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A Multi-Modal Graph Learning Framework to Capture the Evolution of Global Terrorism

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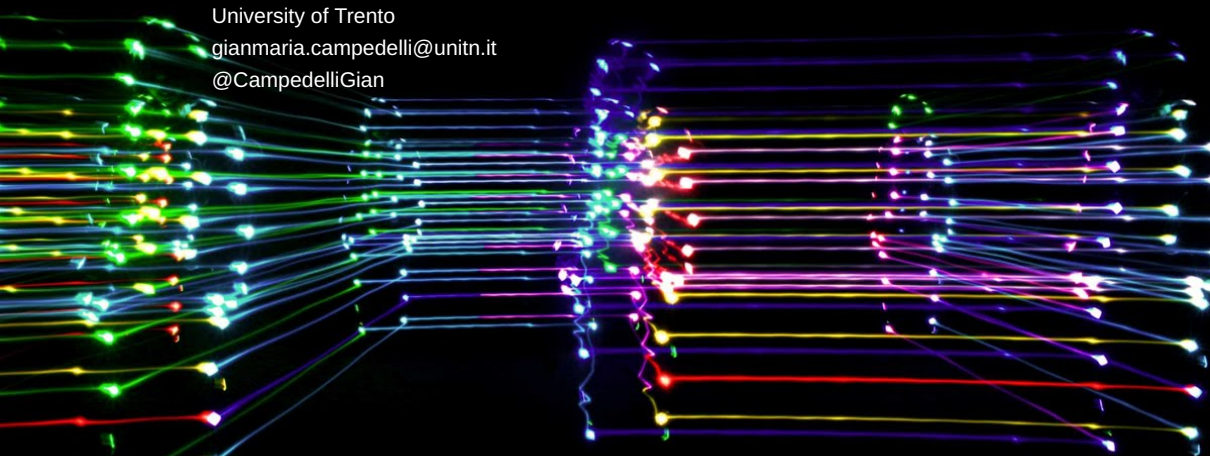

Background

Terrorist attacks are the most concrete consequence of terrorists' decision making processes $\Rightarrow$ the combination of weapons and targets and timing constitutes a group's *operating profile* (McCormick 2003)

Groups' operating profiles are constrained by a number of factors:

- *Material resources* (Dolnik 2007; Koehler-Derrick and Milton 2019)
- *Support* (Polo and Gleditsch 2016)
- *Goals* (Polo 2020)
- *Ideology* (Drake 1998; Asal et al. 2009)

+ research on terrorists' life cycle reveal temporal variations in goals, resources, strategies, and therefore **attacks** (Clauset and Gleditsch 2012; Yang, Pah, and Uzzi 2019)

Research Gap

Lack of fundamental knowledge about operational and behavioral similarity patterns across different organizations. (Some) Unanswered questions:

- *How wide is the behavioral complexity spectrum of terrorist behaviors at the global level?*
- *What overall trends can be observed about global terrorism from a comparative perspective?*
- *Are there behavioral connections between groups that operate in very different geographical contexts and for very different motives?*

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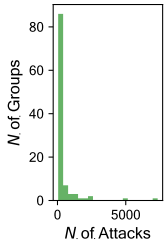
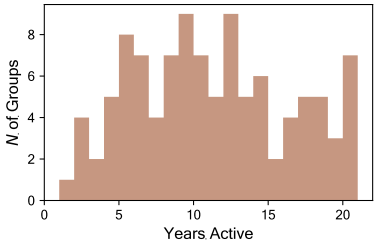
To answer these questions, we leverage multi-modal networks to represent terrorist behaviors at the yearly level:

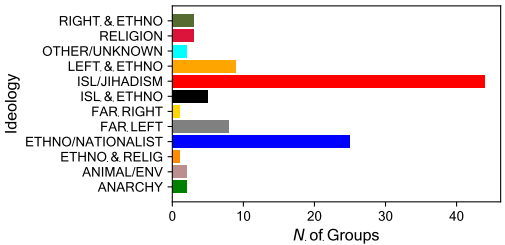
- Multi-modality as an approach to capture different (non necessarily correlated) dimensions of terrorist attacks
- Dynamic component to observe behavioral variations over the years

