SAND2012-1258P

DIFFUSION AMONG COGNITIVELY COMPLEX AGENTS

Cognitive Science and Applications

Sandia National Laboratories

Early Career LDRD

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March 12, 2013

Outline

- Project overview
- Technical overview of the DACCA model
- Applying DACCA model to the influence maximization problem
- Preliminary results
- Impact and relevance
- Conclusions
- Bibliography

Project Overview

- **Problem**: How do we predict and influence changes in population wide attitudes?
- **Approach:** Use computational models as a test bed to explore population dynamics and evaluate hypotheses.

Important Factors

To model large scale human behavior we need to capture both cognitive and social factors.

Cognitive

- Cognitive biases
- Multiple, interacting attitudes
- Information distortion
- Cognitive effort

Social

- Conformity
- Community
- Norms/Conventions
- Culture

State of the Art

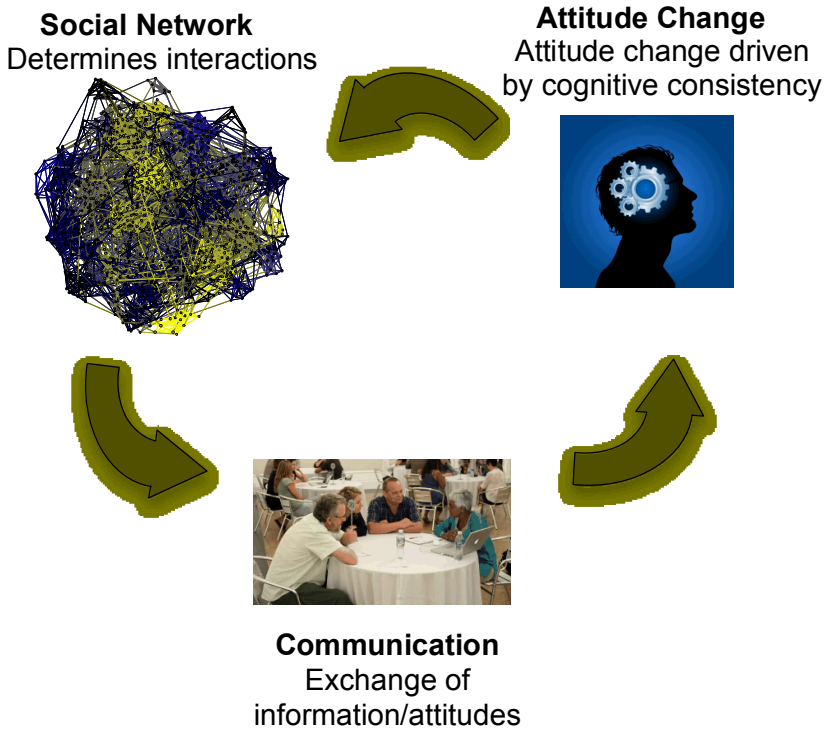
- Multiple domains:
  - Sociophysics (Sood & Redner, 2005), (Sznajd-Weron & Sznajd, 2000)
  - Control theory (Olfati-Saber & Murray, 2003)
  - Cultural evolution (Axelrod, 1997)
- Focus on social network topology, but simple cognitive agent.
  - Oftentimes a single, binary (0/1) valued model.

Project Goal

Computational model that captures the interaction of cognitive and social factors in the diffusion of information and attitude change in populations.

Developing a socio-cognitive model that captures:

- Continuous valued attitudes
- Multiple interacting attitudes
- Bidirectional reasoning & cognitive consistency
- Complex social networks



Example problem: Influence Maximization

Suppose a salesman is trying to sell a new product and can give away some samples. Who in town should the salesperson give the samples to, in order to encourage a positive attitude towards the product in the town?

Cognitive factors:

- How does the product align with existing attitudes? (e.g., Plug in Electric Hybrid Vehicles and environmentalism)

Social factors:

- Are my friends using the product?

Programmatic relevance:

- Winning hearts and minds.
- Radicalization
- Diffusion of climate change information.
- Health information dissemination.

