A support system to help fighting game beginners understand mind games

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Artificial intelligence (AI) techniques are actively researched in various fields, such as natural language processing and image generation. Games are also good testbeds for AI that is actively researched. In recent years, AI players have already achieved superhuman levels and beaten professional player (e.g., AlphaGo for the game of Go). Research on AI pursuing "strength" has archived a certain level of success, and research on "teaching" and "entertaining" are new directions to focus.

Fighting games are a kind of digital game where player controls a character to fight one-on-one in real-time. Fighting games are known as a genre with high barriers to entry for several reasons. One is difficult operations; another is that luck is almost not involved in the gameplay, making beginners hardly win against experienced players. We consider that the "mind games" are another big problem preventing beginners from keeping playing the games.

"Mind games" means that players mutually decide their own actions, where guessing the opponents' decisions is also taken into consideration. Mind games occur in daily life, such as rock-paper-scissors game. In these games, it is basically possible to calculate the optimal strategy by game theory, even without mind games. However, in fighting games, possible actions and their risk-return varies with various conditions. Therefore, it is difficult to calculate the optimal strategy, and players need to guess the opponents' actions (read the opponents' minds). The same is true for the opponent, so mind games occur.

The purpose of this research is to help beginners of fighting games to understand mind games. Fighting games contain various elements, such as real-time gameplay and difficult operations, which requires considerable practice before players can experience mind games. Therefore, it is difficult to teach beginners to play mind games in actual fighting games environment. So, we developed a game that can play mind games of fighting games without real-time gameplay and difficult operations. The game is based on rock-paper-scissors game, and the trilemma of rock, paper, and scissors is replaced by "attack", "throw" and "guard" from fighting games. And we created curriculum which provide comprehensive supports for beginners to understand the concept of mind games.

We selected several ways of thinking for mind games that we want to teach and prepared multiple opponents for each way. The combination of a way of thinking and the corresponding opponents formed a learning unit, and

in this research, six learning units were created. The six created learning units were arranged in order from those with typical ideas to those with gradually more complex ideas. The opponents' actions were designed to reflect the way of thinking in the corresponding learning unit, and the order of the matches against the opponents was also arranged in a similar way to the learning units, from opponents who take typical actions to those who gradually get more complex. During the matches, participants were asked to answer the probability distribution of the opponent's next action through choice problems. We used the accuracy of these choice problems to judge whether or not the participant understood the way of thinking set to learning unit. In each learning unit, we also supported players by presenting hints such as information such as the way of thinking set to learning unit and the points to be focused on for each opponent. The order of the learning units, opponents for each learning units, and the hints set for each are collectively referred to as the curriculum.

An experiment was conducted to verify the effectiveness of the created curriculum. In the same experiment, the effectiveness of the order of the learning unit was also verified. The experiment compared the results from three groups: a group receiving the curriculum (hereinafter, called Curriculum group), a group randomly playing against opponents within the curriculum (hereinafter, called Random group), and a group playing against participants same group for the same amount of time as the other groups (hereinafter, called PvP group). A pre-test and post-test were implemented before and after experiment of each group to compare the accuracy of choice problems. This experiment was conducted with a total of 12 participants, four in each group.

The result of experiment showed that even the group with the highest accuracy only increased by 9.0%, from 10% to 19.0% . The accuracy for each participant varied widely, and no trend was seen from all the groups. In a subjective survey, only 2 out of 8 participants felt an improvement in their prediction accuracy. The overall results were poor, but valuable insights were gained into the curriculum and game design. Points to be improved included probability deviation, criterion for correct answers of choice problems, and the difficulty of the test opponents.

The biggest issue was that in playing against an opponent who chooses action based on probability, the influence of luck was too strong. For example, consider an opponent who chooses each of the actions of attack, throw, and guard with a probability of $\frac{1}{3}$ .Assume that the opponent made 7 action selections with a deviated frequency: attack 4 times, throw 3 times, and guard 0 times. In this case, choosing the choice of attack 50%, throw 50%, and guard 0% as an answer to the choice problem is reasonable, but in

this experiment, we judged this answer to be incorrect because it is not the true probability distribution. As a result, participants who could not proceed the curriculum due to low accuracy of choice problems were often seen. Therefore, in the first place, we attempted to improve the curriculum by correcting the probabilities to prevent the frequency becoming deviated, and by judging not only the true probability distribution but also choices close to the actual frequency of the opponent's actions as correct answers.

About the difficulty of the test opponents, both of pre-test and post-test had very low accuracy of choice problems, so we consider the test opponents were too difficult. Therefore, we reduced the difficulty of all opponents and increased the variety of the test opponents to to let participants match against opponents with various difficulty. In addition, we attempted to improve various points that obtained by first experiment.

The second experiment was conducted after improving the curriculum and game design by addressing the issues found in the first experiment. The experimental method and comparison method were the same as the first experiment. The number of participants in the second experiment was 20, with 6 participants in each of Curriculum group and Random group, and 8 participants in PvP group. In the result, the difference in accuracy between the pre-test and post-test showed an increase of 11.0% from 34.0% to 45.0% in Curriculum group, 14.0% from 41.0% to 55.0% in Random group, and 2.0% from 34.0% to 36.0% in PvP group. However, no significant difference was shown between pre-test and post-test or between each group. As for the accuracy of each participant, the growth rate varied, and there seemed to be a relationship with the proficiency of Japanese. According to the subjective survey from the questionnaire, the results improved compared to the first experiment, and 11 out of 12 participants answered that they felt the accuracy had increased. Compared to the first experiment, the numerical growth and subjective survey showed good results, but new issues to improve were also found, such as finding concise and easy easy-to-understand hints.