Inferring Structure and Forecasting Dynamics on Evolving Networks

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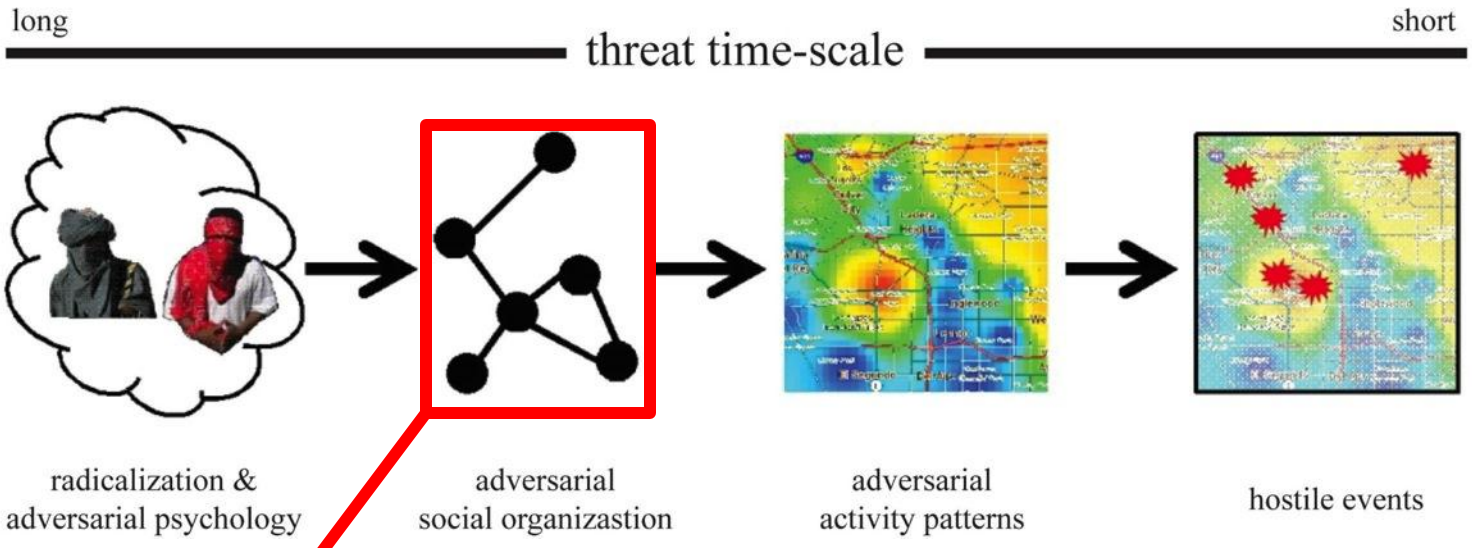
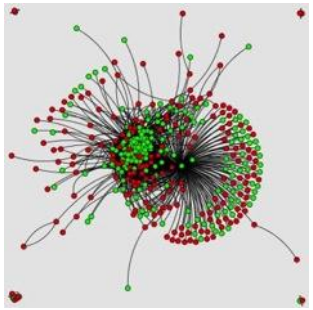
TRUST & INFLUENCE PROGRAM REVIEW, JAN 14-17 2013

hybrid threats



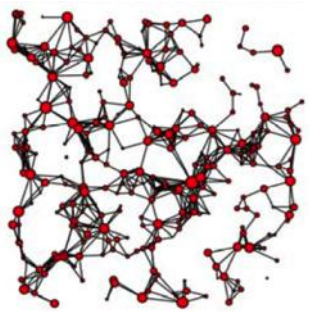
face-to-face

many-to-many



covert

evolving



collaborative efforts

1. community classification from sparse geo-social data

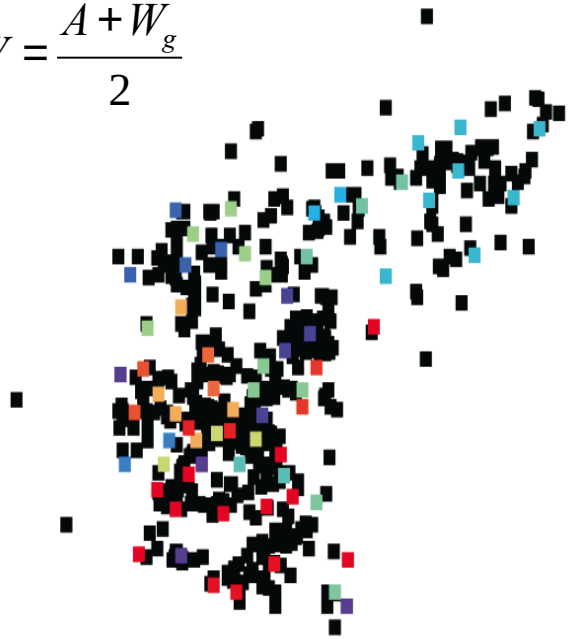
2. sacred values in a networked crime game

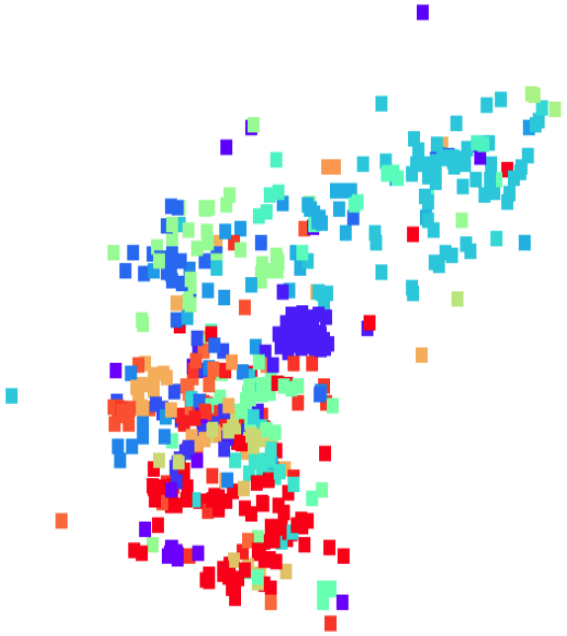
3. gang twitter-space

1. geo-social community detection

assigning individuals to gangs

$$W = \frac{A + W_g}{2}$$





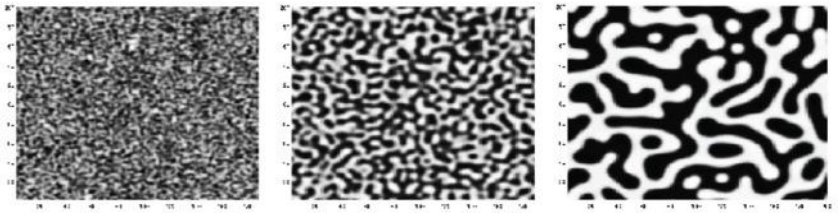
sparse geo-social data

ground truth

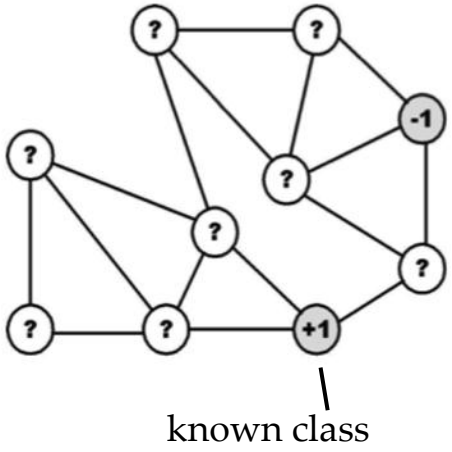
LAPD Hollenbeck Field Interviews in 2009

mathematics of segmentation

Cahn-Hilliard binary fluid separation



Graph with fixed topology



Ginzburg-Landau Functional

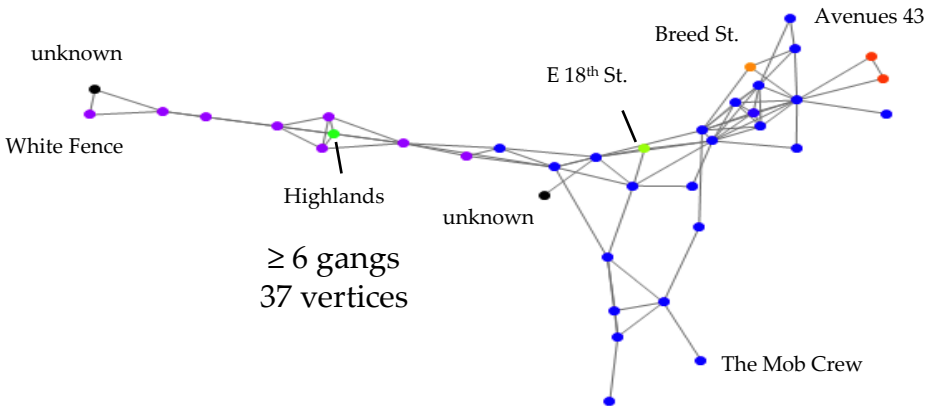
$$E_{GL}(u) = \underbrace{\frac{\epsilon}{2}\int_\Omega |\nabla u|^2\, d\boldsymbol{x}}_{\text{diffuse interface}} + \underbrace{\frac{1}{4\epsilon}\int_\Omega \left(u^2-1\right)^2\, d\boldsymbol{x}}_{\text{double-well potential}}$$

graph Laplacian

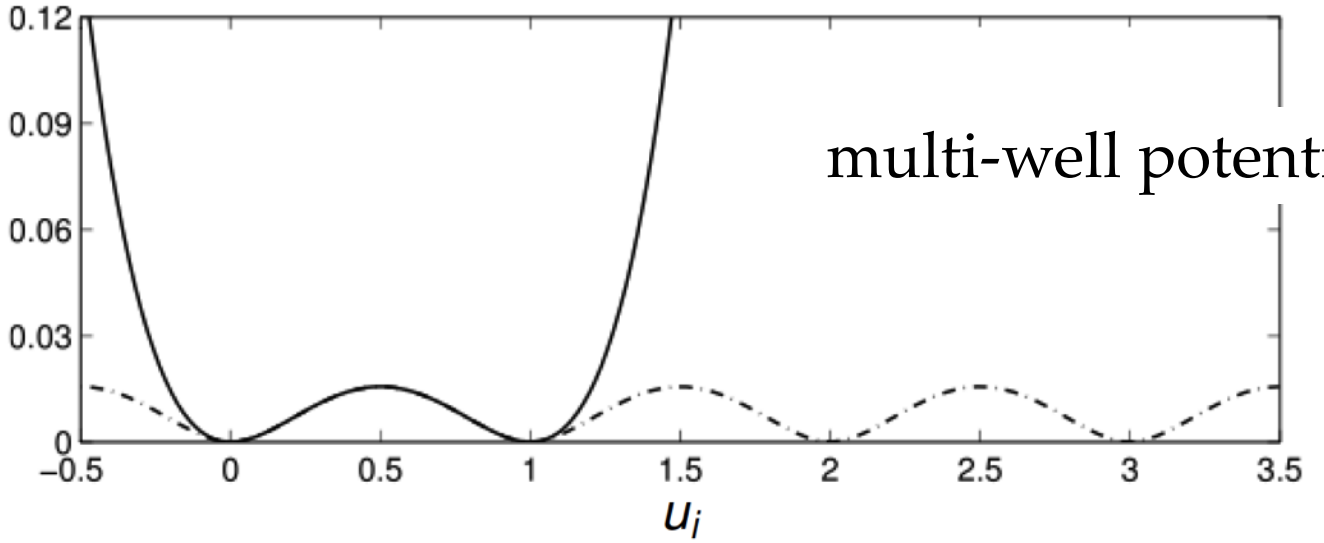
$$E_{GL}(\boldsymbol{u}) = \underbrace{\frac{\epsilon}{2}\langle \boldsymbol{u}, \boldsymbol{L}\boldsymbol{u}\rangle}_{\text{DI}} + \underbrace{\frac{1}{4\epsilon}\sum_{i\in V}\left(u_i^2-1\right)^2}_{\text{DWP}} + \underbrace{\sum_{i\in V}\frac{\lambda_i}{2}\left(u_i-(u_i)_0\right)^2}_{\text{fidelity points}}$$

Bertozzi, Andrea L., and Arjuna Flenner. (2012). Diffuse interface models on graphs for classification of high dimensional data. *Multiscale Modeling and Simulation*, 10:1090-1118.

multiclass segmentation



31 distinct gangs



multi-well potential

Garcia-Cardona, C., A. Flenner, A.G. Percus (2012). Multiclass Diffuse Interface Models for Semi-Supervised Learning on Graphs. Proceedings Pattern Recognition Applications and Methods. (in press).

