Preferential selection promotes cooperation in spatial public goods game

报告人：史冬梅
中国科学技术

Public goods game

The evolution of cooperation among unrelated individuals in human and animals societies remains a challenging issue across disciplines. In this context, two models have attract most attention: the prisoner’s dilemma for pairwise interactions and the public goods games for group interactions.

No matter what kind of the games, normally it has three fundamental factors:

1, players

2,alternative strategies for the players

3,payoff of the players

In a typical PGG (public goods game) played by N individuals, each individual can choose to cooperate or defect. Cooperators contribute an amount C to the PGG, while defectors don't contribute. The total contribution is multiplied by a factor r (multiplication factor), and then redistributed uniformly among all players.

So for a player, the payoff is given bellow

$$P = \frac{rn_c}{N}C - C$$ for a cooperator

$$P = \frac{rn_c}{N}C$$ for a defector

Cooperation density is defined,

$$\rho_c = \frac{N_C}{N}$$

It is shown that for the values of r<N in the well-mixed population, the defectors will dominate the whole population.

Updating: after a interaction, players will consider the strategy in the next interaction, in the classical versions, they follow the strategies

1) Selective strategy : stochastic , select a neighbor randomly.
2) Updating strategy: Fermi principle. The player x will adopt the selected neighbor y's strategy in the next time step with a probability depend

depending on their payoff differences presented as

$$W(s_x \to s_y) = \frac{1}{1 + \exp[(P_x - P_y)/\kappa]},$$

P is the payoff , κ is the amplitude of the noise.

My work

1,model

A population of N=100*100 individuals on a square lattice. Each individual only has two strategies, cooperate and defect. Initially, the two strategies of C and D are randomly distributed among the individuals with equal probability. Each individual only interacts

his four nearest neighbors, and the payoff is

$$P_x = \frac{rn_c}{g} - 1, \quad if \quad s_x = C,$$

$$P_x = \frac{rn_c}{g} - 0, \quad if \quad s_x = D,$$

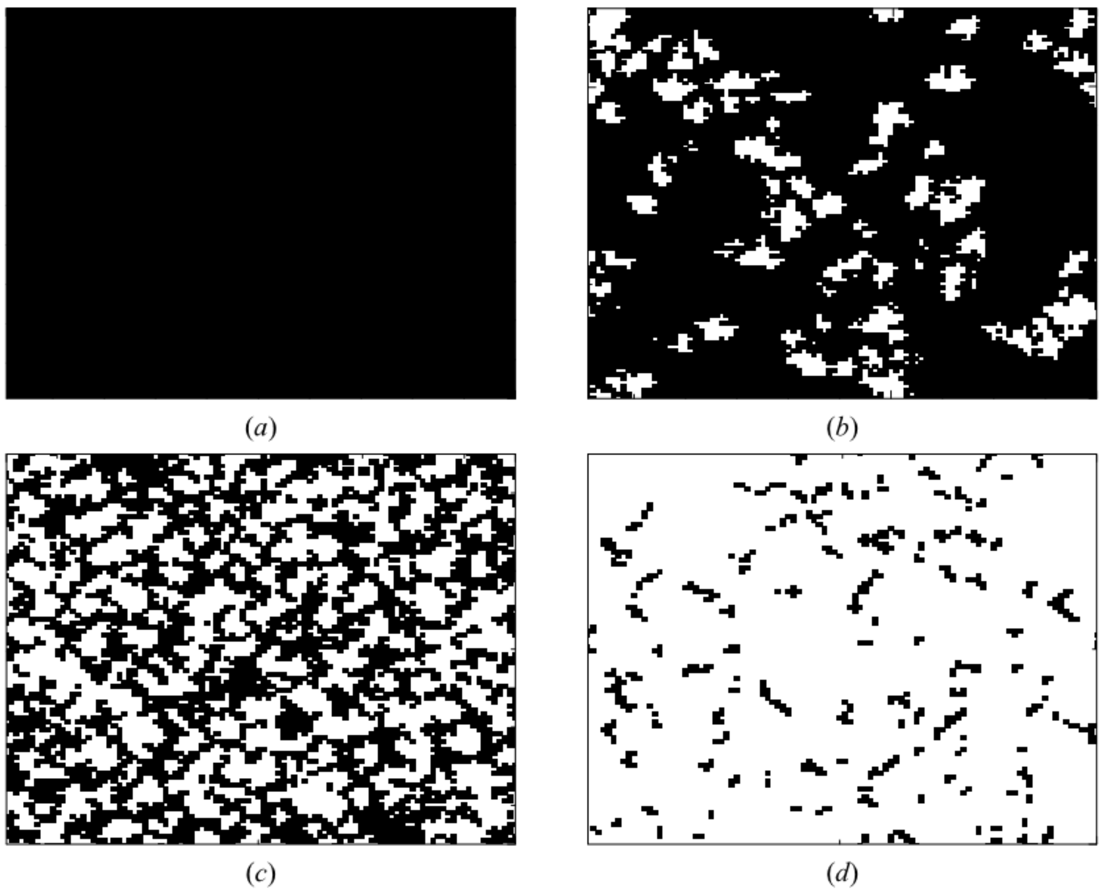
Innovation: preferential selected strategy

