Search efficiency in Computer Shogi: A case study using TACOS

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Abstract

The enhancement of the search efficiency in a computer Shogi program is studied. Several well-known methods for selecting the promising moves, which have been used by the strongest programs, are investigated by examining the results obtained by applying these methods for the move ordering in the endgame problems and some kinds of grandmasters' games. The cut-off by selecting the escape moves is relatively significant in the static positions such as opening, while the cut-off by selecting the capturing moves is greatly significant in the tactical positions.

1 Introduction

In the development of computer Shogi, the search efficiency is very important. Generally, the alpha-beta algorithm and its variants such as iterative deepening have been used as the representative efficient searches [1]. However, in the domain of computer Shogi, the efficiencies of such searches have not yet sufficiently been studied. This paper presents the concrete results of applying several enhancements related to the search efficiency to our computer Shogi program TACOS.

2 Methods for Selecting the Promising Moves

Since the full-width search is impractical in computer Shogi, several methods to select the promising moves have been well known. These methods, which are categorized below, have been used by the strongest programs such as Kanazawa Shogi, IS Shogi, and YSS [2, 3].

1. The domain-independent criteria

   (I) Best move of the previous iteration (*best move*)
   A best move selected at the previous iteration in the search with iterative deepening is very often the best also at the current iteration.

   (II) Killer move [4] (*killer move*)
   In the search of a chess-like game, a best move for a certain node is often the best for its sibling nodes. The best move of a sibling node is recognized as a killer move.

2. The domain-specific criteria (*heuristics*)

   (III) Capturing move of the opponent piece that has just moved (*just capture*).
   In Shogi, a move that captures an opponent piece that has just moved at the previous turn is often a good move.

   (IV) Capturing move of a piece with the highest value (*highest capture*).
   A move that captures an opponent piece with the highest value is mostly a good move.

   (V) Escaping move from the opponent attack for the piece with the highest value (*escape move*).
   Escaping moves from the opponent attack are generally good moves. Among them, the moves of the piece that has the highest value are most likely good.

3 Experiments

TACOS uses the iterative deepening with increasing the search depth. In the experiments, a full-width search up to the depth 4 is used.

In order to evaluate the enhancements of efficiency, we performed the experiments to compare the number of searched nodes with using one or more moves listed above for the move ordering. As a test set, we chose fifty-six artificially created problems in Tanigawa's book [5]. This time, we do not care whether the program gives a correct answer, since the moves that the program answers are all the same independent from the selection methods because of the full-width searches. In addition, we investigated the dependency of the results on the characteristics of the positions.

Since the test set mostly contains the positions in middle games or endgames that are relatively tactical, the test set does not represent the overall positions in the Shogi games. The opening positions are often not tactical but static or prepositional. It is important to know the effects of the selection methods in such static positions. Here, we performed the experiments with using all the positions in Black's turn with using three games by grandmasters. We also compare the number of searched nodes with using one or more selection methods listed above.

The three games are: the 4th game of the 13th Ryu-O title match as a model of the slow game (*Ibisha* vs. *Furibisha*), the 7th game of the 58th Meijin title match as a model of early fight (*Kakugawari-Koshikakegin*), and the 5th game of the 58th Meijin title match as a most popular game (*Yokofudori*).

4 Results and Discussions

The results of the experiments using Tanigawa's problems are shown in Figure 1 and using three grandmasters' games are shown in Figure 2. The numbers of nodes are shown by millions.

