An Evaluation Function for Shogi

Reijer Grimbergen
Electrotechnical Laboratory,
1-1-4 Umezono, Tsukuba, Ibaraki, Japan 305.
E-mail: grimberg@etl.go.jp

Abstract

Shogi and chess are similar games. The aim in both games is to mate the opponent's king. However, the main difference between shogi and chess is that in shogi pieces taken from the opponent can be used again. This has important consequences for the evaluation function. In chess the material balance is vital for the evaluation of a position while in shogi the evaluation of a position is much more based on abstract concepts like bad piece formations and danger to the king. In this paper a set of features will be proposed that are vital for an evaluation function for shogi. These features have been implemented in an evaluation function which is part of a complete shogi playing program. This evaluation function has been tested by comparing its position assessment with the opinion of professional players in 54 middlegame positions and 46 endgame positions from professional games. The evaluation function agreed with the expert opinion in 64 of these positions, judging the middlegame positions a little better (67%) than the endgame position (61%).

Keywords: Complete information games; Evaluation function; Computer shogi

1 Introduction

In AI research, the game of chess has a long history dating back to the 1950s. With the win of the Deep Blue program over world champion Kasparov, the competitive challenge of making a strong program to beat the best human players might soon no longer be the driving force it once was. Realizing this, we have looked at other two-player, complete information games as possible targets for AI. We have compared go, xiang qi (Chinese chess) and shogi (Japanese chess) with chess, both in the features of these games and the computational differences [5]. Our conclusion was that shogi is well suited for AI research. This is because shogi is similar to chess, yet significantly different from chess. Its similarity lies in the goal of the game, which is mating the opponent's king in both shogi and chess. The main difference between chess and shogi is that in shogi the pieces taken from the opponent can be reused by putting them back on an empty square instead of playing a move by one of the pieces on the board (this is called *dropping* a piece). Another difference between shogi and chess is that most pieces have only limited movement. This leads to a slow build-up of the game and also to the problem of using pieces efficiently. Pieces that are placed badly can not be moved to better positions easily. For a more detailed comparison of chess and shogi, see [6].

From a computational point of view, these differences have some important consequences. First of all, the average number of legal moves in a shogi position is much higher than in a

chess position. In shogi the branching factor of a full-width search tree is estimated at 80 [4], while the branching factor of chess is estimated at 35 [3]. To cope with this difference, I am currently building a shogi program that, by using pattern recognition, only generates a limited number of suitable candidates in a position [2].

The differences between chess and shogi also have important consequences for the evaluation function. In chess, positional evaluation is based primarily on material. Of course, a good evaluation function is able to judge whether there is positional compensation for the loss (or sacrifice) of a pawn, but usually in chess the loss of material determines the outcome of the game. Also, a chess game is hardly ever played out until the mating stage. Long before that, a theoretical endgame is reached where both players know the outcome of the game and one player resigns or both players agree on a draw. In chess, there has been considerable research in setting up endgame databases that play endgames perfectly [9]. In shogi, there are no theoretical endgame positions. Because of the reuse of pieces, a shogi endgame is usually a mating race between the two players. In this mating race speed is more important than material, but when an attack runs out of steam, material given to the opponent while attacking might turn around the game. Building good defensive and attacking formations, effective use of pieces and good judgment of the mating race is therefore vital to the evaluation of shogi positions.

Evaluation functions have not been the subject of intensive study in most games. Only in go, where the evaluation is currently much more important than search, the evaluation of positions gets considerable attention ([7], [10]). In shogi, there has been some research into the evaluation of danger to the king to guide tsume shogi search [8], but no publications on a general evaluation function. One of the reasons is probably that an evaluation function contains a lot of specific game knowledge. An evaluation function of one game does not carry over to other games. Still, we feel that research into the evaluation of positions can give important insights in the problem solving behaviour of human players.

In this paper the features will be discussed that should be part of a shogi evaluation function and how these features should be balanced in the different stages of a shogi game. For example, in the opening it is more important to build a solid formation than to attack the enemy king (even though there are openings where the attack starts almost immediately). The features of an evaluation function for shogi will be described in section 2. These features have been implemented in an evaluation function that is part of a shogi playing program. Some implementational issues of the evaluation function will be discussed in section 3. The results of the implemented evaluation function will be given in section 4. I will end with some conclusions and give some plans for further research.

