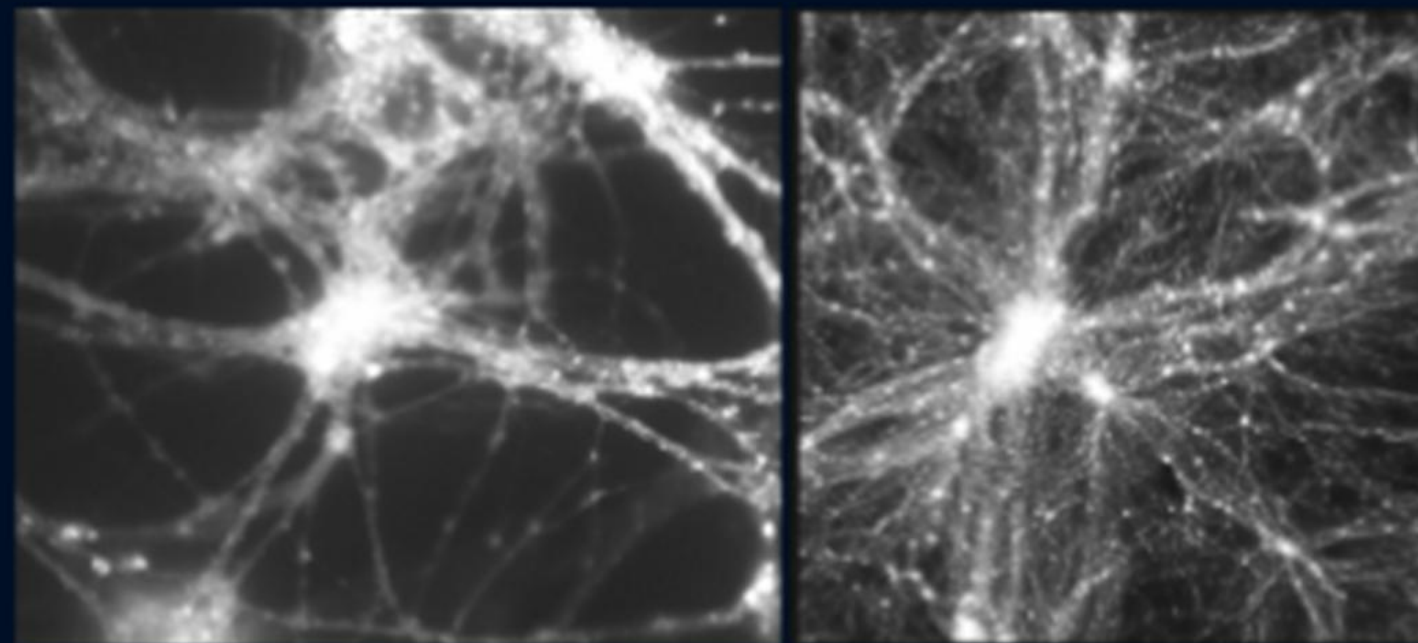


AI-Based Geometric Analysis of Cultured Neuronal Networks: Suggestive Parallels with the Cosmic Web

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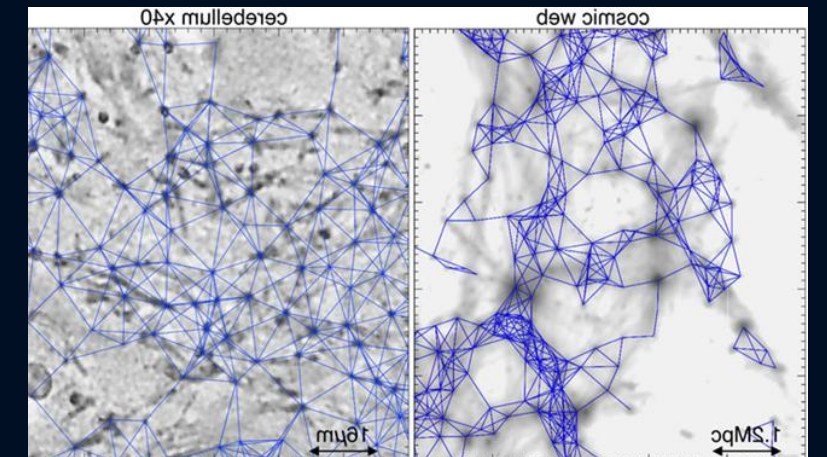


Neurons? Cosmic web?



