Does Cooperation Help: A Study Based on Agent Based Modelling

Cognitive Science
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Introduction

❑Cooperation, or the act of paying the cost for someone else to benefit is fairly common in nature.

❑Agent based models have been used to study cooperation especially in game theoretic settings to find which strategies are preferable and in which situations. We use MESA for the purpose.

❑We ask: Does cooperation help in very simple settings that are concerned with survival? In other words does cooperation have any evolutionary benefit? We study this question by an agent based simulation in specific kind of artificial world.

❑Our basic idea is to use Agent Based Modelling to artificially mimic primitive, semi-nomadic, hunter-gatherer communities, where Cooperation is modelled as sharing of information about randomly scattered energy sources in that society that an agent may know. Degree of cooperation be graded by the amount of details agents share with another.

Method

Design

❑The world is modelled as a 100 x100 multi-grid cells, having limited number of decaying energy source

❑Two types of agents, EXPLOITERS, EXPLORERS.

❑Exploiters, have higher living - moving costs and are largely static. They congregate around energy sources and move only when energy levels are exhauste

❑Explorers spawn in a base location and constantly search, move with random drift, for energy sources returning to base location at fixed intervals to communicate information variedly. They have lower moving costs and mining rates and higher communication and sensing ranges.

❑An agent (applies mostly to explorers) can sense the presence of an energy sources up to a certain distance. When agents meet at certain distances they can decide to communicate their knowledge of energy sources to each other to varying levels. Agents at energy source refill energy levels consuming energy from sources at a certain rate (mining rate).

Simulation steps

Energy sources decay naturally & with consumption by agent. Below a certain threshold, it vanishes. If the total world energy in the world falls below a certain threshold, an energy source is added back. All parameters are chosen from pre-defined normal distributions. Looking for last-ditch energy, agent epsilon-greedily selects and goes to the best source among the ones in memory by estimating expected energy content of each resource from its informations (time of sight, capacity, location, decay-rate). When needed, explorers borrow energy from exploiters with some low probability. Population grows as agents reproduce when above a certain energy threshold and spend a large amount of energy to spawn a new agent

Experiments with the grid world

Communication in the grid is driven by three independent factors and we test for their impact on overall output of world.

Independent parameters:

1. **Communication Range** (max distance between agents such that they can communicate)
2. **Communication probability** (INTRA and INTER for Explorers/Exploiters for intra and inter group)
3. **Memory Sharing** (proportion of information in memory an agent will share with others).

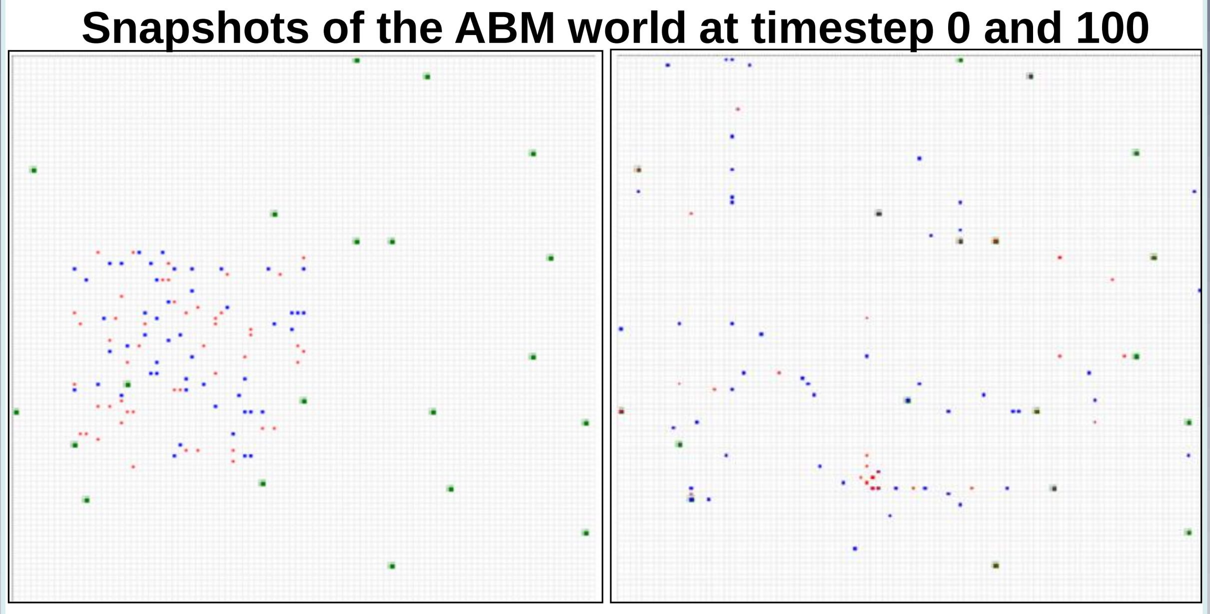
▪We test effects for these parameters independently as well as look at how they affect the outcome when working in tandem under the umbrella term **'Communication Level'.**

