Network Science Center at West Point

Project Algorithmic Network Science: Using Network Models to Develop of Novel Algorithms for Hard Problems

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Overview: Project Algorithmic Network Science explores network models in computer science, biology, physics, and mathematics with the intention of creating novel algorithms for the purpose of knowledge creation. On the application level, we are looking to apply this work to various problems in counter-insurgency, intelligence analysis, cyber-security, social networking, and biology. We seek to study a wide class of difficult problems which include (but are not limited to) identifying nodes of maximum influence, calculating fixation probability and mean time to fixation, exploring adversarial games on graphs, identifying communities, studying the evolution of graph topology over time, creating generalized models of stochastic processes on graphs, fast computation of centrality measures, responding to Sybil attacks, and scaling various graph algorithms for extremely large networks. We look to use real-world data to validate our algorithms as well as create usable tools for the practitioner - particularly with military, sociological, and biological domains.

Objectives: This project seeks to gain a more complete understanding about various stochastic processes associated with networks, including both diffusion and evolution. Though these models come from a variety of disciplines many of them have certain commonalities. For example, Masuda and Ohtsuki show that, in certain cases, both the voter model from physics and invasion process from biology can be encoded in the link dynamic model. Likewise, Kempe et al. show that several models from sociology and economics can be encoded in the linear threshold model of computer science.

Once a more full understanding of these models is obtained, we can turn our focus to various queries. For example, the classic "maximum influence" problem seeks to identify a certain set of vertices in a network that maximizes the spread of some phenomenon. However, often it is the case that different models can lead to different conclusions in this problem. We look to create novel algorithms to solve these problems.

After we create algorithms that can address these problems, our goal shifts to practicalities. How can such an algorithm be implemented in a usable piece of software? How can the results of said algorithm be best displayed? For military applications, we also look to work with our outreach partners in the U.S. Army to obtain meaningful feedback.

Approach: We look to leverage models from a variety of disciplines and create algorithms using a variety of techniques which include probabilistic reasoning, combinatorial optimization, approximation algorithms, linear programming, network centrality measures, and evolutionary computing.

Impact: This project seeks to make a major impact in the field of network science by showing inter-relationships among network science as described in various disciplines. We also look to make an impact on the Army by creating novel software to aid in various aspects of combat.