

ODD Protocol

Mohtashemi, M & Mui, L. (2003). Evolution of indirect reciprocity by social information: The role of trust and reputation in evolution of altruism. *Journal of Theoretical Biology*, 223, 523-531.

1. Overview

- Purpose : The purpose of the model is to explain evolution of indirect reciprocity in terms of social information. By social information, it means the information retrieved and propagated not randomly in the whole population but selectively through dynamically evolving networks of friends and acquaintances; for example, trust or reputation. From this model, we can learn about the influence of social information which spreads in and also comes from the set of friends.

- Entities, state variables, and scales : There are two kinds of agents, potential donor and potential recipients, which are randomly selected from the populations. And all agents in the model are born in the non-overlapping subgroups of acquaintances of the same size. All agents have variables of image score s , which ranges from -5 to 5, and strategy k , which ranges from -5 to 6. And there are two kinds of acquaintanceship; one-way and two-way. The time scale of this model is abstract time step. It has generation and there are rounds in each generations. There is no specific spatial scale.

- Process overview and scheduling : Every generation consists of a fixed number of m rounds. The donor has the option of helping or defecting upon the recipient. The donor cooperates when the image score s of the recipient is not less than the strategy k of the donor himself. When donor cooperates, the image score of the donor increases by one unit, and if he defects, it decreases by one unit.

If the donor cooperates, it will cost him a value of c and the recipient receives a benefit value of b ($b > c$). At the end of generation, everyone dies and produce offspring in proportion to the total payoff. The children does not inherit the image score and acquaintances, but only inherit the strategy of their parents. There is 0.001 of mutation rate in this inheritance process, which the children inherit not their parents' strategy but random value of strategy.

Once the donor performs an action, he becomes a one-way acquaintance of the recipient and her acquaintances if he is not already. Also, the donor's acquaintances become one-way acquaintances of the recipient and her acquaintances.

And when the donor performs and action, the donor's image score is updated for his acquaintances and the recipient.

2. Design Concepts

- Basic Principles : The basic principle underlying this model is that if the information about a member of a population can be obtained, then an informed donor only helps those who are likely to help others. And the information is obtained preferably from friends and acquaintances.

- Emergence : Basically, this model shows the emergence and the maintenance of cooperation based on the condition with only limited number of initial acquaintances. And there was effect of the size of initial clique on the evolution of cooperation. With more initial acquaintances, cooperation is more likely to be evolved and sustained.

- Adaptation : There is no adaptation of strategy. Strategy k is randomly selected in the beginning of each simulation, and inherited to the offspring with the rate of 0.001 of mutation.

- Objectives : In this model, agents do not behave under the specific object like fitness or utility. They have simple choice either to cooperate or to defect based on the comparison between their own strategy and the image score of the counterpart.

- Learning : There is no learning in this model.

- Prediction : There is no prediction in this model.

- Sensing : There is no sensing in this model.

- Interaction : In every rounds, two randomly-selected agents interact; one is potential donor and the other is potential recipients. The potential donor cooperates if the recipient's image score is not less than his strategy. Cooperating costs c to the donor and gives benefit b to the recipients. If the donor cooperates, his image score increases by one unit, otherwise decreases by one unit.

If the donor does not know the image score of the potential recipients, he uses the information from his acquaintances by asking them if they have ever played in the recipient role against the current recipient, that is, if the current recipient is a one-way acquaintance of the donor's acquaintance set. If there is no information, the potential donor assumes that image score of current recipient is 0. Otherwise, he calculates the reputation of the recipient by adding up the recipient's image scores, provided by members of his acquaintance set, and dividing by the total number of encounters. Then he compares this score with his own strategy, and he cooperate if the score is not less than his strategy.

- Stochasticity : In the initialization of the model, all agents are randomly assigned to the non-overlapping cliques with certain number of agents. And two agents are

randomly selected from the entire population; one is potential donor and the other is potential recipients.

- Collectives : All of the agents in the model are assigned to the non-overlapping cliques with certain number of agents. Agents use the information from their clique group making decision whether to cooperate or defect when they don't know about the recipient.

- Observation : To observe the evolution of cooperation, we should observe the frequency of strategy which ranges from -5 to 6.

3. Details

- Initialization : In initialization phase, population of n of agents are created and all agents are randomly assigned to the clique groups with same size. The image score s of all agents is set to be 0, and the strategy k is randomly selected from the range from -5 to 6.

- Input Data : There is no input data in this model

- Submodels : There is no sub model in this model.