Differences between Shogi and western Chess from a computational point of view

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I. Introduction

In this paper the differences between Shogi (Japanese Chess) and western Chess are discussed from a computational point of view. Shogi and chess are very similar but a game-tree complexity of shogi is far larger than that of chess. We think shogi is an interesting game for game research as chess.

II. Shogi

Shogi, Japanese chess, is played by two players on a board of 9×9 squares. The players make moves alternatively, attempting ultimately to capture the opponent's king. The initial set-up of the game is shown in Diagram 1[1]. Each player has 20 pieces. The first player to move is called **Black** or *Sente* (in Japanese) and plays with the pieces on the bottom three ranks of the diagram. The other player is **White** or *Gote* and his pieces are on the top three ranks of the diagram. In the diagram you can see that black's pieces are being displayed normally, while white's pieces are displayed upside down.

The important difference between shogi and chess is the possibility of reusing pieces previously captured. Pieces previously captured can be put back on the board on almost any vacant square (this is called "dropping a piece"). In diagram 4 these captured pieces are shown beside the board, black's pieces on the right and white's pieces on the left.

Each square on the board is represented in algebraic notation like in chess, and so are the moves. For example, the white king in Diagram 1 is on square 5a. If it were to move to 4b, this move would be represented by K5a-4b or K4b in short.

As can be seen in Diagram 1 black's camp is on the bottom three ranks (**i** to **g**), which is also white's promotion zone. Correspondingly, white's camp is on the top three ranks (**a** to **c**), which is black's promotion zone. Most pieces in shogi can promote, but promotion is not obligatory like it is in chess. In the diagrams we use in this article the color of a promoted piece is black (see Diagram 4).

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[1]Diagrams in Japanese shogi magazines and books are exclusively written in kanji (see Diagram 2). Diagrams used in this article are for the international community only.

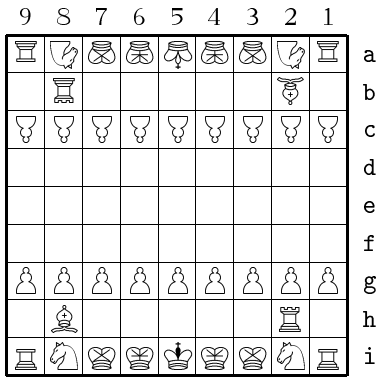

Diagram 1: Initial set-up of *Shogi*

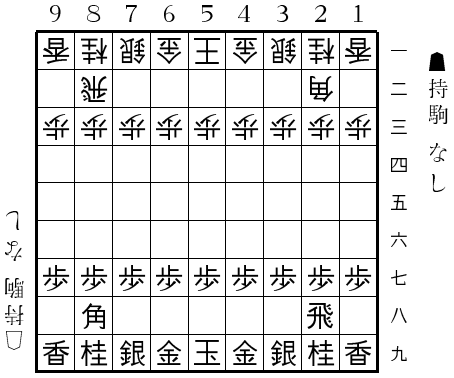

Diagram 2: Initial set-up of *Shogi* in Japanese

In shogi there are eight kinds of pieces. At the initial position of a normal game, each player has a king ♔, a rook ♖, a bishop ♗, two golds ♕, two silvers ♕, two knights ♘, two lances ♖, and nine pawns ♙. For each of the pieces we will now describe how it can move and what happens to the piece if it promotes.

King or Gyoku A king ♔moves like a king in chess, so it can move one square in every direction (horizontally, vertically and diagonally). A king can not promote.

Rook or Hisha A rook ♖moves like a rook in chess, i.e. any number of squares horizontally or vertically, but without the ability to jump over other pieces. The promoted rook ♜keeps its original movement, but the ability to move one square diagonally in every direction is added.

Bishop or Kaku A bishop ♗also moves like a bishop in chess, i.e. any number of squares diagonally (also without jumping over other pieces). A promoted bishop ♝keeps its original movement, but the ability to move one square horizontally or vertically in every direction is added.

Gold or Kin A gold ♕moves like a king, except for the two squares diagonally backwards to which it can not move. A gold can thus move to six squares. A gold does not promote.

Silver or Gin A silver ♕moves like a king, except for the two horizontal squares and the square backwards. A silver can thus move to five squares. A promoted silver ♕moves like a gold.