Technical Overview

- Development of a socio-cognitive model.
- Two components:
  - Cognitive network
  - Social network

Cognitive Network

Attitudes

"General, relatively enduring evaluation of an object" (Visser, 2003)

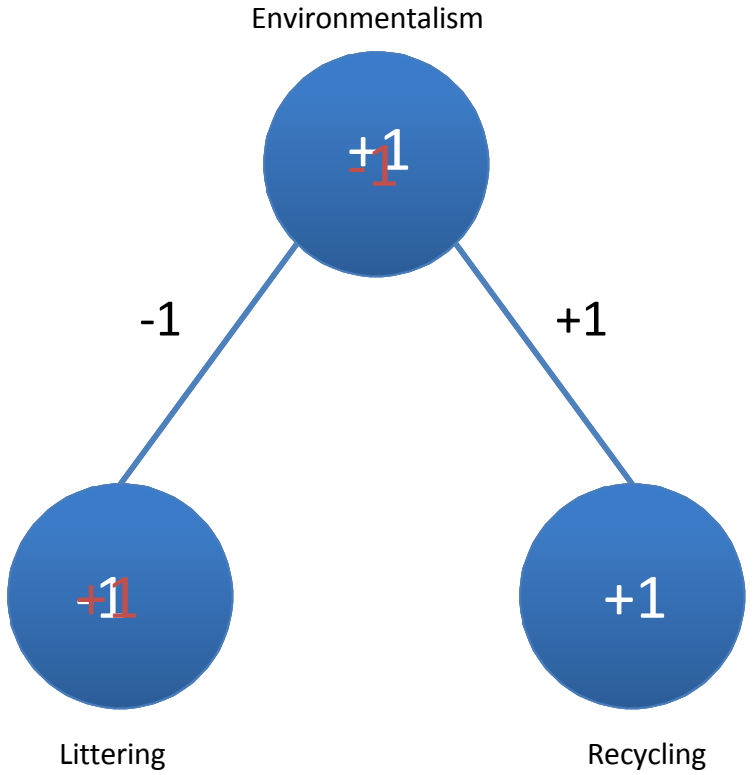
- Object: Person, group, concept, issues
- Valence: Positive or negative evaluation
- Strength: Certainty of evaluation

Attitude Interaction

- Drive for consistency
- Example: Cognitive Dissonance (Festinger, 1957)
- Key idea: Maintain a consistent set of attitudes.

Bidirectional Reasoning

- Conclusions affect belief in premises.
- Effects seen in:
  - Legal reasoning (Simon, Snow and Read, 2004)
  - Political attitudes (Judd and Krosnick, 1989)



Attitude update rule:

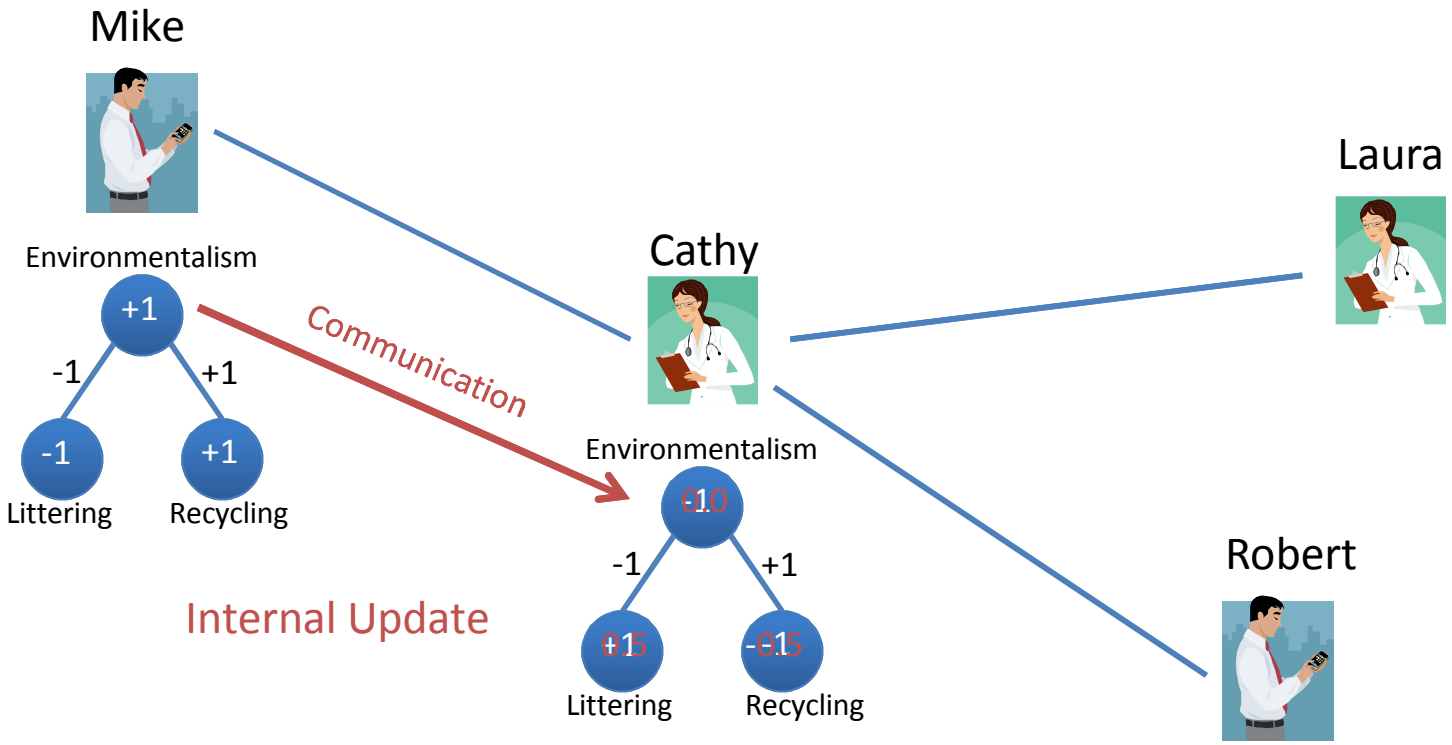
$$\text{New attitude value} = \text{Old attitude value} + \text{Weighted sum of neighboring attitudes}$$

See (Kunda and Thagard, 1996) for details.

Social Network

Representation of actors (people) and the relations between them.

Incorporate cognitive model for each individual.



Two Options

- Option 1:
  - Provide samples to the most popular individuals.
  - Find the “opinion leaders” (Rogers, 2003)
  - Identify based on number of contacts: “social participation” (Generalization 8-6, Rogers, 2003)

Opinion leaders “highly conforming to system norms” (Rogers, 2003).

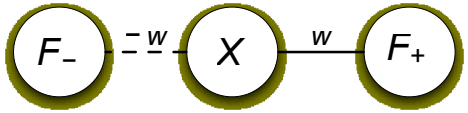
- Option 2:
  - Provide samples to a small, but tightly linked, group of individuals. – “cliques”
  - Individuals can support each other.
  - Example: Diffusion of modern math in Allegheny county (Rogers, 2003; Carlson 1965)

Hypothesis

Providing samples to small groups of friends will have a stronger positive attitude effect than providing samples to high popularity individuals.

