The History of the World Computer Shogi Championship (WCSC)

Takenobu Takizawa
Faculty of Political Science and Economics, Waseda University

A quarter of a century has passed since the first Computer Shogi Championship was held. The strength of the top computer shogi programs that entered the last World Computer Shogi Championship is the same as the strength of the top human players. In this paper, there will be a brief history of computer shogi, including the history of before the first Computer Shogi Championship, an overview of the (World) Computer Shogi Championship, and discussion of some of the remarkable programs (algorithms) that have been involved, together with a brief history of human-computer matches.

1. Introduction

The first computer shogi program was developed in November 1974 by Takenobu Takizawa and his research group. The Computer Shogi Association (CSA) was jointly established in 1986 by Takizawa and Yoshiyuki Kotani, Professor Emeritus of the Tokyo University of Agriculture and Technology. This organization started organizing computer shogi tournaments, the World Computer Shogi Championship (WCSC), in 1990. Actually, the first through ninth WCSCs were each called the “Computer Shogi Championship,” but this was subsequently changed to the “World Computer Shogi Championship.” There were no restrictions on participation and many foreign programs were entered. All the championships in this article are described as WCSCs. The WCSC is supported by the Japan Shogi Association (JSA) 1)2)3)4)5).

The purposes of the championship are shown in the Championship Policies declared on January 23, 2012, although the purposes have not changed throughout the history of the tournament:

(1) The WCSC is held for the purpose of deciding the strongest computer shogi program at the time, under conditions of fair and impartial operation.

(2) The CSA imposes no restrictions on the hardware of any entrant for the WCSC. Furthermore, any person may enter the WCSC without restriction.

(3) The CSA maintains interchange among developers at the WCSC.

2. Overview of the WCSC

2.1 Results of the World Computer Shogi Championship

In 1997, when Deep Blue beat Gary Kasparov, the strongest computer shogi program was only a little stronger than an average club player. In 2002, Yoshimasa Tsuruoka, et al., the developers of a computer shogi program Gekisashi, installed their realization probability method and won the 12th and 15th championships. Gekisashi was invited to an Amateur Ryu-O tournament and was 16th, evaluated as close to top amateur shogi players.

In 2006, Kunihiro Hoki, the developer of the computer shogi program Bonanza, installed the "Bonanza Method" and won the 16th championship. Hoki disclosed the source code of Bonanza in 2009 and allowed any participant of the WCSC to include the code into the participant’s own program. Clearly, Hoki accelerated the progress of computer shogi very much.

The results of the WCSCs are shown in Table 2.1.

2.2 Winners

Eleven different programs have won a tournament. Kanazawa Shogi has won five times, IS Shogi and Gekisashi four times each, YSS three times, Bonanza and GPS Shogi twice each, and Eisei Meijin, Morita Shogi, Bonkras, Apery, and ponanza once each.

2.2.1 Kanazawa Shogi (Shin-ichiro Kanazawa)

Kanazawa Shogi entered the WCSC 15 times (2nd through 16th WCSCs), won 5 times (3rd through 6th, and 9th WCSCs), came second 4 times (2nd, 7th, 8th, and 11th WCSCs), and has gained legendary status in the WCSC as a result.

Table 2.1 Results of World Computer Shogi Championship

No.	Date(s)	Venue	Number of Participants	Winner	Second	Third
1	1990.12.2	TSK	6	Eisei Meijin	Kakinoki	Morita
2	1991.12.1	TSK	9	Morita	Kiwame	Eisei Meijin
3	1992.12.6	TSK	10	Kiwame	Kakinoki	Morita
4	1993.12.5	TSK	14	Kiwame	Kakinoki	Morita
5	1994.12.4	SGTBH	22	Kiwame	Morita	YSS
6	1996.1.20-21	SGTBH	25	Kanazawa	Kakinoki	Morita
7	1997.2.8-9	SGTBH	33	YSS	Kanazawa	Kakinoki
8	1998.2.12-13	SGTBH	35	IS	Kanazawa	Shotest
9	1999.3.18-19	SGTBH	40	Kanazawa	YSS	Shotest
10	2000.3.8-10	SGTBH	45	IS	YSS	Kawabata
11	2001.3.10-12	KAC	55	IS	Kanazawa	KCC
12	2002.5.3-5	KAC	51	Gekisashi	IS	KCC
13	2003.5.3-5	KAC	45	IS	YSS	Gekisashi
14	2004.5.2-4	KAC	43	YSS	Gekisashi	IS
15	2005.5.3-5	KAC	39	Gekisashi	KCC	IS
16	2006.5.3-5	KAC	43	Bonanza	YSS	KCC
17	2007.5.3-5	KAC	40	YSS	Tanase	Gekisashi
18	2008.5.3-5	KAC	40	Gekisashi	Tanase	Bonanza
19	2009.5.3-5	WU	42	GPS	Ootsuki	Monju
20	2010.5.2-4	UEC	43	Gekisashi	Shueso	GPS
21	2011.5.3-5	WU	37	Bonkras	Bonanza	Shueso
22	2012.5.3-5	UEC	42	GPS	Puella alpha	Tsutsukana
23	2013.5.3-5	WU	40	Bonanza	ponanza	GPS
24	2014.5.3-5	KAC	38	Apery	ponanza	YSS
25	2015.5.3-5	KAC	39	ponanza	NineDayFever	AWAKE

