Can we predict performance of diffusion source localization using navigability?

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A complex network is a network of interconnected nodes, such as a social network, a transportation network or a network of neurons in the brain. One important property of complex networks is the existence of hidden metric spaces. In a hidden metric space, the points represent nodes in the network, and the distances between them reflect the underlying structure of the network. The closer the nodes are in the hidden space, the more likely they are to be linked in the observable topology. However, this structure is not immediately visible in the network itself and may require some analysis to uncover. For example, in a social network, the true underlying metric space could be the distance between two people in terms of their interests or opinions. The most widely-known models of hidden metric spaces are the so-called S1 and H2 models [1].

It has been shown that the underlying hidden metric space gives a significant effect on several observable features of the network, including navigability in the sense of greedy routing algorithm efficiency [2]. Several real-world networks have been recognized as navigable, for instance, the Internet or the air transportation network, meaning that a message or a traveler may find its destination node without knowledge on the entire structure of the network but using only locally-available information. The studies revealed that large small-world networks with power-law degree distribution of nodes tend to be navigable if their power-law exponent is lower than 2.6, i.e., that strong clustering improves navigability metrics.

On the other hand, nowadays, there exist a large number of algorithms to find sources of diffusion or information spread in complex networks. That topic has become particularly important in the face of novel problems as fake news and fake rumors. Methods for that purpose include classes of algorithms based on epidemic models, independent cascades, or centrality measure.

Here, we posed several research questions. Is there straightforward relation between efficiency of the source-finding algorithms and navigability? How do source-finding algorithms behave depending on the hidden metric space underlying the network? Can we (specifically, to what extent and in which conditions) simply predict the performance of the source finding algorithm basing on the known navigability of the network? At first, we considered the model based on time-reversal backward spreading [3] and tested it against S1 model of hidden metric space. First results indicate that, for a small number of observers in the network (e.g., 1%), efficiency of the source localization behaves similarly as navigability, however, it not the case for large numbers of observers (e.g., 10%). Currently, we pursuit to find large-network limit of this relation. Eventual conclusions will allow to establish stronger relationship between diffusion spreading and hidden metric models.

References

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