The Ultimatum Game: Using Reputation to Promote Cooperation

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Abstract

In the Ultimatum game two players are asked to split a sum of money. The proposer makes an offer and the responder can either accept or reject that offer. If the offer is rejected both players get nothing. If the offer is accepted both players receive that spilt of the total sum. The rational solution is for the proposer to exploit the responder and take most of the sum. In human players this exploitation is not as widespread, altruism and fairness prevails. We are developing an evolutionary approach to the Ultimatum Game to test the effects of both spatial settings and reputation in an effort to promote cooperation.

1. Introduction

The evolution of cooperation is a topic that has interested many in the scientific community. Understanding this process is thought to shine a light on how complex communities and ecosystems developed from organisms maximizing their return on survival and reproduction. Cooperation in humans has developed with generations of countless social interactions. These interactions can be boiled down using Game Theory. Made famous by Axelrod[1] and his Prisoners Dilemma round robin tournament. 2 players, with 2 possible strategies, 4 definite outcomes and 4 payoffs (Fig.1).

		Prisoner 1: Cooperate	Prisoner 1: Defect
Prisoner 2	Cooperate	3,3	0,5
	Defect	5,0	1,1

Figure 1: Payoff matrix for prisoner's dilemma.

Altruism, to perform costly acts that have benefits to others, is a key stimulant of cooperation. A framework that has shown to be very useful in exploring this trait is the Ultimatum Game (UG)[2]. Two players are offered a gift (sum of money) from a generous benefactor. They can keep the gift only if they agree on how to split it. One player is designated the Proposer and the other player is designated the Responder. The Proposer suggests how the gift should be spilt (their part in the game is now over) and the Responder either agrees or rejects the terms of the deal. The decision is final and the game ends.

The strategies for rational players are simple. Responders should accept even the smallest offer, since the other option is receiving nothing. Proposers, who believe their opponent is rational, should only offer the smallest amount possible and take almost the entire sum. When this game was played with humans it was found that proposers preferred a fairer split, most offering 30-50% of the sum to the responder. Along with around 50% of responders rejecting offers lower than one third of the sum[3]. Why is this so? It is thought that human players expect repeated interactions with their responder counterpart and do not want repercussions for selfish 'rational' actions. The human player is making their decision with more 'information' than artificial agents, even if that information assumed.

2. Promoting Cooperation

Page *et al.*[4] uses evolutionary game theory to analyse the ultimatum game and show that in a "non-spatial setting, natural selection chooses the unfair, rational solution". While in a spatial setting the outcomes are fairer. This work was followed up by Iranzo *et al*[5] who showed that in a spatial setting "quasiempathetic individuals whose offers are very close to their acceptance thresholds", had evolved from the playing population. It is clear that the placing of playing populations on some sort of spatial framework increases the likely hood of fairer offers evolving through generations of players

Brandt *et al.*[6] uses the public goods game to work on the emergence of cooperation. They introduce a third player, the opportunity to punish non-cooperative players and the reputation of an agents willingness to punish. This added information of an agents reputation allows agents to modify their strategy depending on who they are playing. If a player meets a non-punisher, they can change their strategy to exploit that player for this round and change back. Brandt *et al*. reports that "the readiness to cooperate is greatly enhanced and asocial strategies can largely be suppressed".

Nowak *et al.*[7] uses an evolutionary approach to the ultimatum game adding information available to the players on what deals their responders have accepted in the past. They show that fair strategies can evolve if the proposer can obtain this information about the responder. "Hence, the evolution of fairness, similarly to the evolution of cooperation, is linked to reputation".

3. Research Goal

The aim of this research is to develop a population of agents that will play the Ultimatum Game with different environments, rules and strategies. Using evolutionary game theory evolve this population and observe the outcome.

4. Methodology

A population of *N* agents (artificial players) is created. Each agent has two values assigned to them. An offer value, the amount of the sum that they are willing to offer the proposer, *o*. And an acceptance value, the minimum amount of the sum that is needed for the responder to accept the terms of the deal, *a*. Each agent can play the Ultimatum game as a proposer or a responder. In all iterations of the game each agent will play as the responder and the proposer an equal number of times. Accumulative scores are kept for each agent during a generation.

The agents interact and play the game with either :

1. *global population*: an agent playing the rest of the population once as a proposer and once as a responder.
2. *spatial neighborhood*: agents on a spatial framework or graph can interact/play with a designated neighborhood of players around them

4.1. Spatial Topology

The agents will be placed on a graph or spatial framework(Fig.2) which will control which agents they can interact with. This also helps develop cooperative 'communities' or pockets which can protect each other from exploitative players[4]. An increase or decrease in the neighborhood size can change the dynamic of the playing population.

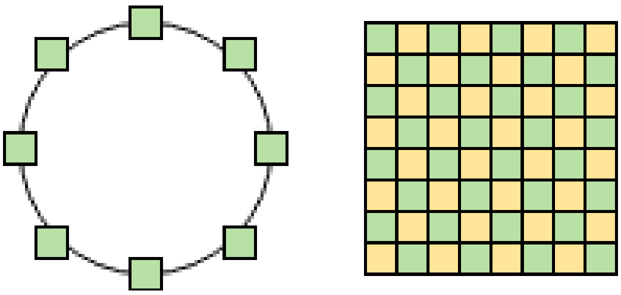

Figure 2: (Left to Right) One dimensional Ring and Two Dimensional Lattice Topology.

4.2. Reputation

We are developing a reputation scheme that will be based off of what an agent has offered or accepted in the past, modeled after Nowak *et al.*[7]. We will either have a separate reputation value for both offer or acceptance values or a singular reputation value based off of relative fairness(how fair is agent *x*?).

How is this information going to spread across the population? Will it be global or only available within an immediate neighborhood? Will the information travel through an interaction between two agents in a game? Will agents share information on their past opponents? There are many possibilities on how this information will travel and be shared. This will be a focus of the work to come in this research project.

4.2. Strategies

Each agent's strategy, their *o* and *a* values, can be randomly generated at the start of the first generation. We will observe which strategies are being adopted during the evolutionary process. Conversely specific strategies can be given to some agents to test the robustness of the population. e.g. Agents with low *o* values to exploit agents, or empathetic agents with fair(~50%) *o* and *a* values can be seeded into the population to promote cooperation.

We want the agents to be able to modify their strategies with the information they obtain of their co-players past games. If a proposer (*o* = 40%) comes up against a responder who's reputation is that they will accept low offers(*a* = ~20%) then the proposer can temporally change its *o* to maximize its return.

5. Initial Testing

Initial tests with agents playing the rest of the population suggests there is a strong correlation between the overall accumulative score of an agent and their acceptance value. While accumulative score and offer values do not seem to show a correlation.

6. Future Work

The ultimate aim for this work is to evolve a population of agents on a spatial topology with a reputation scheme in place and have the agents adapt their strategies to specific games based on their opponents reputation. To get there the reputation scheme and how that information travels needs to be worked on and finalized. Also work needs to continue on the method by which the agents use that information to alter their strategies.

7. References

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