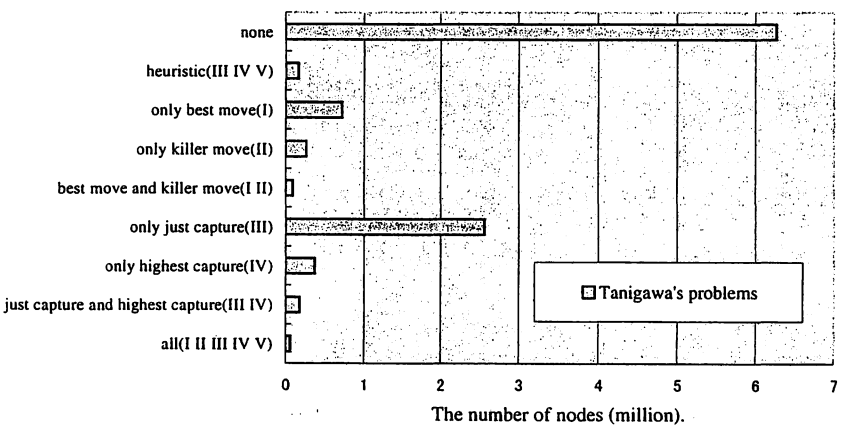

Figure 1: Number of nodes for Tanigawa's problems

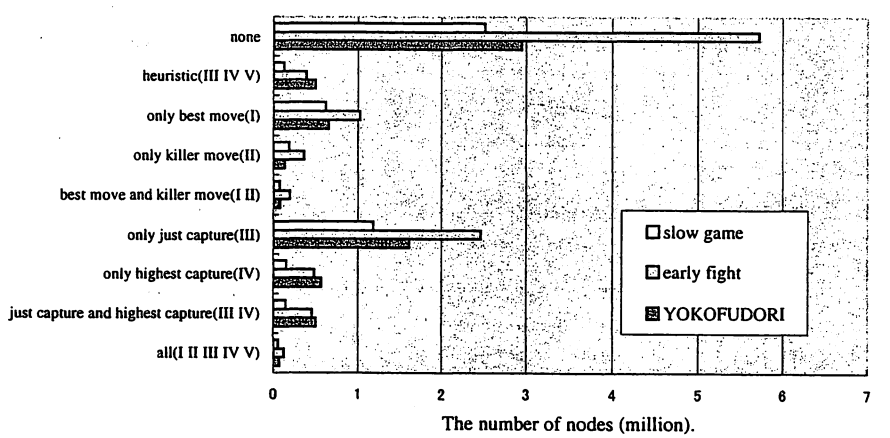

Figure 2: Number of nodes for grandmasters' games

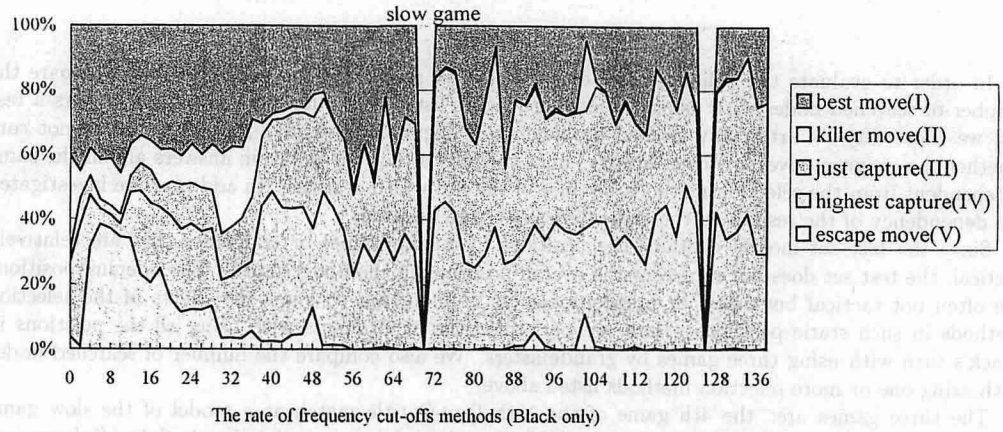

Figure 3: The cut-off rates throughout a slow game depending on the selection methods

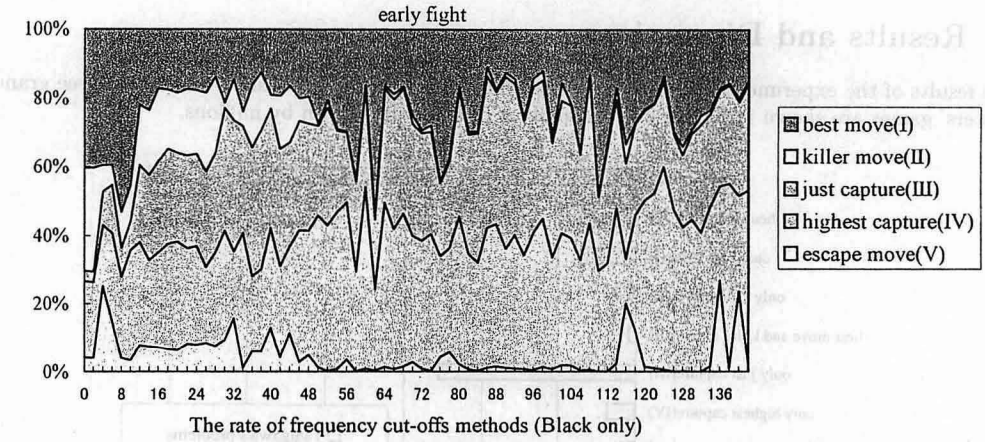

Figure 4: The cut-off rates throughout an early-fight game depending on the selection methods

4.1 For the artificially created problems (Figure 1)

The number of nodes with the *highest capture* (IV) much decreased than the case with the *just capture* (III). This shows that the *just capture* is not so efficient, while the *highest capture* is very efficient. The number of nodes with the *killer move* (II) so much decreased that 96% of nodes were pruned off.