$$Q_{x\to y} = \frac{\exp(P_Y * A)}{\sum_{z\in\Omega_x}\exp(P_z * A)}$$

A=0, it returns to the original model. A>0, the neighbor with higher payoff has more probability to be selected.

Updating rule is the Fermi principle.

2,Simulation results



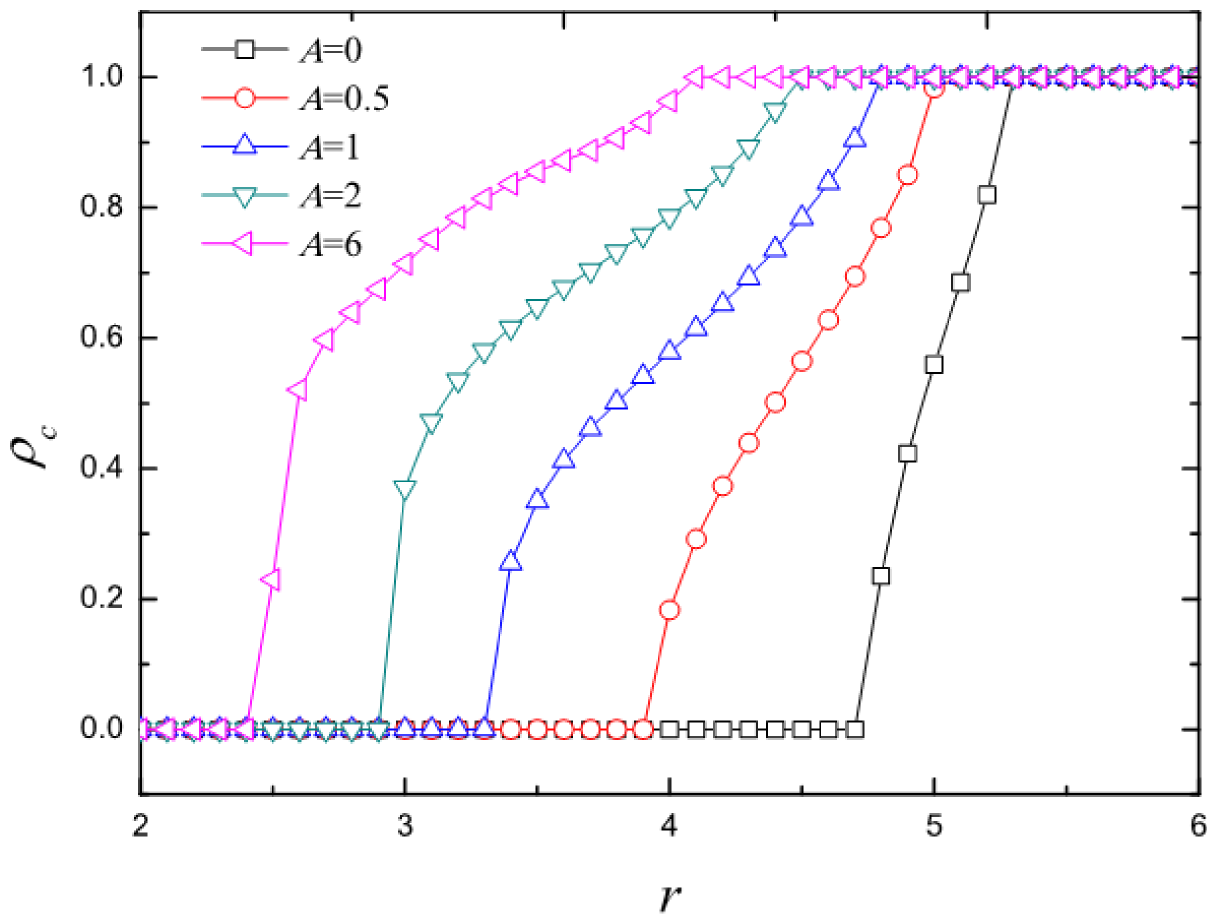
r=4.0,

(a) A=0

(b) A=0.5

(c) A=1.0

(d) A=4.0



A=0
A=0.5
A=1
A=2
A=6
1.0
0.8
0.6
0.4
0.2
0.0
ρ_c
2
3
4
5
6
r

Thank you very much

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