Criminal Investigations and Network Analysis
A DHS CENTER OF EXCELLENCE

GEORGE MASON UNIVERSITY

PennState

Exploring Graph Neural Networks for Attributed Multilayer Criminal Network Analysis

LEAD PI: SUHANG WANG

Criminal Network Analysis

SUMMARY

Networked criminal activities, such as narcotics trafficking, fraud, armed robbery, and terrorism, pose serious threats to the homeland. Criminal networks have also evolved from simple to complex, which challenges existing methods for criminal network analysis. DHS requires advanced tools to proactively identify, investigate, and disrupt such networks. This project will extend the state-of-the-art in criminal network analysis and investigate attributed multilayer criminal networks with graph neural networks to facilitate link prediction, community detection, and node classification; explore network disruption; and transfer learning between criminal networks.

PROBLEM STATEMENT

Despite various approaches developed for criminal network analysis (CNA), most existing methods treat criminal networks as single-layer non-attributed graphs and adopt simple network analysis tools developed decades ago to analyze criminal networks, while real-world criminal networks are usually much more complex attributed multilayer networks, which contain richer information and require more advanced graph mining techniques to analyze them. Though it is critical to model attributed multilayer criminal networks, we lack effective algorithms to do so. Recently, graph neural networks (GNNs) have shown great promise in modeling complex graphs. Hence, this project will systematically investigate GNNs for attributed multilayer CNA.

APPROACH

We will focus on three tasks. For task 1, we will develop novel GNNs for attributed multilayer criminal networks, which can capture complex network structure and node attribute information to facilitate link prediction, community detection, and node classification. For task 2, we will study GNNs for effective multilayer criminal network disruption. As the criminal network is resilient and the operation of removing nodes is discrete, we will investigate GNN with reinforcement learning for effective network disruption. Because similar types of criminal networks share similar structures, for task 3, we will study transfer learning to transfer knowledge from one multilayer criminal network to another, aiming to alleviate issues of noisy and incomplete criminal network data, and to facilitate link prediction and node classification.

ANTICIPATED IMPACT FOR DHS

First, this project will develop innovative solutions for attributed multilayer criminal network analysis and a toolbox to help HSE and stakeholders be more effective and efficient in thwarting and disrupting networked criminal organizations. Second, this project will train graduate research assistants and undergraduate students to develop novel algorithms on multilayer criminal network analysis, cultivating the next generation of researchers and engineers for HSE. Third, the findings will be integrated into courses that the PIs are teaching, such as DS 420 Network Analytics and DS 310 Machine Learning and Data Analytics, which can also inspire students to work in this area.