Agent UNO: Winner in the 2007 Spanish ART Testbed competition

Javier Murillo and Víctor Muñoz

Universitat de Girona
Institut d'Informàtica i Aplicacions
Av. Lluís Santaló s/n 17071 Girona
{jmurillo, vmunozs}@eia.udg.es

Abstract. In multi-agent systems where agents compete among themselves, trust is an important aspect to have in mind. The ART Testbed Competition has been created with the aim of evaluating objectively different strategies that agents can use in this kind of environments. In this paper we present the winning strategy at the Spanish competition of 2007 with an analysis of the factors that have contributed to this success.

1 Introduction

In shared and competitive environments, agents interact with each other in order to achieve their goals. This interaction allows them to obtain better results than would get isolatedly. However, since agents are not interested in global outcome but only their own, maybe some of this interaction will be done with the intention of disserving them. In such situations agents need to use a trust and reputation mechanism, providing them with an uncertainty model allowing them to discern other agents' behaviors, by means of whom the agent could be able to select when and which agents to trust.

In recent years there has been a growing interest un trust mechanisms for multi-agent systems [9] and a good number of models and strategies have been proposed to deal with this [10, 3, 8]. Unfortunately, models have been tested in dissimilar problems. In consequence, with the goal of providing a "*common platform on which researchers can compare their technologies against objective metrics*" the Agent Reputation and Trust (ART) Testbed Competition was created in 2006, at both national and international level [7, 6, 4, 5]. This competition serves also as an impulse to promote research in this field and to design new strategies applicable in the real world. See [1] for more information about the ART Testbed and international competition.

In this paper we describe the winning strategy used in agent UNO for the second Spanish competition held in Valencia in March 2007. The paper is structured as follows. The next section describes the general functioning of the agent UNO. The next two sections show two fundamental components of the strategy, namely, the question and answer procedures. Then we present the results obtained with the agent in both national and international competitions of 2007.

We finally derive some conclusions and outline improvements for future competitions.

2 General considerations

For the design of the agent UNO two parts of its behavior have been studied independently, namely, the *asking* and *answering* procedures. In the first one the agent decides, for the paintings that have been assigned to it, which agents to request information from and which weight give to their answers. On the other hand in the answering procedure the agent receives a set of questions coming from other agents and has to determine how much money to spend on each appraisal.

Both procedures make use of the knowledge that the agent has about the other agents. The information that UNO stores about other agents is:

- Error committed on their appraisals
- If the agent answers or not to the asked questions
- The total number of questions the agent has asked to UNO

We could also consider the certainty value that agents inform before performing an appraisal indicating their expertise in the respective era. However we have decided not to consider it; we believe it is more robust to work directly with the real error committed by each agent, moreover considering that there are few agents participating in a game, therefore the savings obtained by not asking an agent after considering its certainty level, compared with always asking without considering it is not much significant.

Another subject that we have decided not to use is the reputation. The reasons are the same as for the certainty, but adding that it is possible that the agent asked for the reputation of another does not have sufficient knowledge of it. Moreover it is possible for an agent to behave opposedly for different agents. Therefore we decided not to use reputation and base our strategy solely on the knowledge that we learn directly from other agents. This feature gains special meaning when there are few agents participating in a game.

3 Questions Procedure

In order to know who to ask to, agent UNO calculates a weight $P_{i,j}$ for each agent and era. This value is used later to inform the simulator about the weights that will be assigned to each agent to make the final appraisal. The weight of an agent i in the era j is calculated using the following formula:

$$P_{i,j} = (1 - error_{i,j}) \cdot trust_i \cdot knowledge_{i,j} \cdot necessity_j \tag{1}$$

where:

Error. The value $error_{i,j}$ measures the inaccuracy committed by agent i over era j. The error of each appraisal is calculated using this formula:

$$error = \frac{realValue - appraisedValue}{realValue} \tag{2}$$

Trust. The value $trust_i$ reflects the certainty UNO has about agent i to tell him the truth. It is obtained computing the percentage of *lies* in relation to the total of appraisals made. We consider that an agent has lied intentionally when the error committed with an appraisal is higher than a certain threshold (now set to 3) given that it is highly improbable to produce such an error still assuming the agent to be completely inexpert in that era.

$$trust = 1 - \frac{lies}{total\ appraisals} \tag{3}$$

The trust value is modified later to avoid trusting agents that do not trust ourselves. We have called this *"bilateral trust"*. The thing is that if an agent never makes us questions, then our trust in him is set to 0.

