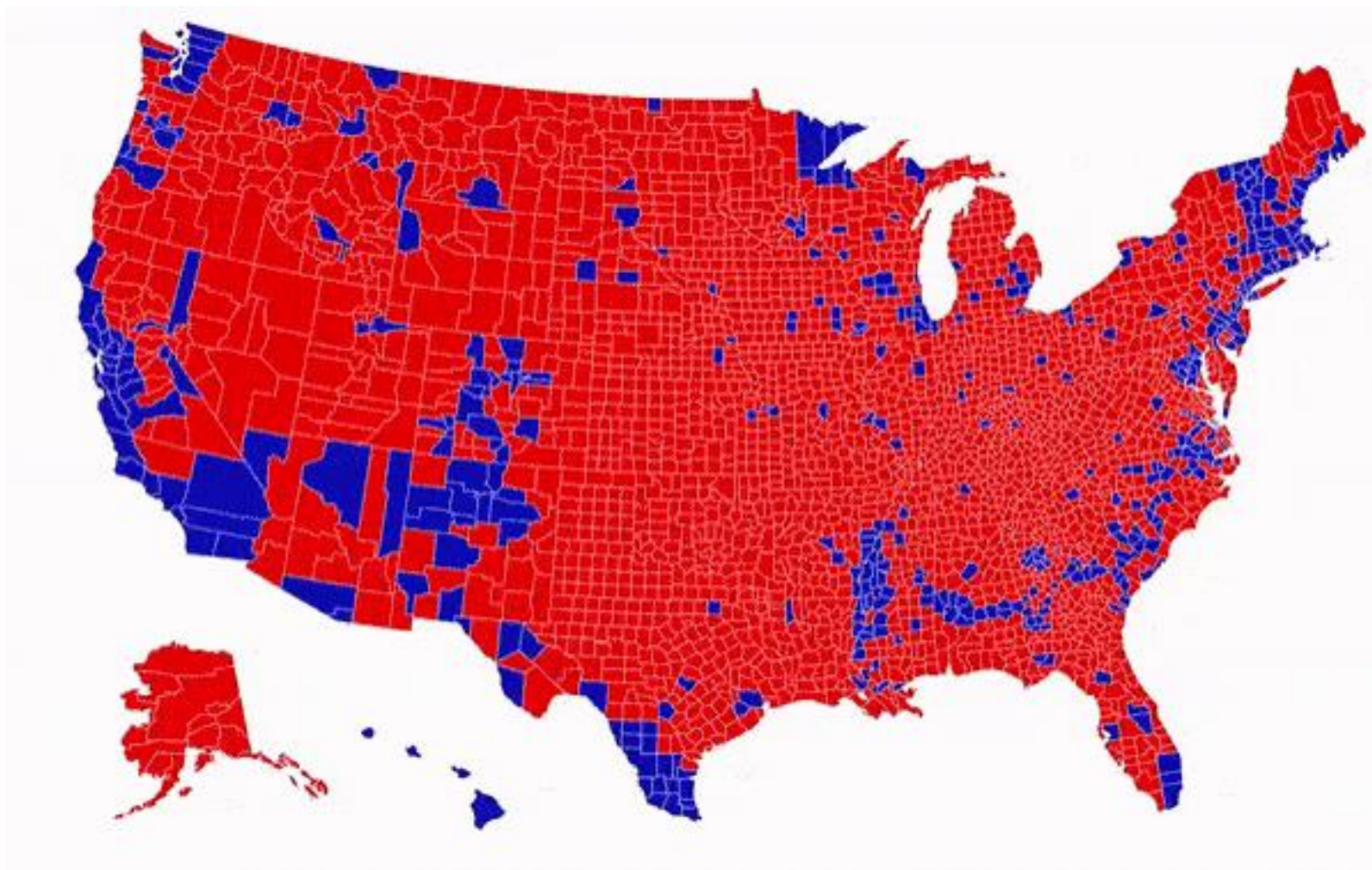
US Presidential Election 2016



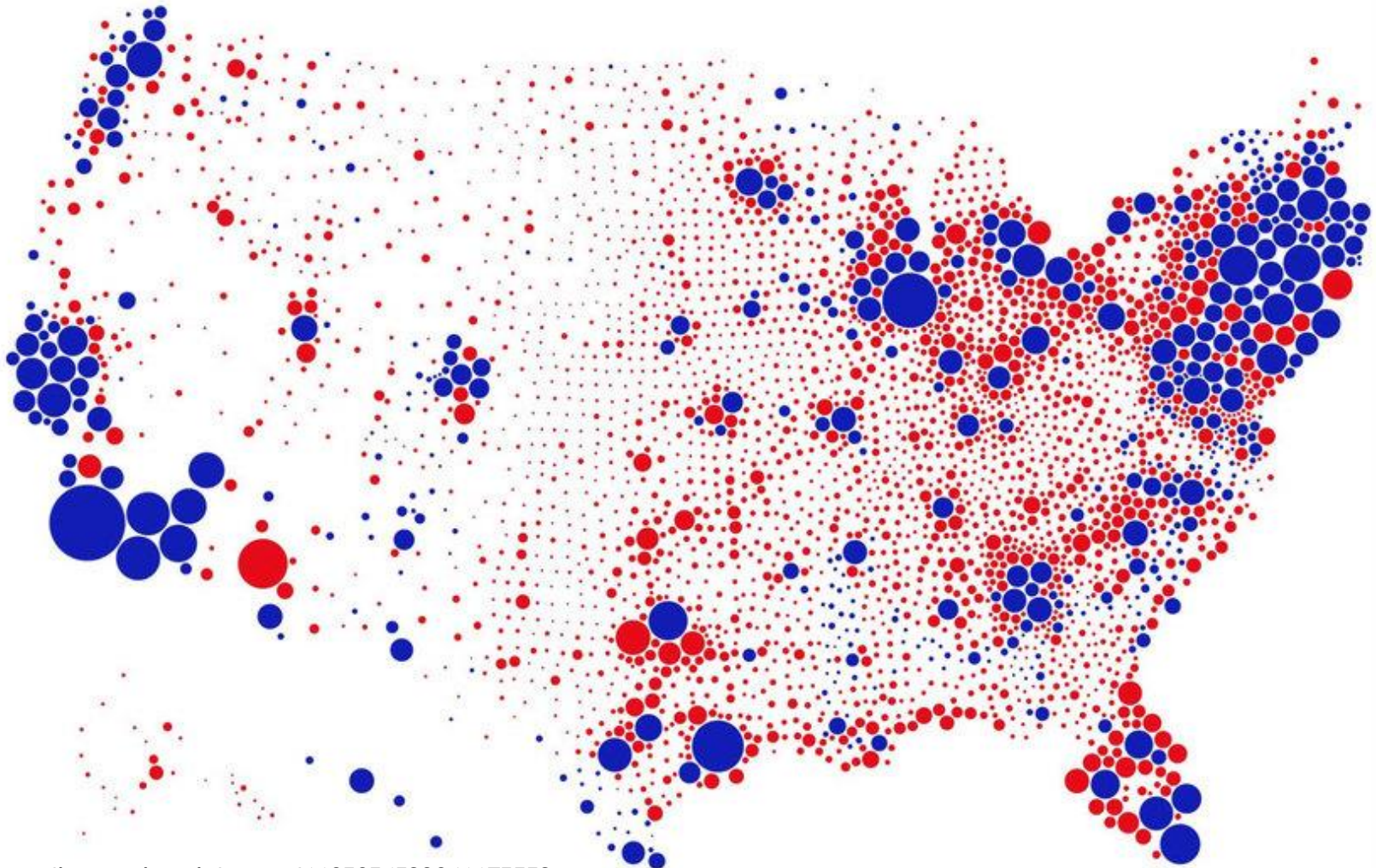
<https://twitter.com/LaraLeaTrump/status/1178030815671980032>

“Try to impeach this.”

Visualization

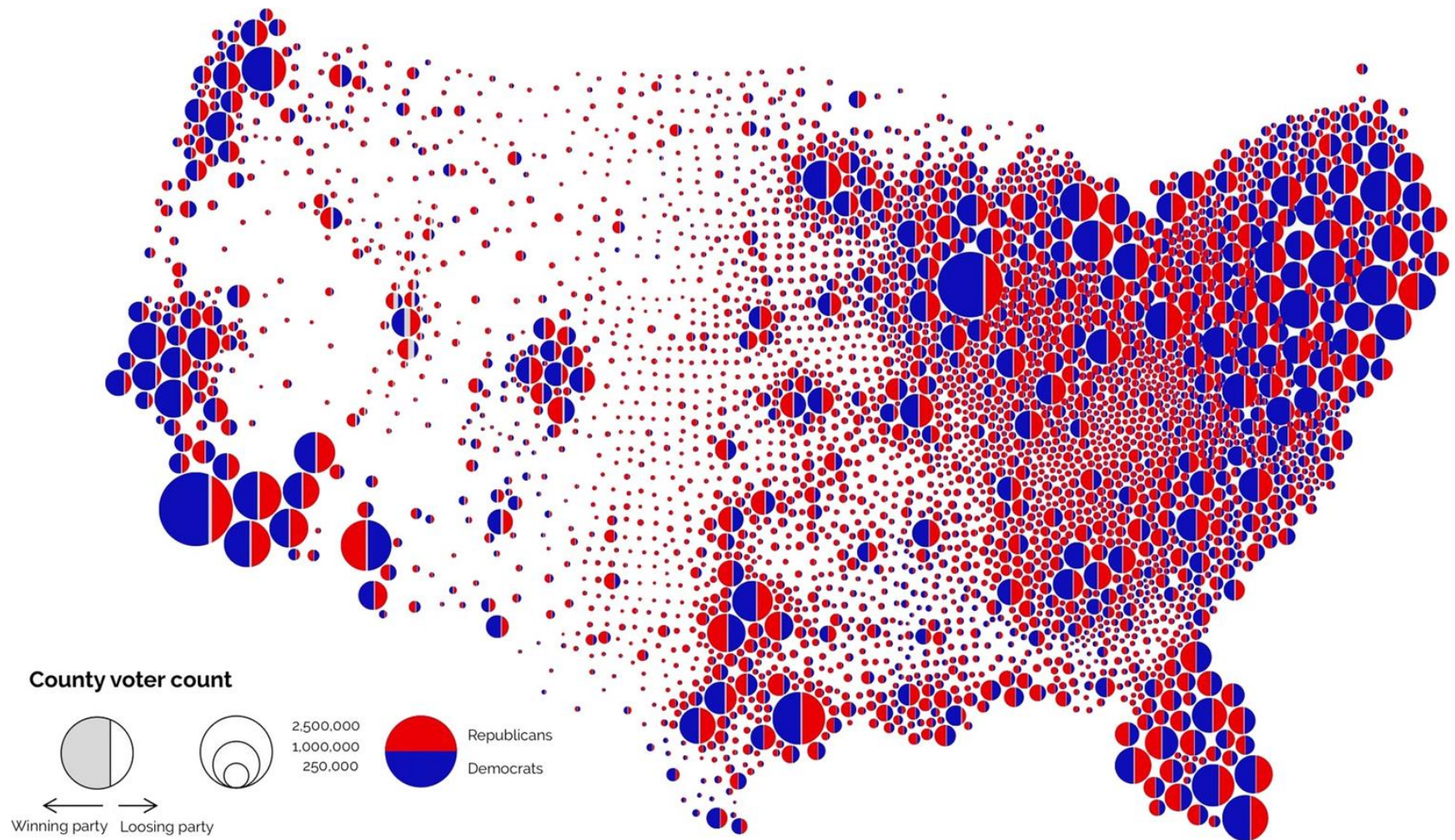


Visualization



https://twitter.com/karim_douieb/status/1185854523841175552

Visualization



Try to impeach this? Challenge accepted!

<https://observablehq.com/@karimdouieb/2016-u-s-presidential-election>

 karim_douieb

Visualization

- Helping people to find, understand and share insights in data
- Three missions:
 - **Exploration.** Searching for significant facts within the data to discover meaningful insights
 - **Validation.** Examining and making sense of data
 - **Explanation.** Conveying relevant insight to others to raise comprehension, awareness and engagement

Visualization

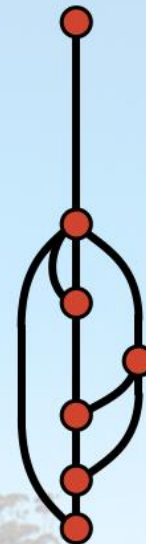
- Data exploration is about the journey to find a message in your data.
 - The analyst is trying to put together the pieces of a puzzle.
- Data explanation is about sharing the solved puzzle with people who can take action on the insights.
 - Explaining the results of analysis