Data

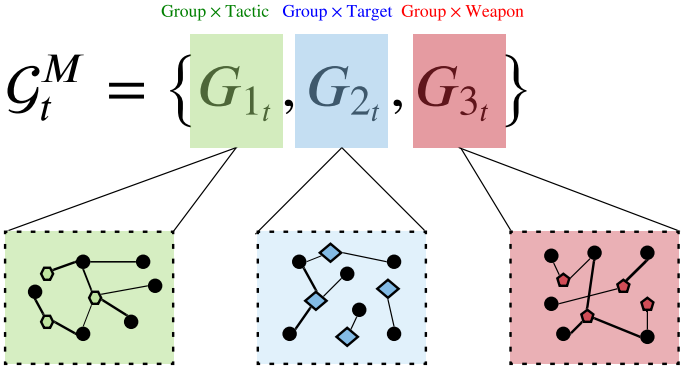
- **Main Source:** Global Terrorism Database (+ BAAD, TRAC, EDTG)
- **Sample:** terrorist actors responsible for at least 50 attacks from 1997 to 2018: *105 groups (42,000+ events)*
- **Focus:** each group's yearly deployed *tactics*, attacked *targets*, utilized *weapons*







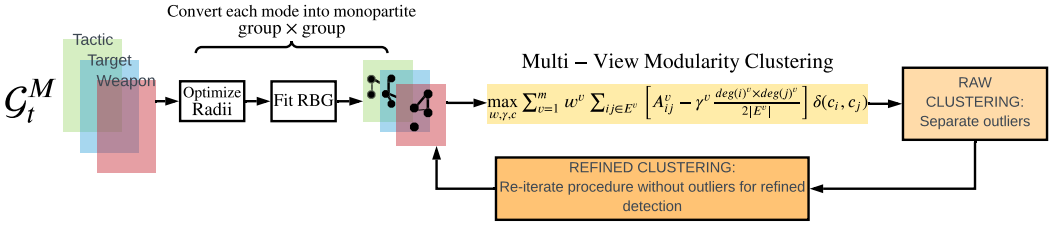
Computational Methodology: Overview/1



Computational Methodology: Overview/2

Group × Tactic Group × Target Group × Weapon

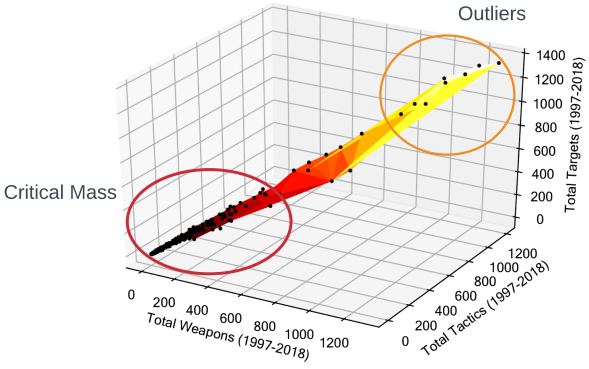
$$\mathcal{G}_t^M = \left\{ G1_t, G2_t, G3_t \right\}$$



Why Iterative Refining?

- Terrorist actors display extremely skewed activity
- Outliers being very active (10 groups account for $\sim$ 60% of total attacks)
- Parallelly, critical mass of groups characterized by low frequency but distinct distributions of feature weights

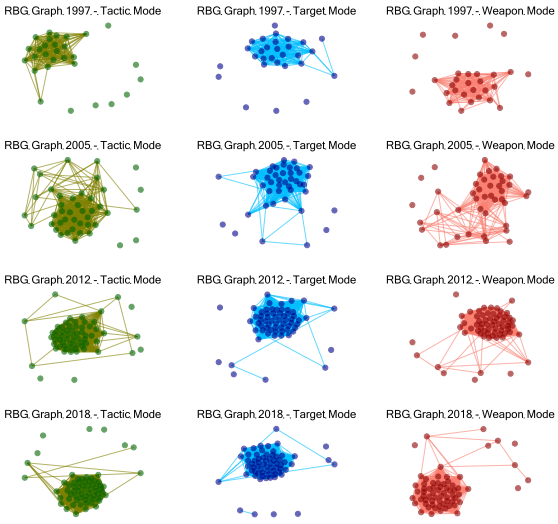
$\Rightarrow$ Refined procedure allows to disentangle more nuanced patterns in the "critical mass" yearly subsamples



