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Cooperation of Autonomous Agents Seen throug the Prisoner's Dilemma Game

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Cooperation of Autonomous Agents seen through the Prisoner's Dilemma Game.

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Abstract. Through many simulations on the so-called Prisoner's Dilemma Game, even cold-blodded machine can cooperate and begin to surve for others. This suggests possibility of the emergence and the evolution of social cooperative spirits.

1. Prisoner's Dilemma Game.

Among the mathematical theory of games, the most complete and beautiful one is the theory of two-person zero-sum game. But this is nearly a mathematical theory. There are many discrepancies and difficulties for practical applications.

Even within the two-person game, non zero-sum case is quite different to the zero-sum case. One may not behave egostically, since the loss of the opponent does not mean the other's profit. Rather, cooperation may bring gain for both players.

A typical situation of two-person non zero-sum game is known as Prisoner's Dilemma. Originally this comes from the stratage of confess between two accomplies arrested separately.

But now this terminology is used for the game with the following gain table. As a typical model, we show a standard one.

A \ B	C	D
C	3 : 3	0 : 5
D	5 : 0	1 : 1

The meaning of the table is as follows. Two players A and B match and they use either C (Cooperation) or D (Defect) at each move. For each case, the left and the right number mean the gain of A or B respectively. For example, if both cooperate, both gain 3 points, higher than the gain 1 for defect.

Pure mathematical theory suggests through the gain table that each player has advantage to use D rather than C, without regarding the opponent's move, though this is not a nice choice. If both cooperate, both have points higher than the case of defect. Why did such discrepancy occur? This is just the essential problem of this game.

2. Previous results.

Since it is difficult to solve theoretically, many scientists have studied the problem by computer simulation. When each player repeat the game with different opponents in many times, egoistic move is surely bad. If both player behaves to use the move D, they gain only 1 point, much worse than the cooperative case. Hence, in any sense, cooperative move must emerge.

Axelrod [1] and Genesereth et al. [2] have actually studied the problem through many computer simulation. After a huge amount of experiments, they have clarified the following interesting results.

1. If the game overs only once, most players prefer to select D and find difficult to cooperate. However, if each player expects repreated games to the same opponents in the furure cooperative activity emerges.

2. In their simulation, the most effective stratage has been Tit-for-tat (TFT), which uses at first C, and thereafter uses the opponent's last move.

3. In general, effective stratage must have the following properties: It may not too aggressive, should be polite but must have defensive power for evils. The defense may be neither too rigorous nor too generous.

Certainly, this suggests the "heart to serve others".

It is widely said that the experiments may explain at least partly the stablity structure of the cold-war time during 1960-70.

But the above model was repeated game with same opponents. In our real world, one should match with various agents with different stratages. Recently, Ito-Yano [3] tried a new version of the simulation, and obtained much interesting results.

3. New Simulation model

Ito-Yano took a modified version. First they subtract a "due" from the gain table to make the mean-point to be zero.

But zero-sumness is merely apparent and this is not an essential modification. The most important variation is at the followings. They introduce many autonomous agents(players) with different stratages, and each player moves along the lines on a huge board. If two players meet at the same corner, they must match,i.e., both are forced to show their own move C or D. The referee (computer) computes each player's point and let them know the results. The referee also adds or subtracts the points from each player. Though each agent cannot see the stratages of the others, all matching results are open and can refer at any time.

If a player looses all his/her own point, it dies or extincts. If a player gain higher points than twice of the original one, he/she can bear a child, which has the same stratage to the parent, and begin to move independently with the standard initial point. Thus effective groups grow, and unsuitable agents will extinct.

To help their study, Ito-Yano first introduced a few simple fundamental agents, say:

1. CCC: Complete cooperative good person, or non-registant. They always play the move C and never use D.

2. RAN: Random or foolish person. Regardedless the opponent, use C or D randomly in half-and-half probabikity.

3. DDD: Demon or the worst knives. Always play D and never cooperate.

4. TFT: Tit-for-tat. Use the opponent's last move.

For the first contact, play C.

Later they consider various modifications. But as a result, the following two are essentially new groups.