Visualization

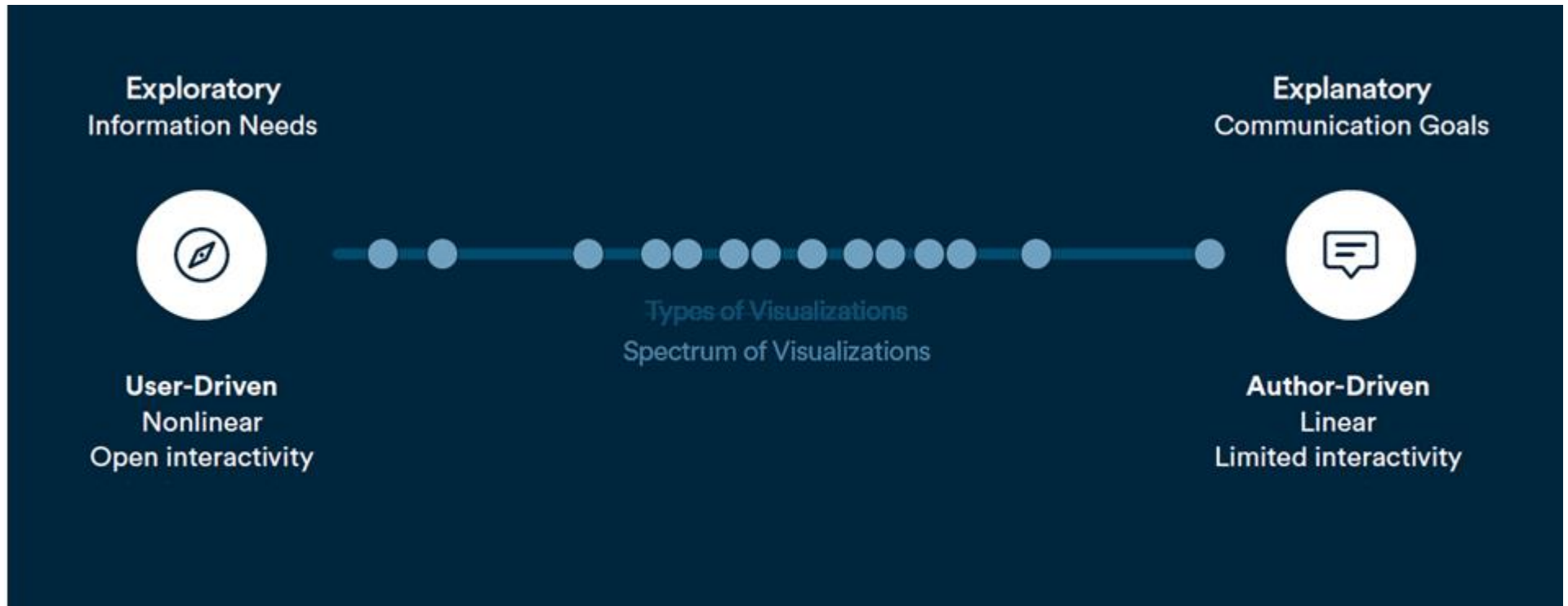
a walkabout



a guided safari



Visualization



Visualization

- Enrich the collective knowledge

Human readable data

Transform into knowledge

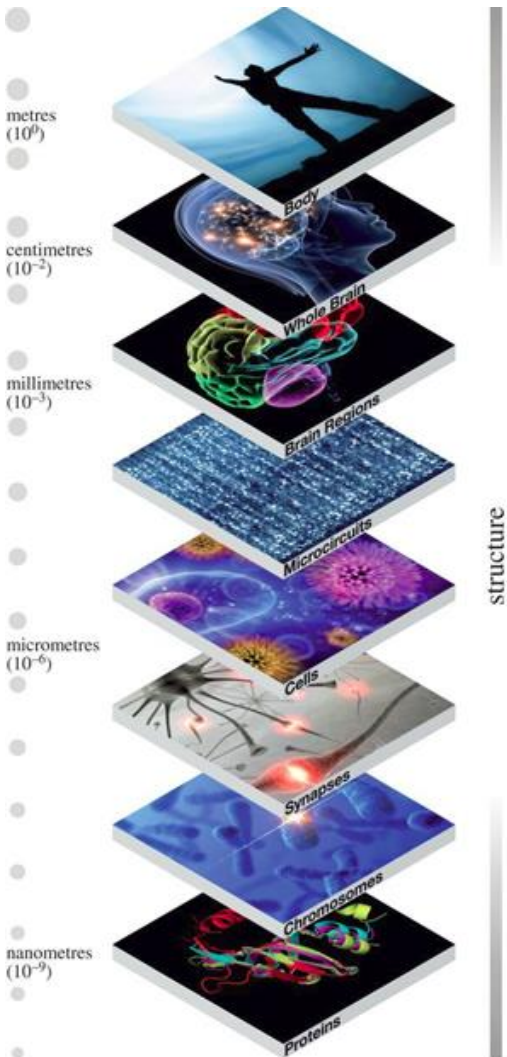
And share them



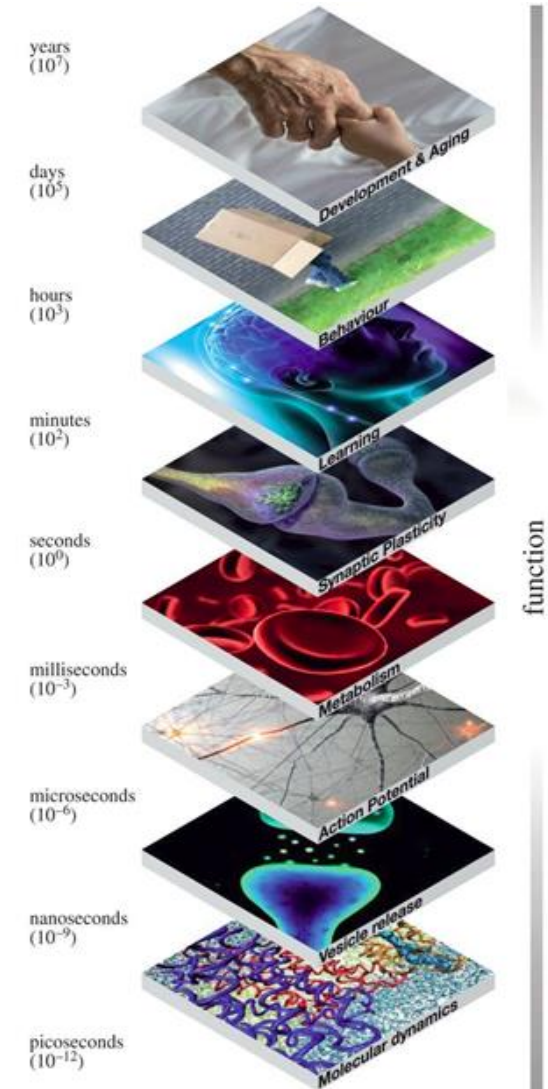
“The ability to take data - to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it’s going to be a hugely important skill in the next decades”

Hal Varian- Google’s Chief Economist

Visualization approach for the HBP



- Multiple levels of brain organization
- Multiple spatio-temporal scales
- Huge data
- Studied from different perspectives
 - Structural
 - Functional
 - Connectivity



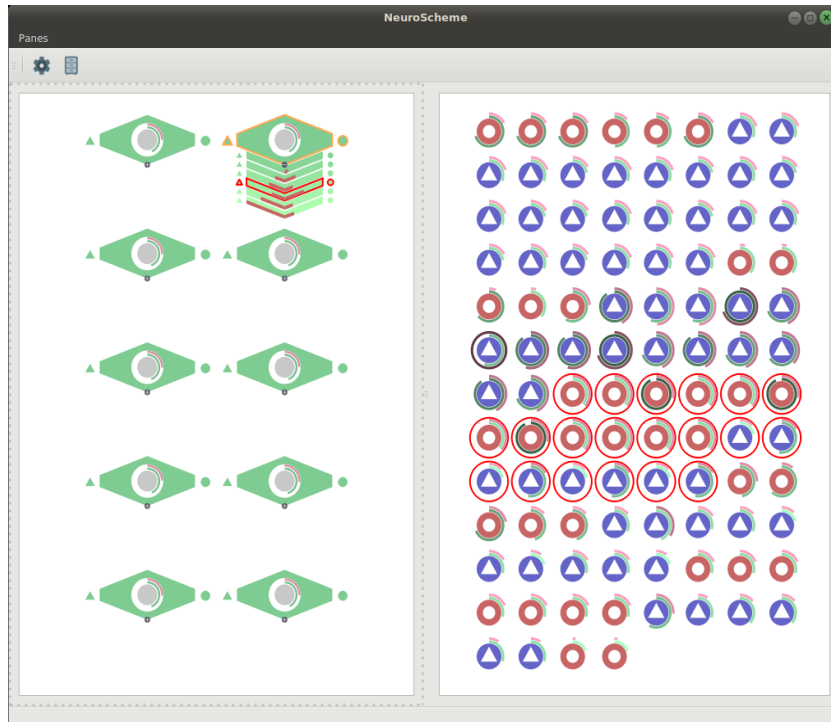
Images edited from Frackowiak 2015

Visualization approach for the HBP

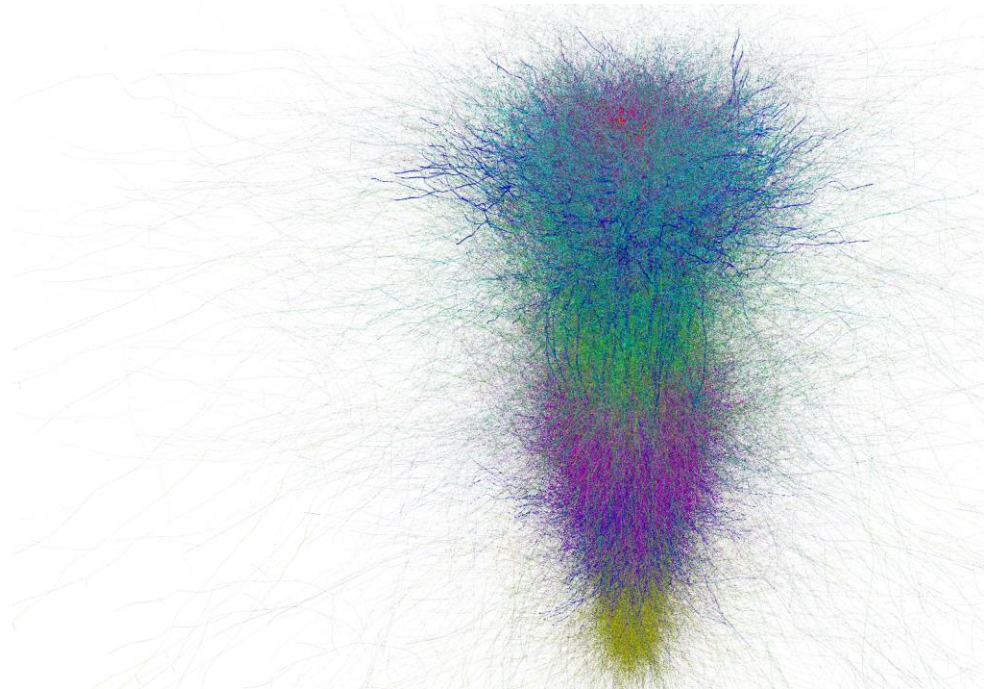
- **Multiscale**
 - Different levels of abstraction
- **Complementary representations of the same data**
 - Realistic or abstract
- **Multiple domains**
 - Structural, functional, connectivity
- **Coordinated views**
 - Simultaneous visualization of multiple domains
- **Interactive**
 - Exploratory and explanatory visualizations

Visualization of anatomical structures

■ Symbolic

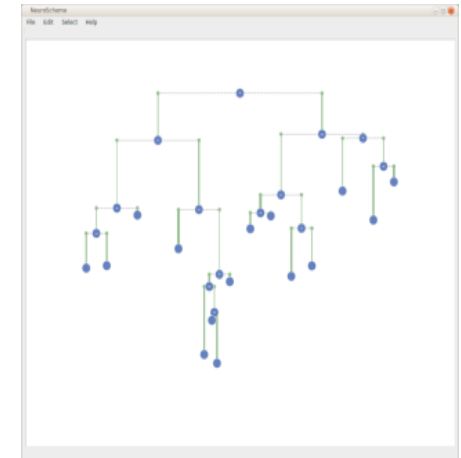
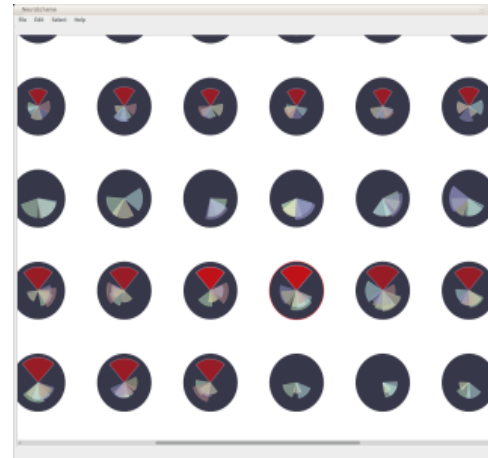
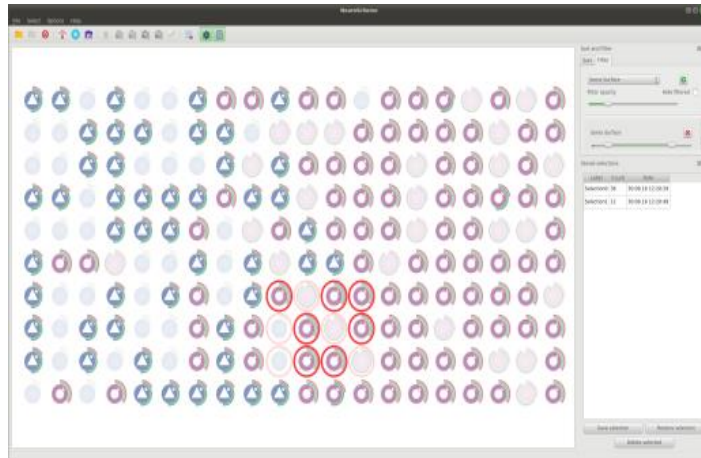
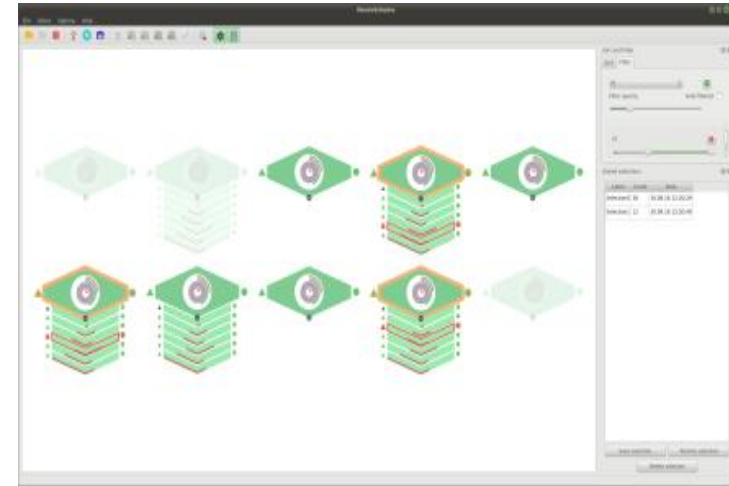
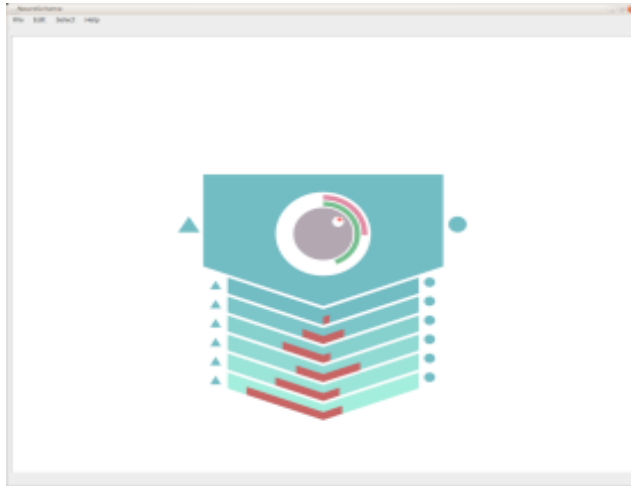


■ Realistic



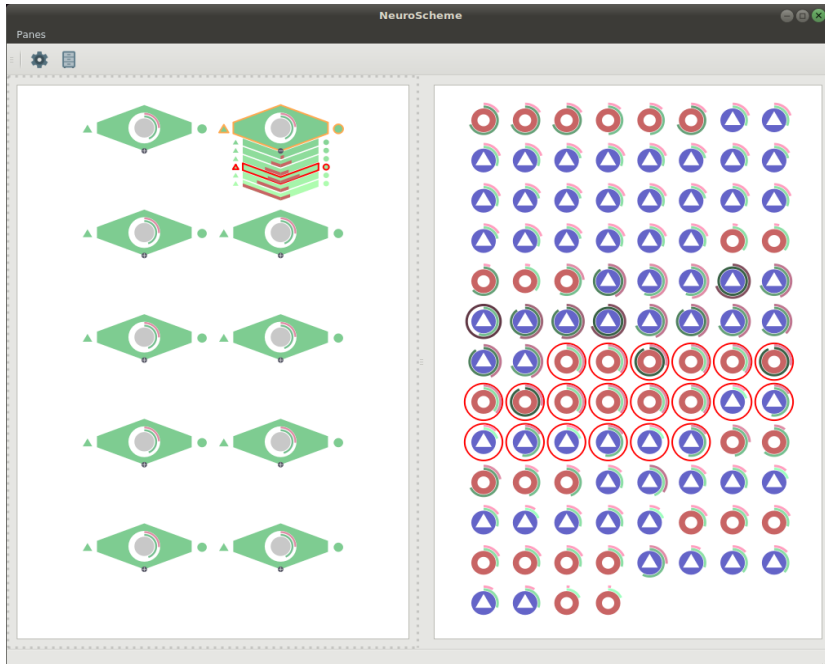
Symbolic Structural Visualization NeuroScheme (URJC/UPM-Madrid)

Navigation based on levels of abstraction

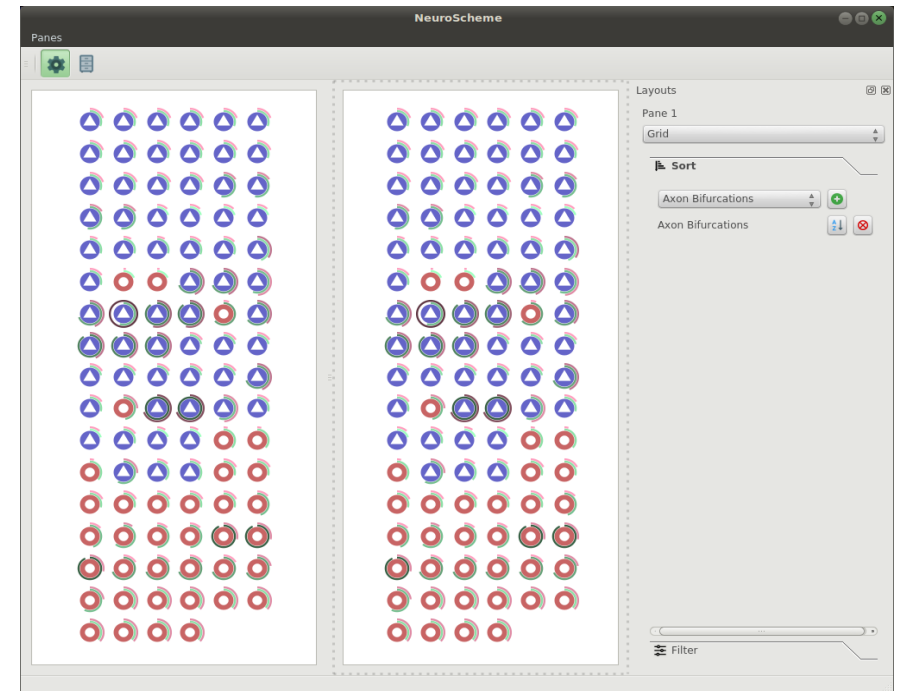


Symbolic Structural Visualization NeuroScheme (URJC/UPM-Madrid)