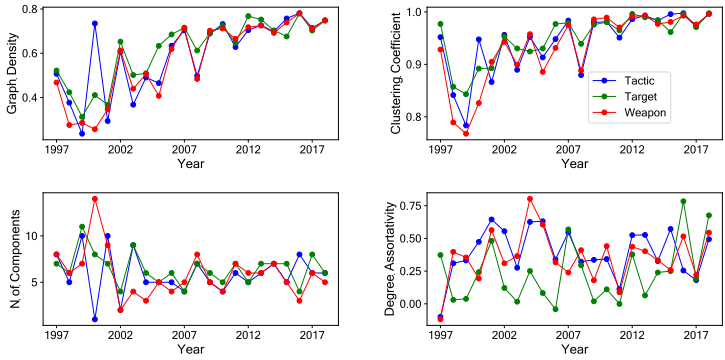
RBG Multi-modal Unipartite Nets

- Transformation from bipartite to unipartite nets to compute mode-weighted resolution-corrected *modularity*
- *Radius Ball Graph*: variant of the nearest neighbor problem in computational geometry
- Radius optimization using Euclidean distance

⇒ **Result:** modal weighted networks connecting groups which are operationally similar with respect to a particular mode

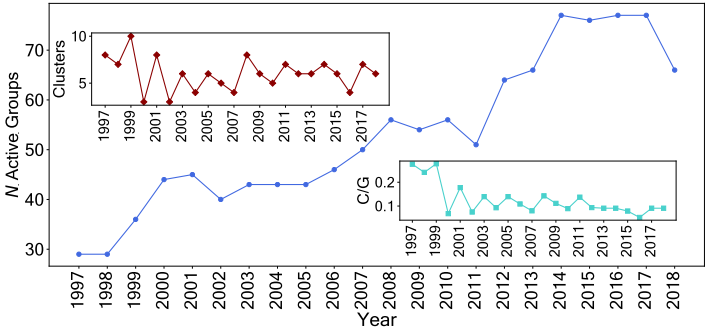


Results: Dynamics of RBG Networks



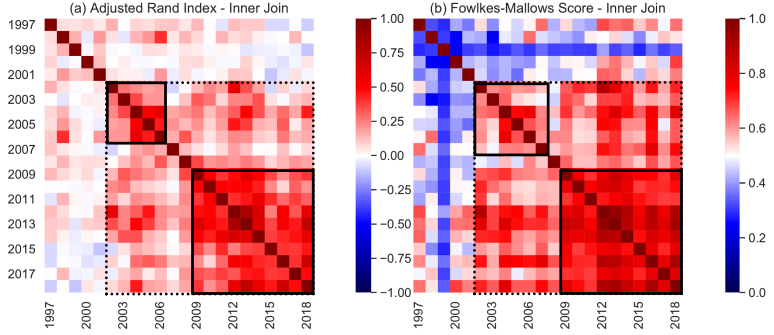
- RBG networks anticipate cluster trends: all modes document increasing density and clustering coefficient. Stable N of components → *reduction in heterogeneity of behaviors?*
- Asynchronous trends in degree assortativity → different network structures in each mode highlight importance of evaluating behaviors in a multi-modal framework

Results: Detected Clusters



- The number of clusters oscillates from 3 to 10, no clear pattern
- In line with RBG network dynamics: ratio clusters/groups shows a downward trend $\rightarrow$ increase of homogeneity at the global level

Results: Co-clustering Stability



- High stability from 2009 to 2018 and from 2002 to 2006
- Co-clustering similarity not always higher for closer years: some groups change their behaviors temporarily and then switch back to previous operating profiles, e.g. $sim[C(2013; 2018)] > sim[C(2017; 2018)]$
- Before 2002: high variability

Results: Drivers of Similarity/1

What are the drivers/correlates of co-clustering, aka operational similarity?

