The impact on collaborate level of cluster

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Abstract

Due to the impact of the characters of nodes in complex network on collaboration level, we put forward a new iterated game model based on conformist mechanism. In this model, nodes can update tactic not only according to their payoffs but also to their species, which they belong to. The new model can assure that nodes in the same species adopt the same tactic. Simulation results show that the collaboration level of the networks that adopt conformist mechanism is higher than the networks that adopt normal mechanism. In the other words, the collaboration level is in inverse proportion to the species number. On the other hand, we find that the average payoffs increased with the penalty gene instead of increasing alternately. So the new model can promote the collaboration level and the average payoffs of the nodes in network at the same time.

Keywords: Conformist Mechanism, Iterated Game, Collaborate Level, Complex Network

1 Introduction

Traditional evolutionary game theory considers the main nature, which prefers to select selfish and stronger individuals. However, there are lots of cooperation behaviours in nature, which contradicts the natural section rule. Game theory is an efficient tool in the field of studying biological, economic, and social relations of complex network etc. Especially after the notion of Prisoner's Dilemma Game (PD game) proposed by Neumann and Morgenstern, various related research works are applied into many fields. The prisoner's dilemma is a canonical example of a game analysed in game theory that shows why two purely "rational" individuals might not cooperate, even if it appears that it is in their best interests to do so. It was originally framed by Merrill Flood and Melvin Dresher working at RAND in 1950. Albert W. Tucker formalized the game with prison sentence rewards and named it "prisoner's dilemma" (Poundstone, 1992).

The basic idea of PD game is as follows: two thieves are arrested and imprisoned. Each thief is in solitary confinement with no means of speaking or exchanging messages with the other. Here is how it goes:

(1) If A and B both defect from the other, each of them serves 2 years in prison.

(2) If A defects from B but B remains silent, A will be set free and B will serve 3 years in prison (and vice versa).

(3) If A and B both remain silence (which means that they cooperate), both of them will only serve 1 year in prison (on the lesser charge).

It is implied that the prisoners will have no opportunity to reward or punish their partner other than the prison sentences they get, and that their decision will not affect their reputation in future. Because defect from a partner offers a greater reward than cooperating with them, all purely rational self-interested prisoners would defect from the other, and so the only possible outcome for two purely rational prisoners is for them to defect from each other. The interesting part of this result is that pursuing individual reward logically leads both of the prisoners to betray, when they would get a better reward if they both cooperated. In reality, humans show a systematic bias towards cooperative behaviour in the similar games, much more than predicted by simple models of "rational" self-interested action. A model based on a different kind of rationality, where people forecast how the game would be played if they formed coalitions and they maximize their forecasts, has shown to make better predictions of the rate of cooperation in this and similar games given the payoffs of the game.

Generally, in PD game, each party (denoted as P1 and P2) has two choices: Cooperation (C for short) and Defection (D for short). Utility is defined as follows:

The utility is T for P1 when P1 adopts D and P2 adopts C;

The utility is S for P1 when P1 adopts C and P2 adopts D;

Both P1 and P2 get R if they adopt C;

Both P1 and P2 get P if they adopt D.

We often use a matrix A to describe the relationships between P1 and P2.

$$A=\begin{bmatrix} R & S \\ T & P \end{bmatrix}, T>R>P>S, 2R>T+S.$$

For one-short PD game, where the game is played only once, both parties would rather to adopt D since D is dominating strategy for them. However, the optimal result for both parties is (C, C) since R is bigger than P.

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Therefore, the problem is how to encourage both parties to cooperation in PD game. One solution for this problem is iterated PD game, where parties interact for several rounds. The reason is that in iterated PD game, parties can adopt certain retaliatory measures to punish those who adopt D. Thus, parties who adopt D may not defect in the following rounds PD games. Therefore, both parties would like to cooperate in iterated PD games.

On the other hands, cooperation often appears in complex network. Santosand Pacheco [1] fink that the scale-free network is beneficial to cooperation emergence and maintenance. Furthermore, they also discuss snow-drift game model in scale-free network [2] and the results show that mixed network is more conductive of cooperation emergence. Vainstein and Arenzon [3] find that some potential disruption in sparse grid can strengthen the density of cooperation. Riolo [4] studied a game model, where does not exists any reciprocity.

In this model, parties decide whether to cooperate according to the similarity of their opponents. Although this model may boost cooperation, it has a strong assumption. That is each party in this game must interact with those who are similar to him. This game is degenerated to PD game once this assumption is released. Therefore, cooperation may not appear in the model without reciprocity mechanism.

