

The Problem of Action at a Distance in Networks and the Emergence of Preferential Attachment from Triadic Closure

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We discuss the notion of action at a distance in networks, in the context of graph growth models. Action at a distance is a notion from physics that refers to certain interactions (forces) seemingly acting between objects that are far from each other, independently of any intervening matter. In the network setting, the analogous phenomenon refers to graph models in which edges are created between nodes that are seemingly far from each other, without taking into account the network structure between them. In particular, we argue that preferential attachment represents a form of action at a distance that can be explained as an emergent phenomenon in the context of triangle closing, thus allowing us to explain real-world graph growth without inherent action at a distance. To support our claims, we present both theoretical and experimental evidence.

As theoretical evidence, we show that preferential attachment arises in the limit of a particular random graph model in which triangle closing is allowed. The derivation is exact in the limit when the number of nodes goes to infinity, and takes a random process of triangle closing as a starting assumption.

Experimentally, we show evidence for preferential attachment in a continuum of random graph models that include only local graph growth rules. Specifically, we explore graph models that include triangle closing. We test our results statistically by comparing them with complete random graphs (Erdős–Rényi) and preferential attachment models (e.g., Barabási–Albert).

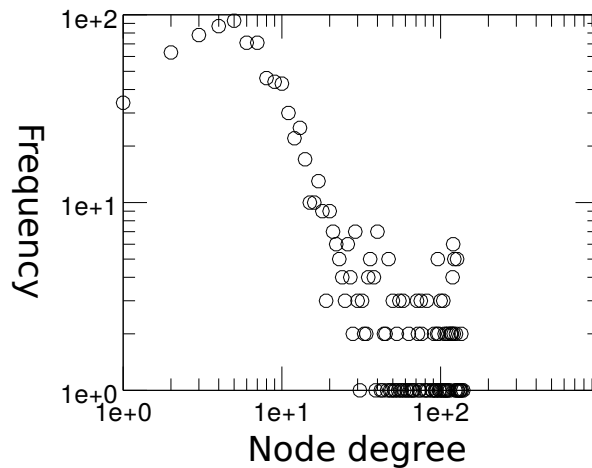


Figure 1: The degree distribution of a synthetic graph based on a graph growth model using only local graph growth rules. Despite the lack of preferential attachment in the graph model, the resulting graph displays scale-free behavior, an example of what we characterize to be, in the paper, action at a distance.