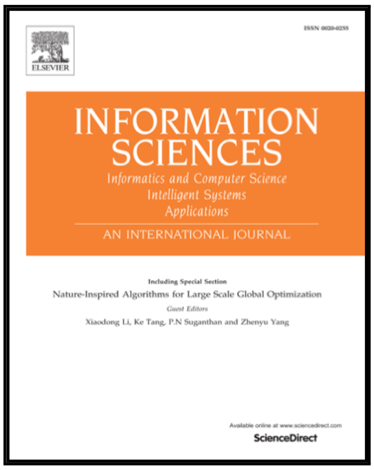

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Linguistic Geometry Approach for Solving the Cops and Robber Problem in Grid Environments

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Abstract—The Cops and Robber problem is a game played between two adversary groups, in which one group (cops) attempts to capture the other group (robber). In this paper, the *optimal capture time problem* is addressed, which seeks the best motion strategy from the viewpoint of the cops for capturing the robber within the minimum time or number of steps, and a new algorithm based on linguistic geometry (LG) is proposed. LG is widely used for solving two-player abstract board games and wargaming problems by breaking the system (problem) into several subsystems, in each of which the playing elements and their paths (called 'trajectories') are identified, and a network consisting of these trajectories is constructed. A solution is identified by searching the subsystems by the alpha-beta pruning method. Also, to provide a lower bound for the robber's capture time, we have enhanced the alpha-beta pruning method by incorporating a new admissible heuristic more informed than existing heuristics. As a result, the branching factor of the search is decreased, and the problem is solved more efficiently. For experimentation, several cops and robber problems on regular and holed square grids were solved by the LG-based method, and the results were compared with the Reverse Minimax A* (RMA*) algorithm. According to the results, the presented algorithm requires far less computational time and memory than the RMA* method (in fact, approximately 95.5% and 97.5% are saved on average, respectively), and near-optimal solutions were obtained. Also, it was observed that while increasing the number of cops severely affects the computational time and required memory of the RMA*, it has insignificant effects on our algorithm.

Keywords: Pursuit and Evasion; Cops and Robber; Linguistic Geometry; α–β Pruning; Forward Estimation; Decision Tree

Introduction

In a Pursuit-Evasion game, one or several pursuers attempt to track down members of a team of evaders [8]. In robotics, pursuit-evasion is considered as an adversarial game that has lots of applications such as rescue and search, network security, security systems design, hide and seek, capturing burglars, and traffic control [12]. This game is sometimes played in the worst case, like in rescue and search, where the searchers do not have any information about their adversaries and must find a strategy that guarantees their success in finding the evader(s) with any random movements.

The pursuit-evasion problem has been studied in many variations, and so a vast range of subproblems exist in the literature. Various elements that create such variations include [12]: Environment (continuous, graph, polygon, or grid); Information (completely known, visibility known, or unknown); Controllability (in speed and angle rotation); and Capturing (seeing or touching). There are two important questions that must be answered in all pursuit-evasion problems [10]: (1) what is the minimum number of pursuers sufficient for capturing the evaders? and (2) what is the best strategy for the pursuers to capture the evaders within the minimum steps or time?

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