2 Features of an evaluation function for shogi

If we look in the shogi literature, we find that there are a number of important concepts which are vital to understanding a shogi position. One of the best examples is the book *Better moves for better shogi* [1]. Here the principles of good positional shape and bad positional shape, castling formations, the importance of pieces according to the position of the king, calculating the speed of the mating race and the importance of potential and initiative are discussed.

I will now look at each of these features, as well as to some of the standard features of an evaluation function like material balance and controlled squares.

2.1 Material

Even though material considerations are not decisive for the outcome of a shogi game, material is clearly important. Especially in the early stages of the game, loss of material might make it impossible to set up a decent attack and will lead to a loss by a wide margin.

There are some important problems with evaluating material in shogi. Firstly, in shogi loss and gain of pawns is usually not very important. Pawns are often sacrificed to force pieces to bad squares. On the other hand, having no pawns at all to use for these sacrifices is often (but not always) a big disadvantage.

Secondly, there is the problem of the value of promoted pieces. In shogi most pieces promote. Furthermore, they promote on three ranks instead of only one as in chess. Sometimes a promoted piece only gets some extra possibilities, but often the movement of the piece changes completely. Promotion is almost always optional, so the decision between promoting and non-promoting a piece is not only a matter of material advantage, but is based on positional considerations as well.

A special case among promoted pieces is the value of a promoted pawn. In shogi, promoted pieces that are taken lose the extra possibilities gained from promotion. Therefore, when a promoted pawn is taken, it becomes only a pawn for the player to drop. The advantage of having a promoted pawn is therefore bigger than its value as a promoted piece, which is the equivalent of a golden general.

2.2 Castling

In shogi there is no standard castling move like in chess. An important part of the opening strategy is therefore to build a castling formation of generals and move the king in this formation. There are about fifty different standard ways to build such a castling formation. As an example, on the left of diagram 1, we have the *Yagura* castle.

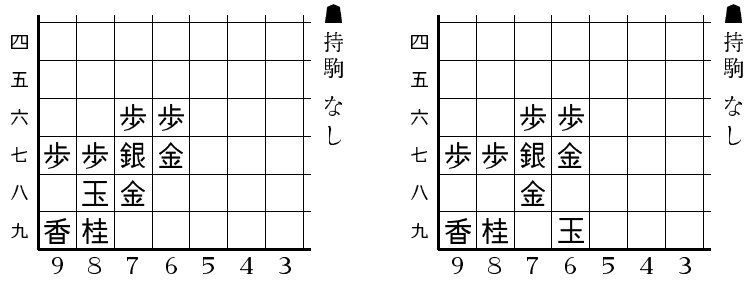

Diagram 1: Yagura castles

Building a strong castle takes time and this poses two problems for an evaluation function. First, a castle formation is only good when the king is moved into it. For example, on the left of diagram 1 the king has moved safely into the castle formation. However, on the right of diagram 1 the king has not yet been moved into the castle. It will take two more moves to get from the right of diagram 1 to the left of diagram 1. A static evaluation should be able to assess if there is time for the king to move into the castle.

The second problem is to evaluate what shapes are actually castling shapes. This is especially

difficult for the strongest castles, which are usually build in several stages. An example is the *Anaguma* castle (diagram 2). This is the strongest castle in shogi. On the left of diagram 2 we see the anaguma in its complete form. On the right of diagram 2 one of its preliminary stages is given. Whether the position on the right is also a castle formation is arguable.

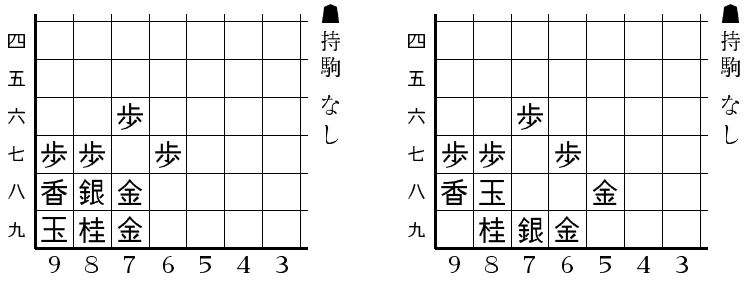

Diagram 2: Anaguma castles

2.3 King safety

The safety of the king is probably the most important feature of an evaluation function towards the end of the game and therefore vital to the strength of any shogi-playing program. Mistakes in opening and middlegame can often be repaired, but mistakes in the endgame can mean the difference between winning and losing.