This paper proposes a conformity mechanism, which considers the impact of conformity to the results of game theory. Here parties should not only consider his own utility but also majority parties in the same set. Firstly, this paper describes the basic idea of conformity scheme. Secondly, discuss the simulation results of the scheme. The results show that this scheme can greatly boost cooperation among parties in network. Furthermore, conformity can avoid the average utility rise alternately such that it has a proportional relationship with punishment factor.

2 The conformity scheme

In order to boost cooperation among parties, scientists propose various methods and schemes. A simplest strategy is Tit-for-Tat (TFT for short).

Tit for tat is a highly effective strategy in game theory for the iterated PD game. The strategy was first introduced by Anatol Rapoportin Robert Axelrod's two tournaments [1], held around 1980. Notably, it was (on both occasions) not only the simplest strategy but also the most successful in direct competition. An agent using this strategy will first cooperate, and then subsequently replicate an opponent's previous action. If the opponent previously was cooperative, the agent is cooperative. If not, the agent is not. This is similar to super-rationality and reciprocal altruism in biology. The success of the tit-for-tat strategy is astonishing, which is largely cooperative despite that its name emphasizes an adversarial nature. Arrayed against strategies are produced by various teams it won in two competitions. After the first competition, new strategies formulated specifically to combat tit-for-tat failed due to their negative interactions with each other; a successful strategy other than tit-for-tat would have had to be formulated with both tit-for-tat and itself in mind.

The results may give insight into how groups of animals (and particularly human societies) live in largely (or entirely) cooperative societies, rather than the individual way, which is in "red in tooth and claw" way that might be expected from individuals engaged in a Hobbesian state of nature. This, and particularly its application to human society and politics, is the subject of Robert Axelrod's book "The Evolution of Cooperation".

Moreover, the tit-for-tat strategy has been of beneficial used to social psychologists and sociologists in studying effective techniques to reduce conflict. Research has indicated when individuals who have been in competition for a period of time no longer trust one another, the most effective competition reverser is the use of the tit-for-tat strategy. Individuals commonly engaged in behavioural assimilation, a process in which they tend to match their own behaviours to those displayed by cooperating or competing group members. Therefore, if the tit-for-tat strategy begins with cooperation, then cooperation ensues. On the other hand, if the other party competes, then the tit-for-tat strategy will lead the alternate party to compete as well. Ultimately, each action by the other member is countered with a matching response, competition with competition and cooperation with cooperation.

In the case of conflict resolution, the tit-for-tat strategy is effective for several reasons: the technique is recognized as clear, nice, provocable, and forgiving. Firstly, it is a clear and recognizable strategy. Those using it quickly recognize its contingencies and adjust their behaviour accordingly. Moreover, it is considered to be nice as it begins with cooperation and only defects in following competitive move. The strategy is also provocable because it provides immediate retaliation for those who compete. Finally, it is forgiving as it immediately produces cooperation should the competitor make a cooperative move.

Individuals who employ the tit-for-tat strategy are generally considered to be tough but fair—a disposition that is often respected in the business/organization world. Those who always cooperate with a competitor are often viewed as weak, while those who consistently compete are perceived as unfair. In any case, the implications of the tit-for-tat strategy have been of relevance to conflict research, resolution and many aspects of applied social science.

In addition, if parties in game theory can observe other parties' strategy and assign values on reputation, then this indirect reciprocity can explain why cooperation emergence. However, it is a controversial topic which scheme leads to this cooperation. Recently, some research works show that some different indirect reciprocity can effectively result in cooperation emergency.

The models without reciprocity can also lead to cooperation emergence such as Riolo model. Although this model has some shortcomings it has caught wide interests since it makes parties to cooperate on the basis of similarity. If interaction is not random, then the group of co-operators can exist in the settings without cheaters. That is cooperation mechanism based on similarity can lead to a high level of cooperation.

Previous models only consider his own utility while they do not consider the impact when other parties update their strategy. In fact, parties' strategy are easy affected by other parties' strategy. This is what we called conformity. More specifically, parties would like to adopt the strategies which are adopted by most parties in network although this strategy may be not optimal.

In interpersonal network, nodes denote parties in games, lines between nodes denote the relationships of two parties. Previous research work often neglects some properties of nodes. In this paper, we set up a network considering those properties. For example, a node has commercial benefits and then we can divide nodes into several groups according to their different characters. The conformity idea is similar to Riolo model. The difference lies in that Riolo model release the limits for parties, where they cannot only interact with parties in the same group but also parties in other groups. Furthermore, the utility matrix is changed with strategy. In iterated PD games, we adopt dynamic matrix. The game model is set up as follows.

(1) Choose Zachary [6] network as research object. Zachary's karate club: social network of friendships between 34 members of a karate club at a US university in the 1970s. Please cite W. W. Zachary, An information flow model for conflict and fission in small groups, Journal of Anthropological Research 33, 452-473 (1977).