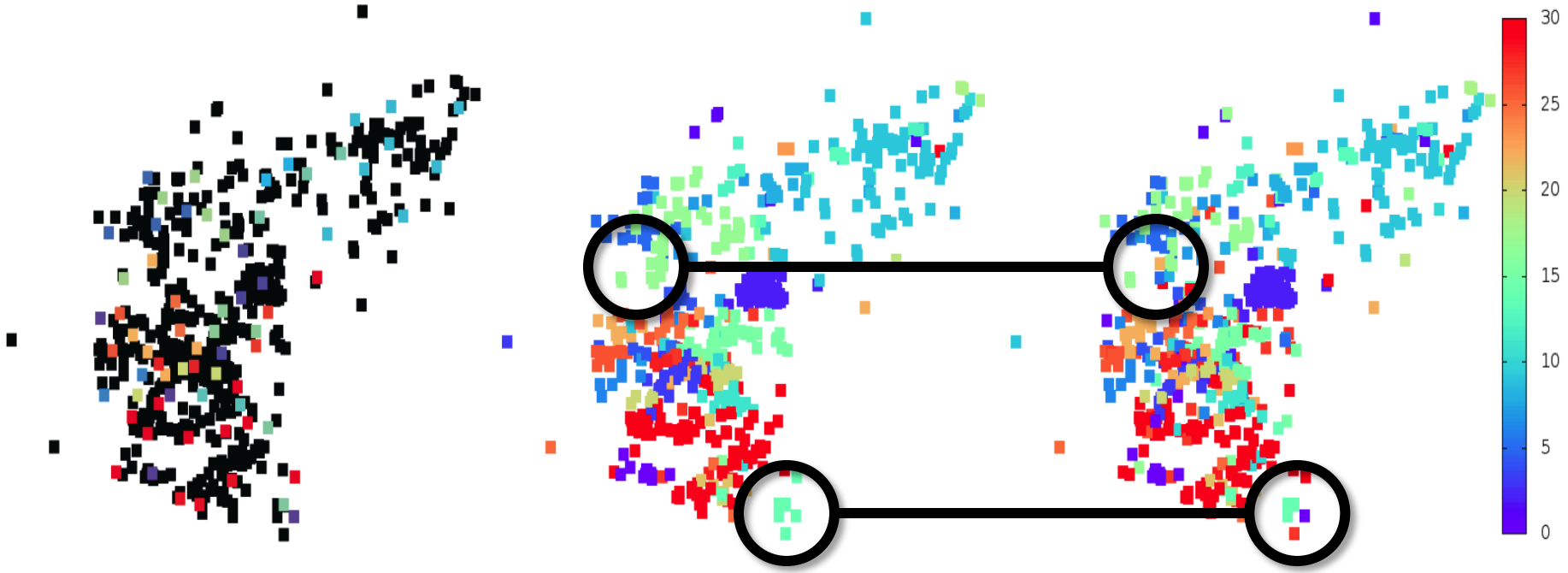
rapid discovery of gang affiliations

starting

multi-well
first step

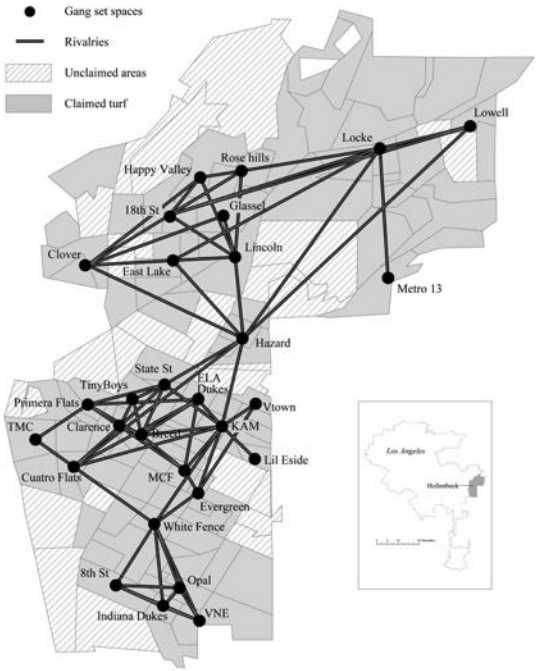
ground truth

group heterogeneity



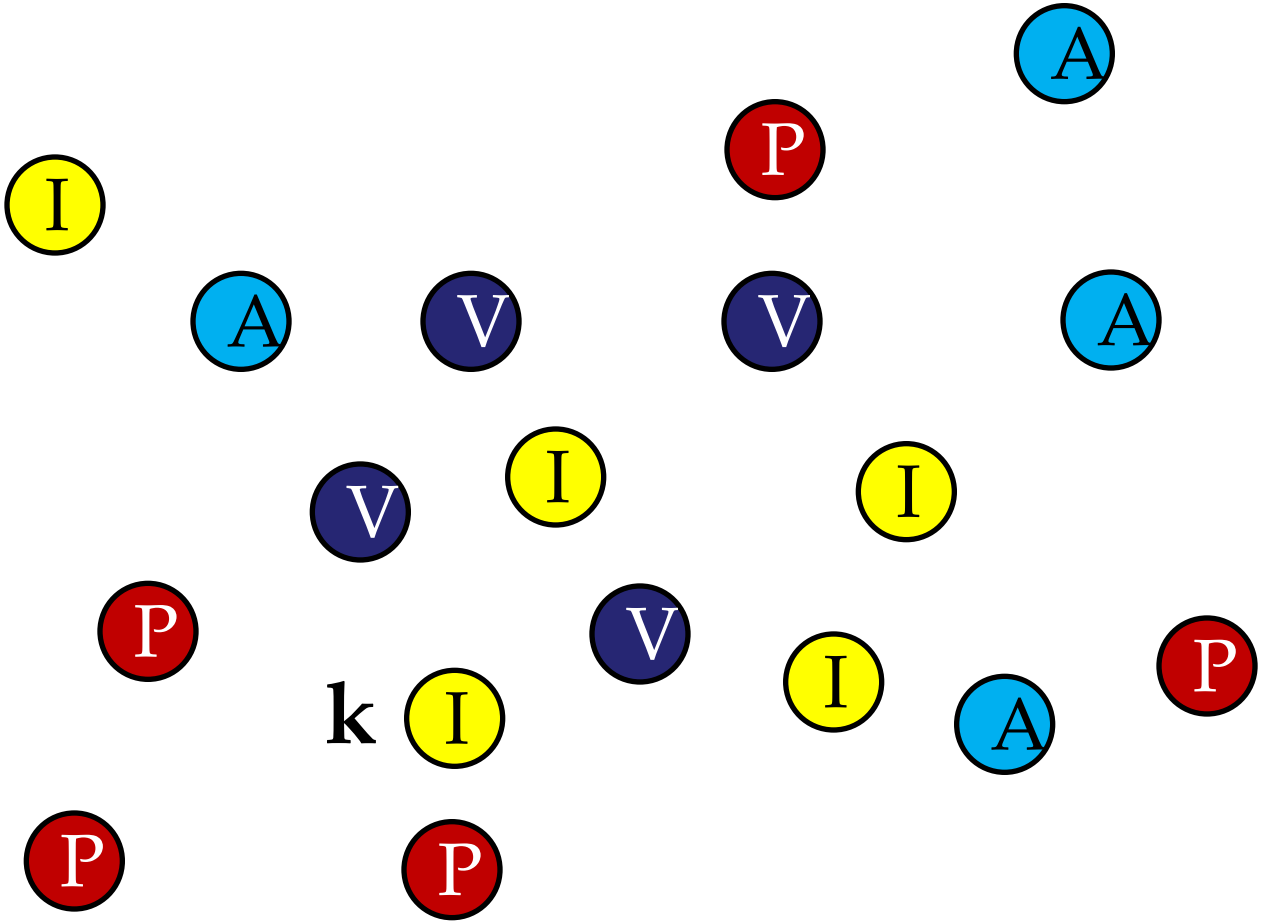
starting accuracy 69% ground truth

2. sacred values networks



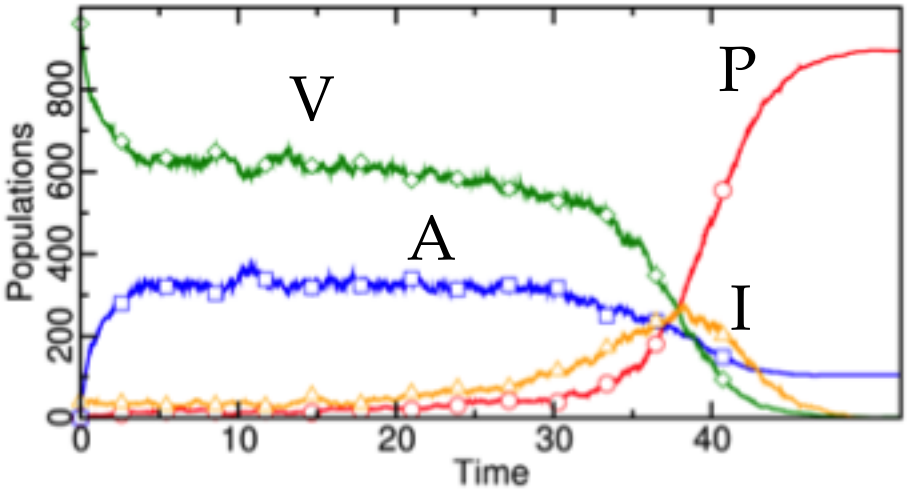
within-gang opportunity between-gang focus

