Linking Terrorist Network Structure to Lethality

Counterterrorism efforts over the last 20 years have included several instruments intended to reduce the lethality of terror networks. Without measures of the lethality of terrorist networks, it is very difficult to assess if placing a bounty on a terrorist or capturing a terrorist is effective. Researchers now at NSAIL have developed a novel algorithm called PLATO (Predictive Lethality Analysis of Terrorist Organization) for this purpose. PLATO merges machine learning with techniques from graph theory and social network analysis to predict the number of attacks that a terrorist network will carry out based on network structure alone.

When a counterterrorism agency considers removing a terrorist, it can use a system such as STONE [1], [2] to identify the new possible networks that result (and their associated probabilities) and then use a lethality model such as PLATO to identify the expected lethality of the resulting network.

Networks and Features

The PLATO algorithms and software code were tested with two novel longitudinal network datasets detailing the relationships between members of two prominent terror groups, Al Qaeda and the Islamic State (ISIS). Our Al Qaeda time-series network dataset consists of 16 years of data comprising 139 networks. Our ISIS dataset consists of 49 networks spanning 4 years. Nodes in these networks represent terrorists. Each terrorist has an associated functional category (Operational, Financial, Logistical, Recruitment&Training, Public Communications, Leadership), a rank, and a status (alive, dead, arrested, unknown) which can change with time.

Jointly with our partners, we designed a codebook describing the data collection procedures involving 20+ social scientists to code the data. The data was collected from a variety of open-source materials in multiple languages, including English, Arabic, French, and Spanish. To our knowledge, these are the most extensive datasets showing the evolution of these two networks over time.

PLATO uses a set of network-related features, some of which are used for the first time in terrorist network analysis. These features are based on the functional roles played by individual terrorists and the subnetworks induced by different functional categories using concepts from graph theory and social network analysis.

NSAIL Researchers discovered that the most significant features for predicting Al Qaeda’s lethality are related to their Public Communications and Logistical subnetworks, while the Leadership and Operational subnetworks are most impactful for predicting ISIS’s lethality.

Predictive Lethality Analysis of Terrorist Organizations

Our PLATO algorithm is an ensemble that uses a mix of regression methods, feature selection methods, and time lags to predict the lethality of a new network as soon as it emerges, e.g. after the death or capture of a terrorist. PLATO is initially invoked with a set of features, some of which are eliminated by the algorithm. Using past ground truth data up to and before the time period of the new network, PLATO identifies the best parameters for an ensemble of regressors and uses late fusion to learn the optimal weights. Thus, PLATO uses a careful mix of feature engineering, subnetwork selection, feature selection, regression, together with an ensemble model for generating predictions.

Experimental analysis shows that PLATO significantly beat out a strong regression baseline in terms of predictive accuracy measured by Pearson Correlation Coefficient (PCC).
Comparison between the predicted attacks and the real attacks carried out by ISIS

Predicting the Density of Attacks
We used PLATO to predict the number of attacks and the density of the attacks. The latter corresponds to the number of attacks per month when the network is valid. Predicting density is complementary to predicting the number of attacks and is of interest to analysts who cannot estimate the duration of a network. This makes no difference for the prediction for ISIS, as the duration of each network in ISIS is about one month. For Al Qaeda, density predictions by PLATO are more accurate, improving PCC scores of 3.4% and 4.1% on average as opposed to predicting the raw number of attacks.

Features relevant for predicting Lethality
PLATO identifies features that are important for the prediction. Because many features vary slightly, we introduced the concept of a macro-feature, which is an aggregation of similar features into one. We studied which macro-features are most closely linked to Al Qaeda and ISIS’s lethality. Surprisingly, the subnetwork of Al Qaeda involved in Public Communications contributes to 5 of the most significant macro-features, while the Logistical subnetwork of Al Qaeda is involved in 4. In contrast, in the case of ISIS the top 10 most significant features are dominated by the Leadership subnetwork (6 of 10), followed by the Operational subnetwork (2 of 10).

Moreover, in the case of Al Qaeda, the average degrees of nodes in various subnetworks are strongly linked with lethality, as are properties associated with the diameters of the strongly connected components, as well as other centrality measures. This is also mirrored in the case of ISIS where degrees, centrality measures, and diameters of strongly connected subnetworks play important roles.

References

https://sites.northwestern.edu/nsail/projects/plato/