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Japan Advanced Institute of Science and Technology

Research of Tsume-Shogi Composing Algorithms

Taichi Ishitobi (1110005)

School of Information Science,
Japan Advanced Institute of Science and Technology

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In the 1950s, Shannon described the Minimax search algorithm and after 60 years, it still provides advances in game research. Japanese researchers tried to develop computer Shogi, like Shannon tried to make computer chess. Currently, computer Shogi can play with professional Shogi players, and researchers continue to develop stronger AI. On the other hand, researchers have also begun to focus on research other than powerful AI. That is, entertainment. In recent years, researchers have started to analyze the question of what is interesting, and what is entertainment. We focus on this research too, and use "Tsume-Shogi" to analyze what is interesting or not.

The Shogi mating problems (called "Tsume-Shogi") are puzzles using Shogi rules. These puzzles are made with an endgame position of Shogi, and use some special rules not found in original Shogi rules. And, one charateristic of Tsume-Shogi is that there exists only one answer. Some problems of Tsume-Shogi are called masterpiece, and these problems are regarded as really interesting. Why these are masterpieces? Trying to answer to this question could help to understand what kind of problems are interesting.

There exists two main researches about Tsume-shogi. One of the research is solving Tsume-Shogi, and the other one is composing Tsume-Shogi. The research about solving Tsume-shogi has progressed greatly in the recent years, and solvers can solve almost all Tsume-shogi. So, we think research

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about solving Tsume-shogi is close to the end. However, research about composing Tsume-shogi is not so active. We know some Tsume-Shogi composing algorithms, but these algorithms have difficulties to compose long step problems or interesting problems like humans can make. So, in this thesis, we focus on these problems.

Human players can get interested in solving Tsume-shogi, but it depends on the problems. There are problems that we can forget immediately, and on the other hand there are problems considered as very good problems by human players and recorded for a long time. What is this difference? We think that if we detect this difference by analysis then we can know what is the interesting. There is a previous research by Koyama. Koyama examine each element of Tsume-shogi(How many pieces used, Where is the King starting position, etc...). And, he compared good Tsume-shogi and general ones about each element. The good Tsume-shogi are decided by Tsume-shogi contest from magazine "Shogi Sekai". First, this contest collects 5 steps and 7 steps problem from the readers. Next, professional shogi players select good Tsume-shogi and these are placed on "Shogi Sekai". And, the best problems are chosen by a vote of the readers. Finally, "Shogi Sekai" showed top 3 good Tsume-Shogi problems. These are "good Tsume-Shogi". More general problems are published in problem books, Internet, and others. These problems are not judged about good or not. Koyama compare these problems and show some results. These results are useful for seeking which problems are good. However, in this work, the level of interest of each problem is not evaluated numerically. Because, there are many elements in Tsume-shogi, and they are difficult to evaluate numerically.

So, in this research, we work on these problems and try to show the level of interest by a numerical value. We used the proof-number and disproof-number to evaluate the level of interest. The proof-number and disproof-number are the values used in Proof-Number Search by L.V.Allis. The proof number is defined as the minimum number of leaf nodes that must be proven in order to prove the node. And, The disproof number is defined as the minimum number of leaf nodes that must be disproven in order to disprove the node. These two values are usually used only by the searching algorithms. But, in the case of Tsume-Shogi, we can look at them from a different point of view. In Tsume-Shogi, proof number is

the minimum number of positions that must be mated in order to win. So, we can consider proof number as Tsume-shogi difficulty. And, disproof number is the minimum number of positions that must be searched in order to lose. So, we can consider disproof number as the scales of Tsume-Shogi. In order to investigate these hypothesis, we perform an experiment and record proof and disproof numbers during the search.

The root node on Proof-Number Search have proof number and disproof number about all of game tree. And, Proof-Number Search is best first search algorithm. So, the value on the root node is renewed when a leaf node is expanded. We record proof and disproof number of root node on every renewal time to analyze the proof and disproof number evolution. Especially, we recorded the maximum value of proof number, maximum value of disproof number, number of renewal times, average proof number and average disproof number. The maximum proof number and disproof number are the values recorded during the search before mating. The proof number is related to the difficulty, so maximum proof number show the peak difficulty. The disproof number relates to the scale of Tsume-Shogi, so the maximum value of disproof number relates to the worst scale. The number of renewals show how many times root node is renewed. The average proof and disproof number is the sum of all proof (respectively disproof number) divided by the number of renewals. The average proof number show the average degree of difficulty to solve the Tsume-Shogi. And average disproof number show the average scale. We compare these numbers and get some results.

The good Tsume-shogi had large proof number against general problems. And, 7 step contest problems line up maximum proof number. But, 5 step contest problems are not lined by maximum proof number. So, we compared top contest and general problems. Then, we found the maximum proof number of top contest problems are bigger than general ones. Thus, we found the proof number is important to judge the Tsume-shogi. Also, the maximum disproof number is different on problems with the same maximum proof numbers. If we analyze more precisely, maybe we could understabd better what is the meaning of the disproof numbers in this context. And, sometimes, the number of renewals is also very different even with same steps problems and same maximum proof number. So, the

number of renewals show important things too to judge the Tsume-shogi.

In addition, we analyze automatically problems composed by two algorithms. Then, the problems by Noshita's algorithm have good maximum proof number. On the other hand, the problem by Hirose's algorithm is not so good. This algorithm cannot compose long step problems and get small maximum proof numbers. Thus, Noshita's algorithm appears promising, but that algorithm cannot compose long step problems like over 100 steps. And, the problems are composed randomly, so one cannot get good Tsume-Shogi as he likes. So, if we want to compose good Tsume-Shogi then we need to develop new algorithms.

This paper focus on entertainment in Tsume-Shogi. We anakyze the proof number and disproof number values when solving Tsume-Shogi. Finally, we show that proof number and disproof number relates to the Tsume-Shogi quality. Some research problems still remain. We plan to continue the research on these problems.