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Decision Complexity Estimation of Game Positions to Establish Master's Global Perspectives and Aesthetics of Well-Played Games

Abstract

 Although computer shogi has reached the master's level in terms of strength to win, there are performances that only the master can do, such as flexible strategies by global perspectives and resignation respecting aesthetics. The purpose of this study is to clarify an important factor for understanding the master's thinking.

 The notion of decision complexity is important to understand the depth of master's thinking in the domain of game playing. This thesis concerns the estimation of decision complexity of game positions based on the concept of conspiracy numbers. The estimation methods are proposed and applied in the domain of shogi to establish the master's global perspectives and aesthetics of well-played games.

 Chapter 2 outlines the programming technologies which have been developed in the two-person complete-information games such as chess and shogi. In addition, we describe an overview of computer shogi *Shueso* that has been used for the verification of the proposed ideas in this study.

 Chapter 3 presents two estimation methods of decision complexity of game positions in shogi. The number of nodes visited during a search which is restricted to the advantageous positions is similar to the disproof numbers for wins in the proof number search (Allis et al. 1994). Therefore, the first approach indicates the difficulty for wins with focus on the effective branching factor in a game-tree search. The validity of this estimation method can be confirmed by analyzing the initial positions of handicap matches. The analysis results show that the degree of difficulty or decision complexity decreases as computer's performance becomes higher. The second approach for estimating decision complexity uses the correlation coefficient between two evaluation values of the root node and leaf level of a game tree. Search is performed to determine the evaluation value at the root node with focus on the ratio between positive and negative values of position scoring at leaf nodes. We verify the validity of this approach by self-play tournament of handicap matches. The proposed method is able to identify the balanced games or well-played games by estimating the decision complexity.

 Chapter 4 explores the resignation positions identification in shogi. A similar factor to conspiracy numbers or proof numbers is effective to identify the resignation positions. Then, a resignation model was proposed using the effective branching factor of a game-tree search which is restricted to the advantageous positions. In order to confirm the validity of the proposed model, we analyzed actual game positions played by grandmasters, in which they resigned later on. Recognizing that the effective branching factor is reduced, the proposed model can reflect the characteristics of the resignation positions.

 Chapter 5 focuses on the artistic assessment of experts by using more insightful information than positional scoring in the minimax tree framework. Several games, played by masters and computers in the domain of shogi, were analyzed while applying the proposed method. The results show that the ratio between positive and negative values of position scoring at leaf nodes can be a practicable factor for decision complexity, and effective information can also be obtained from the velocity and acceleration of this factor. Furthermore, the play of masters and the difficult or interesting positions could be identified by the correlation coefficient of the estimated evaluation values with Kalman filter more clearly.

 The proposed decision complexity is useful factor for understanding the master's global perspective and aesthetics of well-played games to impress the spectators. The research results are expected to affect the breakthrough of the expert's thinking and the mechanism of impression in the other fields.