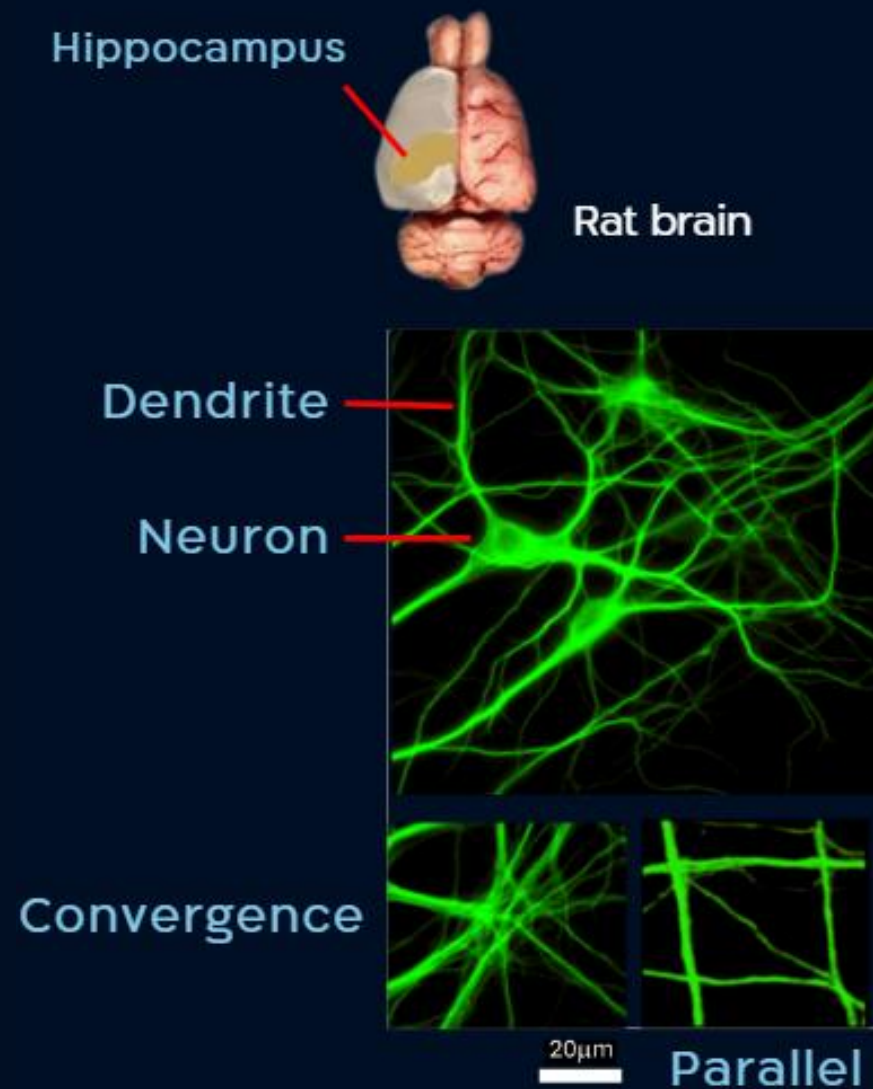
Neurons in a petri dish

Cosmic web
simulation



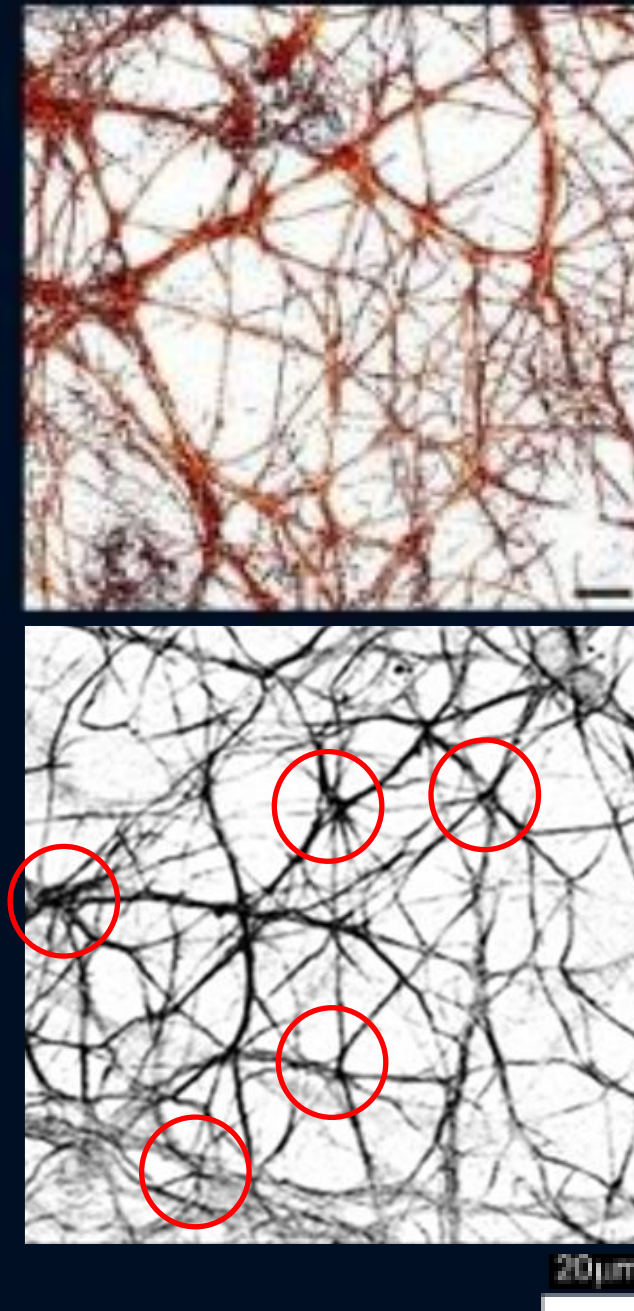
[1] Vazza, F. & Feletti, A. (2020).
Frontiers in Physics, 8, 525731.
<https://doi.org/10.3389/fphy.2020.525731>