an evolutionary crime game



victimization → social response → strategy replication

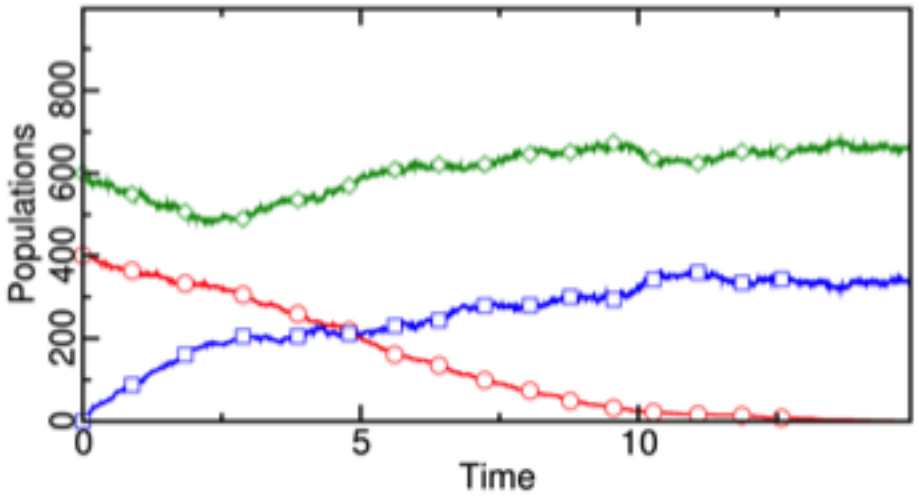
Utopia



utopia achieved with initial conditions N = 1000, I = 40, V = 960

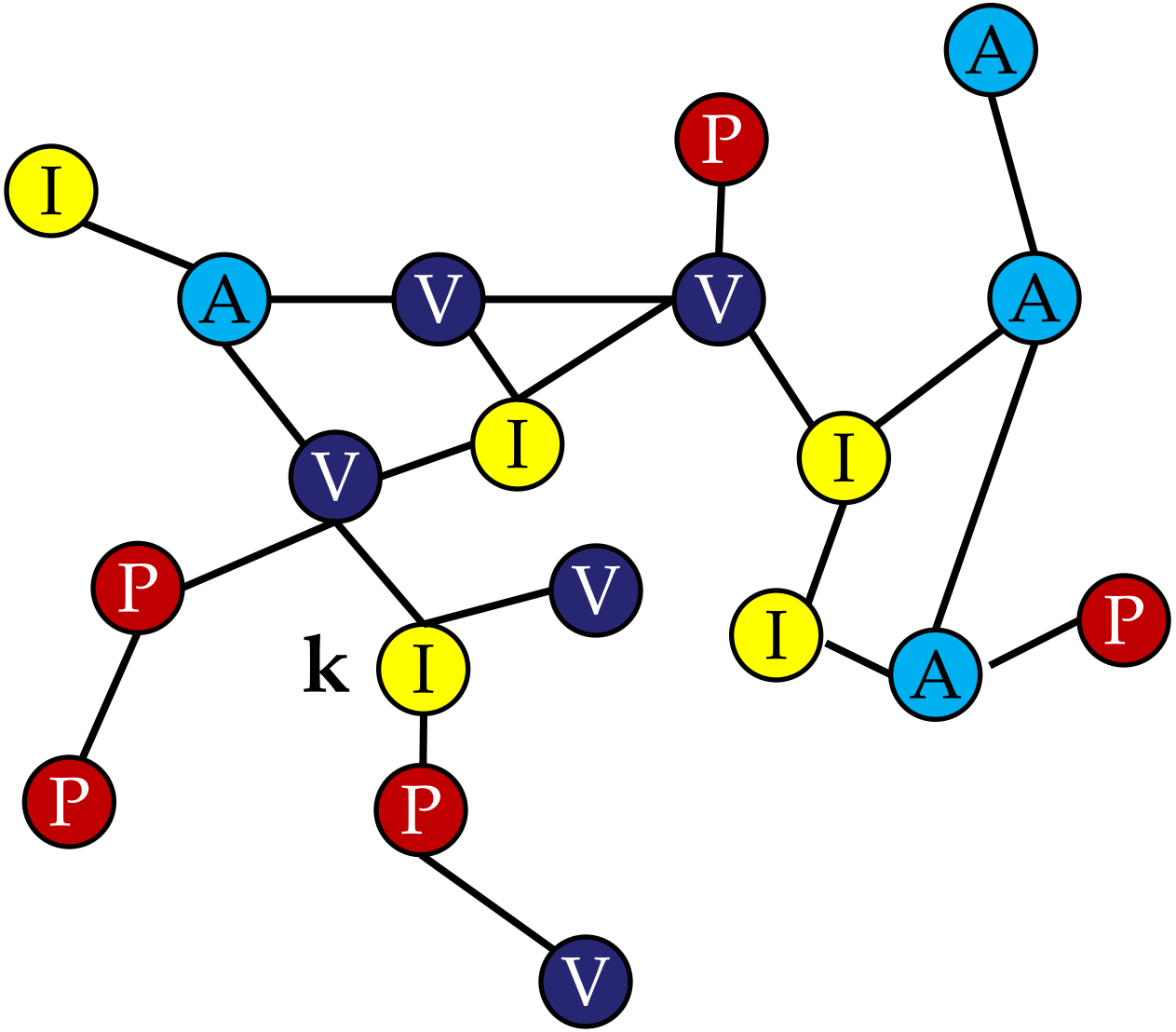
Dystopia

dystopia achieved with initial conditions N = 1000, P = 40o, V = 600

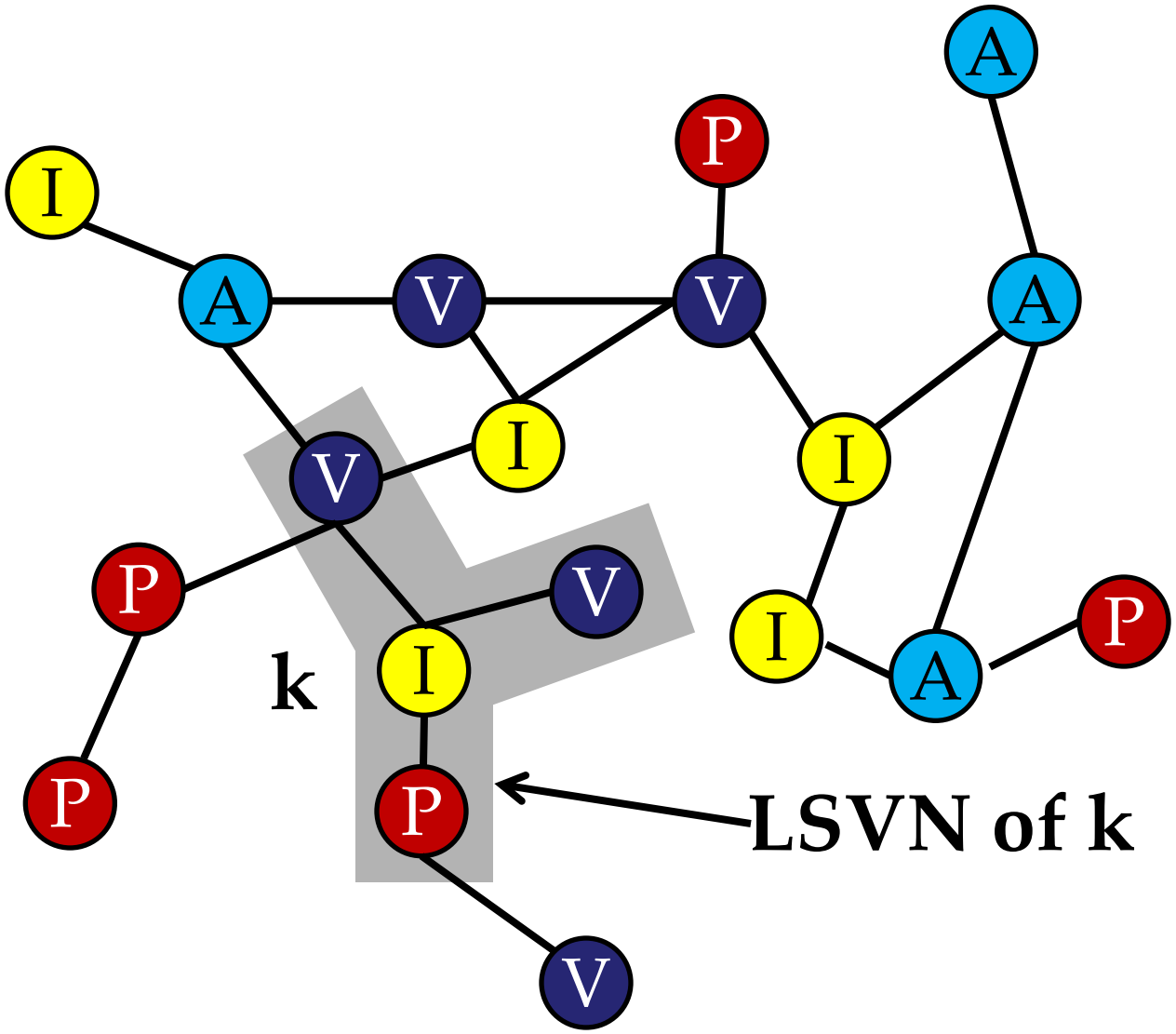


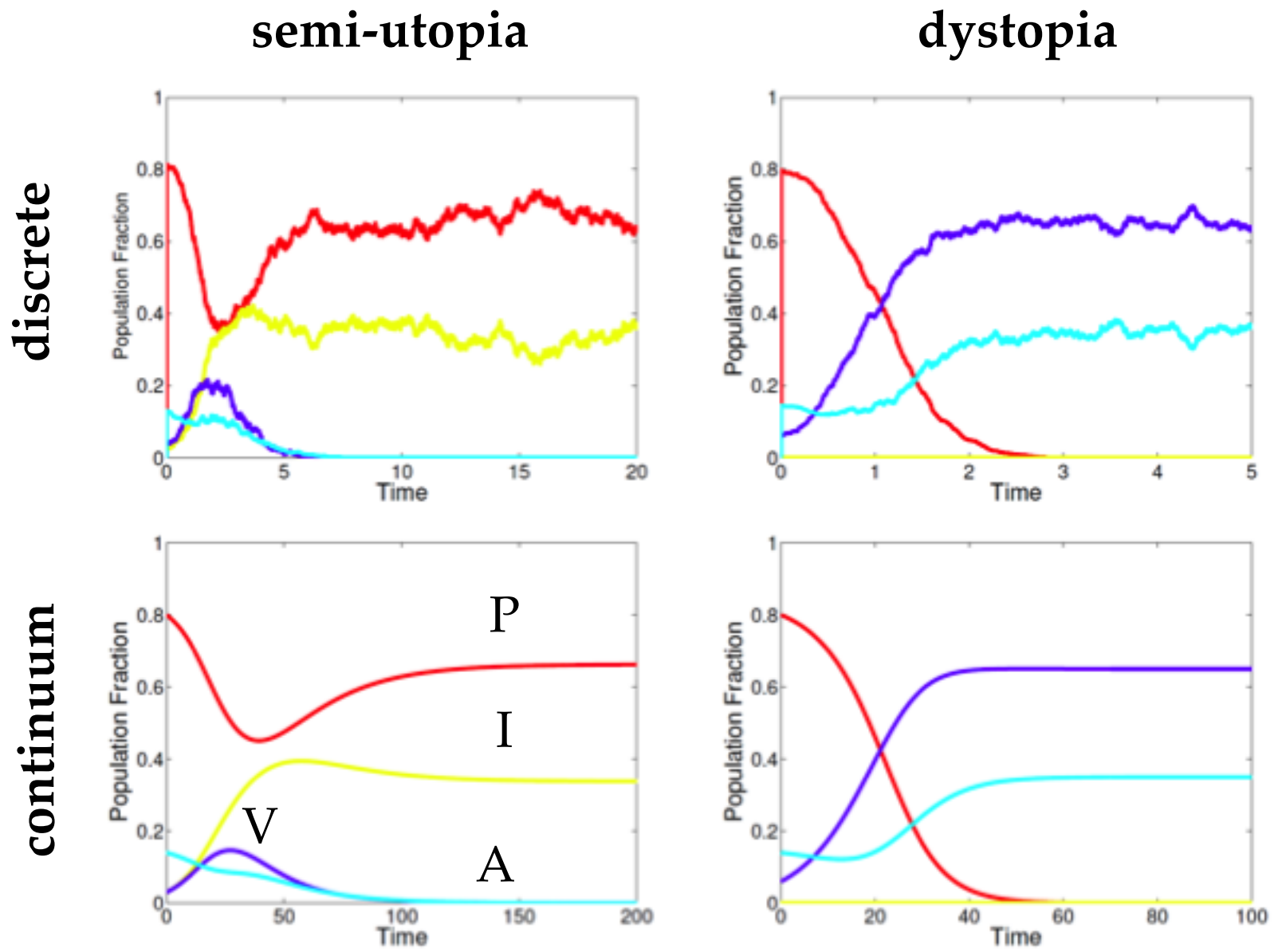
M.B. Short, P.J. Brantingham and M.R. D'Orsogna. (2010). Cooperation and punishment in an adversarial game: How defectors pave the way to a peaceful society *Physical Review E* 82:66114-1-7.

