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The Impact of Attitude Resolve on Population Wide Attitude Change

Craig Vineyard[1], Kiran Lakkaraju[1], Steve Verzi[1], and Joseph Collard[1]

Sandia National Laboratories
Tel.: 505-284-4118
cmviney@sandia.gov

Abstract. Attitudes play critical role in informing resulting behavior. Extending previous work, we have developed a model of population wide attitude change that captures social factors through a social network, cognitive factors through a cognitive network and individual differences in influence. All three of these factors are supported by literature as playing a role in attitude and behavior change. In this paper we describe this new model and some of the supporting literature, then provide preliminary experiments investigating the dynamics of the model.

Keywords: Computational model, attitude change, cognitive modelling, social modelling, game theory

1 Introduction

Attitudes are “general and relatively enduring evaluative responses to objects” where objects can be “a person, a group, an issue or a concept” [1, Page 1]. Attitudes are shown to have an impact on, and can sometimes predict, the behaviors of individuals (e.g., voting behavior [2], consumer purchases [3, 4]).

Understanding population wide attitude change is thus an important step to understanding the behavior of societies. For instance, consider the change in attitudes towards global warming and the environment that has resulted in a significant change in public policy and national priorities [5].

While there are a number of factors that influence attitude change [6], we focus on three. The first is social – individuals are exposed to various attitudes and information through interaction with others. Family, friends, acquaintances, and the media all influence the attitudes of individuals by providing new information/opinions.

The second factor is cognitive – individuals tend to hold a set of attitudes that are consistent with each other [7–9]. According to these *cognitive consistency theories*, an individual holding a strong positive attitude towards environmentalism should also hold a strong positive attitude towards recycling; if they do not, the attitudes are inconsistent with each other and could cause an uncomfortable feeling (i.e. *cognitive dissonance*) which tends to result in either attitude or behavior change [6].

The third factor is individual differences in influence. Intuitively, some individuals seem more likely to change than others. This intuition has been supported by research from the marketing and social psychology fields (see Section 2 for more details).

Previous work [10, 11] has described a socio-cognitive model that captures the social and cognitive aspects. This work extends previous work by incorporating individual differences in influence. In our model we have two types of individuals, "susceptibles" and "advocates". "Susceptibles" represent individuals that are strongly influenced by others. Thus in any interaction they change significantly. "Advocates" represent individuals that do not change as much.

In this paper we present preliminary work on a new model that captures these three elements. We describe the basis of this model, then show some simple simulations that explore the dynamics of this model.

2 Theoretical basis

Intuition and common experiences seems to indicate that people vary in how they are influenced by others. Some people stand firm and rarely change their decision, while others often vacillate. Research in social psychology and marketing has provided some evidence to this folk psychological idea.

Decades of research has occurred in the marketing domain to understand how consumer purchasing decision are influenced by others. Two types of influence are usually described, (1) informational – where individuals are influenced by obtaining new information from peers; and (2) normative – where individuals are influenced to conform to others decision in order to liked [12]. The unit of analysis here is on individuals, and the demographic characteristics that can make them change, such as age or gender [13].

Another branch of research has focused more on attitudes themselves rather than individuals. *Strong* attitudes are: "resistant to change, are stable over time, and have power impact on information processing and behavior" [14, page 279]. Several characteristics of the attitude (such as its importance to an individual or its accessibility) can influence it's strength.

3 Model Description

An attitude dissemination model consists of various levels of interactions. At the social level, some mechanism selects which agents are to interact with one another. Numerous possibilities exist such as teacher-student interactions, co-worker interactions, or a discussion amongst friends/peers to name a few. Each of these interaction types may have subtle effects with regards to how the selected interacting agents, affect one another. Upon selecting the interacting agents, their affect upon one another must be assessed in some manner. And finally, at the individual level, any internal changes brought about by the social interaction may lead to a cascade of changing beliefs or a resilience of the agent's original attitudes.

Game theory is a branch of mathematics pertaining to strategic interactions. As such, it is applicable to the development of a framework which can address any of the levels of interaction in an attitude dissemination model. In this work, we have investigated applying game theory to the agent interaction level. Before describing our game theoretic approach to agent interaction, we will first give an overview of the social and individual level implementations of our model (for a more detailed description see [11]).

Our model is composed of three elements:

$$< A, G, C > . \tag{1}$$

A represents a set of n agents that represent individuals, C is a *cognitive network* that represents the internal cognition that drives change in an attitude, and $G$is the social network graph that defines the social structure of the population. Each agent has the same number of concepts (m), and the same weights between links (W), however each agent can differ in the value of those concepts.

We assume turn based dynamics – at each timestep the following actions are taken:

1. A single agent is uniformly randomly chosen from the population. We call this agent the *speaker*. One randomly chosen neighbor of the speaker is designated the *hearer*.
2. A single concept is chosen as the *topic* of communication.
3. The speaker and hearer communicate with one another regarding the topic of communication. This is the *communication* step.
4. The interacting agents engage in an *information integration* step.
5. The interacting agents modify the values of their individual Parallel Constraint Satisfaction (PCS) model cognitive networks in order to find a more consistent set of beliefs. This is the *agent update* step.