Experiment Setup

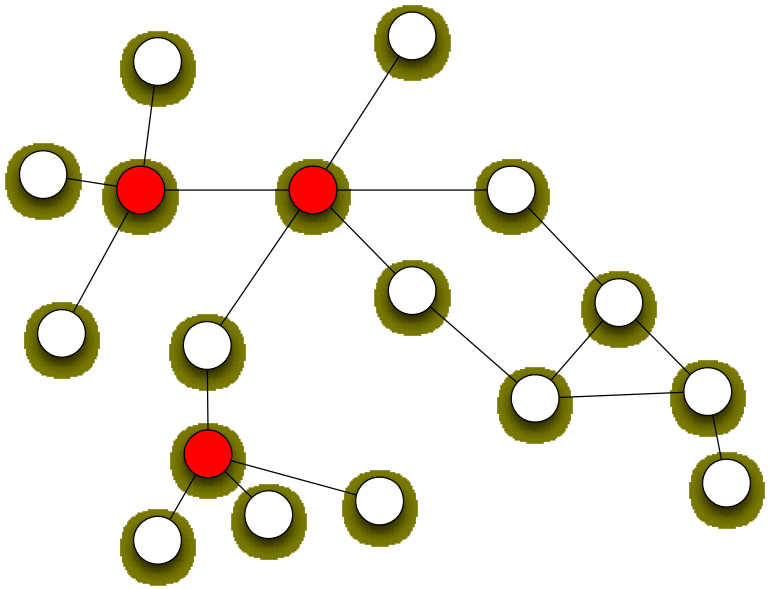
- Social network:
  - 1000 agent community structured network.
  - Option 1: Degree based assignments
  - Option 2: Clique based assignment
- Cognitive network:



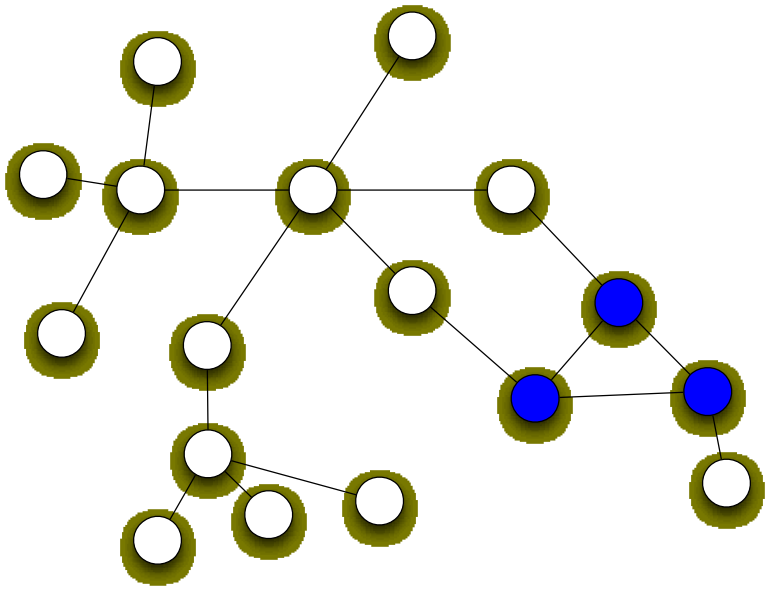
- Assign 10% to positive attitudes.

