The distance backbone of complex networks

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Redundancy needs more precise characterization as it is a major factor in the evolution and robustness of networks of multivariate interactions. We investigate the complexity of such interactions by inferring a connection transitivity that includes all possible measures of path length for weighted graphs. The result, without breaking the graph into smaller components, is a distance backbone subgraph sufficient to compute all shortest paths. This is important for understanding the dynamics of spread and communication phenomena in real-world networks. The general methodology we formally derive yields a principled graph reduction technique and provides a finer characterization of the triangular geometry of all edges—those that contribute to shortest paths and those that do not but are involved in other network phenomena. We demonstrate that the distance backbone is very small in large networks across domains ranging from air traffic to the human brain connectome, revealing that network robustness to attacks and failures seems to stem from surprisingly vast amounts of redundancy [1].

References

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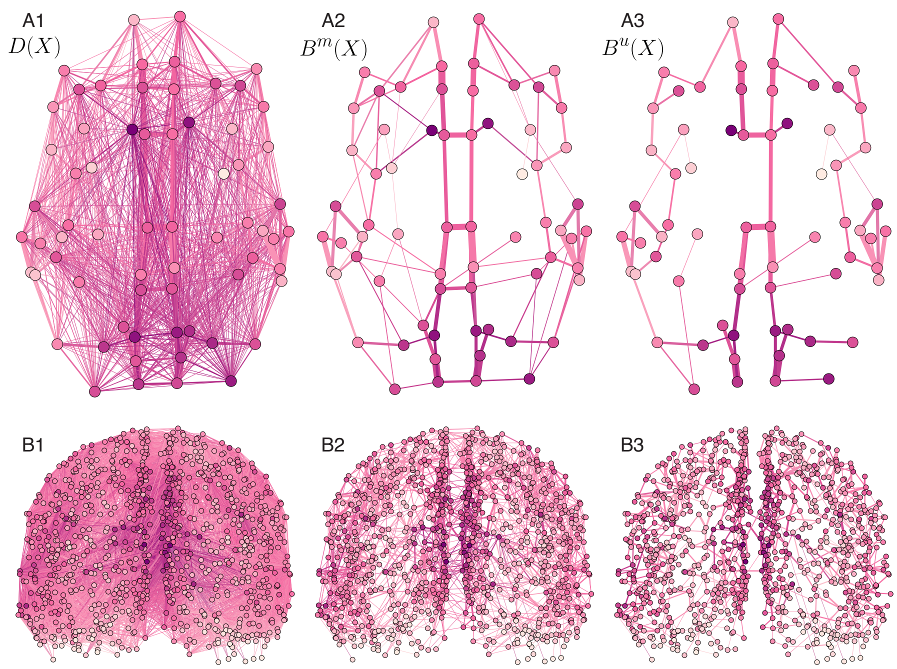

Fig. 1. Human Connectome Network (HCN) and Backbones. (**A1-3**): HCN-Coarse. (**B1-3**): HCN-Fine. (**A1,B1**): Original distance Networks [2], whose distance weights are inversely proportional to the volume of cortico-cortical axonal pathways between brain regions (nodes), obtained via diffusion spectrum imaging. (**A2,B2**). Metric backbone with only 9.23% and 17.57% of original edges HCN-Coarse and HCN-Fine, respectively. (**A3,B3**). Ultrametric backbone with only 5.66% and 5.53% of original edges for HCN-Coarse and HCN-Fine, respectively.