Review

Student: **Zhang Boxin**

Title: **Irrational-Behavior-Proof Conditions for the Group Pursuit Game**

Zhang Boxin's graduate qualification work delves into the problem of one-pursuer-multiple-evaders pursuit-evasion game, proposing, for the first time, an acceleration for the evaders. Through analyzing the pursuit-evasion problem under nonzero-sum and matrix game frameworks, the author puts forth insightful viewpoints and achieves significant results through empirical analysis. From a mathematical perspective, the author skillfully integrates two different types of games into a single model, demonstrating a profound understanding of game theory. Importantly, the author utilizes computer simulation to derive the players' payoff matrices within the matrix game framework and analyzes the strategy variations under rational and irrational behaviors.

In the first three sections, the author initially introduces the innovative aspect of this article in the abstract, which is the introduction of a new velocity-\alpha^+, for the pursuer to serve as a punish velocity used for capturing when the evader deviates from the prescribed direction of movement. The author elucidates the findings of this paper in nonzero-sum game and matrix game. Subsequently, a brief overview of game theory is provided, including its emergence in the early 20th century and subsequent development. Due to the continuous evolution of game theory, numerous branches have emerged, and the author describes several major branches that have arisen from it. As this paper focuses on the study of pursuit-evasion game, the author describes the arguments of some researchers in this field in the relevant literature. Based on this, the author identifies a departure from previous research by introducing an additional velocity for the pursuer in the pursuit-evasion game involving one pursuer and multiple evaders.

In the fourth section, the author presents the entire game model, utilizing differential equations to describe the players' movements. The process of the game is outlined, detailing the strategies for both the pursuer and the evaders, as well as the punishment strategies, and how their payoffs are calculated.

In the fifth section, a nonzero-sum pursuit game is defined. Two escape strategies are introduced for the evaders: moving either in the direction specified by the pursuer or deviating from the original direction. By determining the capture point and the coordinates of the evader's position at different time instant, the existence of Nash equilibrium is geometrically demonstrated. Additionally, the effective conditions for the pursuer's punishment strategy are separately proven for cases where the evaders have either the same or different velocities.

In the sixth section, the author views the evaders as a whole and defines a matrix game with the pursuer, providing a new description of the different strategy combinations and calculation methods for the payoff matrix between the pursuer and the evaders. The author uses a graphical representation to illustrate how the evader changes the pursuer's pursuit order at different times. Assuming the evaders are

positioned symmetrically in four coordinate systems, the pursuer's two velocities are altered, and a computer simulation is conducted to obtain the payoff matrix. Using the maximin principle, the author investigates the strategy changes of the evaders under rational behavior. Furthermore, based on the simulation results and the previously obtained conditions for effective punishment strategies, the author examines the strategy changes of the evaders under irrational behavior.

At the same time we can make the following suggestions for further research:

In this paper, the author only discusses the case of four evaders in the nonzero-sum game. Although this simplification is advantageous for the subsequent study of matrix games, it can also be extended to investigate scenarios involving a larger number of evaders.

Furthermore, matrix games may overlook the issue of asymmetric information between pursuer and evaders. For instance, pursuer may not have access to real-time location information of the evaders. This is a consideration the author needs to address in practical scenarios.

The given remarks don't reduce the high level of work of the applicant, from what follows that the graduate qualification work Zhang Boxin 'Irrational-Behavior-Proof Conditions for the Group Pursuit Game' is a completed scientific qualification work.

The graduate qualification work demonstrates a certain level of innovation and depth in both theoretical research and empirical analysis; it meets the requirements for master's graduate qualification works. Set goals and objectives, successfully solved. The author Zhang Boxin deserves the grade 'good' and the awarding of the master's degree.

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