Topological Defects in Prisoner's Dilemma Game: Superiority of All Cooperate

Yu Itoh, Kei-ichi Tainaka, Naoto Ooka, and Tomoyuki Sakata
Department of Systems Engineering, Shizuoka University, Hamamatsu 432-8561, JAPAN

Introduction

So far, All Cooperate (AC, indicating unconditional cooperation) has been considered to be inferior to other strategies, especially to All Defect (AD) and Pavlov.

In the present paper, we introduce a patch system, and illustrate that AC beats not only AD but also any other strategy.

The Model and the Result

The PD game with noise is played among four strategies, AC, TFT, Pavlov, and AD, on one-dimensional lattice. The lattice site corresponds to a patch (or a family) which contains several players of a single strategy. Each player on a lattice site plays m games with players in the same site ($0 \leq m$), while he plays one game with those in its ajacent sites, respectively. The value of m may increase, when the relatedness among members in a family increases.

Simulation reveals that for $m_c \leq m$, the strategy AC completely wins the game. The critical value m_c depends on noise intensity x.

Conclusion

For various animals, altruism more or less evolves. The evolution of altruism among related animals has been explained by the theory of kinship (Hamilton, 1964) or selfish genes (Dawkins, 1976). On the other hand, the altruism among unrelated animals has been usually explained by TFT or Pavlov by the use of the terms "reciprocal altruism"; individuals mutually give their service. It is fair to say that from the altruism, one associates the strategy AC (Axelrod, 1984) rather than TFT or Pavlov. Hence, the superiority of AC, described in this paper, accounts for the evolution of altruism among unrelated animals.

According to the kinship theory, the relatedness plays an essential role to measure the degree of altruism. On the other hand, among unrelated animals, no measure has been presented. However, we introduce the quantity m which measures the degree of altruism among both related and unrelated animals. The frequency m increases with the increase of relatedness. However, this does not always hold; for example, if a parent live far from her eggs, then m (or relatedness) takes a small (or large) value. On the contrary, if an adult cares and lives together with a child, altruism between them may evolve without any relationship.

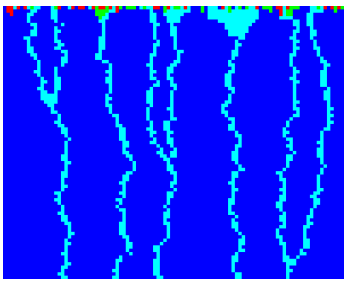

Fig. 1: $x = 0.1, m = 6$
Topological defects appers.

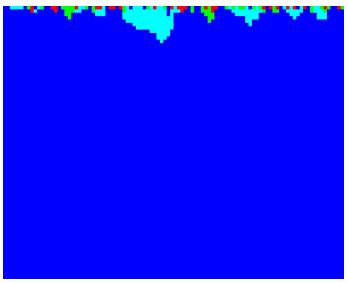

Fig. 2: $x = 0.1, m = 10$
AC wins completely.