Social Network Intelligence Analysis to Combat Street Gang Violence

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Outline

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  - Computing Degree of Membership
  - Discovering Seed Sets
  - Identifying Ecosystems
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Problem

There are several analytical problems faced by law enforcement when analyzing violent street gangs.

• Visualize social network representations of the street gang organizations
• Determine gang membership of “unaffiliated” gang associates
• Identify influential gang members
• Identify “corner crews” and sub-groups of a given gang
• Understand the relationships between different street gangs
Problem: Visualizing Social Network

- Collect data on arrests from arrest records
  - Personal information
  - Admitted gang affiliation
  - Other people arrested with individual
- Provide useful visualization representative of the social structure of the gang
Problem: Determine Gang Membership

- Not all gang members admit affiliation when they are arrested
- Assign unaffiliated individuals to a gang with a reasonable level of confidence
Problem: Identify Influential Members

- Gangs are generally decentralized
- Members of law enforcement still suspect that individuals or groups who are particularly influential exist in gangs
Problem: Identify Corner Crews and Sub-Groups

- Criminal street gangs are often highly modular
  - Many identifiable sub-groups
- Corner crews are highly connected clusters of gang members who sell drugs together on the same street corner
Problem: Understand Relationships between Gangs

- There are often relationships between different gangs
- Includes entire gangs and sub-organizations within gangs
- Relationships exist between sub-organizations within the same gang and across different gangs
Problem

In this talk we introduce

**ORCA**

Organization, Relationship, and Contact Analyzer
Technical Overview

- Arrest record data
- Create social network
- Compute degree of membership (MANCaLog framework)
  - Determine gang ecosystems
  - Partition network to identify sub-groups (Louvain Algorithm)
  - Identify core members of gangs or factions (TIP_DECOMP)
- Identify connectors
- Report generation
Technical Overview: Degree of Membership

- ORCA learns *logical rules* to determine the degree of membership in a given gang based on the number of associates in that gang.

- It then utilizes MANCaLog (Shakarian et al. ‘13) to apply the rules to “unaffiliated” gang associates.

\[
grp_1 \leftarrow \bigvee_i \neg\langle grp_i, 1 \rangle, (grp_1)_{iR}
\]
Technical Overview: Discovering Seed Sets

- ORCA discovers seed sets based on the *tipping model* where an individual adopts a behavior if half of his friends previously adopted.

- We use the heuristic TIP_DECOMP of Shakarian & Paulo ‘12 to quickly identify sets of individuals who can cause universal adoption in a given gang under the tipping model.
Technical Overview: Identifying Ecosystems

- Identifying “corner crews” and other sub-groups of street gangs is an important concern.
- ORCA accomplishes this by finding a partition of the network of a given gang that maximizes modularity (Newman & Girvan ‘04) using the Louvain heuristic (Blondel et al. ‘08).

\[
M(C') = \frac{1}{2m} \sum_{c \in C} \sum_{i, j \in c} w_{ij} - P_{ij}
\]

\[
P_{ij} = \frac{k_i k_j}{2m}
\]
Prototype

• ORCA was implemented in Python 2.7.3 and uses the following libraries:
  • NetworkX 1.7 (support for social network data structures)
  • TKinter 8.5 (GUI)
  • Matplotlib 1.2.0 (Network visualization)
  • PyFPDF 1.7 (PDF report generation)
  • CRANS implementation of the Louvain Algorithm
  • USMA implementations MANCaLog and TIP_DECOMP
Prototype
Evaluation

We used a current real-world law enforcement data set from our partners at a major American metropolitan police department:

- 1 police district
- 5,418 arrests
- 11,421 relationships among arrests
- 1,468 individuals (in one of 18 gangs)
- 1,913 relationships among individuals
Evaluation: Degree of Membership

• The relationship between degree of membership and connections in a given gang mirrors that of previous work (Centola ‘10).

• All 180 unaffiliated gang associates were assigned a degree of membership greater than zero.

• The majority of these individuals would be assigned a degree of membership greater than 0.5.
Evaluation: Degree of Membership

- Plot of inference function for 5 of the gangs (top) displays connection between relationships in gang and degree of membership
- Plot of individuals assigned a certain degree of membership (bottom) shows most were assigned a degree greater than 0.5
Evaluation: Identifying Seed Sets

• Gangs are segregated along racial lines, and belong to one of two racial groups.
• Anecdotally, police report that Racial Group A is more hierarchical than Racial Group B (which is more decentralized).
• We found (on average) that gangs in Racial Group A had seed sets 3.86% smaller than those in racial group B.
Evaluation: Community Structure

- In finding high-modularity communities with the Louvain algorithm, we also found a racial difference among gangs.
- We found (on average) that gangs in Racial Group A (hierarchical) had a modularity 11.2% less than those in Racial Group B (decentralized).
Evaluation:
Ecosystem

- ORCA also generates a network of gang sub-groups based on the ties between them. The sub-graph of this network containing all sub-groups of a given gang (and their neighbors) is the “ecosystem” of that gang.

- This is of particular importance in cases where allied gangs conduct mutually-supportive operations (i.e. in cases of gang retaliation).
Evaluation: Ecosystem
Evaluation: Connecting Individuals

- ORCA also identifies individuals that either claim membership or have connections to multiple gang sub-groups.
- These individuals are important to law-enforcement as they may be important conduits of information between these groups.
Demonstration
Conclusion

• We introduced ORCA, built from the ground-up to aide law-enforcement personnel in intelligence analysis of violent street gangs.

• Currently, we are working with our law enforcement partners to deploy this system to the field and modify it based on their operational needs.

• Additionally, we are starting to consider geographic information as we refine our system.
Questions?