Kanazawa is the successor of Kiwame.

Puella alpha is the successor of Bonkras.

TSK: Tokyo Shogi Kaikan, SGTBH: Sheraton Grande Tokyo Bay Hotel, KAC: Kazusa Akademia Center, WU: Waseda University, UEC: The University of Electro-Communications

2.2.2 Gekisashi (Yoshimasa Tsuruoka, Daisaku Yokoyama, Takashi Maruyama, Ryo Takase, Takumi Oouchi)

Gekisashi entered 16 times (10th through 25th), won 4 times (12th, 15th, 18th, and 20th), and came second once (14th). Member of Akara 2010. Used a realizationprobability algorithm, the Bonanza method, a df-pn algorithm.

2.2.3 IS Shogi (Yasushi Tanase, Ayumu Nagai, Akihiro Kishimoto, Norifumi Goto)

IS Shogi entered 9 times (7th through 15th), won 4 times (8th, 10th, 11th, and 13th), came second once (12th). IS's main programmer, Yasushi Tanase rewrote a program (Tanase Shogi) from scratch. Tanase Shogi entered twice (17th and 18th) and came second on both occasions.

2.2.4 YSS (Hiroshi Yamashita)

YSS entered 24 times (2nd through 25th) won three times (7th, 14th, and 17th), came second 4 times (11th, 12th, 15th, and 18th), and came 8th or better on every occasion. Member of Akara 2010. Used a loosely coupled multi-processor system with parallel search, the Bonanza method.

2.2.5 Bonanza (Kunihito Hoki)

Bonanza entered 9 times (16th through 24th), won twice (16th and 23rd). Member of Akara 2010. Used the Bonanza method for

a huge number of parameters, as well as a consultation algorithm.

2.2.6 GPS Shogi (Tetsuro Tanaka, Tomoyuki Kaneko, Daigo Moriwaki, Shunsuke Soeda, Yoshiki Hayashi, Shogo Takeuchi)

GPS entered 14 times (11th and 13th through 25th), won twice (19th and 22nd). Member of Akara 2010. Used a loosely coupled multi-processor system with parallel search, the Bonanza method, a realization probability algorithm, a df-pn algorithm.

2.2.7 Eisei Meijin (Nobuhiro Yoshimura)

Eisei Meijin entered 10 times (1st through 3rd and 8th through 14th) and was the winner of the first championship. It won the WCSC once (1st).

2.2.8 Morita Shogi (Kazuro Morita)

Morita Shogi entered 9 times (1st through 9th), won once (2nd), and came second once (5th WCSC). Morita Shogi was the strongest program before the CSA began to manage the WCSC.

Kazuro Morita was an active member of the CSA. It was sad news when Mr. Morita passed away in 2012.

2.2.9 Bonkras/Puella alpha (Eiki Ito)

Bonkras (Puella alpha) entered 8 times (9th, 12th, 15th, and 18th through 22nd), won once (21st), and came second once (22nd). Used the Bonanza method. Eiki Ito made a program using a field programmable gate array (FPGA) system "A-Class League Move #1" and entered twice (18th and 19th).

2.2.10 Apery (Takuya Hiraoka, Ayumu Sugita, Shuhei Yamamoto)

Apery entered 4 times (22nd through 25th), and won once (24th). Used a Stockfish-like search, the Bonanza method for three-piece relationships, a magic bitboard.