By using the *heuristics* (III,IV,V), 97% of nodes were pruned off. Moreover, 34.5% of nodes were pruned off by additionally using the *heuristics* (III,IV,V) compared to the case with using the *best move* and the *killer move* (I,II).

4.2 For the grandmasters' games (Figure 2)

As shown in Figure 2, the number of nodes was greatly pruned off by using the *highest capture* or the *killer move* just the same as the artificially created problems. For all positions, the number of nodes were decreased by additionally using the *heuristics* (III,IV,V) compared to the case with using the *best move* and the *killer move* (I,II).

In the slow game 21.4% of nodes were pruned off, while 37.6% were pruned off in the early-attack game and 17.9% were pruned off in the game of *Yokofudori*. There are many collisions of pieces in the early-attack game and then most capturing moves are the good moves. For this reason, the number of cut-offs was greater than that in the slow game and *Yokofudori*.

The changes of the cut-off rates throughout the three games depending on the selection methods are plotted in Figure 3, 4, and 5, respectively for the slow game, the early-fight game, and the game of *Yokofudori*.

As for the slow game, the number of cut-offs by the *escape move*, the *killer move* and the *best move*

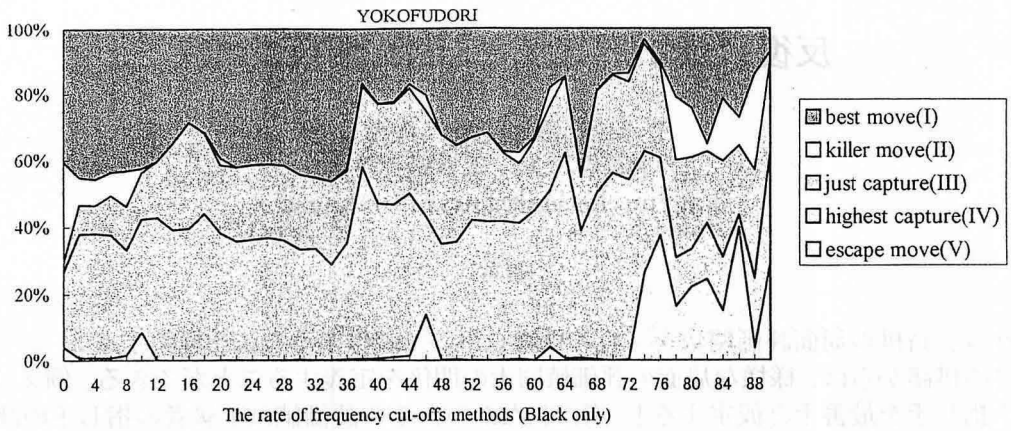

Figure 5: The cut-off rates throughout a *Yokofudori* game depending on the selection methods

was significant in the opening. When White block the bishop's diagonal (4th move), the cut-off by the *highest capture* decreased and that by the *escape move* increased. After entering middle game, the number of cut-offs by the *highest capture* and the *just capture* increased. There are two gaps around the 70th and 126th move. This is because the Black's king is checked by White's piece and there is only one possible move in each position.

As for the early-fight game, the number of cut-offs by the *heuristics* was significant overall. When White opened the bishop's diagonal in the 8th move, the cut-off by the *best move* increased. This was because the program judged exchanging bishop is the best move. Since there occur the threats to capture the pieces near the opponent's camp both in the 58th and 62nd moves, the cut-off by the *best move* also increased.

As for the *Yokofudori* game, the cut-off by the *best move* decreased after the bishop exchange (38th move). Since there occur the threats that a rook is captured by a knight in the 46th move, the cut-off by the *escape move* increased. In the 66th move, the cut-off by the *highest capture* decreased. This was because a knight blocked the attack of an opponent bishop to a gold.

In summary, the cut-off by the *escape move* was relatively significant in the static positions such as opening, while the cut-off by the *just capture* and the *highest capture* was greatly significant in the tactical position. It seems that how the cut-off of each selection method changes throughout a game may be somewhat dependent on the type of the game.

5 Conclusion

We have evaluated the enhancements of the search efficiency when several well-known methods for selecting the promising moves are used. The examined methods are the best move of the previous iteration, the killer move and the Shogi-specific heuristics. Although the efficiency is enhanced by using each method alone, it is much more enhanced by using all methods simultaneously.

If we would determine the trade-offs between the decrease of the number of searched nodes and the costs to applying these methods, we can give the clear guideline for those who are going to develop a strong Shogi program.

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