In step one, for a directed network, the algorithm to choose the two nodes to interact is:

- Choose one node, i, uniformly randomly.
- Choose one *out-neighbor* of i – a neighbor of i such that there exists a directed edge from i to j.

In the communication step, our game theoretic approach to agent interactions incorporates agent personality types such that each agent is either an *advocate* or *susceptible*. Much like the canonical Hawk-Dove game, this approach yields differing payoffs depending upon what types of players interact. If an advocate speaks with a susceptible agent, then the advocate will have great success in influencing the suspectible agent towards their attitude with little concession on their own part. However, if two advocates interact with one another, neither is able to persuade the other to budge in their attitude. When two susceptibles interact they are both moderately successful in influencing the other. And so, while being an advocate and aggressively trying to influence the agent you are interacting with is quite successful when dealing with susceptible agents it is a poor strategy in dealing with another advocate. The level of influence one agent has on another is the information integration step. Consequently, new strategic dynamics emerge regarding societal interactions.

Formally, the following update equations govern this agent interaction. Let $x_i(t+1)$ be the activation of node x for agent i at time $t+1$. Let $w_a \in [0,1]$ be the weight of influence of an advocate. Let $w_s \in [0,1]$ be the weight of influence of a susceptible agent. Then the update equations are:

$$x_i(t+1) = \begin{cases} w_a x_i(t) + (1-w_a)x_j(t) \text{ if} i = A, j = S \\ w_a x_j(t) + (1-w_a)x_i(t) \text{ if} i = S, j = A \\ 0.5x_i(t) + 0.5x_j(t) \text{ if} i = j = S \\ x_i(t) \text{ if} i = j = A \end{cases} \tag{2}$$

4 Experimental Results

4.1 Parameterizations:

In order to select functionally realistic values for the influence weights of both the advocate and susceptible agent types we performed an empirical value sweep over numerous possible weight combinations while keeping the other influential variables such as cognitive edge weights (+/- 0.05) and cognitive effort iterations (5) fixed. After assessing the results over several interaction sequences as well as various ratios of advocates to susceptible agents, we found intuitively plausible behaviour to occur with an advocate agent edge weight (w_a) of 0.7 and susceptible agent edge weight (w_s) of 0.3.

4.2 Experiment 1: Number of Advocates

To investigate the influential power of advocates who may significantly change susceptible agents and are not easily influenced themselves, we experimented with small, randomly connected networks and varied the percentage of advocates in the overall population. Using a three node cognitive network, we would initialize all of the agents in the network to be cognitively consistent with an attitude value ranging from zero to a negative attractor value which is determined by the weight values in a PCS model. Then we would select a minority percentage of agents to adopt the opposing positive attitude value. The negative attitude value agents are susceptible agents and the positive attitude value agents are advocates.

Iterating over this initialization, we investigated whether 10, 20, or 30 percent positive attitude advocate agents would be sufficient to persuade the opposing majority of susceptible agents to change their attitude belief or conversely if the majority of susceptible agents would be able to overwhelm the minority advocates.

4.3 Experiment 2: Position of Advocates

Beyond investigating the affect of the number of influential advocates in a network, we also examined the significance of the particular position of an advocate within a network. To place advocates in a meaningful location we used small hierarchical and ring network topologies in which we could manually specify which specific agents would be potentially significant as advocates due to their connectivity or position within the topology.

5 Discussion

5.1 Experiment 1

We have used a small ten node, randomly connected network so that it is tractable to analyze the interactions and attitude values over each time step of our simulation. A single advocate (ten percent of the population) was never able to convert a single susceptible agent and eventually is overwhelmed to adopt the negative strategy itself. Using two advocates (twenty percent of the population) allows for possible advocate-advocate interactions as well as doubles the possible conversion influence. We began by randomly selecting two random agents as advocates and as before, despite their increased influential capabilities, the two minority advocates were not sufficient to persuade the majority susceptible agents. Selecting two connected agents, each with low social connectivity, as the advocates was sometimes able to convert the opposing eight susceptible agents. Increasing the advocate population to three (thirty percent) typically was sufficient to convert the majority seven opposing attitude susceptible agents simply by using randomly selected advocates.

5.2 Experiment 2

To study the significance of the position of advocates within a network, we used the small ring and hierarchical network topologies shown on the left and right side of Figure 1 respectively.

For the ring network we experimented with setting agent 0 as the sole advocate since it is the most connected agent. However, despite being the most connected agent it was unable to overcome the nine opposing attitude susceptibles. As one might expect, it was able to raise the attitude values of the agents it was connected to, but not sufficiently to convert any of them. Additionally, we also experimented with setting agent 2 as the sole advocate. As an member of the perimeter of the ring which only interacts with its two adjacent neighbors agent 2 was also unable to convert the opposing 9 susceptibles. Finally, setting both agents 0 and 5 as advocates was typically able to convert the other 8 agents despite the fact that neither is directly connected to many of the other agents in the ring. In this pairing, agents 0 and 5 were able to reinforce one another and eventually persuade the other agents despite being outnumbered.

