Puzzle Generation for Improving Players' T-Spin Skills in Tetris

1810027 Taishi Oikawa

Games are not only an important culture of human beings but also a good testbed for research in information science. With the development of techniques such as deep learning, computer players have already achieved superhuman levels in many games. Other than this, more and more attention in recent years has been given to research in artificial intelligence (AI) for making games more interesting and improving players' satisfaction. For example, AIs are applied to generate game content such as maps and stories automatically, create teammate computer players, and assist human players in improving playing skills by computer coaches.

Tetris is a popular falling block puzzle game, which was originally designed as a single-player game. In recent years, competition variants for two or more players also gain increasing popularity. In competition variants, when players clear multiple rows at a time, they can "attack" the opponents. Moreover, clearing rows by some special techniques can cause greater damage to opponents than usual. T-spin is such a technique and has a significant influence on players' strength. However, making patterns for clearing rows by T-spin is one of the biggest obstacles for beginners, which makes players struggle to improve their playing skills.

To make T-spin patterns, players need to arrange cleverly the blocks, or so-called tetrominoes, given in random order. The task itself is not easy, not to say the stress caused by time limits on placing tetrominoes or opponents' attacks. Thus, it is difficult to practice the T-spin technique through real plays. Environments close to real plays, but not stressful, for players to practice efficiently are desirable but insufficient. Not limited to Tetris, this is also an issue for many games.

This research aimed to clarify how to assist human players in quickly mastering important but hard-to-learn techniques. More specifically, we focused on a training system for learning the T-spin technique in Tetris. We also verified the effectiveness of the system.

In this research, to train players efficiently for learning T-spin, we proposed "T-spin puzzles." The concept was similar to tsume-go (life and death problems for the game of Go) and tsume-shogi (mating problems for shogi). Players would be asked to accomplish tasks such as "making a T-spin pattern with the two given tetrominoes." Although the puzzles are only parts of the gameplay, players could become familiar with T-spin patterns so as to improve their skills.

Usually, puzzles were designed by human experts. However, a massive generation was impractical due to time-consuming and the limited number of experts. To overcome this problem, we applied the "reverse method," which removed tetrominoes one at a time from T-spin patterns, to generate various T-spin puzzles automatically.

Among generated puzzles, some might be boring and thus unsuitable for training players. To enable training players by proper puzzles only, with considering factors such as difficulty and interestingness, we worked on models that could predict those factors for puzzles. In more detail, we conducted a subject experiment that asked ten beginners to solve 42 "one-step T-spin puzzles" and rate the interestingness and the difficulty in five-grade evaluation (1, 2, 3, 4, and 5) for each puzzle. In an n-step T-spin puzzle, players can make T-spin patterns with n given tetrominoes in order. From the analyses, the correlation coefficient between interestingness and difficulty was higher than 0.95, which showed a very high correlation. We concluded that the more difficult the puzzles, the more the players tended to feel interesting. Furthermore, we applied supervised learning to predict the beginners' ratings from some manually designed features of the puzzles. The models were highly accurate, where the mean absolute errors (MAEs) of interestingness and difficulty were 0.401 and 0.400, respectively.

A similar experiment was then conducted on two-step T-spin puzzles, which we considered closer to real plays. Fifteen beginners solved and rated the interestingness and the difficulty of 50 two-step T-spin puzzles. From the results, the correlation coefficient between interestingness and difficulty was higher than 0.85, which still showed a high correlation. Different from one-step puzzles, players felt uninteresting about some too-difficult two-step puzzles. The model for predicting the interestingness had a very high accuracy with an MAE of 0.27.

We also asked a Tetris expert to check one-step and two-step T-spin puzzles that were predicted to be interesting or difficult by the models. The expert approved that the selected puzzles should be useful for beginners to practice.

Based on the automatic generation and selection of T-spin puzzles, we verified how much players' T-spin skills could be improved. Fifteen beginners were divided into two kinds of groups for comparison and trained for two hours. The first kind was trained by playing a competition variant of Tetris only, while the second kind by also combining T-spin puzzles. For players in the first kind of groups, the frequency of clearing rows by T-spin did not increase at all. In contrast, the frequency was significantly increased by 3.63 times on average for players in the second kind of groups. Further, among these players, for those provided with only interesting puzzles, the frequency was increased by 4.34 times. The experiments demonstrated the effectiveness of the proposed approach in this research.