

Day 2

Evolution Beats Random Chance: Performance-dependent Network Evolution for Enhanced Computational Capacite

Plenary
Talk 3

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The quest to understand structure-function relationships in networks across scientific disciplines has intensified. However, the optimal network architecture remains elusive, particularly for complex information processing. In this talk I will report on results from my recent paper, written with Manish Yadav and Merten Stender (Phys. Rev. E 111, 014320, 29 January 2025) where we investigate how optimal and specific network structures form to efficiently solve distinct tasks, using a framework of performance-dependent network evolution, leveraging reservoir computing principles. Our study demonstrates that task-specific minimal network structures obtained through this framework consistently outperform networks generated by alternative growth strategies and Erdős-Rényi random networks. Evolved networks exhibit unexpected sparsity and adhere to scaling laws in node-density space while showcasing a distinctive asymmetry in input and information readout node distribution. Consequently, we propose a heuristic for quantifying task complexity from performance-dependently evolved networks, offering valuable insights into the evolutionary dynamics of the network structure-function relationship. Our findings advance the fundamental understanding of process-specific network evolution and shed light on the design and optimization of complex information processing mechanisms, notably in machine learning.