defining sacred values



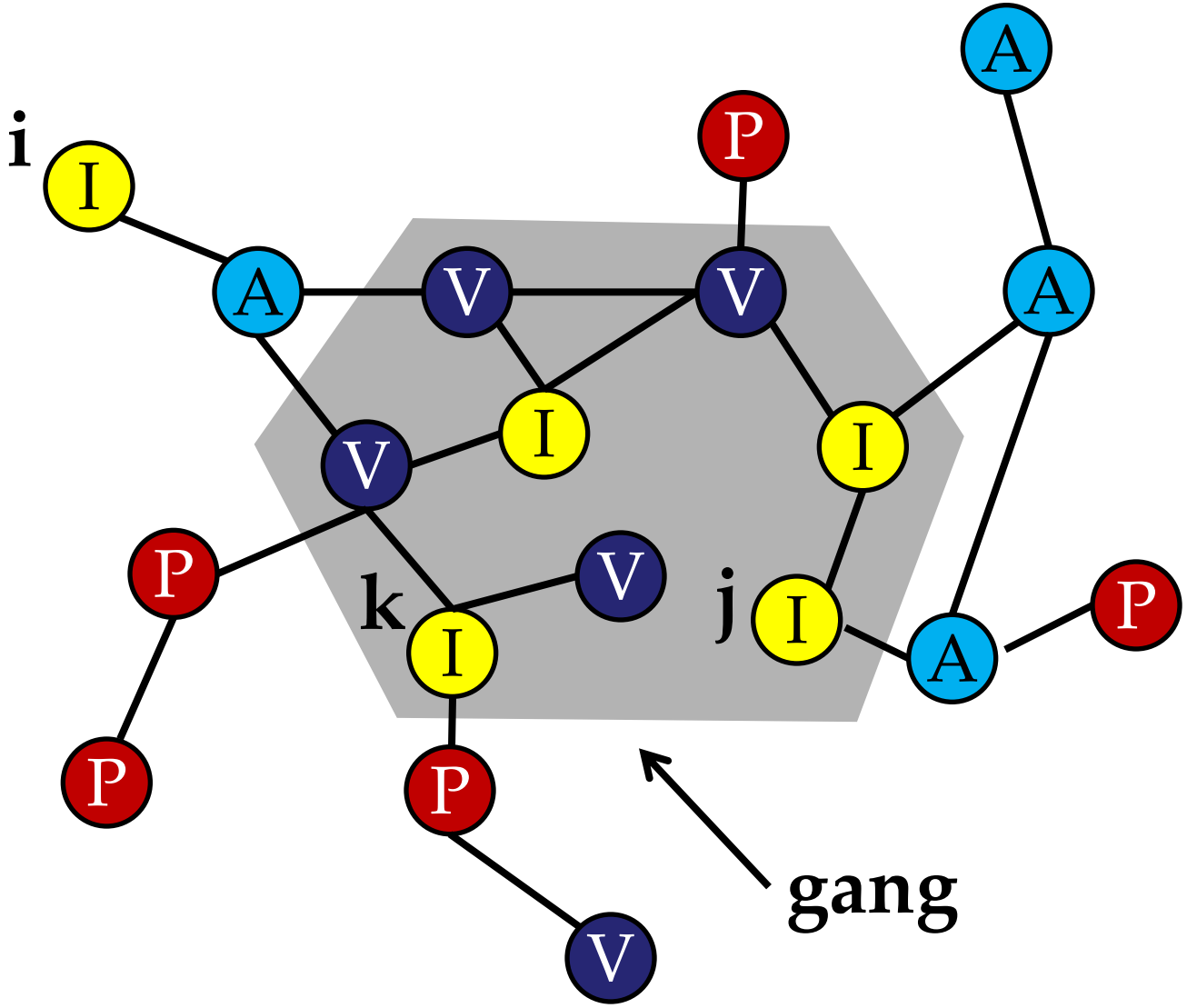
defining sacred values



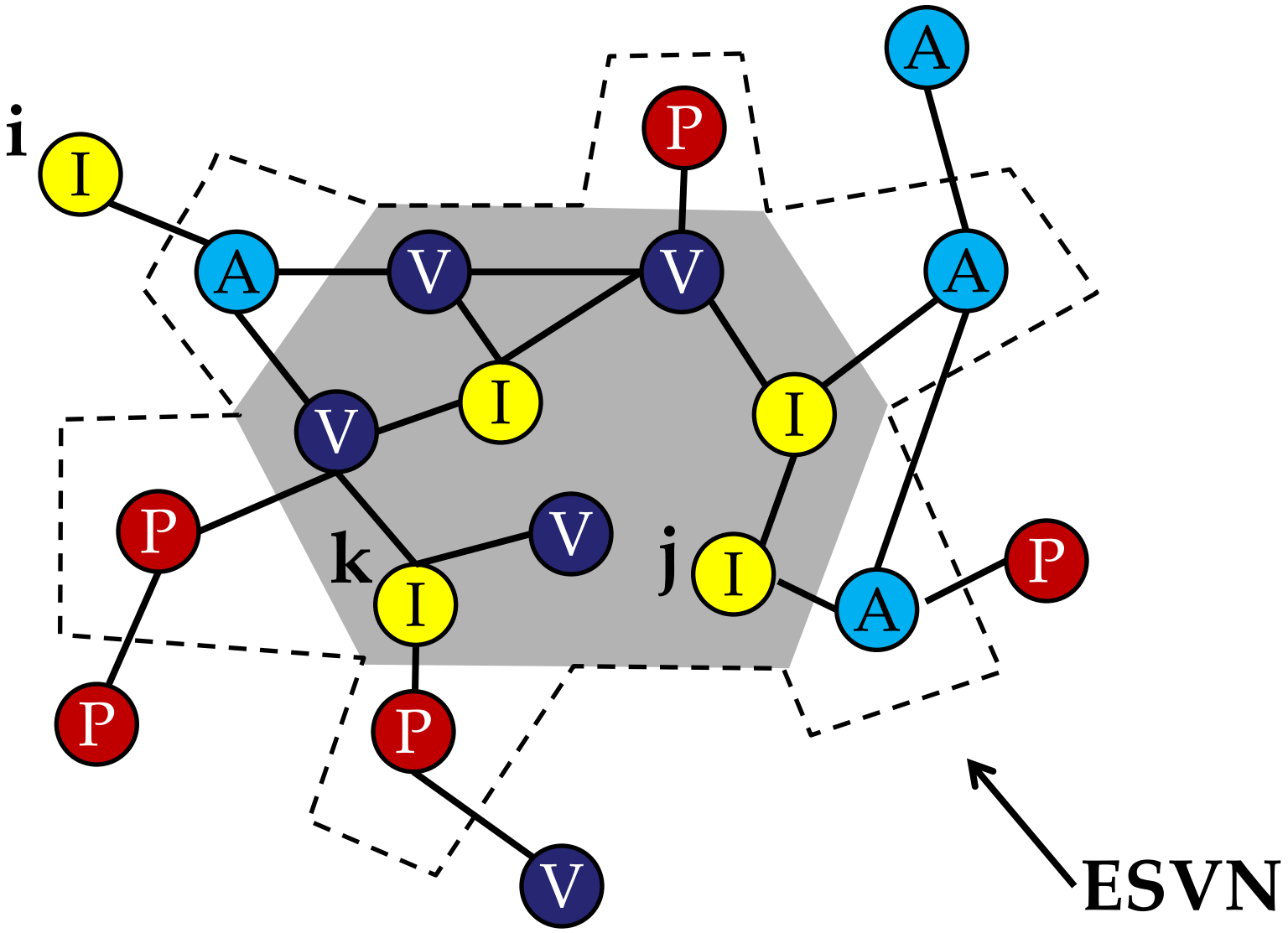


S.G. McCalla, M.B. Short and P.J. Brantingham. (2012). The Effects of Sacred Value Networks within an Evolutionary, Adversarial Game. *Journal of Statistical Physics.* (in press).