2.2.11 ponanza (Issei Yamamoto, Akira Shimoyama)

Ponanza entered 7 times (19th through 25th), won once (25th), and came second twice (23rd and 24th). Used a magic bitboard, the Bonanza method. Akira Shimoyama had previously developed Blunder. Blunder entered 5 times (19th through 23rd) and used the Bonanza method and a df-pn algorithm. Shimoyama joined the ponanza team in 2014.

2.3 Programs from Outside Japan

Many programs from outside Japan have entered the WCSC.

2.3.1 GNU shogi (Matthias Mutz, USA)

GNU shogi was the first foreign entrant to the WCSC. It entered the WCSC once (5th WCSC), and came 7th out of 22 entrants.

2.3.2 Shotest (Jeff Rollason, UK)

Shotest entered 12 times (7th through 12th and 15th through 20th) and came third twice (8th and 9th).

2.3.3 SPEAR (Reijer Grimbergen, the Netherlands)

SPEAR entered 14 times (7th through 20th) and came 12th twice (17th, among 40 entrants, and 19th, among 42 entrants).

2.3.4 Shogi Gold (Andrew Pearce, Australia)

Shogi Gold entered once (7th).

2.3.5 KCC Shogi (An KyongNam, et al., North Korea)

KCC entered 9 times (9th through 16th and 19th), came second once (15th) and third three times (11th, 12th, and 16th).

2.3.6 Shocky (Pauli Misikangas, Finland)

Shocky entered 3 times (9th through 11th) and was once a finalist (10th, where it came 8th among 45 entrants).

2.3.7 Tejin (Tejin Potongan Soft, North Korea)

Tejin entered once (12th), and came 15th among 51 entrants.

2.3.8 Inaka Shodan (Till Plewe, Germany)

Inaka Shodan entered twice (14th and 15th).

2.3.9 God Shogi (Larry Tu, Taiwan)

God Shogi entered twice (16th and 17th).

2.3.10 Mumyo (David Wada, USA)

Mumyo entered six times (20th through 25th).

2.3.11 Koorogi (Jonathan Huang, USA)

Koorogi entered once (25th).

2.4 Other prominent participants

2.4.1 Kakinoki Shogi (Yoshikazu Kakinoki)

Kakinoki Shogi has entered the WCSC on all 25 occasions, and came second 4 times (1st, 3rd, 4th, and 6th WCSCs). Kakinoki Shogi is the first program that has won and lost more than 100 times each.

2.4.2 Ootsuki Shogi (Tomoshi Ootsuki, Natsumaro Kutsuna, Jun Araki)

Ootsuki Shogi entered 12 times (12th through 23rd) and came second once (19th).

2.4.3 Shueso (Akira Takeuchi)

Shueso entered 7 times (18th through

24th) and came second once (20th). Used the Bonanza method for a nonlinear evaluation function like a function from a three-layer perceptron in a neural network, and a df-pn algorithm.

2.4.4 NineDayFever (Yuji Kanazawa)

NineDayFever entered three times (23rd through 25th),and came second once (25th). Used the Bonanza method.

2.4.5 Kawabata Shogi (Shoichi Kawabata)

Kawabata Shogi entered 4 times (8th through 11th) and came third once.

2.4.6 Monju (Takuya Obata)

Monju entered once (19th) and came third once. Used the Bonanza method. A consultation algorithm was first implemented in Monju.

2.4.7 Tsutsukana (Takanori Ichimaru)

Tsutsukana entered five times (20th through 24th), came third once. Used the Bonanza method with extension of reduction of moves.

2.4.8 AWAKE (Ryoichi Kose)

AWAKE entered four times (22nd through 25th) and came third once.

2.4.9 Maruyama Shogi (Toru Maruyama)

Maruyama Shogi entered 11 times (6th through 16th). It won the 1057-move (ply) game (the opponent's machine stopped after the 1057th move) at the second preliminary contest of the 15th WCSC.

Maruyama Shogi played in a very special way (the goal is a perpetual loop and thus a draw) against the opponent. The opponent program refused the perpetual position and played through the 1057th move, but it went down after that move.

2.4.10 Inaniwa Shogi (Taketo Konno)

Inaniwa Shogi entered once (20th) and came 26th among 43 entrants. Inaniwa Shogi beat ponanza and Tsutsukana in the first preliminary contest and beat Shueso in the second preliminary contest of the 20th WCSC.

Inaniwa Shogi played in a more accurate way than Maruyama Shogi. The goal is a perpetual loop and a draw or a win by forcing the opponent to run out of time. Inaniwa Shogi got five wins and five draws in 16 games.

