Coursework 2: Agent Based Modelling

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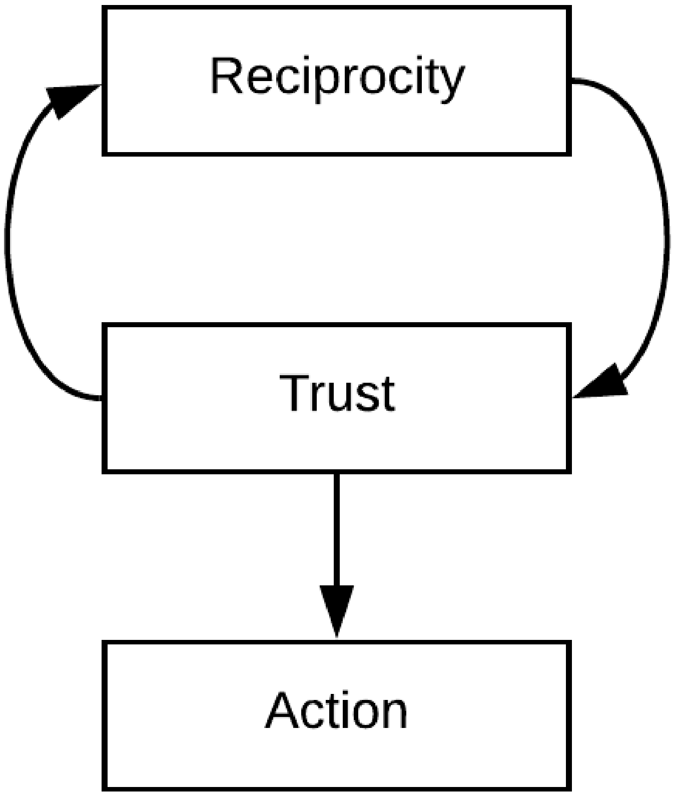


1 Introduction

This report extends the model presented by Smaldino (2013) to answer whether, and under what circumstances, an element of reciprocity, or earned trust, is beneficial to cooperative agents. This report extends the Spatial Prisoner's Dilemma game to include adaptive agents which choose to co-operate more frequently if their past interactions indicate that partners will reciprocate. Following Dasgupta's definition of trust, we consider trust to represent an agent's assumption about its partners choice of action, which will subsequently affect its own action. We consider reciprocity as a means to either reward or punish agents (a "tit-for-tat" strategy), indirectly affecting cooperation (Phelps, 2013). We test the hypothesis that an increase in the initial proportion of adaptive agents significantly decreases the long-term proportion of rational agents. We also explore the effect of using both long and short term memory.

2 Approach

The Spatial Prisoner's Dilemma game has three types of agents.

1. A myopic **rational** agent, which always defects, as this is the dominant local strategy.
2. A **cooperative** agent, which always cooperates.
3. An **adaptive** agent, which co-operates with probability $t \in [0, 1]$ representing trust.

In each simulation there is initially a total of 1000 agents and the carrying capacity of the environment is 4000. There is a moderate cost of living, in which all types of interactions are sustainable except DD and CD. 50% of the agents are rational, and the remaining agents are cooperative and adaptive agents. The initial proportion of adaptive agents is $a_0 \in [0, 0.5]$ and the initial proportion of cooperative agents is $0.5 - a_0$.

On initialisation, the adaptive agents are assumed to have no prior knowledge of the behavior of any other agents, therefore the trust, t, is initialised as 0.5. Trust is then updated based on the proportion of interactions where the agent chooses to cooperate, and it's partner reciprocates.

