Supplementary Information for:

Visualization and Simulation of Full-Scale Point-Neuron Circuits via the Neural Circuit Visualizer web platform

Visualization and simulation framework comparative analysis

Feature	NCV	ViSimpl	VisNEST	brainrender	The Virtual Brain
Primary objective	Interactive visualization and simulation of large-scale spiking neural circuits	Multi-view visual analysis of neural simulation output	Interactive exploration of large-scale brain simulations	Visualization of anatomically registered, atlas-based multimodal data	Simulation of whole-brain network dynamics
Abstraction level	Single-neuron, spike-resolved	Particle-based, spike resolved	Population- and brain-area level	Cellular and anatomical (meshes, points, volumes)	Brain-region / neural mass and neural field
3D single cell activity representation	Interactive, cell and simulation time resolved spiking playback	Interactive, cell and simulation time resolved spiking playback	Raster plots in coordinated views	-	-
Anatomical context	Point neuron location Color coded cell-type (color coded regions and layers for the embedded mouse circuit)	Limited anatomical context for spatial reference	Brain-area geometry and parcellation	Atlas-based anatomical meshes and hierarchies	Brain surface and region parcellation
Interactive selection and filtering	Cells, regions, layers, and cell types for the embedded mouse circuit	Selection and filtering via linked, coordinated views	Interactive selection of brain areas and populations	Supported primarily via scripting and GUI; limited analytical interaction	Regions and network nodes
Temporal navigation	Continuous playback with speed control and scrubbing	Synchronized playback control across views	Playback control with synchronized views	Keyframe-based or scripted animations (not signal-driven playback)	Time-series navigation of region-level signals
User-defined data input	Generic CSV and HDF5 formats	Simulation-output–dependent formats	Model- and simulation-specific formats	Multiple anatomical, mesh, image, and tabular formats	Simulator-specific formats
Deployment model	Fully browser-native (no local installation required)	Local desktop application	Local desktop / VR application	Local Python installation (optional HTML export)	Local or server-based installation
Simulation environment	Remote execution via integrated HPC backends	-	-	-	Integrated simulator
HPC workflow integration	Job submission, monitoring, and result retrieval	-	-	-	Partial (server-side execution)
Reported single cell scale of evaluation	10^4–10^6 neurons (demonstrations beyond 10^6)	Up to ~8×10^5 particles (reported in case studies)	-	Benchmarks reported up to ~10^6 points/cells	-

Table S1. Scope-aware and literature-based comparison of the NCV to a range of neural simulation and visualization tools

Whole hippocampal formation mouse model parameters

Parameter	Value	Unit	Source / Derivation	Description
I. Anatomical Data (Rat)				
CA1 PC dendritic length in SR	4,465.3	µm	Hippocampome.org (Synaptic Probability menu)	Total length in Stratum Radiatum (SR)
CA1 PC dendritic length in SO	3,795.6	µm	Hippocampome.org (Synaptic Probability menu)	Total length in Stratum Oriens (SO)
II. Volumetric Scaling			Tecuatl et al.[68]	
Volume of SR (Mouse)	2.83	mm^3		
Volume of SR (Rat)	10.95	mm^3		
SR scaling factor (SF_{SR})	**0.637**		$\sqrt[3]{(2.83 / 10.95)}$	Cubic root of volume ratio
Volume of SO (Mouse)	1.50	mm^3		
Volume of SO (Rat)	6.47	mm^3		
SO scaling factor (SF_{SO})	**0.614**		$\sqrt[3]{(1.50 / 6.47)}$	Cubic root of volume ratio
III. Scaled Lengths (Mouse)				
Scaled SR length	2,844.4	µm	4,465.3 × 0.637	Used at 100% for CA3 input
Scaled SO length	2,330.5	µm	3,795.6 × 0.614	
Adjusted SO length	**1,165.3**	µm	2,330.5 / 2	50% adjustment for local CA1 inputs
Total effective length (L_{total})	**4,009.7**	µm	2,844.4 + 1,165.3	Total dendritic length for CA3 synapses
IV. Spine & Synapse Parameters				
Spine density	**0.92**	μm^{-1}	1 / 1.09	Inverse of inter-spine distance
Total spines per CA1PC	**3,689**		4,009.7 × 0.92	Total synaptic sites for CA3 input
Avg. synapses per connection	**7.24**		Hippocampome.org (CA3→CA3)	Used as estimate for CA3→CA1
V. Convergence & Divergence				
Convergence	**510**		3,689 / 7.24	Unique CA3PCs contacting a single CA1PC
Number of CA1PCs (N_{CA1})	159,341		Hippocampome.org (Neuron Census)	
Number of CA3PCs (N_{CA3})	75,376		Hippocampome.org (Neuron Census)	
CA1/CA3 ratio (R)	**2.114**		159,341 / 75,376	
Divergence	**1,078**		510 × 2.114	CA1PCs contacted by a single CA3PC

Table S2. Parameters and stoichiometric calculations for the CA3-CA1 Pyramidal connectome model

Benchmarking and Validation

To test the NCV's rendering robustness and reliability, we created four different networks composed of 10k, 100k, 1M, 5M neurons, respectively. For each network, we artificially generated a simulated activity (through a gaussian distribution) in such a way that each neuron had about 8Hz mean firing rate (MFR). We chose this non-physiological high value for all neurons to test the system in a highly resource demanding scenarios. To visually verify that all the spheres are correctly drawn (i.e., no hole is present in the matrix), we placed all the neurons in a 2D matrix (this layout is more accessible than a 3D structure, where the rear neurons are covered by the fore ones). Then, we ran the visualization of chunks of spiking activity approximately 200MB large (this dimension can slightly change, together with the number of spikes contained in the chunk, depending on the file splitting procedure implemented at the backend level). First, we visually checked, on randomly selected areas, that all the neurons were shown and their color changed in case of firing. Then, we monitored the frontend logs to verify that the rendering JavaScript code raised no error and skipped no iteration. Finally, we computed the mean Inter Frame Interval (IFI), occurring at each simulation timestep (i.e., 0.1 ms) and its standard deviation from the frontend (see Table S3). The obtained results show that the spiking activity is consistently rendered with a relatively small-scale factor with respect to the simulation timestep and suggest that the rendering latency does not affect the interpretation of neither slow nor fast dynamics.

Network Size (# neurons)	**Mean IFI (ms)**	**IFI std**	**Rendering Time**	**Simulation duration**	**Total # spikes**
10k	4.02	1.8	266 min 20 s	399 s	31,756,202
100k	4	0.84	28 min 56 s	43.34 s	34,673,614
1M	4	0.92	2 min 30 s	3.8 s	30,377,893
5M	25.11	1.9	2 min 49 s	673 ms	26,951,317

Table S3. NCV performance results. Visualization tests were run on an Apple M3 Pro, 36 GB RAM. The Chrome browser was used on a 3440 x 1440 screen.