Knight or Keima A knight ♘moves like a knight in chess, that is one square straight followed by one square diagonally. As in chess, it can jump over other pieces. However, a knight in shogi can only jump to the two squares that are furthest up the board. For example, a black knight on 5f can only jump to 6d or 4d. A promoted knight ♞moves like a gold.

Lance or Kyosha A lance ♖can vertically move any number of squares, but only forward. It can not move backwards and it can not jump over other pieces. A promoted lance ♜moves like a gold.

Pawn or Fu A pawn ♙can only move forward. There is no difference in the first move and capturing pieces is not done diagonally like in chess. A promoted pawn ♟moves like a gold.

Shogi has a history of over 500 years and currently over 10,000,000 people in Japan play the game. There is also a professional competition, which is completely separated from amateur play. The present top player, Y. Habu, earned over $ 1,000,000 on game fees alone in 1996.

More elaborate introductions to shogi have been written by Leggett (1966) and Fairbarn (1984).

III. Games from a computational view

Considering the state of the art in game programming research, we feel that western Chess and Shogi are both interesting. Interesting can be defined here as competitively challenging, i.e. not yet playing at world championship level.

Chess and shogi are both complex games. In this article we will use two types of complexity:

State-space complexity This is the number of legal game positions reachable from the initial position of the game (Allis, 1994). It is clear that an exact number for the state-space complexity can not be obtained and that we can only estimate an upper bound to the the state-space complexity. An upper bound to state-space complexity should be obtained by taking into account that symmetrically equivalent positions must be counted only once. An upper bound to state-space complexity for chess and shogi is estimated as:

- *Chess*: Some authors estimate the upper bound of the state-space complexity of chess as 10^{43} (Schaeffer *et al.*, 1991), while Allis (Allis, 1994) estimates it as being close to 10^{50}. Even more confusingly, a recent work on estimating an upper bound to state-space complexity (Ohtsuki, 1995) estimates it at 1.07×10^{54}.
- *Shogi*: 10^{71} (Ohtsuki, 1995).

Game-tree complexity This is the search space that can be expected in a game, based on the average branching factor and average game length in plies. For each game the game tree-complexity is estimated as:

- *Chess*: 10^{123} based on a branching factor of 35 and an average game length of 80 ply.
- *Shogi*: 10^{226}, based on a branching factor of 80 (Matsubara & Handa, 1994) and an average game length of 115 ply (Yearbook, 1994).

II. Chess and Shogi: Differences and Similarities

In this section we will closely look at the similarities and differences between shogi and chess, both regarding rules and computational aspects.

A. Similarities

1. Both chess and shogi are two-person perfect-information games. Therefore, in every position all possible moves can be considered and a game-theoretical value can be attached to each position (Allis, 1994).
2. Both games are sudden-death games. The game can end abruptly when the king of either player is captured (check-mate).
3. Most pieces in chess and shogi are either the same (king, rook, bishop) or similar (pawn, knight). Only three pieces are different: in shogi there are golden generals (short: gold), silver generals (short: silver) and lances.
4. In both games is it possible to draw by repetition of moves. Both in chess and shogi this way of drawing is not very common.

B. Differences

1. Rule differences

In this section we will only look at those differences that are important from the game programming point of view. We will therefore not discuss unimportant details about the shape of the pieces or that in shogi black plays up the board and is the first player to move instead of white.

1. Chess has an 8×8 board, while shogi has an 9×9 board.
2. In chess there are 6 different pieces, in shogi there are 8 different kinds of pieces. In chess each player has 32 pieces in total (16 pieces each) while in shogi each player has a total of 40 pieces (20 pieces each).
3. Most pieces in shogi are short range pieces. Each side has only one rook and one bishop. Among the other pieces, only lance and knight can move more than one square from their starting square. In chess, only the king, knight and pawn are limited in their movement. Metagamer's analysis (Pell 1993, Pell 1994) showed that most pieces in shogi were short range (see Table 1 and Table 2). C in Table 1 means "promoted Bishop" and Q means "promoted Rook". Important features are:

Material Analysis: Shogi										
	Piece									
Advisor	B	C	G	K	L	N	P	Q	R	S
max-static-mob	16.0	20.0	6.0	8.0	8.0	2.0	1.0	20.0	16.0	5.0
max-eventual-mob	15.0	24.5	11.23	14.0	5.0	3.562	1.996	26.0	25.0	11.16
avg-static-mob	10.1	13.6	5.1	6.7	4.0	1.4	0.9	19.2	16.0	4.0
avg-eventual-mob	13.4	21.9	8.4	10.3	3.0	2.2	1.8	25.8	25.0	8.2
eradicate	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
victims	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
immunity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
giveaway	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
stalemate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
arrive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	65.5	71.0	41.73	51.0	31.0	20.56	16.7	102.0	93.0	39.36

Table 1: Material value analysis for shogi

Material Analysis: chess						
	Piece					
Advisor	B	K	N	P	Q	R
max-static-mob	13.0	8.0	8.0	1.0	27.0	14.0
max-eventual-mob	12.0	12.9	14.8	1.99	23.5	20.2
avg-static-mob	8.75	6.56	5.25	0.875	22.8	14
avg-eventual-mob	10.9	9.65	11.8	1.75	22.4	20.2
eradicate	0.0	1.0	0.0	0.0	0.0	0.0
victims	6.0	6.0	6.0	6.0	6.0	6.0
immunity	0.0	0.0	0.0	0.0	0.0	0.0
giveaway	0.0	0.0	0.0	0.0	0.0	0.0
stalemate	1.0	1.0	1.0	1.0	1.0	1.0
arrive	0.0	0.0	0.0	0.0	0.0	0.0
Total	51.7	45.1	46.9	12.6	103.0	75.5

Table 2: Material value analysis for chess

- max-static-mob: The maximum static-mobility for this piece over all board squares.
- avg-static-mob: The average static-mobility for this piece over all board squares.

The values of most pieces in chess are large but not in shogi.

4. In chess only the pawn is allowed to promote. In shogi promotion is allowed for 6 different kinds of pieces. Also, in chess promotion is only allowed on the 8th rank (for white) or the 1st rank (for black). In shogi promotion is possible in the camp of the enemy, being the top three ranks or the bottom three ranks of the board. Another interesting difference as far as promotion is concerned is the fact that in shogi promotion is not obligatory (except in a few minor cases).

5. The most important difference between shogi and chess is the possibility of reusing pieces in shogi. When a piece is captured, this piece does not disappear from the game (like in chess), but is put next to the board. If it is a player's turn, he can either choose to play a move with a piece on the board or take one of the pieces previously captured and put it on a vacant square on the board[2]. There are almost no limitations to where a piece can be "dropped", even giving mate by putting a captured piece back on the board is allowed.

6. A draw by agreement or a draw because of the fifty move rule is not possible in shogi. Stalemate is theoretically possible, but because of the possibility of drops this has never happened in a normal game.

[2] As a result, all pieces in shogi have the same colour. The difference between one's own pieces and those of one's opponent is only determined by the shape of the piece, which is not symmetrical.

However, there is the possibility of impasse, where both kings enter into the enemy camp and can no longer be mated (*jishogi*). On average, only 2 out of every 1000 professional games end in jishogi (Yearbook, 1994). At amateur level, this is even rarer. As a result of these differences in the rules concerning draws, a draw is quite rare in shogi. Less than 1% of all professional shogi games end in a draw. Again, this figure is even less for amateur players.

B. Game programming differences

The rule differences between chess and shogi lead to differences in various aspects of game programming:

1. Chess is a converging game (number of possible moves decreases in the later stages of the game), while shogi is diverging (in the endgame the number of possible moves increases). This is mainly caused by the possibility of drops. However, since chess is slowly converging, the use of endgame databases is not so important as it is for example for mankala games and go-moku (Allis, 1994). In shogi, no endgame database is of any use, even though a special Tsume Shogi[3] solver is part of almost every shogi computer program.

