ACMS Applied Math Seminar

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Thurs, Apr 9
127 Hayes-Healy
4:00 PM

The Brain in Space

Recent advances in neuroscience have raised interest in large-scale brain networks. Using a consistent database of cortico-cortical connectivity, generated from hemisphere-wide, retrograde tracing experiments in the macaque, we analyzed interareal connection weights and axonal projection distances to reveal an important organizational principle of brain connectivity. Using appropriate graph theoretical measures, we show that although very dense (66%), the interareal network has strong structural specificity. Connection weights exhibit a heavy-tailed lognormal distribution spanning five orders of magnitude and conform to a distance rule reflecting exponential decay with interareal separation. Based on this rule, we introduce a single-parameter random graph model, the EDR model, which predicts all local and global features of the cortical network: (1) the existence of a network core and the distribution of cliques, (2) global and local binary properties, (3) global and local weight-based communication efficiencies modeled as network conductance, and (4) overall wire-length minimization. Finally, using data provided by the Paul Allen Institute in the mouse brain and University of South California, we show that that the EDR model describes the mouse cortical network as well (using the corresponding decay rate of connection probability in the mouse and the intearareal distance matrix from direct measurements). These findings underscore the importance of distance and weight-based heterogeneity in cortical architecture and processing and provides a way to quantify the large-scale cortical network through the mammalian evolutionary tree.

The Department of Applied and Computational Mathematics and Statistics

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