Two important and conflicting issues in king safety are *thickness* and *escape routes*. Thickness is the number of defending pieces surrounding the king. Escape routes give the possibilities for the king to run away from threats. The two extremes can be seen in diagram 3. On the left of diagram 3, the king is completely surrounded by defending pieces, but it has nowhere to go. On the other hand, on the right of the diagram the king has no defenders, but can run away in all directions. Usually an endgame position lies between these two extremes and the evaluation function has to decide which defending pieces add to the thickness of the king and which escape routes are safe.

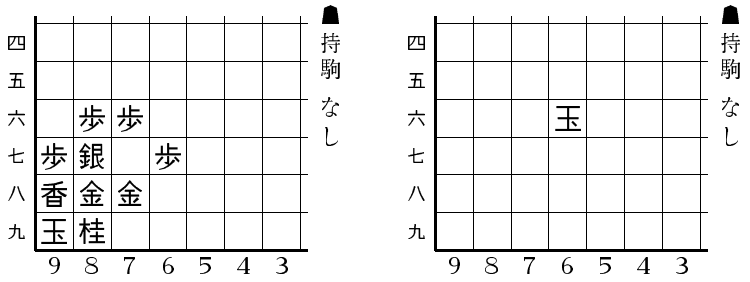

Diagram 3: Thickness and escape routes

Another issue of king safety are the attacking pieces and the strength of the defensive points these pieces are attacking. The position of a king can be very bad, but if there is no way for the opponent to attack the king effectively, the king is not in danger and there is no need for defensive action.

Finally, there is the problem of *entering king*. In shogi it is usually a big advantage to drive the king into the open board. However, there are situations where this takes a lot of material and the king can escape by crossing over the board and moving into the enemy camp. Because most shogi pieces have a forward movement, it is difficult to attack the king when it has managed to pass the attacking pieces. When both players manage to bring their king into the opponent's camp, it is possible that the game ends in a draw. This is very rare (less than 0.5% of professional games end this way and in amateur shogi this is even rarer), but a good evaluation function should be able to judge the possibilities of making an entering king.

2.4 Good shape and bad shape

Another important feature of the evaluation of shogi positions is the notion of good shape and bad shape. A piece can be considered to be well positioned if it has freedom of movement or is part of a good attacking or defending formation. Examples of good defending formations have already been given in section 2.2. Some other examples of good shape and bad shape are given in diagram 4.

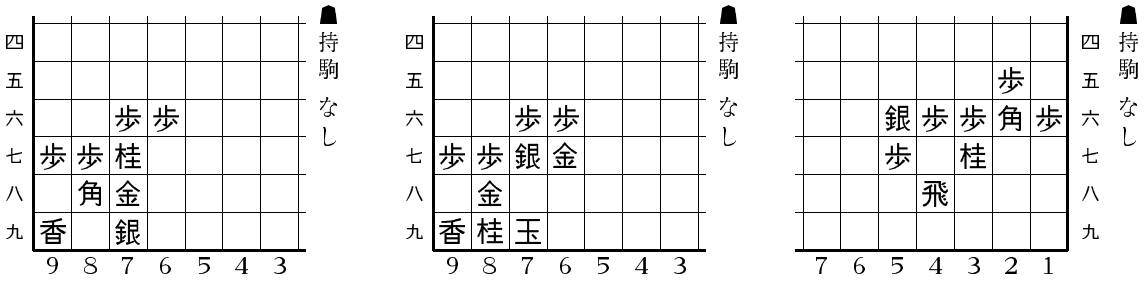

Diagram 4: Good shape and bad shape

On the left of diagram 4 we see a position where the black bishop on 8八 is completely boxed in. This bishop is clearly not working and if there is time, black should try and improve the position of this piece. In the middle of diagram 4 we see a castle formation that is mangled. It looks very similar to the yagura castle position given before, but the gold on 8八 makes it impossible for the king to enter the castle. The black king is now very vulnerable and moving the gold from 8八 to 7八 is a high priority move.

Finally, at the right we see an ideal black attacking formation. In shogi the golden rule is to use three generals for the defense of the king and combine rook, bishop, knight and the remaining general to attack.