2. As stated in the introduction, there is a considerable difference in state-space or game-tree complexity due to the dropping possibility, the extra promotion possibilities and the virtual impossibility of draws. As said, the study by Matsubara and Handa (1994) shows that shogi has an average branching factor of about 80. In chess this is estimated at 35. It is also known that the maximum branching factor in shogi is 593. The following diagram[4] is taken from Nozaki (1990):

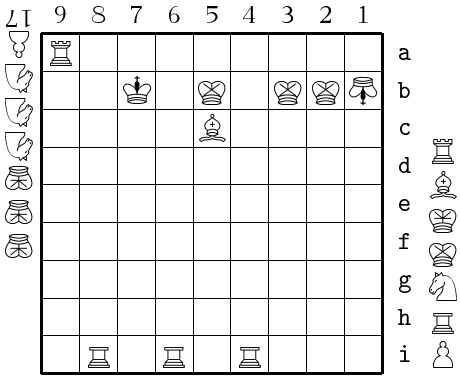

Diagram 3: An example of a maximum branching factor of 593

We do not know if such an upperbound is known for chess, but we believe that it is considerably smaller than 248, which is the maximum branching factor if all pieces are on the board and have their maximum moving ability[5]. We expect that the maximum branching factor of chess will be about 150.

It is also interesting to look at normal branching factors in the endgame (in shogi usually the stage of the game where the result is decided). In diagram 4, an example of a position that occured in an actual game between top players M. Nakahara and K. Yonenaga.

This position occured in the first game of the match for the most prestigious professional title, called *Meijin title*. Here, black (playing up the board) resigned. In this position, black has 159 possible moves, while white (in the previous position) had 158. These are common values in the endgame of shogi.

3. On average, a game of shogi takes about 115 ply. The maximum game length (in actual games) is more than 500 ply. In chess, the average is about 80 ply, while the record game length is currently 382 ply.

4. As said, many pieces in shogi have limited movement. This leads to a slow build-up and influences the average game length. It also influences the opening database that is so important in chess. There is a

[3] Tsume shogi is a shogi problem position where the king has to be mated by giving check with each move. The idea is to mate before the opponent has a chance to counterattack, since check is a forcing move. In Japan, composing and solving Tsume shogi is very popular. There are more than 100,000 different problems.

[4] Diagrams were produced by a special tool called OHTEXfor LATEX.

[5] It is possible to create a position with multiple queens, but as the 8 queen problem shows, it is not easy to align multiple queens in such a way that their interference is minimized.

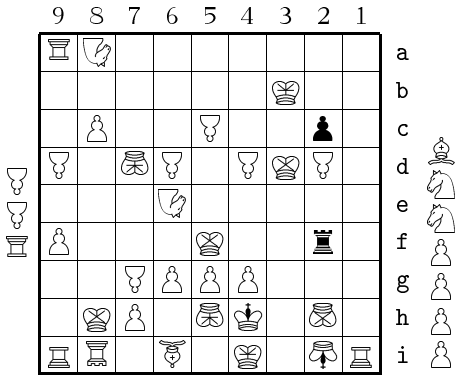

Diagram 4: An example of a position in an actual game played by two top players.

large number of books written on opening theory in shogi, but in general only patterns instead of strict move orders are being discussed. Also, new and interesting opening patterns are being developed until this day. Therefore, building a good opening database is more difficult in shogi.

We can see that shogi and chess are very similar. However, from a programming point of view there are some important differences. A slow build-up and the diverging nature of shogi makes it more difficult to aid the program in the opening and in the endgame. The most important difference, however, is the large game-tree complexity of shogi compared to chess.

IV. History of Computer Shogi

In the early 70s the first working computer shogi programs were written. These program could not cope with the game tree complexity very well, so they could only play at the level of a beginner. However, important break-throughs in hardware development, that have increased the strength of chess programs enormously, have also influenced computer shogi. Currently, the ability of computer shogi programs roughly correspond to that of Machack in computer chess. At the moment there are many commercial shogi programs on the (Japanese) market, the strongest of which play at the level of an reasonably strong amateur. In the Japanese grading system this roughly corresponds to a level of 1-dan or 2-dan, being the first and second grade of the strong amateur class. A complicating factor is that in shogi (as in other Japanese sports like judo and karate), there is no ELO like system to establish current playing strength. Grades are based on optimal performances and a grade once gained can not be lost. We estimate that an active 1-dan or 2-dan player roughly corresponds to a player with an ELO of 2000 in chess.

A society for the study of computer shogi called the Computer Shogi Association (CSA for short), was established in 1987 in Japan[6]. The CSA has motivated the leading researchers in computer shogi to describe their programming techniques in a book (Kotani et al., 1990). After that, many shogi programs have been written. An annual shogi tournament for computer programs has been organized by CSA since 1990. At the moment, YSS and Kanazawa Shogi are the names of the strongest programs. Mr. Kanazawa has won all the tournaments until the 1997 edition with programs under different names. However, in the recently held 1997 tournament the program was beaten by YSS. Both YSS and Kanazawa Shogi run on NEC personal computers, and are commercially available on the Japanese market. The results of the 1997 tournament are shown in Appendix A. A game score of the decisive game between YSS and Kanazawa Shogi is given in Appendix B.

