Reputation in the Venture Games

Philip Hendrix
School of Engineering and Applied Sciences
Harvard University
Cambridge, MA 02138 USA
phendrix@eecs.harvard.edu

Barbara J. Grosz
School of Engineering and Applied Sciences
Harvard University
Cambridge, MA 02138 USA
grosz@eecs.harvard.edu

Introduction

In many environments, interdependent agents must work cooperatively to be successful. Cooperative ventures require the participation of multiple partners, and successful ventures require that all partners in the venture fulfill their obligations. In such environments, an agent must identify potential partners with the ability and willingness to help it reach its goals while avoiding potential partners who lack the skill or the motivation to help the agent succeed.

This paper addresses the problem of how agents in an uncertain world may gain knowledge about the competence of potential partners under a variety of circumstances and use that knowledge to their benefit. As used in this study, competence is a measure of whether an agent has the skills and resources to complete a venture successfully. Different potential partners have different levels of competence, so any knowledge regarding the competence of particular individuals provides a competitive edge in deciding whether to deal with those individuals. Reputation—a community-based assessment of agent competence—can augment direct experience, but is prone to error.

A large series of experiments was conducted to study systematically the extent to which the usefulness of reputation information varies by group size, group competence, use of reputation, and error in the reputation information. Results confirm that the relative usefulness of direct experience and reputation depends on the particular multi-agent setting and that the utility received from reputation increases as group size increases.

The study also yielded two surprising results: first, a pigeonholing phenomenon in which reputation wrongly identifies some agents as having sub-par competence based on early random sequences of poor performance, even when agents are generally highly capable. This effect can be countered by introducing systematic positive bias to the reputation system. Second, reputation is useful even in small groups, but only before agents have had much opportunity to interact.

Results

A white-box reputation system, which reports the exact competence of other agents’ performance, was used in our experiments. These experiments used partially observable Markov decision processes (POMDP) to learn agent competencies. We investigated the influences of associating a cost with reputation information and of lying on utility.

The Venture Games

As an experimental platform, we created two new games called Joint Venture (JV) and Surrogate Venture (SV). These games were designed to have attributes essential for investigating how agents should adapt their behavior based on information about the competence of others, but to minimize the need for modeling a complex domain. These essential game attributes are that agents are self interested and interdependent, and their individual competences affect game outcomes. The games are played in rounds, giving agents opportunities to learn about each other’s competence.

At the beginning of each round of JV, agents are randomly paired and asked to decide whether to enter into a joint venture with the prospective partner. The joint venture only takes place if both players agree; otherwise, neither agent plays. To enter, each partner must put up an investment. If the venture is successful, both partners receive a reward; otherwise, the venture fails, and both partners lose their investment. The success or failure of a venture is determined stochastically, based on the combined competencies of the partners in the venture.

In the SV game there are two types of agents: investor agents and worker agents. The worker agents are assigned competencies and perform all the work in a venture, acting as the surrogates for the investors. The outcome of a venture is stochastically determined by the competence of the worker. One investor agent plays many games of SV and learns, using a POMDP, whether to finance ventures with a particular worker agent.

To score well in either game, players must select partners of above average competence.

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1This work distinguishes competence from strategic behavior similarly to Smith and desJardin (2005).

2The pigeonholing phenomenon bares no relation to the pigeonholing principle used in discrete mathematics.

3The full version of this paper, including a detailed description of the Joint Venture and Surrogate Venture games, experimental setup, results and discussions, can be downloaded from http://eecs.harvard.edu/~phendrix/papers/hendrix_jv.pdf and http://eecs.harvard.edu/~phendrix/papers/hendrix_iv.pdf.
Table 1: Order of winning strategies for the 20 combinations of group size and competence after 500 rounds, where \( w \) = white box; \( r \) = reputation only; \( p \) = personal model only with no reputation. The \( wpr \) combination, which was the expected result, is the most common, and is shown in bold.

Agent populations created using a standard deviation of 0.2. experiments to provide a “gold standard”; it establishes the best performance agents could achieve. Table 1 compares performance in JV of agents using only personal knowledge or only reputation system information with this gold standard for twenty different combinations of competence and game size. As it shows, results depend on group size and mean competence. The entry \( wpr \) indicates that white box was most successful, followed by reputation only, followed by personal data only. The \( wpr \) combination, which was the expected result, is the most common in the table above and is shown in bold. The \( wpr \) entries in the lower left corner of the table indicate that personal knowledge triumphs over reputation knowledge in small groups or when most players have high competence. However, our results also showed that reputation is useful in small groups during initial rounds of play before agents using their own personal knowledge have sufficient information to judge their partners adequately.

The results for small groups raise the question of why agents in such groups who do not use reputation are able to accumulate a higher score than agents using the reputation system. The reputation system calculates reputation for a single agent based on information from ventures in which the competences of both agents participating in the venture are unknown. Therefore, the reputation information is not as accurate as personal data that are based on a limited number of precisely identified experiences. If there are enough personal experiences, their quality of accuracy eventually outweighs the quantity of samples from the reputation system.

The most surprising, unexpected result was that use of a reputation system may lower overall scores, because agents that are generally high-capability may be mis-categorized as low competence based on early sequences of low performance. (Such sequences are a result of randomness in determining venture outcome; they occur infrequently.) We call this phenomenon pigeonholing.

Our investigations also showed that the use of positive distortion can decrease the occurrence of pigeonholing and thus increase the mean aggregate scores of agents. By reporting reputations slightly higher than true reputation, the system can cause agents mischaracterized as low-competence to be more accurately characterized.

Results of the investigations using SV and POMDPs showed that agents with access to reputation information would stop requesting the reputation information as the rate of lying to the reputation system increased. This prevented agents with the ability to use reputation information from ever performing more poorly than agents without the use of reputation information.

Agents also stopped requesting reputation information as the cost of the information increased. When the benefit of reputation information is outweighed by its cost, the agents learned not to request the reputation information and received utilities equal to those agents not using reputation information.

Previous Work

This section briefly describes the work most closely related to our investigations. Additional comparisons are available in the full paper. Teacy et al. (2005) and Huynh et al. (2004) provide quantitative results with respect to reputation that vary the amount of interaction between agents in the system. Khopkar et al. (2005) and Dellarocas et al. (2004) determine the reputation statistics that are acceptable in real world scenarios such as eBay. Their results are limited to single populations of players where the population size and the distribution of the agent behavior were fixed. Sen et al. (2000) describe experiments in which the percentage of selfish agents vary, but they do not discuss how population size, makeup, or time affect the scores of his agents.

The pigeonholing phenomenon may appear similar to the work of Khopkar et al. (2005) who found that auctioneers using the popular auction site eBay have a high propensity to lose their good reputations after just a few negative feedback ratings from an auction and are shunned. However, the relative causes of pigeonholing and shunning are different in that pigeonholing only negatively affects generally highly-capable agents. Furthermore, our work examines the use of positive distortion as a means to correct for this phenomenon.

References