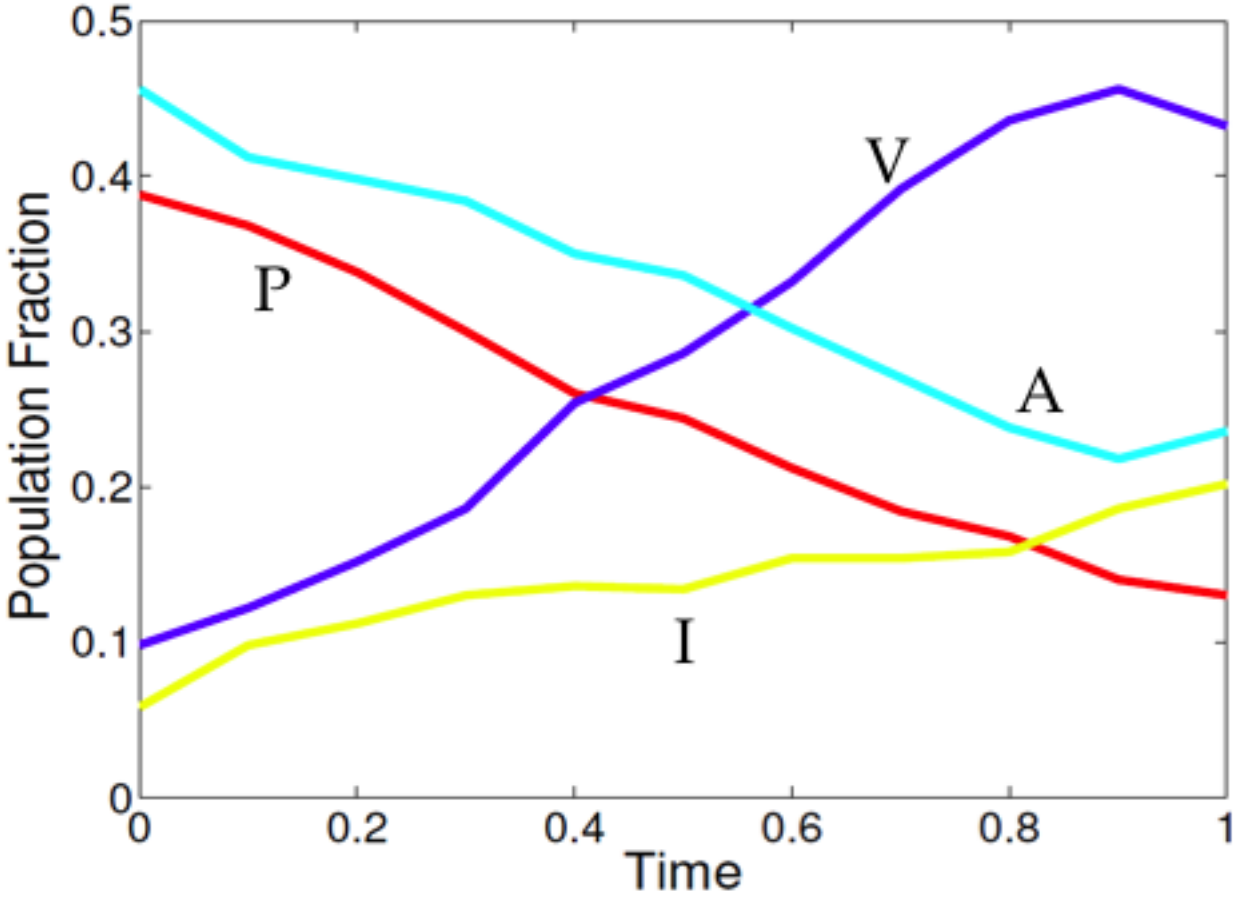
defining gangs



gangs + Extended SVN



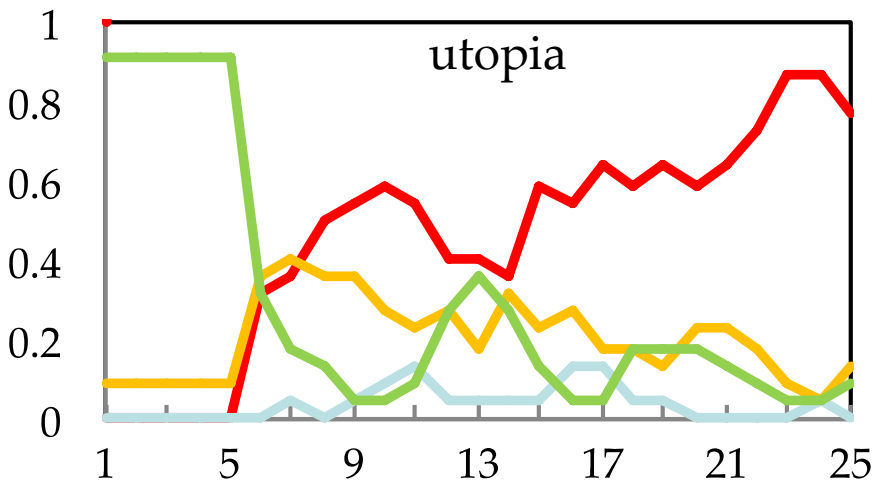
semi-dystopia



the negative consequences of tribalism

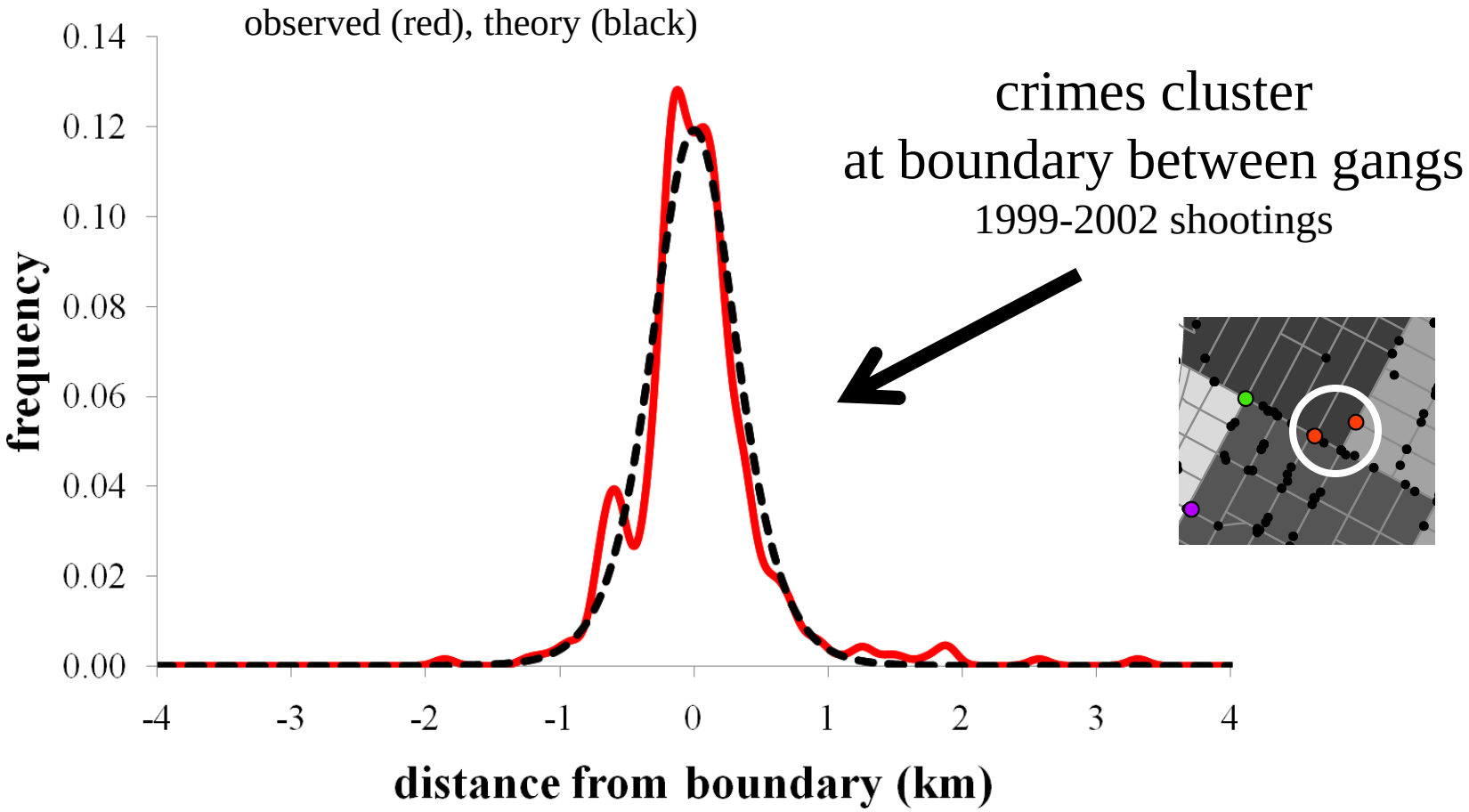
gangs in the lab

- peripheral members of larger gangs will show a greater tendency to…
  - become a criminal type & join their adjacent gang
  - form LSVN links with all gang members
- lab-based experiments scheduled…



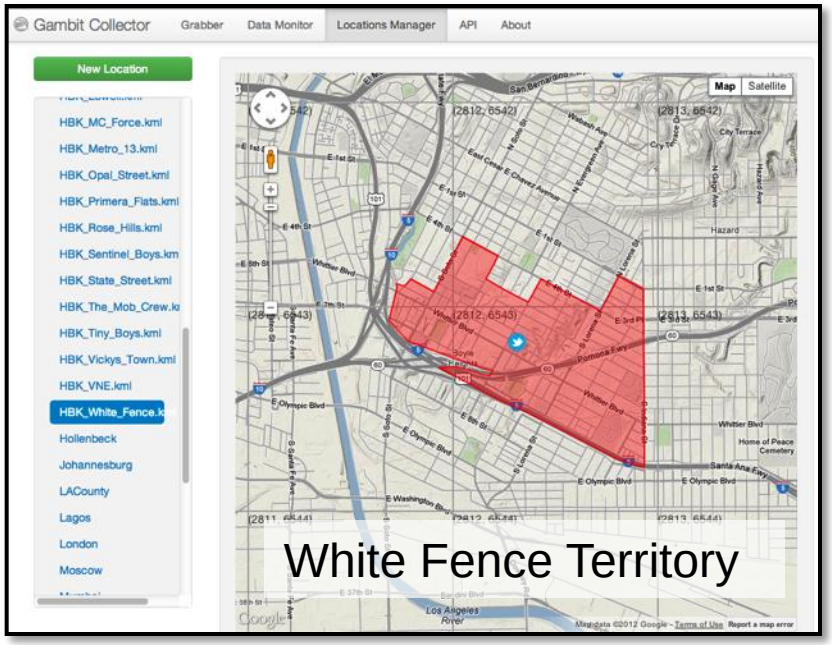
M.R. D'Orsogna, R. Kendall, M. McBride and M.B. Short. (2013). Criminal Defectors Lead to the Emergence of Cooperation in an Experimental, Adversarial Game. submitted to *PLoS One*.

3. gang violence & routine activity

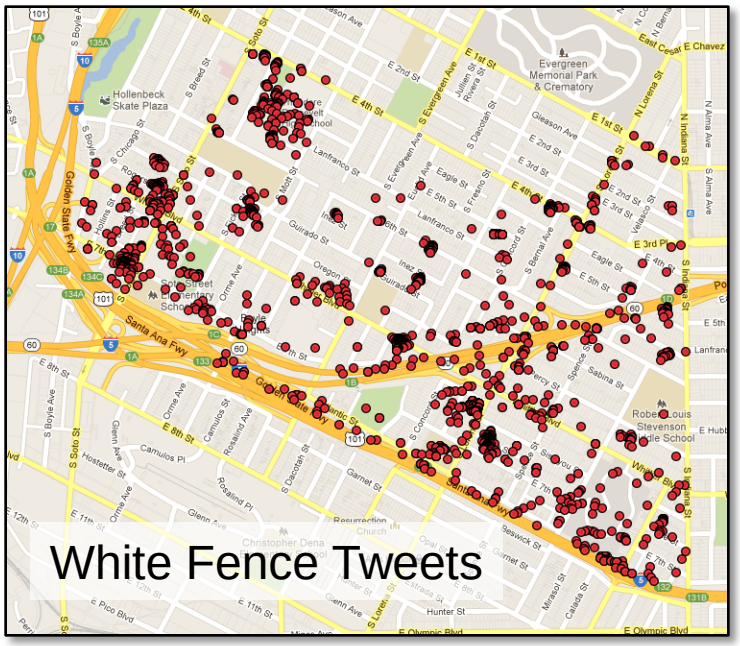


P.J. Brantingham, G.E. Tita, M.B. Short, S. Reid (2012). The Ecology Gang Territorial Boundaries. *Criminology* 30:851-885.