Multiple coordinated views



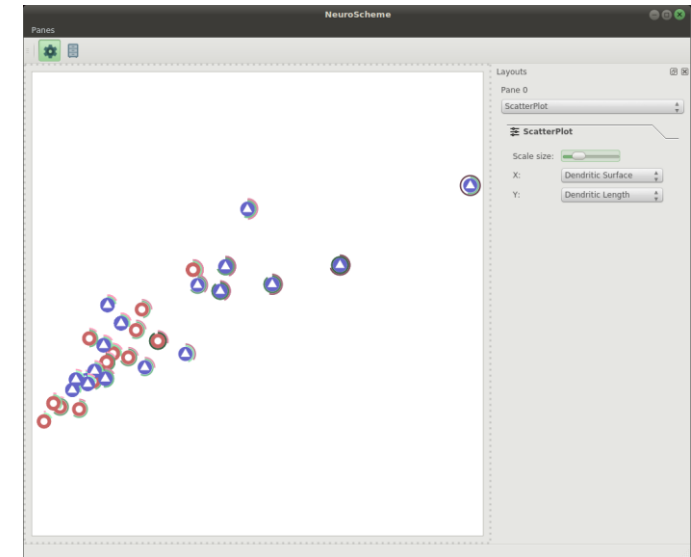
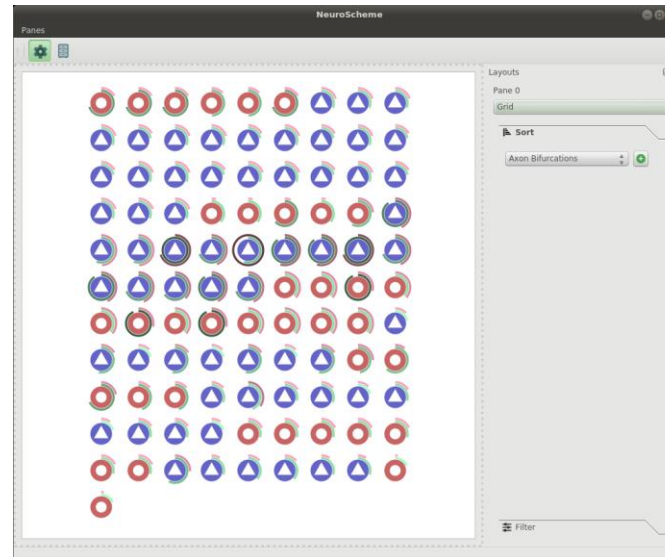
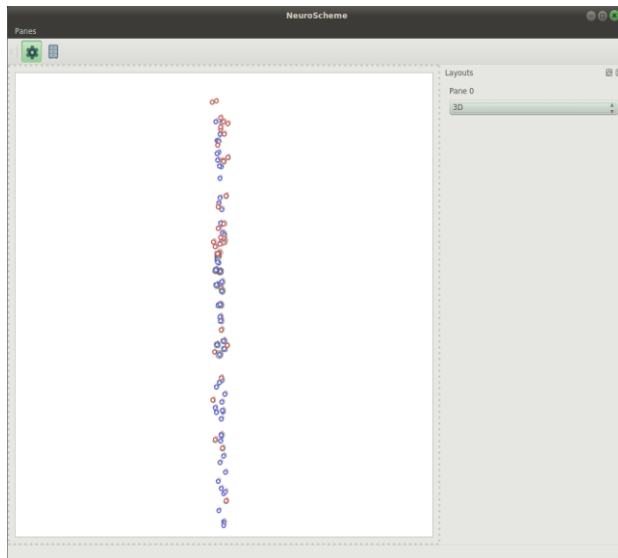
Focus and Context



Comparison

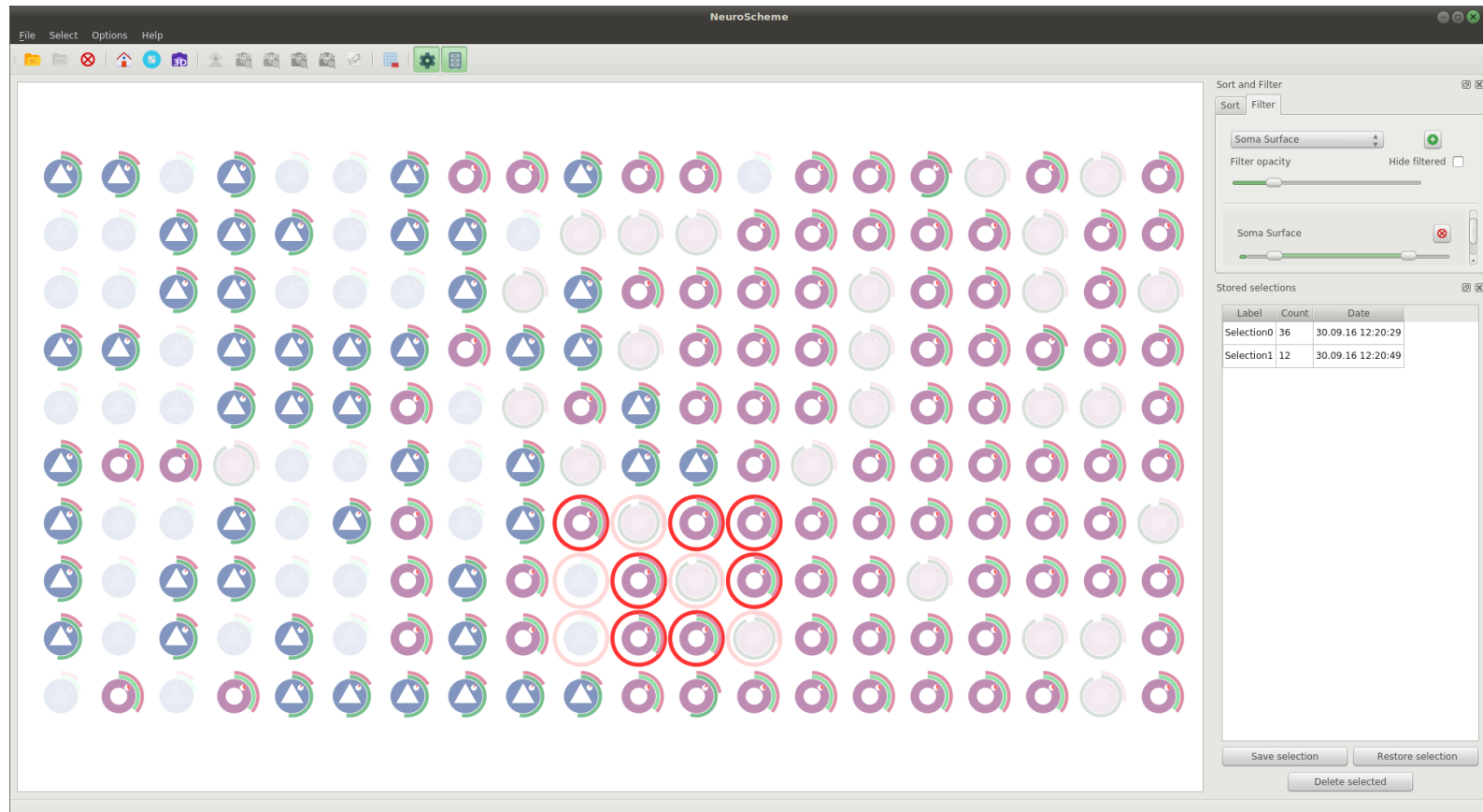
Symbolic Structural Visualization NeuroScheme (URJC/UPM-Madrid)

Multiple Layouts



Symbolic Structural Visualization NeuroScheme (URJC/UPM-Madrid)

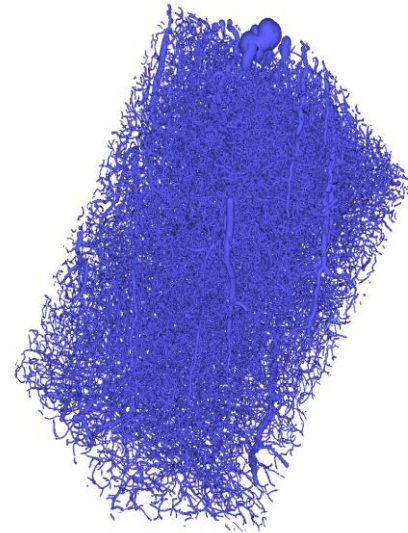
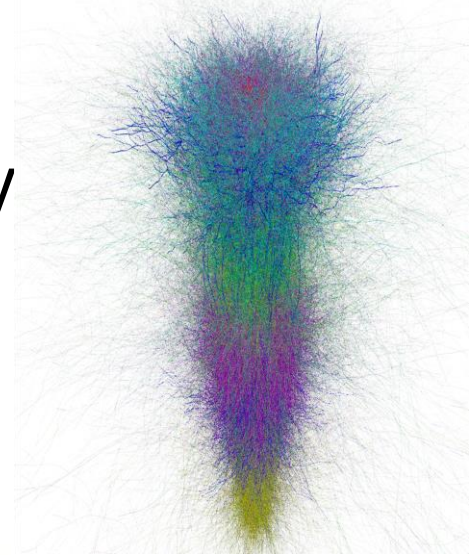
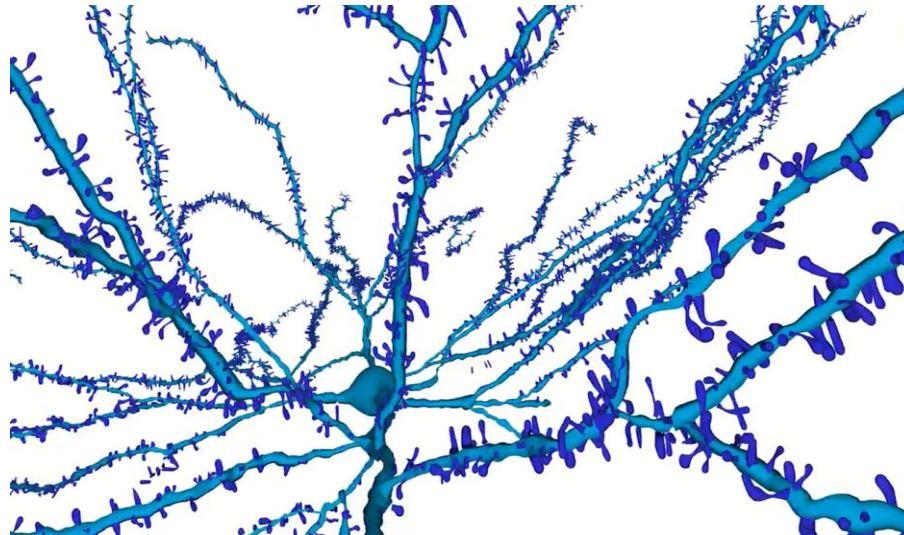
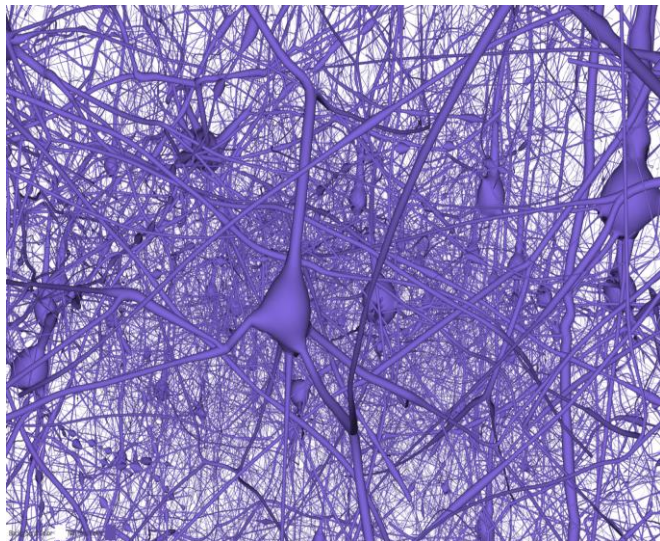
Selecting/Sorting/Filtering



Realistic Visualization of Morphology

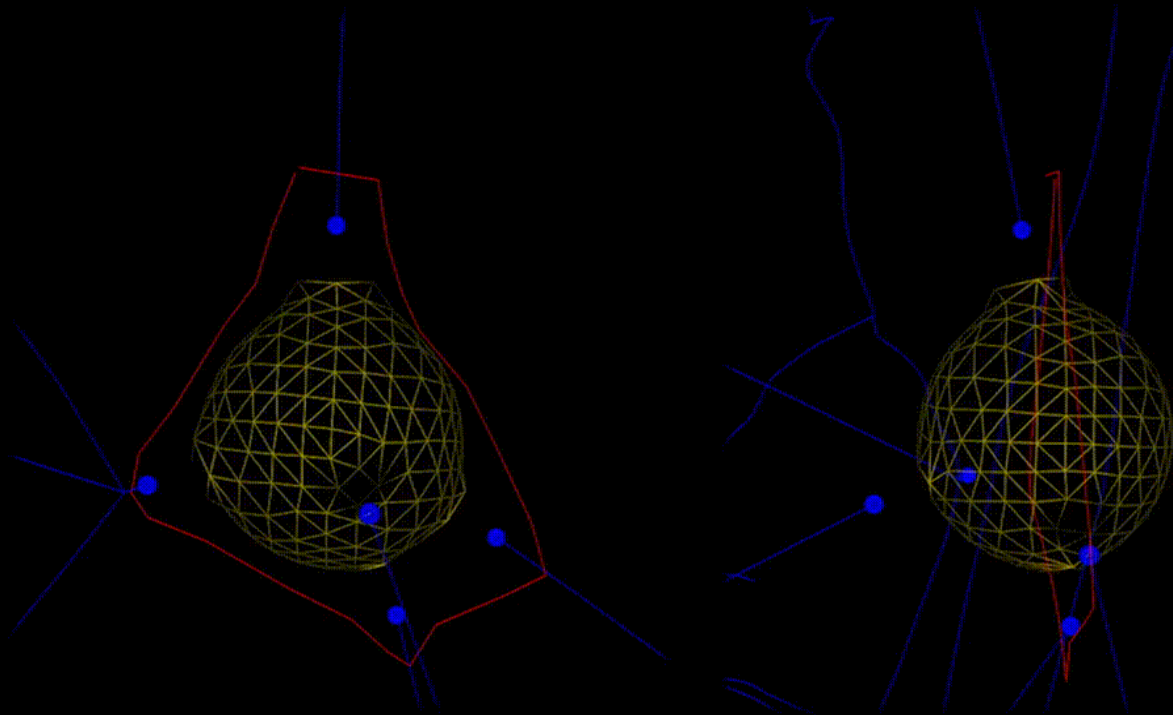
NeuroTessMesh (URJC/UPM-Madrid)

- On-the-fly neuron 3D models generation
- From very compact neuron description to highly detailed meshes
- Applicable to other structures (eg. vascularity)



