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AI players that play mind games like humans in imperfect-information simultaneous games

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Artificial intelligence (AI) techniques are actively researched in various fields, including image processing and natural language processing. These techniques are expected to be further developed and contribute to society. Games are also one of the actively researched fields. As a symbol of intelligence, for games such as chess, it has long been a goal to create AI players that surpass human players. Although this goal has been achieved in many games, such AlphaGo for the game of Go, there are still many issues to be addressed in research to use AI players in various ways other than being strong opponents. Examples include "entertaining" and "teaching".

In imperfect information games, where players cannot accurately grasp some information, there are Nash equilibrium strategies that are not taken advantage of by the opponents. However, it is infeasible for human players to obtain such strategies in complex games. Therefore, human players usually try to "read" their opponents' minds to predict the opponents' information and actions. The players then choose actions that may give them advantages according to the predictions. In some games, most human players choose their actions based on "mind games" where the players try to read the opponents' minds and also consider that their minds are read by the opponents. This kind of gameplay is an important element in the enjoyment of the game.

However, only a few researchers focused on creating AI players that play mind games. Existing AI players are hard to produce behaviors as they are playing mind games. This is one of the challenges for AI players in some imperfect information games.

In this study, we focus on simultaneous games (i.e., players choose actions at the same time) and try to make AI players play human-like mind games. We propose a simplified version of Pokémon battle, a game in which the main strategy among human players is to read each other's actions based on type superiority.

We propose a method to play mind games, which is to generate moves that human players find natural (called standard moves) and then strengthen moves with human-like habits or tendencies and moves that mimic humans' reading (called bias moves). The AI player for the proposed method consists of a standard move generator, a bias move generator, and an exploitation strategy. The approaches and their effectiveness are explained as follows.

The standard move generator generated standard move strategies that look natural to human players. As the first step, we created AI players based on the Monte-Carlo method. These Monte-Carlo players were strong to some extent, where the win rates against random players were higher than 97%. However, we also confirmed that some moves were unnatural due to problems such as overestimation or underestimation of states.

To solve these problems, we calculated the theoretical win rates (payoffs) for all states of the simplified Pokémon battle by retrograde analysis. We then created a Nash player that follows the Nash equilibrium strategy based on the payoff matrix. The Nash player had a win rate of 72% against the Monte-Carlo player. In addition, the Nash player had fewer unnatural moves that would be considered "bad moves" by humans. However, we face two new challenges. First, the Nash player is too strong as an opponent for average human players. Second, the Nash player sometimes fails to select moves that seem promising to humans.

To adjust the strength of the Nash player, we created a δ-Nash player that adds noise of size δ to the payoff matrix (mimicking human misperception) before finding a Nash equilibrium strategy. Taking the initial state of the game as an example, the δ-Nash player uses a mixed strategy in which three or more actions, including moves that look promising to humans, are selected probabilistically. We consider that this makes the AI players more human-like in the game. In an evaluation experiment, we let the δ-Nash players with different δ settings play against the Nash player. The win rates were between 31% and 53%, which means that we could adjust the strength of the δ-Nash players by varying δ.

The bias move generator generated move strategies with human-like habits and tendencies by adding additional biases to the payoff matrix for the δ-Nash player. We created four players with different biases: favoring attack, favoring exchange, favoring effective attack, and favoring ineffective attack. We confirmed that the four players had higher probabilities of selecting the moves corresponding to the preferences we assigned. The player favoring attack selected 8% more attacks than the δ-Nash player, the one favoring exchange selected 13% more exchanges, the one favoring effective attack selected 26% more effective attacks, and the one favoring ineffective attack selected 29% more ineffective attacks.

When evaluating the strength of the biased players in terms of their win rates against the Nash player, we found that even the player with the worst win rate (the player favoring ineffective attacks whose win rate was 43.6%), the win rate was comparable to the δ-Nash player whose win rate was 45.6%. The results indicated that the biases did not force the biased players to select the biased moves in states where these moves were clearly inappropriate.

In addition, we conducted experiments to examine the effects of noise δ and bias parameter α on player strength and move probability. We found that the noise δ and the bias parameter α can be adjusted relatively independently for the strength (win rate) and the move bias, respectively. This allows us to create a variety of move strategies suited to playing mind games.

Finally, for the exploitation strategy, we proposed a method that mimicked human players' reading in games to make human players believe that they have been read. This method has not yet been evaluated with a complete implementation and will be left as future work.