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Machine Learning Analysis of Complex Networks in Hyperspherical Space

Complex networks represent the topological skeleton of complex systems in a variety of scenarios, ranging from molecular to social and ecological ones. We discuss here the way in which information diffuses through the nodes and edges of such networks in an "all-routes" way instead of by using "shortest-paths" only. Then, we defined a communicability function that accounts for such kind of all-routes communication in networks. We then prove analytically that such communicability function induces an embedding of any network into a hyperspherical space. The main parameters for defining this embedding are the communicability distance and communicability angles. We then use machine learning techniques, such as nonmetric multidimensional scaling (NMDS) and clustering analysis to extract information about these networks in the (n-1)-spheres in which they "live". Using NMDS we produce pictorial representations of random and real-world networks as 3-dimensional Euclidean spheres. The clustering analysis by using K-Means reveals the existence of communities in real-world networks which coincide with the ground truth structure of such networks. We finally illustrate some examples of the importance of considering communicability shortest paths between nodes as a way in which items are transmitted through real-world networks.