Neuronal Culture



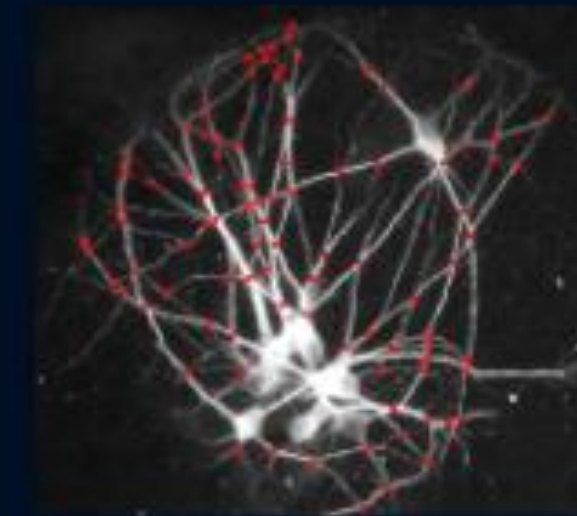
Dendritic Lattices

Parallel Growth
Hubs & Voids



AI-based Lattice Graphing

Graph representation



Dendrites
Intersections



Edge = Dendrites
Node = Intersection

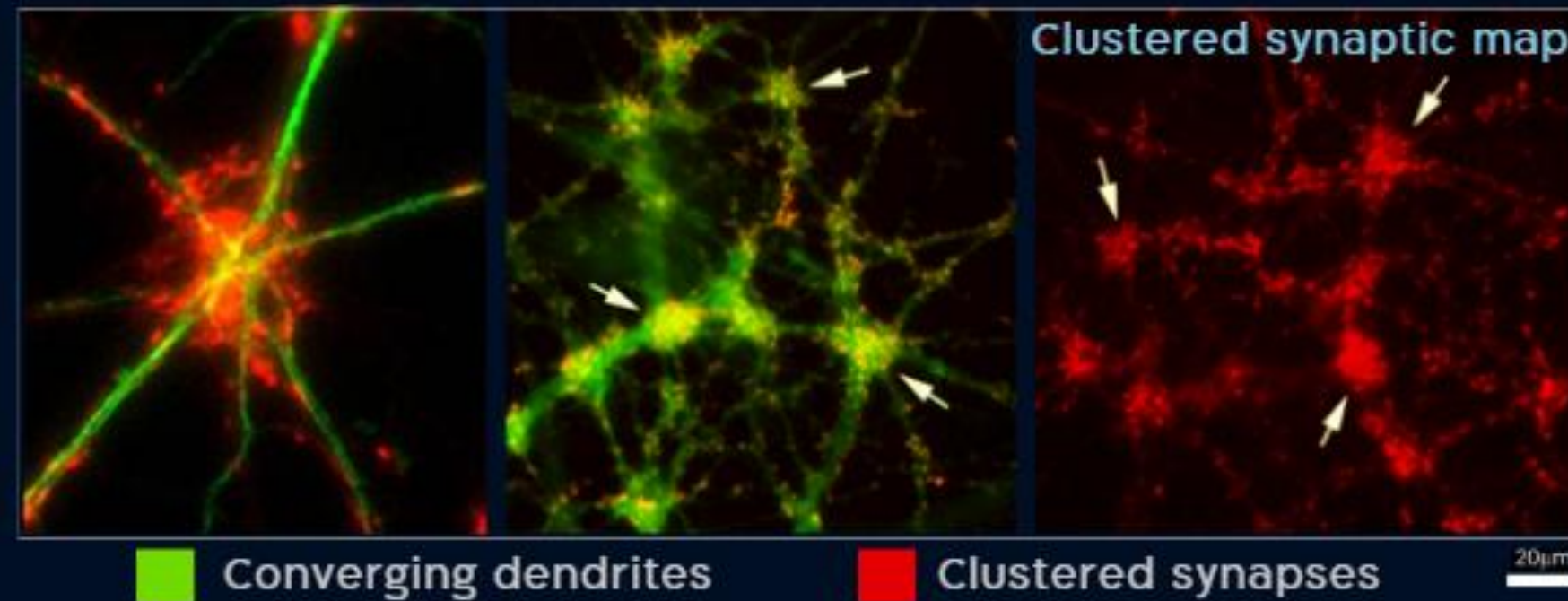
AI

Node detection: YOLOv8, CNN
Edge detection: Segmentation

Key Findings on Dendritic Lattices

- Dendritic lattices are shaped by non-random wiring rules (32 rules were identified).
- The lattices form hub-like configurations interspersed with large voids.