Realistic Visualization of Morphology

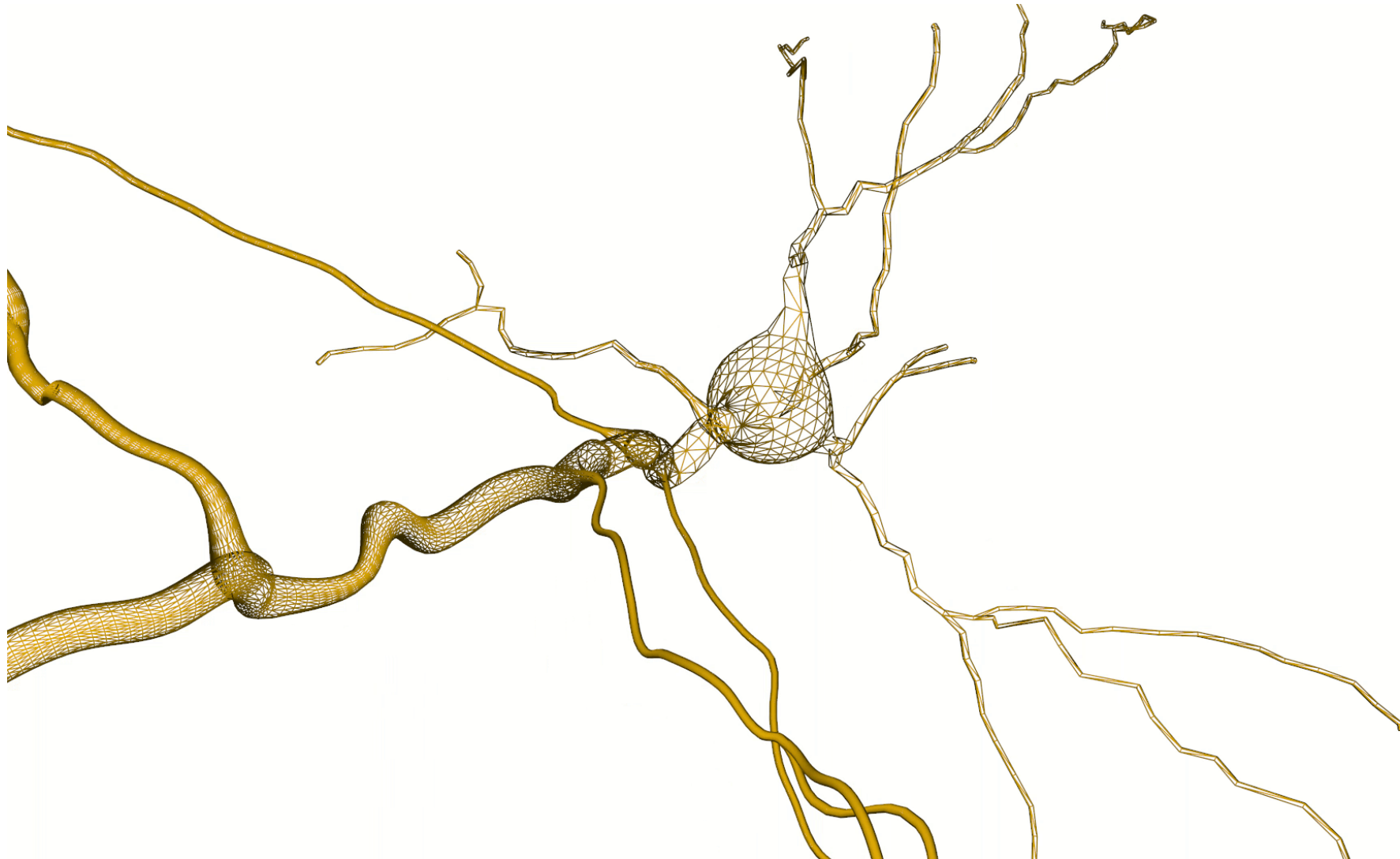
NeuroTessMesh (URJC/UPM-Madrid)



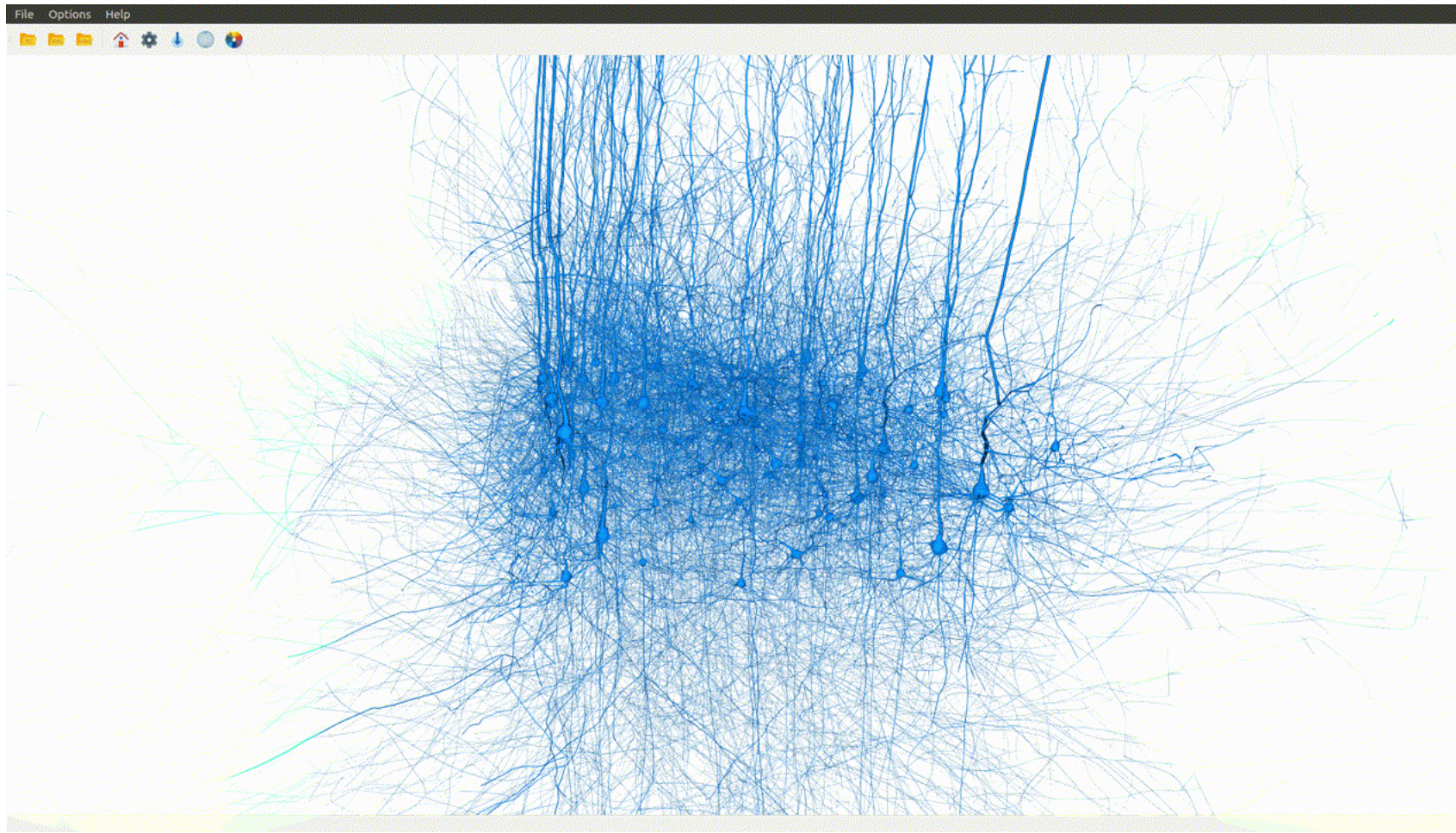
Neural soma is reconstructed through a FEM deformation of an elastic icoesphere attracted towards the neurites (in blue)

Realistic Visualization of Morphology

NeuroTessMesh (URJC/UPM-Madrid)

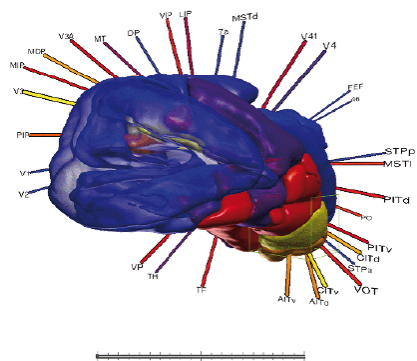
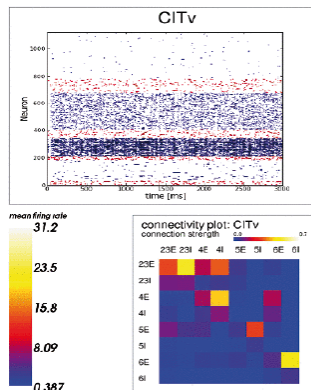


Realistic Visualization of Morphology NeuroTessMesh (URJC/UPM-Madrid)

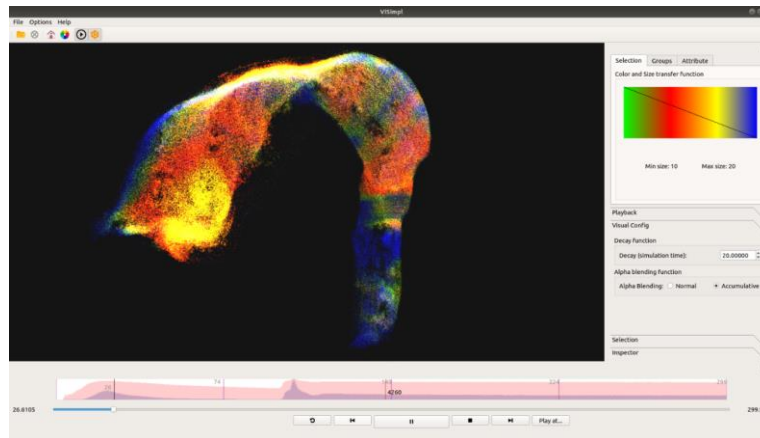


Visualization of Activity

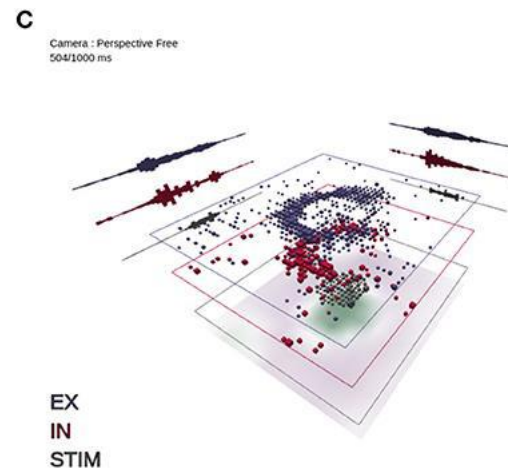
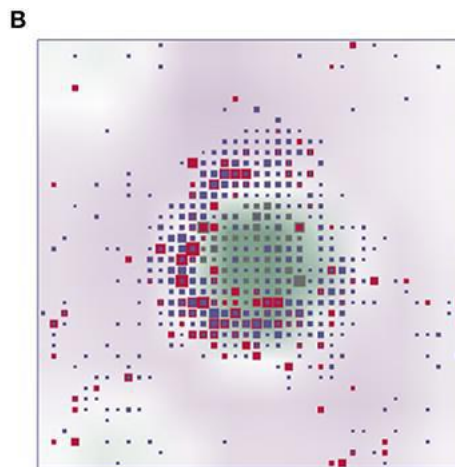
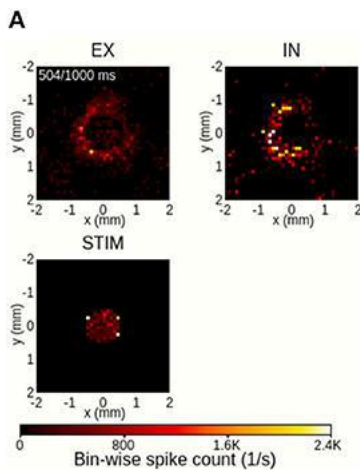
- Areas



- Neurons

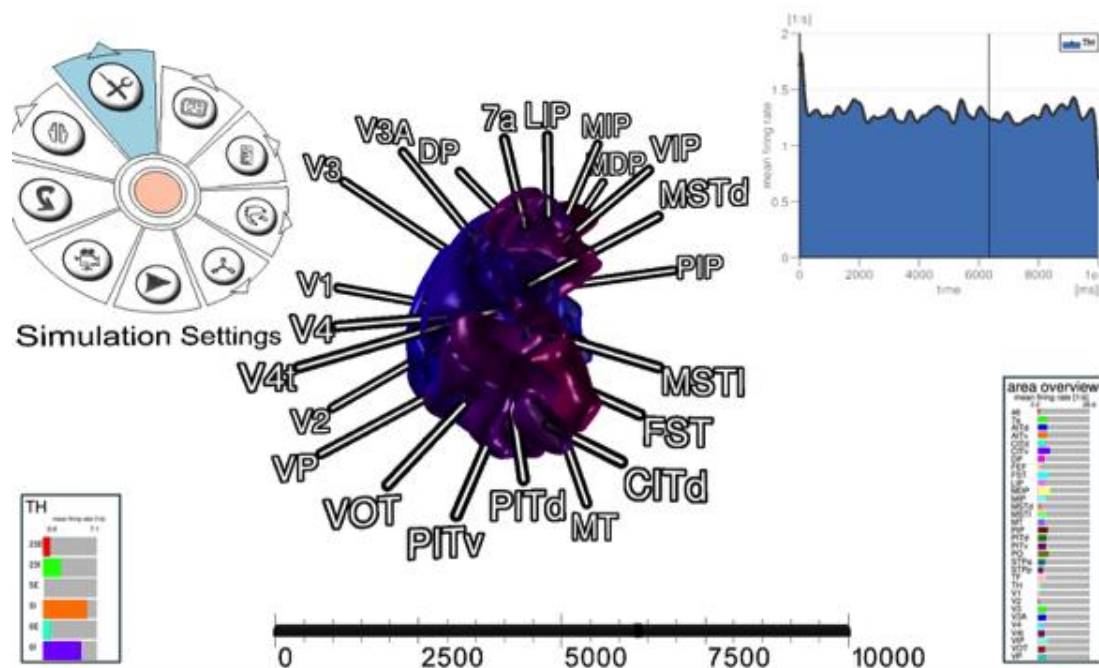


- Layers



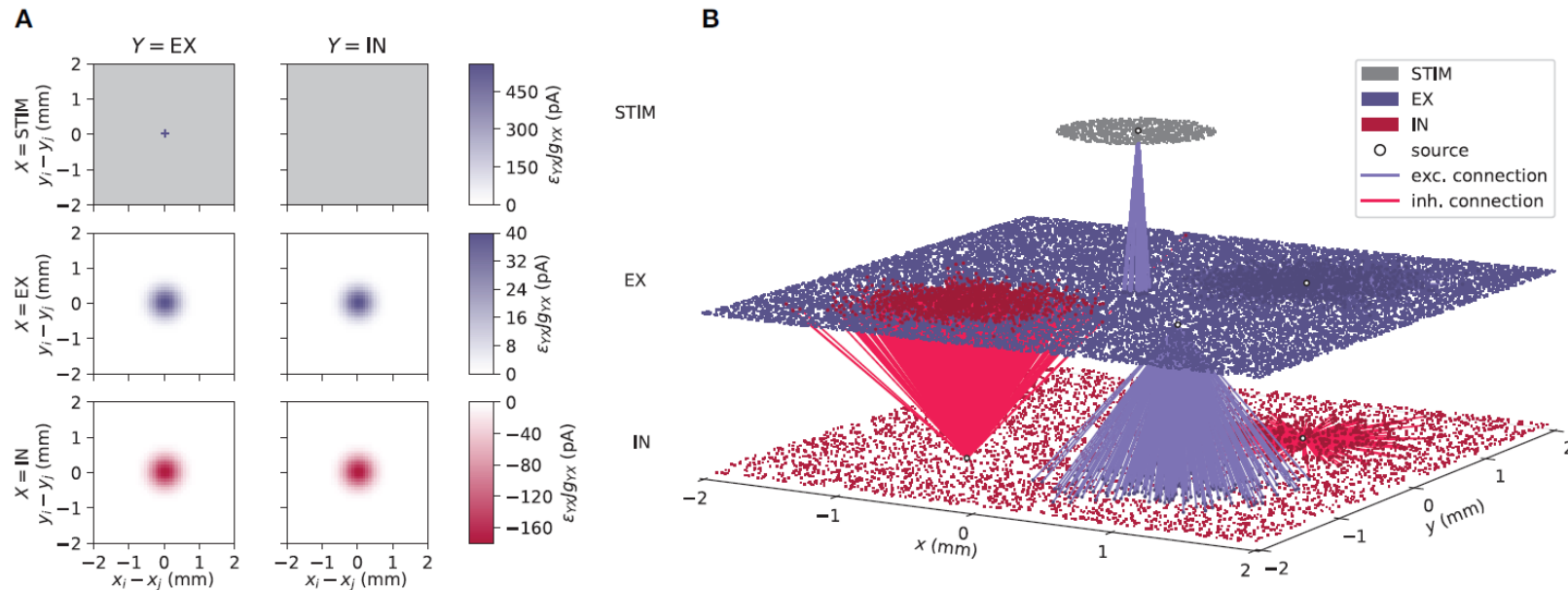
VisNet (RWTH-Aachen)

- Visualizing neural network simulations of the macaque visual cortex.
- Allows for exploring
 - mean activity rates
 - connectivity of brain areas
 - information exchange between pairs of areas.



