STRUCTURE AND RANDOMNESS IN COMPLEX NETWORKS APPLIED TO THE TARGET SET SELECTION PROBLEM

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Abstract

Advances in technology have enabled the empirical study of large, so-called 'complex' networks with tens of thousands to millions of vertices, such as social networks and large communications networks. It has been discovered that these networks share a non-random topology characterised mainly by highly skewed, heavy-tailed degree distributions and small average distances between vertices. The work of this thesis is to attempt to leverage the well-known topological properties of complex networks to efficiently solve difficult NP-complete problems, with the aim of obtaining better or faster solutions than would be possible for general graphs.

Two related NP-complete problems are selected for study: the minimum target set problem, and the maximum activation set problem. Both problems relate to finding a 'target set' of vertices which is capable of initiating a spreading process (such as the spread of a rumour) that reaches a large proportion of the network. This thesis introduces several novel heuristics for these two problems inspired by the topology of complex networks. It is discovered that in many (but not all) cases it is possible to make relatively small alterations to the network that enable the computation of a considerably smaller target set than would be possible on general graphs.

The evaluation of the various heuristics is entirely experimental, which required the development of procedures to generate 'random' networks that can be used as experimental controls. This thesis includes a survey of several popular techniques for generating random networks and finds all but one (random rewiring) to be unsuitable as controls. The validity of random rewiring relies on a somewhat obscure theorem. Although a proof of the theorem (essentially an existence proof) is already known, this thesis offers a constructive algorithmic proof. The new proof advances on the old by providing an upper bound on the maximum number of rewiring operations required to transform between networks of the same degree-sequence, whereas an upper bound could not be determined under the old proof.

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