Normative Agents for Real-world Scenarios

(Doctoral Consortium)

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ABSTRACT

Norms are an important part of human social systems, governing many aspects of group decision-making. Yet many popularly used social models neglect to model normative effects on human behavior, relying on simple probabilistic and majority voting models of influence diffusion. Within the multi-agent research community, the study of norm emergence, compliance, and adoption has resulted in new architectures and standards for normative agents; however few of these models have been successfully applied to real-world public policy problems.

During our research we introduced a new hybrid architecture, Cognitive Social Learners (CSL), that models bottom-up norm emergence through a social learning mechanism, while using BDI (Belief/Desire/Intention) reasoning to handle adoption and compliance. Our proposed cognitive architecture includes the interaction between rational thought, reward-based learning, and contagious social behaviors. The future plan is to employ this architecture for constructing normative agents to model human social systems; the aim of our research is to be able to study the effects of different public policy decisions on a community and studying the emergence of norms in real-world cases.

Categories and Subject Descriptors

I.2.11 [**Distributed artificial intelligence**]: Multi-agent systems

Keywords

norms, agent architecture, agent-based modeling

1. INTRODUCTION

One barrier to creating realistic large-scale models of human social systems is the lack of good general purpose computational models of human interactions; without such models, it is impossible to accurately account for the intricate action dependencies engendered by both explicit and implicit interpersonal communications. However research on special purpose human interaction models has flourished, bringing a greater understanding of the computational processes underlying teamwork, information diffusion, and adversarial situations. We believe that the research on computational models of norms and normative agent architectures is ripe for greater inclusion in social simulations.

The existence of social norms, implicit expectations about the behavior of in-group members, can be viewed as a consequence of these group-based social forces. Norms play a significant role in determining the behavior of people in human societies, and have been used as a computational mechanism for creating coordinated action within normative multi-agent systems. Previous work on modeling norm lifecycles can be organized into two categories: internal and external. In the first category, norms are characterized as arising from internal mental processes that can be specified using cognitive modeling techniques, and normative behavior is viewed as the outcome of internalizing external preferences. The normative agents are able to acquire new norms, rather than relying on preexisting constructs, and can deliberate about norm compliance autonomously. In the second category, the focus is on social interactions, and game-theoretic models are used to quantify the bottom-up process of recognizing and complying with norms in the external social system. Convergence occurs when agents arrive at a mutually agreed upon utility maximization strategy. A limitation of this type of system is that the agents lack a sense of normative expectation and do not distinguish between a strategy and a social norm [4].

A normative agent refers to an autonomous agent who demonstrates normative behavior; these agents must be able to reason about the norms with which they should comply, and occasionally violate them if they are in conflict with each other or with the agent's private goals [3]. Both theoretical and computational models have been presented to describe norm emergence in social systems. Previous work on norms has shown promising results on modeling real-world phenomena such as traffic patterns, Wikipedia article authorship, and financial decisions. We seek to integrate normative effects with other types of human behavior models to produce a more comprehensive picture of human communities, rather than limiting our analysis to norms alone. Hence we simulated both environmental and network effects, in combination with norms.

Human social systems tend to be complex by nature; our philosophy is that constructing multi-layered models is of paramount importance when simulating real-world scenarios, since it is unlikely that a single type of interaction model will correctly account for all the observed effects. We proposed a normative architecture, Cognitive Social Learners (CSL), that bridges the gap between the two introduced

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types of architectures and provides a computational mechanism for transitioning behaviors learned during repeated social interactions into the agent's internal cognitive model of preexisting beliefs, desires, and intentions. Rather than modeling the normative lifecycle as a sequence of stages (e.g., recognition, adoption, compliance), CSL implements norms through an iterative process in which the normative behavior is developed incrementally within each agent's cognitive model before it emerges in consistent patterns of observable behavior.

The overarching aim of our research is to create a general purpose agent-based modeling (ABM) and simulation system for studying the effects of public policy decisions on a large range of social phenomena, including personal health decisions, sustainability behaviors, and opinion formation. Norms are an important key to understanding the function of human groups, teams, and communities; they are a ubiquitous but invisible force governing many human behaviors.

2. RELATED WORK

One of the frequently referenced normative architectures for agent-based and simulating models is the EMIL framework [2] that represents the culmination of extensive research on norm emergence. The main disadvantage of EMIL is that the agents obey all recognized norms blindly without considering their own motivations [1]. EMIL and similar architectures can model *norm internalization* in which agents manifest behaviors, not because of existing rewards or punishments in the environment, but as a personal objective. Another weakness with these models is that they devote less attention to norm emergence at the population level.

Interaction-based approaches create agent models that can detect norms from what they observe in the environment and their interactions with other agents. Often the agents are equipped with the ability to learn from experience, and interactions among agents are modeled as repeated games with payoff matrices. A norm emerges when the entire population's actions converge to the same action, based on updates to the payoff matrix specifying the reward for the possible actions. Several variants of multi-agent reinforcement learning have been demonstrated for this interaction model. However, a general concern that exists about this family of repeated game interaction models is that 1) they do not capture many of the rich interactions that take place in real world scenarios and 2) can fail to converge when the agents have a large action-space. We have shown that our CSL architecture is more robust against increases in action space size.

Outside of computer science, the social norm marketing approach has become an important tool for public health messaging and culture shaping. There the emphasis is on changing human social norms, rather than computationally modeling them. For instance, these types of methods have been very successful at curbing college drinking and substance abuse. This indicates that our proposed approach of building normative effects into our model should be highly effective, given the previously demonstrated relevance of norms to human behaviors.

3. FUTURE WORK PLAN

At this stage the main future work that is planned for this ongoing PhD research include:

- Improving the current normative architecture by incorporating features from social cognitive theory in order to improve its performance on real-world scenarios.
- Before evaluating the framework on a large real-world scenario, several artificial scenarios are going to be studied. The current scenarios that are implemented are littering and trash cleanup in a public domain. These scenarios will be modified, in order to pose more complicated challenges for the whole system. The number of available normative actions (e.g. littering) will be increased. Synthetic friendship network structure will be included in the system. Also multiple environments with different characteristics will be designed.
- The final framework will be used for simulating normative behaviors of students at University of Central Florida. At the beginning of my research, we introduced a method for generating agent activity profiles from survey data for an agent-based model (ABM) of transportation patterns of 47,000 students. Later, this model was merged into a detailed simulation of smoking cessation trends on campus. This model was validated with some independently collected data by health services. This model will be extended in order to create a complete model, including simulation of all components which could affect the students' normative behaviors. For example, road maps, class schedule, and friendship network will be included in the new system. One existing challenge is how to obtain needed data. At this stage, we do have a set of valuable data about students' movement patterns, their schedule, and their smoking behavior; but there are some other datasets that need to be collected through surveys, or obtained from other sources.

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