Title	パズルの解法アルゴリズムと情報推移に伴うエンターテインメントの解析
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Abstract

As a human activity with an ancient history, games not only serve for fun but also promote the development of entertainment technology. The vast majority of puzzle games are known as single-agent games in the area of mental exercises, such as N-puzzle and Rubik's Cube. Solving puzzles helps to understand better information variation and stochastic characteristics in the solving progress. Puzzles can be divided into two categories: puzzles without hidden information and puzzles with hidden information, representing the certainty and uncertainty factors in the puzzle-solving process, respectively.Uncertainty in a puzzle affects the way players experience entertainment and affects the solvability of the puzzle. In general, the purpose of a puzzle is to allow the player to explore for the optimal solution. Recent related work on applying search algorithms to the puzzle domain can be divided into two directions. The first direction is using puzzles as experimental platforms to verify the performance of the algorithm, while the other is using the search algorithm to find the optimal solution to the puzzle. Few studies have focused on hidden information in puzzles on solvability. However, observing the information in the puzzle-solving process may lead to a link between the puzzle and the game.

In this thesis, the A* algorithm was used to solve N-puzzle and dynamic information in the solving progress. It explores information by solving puzzles in an optimal way and entertaining analysis way. In addition, a solving strategy based on Gauss–Jordan Elimination and Constraint Satisfaction Problem was proposed to solve Minesweeper to explore the link between puzzles and games. The winning rate based on this strategy provides a new perspective on the definition of puzzles.

This thesis focuses on solving puzzles, and its entertaining analysis of information progresses. (1) Solving an 8-puzzle with the randomly generated initial position using the A* algorithm as the AI player. By adopting total steps to solve the game and the success rate as the game progress model, the attractiveness and sophistication of this puzzle have been discussed. Such findings could contribute to the evolutionary changes in

sliding puzzle games. (2) To develop an AI solver of Minesweeper with the configuration of $9\times9|10$, $16\times16|40$, and $16\times30|99$, based on the obtained information on the board, called the 'PAFG' strategy, which stands for the primary reasoning, the advanced reasoning, the first action strategy, and the guessing strategy. The first two strategies take advantage of knowledge-based rules and linear system transformation (Gauss-Jordan elimination algorithms) to determine the probability of making a move independently. The last two strategies explore the beginning and ways to determine hidden puzzle states to enhance the winning rate of the AI solver. Such an AI solver could contribute to classifying single-agent stochastic puzzles and establishing the boundary of the puzzle-solving and game-playing paradigm. (3) To explore puzzle categories based on the perspective of Minesweeper solvability and find the border between puzzles and games, as well as study the motion in mind to the entertainment analysis of solving puzzle field. Moreover, to discover significant characteristics from the perspective of information dynamics in the solving process and reveal the internal laws behind players' behavior. The experiment demonstrates the link between solving puzzles and playing games from an entertaining analysis view. Even more, it has become indispensable in the field of puzzle-solving and entertainment analysis and influences the way of puzzle-solving and the solving experience.
Keyword: *Puzzle Solver*; *Information Dynamic*; *A* algorithm*; *Gauss–Jordan Elimination*; *Constraint Satisfaction Problem*