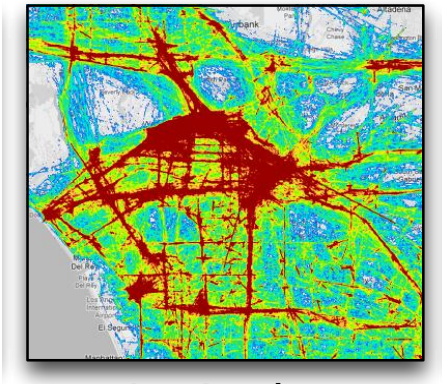
gang “Twitter-space”

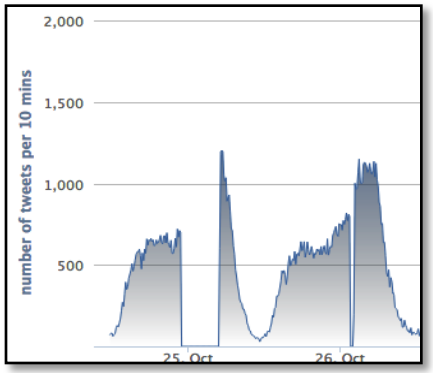


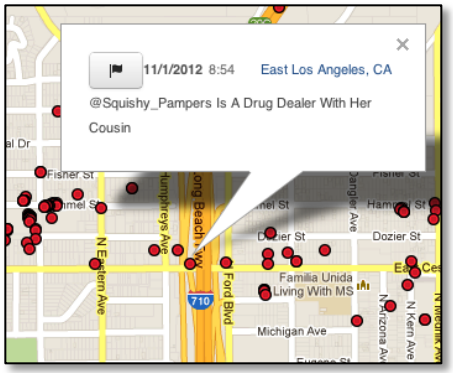
White Fence Territory

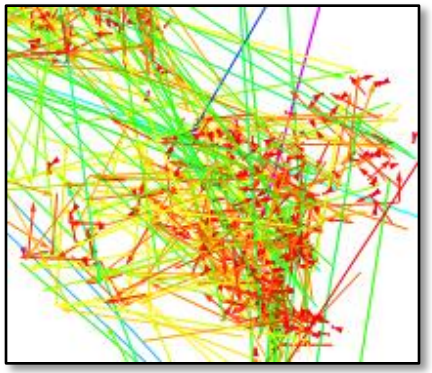


White Fence Tweets







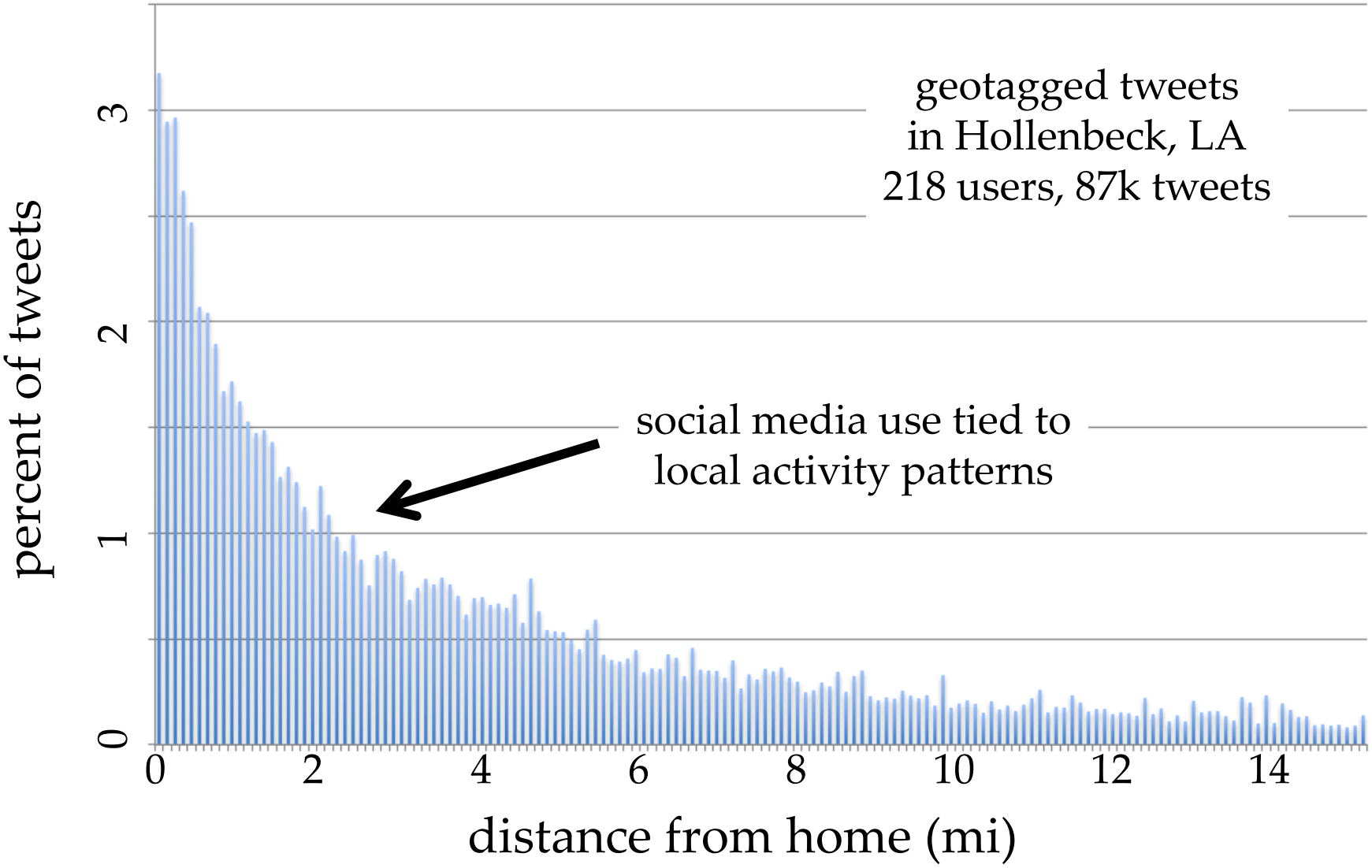


spatio-temporal activity

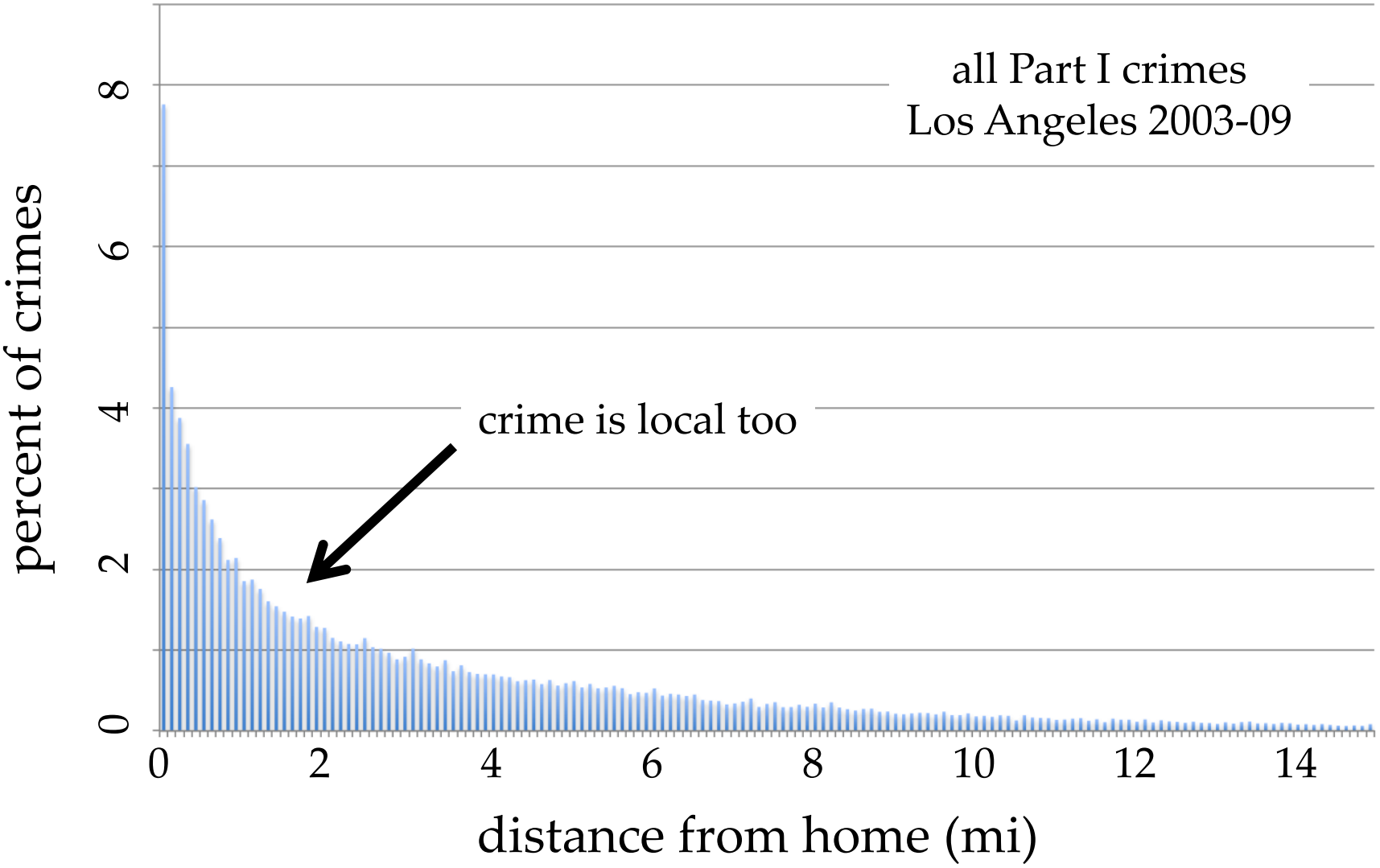
content

crime correlations

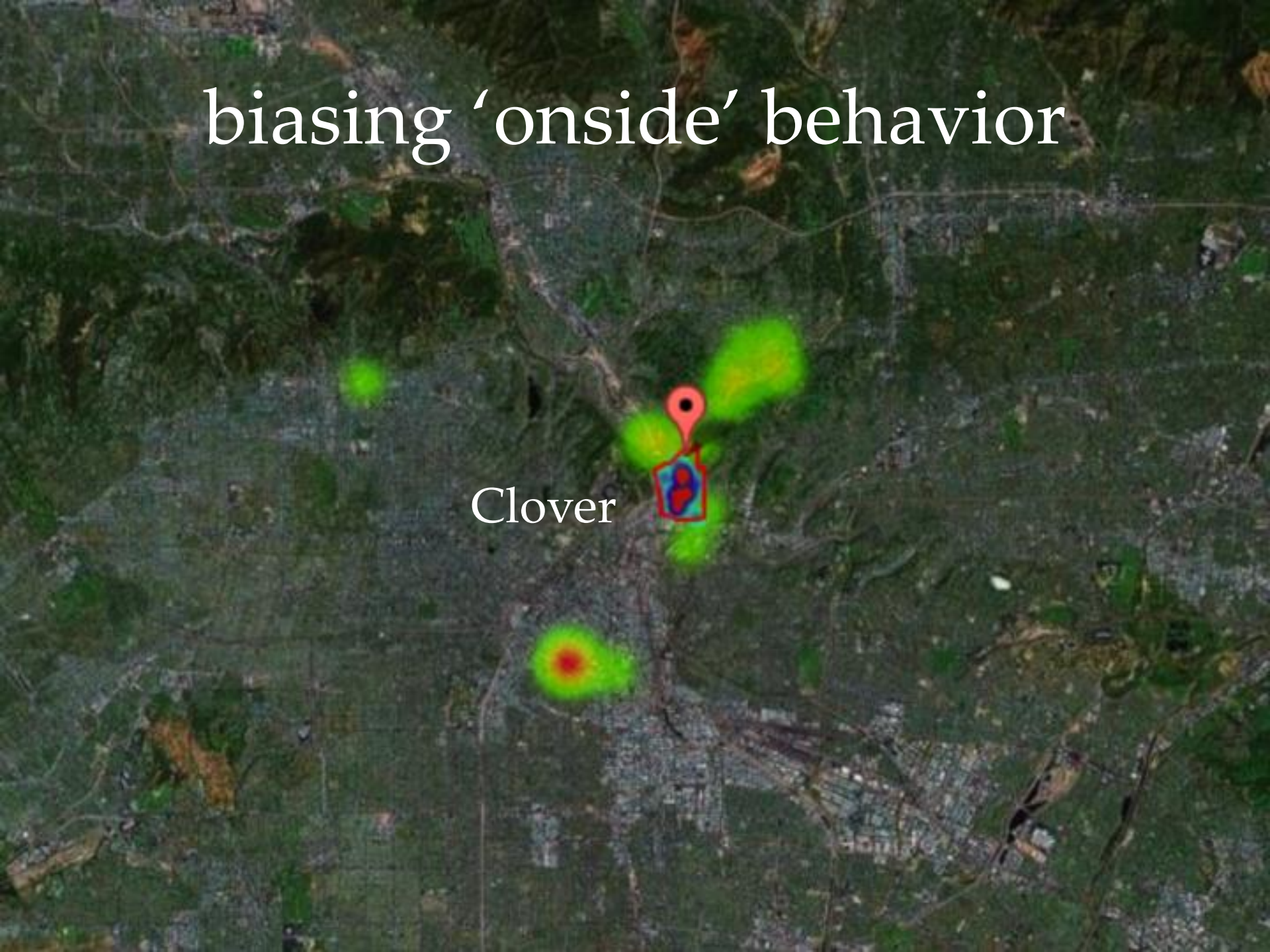
journey-to-tweet