Knowledge. The value $knowledge_{i,j}$ represents the degree of information that we have about the agent i on the era j. First of all, to compute this value we need to define the number of questions that an agent has to have answered (in one era) to consider that we completely know him, that is the $minimum\_knowledge$. Then $knowledge_{i,j}$ is computed as the percentage of answered questions in relation to this parameter previously defined (setting a maximum of 1).

$$knowledge = \min\left(\frac{total\ answered\ questions}{minimum\_knowledge}, 1\right) \tag{4}$$

Necessity. It stands for the urgency that the agent has in an era to ask others for help. As more expert the agent is in the era, lower is its necessity. Necessity values are predefined for each era j and for each possible expertise value of the agent following this formula:

$$necessity_j = 1 - experience_{UNO,j} \tag{5}$$

We also use a limit to reduce the total number of questions. Once the weights are computed we fix a maximum limit n of questions to be made on each appraisal. This limit is calculated based on the percentage of earnings (money won with appraisals) that we want to waste asking other agents, according to this formula:

$$n = \left| appraisalCost \cdot \frac{percentage\ of\ waste}{opinionCost} \right| \tag{6}$$

After that, with the weights referencing the same era we select only the n higher ones and the others are set to zero. Nevertheless, some of the selected weights might be so close to zero that would barely affect on the final appraisal (although we should pay the same money for asking them). In order to avoid these kind of questions we apply two thresholds (one absolute and another relative) that set to zero the values considered to be insignificant.

Finally the agent UNO selects the weights greater than zero to ask them using the calculated value as the weight for the appraisals. However if the agent finally is going to ask less questions than the calculated limit, the remaining questions are made to the less known agents so far (if there are).

4 Answers Procedure

To decide the amount of money UNO will spend on generating opinions for other agents, we first calculate the degree of *friendship* with each agent. The agent will then spend more money with the "friendlier" agents. The friendship with an agent i ($friendship_i$) is calculated with the following way:

$$friendship_i = \sum_{j=1}^{eras} \max(error_{UNO,j} - error_{i,j}, 0) \tag{7}$$

This calculation results in an "interested" friendship, since it actually measures the amount of information other agents do have and UNO does not. Consequently, agent UNO spends more money in the agents in which it needs their information (they are expert in eras in which UNO is not), with the aim of obtaining a mutual collaboration so that they contribute with his appreciated information.

This mechanism favors the interaction between agents needing mutual help, increasing both their benefits, but on the other hand the unfriendship generated with other agents can be detrimental in games where there could be changes of expertise, as it is the case in the international competition.

5 Results

During the development of agent UNO, agents of the international competition of 2006 were used for testing. Figure 1 shows the results of agent UNO competing with the finalist agents in the past international competition; in the right it appears the average and the standard deviation after repeating the game 50 times. Agent UNO is the one having the higher average of money, and its standard deviation is very similar to the second agent (IAM).

Agent UNO participated in the national competition celebrated in Valencia [2] obtaining the first position. In this competition 13 agents participated playing 6 different games with 5 agents each. Each game was repeated 3 times. The results are shown in Figure 1 showing in the left the total of money obtained. 3 variants of the agent explained in this paper where competing and they together obtained the 3 first positions.

