CoMET: A Novel Graph-based Machine Learning System for Predicting Topological Features of Dynamic Covert Networks with Applications in Counterterrorism

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Terrorism is one of the most prevalent problems in today's world, with over 21,000 people killed each year and many others adversely affected as a result of terrorist activity. Terrorist networks fall into a broader class of social networks known as covert networks. Due to their inherently secretive nature, little data and research exists on real-world covert networks. This lack of data makes it essentially impossible to perform analytical studies on covert networks or to develop machine learning (ML) models for tasks such as node classification, link prediction, and community detection. This research presents CoMET (Covert network analysis via ML-based Evaluations of Topology), a novel graph-based machine learning system which fulfills the need for data in covert network research and provides a set of effective ML algorithms for various predictive tasks. CoMET employs a parametric mathematical model to stochastically generate networks whose topologies resemble real-world covert network topologies. Using this model, CoMET can fuel its graph-based ML algorithms with far more data than readily exists in covert network datasets. CoMET performs node classification by generating inductive node embeddings via spectral diffusion wavelets. These node embeddings are then used to cluster nodes into discrete categories via a Gaussian mixture model. CoMET performs link prediction via deep sampling-and-aggregation models, and utilizes greedy modularity maximization algorithms for community detection. Experiments show that CoMET yields far more accurate ML models than those obtained using other techniques and datasets. CoMET can be readily applied in counterterrorist efforts; predicting roles of agents, links between agents, and subgroups of agents with high accuracy is now possible.

Awards Won:

Second Award of $2,000

American Statistical Association: Certificate of Honorable Mention