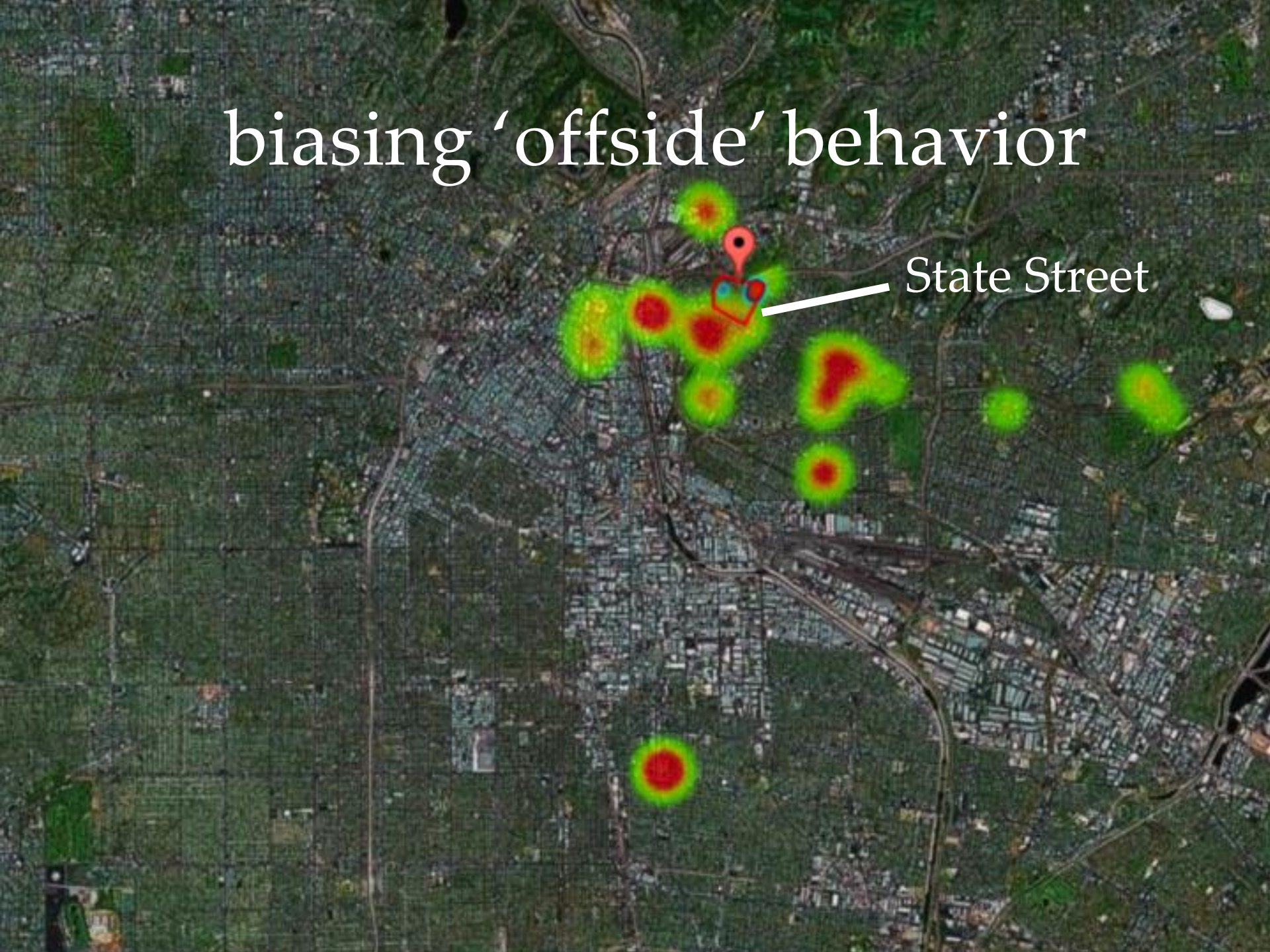
journey-to-crime



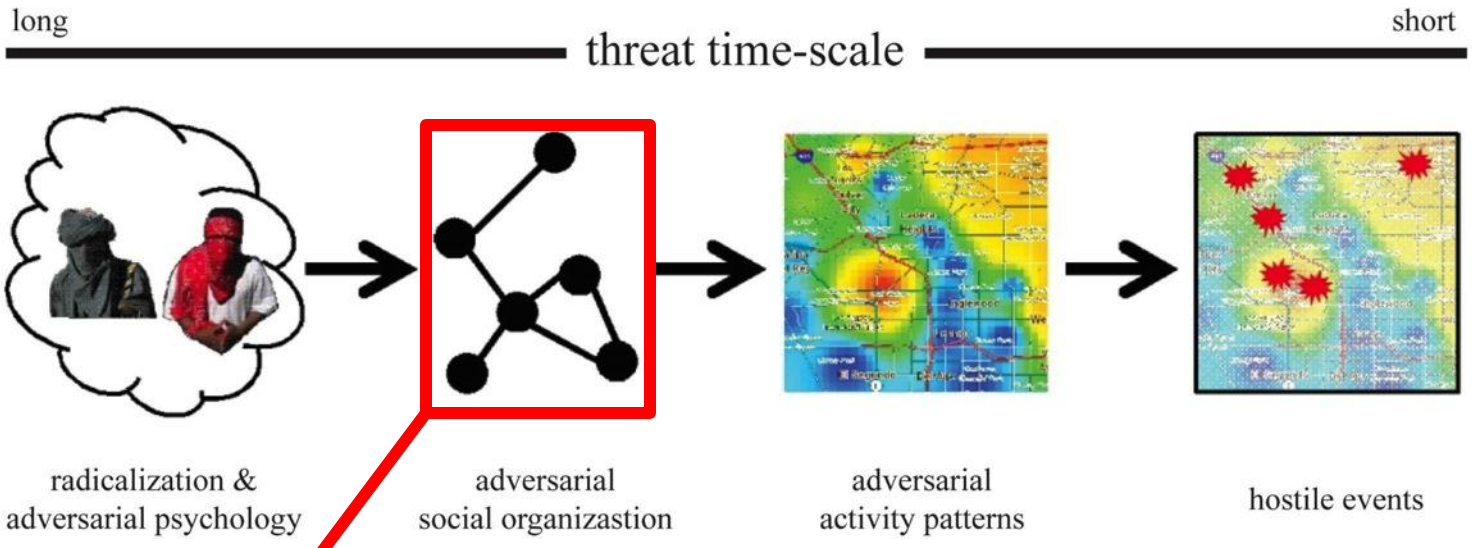
biasing ‘onside’ behavior



biasing ‘offside’ behavior

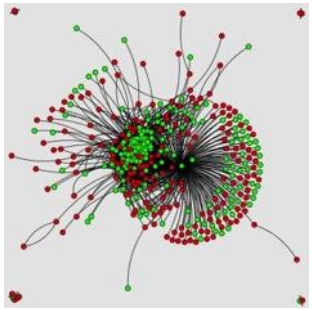


hybrid threats



face-to-face

many-to-many



covert

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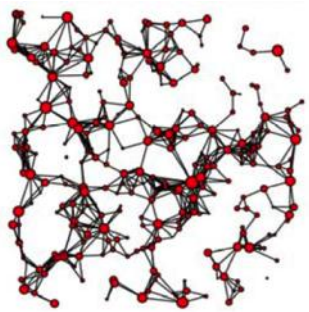

research productivity

- 41 papers published or in press (CUMULATIVE)