Our agent also participated in the international competition of 2007 celebrated in Hawaii, which consisted in a first round and the final. In the first round 8 games were played with 8 agents each. Games were played in 3 variants. In the first variant, expertise values were maintained during the game, in the second variant there was one single change in expertises during the game and

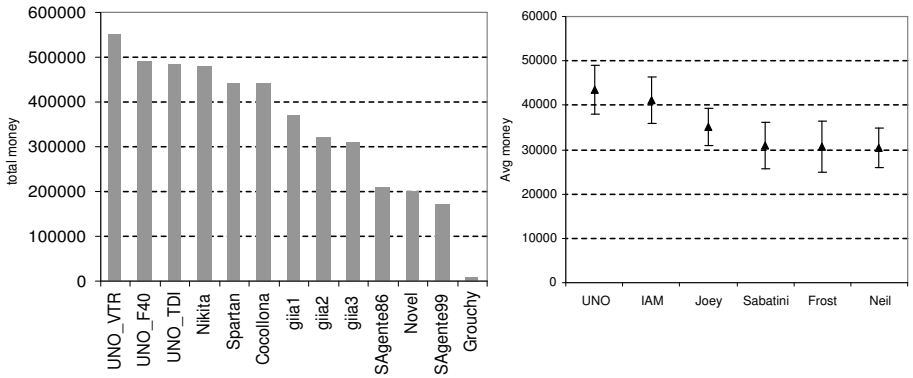

Fig. 1. Classification in the 2007 Spanish competition (left) and tests done with the finalists agents in the 2006 international competition (right)

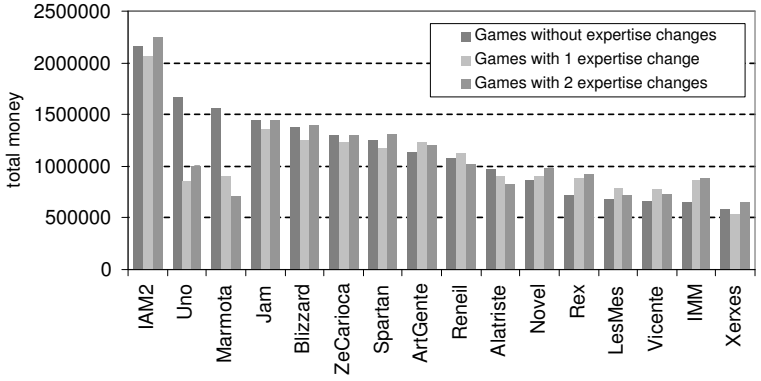

Fig. 2. Money obtained in the first round of the 2007 international competition

the third variant had two changes. Agent UNO was not prepared to work with expertise changes and that was the reason not to pass the first round. The two versions of the agent (UNO and Marmota) finalized in the seventh and ninth position respectively (of a total of 18). However, these results are not so bad because if we analyze the 3 variants individually, as it is shown in figure 2, our agents were the second and third best in the games without expertise changes.

6 Conclusions

In this paper we have presented the winning strategy used in agent UNO in both Spanish national competition of 2007 and international the same year. The agent was the winner of the national competition and finalized seventh in

the international. The results are encouraging given that, even though the final position in the international competition was not so good, considering only the games without expertise changes, UNO was the second agent getting more profit.

Viewing the results, we can draw out some conclusions that are in fact applicable to any multi-agent system where trust and reputation play relevant roles.

In general, lying is not a good strategy, since other agents stop trusting you and begin also to tell you lies, so you end up by having to only shift for yourself, and the results using only your own expertise would be without a doubt worse than other agents' collaborating mutually.

When the number of participating agents in a game is not great, it is better to know other agents by your own experiences uniquely, instead of asking other agents the opinion whom they have on third.

Starting with a low trust on other agents, and increasing it as the agent gathers more knowledge about them, as well as not to trust agents that do not trust us, induces robustness in the agent specially in games where there are participating liar agents.

In the future we plan to provide the agent UNO with a system to take into account the possible expertise changes occurred during the game. We also plan to use reputation to improve the agent when participating in games with a big number of agents.

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