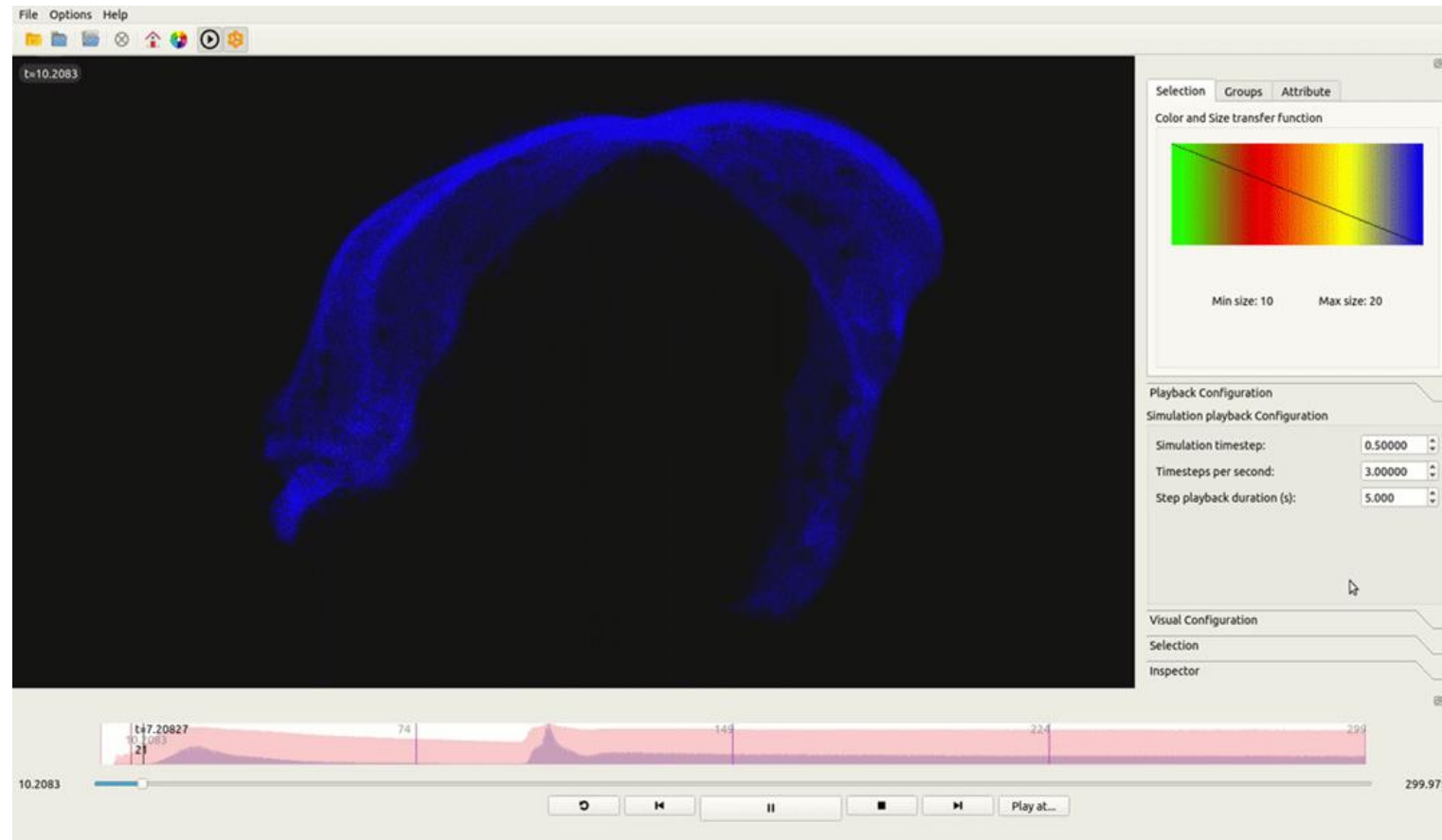
Viola (RWTH-Aachen)

- A multipurpose web-based visualization tool for simulation output
- Visualization of spiking activity of layered point-neuron models
 - Interactive multiview analysis
 - Visualize activity data in multiple layers



Neuronal activity

ViSimpl (URJC/UPM-Madrid)

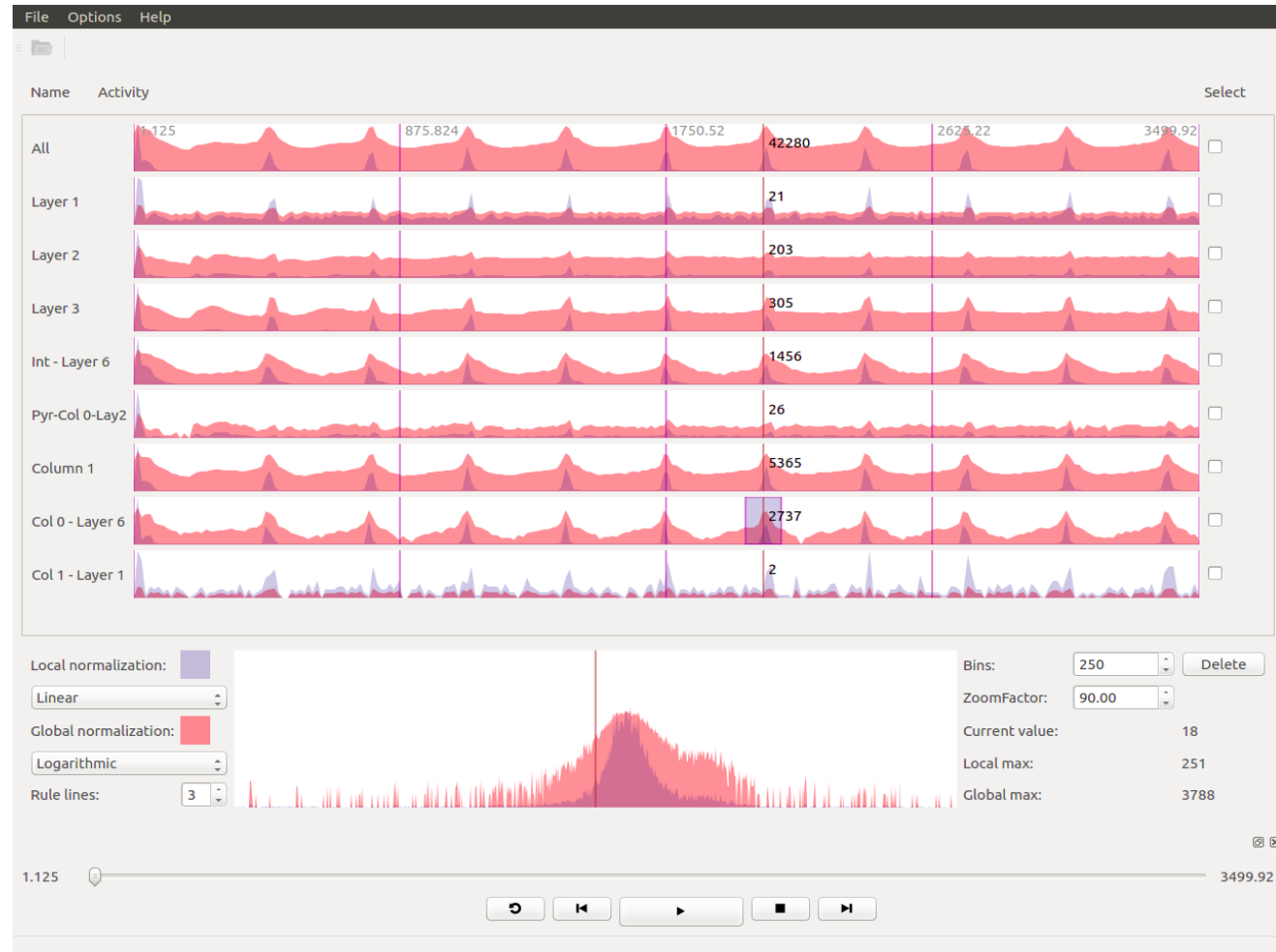


"This model of the hippocampus has been simulated by Michele Migliore (CNR; HBP Brain Simulation Platform) and his project partners using HPC resources at CINECA. The visualisation with ViSimpl has been rendered on the GALILEO HPC system at CINECA."

Neuronal activity

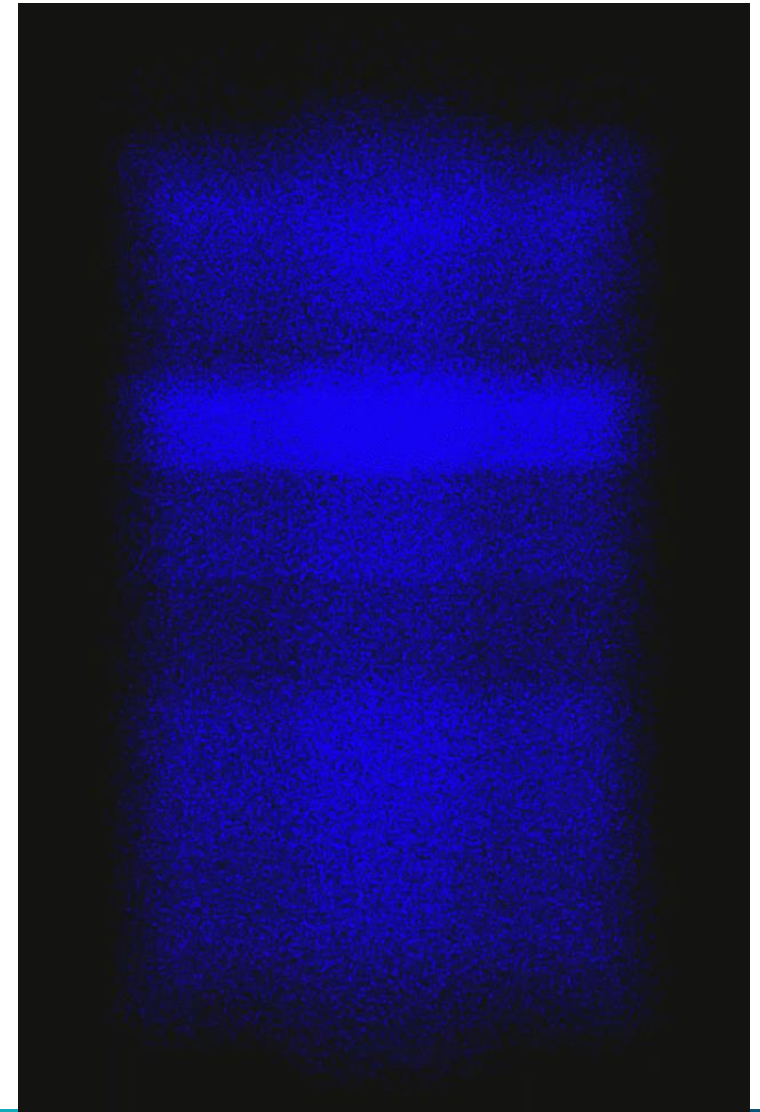
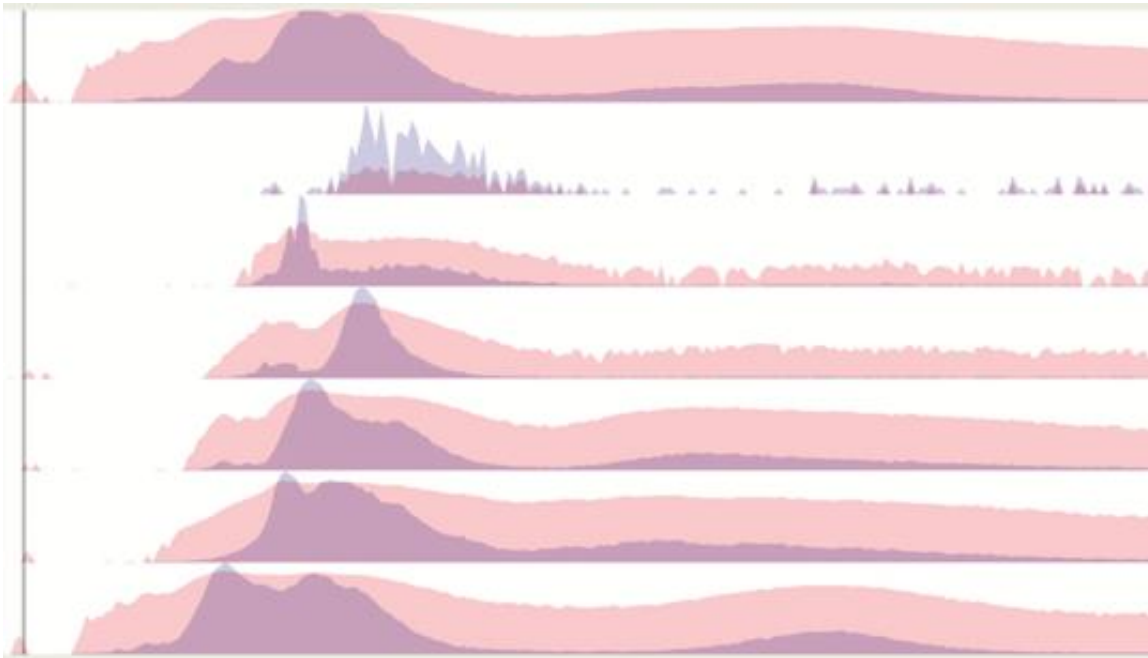
ViSimpl (URJC/UPM-Madrid)

- Activity:
 - Spikes histograms
 - Average voltage
 - Agregations



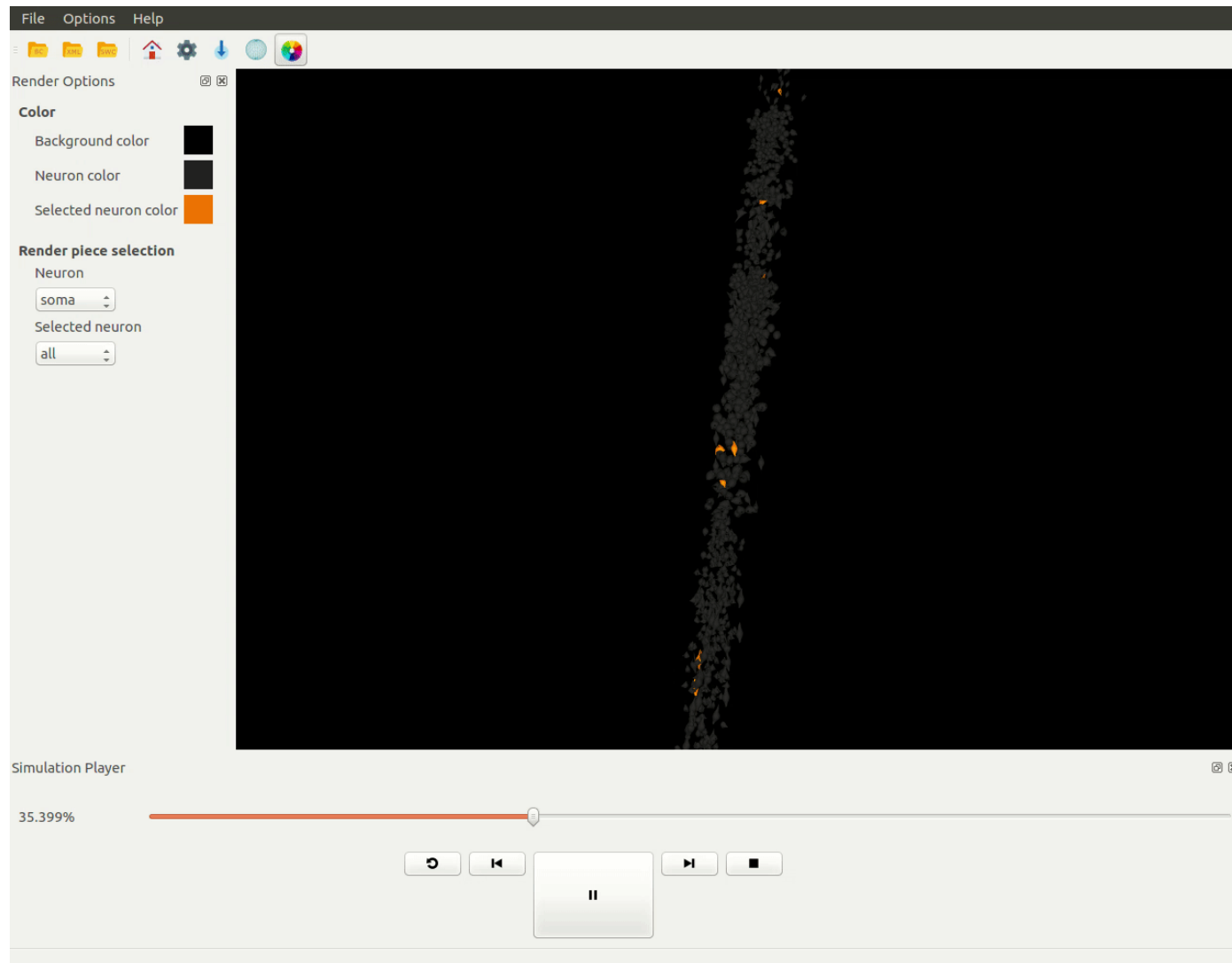
Neuronal activity

ViSimpl (URJC/UPM-Madrid)



