A study on Competition Co-evolution Model for a Iterated Prisoner's Dilemma Game

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The problem of understanding how cooperative relations arises has been studied in various fields, such as politics, economics, and biology. Most of those researches focus on the problem of knowing whether it is possible to obtain cooperative relations from a group of selfish decision makers (agent). Especially, the problem in which dilemma exists has mutually complicated relations, and is difficult to be analyzed. The aim of this research is to know whether a large group of selfish agents can evolve into a cooperative one in a dilemma.

In order to analyze the complicated situation with such dilemma, we use the game theory. The game theory is a field of the applied mathematics, and aim to analyze competition of the interest between players (decision makers). Moreover it is considered as a framework for analyzing decision-making situation in various research fields, such as economics, biology, politics, and information science. The prisoner's dilemma game is known as one of typical models representing dilemma situation. The game in which the prisoner's dilemma is iterated unknown number of time is called the iterated prisoner's dilemma game (IPD).

In this research, each agent is considered as a strategy in IPD, and we make experiments in which such a group is evolved using an evolution models. In many researches the genetic algorithm (GA) is used as an evolution model, and it is reported that cooperative relations can be derived. Research by R.Axelrod is the most famous one. The purposes of the research of Axelrod are to understand in which situation cooperative relations arise, and to clarity which action is appropriate in order to develop cooperative relations in specific situation. By a round-robin tournament of various strategies, and the character is tics of strategies are analyzed.

As typical strategies used by these researches, is $AllC$(it always cooperates as partner) $AllD$(partner is always betrayed) TFT (retaliation)are known. $AllD$ and TFT are called collectively stable because they cannot be invaded by any individual. Especially, TFT is a strategy that attracts attention in many researchers, and is considered that its existence is one of the main factors for a group to become cooperative one.

In this research, we focus on the following problem not considered in previous researches. Although GA can analyze the relation between agents, it cannot analyze the relation between groups. Because GA is a mechanism in which only one group is evolved. In modern societies where cooperative relations arise, it is considered that such a simple modeling of societies is insufficient. To model complicated modern societies more faithfully, we apply more complecated models for societies to the evolution of strategies in IPD.

In this research, the competition co-evolution model (CCE) is used as the evolution model. Under the same condition, strategies of IPD are evolved by both of GA and CCE, and the difference between them is clarified. More precisely, we start the simulation from a group consisting of TFT and $AllD$, and observe speed of convergence, features of generated group, and individuals in these groups.

Convergence means convergence of the average value of the fitness of each individual. We investigate the number of generations needed for the average value of the fitness to converge, and also how the value changes. As result, groups evolved by CCE converge slower than those by GA. In addition, they take various from in the graph of the average fitness values.

Next, groups are classified into three kinds, "cooperative group", "non-cooperative-group", and "other group", in order to investigate the feature of generated groups. We have obtained the result that CCE tends to generate "a cooperative group", comparing with GA, when the percentage of TFT in the initial group is low.

Finally individuals in each group are compared. To investigate the feature of each individual, individuals are classified into four kinds. As a result, when the percentage of TFT in the initial group is low, the difference between CCE and GA is big. Moreover, the feature of an individual and the feature of a group are closely related.

By above argument, we can conclude that CCE in IPD has the following feature comparing with GA : The group evolved very slowly keeping the variety of individuals. Moreover, even if the percentage of TFT in the initial group is low, the possibility of evolving into a non-cooperative group is relatively low.

Remaining subjects are consideration on the coding method and terminating condition of the simulation, and precise analysis of "other groups".