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Iterated snowdrift game among mobile agents with myopic expected-reward based decision rule: numerical and analytical research

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Abstract: Iterated spatial game among mobile population is an interesting problem in the fields of biological, social and economic sciences. Inspired by some recent works, this paper concentrates on iterated snowdrift game among movable and myopic agents. Two difference decision-making schemes, namely the utility-maximum rule and the Fermi rule, are applied and examined. In the former case, cooperation is found to be enhanced by moving velocity with an upperbound. The analytical results of the model are deduced at two extreme cases when agents cannot move or move quickly. In the latter case, the influence of velocity and temptation-to-defect are much more complicate. These results allow a deeper insight of related model as well as the emergence of cooperation.

Keywords: Iterated snowdrift game; Expected-reward; Mobile agent; Random-pairing.

1. Introduction

The emergence of cooperation among selfish individuals has attracted an amount of attention. In this light, game theory describes such cooperation and competition between individuals. In relation to this theory, two simple but classic games have been developed: the prisoner's dilemma game(PDG) and the snowdrift game (SDG). In each game, an individual has two choices: to cooperate (C strategy) or to defect (D strategy).

A cooperator earns reward R if he faces another cooperator, and receives reward S if his opponent chooses to defect (in this situation the defector earns reward T, T is often the highest reward, and is known as the 'temptation-to-defect'). If both defect, then each earns reward P. A reward matrix describes the rewards of the four different combinations as follows,

$$\begin{Bmatrix} R & S \\ T & P \end{Bmatrix}.$$

The reward matrices of PDG and SDG differ. In PDG, the reward matrix satisfies $T > R > P \geq S$, whereas that in SDG is $T > R > S > P$. Hence, always-defect is classically considered the best choice for both sides in PDG, and cooperators do not survive. By contrast, SDG encourages cooperation. Strategy C favors an agent when his opponent plays D, but D is the best response if his opponent plays C. Nonetheless, cooperators do not dominate the system in either case.

Spatial evolutionary game theory, which was pioneered by Nowak and May[1], greatly enhances research on the emergence of cooperation. In their model, an agent plays PDG with his "neighbors" in a 2D lattice structure. Cooperators gather in groups and survive the invasion of defectors. This work indicates that repetition and spatial structure are critical to the improvement of cooperative behavior.

The evolutionary PDG has since been extended to other spatial structures. In particular, the evolutionary PDG in complex networks has received much attention. Complex networks are considered good frameworks for the emergence of cooperation[2]. In addition to spatial structures, related studies also investigate the behavioral scheme of game agents. Factors such as age, individual learning abilities, and memory have been incorporated into new models to mimic real-world behaviors[3—6].

Meanwhile, SDG is also widely played in the real world. It explains many phenomena in the microbial

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