Good shape and bad shape are most important in opening and middle game positions. In the endgame the mating of the king becomes the number one priority, and shape considerations unrelated to the king position do not play an important role.

2.5 Distance to the kings

As said, a shogi game only ends in mate (or by the rare case of mutual entering king). This means that the pieces that can actively take part in the mating process become more and more important towards the final stages of the game. Pieces that are far away from the king

can be valuable in the middle game where these pieces can be used to break into the enemy camp. Also, in the middle game it is still possible to find the time to move bad pieces to better positions. In the endgame there usually is no time and pieces far away from the king have almost no value at all. On the other hand, even insignificant pawns can become vital anchors for attack when they are placed close to the king. An example can be seen in diagram 5. The difference between the pawn on 2四 and the pawn on 6五 in this position is huge.

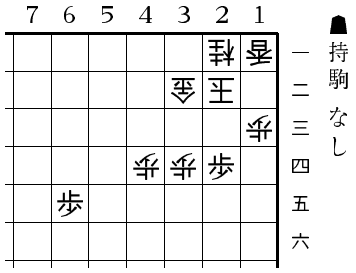

Diagram 5: Distance to the king

2.6 Controlled squares

More freedom of movement means more options and more chances for a lasting advantage. Controlled squares is a way to measure this freedom. In shogi, it is especially important to control the squares in one's own camp, which takes away possibilities for dropping pieces behind enemy lines. This is especially important in the middlegame. In the endgame, the controlled squares around the king become very important.

2.7 Pieces in hand

This is an evaluation feature very specific to the game of shogi. Pieces that can be dropped have a lot of potential (the threat of dropping a piece can already influence the game), which is taken away by actual dropping them. On the other hand, waiting too long before dropping pieces is a common mistake of weak players. If there is a good square for a piece to drop it on and if there is time, one should play that drop. An evaluation function should be able to judge if there are good squares for the pieces in hand.

2.8 Initiative

Initiative is very important in shogi. As long as the opponent has to answer to threats, he has no time to make his own threats. Close shogi endgames are often won by the player who has the initiative. That player can often make mating threat after mating threat until finally there is no more defense.

2.9 Potential

Judging whether a piece has potential is not easy. It is closely related to the concept of good shape. For example, the pawn on 2四 in diagram 5 is a piece with potential. Even if black has

no pieces in hand to drop at 2 三, there might come a point in the game where such a drop is possible.

2.10 Mating race speed

Counting how many moves both sides need to mate the king is important for understanding which side is ahead in the endgame. This evaluation also dictates whether one can attack or whether one should defend.

3 Implementation of an evaluation function

The features described in the previous section have been implemented into an evaluation function used in a shogi playing program. The evaluation function makes a difference between middlegame and endgame. A position is considered an endgame position if the danger to the king is higher than a certain threshold. Concerning the issues raised the following choices have been made:

Material Loss and gain of pawns is not taken into account when evaluating material. Only if there are no pawns in hand the position is evaluated negatively.

Promoted pawns are equal in value to a golden general, which is the piece the pawn promotes to. However, bonus points are given if a promoted pawn is attacking another piece.

No special measures have been taken concerning the value of promoted pieces. Regarding material balance, promoting is always considered better than not promoting. If a piece becomes a bad piece due to promotion, this should be covered by the evaluation of good shape and bad shape.

Castling A castle formation is only considered good shape when the king has moved into the formation. Furthermore, preliminary castling formations are also given bonus points, but not as many as the standard castles. This is to assure that the program will not play castling moves only, but will give those moves some priority.

King safety This is probably the most difficult concept to add to the evaluation function. The evaluation function that has been implemented looks at thickness, escape routes and the opponent's attack, but only at the squares adjacent to the king. Entering king is not handled as a special case.

Good shape and bad shape The evaluation function currently looks at about 100 good shape and bad shape formations (excluding castle shapes). This assessment of shape is important in the opening and middlegame, but not considered in the endgame.

Distance to the kings This is the most important feature in the endgame, but not considered in the opening and middlegame. Pieces are given points based on the nearest square they are covering relative to the own or the enemy king. Covering instead of actual piece position is used to judge the distance to the king of long distance pieces like bishop and rook.

Type of position	Number of positions	Correct
Middlegame	54	36 (67%)
Endgame	46	28 (61%)
Total	100	64 (64%)

Table 1: Total results of the evaluation function

Controlled squares If a square in the camp of the opponent is more attacked than defended, extra bonuspoints are being given. This feature is only looked at in the opening and middlegame.

