Norm Game and Indirect Regulation of Multi Agents Society

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Abstract

In this paper we focus on agent society and its indirect control. For the purpose we deal with the norm game as a material and introduce replicator dynamics (RD) of norm game. The norm game was introduced by R. Axelrod to explain how norm collapse [1].

We reformulate the norm game as a weak coupling model between two 1 dimensional RD. The one represents population dynamics of alternatives {C,D}. The other represents population dynamics of normative attitude. We also extend this model and introduce several types of centralized and decentralized indirect control mechanism on the agent society [2].
Key word: Norm Game, Multi Agent System, Replicator Dynamics, Indirect Control, Indirect Regulation, Poly Agent System

1. Introduction

In this paper we analyze the concept of the norm as a decentralized indirect regulation by using replicator dynamics (RD). RD is usually derived from random matching no cooperative game that represents evolutionary process [3]. In this paper we extend RD and use it for social learning process.

Axelrod introduced the norm game as an extension of n-person Prisoner's Dilemma. He added a new feature of normative attitude to the dilemma game such as punishing defector. Player's Strategy consists of two dimensions. He introduced the alternatives {Boldness, No-Boldness } and {Vengefulness, No-Vengefulness }. The former represents enough boldness to defect or not. In other words it means following the norm or not. The later represents enough vengeful to punish the agent who does not follow the norm or not. The later decision means mutual regulation of the norm.

We reformulate his norm game by replicator dynamics. For the purpose we introduce the concept of decentralized indirect regulation or indirect control of agent society. We also assume social learning interpretation of RD.

2. Norm and its Replicator Dynamics

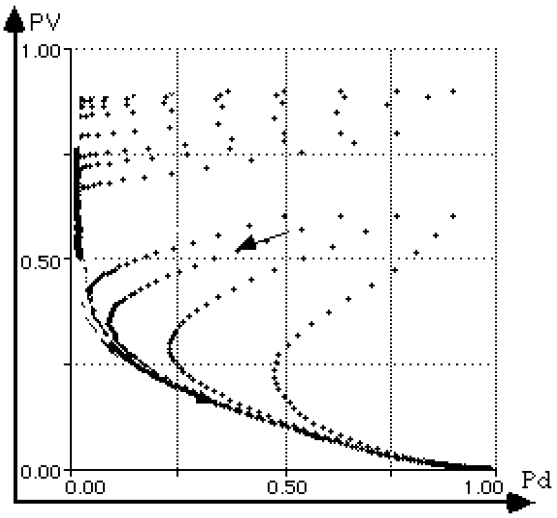
In the norm game if a player dose defect then he gets payoff T=3. Pd and Pc denote the normalized population ratio of the selection of Boldness and No-Boldness respectively. Pc=1-Pd holds from definition. PV and Pnv denote the normalized population ratio of the selection of Vengefulness and No-Vengefulness respectively. Pnv=1- PV also holds.

We introduce RD for Pc and PV as follows.

$dPc/dt = Pc*(1-Pc)*(EC-ED)$, $dPV/dt = PV*(1-PV)*(EV-Env)$

$EC = -1*(1-Pc)$, $ED = 3*Pc-9*PV$, $Env = 0$, $EV = -2*(1-Pc)$, $pd = 1-Pc$, $Pnv = 1-PV$

We add the perturbation factor to this model. Then we get the figure 1 as a result of simulation. The result shows the collapsing process of the norm and it corresponds to the Axelrod's simulation by using genetic algorithm (GA).



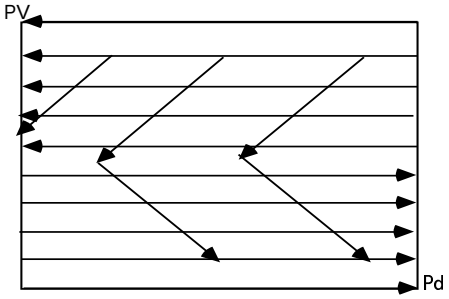


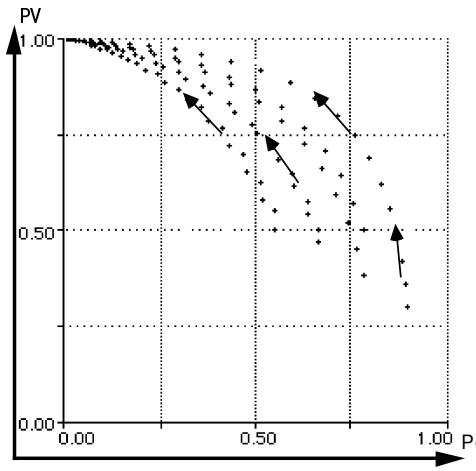
Figure 1 Norm Collapse **Figure** 2 Bifurcation of Pc Dynamics