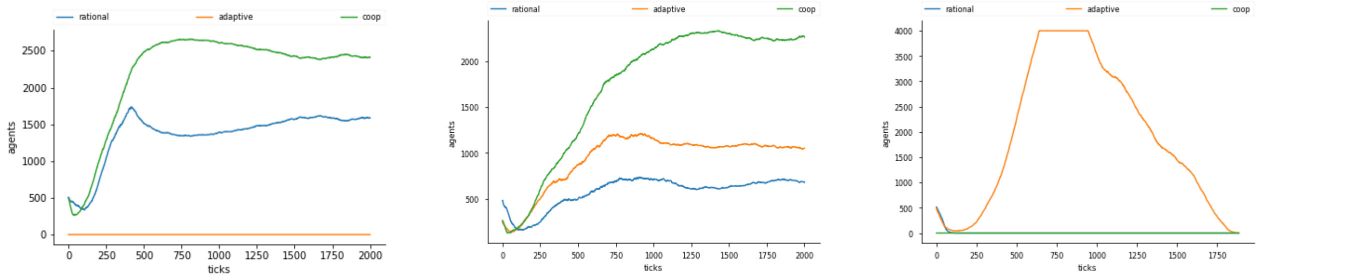
$$t = \frac{\#(CC)}{\#(CC) + \#(CD)}$$

In the long term memory model (LTM), memory is updated indefinitely for all interactions, whereas in the short term model (STM), trust is based only on the last five interactions.

We vary the proportion of adaptive agents, a_0, and record the evolution of the number of each type of agent for 2000 ticks. We then compare the mean proportion of rational agents, $\bar{r}_{2000}$, for $a_0 \in \{0, 0.25, 0.5\}$, and for LTM and STM, with 20 trials for each (a , LTM/STM) configuration.

3 Results

The simulations shown in Figure 1 show how the presence of adaptive agents influences the behaviour exhibited by the simulation relative to the baseline Smaldino (2013) model (Figure 1a). In Figure 1b the proportion of rational agents is lower throughout and the proportion of cooperative agents is relatively similar, suggesting that the adaptive agents replace the rational agents. In Figure 1c the adaptive agents initially dominate the rational agents, reducing their population to zero, the adaptive agents then exhibit a chain reaction of low trust and DD interactions, eventually reducing the population to zero.



(a) $a_0 = 0\%$ (b) $a_0 = 25\%$ (c) $a_0 = 50\%$

Figure 1: Typical short term memory simulations

The simulations for long term memory are structurally similar for $a_0 = 25\%$ but with less replacement of the rational agents. However, for $a_0 = 50\%$ the adaptive agents often do not completely eradicate the rational agents and never experience the same chain reaction, instead a stable dominance of the adaptive agents is exhibited.

The results presented in Table 1 reveal a significant impact of the initial proportion of adaptive agents, a_0, on the long-term proportion of rational agents, r_{2000}. Additionally, the short term memory model is significantly more effective in reducing r_{2000} than the long term memory model (when $a_0 \neq 0$). In all 20 runs of the $(50\%, STM)$ configuration the rational agents all die before 2000 ticks, and often, all the agents die before 2000 ticks.

a_0	STM/LTM	$\bar{r}_{2000}$
0%	STM	33% (4.15%)
0%	LTM	31% (4.30%)
25%	STM	9% (2.95%)
25%	LTM	18% (4.17%)
50%	STM	NA (NA)
50%	LTM	3% (1.66%)

Table 1: Proportion of rational agents after 2000 ticks under different configurations of a_0 and the memory length

4 Discussion

Building on the work done by Smaldino (2013), we have presented a model that investigates the importance of trust in a spatial simulation. Our results show the necessity of a well balanced ecosystem where the adaptive agents punish the rational ones by reciprocating their actions, in a tit-for-tat fashion (James Jr, 2002). Moreover, in the scenario where there are no cooperative agents, after the adaptive agents kill all the rational agents they start to prey on each other. Further work can examine the catalyst for this behaviour and how the chain reaction takes hold. A significant phenomenon that we encountered during our experiments is that short term memory in agents produces different results compared to long term memory. Our results show that agents which can forget past interactions, and forgive indirectly encourage co-operation. This is consistent with evidence presented by Imhof and Nowak (2010) which shows that forgiveness is directly correlated with the evolution of cooperation, in a model where direct reciprocity is favoured.

5 Conclusion

In this project we were tasked with exploring the utility of cooperation in a spatial simulation. We built on top of an existing simulation, specifically the one presented by Smaldino (2013). Our additions are trust and reciprocity elements, using a new *adaptive* agent. In terms of behavior, we explored reciprocity as a *tit-for-tat* action. Our studies can be further expanded by introducing new concepts such as reputation, as demonstrated by Mui, Mohtashemi and Halberstadt (2002).

References

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