The Utility of Adaptation vs. Signaling Action Tendencies in the Competition for Resources

Matthias Scheutz
Department of Computer Science and Engineering
University of Notre Dame, Notre Dame, IN 46556
mscheutz@nd.edu

Abstract

We explore strategies to resolve conflicts in multiagent environments that arise when agents compete for resources they need for survival and procreation. As expected, social strategies are better than asocial strategies and adaptive strategies are better than non-adaptive ones.

1. Introduction

Conflicts arise when two or more agents require a non-sharable resource at the same time. We explore different strategies to resolve conflicts game-theoretically [3, 2] and investigate the relationship between conflict games and larger games of survival in which they are embedded.

2. The Conflict Game

The survival game can be viewed as a tournament [1] consisting of lots of individual conflict games, where agents can perform two actions: they can "continue" the conflict game or they can "quit" the game . Each action has a cost associated with it, which the agents have to pay from their current budget (agents are permanently removed from the tournament if they cannot pay). The resource has a benefit associated with it, which only the winner of the competition gets. The losers might be able to get other resources with a certain probability ("the benefit of leaving"). Agents whose budget exceeds a certain amount C_D will produce an exact copy of themselves, which will be added to the tournament. A *strategy* for the conflict game can be defined in terms of the probability P_A that an agent A will continue a game.[1] The utility function $U_S(n)$ for the expected outcome for player S in a two-player game (with players S and O) after n rounds is given by: $U_S(n) = P_S \cdot P_O \cdot (C_P + U_S(n+1)) + P_S \cdot (1-P_O) \cdot (B_P + C_P) + (1-P_S) \cdot P_O \cdot (B_L + C_L) + (1-P_S) \cdot (1-P_O) \cdot (B_L + C_L)$. It is strictly decreasing, as for every round the game is continued the cost C_P has to be paid, and has two maxima at $P_S = 0, P_O = 1$ and $P_O = 0, P_S = 1$. Consequently, it is clear that long games only incur costs and that the best game is a one-round game.

One way to shorten games is for an agent to lower its probability of continuing if the other agent's probability is higher than its own, and otherwise increase it, call it the *Social Rule*: S increases its probability P_S to continue the game by a factor of $\frac{1-P_S}{P_S} \cdot (P_S - P_O)$ if $P_S > P_O$ and decreases it by a factor of $\frac{P_S}{P_O} \cdot (P_P - P_S)$ if $P_S < P_O$, otherwise it remains the same.

The repeated application of the social rule in the limit leads to the *Rational Rule*, which ensures one-round games: S plays 0 if $P_S <= P_O$ and 1 otherwise. It is based on the assumption that contestants do not know the actual value of B_P, B_L, C_P, and C_L, hence cannot compute whether $(1 - P_O) \cdot B_P + C_P > B_L + C_L$ (otherwise they could play pure strategies). Note that this strategy, however, is not *fair* in that repeated encounters between the same two individuals will lead to the same outcome, i.e., the same individual will win over and over again. In a group that means that the agent A with highest P_A will have $n \cdot ((1-p) \cdot B_P + C_P)$ payoff after n encounters and the bottom one P_A will have $n \cdot (B_L + C_L)$.

A fair way to distribute resources given that the utility function has a maximum for both $P_S = 1, P_O = 0$ and $P_S = 0, P_O = 1$, is to alternate between getting $B_P + C_P$ and $B_L + C_L$, which allows each player to get the average payoff $(B_P + C_P + B_L + C_L)/2$ every turn. We will call this the *Turn-Taking Rule* (for a details, see [4]).

3. Experiments and Results

We conducted extensive simulation studies in an artificial life simulation environment called *SWAGES*, which

1 We will use C_P to denote the cost for playing the game, C_L to denote the cost for quitting, B_P to denote the benefit of winning, and B_L to denote the benefit of losing. Typically, $B_P + C_P > B_L + C_L$.