The norm game provides a new conceptual model for the norm. The GA simulation provides experimental discovery such as collapsing process of the norm. On the other hand GA is a complex and complicated algorithm. It is difficult to extract systemic properties from the simulation. It is also difficult to extend the model to more general centralized and decentralized regulation process of an agent society. We reformulate the mechanism by the population dynamics called RD. When once we give the mathematical formulation then it is easy to analyze and extend the mechanism. The model consists of two 1 dimensional RD and its weak coupling. V becomes a bifurcation parameter for the basic dynamics of alternatives {C,D}. If PV is enough large then Pc increases. If V becomes small then the system bifurcates and Pd increases. The bifurcation structure is shown as figure 2.

Axcelrod's concept of meta norm is also shown as follows.

dPc/dt = Pc*(1-Pc)*(EC-ED), dPV/dt = PV*(1-PV)*(EV-Env)
dPMV/dt = PMV*(1-PMV)*(EMV-EMnv), EC = -1*(1-Pc), ED = 3*Pc-9*PV
EMnv = 0, EMV = -2*(1-PV), Env = -9*PMV, EV = -2*(1-Pc)
Pd = 1-Pc, Pnv = 1-PV, PMnv = 1-PMV

Figure 3 shows the result of the simulation of the meta norm.



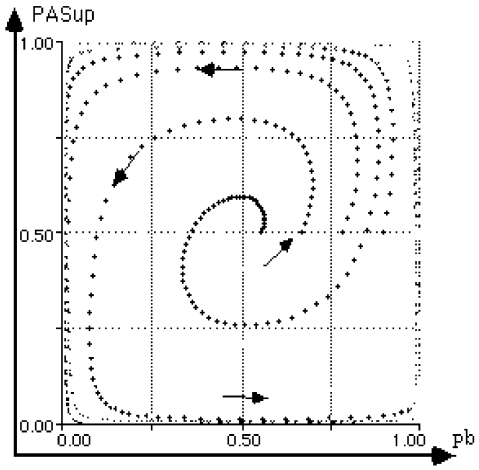


Figure 3 RD for Meta Norm **Figure** 4 Fashion Cycle

3. Decentralized and Centralized Indirect Regulation of Agents

When once we formulate the mathematical model of the norm and analyze its bifurcation mechanism then we can extend the model to the more general mechanism of mutual reference and sanction. We call the mechanism decentralized indirect control or regulation of an agent society. The word control and regulation are used in the same meaning depending on the context.

3.1 Fashion Cycle

The following is a model of the fashion cycle between alternative "a" and "b".
dPa/dt = Pa*(1-Pa)*(EA-EB)+fract1, dPASup/dt = PASup*(1-PASup)*(EASup-EBSup)
EA = 0*(1-Pa)+3*Pa+5*PASup, EASup = -5Pa, EB = 0*Pa+3*(1-Pa)+5*(1-PASup)
EBSup = (1-Pa)*(-5), fract1 = IF(Pa<0.5) then RANDOM(0,0.05) else -RANDOM(0,0.05)
pb = 1-Pa

The RD model for Pa and Pb include bandwagon effect of fashion that shows the following the current fashion. The model also includes avant-garde supporting attitudes for creating the next fashion that are denoted by ASup and BSup. The attitudes show anti bandwagon effect that leads next fashion. As a result the fashion of “a” and “b” circulate and ASup and BSup also circulate as figure 4 shows.