(2) Set up utility matrix. We adopt the matrix as Nowak and May $A=\begin{bmatrix}1 & 0\\ b & 0\end{bmatrix}$, where 1<b<2.

(3) Randomly initialize strategies for each party.

(4) Node I play games with his neighbour j. If i adopt strategy C then we do not update utility matrix.

Otherwise, the game proceed into next round. Before entering the next round, let b=b-Q, where Q is punish factor. The utility of each neighbour lj_i of party i is $S(lj_i)$. After party i interact with all neighbours, choose maximize utility $\max(S(lj_i))$ among $lj_{\max i}$. Finally update the strategy of party i as his neighbours' strategy $lj_{\max i}$.

(5) Entering the next round, divide different groups according to their strategies. That is, parties belong to the same group if they adopt same strategies. Here in order to contrast the efficiency of new schemes, we adopt a reference experiment. In the reference experiment nodes adopts the strategy of those who have highest utility.

(6) Repeat step (4), (5) till the game end.

In the new model, nodes in network first play game with his neighbours and adopt strategies of those who have the highest one. If the game proceeds into the next round, nodes will adopt the strategy, which is adopted by most parties in the same group. This agrees with conformity and is presented in Figure 1.

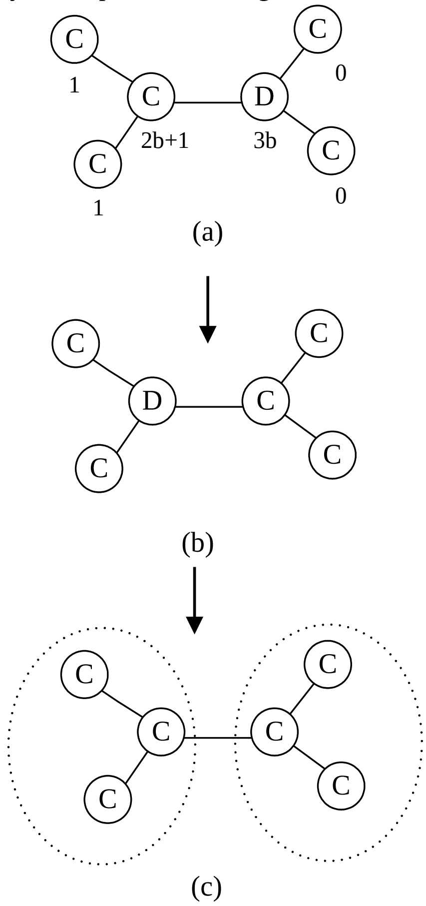
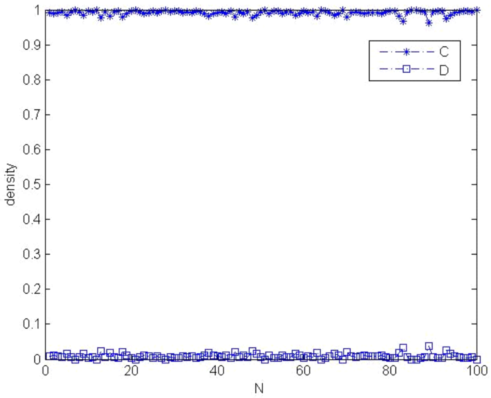


FIGURE 1 The proceed of conformity

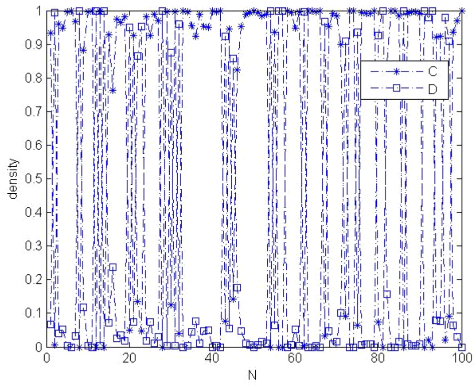
Since initial strategy is randomly set, the initial utility of the node is shown in Figure 1(a). Then after one round of game, node A adopt the strategy of node B. Since node B has the highest utility among all neighbours of node A, node A adopt the strategy of node B in next round. For the same reason, node B adopts the strategy of node A. This proceed is shown in 1(b). However, node A should adopt the strategy of those most parties adopt in the same group according to the conformity scheme as shown in 1(c), where dotted line mean two groups. We can see that the cooperation level in the network is improved due to conformity.

3 Simulation results

When node is in the same group, this model reduces to the model in [4]. When parties update their utility after one round, then this model reduce to the model in [7]. When the network is divided into three groups, the impact of this model and models in [7] is shown in Figure 2.



