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**UofMN Course Number# Assignment/lab #**

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# Summary

In [1], the authors introduce a theoretical framework for analyzing the evolution of cooperation through indirect reciprocity. The framework is based on a simple game theoretic construct involving two player roles: a donor and a recipient. The donor is offered the opportunity to incur a cost *c* in order to provide a benefit *b* to the recipient. The game is repeated for several rounds with any two players interacting at most once.

The authors introduce a simple strategy that can promote cooperation among the players of this game. The strategy consists of a simple social norm for tracking agent reputations and a simple rule that the donor can use to decide whether to cooperate by donating to the recipient.

The simple social norm, labeled “scoring” in follow-on studies, takes two forms. The first form involves tracking agent reputations using an *image score* that ranges from -5 to +5. Each agent starts with an image score equal to zero. The agent’s image score is increased by one (up to +5) each time the agent cooperates and decreased by one (down to -5) each time the agent defects. The second form simplifies the image score down to two *images*: *bad* and *good*. Each agent starts with a good image and then its image is determined based on the last action it has taken. If the agent cooperates, its image becomes good. If the image defects, its image becomes bad.

The authors proposed a simple action rule that only depends on the reputation of the recipient. When using the image score form of reputation assessment, the rule specifies to cooperate when the recipient’s reputation is greater than a specified threshold *k*. When using the simplified good/bad image form of reputation assessment, the rule specifies to cooperate if the agent has a good reputation and defect otherwise.

Obviously, different social norms and action rules are possible and, since the publishing of this paper, much debate has ensued regarding which social norm and action rule combination is most likely to lead to a cooperative outcome.

This simplified model has lead to

Public goods games can also benefit from such a theoretical framework… ???

This framework has served as the basis for

The form of the basic donor-recipient game investigated in [1] is the following.

In order to avoid negative pay-offs, the amount c is added to the pay-offs for both the donor and recipient. At the beginning of each generation, the pay-offs of all group members have a pay-off *u0*, which can be zero or positive.

Since the experiments do not incorporate any strategies that use the round number as the basis for decisions, we will not be concerned with the “end effect” which removes the incentive to help in the last round and leads to cooperation unraveling in all previous rounds.

In [1], the authors consider a model in which the population is divided among *g* groups each consisting of *n* members. During each generation, *m* rounds of donor-recipient interactions are played. For each round, two individuals are chosen randomly with one playing the role of the potential donor and the other playing the role of the potential recipient. If the potential donor provides help to the potential recipient, then the usual pay-offs are provided to the players.

After the completion of *m* rounds, the local within-group and global cross-group reproductive probabilities for each strategy are determined as follows. For each group, the pay-offs earned by each strategy in the previous generation are summed and normalized to produce the local within-group reproductive probability for each strategy. To produce the global cross-group reproductive probabilities, the pay-offs earned by each strategy are summed and normalized across all groups.

The strategy followed by each individual in the next generation is determined as follows. With probability p, the individual’s strategy is derived from the local group using the within-group reproductive probability. With probability 1-*p*, the individual’s strategy is derived using the global cross-group reproductive probability. When determining the strategy for an individual in the next generation, a mutation occurs with probability *μ*. When a mutation occurs, the individual’s strategy is selected from among all available strategies with equal probability.

Error in strategy execution…

The donor-recipient game provides a framework for investigating indirect reciprocity. In [2], the authors investigate the co-evolution of social norms and action strategies in the context of the door-recipient game. The model employed by the authors considers evolution at two levels. At the base level, the authors consider the evolution of action strategies in the context of a fixed social norm. On top of this base level, the authors consider the evolution of social norms in the context of competition between groups of agents called tribes.

Let be a tribe of agents and be the *jth* member of that tribe. Let be the social norm used by tribe *Ti*, be the strategy followed by agent *aij* and be the reputation of agent *aij*. The reputation of each agent is considered public shared information.

The simulation proceeds in rounds and each round consists of two stages. During the first stage, each agent participates in one donor-recipient game with every other member of its tribe. The payouts received by each agent are tracked in order to calculate the fitness of each individual in the tribe.

## Critique, Observations, Improvements and Extensions

# References

1. Nowak, M. A., “Evolution of indirect reciprocity by image scoring,” *Nature*, vol. 393, pp. 573-577, 1998.
2. Leimar, O., and P. Hammerstein, “Evolution of cooperation through indirect reciprocity,” Proceedings of the Royal Society London B, vol. 268, pp. 745-753, 2000.
3. Pacheco, J. M., F. C. Santos, and F. A. C. C. Chalub, “Stern-Judging: A Simple, Successful Norm Which Promotes Cooperation under Indirect Reciprocity,” *PLoS Computational Biology*, vol. 2, issue 12, December 2006, pp. 1634-1638.