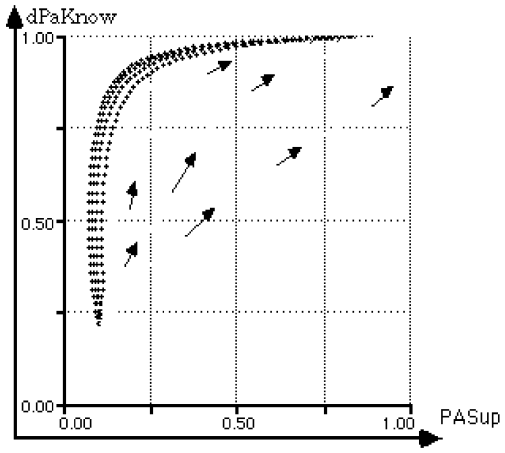
3.2 Education Effect and its Support

Next we add centralized indirect regulation that is shown as monitoring and sanction mechanism by the central authority to an agent society. The norm and the support have much effect on the basic alternatives as decentralized indirect regulations. Now we try to design another indirect regulation mechanism of an agent society. For the purpose we introduce two types of indirect control of centralized and decentralized ones. The RD model is shown as follows. We introduce the alternatives “a” and “b” and the following payoff table. In this case we assume that ”ASup” and ”BSup” are alternatives that mean mutual regulation mechanism of supporting the alternatives respectively depending on bandwagon effect and on the knowledge of alternatives. Alternatives “AKnow” and “Bknow” means the belief that “A” is correct and “B” is correct respectively. In the next simulation we assume that there is a political support for the “Aknow” and “a” is actual good solution as is shown in the payoff table. The initial conditions for the simulation assume that old belief such as PaKnow and PBSup are dominant. In other word the agent society is a slave to convention. But the educational support changes the situation drastically. As the right knowledge spread, agents who support right manner increase. As the right supporting manner spread, agents who chose the right select ion increase. People can abandon the old convention as a result to attain good social welfare.

Table 1 Payoff

	a	b
a	(2, 2)	(-5, 3)
b	(3, -5)	(-2, -2)

dPa/dt = Pa*(1-Pa)*(EA-EB)+fract1
dPaKnow/dt = PaKnow*(1-PaKnow)*(EAKnow-EBKnow)
dPASup/dt = PASup*(1-PASup)*(EASup-EBSup)
EA = -5(1-Pa)+2Pa+3PASup, EB = 3Pa-2(1-Pa)+0*(1-PASup)
EASup = Pa+2PaKnow, EBSup = (1-Pa)+0*(1-PaKnow)
EAKnow = polsupA, EBKnow = 0, polsupA = 1
fract1 = IF(Pa<0.5) then RANDOM(0,0.05) else -RANDOM(0,0.05)
pb = 1-Pa, dPBSup=1-dPASup, PbKnow =1-PaKnow



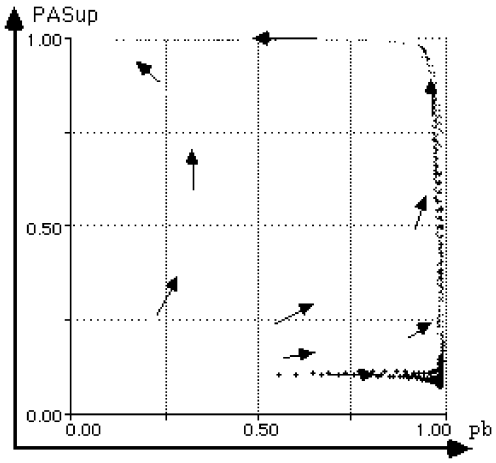


Figure 5 The spread of right knowledge **Figure 6** The spread of right attitude after defeat

We can show the typical example of this type of model. A great deal of effort was put into the project of birth control by the United Nations. But centralized sanction policy was failed. People do not want to change their belief or knowledge. Now they say that the spread of right knowledge and its support for birth control are only the way.

4. Conclusion

In this paper we formalized Axcelrod's Meta norm game by weak coupled replicator dynamics. In this approach we assume that RD represents social learning process. It is different from evolutionary interpretation of RD. To justify this assumption we have to derive RD from stochastic process of social learning. For the purpose it is sufficient to assume the transition probability Pcd and Pdc as Pd*Ed/W and Pc*Ec/W respectively.

We introduced higher order indirect centralized and decentralized regulation or control mechanism of agent society. The theory of indirect control for agent society is a new frontier for agent based approach. For developing this area both of agent based heuristic simulation and theoretical analysis are important.

Reference

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