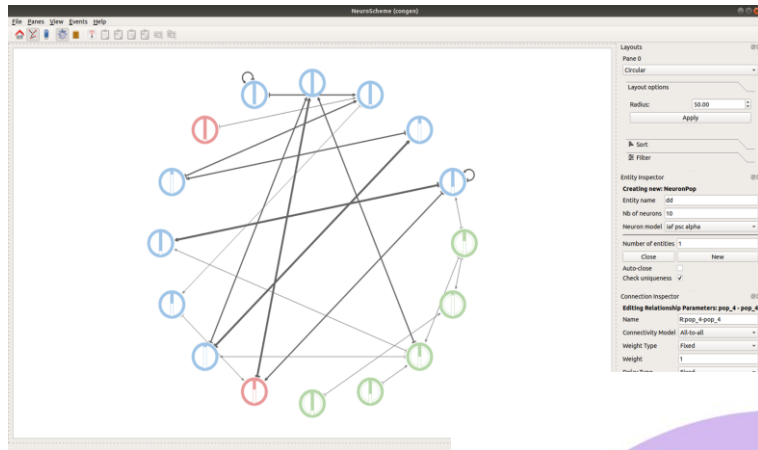
Neuronal activity with detailed morphologies

NeuroTessMesh (URJC/UPM-Madrid)

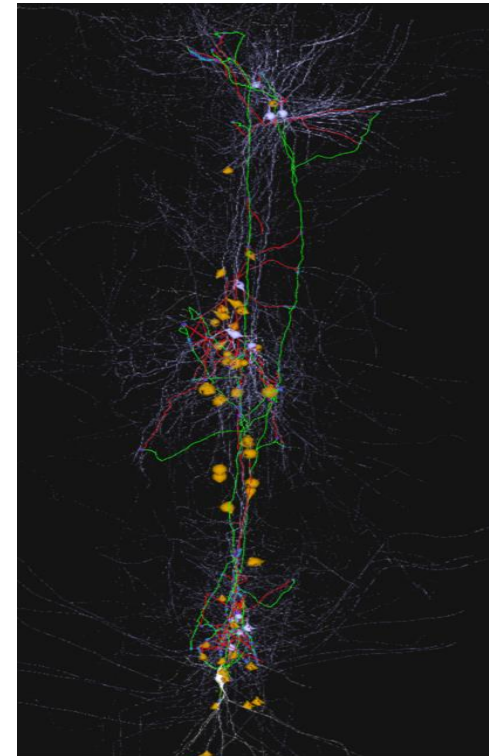


Visualization of connectivity

■ Symbolic



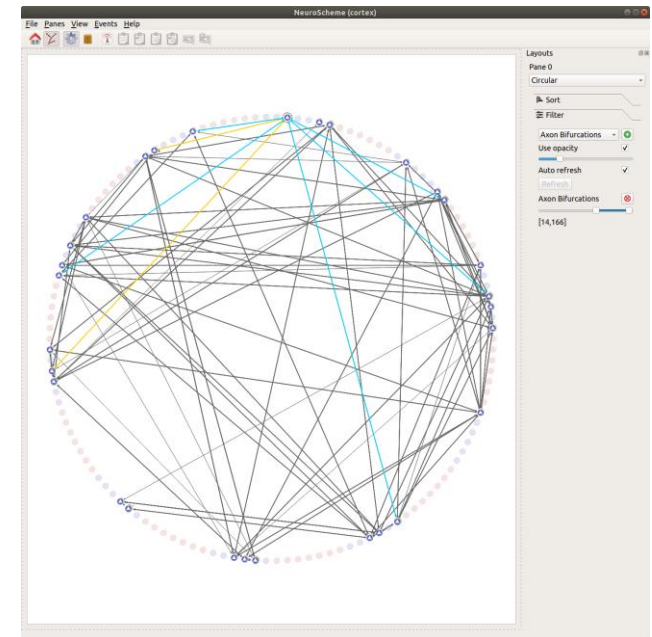
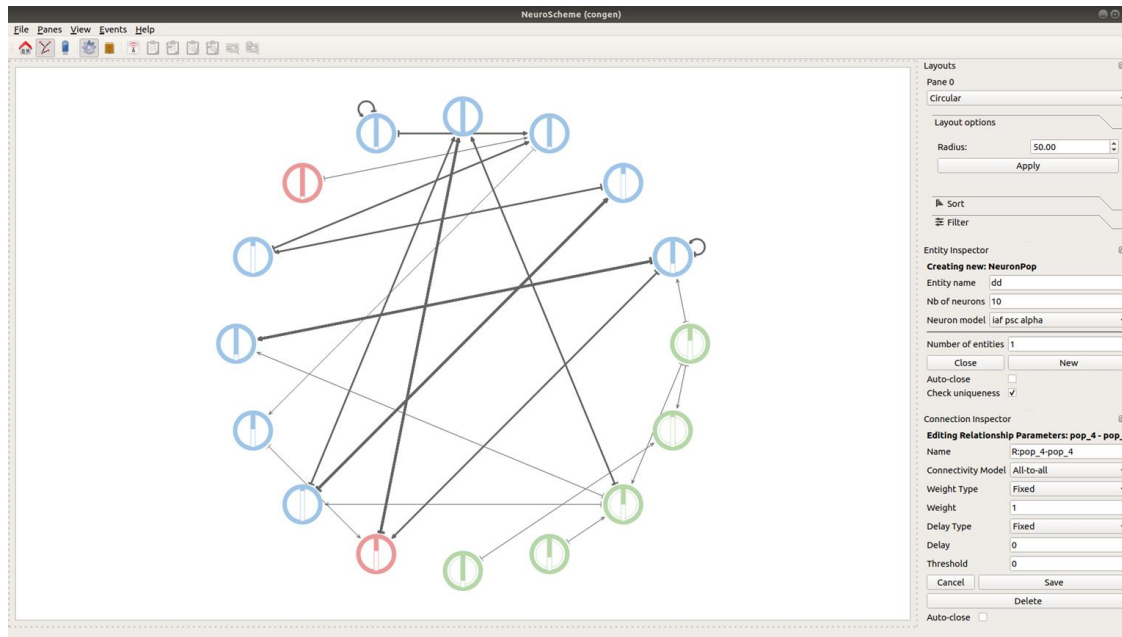
■ Realistic



Symbolic Connectivity

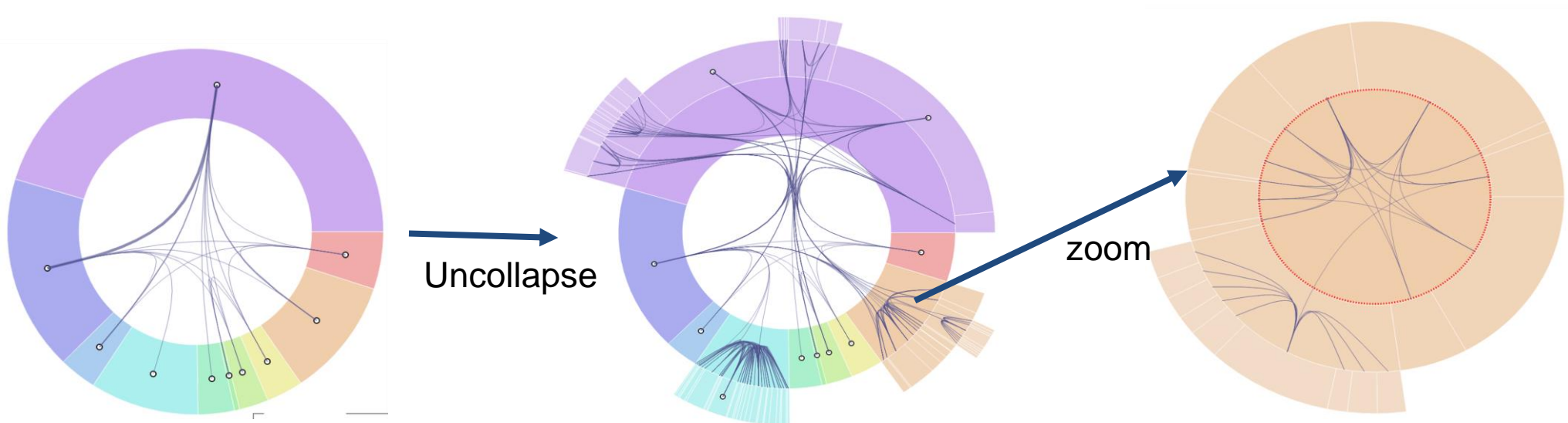
ConGen (URJC/UPM-Madrid)

- Visualization and edition
- Different levels of abstraction (populations and subpopulations)



Symbolic Connectivity Carbonic (URJC/UPM-Madrid)

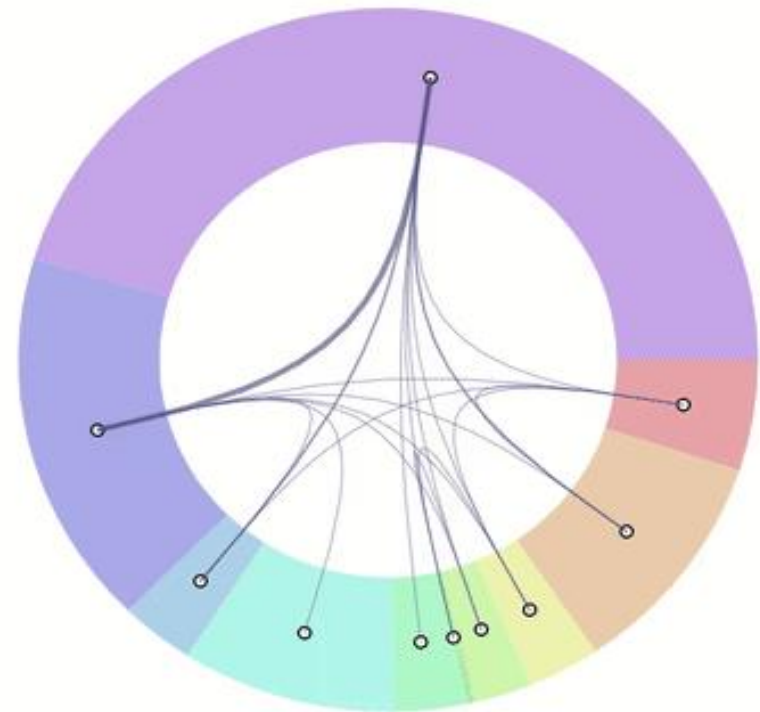
- At different levels of abstraction
 - Hierarchy navigation based on collapse/uncollapse operations
 - Zoom capabilities



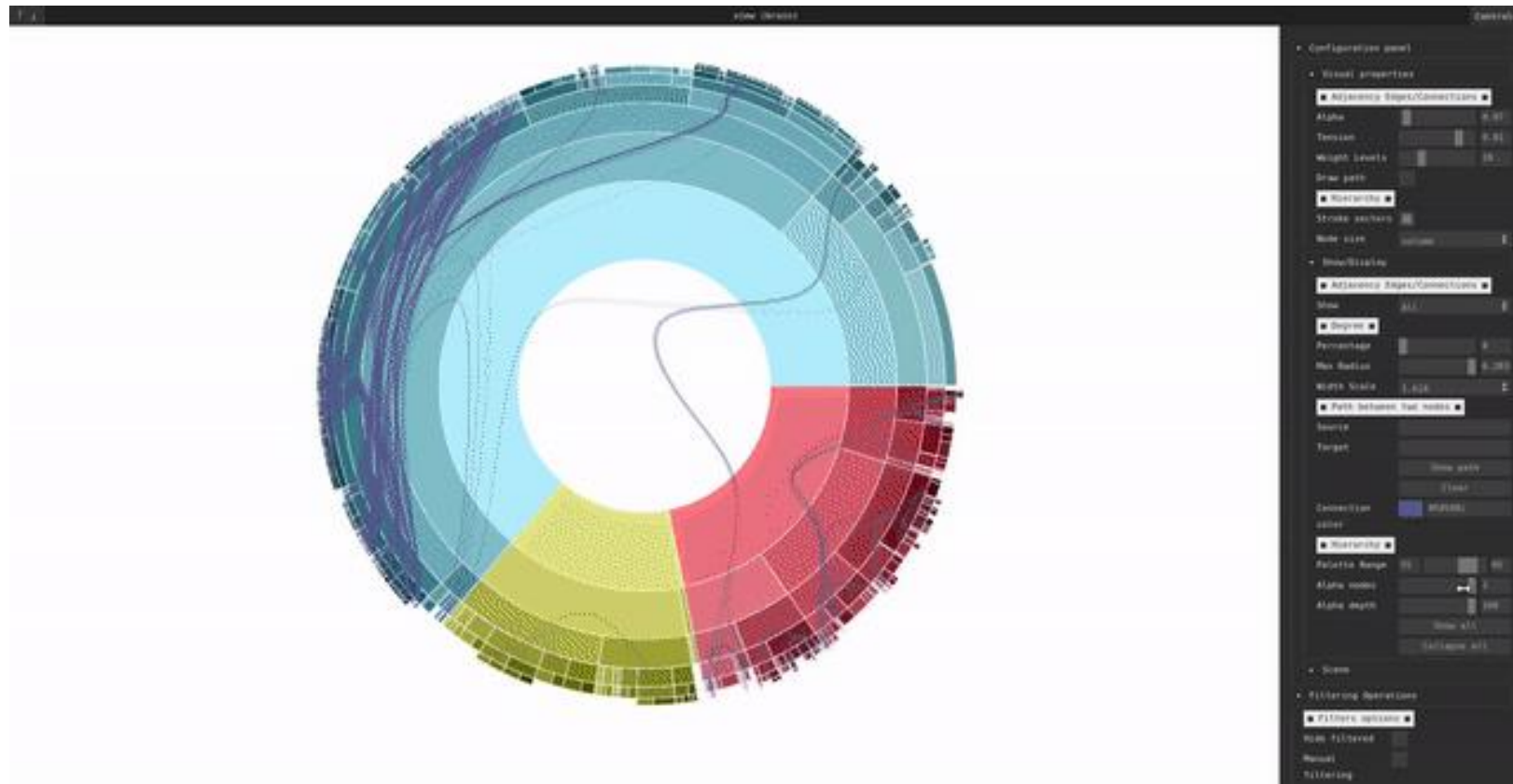
Symbolic Connectivity

Carbonic (URJC/UPM-Madrid)

- Filtering capabilities based on domain properties
- Connectivity
 - Aggregated connectivity
 - Cross-scale connectivity