A typical shogi program consists of an α–β searcher with a static evaluation function, some forward pruning method, iterative deepening and a tsume shogi solver to look ahead for mating.

In Japan, for a long time research on games has been considered unscientific. That is why the tournament above only has commercial programs as participants. Special hardware and super-computers have not yet been used in shogi. Lately, the characteristics of shogi have attracted the attention of more AI researchers and efforts in computer shogi are gradually increasing. The first workshop on computer shogi was organized by the CSA in 1994. Leading topics were techniques for making a shogi program and a tsume shogi solver (e.g. Yamashita, 1994). Shogi has now been established as an important research topic in AI (Iida & Kotani, 1991).

[6]The CSA can be contacted at **csa@etl.go.jp**.

This promises some improvement in playing level, but progress is expected to come at a standstill around the 3-dan grade (ELO estimate: 2100), still far from the level of expert players.

V. Conclusions

In this paper we have explained the differences between Shogi and Chess. We believe that chess and shogi are both interesting in game research, because there are a lot of differences between them from a computational point of view. Shogi is a chess-like game with a game tree complexity far larger than chess. We hope shogi will be a good target for AI research.

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Appendix A Preliminary Contest

No.	Program Name	1	2	3	4	5	6	7	W-L-D	Sa	Sd	Seed
1	YSS	26+	17+	11+	5+	2+	3+	4+	7-0-0	30.0	30.0	1
2	S1.2	28+	25+	24+	16+	1-	12+	6+	6-1-0	24.0	17.0	3
3	Yano	29+	9+	16+	18+	5=	1-	10+	5-1-1	28.0	16.0	2
4	Sekita	22+	16-	23+	6+	11+	9+	1-	5-2-0	28.5	18.5	14
5	J III	30+	12+	19+	1-	3=	11=	14+	4-1-2	28.5	12.0	4
6	IS Shogi	25+	30+	18+	4-	7+	24+	2-	5-2-0	24.0	13.0	26
7	Takada	19-	26+	30+	8+	6-	13+	12+	5-2-0	23.5	15.5	8
8	Oki	15-	27+	29+	7-	12-	17+	16+	5-2-0	21.0	12.0	28
9	Eisei Meijin	10=	3-	28+	15+	16+	4-	18+	4-2-1	25.5	10.5	10
10	SHOTEST	9=	28+	25+	11-	24+	23+	3-	4-2-1	21.5	7.5	25
11	Sougin	13+	15=	1-	10+	4-	5=	17+	3-2-2	32.0	11.5	5
12	Hyper	20+	5-	27+	14+	8+	2-	7-	4-3-0	29.5	13.5	12
13	Yamada	11-	20+	17+	26+	14-	7-	22+	4-3-0	23.0	10.0	20
14	Sakashita	17-	29+	21+	12-	13+	25+	5-	4-3-0	22.0	10.0	24
15	Hashimoto	8-	11=	20+	9-	25+	26=	19=	2-2-3	23.0	5.0	13
16	Tancho	27+	4+	3-	2-	9-	18+	8-	3-4-0	30.5	9.5	6
17	Amano Sr.	14+	1-	13-	19+	22+	8-	11-	3-4-0	29.5	9.5	9
18	Maruyama	21+	24+	6-	3-	19+	16-	9-	3-4-0	26.0	8.0	15
19	Seo	7+	21+	5-	17-	18-	22=	15=	2-3-2	25.0	8.0	23
20	Heishinku	12-	13-	15-	30-	29+	27+	24+	3-4-0	17.0	4.5	27
21	NazotekiDenki	18-	19-	14-	27=	23=	28+	26+	2-3-2	16.5	2.5	30
22	Amano Jr.	4-	23+	26+	24-	17-	19=	13-	2-4-1	21.0	4.0	29
23	Shogi Gold	24-	22-	4-	28+	21=	10-	29+	2-4-1	19.0	2.0	22
24	Kuroda	23+	18-	2-	22+	10-	6-	20-	2-5-0	26.5	5.0	7
25	Shouchan	6-	2-	10-	29+	15-	14-	28+	2-5-0	25.0	2.0	11
26	Kikuchi	1-	7-	22-	13-	30+	15=	21-	1-5-1	26.0	1.0	16
27	Ando	16-	8-	12-	21=	28-	20-	30+	1-5-1	20.0	1.0	21
28	Kien	2-	10-	9-	23-	27+	21-	25-	1-6-0	24.0	1.5	18
29	OM-1	3-	14-	8-	25-	20-	30+	23-	1-6-0	23.0	1.0	17
30	H shogi	5-	6-	7-	20+	26-	29-	27-	1-6-0	22.0	3.0	19

