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Physical Science & Biophysics Journal
ISSN: 2641-9165

The Latest Researches of Kharkov University on the Evolution of Population Behavior Scenarios

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Short Communication

Volume 8 Issue 1

Received Date: April 03, 2024

Published Date: April 29, 2024

DOI: 10.23880/psbj-16000270

Abstract

The results of research on the evolution of population behavior scenarios at the Department of Artificial Intelligence at Kharkov University are considered. The competition between different behavioral scenarios and population agents during the strategies evolution with memory is discussed. The strategies interact with each other in an iterative prisoner's dilemma, earning bonus points according to a payoff matrix. Research focuses on three collective characteristics, such as memory, level of aggressiveness (proportion of non-cooperation), and complexity of strategy (variety of behaviors). Different evolutionary scenarios arise when using different selection rules for strategies intended for removal in subsequent stages of evolution. PACS: 02.50.Le, 05.10.–a, 87.23.Kg, 89.75.Fb.

Keywords: Matrix; Complex Strategies; Aggressiveness

Short Communication

In studies, initiated by prof. Yanovsky V.V., a model of interaction between behavior scenarios of population agents is used based on the prisoner's dilemma [1]. The choice of the prisoners' dilemma matrix has previously shown itself to be very effective in modeling the behavior of scenarios and population agents (for details, see the bibliography in Kuklin VM, et al. [2]). In each interaction cycle, each strategy interacts once with all others. Most studies take into account all 128 thousand strategies with different memory depths. Zero memory does not take into account previous behavior; Memory equal to one takes into account only one last previous interaction. A memory of 2 is implemented when the strategy is based on the results of the interaction over the last two stages of interaction with one's participation. Strategies with memory react only to the remembered previous actions of opponents. The complexity is related to the number of different stages of behavior in one strategy. Aggressiveness increases with an increase in the proportion of refusals to cooperate. After receiving points (according to the prisoners' dilemma matrix), the losing strategies are removed. These underdog strategies can be considered to correspond to the unfortunate behavior of their owners. The duration of each evolutionary cycle is determined by the interaction of each strategy with all others.

1. An approach is considered when, after each cycle of interactions, all accumulated points remaining after the competition of strategies are reset to zero. Strategies that score the minimum number of points are deleted. Under selection conditions, the strategies that are most effective in terms of the number of points scored remain. It is important to note that the average complexity of strategies, as well as the average depth of memory of surviving strategies, practically does not change during

evolution. The history of the evolution of the population is divided into two periods: the primeval (primitive) period and the period of the developed "community" [1]. The primitive stage in the development of strategies is distinguished by the following features:

1. The presence of all the simplest strategies with zero memory.
2. An increase in average aggressiveness (the predominance of refusals of friendly behavior);
3. Having the most aggressive strategy possible.

It was found that as average aggressiveness increases, the number of points scored in the population decreases and vice versa, and there is a universal connection between these values. Despite the above typical average behavior, initially aggressive strategies and primitive strategies with low complexity may turn out to be winners at different points in time. First, average aggressiveness increases. Then, having overcome the primitive stage of development of the world, aggressiveness quickly decreases. By the way, an increase in the average depth of memory for strategies reduces the relative duration of the primitive stage of development and increases the proportion of complex strategies. A paradoxical fact was discovered in these numerical experiments: Friendly scenarios clearly benefit, despite the experimental conditions encouraging hostility and non-cooperation.

2. An interesting case is the evolution of a set of strategies with the accumulation of advantages between generations [3] (when strategies do not reset their scores between cycles). In such a world with zero memory, the most primitive and aggressive strategies win at the first stage. Their history consists only of the primitive period. However, despite the increased vitality of aggressive and primitive strategies in the case of non-zero memory, they still disappear in the process of evolution. All later stages of evolution are dominated by complex strategies. The average aggressiveness of such strategies monotonically increases during evolution. The rate at which the strategy population gains points decreases during periods of increased average aggressiveness. That is, the inverse relationship discovered in numerical experiments between changes in average aggressiveness and changes in the rate of gaining points remains. The most complex strategies with the maximum possible memory dominate, but their aggressiveness is also great. A stationary state with aggressive strategies of maximum complexity is formed. Complexity and memory, as in the previous case, turn out to be evolutionarily advantageous. Thus, by allowing strategies to maintain previously gained advantages, the system rewards aggressiveness.

3. Let's consider another more radical version of an aggressive world. Let the most successful ones, those with the highest number of points, be deleted after each cycle of interaction of strategies. This version of evolution can be imposed on the population, that is, some force intervened. Evolutionary selection prevents the use of the most successful behavior scenarios. Moreover, even with zero memory, primitive strategies quickly gain points. Average aggressiveness first reaches a minimum, and then quickly increases. The set of advantage points behaves exactly the opposite. For strategies that win the competition, aggressiveness and speed of gaining points behave approximately the same. In the case of non-zero memory, primitive strategies also quickly disappear. Very aggressive strategies with the highest memory and complexity dominate. But as in previous cases, complex strategies with large memories remain evolutionarily advantageous, although they are characterized by significant aggressiveness [2].

4. You can introduce agent-subjects who have a set of preferred behavior scenarios [4]. The choice of strategies is random. It is important that now subjects - individuals have new characteristics - average memory values, complexity and aggressiveness of sets of assigned strategies. The strategies initiated by each agent compete in pairs according to an iterated prisoner's dilemma. The losing strategy is removed. Since the number of strategies from memory level 2 is always more than two orders of magnitude greater than the number of strategies from memory 1, it is clear that out of the fifty strategies of each subject, almost all have memory 2. Moreover, the average complexity of the complete the set of strategies in subjects with such memory 2 remains virtually unchanged. Aggression grows and reaches its maximum value in a steady state. The most interesting thing in this case is the nature of the distribution of strategies. The maximum presence of one strategy in the stationary resulting state of the "community" was not observed. The initial set of strategies for each agent contains equal shares of strategies with different memories, and the distribution of strategies by complexity is random and very different. The average complexity does not change, but for individual agents the complexity behavior is quite capricious. On average, the agent retains strategies, although the total number of strategies is reduced by almost 18 times. Average aggressiveness increases and maximum aggression is observed in steady state. But in all cases, the depth of memory and complexity of strategies is an evolutionarily advantageous property. Aggressiveness and the number of points obtained - evolutionary advantages change over time in accordance with the empirical universal law discovered and described above.

5. The increase and maximum number of strategies in the presence of an external source of new strategies is achieved with the maximum complexity of the added strategies [5]. In all cases, the aggressiveness of the strategies decreases. It can be seen that the average complexity of surviving strategies in all considered cases 1-5 increases during evolution, because this is what determines the direction of the time vector.

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