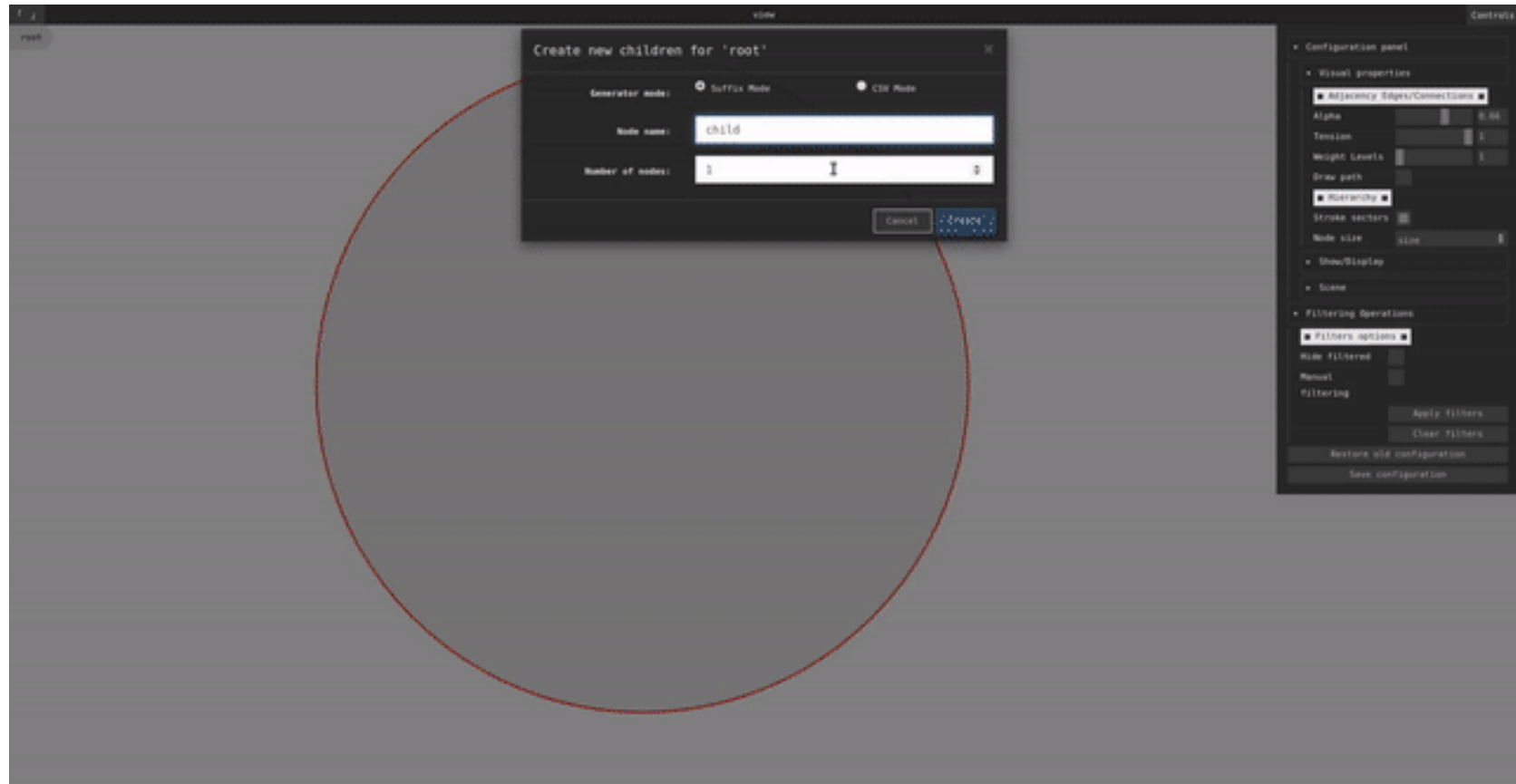


Symbolic Connectivity Carbonic (URJC/UPM-Madrid)

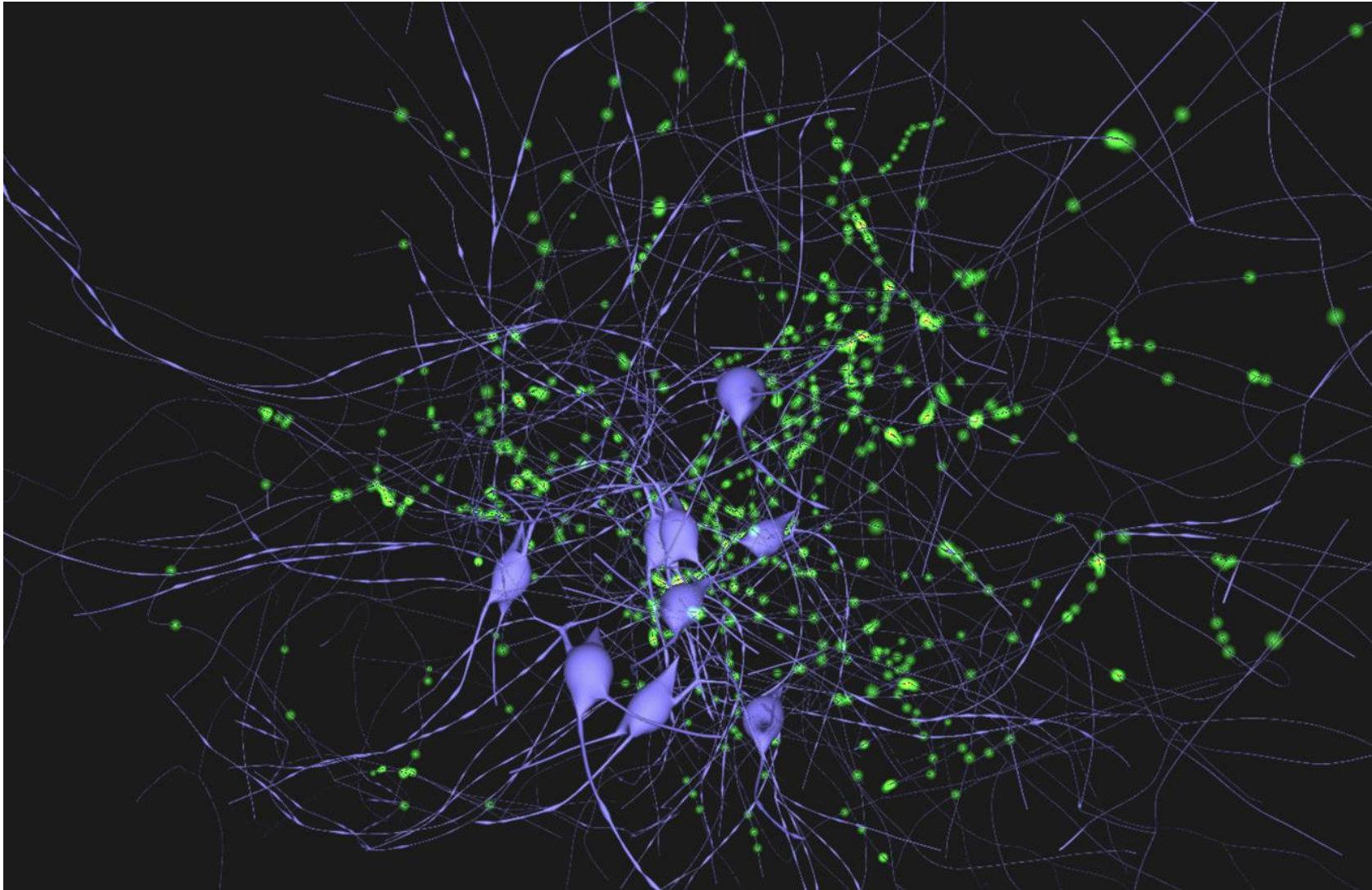


Symbolic Connectivity Carbonic (URJC/UPM-Madrid)

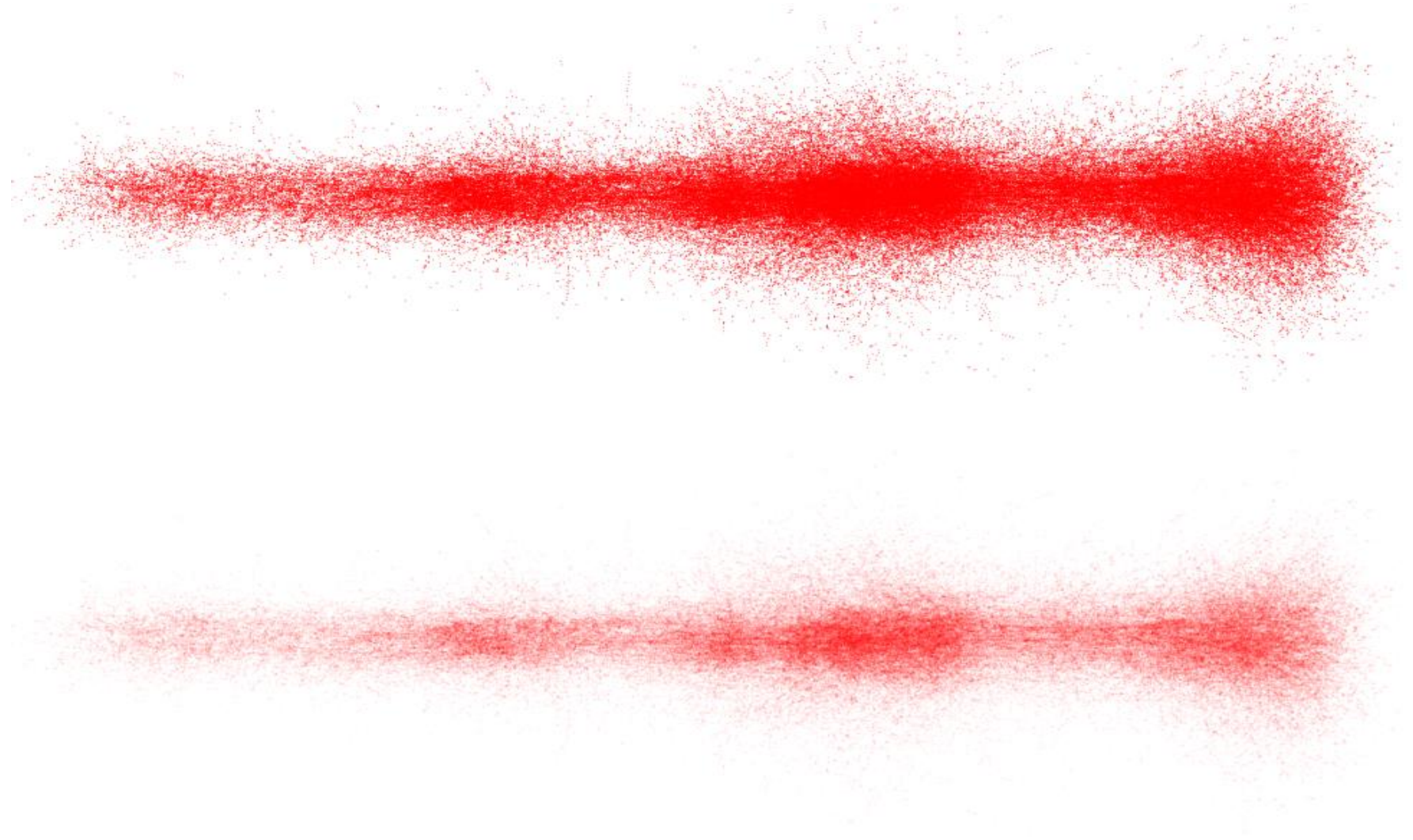
Edition capabilities



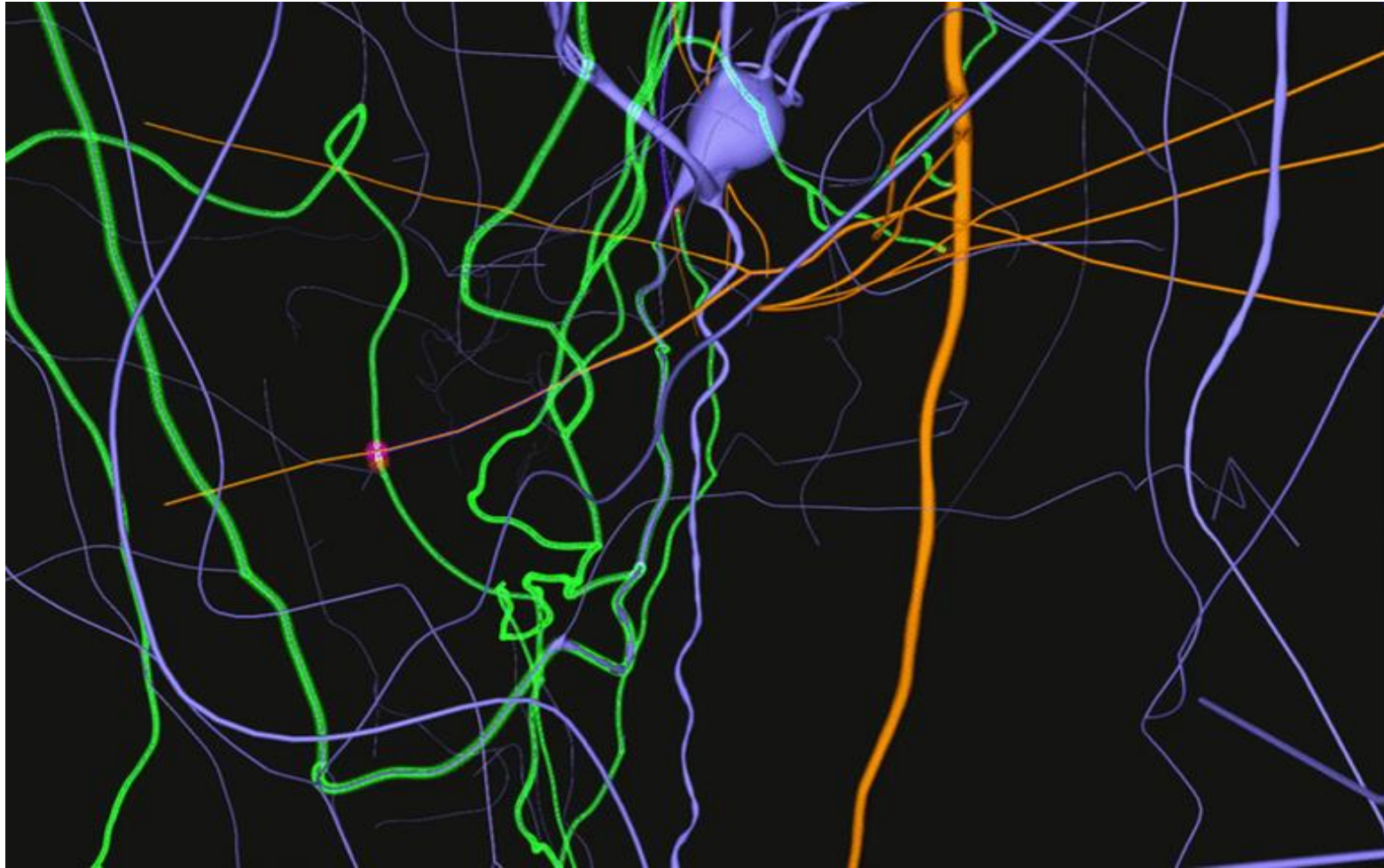
Connectivity over realistic morphologies SynCoPa (URJC/UPM-Madrid)



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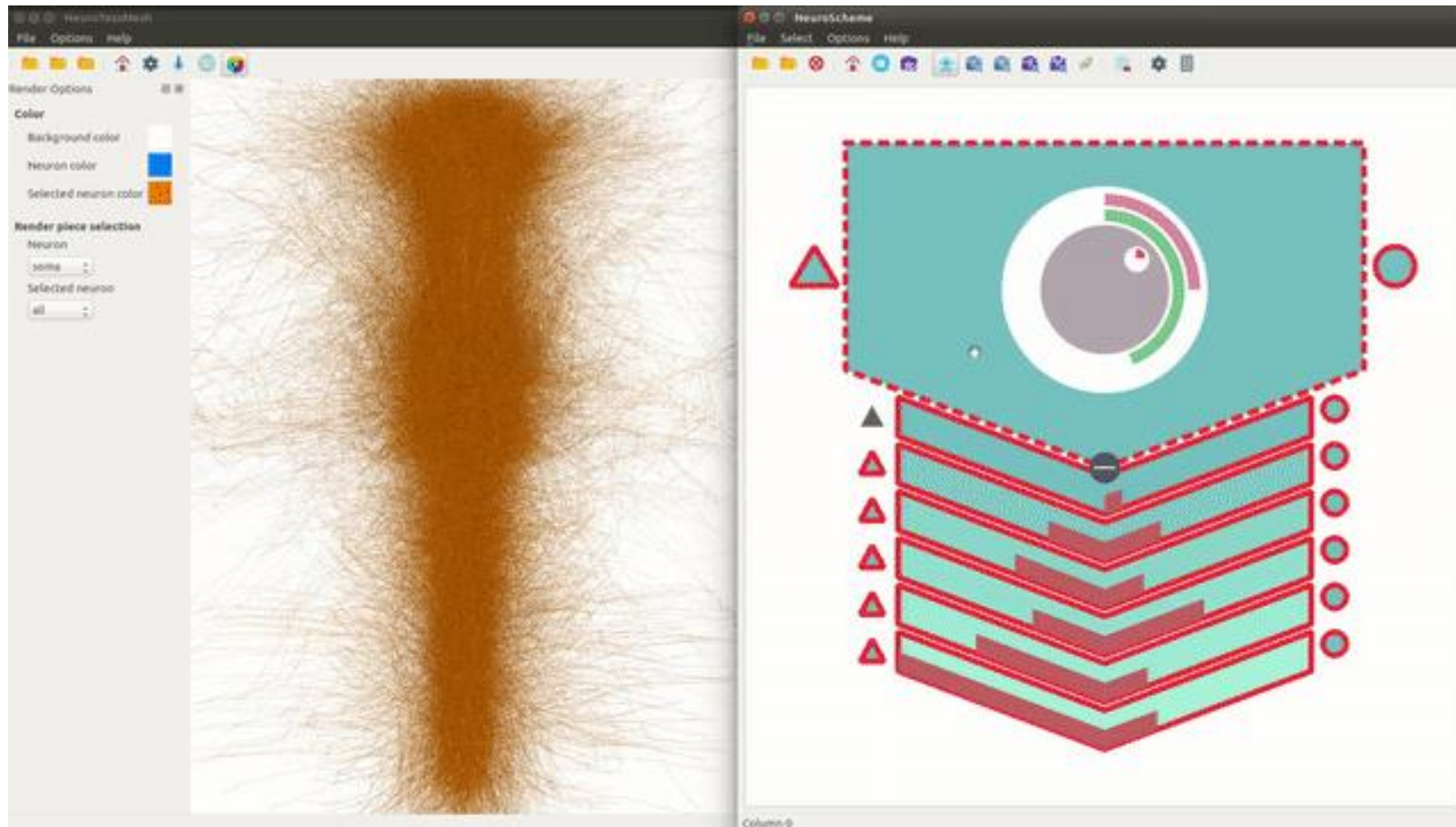
Connectivity over realistic morphologies SynCoPa (URJC/UPM-Madrid)