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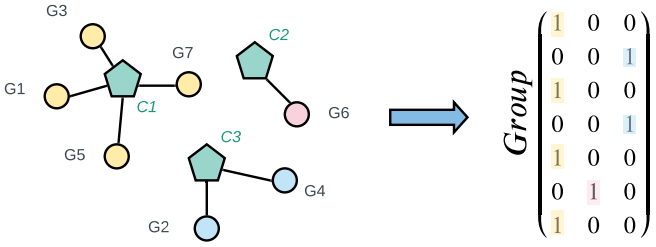
Analytical Strategy: *Exponential Random Graph Models (ERGM)* on the *group* $\times$ *cluster* bipartite yearly networks

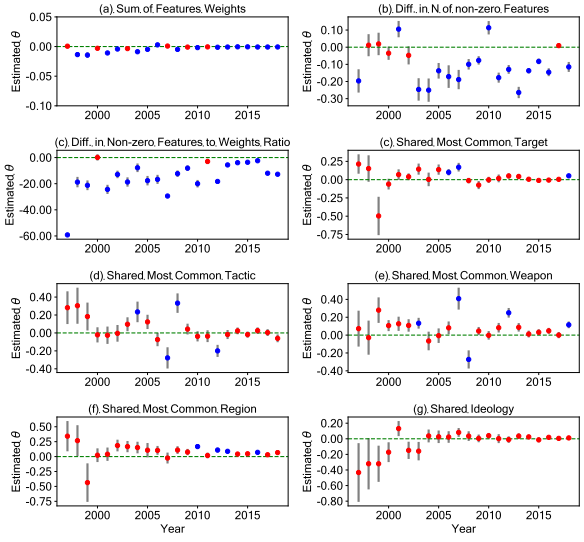


Results: Drivers of Similarity/2

- **Sum of Feature Weights:** *is overall activity a driver of co-clustering?*
- **Diff in N of non-zero features:** *is similarity in repertoire diversity a driver of co-clustering?*
- **Diff in "N of non-zero features to weights" ratio:** *is diversity in relation to overall activity a driver of co-clustering?*
- **Most Common Target:** *are groups with the same target preference more similar?*
- **Most Common Tactic:** *are groups with the same tactical preference more similar?*
- **Most Common Weapon:** *are groups with the same weapon preference more similar?*
- **Region:** *are groups operating in the same region more similar?*
- **Ideology:** *are groups sharing the same ideology more similar?*

Results: What Drives Co-clustering?/3

- **Sum of Feature Weights:** *Is the amount of resources/activity a driver of co-clustering?* YES!
- **N of non-zero features:** *is repertoire diversity a driver of co-clustering?* YES!
- **Diff in "N of non-zero features to weights" ratio:** *is diversity in relation to overall activity a driver of co-clustering?* YES!
- **Most Common Target:** *are groups with the same target preference more similar?* Not Really
- **Most Common Tactic:** *are groups with the same tactical preference more similar?* Not Really
- **Most Common Weapon:** *are groups with the same weapon preference more similar?* Really
- **Region:** *are groups operating in the same region more similar?* Not Really
- **Ideology:** *are groups sharing the same ideology more similar?* NO!



Model Convergence & Overall Robustness

- **ERGM Diagnostics:** convergence has been assessed and confirmed for all the estimated models ✓
- **Results Robustness:** tested on enlarged sample including organizations that have plotted at least 30 attacks from 1997 to 2018 (164 groups, $\sim$57% increase) $\rightarrow$ all outcomes have been confirmed ✓

Limitations

- Yearly focus may obscure micro-temporal patterns $\rightarrow$ *future work should experiment with more restricted time windows*
- This framework does not consider exogenous components (e.g., military campaigns, regime change) $\rightarrow$ *very limited power in causal explanations*

Conclusions

- Increasing homogeneity of behaviors over the years
- Higher stability of co-clustering after 2002, corroborating diminished heterogeneity patterns
- We report organizations' ability to switch back to previously adopted operating profiles, highlighting relevance of dynamic behavioral monitoring
- Operational similarity between pairs of groups is driven by:
  1. groups' overall amount of activity;
  2. similarity in repertoire diversity
  3. similarity in both activity and repertoire diversity combined

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Artwork References

Title Slide: *Flow, Siyon Jin (2011)*
Closing Slide: *The Persistence of Memory, Salvador Dalì (1931)*

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