(a)

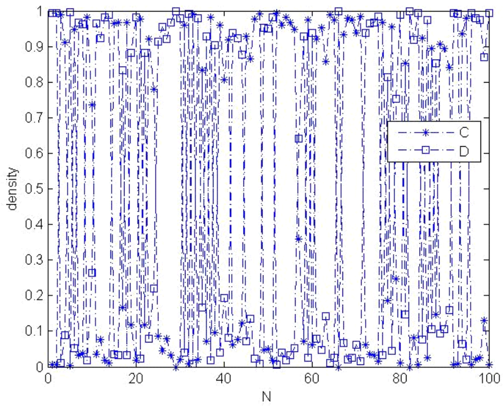


(b)

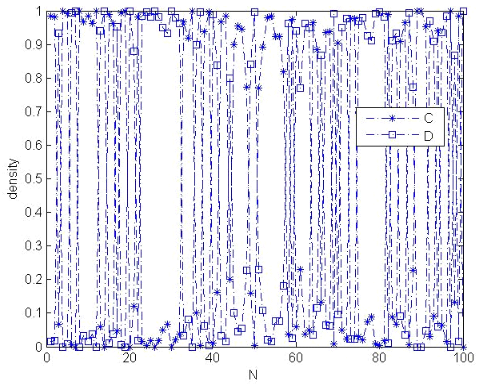
FIGURE 2 Network strategy density (when there are 3 groups)

Figure 2(a) denotes the network strategy density when the network is divided into 3 groups and the rounds number is 100. Figure 2(b) denotes that each node update their utility according to his own strategy. As shown in Figure 2, the cooperation and defect strategy rise alternatively in Tomochi and Kono and there are no obvious bounds. And cooperation level is obviously higher than defect level in our model. This illustrate that conformity greatly improve the cooperation level in the network. Iterated games can improve cooperation level. Therefore, most parties in the network are like to adopt cooperation. Furthermore, nodes in the whole group choose their strategy according to conformity scheme. So we can regard that individual party may give up his own benefit in order to conform to the benefit of the whole group.

Note that conformity scheme may lose his efficiency when the number of nodes is equal to the whole network. That is, each node belongs to one group. The reason is that each node will only consider the strategy of him. There is no group to conform. In order to study the impact of group scale to cooperation level, we discuss the cooperation and defect density when there are 10 groups in one network. The results are shown in Figure 3. Just as before, we also adopt Tomochi and Kono as a reference.



(a)



(b)

FIGURE 3 Network strategy density (when there are 10 groups)

Compared with 3(a) and Figure 2(a), we find that cooperation and defect rise alternatively in both figures and there are also no obvious bound in these two figures. This results show that the impact of conformity scheme when the group number is large is less obvious than that when the group number is small. Compared 3(a) and Figure 3(b), we find that the former has a higher cooperation levels, which shows that conformity scheme is dominating.

Furthermore, we also find that conformity can also improve the average utility in the whole network. The average utility alternatively increases in [7]. However, when we adopt conformity scheme, there is a linear relation between average utility and punishment factor Q. Figure 4 denotes the average utility when the group number is 3 and 10. The results show that the average utility becomes small when the number of groups becomes larger.

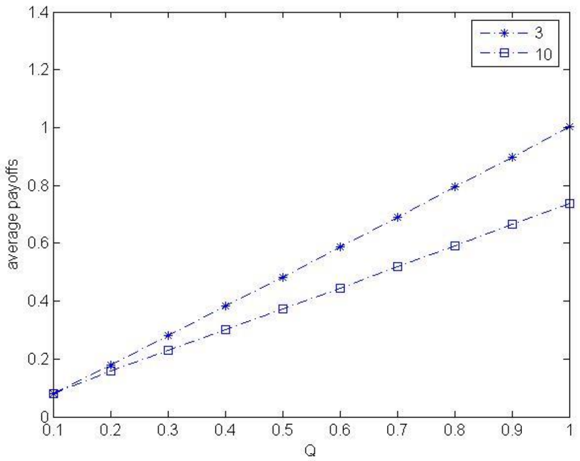


FIGURE 4 Network average utility

4 Conclusions

With the development of complex network, the structure of complex network becomes more and more popular especially for the cooperation strategy. Game theory on complex networks will be more and more interesting and become to be the centre of the evolution theory. The emergence of group cooperative behaviour and stability maintenance are confused phenomenon for scientists and the structure evolution plays an important role in complex system.

This paper proposes a conformity scheme to boost cooperation among parties. The basic idea is to use strategies in iterated games such that each node adopts the strategy of those who have the highest utility in each round. That is, if the strategy conforms to the majority strategies in the group, then parties remain to adopt this strategy. Otherwise, parties adopt the strategy, which is adopted by most nodes in the same group. The simulation results show that this conformity scheme can greatly improve the cooperation level in the network.

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