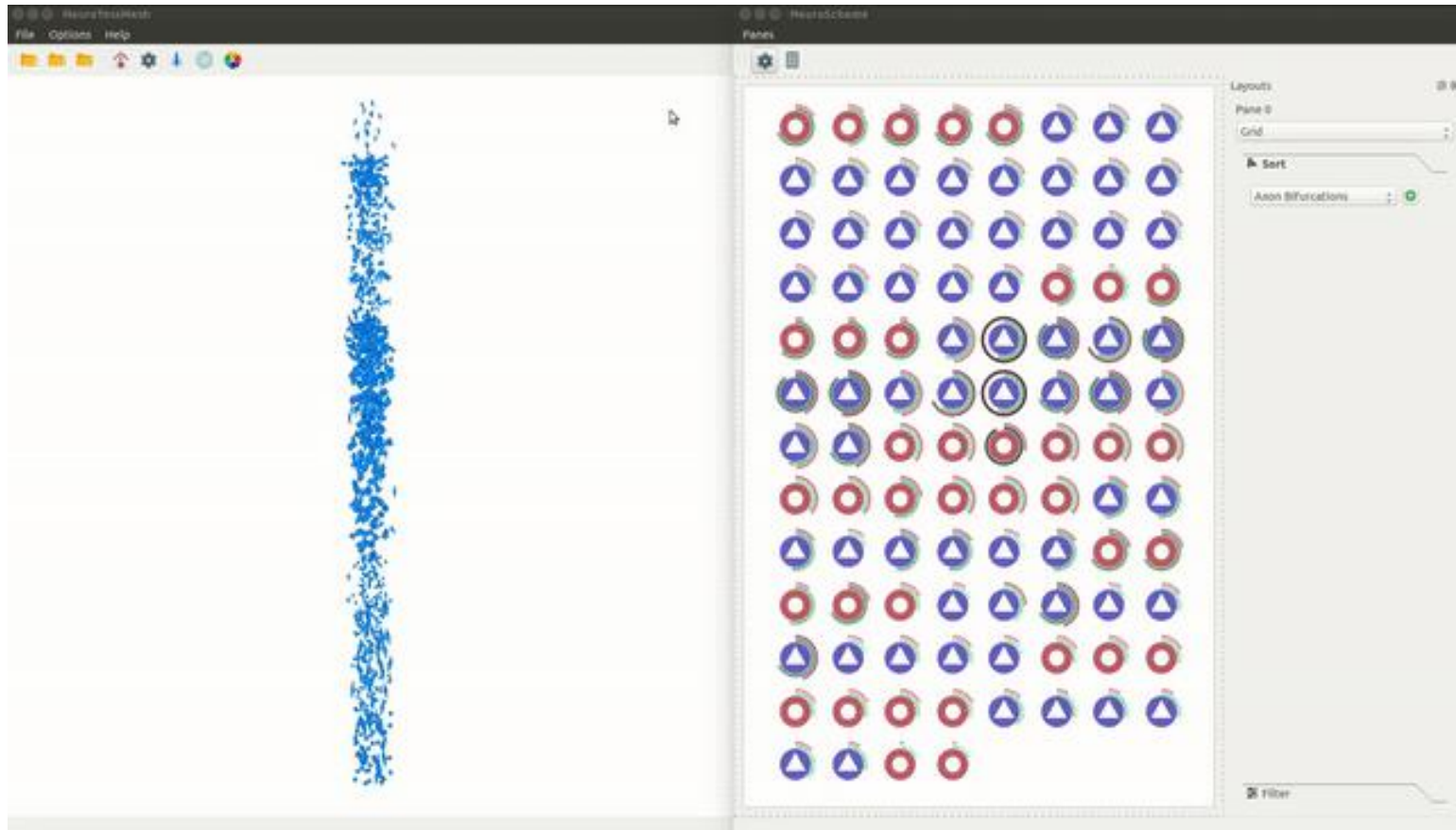
Coordinated Views From Multiple Tools



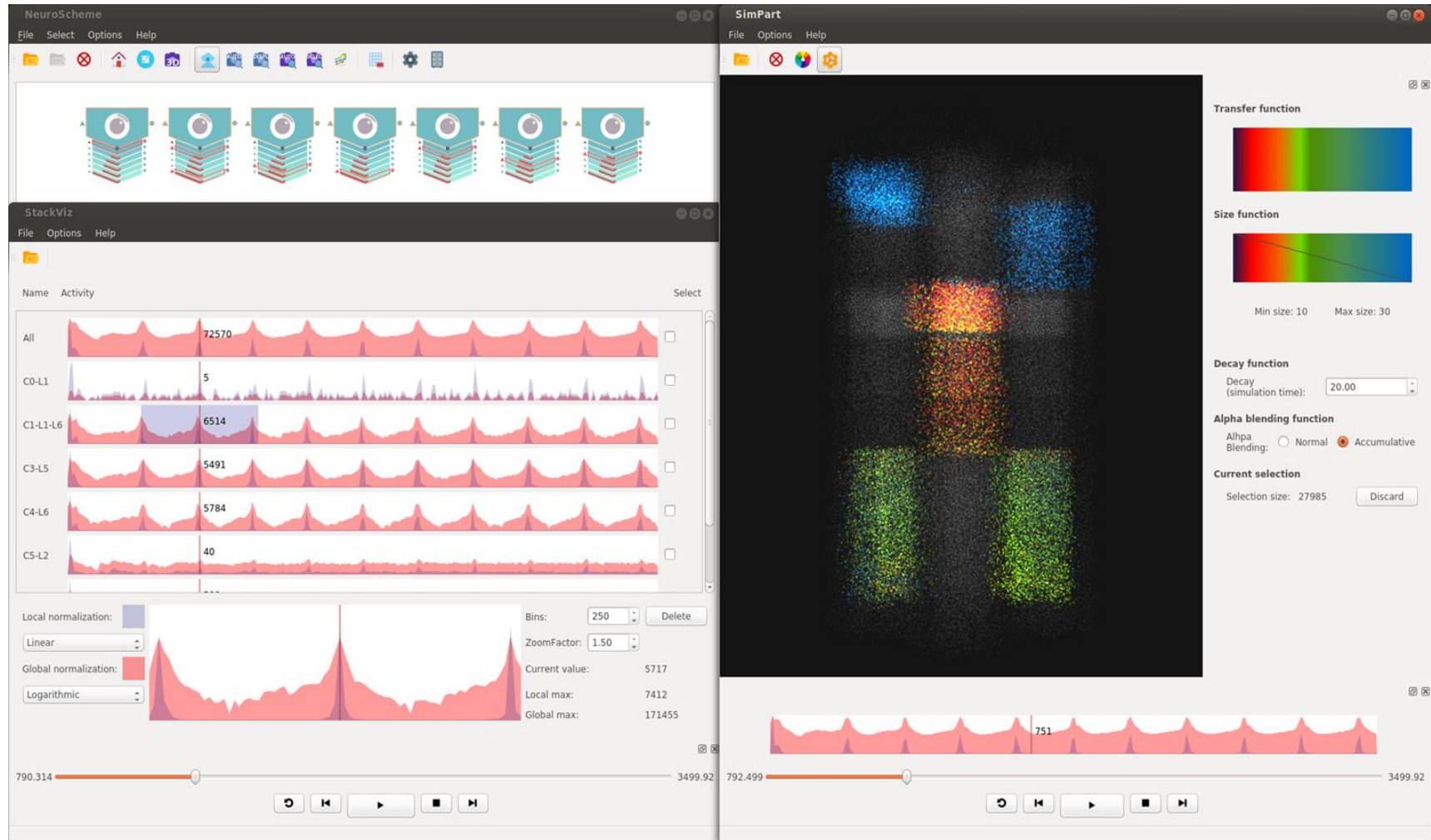
Realistic and Symbolic Structural Visualization



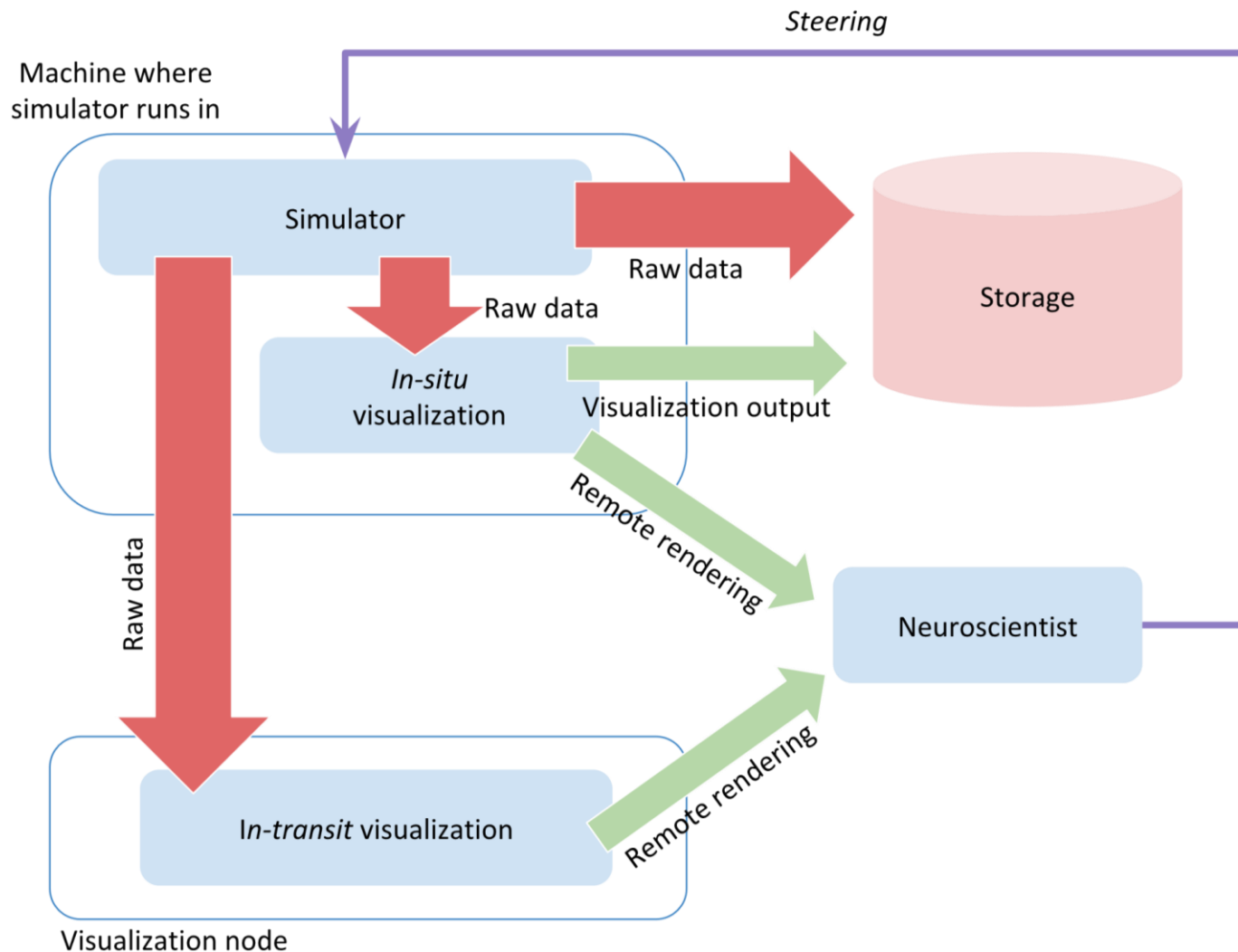
Realistic and Symbolic Structural Visualization



Symbolic structure + neuronal activity

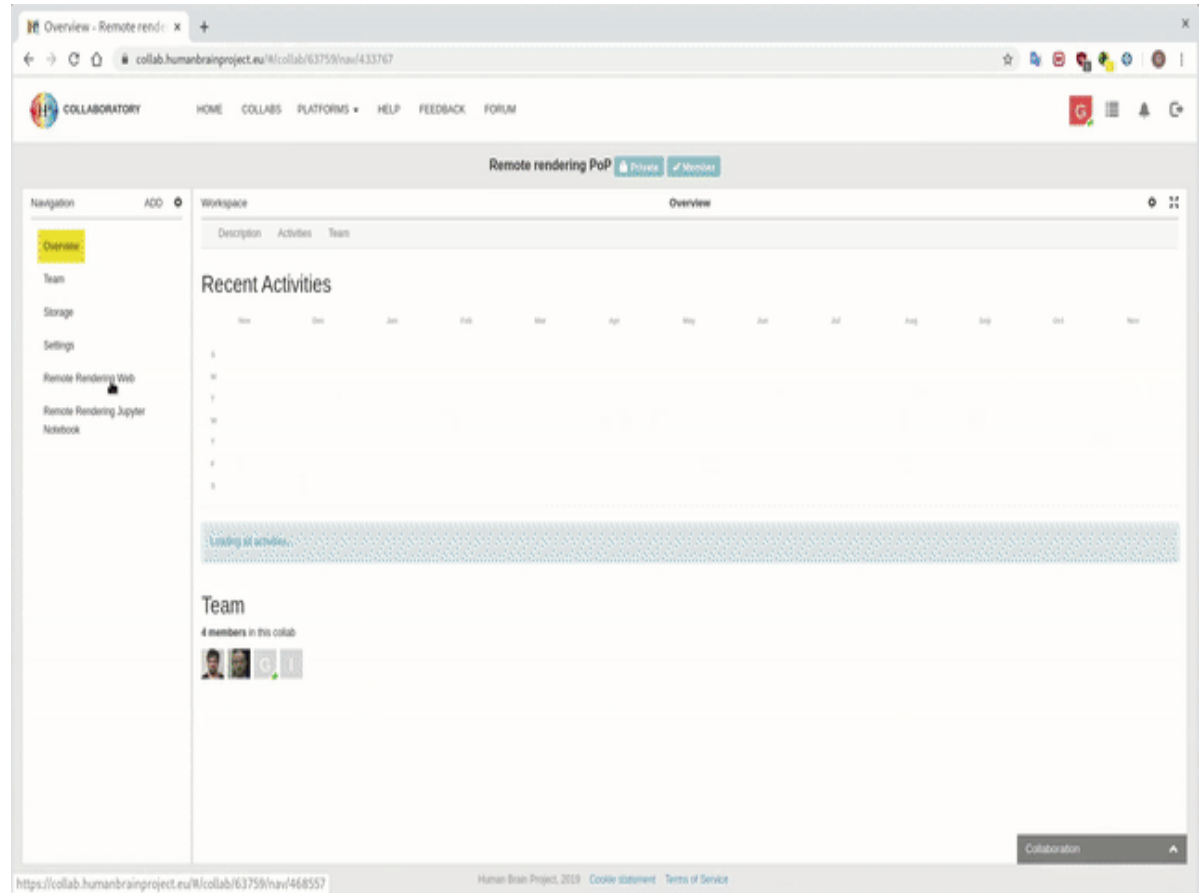


In Situ/In Transit Visualization



Remote rendering

- Custom-made middleware
- Entry point: web page (also through Jupyter Notebooks)
 - Run a tool in the machine where it was deployed / where data are
 - View it in local device



In summary

- Ecosystem of visualization tools
- Multilevel approach
- Coordinated views of single tools
- Different visualizations for the same data

Don't hesitate to get in touch with us!



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Thank You

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