5. REF: Agent with self-reference. For the first contact uses C. Otherwise he/she carefully checks the opponent's previous moves, and use, in principle, the opponent's last move, unless both took D or when the situation seems to have to use D.

6. SLF: Selfish person. He/she checks the opponents previous moves, and uses D if he/she know that the opponent does not belong with same species of his/her own. Otherwise plays C.

4. Theexperimental results.

Ito-Yano took a board of 6X6 lattice, moving speed 1/5 and the initial capital 20 points. As a preliminary test, they first try one-to-one static matchings.

Rationally, CCC looses both for DDD and RAN. TFT vs. DDD or RAN ends as both ruined together. Other groups such as REF or SLF wins both for DDD and RAN. Everytime, the groups CCC,TFT,REF and SLF may cooperate and both can grow.

Next they try the total matching. They repeat the game many times. Through all their experiments, DDD and RAN always extinct relatively soon. It seems rather reasonable, that foolish person (RAN) and devil (DDD) cannot survive in the competing world. DDD extincts quickly, because after the pray (e.g. CCC) extincts, DDD cannot cooperate even among their own

groups.

Up to the present point, the results sound rational, but the evolution of later world seems rather unexpected. There have been several different cases as follows.

Case 1. This is the most common case. TFT, REF and CCC cooperate and grow. They purge SLF and let it to die. SLF used to seem as if it is DDD. This is relatively an ideal society. Interestingly, the weakest good poeple CCC who has no defence power and cannot regist to DDD or RAN in a single group, can survive with the cooperation with TFT and REF.

Case 2. This is relatively few case. SLF grows rapidly and purge all other groups. It seems an appearence of a dictator. But this world is vulunerable as disscussed later.

Case 3. This is a rare case. CCC first grows and then both groups TFT-REF and SLF grow separately in different area, as if the cold-war state. It is not sure, whether this world will be stable or not after long period.

5. Other modifications.

They further introduce "mutation" to the agents. Actually this means the changes of weights in their owen stratages. After a few repetetions, there appear huge amount of new agencies with different stratages. However, almost all agents act like their anscester unless they extinct rapidly.

Another modification is to put devils i.e., to insert a certain amount of DDD group after the worlds seems to be stable. The invader behaves as dangerous virus for human society. In

most cases, the population decreases rapidly, and usually the society no longer returns as before. DDD destroys all other groups, but DDD cannot survive since they do not cooperate. Finally no body survives.

The above case 2 used to fall into such catastrophe. This is the reason why I have said that it is vulunerable.

But in some cases, the world is more happy. A few surviving REF,TFT or SLF groups in remote corners begin counter-attack to the invaders. Finally they win; all the evils extinct and cooperative world came back again.

Further there have been known many interesting drama, but I must omit the details according to time-limitation.

6. Discussion

This is merely an experiment through computer simulation. The results are merely metaphor. But the above results are quite suggestive.

One must not be too selfish or egoistic among others. The group SLF does not always win, as expected earlier. It distinguishes so severely the others, that it looks like DDD for other groups. This also suggests the international behavior among many nations.

Though TFT wins in a repeated competetion as Axelrod did [1], it is not the best stratage with various agents, because simple TFT stratage used to be so aggressive for new opponents, that most agents estimate it as DDD. REF is better, but still not the best. Of course, there may be no best stratage for all.

Even in such a restricted world, we can see cooperation and survice spirit. Even cold-blooded machine can and must cooperate in the society of autonomous agents. Through such purely scientific research, we know again the importance of cooperative heart as most religion talk earnestly.

References

[1] R.Axelrod, The Evolution of Cooperations, Basic Books Inc., 1984.

[2] M.R.Genesereth - M.L.Ginsberg - J.S.Rosenshein, Cooperation without Communication, IAAA-86, IAAA Report 1986.

[3] Akira Ito - Hiroyuki Yano, Can cold-blooded machines ever cooperate.- The emergence of cooperation in a society of autonomous agents (in Japanese), 36th Programming Symposium by Information Processing Society of Japan, 1995, Report p.83-92.

[4] J.S.Rosenshein - M.R.F.Genesereth, Deals among Rational Agents. JJCAI' 85, 1985, p.91-99.

[5] robert Trivers, Social Evolution, Benjamin Commings,1985.