Title	ゲームの定量的解析およびゲームプレイ体験の評価
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Abstract

Over history, games have served multiple purposes. It serves as a fun activity for players who need entertainment to become test-beds for artificial intelligence. Solving games is beneficial in providing a better understanding of how information is progressing throughout the game. Applying search algorithms to solve games divides the game-tree into two areas: "explored nodes" and "unexplored nodes", each signifies certainty and uncertainty value in the game respectively. Uncertainty in games does not only affects the way a game is solved, but also the way the game is experienced. A game typically progresses from uncertain state to certain state. Currently, a game progress can be observed using two different approaches. The first approach is by monitoring its game progress pattern using a certain indicator while the second approach is by analyzing and observing the game information progress model. Previous works have interpreted uncertainty in the game progress through various means, but there has been no clear links among those interpretations. Observing the effect of uncertainty in the game may lead to the linking between those definitions.

In this thesis, the probability-based proof number search and single conspiracy number, which derived from the idea of Conspiracy Number (CN), were used to analyze how uncertainty affects various elements of games. The probability-based proof number search is a domain-independent best-first search algorithm which main purpose is to solve games. It exploits information from both areas of a game-tree by combining certain and uncertain information to reach convergence. The single conspiracy number is an indicator used to evaluate the difficulty of the current state of the game. It is useful to evaluate progress patterns and long-term positions, as well as to evaluate game playing positions.

This thesis focuses on understanding the influence of uncertainty in the best-first search game computation along with its impact on game entertainment. To achieve it, we are guided by three purposes: (1) To find the optimal difficulty ordering procedure for game solver for different game-tree structures. To see how the uncertainty affects ordering process in best-first search, the probability-based proof number search is deployed into several games with notably distinct structures. Results from the experiment on a total of 1000 Othello positions from different stages of the game revealed that information coming from uncertainties affects the result differently in each stage. It expedites the convergence of solved positions, reaching 100% in the end-game positions. Later, the framework is expanded into a single-player game.;(2) To define the indicator for entertainment using a game-tree search framework and (3) To define the link between the game-tree search result and entertainment indicator in different game environments. Using the single-conspiracy number as a game position evaluation indicator based on expert play demonstrates that it can show progress continuity. Furthermore, the indicator is expanded into a single-player game. The expansion result shows the game progress related to simulated players' ability. Finally, the result is used to find the momentum and potential energy of a single-player game using the motion in mind concept. The experiment demonstrates the link between the search indicator of a game-tree and the measure of entertainment. In the end, it is concluded that uncertainty plays an important part in game computation as well as game entertainment. Even more, it has become a requirement in both computation and entertainment measure, as it impacts both the quality of games' computation result and also how the game-playing experience is perceived.

Keyword: *game solver, game progress pattern, probability-based proof number search, single conspiracy number, motion in mind*