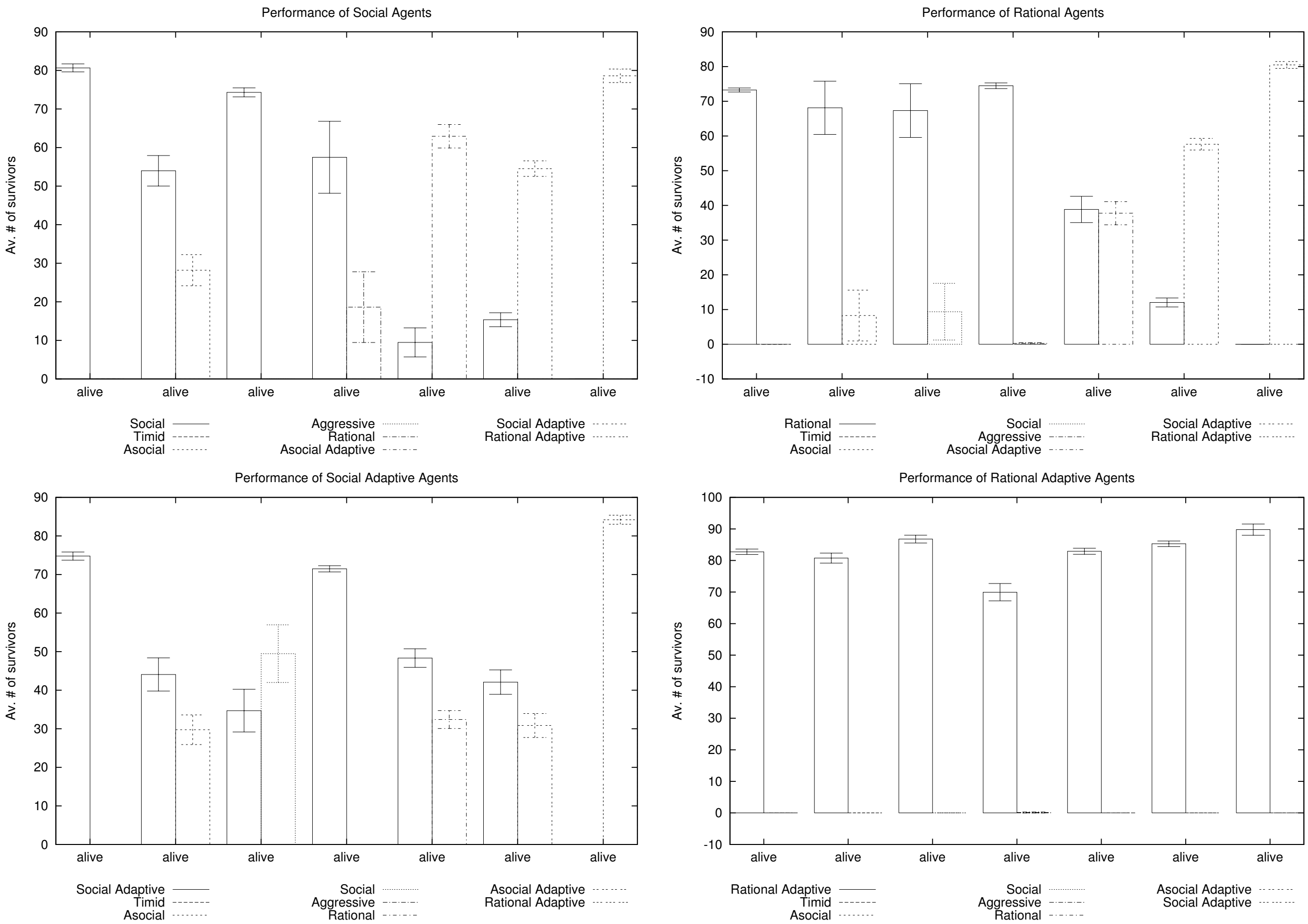

Figure 1. The average number of survivors in experiments with social and adaptive agents.

is under development in our lab. Specifically, we defined 8 basic agent types: *asocial agents* consist of three non-adaptive agents called *timid* (playing "always quit"), *Aggressive* (playing "always continue"), and (prototypically) *Asocial* (playing a mixed strategy), as well as *Adaptive asocial* (playing a mixed strategy with the turn-taking rule. *Social agents* are either adaptive or non-adaptive (prototypically) *Social* (playing the social rule) or *Rational* (playing the rational rule).

Agents play the survival game in a continuous two-dimensional plane, where agents and resources are randomly distributed within an 1800 by 1800 square area. At every cycle a new resources appears at a random location within this area and remains in its location until emptied by an agent (agents can empty resources and add their value to their budget by moving over them; empty resources will be removed). Agents can move in any direction based on their perception of items using a fixed policy [4]. In all experiments, 40 simulations were run, each with 50 randomly placed initial agents (25 each of two different kinds) and 50 randomly distributed initial resources for 10000 cycles. The results (average number of survivors across all 40 runs with 95% confidence interval) shown in Fig. 1 demonstrate that adaptive social agents outperform all other kinds.

References

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