The dependent parameter for simulation:

We hypothesize cooperation to be positive on fitness of a society, and thus we select **average age of the population** as well as the **population size** as dependent parameter. **'Output' or 'Fitness'** ichosen as the product of 2 dependent parameters

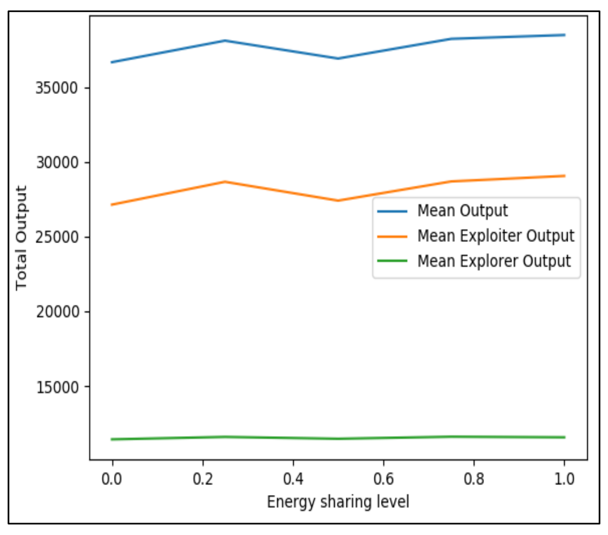
Results

Snapshots of the ABM world at timestep 0 and 100



A 100x100 grid world with 100 initial agents with explorer to exploiter ratio =0.5. In Red, are 50 exploiters while the Blues indicate 50 explorers. The 20 green squares are non-renewable depleting energy sources.

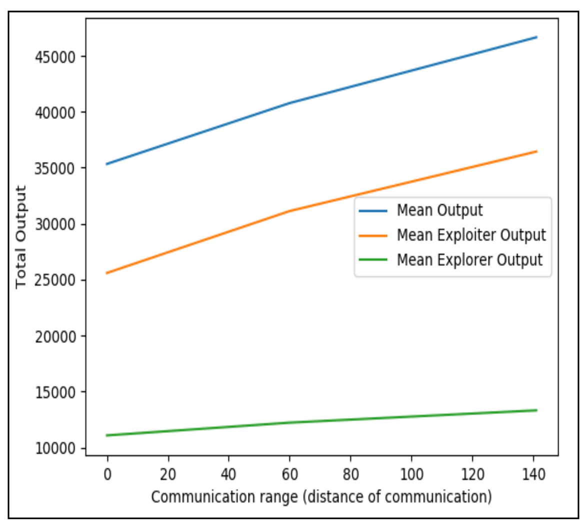
is Energy Sharing a factor in Total Output?



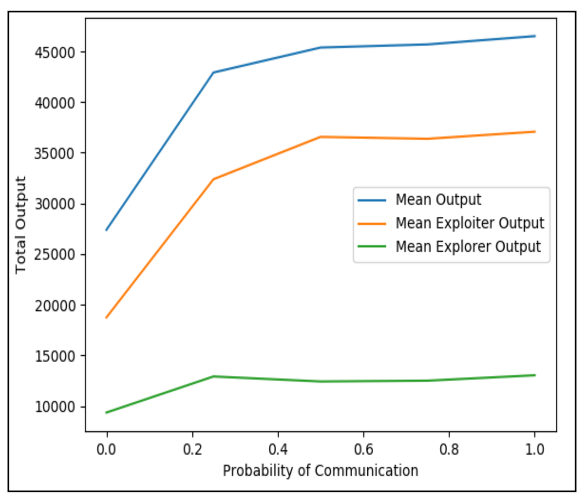
NO evidence of any significant effect of variation in probability of inter-agent energy sharing on the Total Outcome for the society at any levels with p>0.05 for all in probabililty ranges [0, 0.25, 0.5, 0.75, 1] and thus we do not consider it as a factor of our whole communication level.

Communication range as a factor

Increasing communication range has significant effect on fitness increase, with p=.008 for (0 & 141) and p=.04 between (0 and 65); there is a significant effect of communication range on fitness between 65 and 141 with p=.04 i.e p <0.05. Thus it can actually be considered as a factor