- The dendritic lattice patterns and strengthens synaptic connectivity.

Dendritic Lattice–Guided Synaptic Mapping vs. Cosmic Structure Maps



Lattice Control of Network Activity

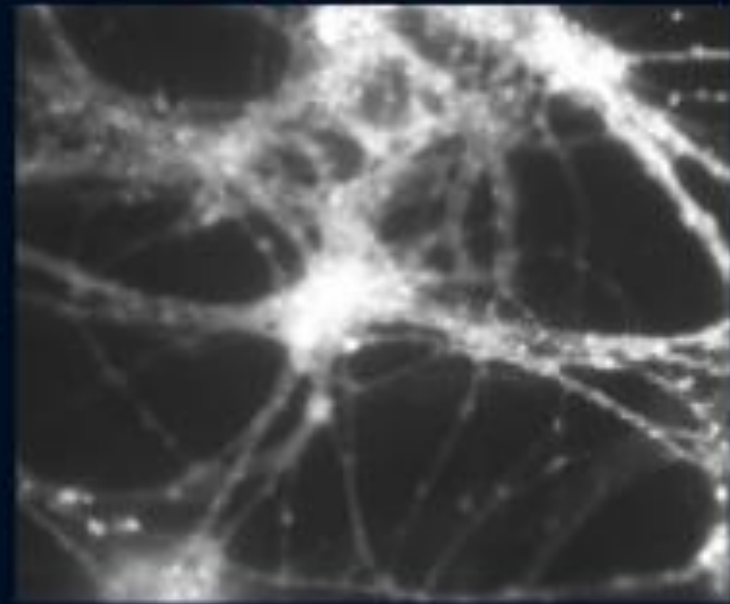


Parallels with the Cosmic Web

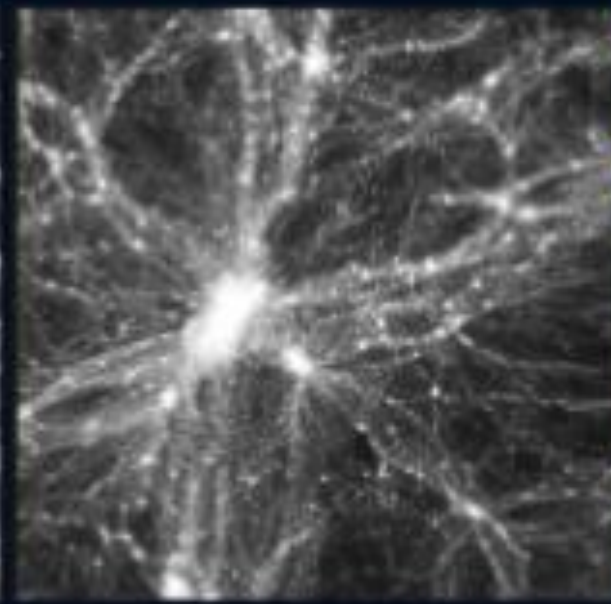
- Edges = dendrites / cosmic filaments
- Nodes = sites of edge convergence
- Synapses / Galaxies
 - Distributed along edges
 - Clustered and strengthened (synapses) / brightened (galaxies) at nodes
- Voids exist in both systems between edges and clusters