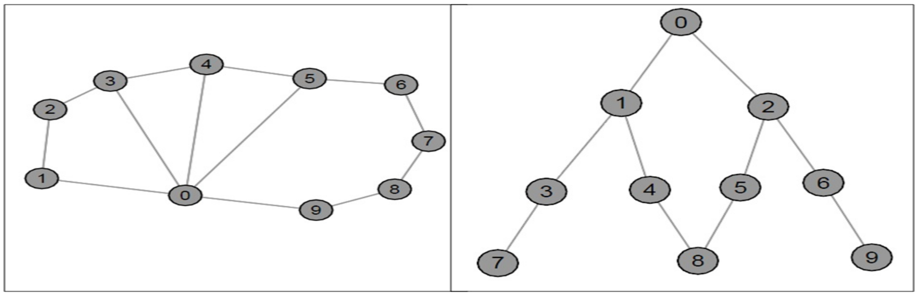

Fig. 1. Small ring and hierarchical network topologies

Figure 2 depicts the affect of different advocate positions within a network. This image plots each agent's attitude value across time. On the left half of Figure 2, two arbitrary agents were selected as advocates, and were unable to persuade the other agents to adopt the positive attitude. This is illustrated by by the full convergence of all agent attitude values to the negative attractor at -0.33. Alternatively, the right half of Figure 2 plots the selection of agents 0 and 5 as advocates. Although they were the only two agents initially in favor of the positive attitude value, over time they are successfully able to pull all the other agents attitude values up to the positive attractor at 0.33.

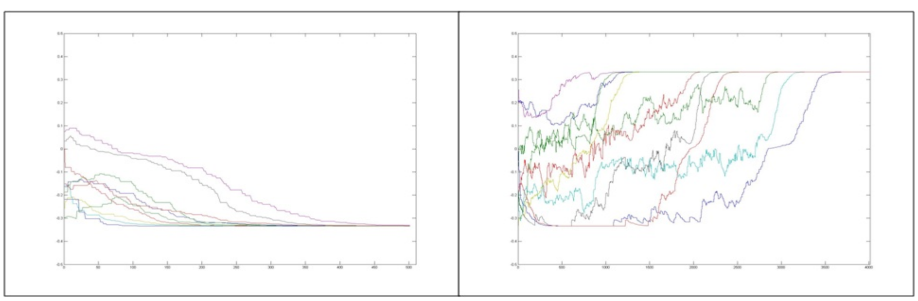

Fig. 2. Drastically different results for different advocate positions within a network

For the hierarchical network, we likewise began by experimenting with single agents as the lone advocate and investigated whether their position either as the topmost node in the network would be sufficient to propagate down and convert the rest of the nodes, or whether being a bottom node would be able to spread upwards and convert the others. In both cases, neither sole advocate was sufficient to overcome the other nine susceptibles. Alternatively, utilizing both a top down and bottom up influence by setting agents 0, 7, and 9 as advocates was largely sufficient to spread their attitude and convert all of the remaining agents despite the fact that their influence is constrained such that they can only interact with one or two other agents whom they must convert and in affect those most continue the spread with their further neighbors.

6 Conclusion & Future Work

6.1 Conclusion

In this paper we have presented a new computation model of attitude resolve which incorporates the affects of player interaction dynamics using game theory. Running a variety of experiments on this model with different network topologies and population mixtures we have investigated attitude adoption and resolve within small networks. These experiments have indicated that selecting specific advocate locations within a population tends to result in a stronger spread of influence, even with only a few advocates in a small network, than random placement. And the enhanced spread of influence can be observed by the ability to convert agents with opposing attitude values that greatly outnumber the advocates as well as through lower diffusion time for the adoption of the opposing attitude.

6.2 Future Work

Having investigated interaction dynamics on computationally tractable small networks, we would like to extend this work to larger real world networks to assess whether the same behavior occurs. Additionally, we can also extend the model to incorporate factors such as more sophisticated cognitive networks.

In addition to incorporating game theory at the agent level we are also interested in looking at the affects of applying game theory at both the social and individual level. At the social level, agent interactions are typically dictated by given static social network topology. An alternative approach would be to investigate coalition formation games from coalitional game theory. This particular branch of game theory seeks to build network structure in a strategic manner. Furthermore, if a particular agent, selected as a speaker, is seeking to maximize the spread of their influence they might want to select the hearer they share their attitude view with strategically rather than randomly from everyone they know. Various aspects of game theory such as coalitional graph games or network routing could provide an alternative framework to model this interaction.

As an alternative mechanism to implement parallel constraint satisfaction (PCS) attitude updates within a single agent, a game may be played amongst two attitudes competing to influence one another. Rather than requiring multiple iterative updates the effect is achieved by a single instance of the game. For attitude nodes connected to (influenced by) several other nodes, the game is played simultaneously with all neighboring nodes and the net attitude change is a synchronous aggregated update of all games played in a pairwise interaction with neighbor nodes.

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