NetArg: An Agent-Based Social Simulator with Argumentative Agents

(Demonstration)

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ABSTRACT

We show how agents with argumentative reasoning abilities can be effectively used to run social simulation experiments with NetArg [4]. NetArg agents interact by exchanging arguments in support or against other arguments or opinions, and adapt to new knowledge. By running simulation experiments, we can replicate a robust result in social simulation, namely that small-world network topologies are able to foster information diffusion and cohesion among a population.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence

General Terms

Theory, Experimentation

Keywords

Social networks, argumentation, agent-based models, agent dialogues, polarization, system demonstration

1. INTRODUCTION

Building on Granovetter's "strength of weak ties" theory [6], sociological research on "small world" networks suggests that in a social network the presence of bridges promotes cultural diffusion, homogeneity and integration (for a review see [3]).

Social simulations often use a network approach to model social embeddedness, but very little explicit reasoning is done –and if it is, it is "compiled" into procedural code. We present an innovative social simulation framework, where agents are embedded in networks, but where explicit reasoning is done by means of computational argumentation.

Following an experimental design due to Flache & Macy [3], we use the "disconnected caveman graph" [8] to represent a situation where components are maximally dense. We allow for two kinds of structural settings. In the first one, components are disconnected and agents are allowed to discuss only within their own "cave." In the other one, bridges are added randomly between components, to lower the geodesic distances in the whole network. Such a network structure, imposed exogenously to agents, is kept static once generated. Bridges are treated as weak links. By connecting previously unconnected densely knit caves, weak links play the role that acquaintances play in real life. Bridges are thus meant to carry all information beyond that available in a single cave.

The NetArg model [4] distinguishes itself from prior art in Agent-Based Social Simulation (ABSS), in that its micro-level foundation is rooted in recent results from experimental psychology. In particular, following Mercier & Sperber [7], NetArg agents reason and interact argumentatively, and implement mechanisms for epistemic vigilance. This makes NetArg an effective and versatile ABSS tool, which can be used to simulate the propagation of arguments and opinions in a social network.

2. REASONING AND INTERACTION

The basic features NetArg agent reasoning and interaction are as follows. Each agent owns a private knowledge, represented as a Dung-style abstract argumentation framework AF [2]. Following Dung AF is a pair $\langle \mathcal{A}, \mathcal{R} \rangle$, where: $\mathcal{A}$ is a set of atomic arguments and $\mathcal{R}$ is a binary *attacks* relation over arguments, $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$, with $\alpha \rightarrow \beta \in \mathcal{R}$ interpreted as "argument α attacks argument β." Sets of "justified" arguments (called *extensions*) can be described by various extension-based semantics [1].

A dialogue (see [5] for a detailed description) starts with an "invitation to discuss" from A (communicator) to B (addressee), by picking a random argument in its own extension. That sparks a dialog, whereby A and B exchange information and establish the coherence of claims against their own beliefs by argumentative reasoning.

If A's argument is incoherent with B's beliefs, and B trusts A, B will revise beliefs so as to be able to agree with A's argument, while maintaining coherence. If instead B does not trust A, B will engage in a dialog with A, by producing arguments against A's argument. Similarly, A can produce arguments for her claims, and encourage B to examine, evaluate, and accept these arguments.

The dialogue continues until one of the agents changes her mind (agreement), or else both agents leave in disagreement.

Agents can revise their beliefs by learning an attack between two arguments and thus update their extensions. For the sake of simplicity, we define trust levels statically.

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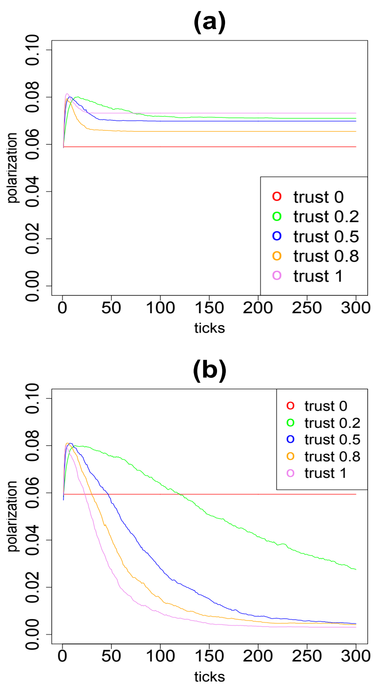

Figure 1: Polarization levels for two conditions: (a) **without random ties,** (b) **with random ties. AFs distribution is** 0.5**. Different levels of trust are shown.**

The dialogue process, where agents put forward their own arguments and convince (or get convinced by) others, gives raise to polarization effects at the population level.

3. EXPERIMENTAL SETTING

We measure the level of polarization P at time t, according to Flache & Macy [3], as the variance of the distribution of the AF distances $d_{ij,t}$:

$$P_t = \frac{1}{N(N-1))} \sum_{i \neq j}^{i=N, j=N} (d_{ij,t} - \gamma_t)^2$$

where:

- N represents the number of agents in the population;
- $d_{ij,t}$ represents the AF distance between agents i and j, i.e., the fact that agent i has an argument in her extension ($\bigcup_{\mathcal{E}}^{i}$) while the other do not, averaged across all available arguments ($|\mathcal{A}|$):

$$d_{ij} = \frac{|\bigcup_{\mathcal{E}}^{i} \setminus \bigcup_{\mathcal{E}}^{j} \cup \bigcup_{\mathcal{E}}^{j} \setminus \bigcup_{\mathcal{E}}^{i}|}{|\mathcal{A}|}$$

- γ_t represents the average distance value at time t;

The model is developed in NetLogo [9], a standard tool in social simulation, along with a Java Extension to deal with the computational argumentation analysis.

The model comprises 20 caves: the parameter cave-size sets the number of agents for each cave. In order to run a simulation, two AFs must be generated, either randomly or by specifying an attack structure. In our experiments, we derive the AFs by analyzing arguments taken from online discussion forums. A parameter (selected-semantic) can be set to choose one among several different argumentation semantics. AFs are thus distributed randomly with probability fract-agents-withAF1 among the population. Trust probability is set at a prob-change-mind value, which is fixed for all agents.

At each time step, each agent is asked to start a dialogue with all its neighbors, which could be restricted to the same cave or not, depending on the presence of bridges if allow-random-ties is true.

In this experimental setting, we use NetArg to answer a fundamental research question: *Does the presence of bridges (or weak ties) lower the polarization level of the population?* In other words: does the model exhibit a long-range ties effect on social polarization?

We start from two AFs. We then control for different combinations of the two AFs among the population, along with different level of trust, and we can conclude, as shown in Figure 1, that the model fits Granovetter's theory: (1) the presence of bridges between caves foster agreement and (2) since only caves with bridges to other caves can receive new information, there is a competitive advantage for non-isolated caves. An experimental run is illustrated and commented in this video: `http://youtu.be/_YfhKpYASf0`.

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