Degree vs. Clique based assignment

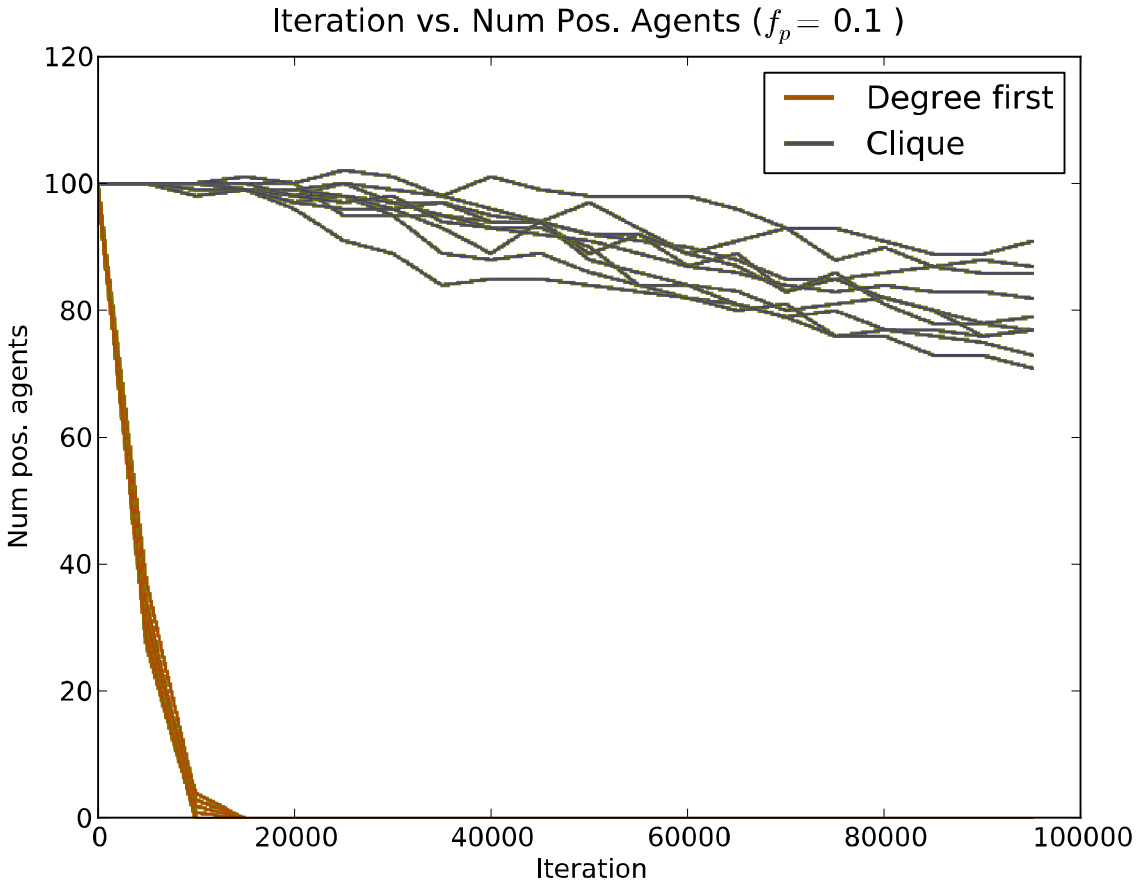
Degree based



Clique based



Initial results



Summary

- Positive agents survive longer when using clique based assignment.
- Possible best strategy for salesperson: provide samples to groups of friends that can talk amongst themselves.
- However, number of positive agents in population is decaying.
  - Does this mean it is necessary to have “zealots” who never waver?

Impact

- Publications:
  - Lakkaraju, K., and Speed, A. A cognitive-consistency based model of population wide attitude change. In *Proceedings of the 2010 American Association of Artificial Intelligence (AAA) Fall Symposium on Complex Adaptive Systems (2010)*.
  - Lakkaraju, K., and Speed, A. Population wide attitude diffusion in community structured graphs. In *Proceedings of the 2011 AAAI Fall Symposium on Complex Adaptive Systems (2010)*.
  - Lakkaraju, K., and Speed, A. Key parameters for modeling information diffusion in populations. In *Proceedings of the 2010 IEEE Homeland Security Technologies Conference (2010)*, IEEE.
  - (In Review) Lakkaraju, K. and Speed A. A cognitive-consistency based model of population wide attitude change. Chapter in upcoming book on the AAAI Fall Symposium on Complex Adaptive Systems.
- Partnerships
  - Working with NISAC to implement model in their CaSoS toolkit.
  - Working with Zach Heath (Systems Analytics group at Sandia/CA)to integrate model into the Cultural Geography toolkit developed at the Naval Postgraduate School.

Relevance

- Scientific
  - Fundamental insight into the dynamics of human populations.
  - Unique model that captures both cognitive and social factors.
- Programmatic
  - Allow analyst to explore “what-if” scenarios.
  - DOE: Climate change.
  - DoD: Hearts and minds, tactics, techniques and procedures.

Conclusion & Future Work

- Computational model of attitude change
  - Social complexity through social network
  - Cognitive complexity through cognitive network
- Future work:
  - Validation: Amazon Mechanical Turk and Massively Multiplayer Online Role Playing Games as sources of validation data.

Comments and Discussion

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