Pieces in hand The evaluation function looks for a limited number of good squares to drop pieces. For example, possibilities for dropping a rook in the enemy camp.

Initiative This concept turned out to be too abstract for a static evaluation function. This particular feature is left to the search part of the program.

Potential This concept is closely related to the notion of good shape and has not been implemented seperately into the evaluation function.

Mating race speed This also is hard to judge without doing search and therefore left to the search part of the program as well. Note that the amount of danger to the king is an indication of which side has the advantage in the attack.

Of course there are a number of conflicting concepts in the evaluation function. For example, is sacrificing the final pawn in hand worth the positional advantage? Or, is winning a rook better than defending one's king? The evaluation function needs a lot of fine tuning to judge these conflicting situations and often only search can provide the answer.

4 Results

The evaluation function has been tested by selecting 100 positions from shogi books and magazines that have been judged by expert commentators. These positions were both middlegame positions and endgame positions. There were 54 middlegame positions and 46 endgame positions. Judgment of the experts was that one side was winning, one side was better or that the position was equal or difficult to judge. The total results of the implemented evaluation function are given in table 1. If we split these results up into the judgment of winning positions, advantageous positions and equal or difficult positions, we get the results given in table 2.

5 Conclusions and further research

The main conclusion is that the evaluation function is able to judge shogi positions reasonably well. From chess research we know that an evaluation is best applied in a quiet position, but these positions are not very common in shogi. Especially in the endgame, quiet positions are the exception rather than the rule. Strong threats are used in the shogi endgame to bring the king nearer to mate.

Expert evaluation	Number of positions		Correct
Winning	Middlegame	4	3 (75%)
	Endgame	21	13 (62%)
	Total	25	16 (64%)
Advantageous	Middlegame	26	16 (62%)
	Endgame	9	7 (78%)
	Total	35	23 (66%)
Equal/difficult	Middlegame	24	17 (71%)
	Endgame	16	8 (50%)
	Total	40	25 (63%)

Table 2: Results according to expert judgment

Another problem is that the analysis of a shogi game is only partly based on static evaluation of positions. It was actually quite hard to find middlegame and endgame positions where the expert actually gives the position a definite judgment. On the other hand, the analysis of shogi games is full of abstract considerations like:

- "If I allow P3e I have no more moves"
- "Black has no mate and there is no defense against (...)"
- "After (...) the endgame becomes very close"
- "If I allow white to attack first, I have no faith in the position, so I pushed on"

These abstract concepts are hard to include in an evaluation function. Seen in this light it is encouraging that the implemented evaluation function agrees with the expert opinion in 64% of the positions. Also, the balance of the evaluation function seems rather good. The percentage of correctly judged positions is almost the same for winning, advantageous and equal positions.

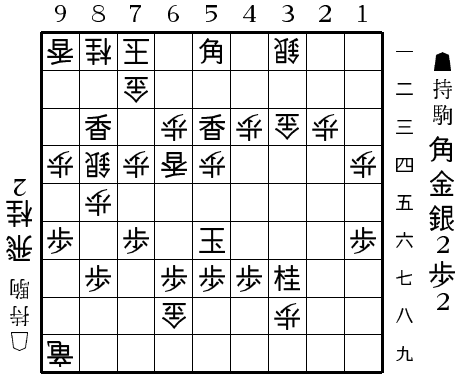

Diagram 6: Evaluation failure

However, there are clearly some unsolved problems. Especially unclear endgames seem to be hard to judge by a static evaluation function. The evaluation function scored only 50% on these types of positions. This is in part caused by the problem of judging dynamic balance,

but it has also to do with the options available in a position. The notion of "there are no good moves in this position" is difficult to incorporate into a static evaluation function.

That this can lead to some terrible misjudgments is illustrated by the position in diagram 6. This is a position from an analysis of a professional game and the judgment was that black is winning, because he has a mating threat white can not effectively defend against, while white has no mate. However, the implemented evaluation function judges this position as being an overwhelming win for white.

Future research will focus on bringing the evaluation function closer to the tree search algorithm. Especially in the endgame, the notion of threats, counterthreats and defense against these threats should guide the search. This will require important changes in the search part of the shogi playing program.

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