1. Bakker, René M., Jörg Raab, and H. Brinton Milward. 2011. A preliminary theory of dark network resilience. Journal of Policy Analysis and Management. in press. doi: 10.1002/pam.20619.
2. Bertozzi, Andrea L., and Arjuna Flenner, Diffuse interface models on graphs for classification of high dimensional data. Multiscale Modeling and Simulation, Multiscale Modeling and Simulation, 10:1090-1118, 2012. doi:10.1137/11083109X.
3. Bradonjić, Milan, Aric Hagberg, Nicolas Hengartner, and Allon Percus. 2010. Component Evolution in General Random Intersection Graphs. In Algorithms and Models for the Web-Graph, edited by R. Kumar and D. Sivakumar. Vol. 6516, pp. 36-49,Berlin: Springer Verlag, 2010. doi: 10.1007/978-3-642-18009-5_5.
4. Brantingham, P.J., and M.B. Short. "Crime Emergence." In When Crime Appears: The Role of Emergence, edited by J.M. McGloin, C. Sullivan and L.W. Kennedy, pp. 73-95. New York: Routledge, 2012.
5. Brantingham, P.J., G.E. Tita, M.B. Short and S. Reid, The Ecology of Gang Territorial Boundaries, Criminology, 2012 (in press). doi: 10.1111/j.1745-9125.2012.00281.x
6. Chang, Y.; Levinboim, T.; Rajan, V.; and Maheswaran, R. Learning and Evaluating Human-Like NPC Behaviors in Dynamic Games. In Proceedings of the Seventh Artificial Intelligence and Interactive Digital Entertainment (AIIDE) Conference, 2011.
7. Cho, Yoon Sik, Greg Ver Steeg, and Aram Galstyan, "Co-evolution of Selection and Influence in Social Networks," In Proc. of the Twenty-Fifth Conference on Artificial Intelligence, 2011. arXiv:1106.2788, 2011
8. Fonoberova, M., V.A. Fonoberov, I. Mezic, J. Mezic and P.J. Brantingham. "Nonlinear Dynamics of Crime and Violence in Urban Settings." Journal of Artificial Societies and Social Simulation 15 (1) 2, 2012. http://jasss.soc.surrey.ac.uk/15/1/2.html
9. Frazier, S., Chang, Y., and Maheswaran, R. Team It: Location-based Network Gaming in Real and Virtual Environments. In the Proceedings of the International Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE), 2012.
10. Garcia-Cardona, Cristina, Arjuna Flenner, Allon G. Percus. "Multiclass diffuse interface models for semi-supervised learning on graphs." Proceedings of the Second International Conference on Pattern Recognition Applications and Methods (ICPRAM 2013), to appear.
11. Ghosh, R. and Lerman, K. A parameterized centrality metric for network analysis. Physical Review E 83(6):066118, 2011. http://pre.aps.org/abstract/PRE/v83/i6/e066118
12. Ghosh, R., and Lerman, K. A Framework for Quantitative Analysis of Cascades on Networks. In Proceedings of Web Search and Data Mining Conference (WSDM), February, 2011. Preprint at arXiv:1011.3571v2
13. Hegemann, R. A., L. M. Smith, A. Barbaro, A. L. Bertozzi, S. Reid, and G. E. Tita, Geographical influences of an emerging network of gang rivalries, accepted in Physica A, 390 (21-22):3894-3914, 2011. doi:10.1016/j.physa.2011.05.040
14. Hegemann, Rachel A., Erik A. Lewis, and Andrea L. Bertozzi, An "Estimate & Score Algorithm" for simultaneous parameter estimation and reconstruction of missing data on social networks. Security Informatics, 2012 (in press).
15. Kianercy, A., and Galstyan, A. 2012. Dynamics of Softmax Q-Learning in Two-Player Two-Action Games. Physical Review E. 85, 041145, doi: 10.1103/PhysRevE.85.041145
16. Kianercy, A., Galstyan, A. Allahverdyan, A, 2012. Adaptive Agents on Evolving Networks. In Proc. of AAMAS-2012.

17. Kim, E.; Chang, Y.; Maheswaran, R; Chi, L.; Ning, Y. Negotiation and Adaptation in Network Games. In the Fifth International Workshop on Agent-based Complex Automated Negotiations (ACAN), 2012.
18. Kim, E.; Chi, L.; Maheswaran, R.; and Chang, Y. Dynamics of Social Interactions in a Network Game. In Proceedings of the Third IEEE International Conference on Social Computing (SocialCom), 2011.
19. Kim, E.; Chi, L.; Ning, Y.; Chang, Y.; and Maheswaran, R. Adaptive Negotiating Agents in Dynamic Games: Outperforming Human Behavior in Diverse Societies. In Proceedings of the International Conference on Autonomous Agents and Multi-Agents Systems (AAMAS), 2012.
20. Lerman, K., and Hogg, T. Using Stochastic Models to Describe and Predict Social Dynamics of Web Users. ACM Transactions on Intelligent Systems and Technology in press, 2011. Preprint at arXiv:1010.0237v1.
21. Lewis, E. G. Mohler, P.J. Brantingham, A. Bertozzi, Self-Exciting Point Process Models of Civilian Deaths in Iraq, Security Journal, in press 2011. doi:10.1057/sj.2011.21
22. McCalla, S.G., P.J. Brantingham, and M.B. Short. The effects of sacred value networks within an evolutionary, adversarial game. *Journal of Statistical Physics*, 2012. (in press)
23. Mohler, G.O., M.B. Short, P.J. Brantingham, F.P. Schoenberg, and G.E. Tita, Self-exciting point process modeling of crime. Journal of the American Statistical Association 106(493):100-108, 2011. doi:10.1198/jasa.2011.ap09546.
24. Pollak, M., and A.G. Tartakovsky. 2011. On the first exit time of a nonnegative Markov process started at a quasistationary distribution. Journal of Applied Probability 48 (2):589-595. doi:10.1239/jap/1308662648.
25. Pollak, M., and A.G. Tartakovsky. Monotone Properties of the First Exit Time of a Markov Process Started at a Quasi-stationary Distribution. In Proceedings of the Markov and Semi-Markov Processes and Related Fields 2011, Porto Carras Grand Resort, Chalkidiki, Greece, September 20-23, 2011.
26. Process Started at a Quasi-stationary Distribution. In Proceedings of the Markov and Semi-Markov Processes and Related Fields 2011, Porto Carras Grand Resort, Chalkidiki, Greece, September 20-23, 2011.
27. Short, M.B., A.B. Pitcher, and M.R. D'Orsogna, External conversions of player strategy in an evolutionary game: a cost-benefit analysis through optimal control. European Journal of Applied Mathematics, 2012 (in press).
28. Short, M.B., G.O. Mohler, P.J. Brantingham, and G.E. Tita, Gang Rivalry Dynamics Via Couple Point Process Networks, Discrete and Continuous Dynamical Systems-A, 2012 (in press).
29. Short, M.B., P.J. Brantingham, and M.R. D'Orsogna. Cooperation and punishment in an adversarial game: How defectors pave the way to peaceful society. Physical Review E 82:66114-1-7, 2010. doi: 10.1103/PhysRevE.82.066114
30. Smith, Laura M., Andrea L. Bertozzi, P. Jeffrey Brantingham, George E. Tita, and Matthew Valasik, Adaptation of an Ecological Territorial Model to Street Gang Spatial Patterns in Los Angeles, Discrete and Continuous Dynamical Systems 39(2): 3223-3244, 2012. doi:10.3934/dcds.2012.32.3223.
31. Stomakhin, Alexey., Martin B. Short, and Andrea L. Bertozzi, Reconstruction of Missing Data in Social Networks Based on Temporal Patterns of Interactions, Inverse Problems 27: 115013, 2011. doi:10.1088/0266-5611/27/11/115013
32. Tartakovsky, A.G., and M. Pollak, Nearly Minimax Changepoint Detection Procedures. In Proceedings of the IEEE International Symposium on Information Theory, St. Petersburg, Russia, July 31-August 5, 2011. doi: 10.1109/ISIT.2011.6034057.
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34. Van Gennip, Y., B. Hunter, R. Ahn, P. Elliott, K. Luhz, M. Halvorson, S. Reid, M. Valasik, J. Wo, G. E. Tita, A.L. Bertozzi , P.J. Brantingham. Community detection using spectral clustering on sparse geosocial data. SIAM Journal of Applied Math, 2012 (in press).

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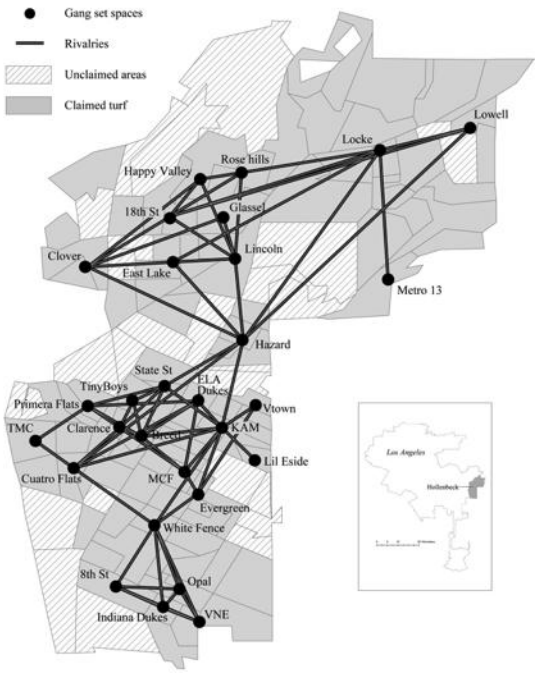
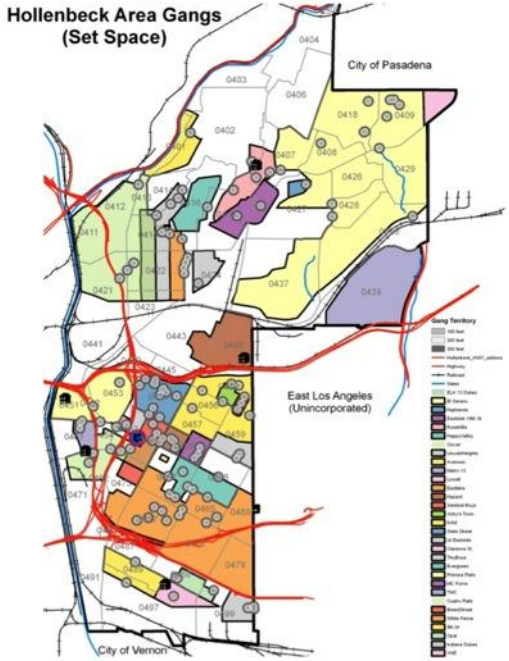
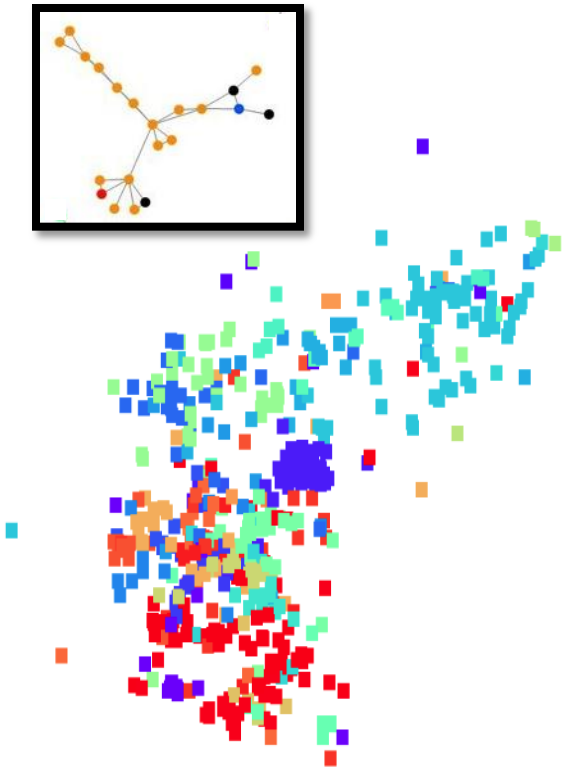
geo-social structure of gangs







rivalry network territories activity patterns

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