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

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It was recently demonstrated [1] that brain networks and the cosmic web share key structural features—such as degree distributions, path lengths, modularity, and information density. Inspired by this work, we apply AI-based methods to study the geometry of neuronal networks formed by isolated brain neurons in culture, with a focus on the spontaneous formation of dendritic lattices and noted patterns that appear suggestive of possible parallels with the cosmic web

Our analysis reveals that these cultured dendritic lattices form non-random geometries shaped by consistent and reproducible wiring rules. Among the observed features are frequent dendritic convergence, parallel growth, hub formation, and small-world connectivity constrained by minimal wiring length. Synaptic positions are not randomly distributed but instead appear to follow geometric and spatial constraints embedded in the lattice itself. These findings suggest that the structural map of connectivity and plasticity may arise from underlying geometric logic, with implications for information processing, data integration, and long-term network stability.

We aim to compare these newly characterized lattice features with structural patterns observed in cosmological simulations and astronomical data. This work proposes a biologically grounded model system for investigating universal organizing principles that may bridge the gap between microscopic neuronal systems and large-scale physical structures. We welcome collaborations in AI and fundamental physics to expand this approach and explore whether shared geometry reflects deeper physical laws connecting neural architecture with the fabric of the cosmos.

Reference

[1] Vazza, F. & Feletti, A. (2020). The Quantitative Comparison Between the Neuronal Network and the Cosmic Web. Frontiers in Physics, 8, 525731. https://doi.org/10.3389/fphy.2020.525731

AI keywords

graph neural networks; topological data analysis; structural pattern recognition

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Session Classification: □ Simulations & Generative Models

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