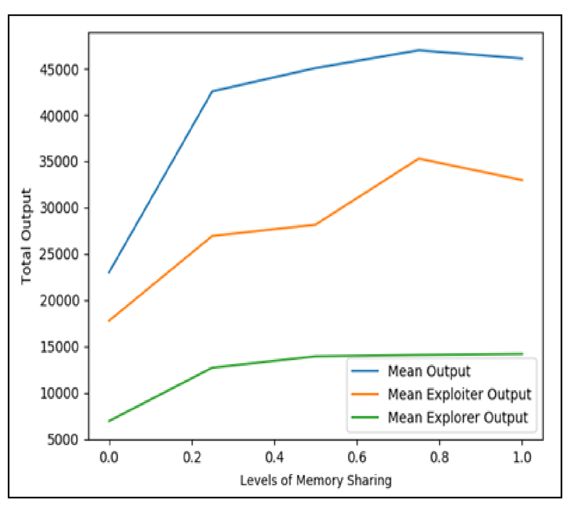
Communication probability as a factor



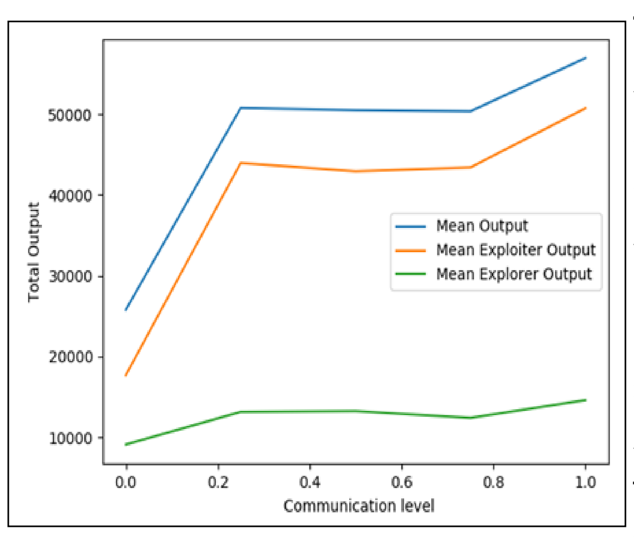
Significant effect of increase in communication probability on fitness (p < 0.05) between 0 and all the higher levels of communication probability, but no significant difference in the outputs at the intervals of higher levels (p > 0.15). It can actually thus be considered as a factor.

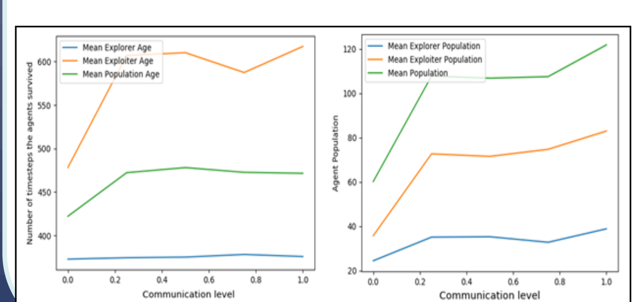
Memory sharing level as a factor

All higher memory sharing probabilities increased Total Output compared to 0 probability with p<0.05 between 0 and .25 and p<0.005 between 0 and others. But no significant effect was seen on increasing fitness in between the higher communication levels,



Communication level as an umbrella for all factors





Total output for a particular society increases for higher communication levels than at lower levels with significant effect of p-value much less than 0.001 between 0 and higher communication levels and significant difference for fitness, (p<0.05) between Communication level at 1 than at the lower levels.

Communication, used as a proxy for cooperation, did improve outcomes.

Summary

❑We have put forward a systematic formalisation of parameters contributing to cooperation in our ABM.
❑We treated inter-agent communication cooperation's proxy.

❑We found that for values higher than 0 (that of no communication), communication range, communication probability and level of memory sharing lead to positive changes in population size and age and thus to the overall fitness outcomes of society even in the very simple world.

❑We also brought all three factors under a common variable 'communication level' and found higher 'level of communication' to always result in significantly improved fitness outcome than 0 communication levels, & often also better than other non-zero but lower communication levels.

❑So, we also did find evidence that for the purposes of our simulated world, Cooperation does help: in that higher level of cooperation, as we see in the higher Communication Level, leads to significant effect on fitness or societal outcome, or 'Total Output' than at no cooperation.

❑We checked if energy sharing in exploiter-explorer had positive effects. But in our study parameters we found none.

Future Direction

❑The gradual saturation of Outcomes at higher levels of individual factors may be an outcome of reaching optimality early since other independent parameters are set to maximum. But this has to be investigated more rigorously..

❑The current model is very basic. To make it more realistic we need competing communities of agents with different levels of cooperation. Agent behaviour needs more sophistication. One way is to incorporate learning and long range planning and have a more finely grained index of cooperation.

❑Since energy sharing probability hasn't been found to have significant impact independently, thus , we can check what follows if energy sharing is intergrated as precondition with communication. We think this may show a significant effect.

❑The model can be made more sophisticated, also in terms of planning and action of the agents in the world by the Implementation of a sense of learning, group thinking, and some better protocols for deciding and acting individually and collectively, all of which are non-implemented for now.

❑We also need a more sophisticated way to measure the index of cooperation as constructed from more basic attributes. The current measure in form of 'communication level' is too coarse grained and rather primitive.

❑Lastly the agent society should be made to learn to value cooperators over non-cooperators and thus have a more enriched model of reciprocity.

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