Synaptic and Galactic Strength Share Spatial Patterns

Strengthening
Brightening

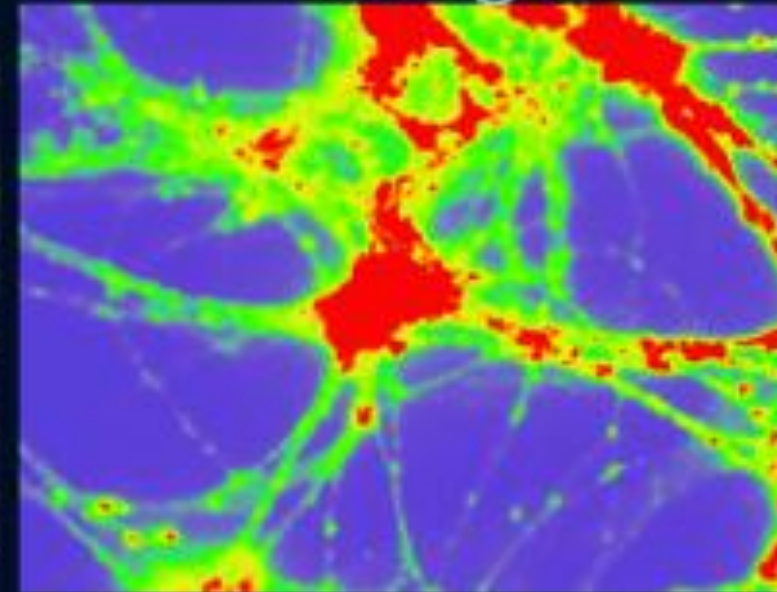


Neuronal Culture

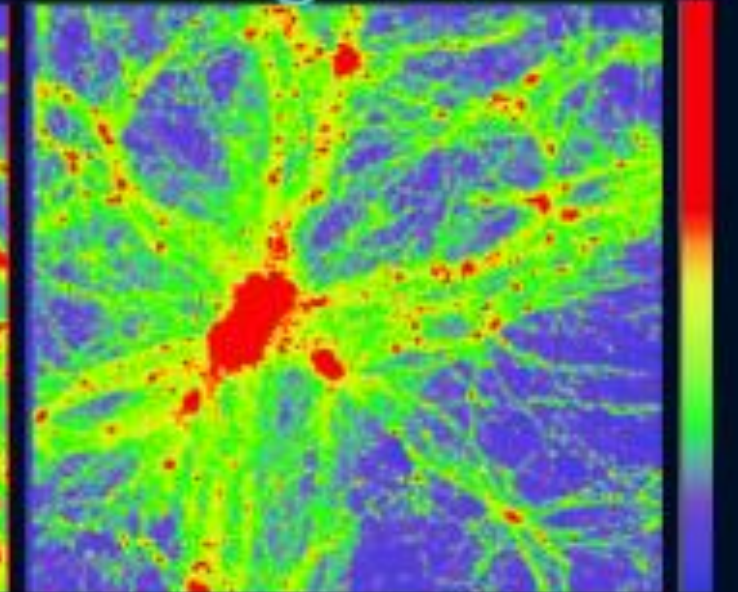


Cosmic web
simulation [3]

Strength



Brightness



Suggestions

- Dendrites ~ cosmic filaments
- Synaptic connections ~ Galaxies
- Synaptic strengthening ~ Galaxies brightening

References

- [1] Vazza, F. & Feletti, A. (2020). *Frontiers in Physics*, 8, 525731. <https://doi.org/10.3389/fphy.2020.525731>
[2] Joseph, J., Courtois, H. M., Pomarède, D., et al. (2020). *The Astrophysical Journal Letters*, 903(1), L32. <https://doi.org/10.3847/2041-8213/abb9f1>
[3] Springel et al., (2005) arXiv preprint astro-ph/0504097, 2005•arxiv.org

We welcome collaborations to explore dendritic lattices, their relation to the cosmic web, and their potential links to fundamental physics.

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**Thank
you**