The top five programs qualify for the final

Table 3: Results of the preliminary contest of the 7th CSA tournament, Tokyo, February 8th 1997

Appendix B The Final

No.	Program Name	1	2	3	4	5	6	7	W-L-D	Seed
1	YSS 7.0	5+	8+	6+	3+	7+	2+	4+	7-0-0	4
2	Kanazawa Shogi 2	6+	5+	7+	8+	4+	1-	3+	6-1-0	1
3	Kakinoki Shogi	8+	7+	5+	1-	6+	4+	2-	5-2-0	2
4	Morita Shogi 6	7+	6+	8+	5+	2-	3-	1-	4-3-0	3
5	Yano Shogi 3	1-	2-	3-	4-	8+	7+	6+	3-4-0	6
6	S1.2	2-	4-	1-	7+	3-	8+	5-	2-5-0	5
7	Sekita Shogi 3	4-	3-	2-	6-	1-	5-	8=	0-6-1	7*
8	J III	3-	1-	4-	2-	5-	6-	7=	0-6-1	8*

Rank 7 and 8 are decided from the preliminary contest.

Table 4: Results of the finals of the 7th CSA tournament, Tokyo, February 9th 1997

Appendix C Games from the final

Black: Kanazawa Shogi
White: YSS 7.0
Finals of the 7th CSA Computer Shogi Tournament, Round 6
1.S-4h P-3d 2.P-2f G-3b 3.P-7f Bx8h+ 4.Sx8h S-2b 5.S-7g S-3c 6.P-6f S-6b 7.G-7h G-5b 8.K-6i K-4a 9.G-5h K-3a 10.K-7i G5b-4b 11.P-5f P-6d 12.S-5g P-8d 13.P-2e K-2b 14.S-4f P-4d 15.S-5e S-6c 16.K-8h P-7d 17.G5h-6g N-7c 18.P-3f P-4e 19.N-3g P-3e 20.Px3e P-5d 21.S-4d N-8e 22.Sx3c+ G4bx3c 23.S-8f S*3f 24.S*4h R-9b 25.B*1h Sx3g+ 26.Sx3g N*4b 27.S-2f G-4d 28.S*5c G4d-4c 29.Sx4b= Rx4b 30.N*3d Gx3d 31.Px3d S-5b 32.P-7e Px7e 33.Sx7e P*7d 34.Sx7d N*7e 35.G-7f S*6g 36.Gx7e B*3i 37.Gx6g Bx2h+ 38.S*5a R-4c 39.N*3e R-4d 40.P-2d Px2d 41.P*2c Gx2c 42.Nx2c+ Kx2c 43.G*3e R-4a 44.G*4b +Bx1i 45.Gx5b R*2h 46.S*7h Rx2f+ 47.Gx4a +Rx3e 48.B-2g +B-2h 49.B-1f K-1d 50.P-3c+ S*2e 51.P*2f +Bx1g 52.Bx2e Px2e 53.R*3d +Rx3d 54.+Px3d K-1e 55.Sx8e Px8e 56.N*2i +B-2g 57.R*2b Kx2f 58.Rx2a+ R*3i 59.N*1i +B-1h 60.S*3g K-1e 61.+R-2d K-1f 62.P*1g +Bx1g 63.+Rx2e Kx2e 64.Nx1g K-1f 65.S-2h R-2i+ 66.B*2e K-1e 67.S-2g S*7i 68.K-7g B*5i 69.G-6h Bx6h+ 70.K-7f G*8f 71.Px8f +Bx8f 72.K-6g S-6h+ 73.K-5g +R-5i 74.G*5h +Rx5h 75.resigns