2.4.11 Shibaura Shogi/Shibaura Shogi Jr. (Harukazu Igarashi, et al.)

Shibaura Shogi entered three times (20th through 22nd). Shibaura Shogi Jr. entered three times (23rd through 25th). Both programs used the Bonanza method. Shibaura Shogi Jr. tried to make opening books (Joseki) from scratch.

2.4.12 Selene (Masahiko Saikaishi)

Selene entered four times (22nd through 25th). Selene managed to win by declaration in the second preliminary contest of the 25th WCSC.

2.5 Tournament Procedures and Pairing Methods

2.5.1 1st through 5th WCSCs

All games were played one day each. A round-robin system was used in the 1st and 2nd WCSCs and the Swiss pairing method in the 3rd through 5th WCSCs. The pairing program was called "suisui," developed by Sadayuki Urabe. He kindly let us use his program at three WCSCs.

2.5.2 6th through 9th WCSCs

There were two-day tournaments for the 6th and 7th WCSCs. Because entrants wanted to play head-to-head games to decide the champion, the CSA decided to have a round-robin final with a preliminary contest. The top three teams at the previous tournament were seeded into the final on the second day; the others entered the preliminary contest on the first day. The top five programs proceeded to the final. A 7-round Swiss pairing method was used for the preliminary contest. Yoshikazu Kakinoki developed the pairing program. We used just the Swiss method for the preliminary contest at the 6th WCSC, but we used an accelerated Swiss (2nd through one round before the last round, supposing the higher-seeded programs win) for the preliminary contest at the 7th WCSC.

The CSA divided non-finalists into two groups and separated the contest into two preliminary contests (upper and lower contests, decided by the order of the results of the previous WCSC) at the 8th WCSC. Four teams from the upper and one team from the lower preliminary contests proceeded to the final. The accelerated Swiss was used in both contests.

The CSA then installed a two-step preliminary contest in the 9th WCSC. Both contests were carried out on one day.

Table 2.2 Tournament Procedures and Pairing Methods

		First (Lower) Preliminary Contest			Second (, Higher, or only) Preliminary Contest				Final			
No.	Total Participants	Pairing Method	Rounds	Participants	Pairing Method	Rounds	Seeded Teams	Participants	Pairing Method	Rounds	Seeded Teams	Participants
1	6(2)								RR	5		6(2)
2	9(1)								RR	8		9(1)
3	10(1)								S	7		10(1)
4	14(1)								S	7		14(1)
5	22								S	7		22
6	25(1)				S	7		22(1)	RR	7	3	8
7	33(1)				MS	7		30(1)	RR	7	3	8
8	35	MS	7	16	MS	7	16	16	RR	7	3	8
9	40	MS	5	22	MS	7	15	20	RR	7	3	8
10	45	MS	7	26	MS	9	16	24	RR	7	3	8
11	55	MS	7	36	MS	9	16	24	RR	9	3	10
12	51(1)	MS	7	32(1)	MS	9	16	24	RR	7	3	8
13	45	MS	7	26	MS	9	16	24	RR	7	3	8
14	43(1)	MS	7	24	MS	9	16	24	RR	7	3	8
15	39	MS	7	22	MS	9	14	24	RR	7	3	8
16	43(1)	MS	7	24(1)	MS	9	16	24	RR	7	3	8
17	40	AS4	7	22	AS4	9	15	24	RR	7	3	8
18	40(1)	AS3	7	22(1)	AS3	9	15	24	RR	7	3	8
19	42	AS3	7	24	AS3	9	15	24	RR	7	3	8
20	43(1)	AS3	7	26(1)	AS3	9	14	24	RR	7	3	8
21	37	AS3	7	20	AS3	9	14	24	RR	7	3	8
22	42(1)	AS3	7	26(1)	AS3	9	16	24	RR	7	0	8
23	40(1)	AS3	7	24(1)	AS3	9	16	24	RR	7	0	8
24	38	AS3	7	22	AS3	9	16	24	RR	7	0	8
25	39	AS3	7	24	AS3	9	15	24	RR	7	0	8

Number of participants includes number of invited participants. Number in parentheses shows number of invited participants.

RR: round robin, S: perfect Swiss, MS: modified Swiss (=accelerated Swiss)

AS4: perfect Swiss (first round), perfect Swiss (supposing the higher-seeded teams win, second round), modified Swiss (third and fourth rounds), perfect Swiss (fifth round and thereafter).

AS3: perfect Swiss (first round), perfect Swiss (supposing the higher-seeded teams win, second round), modified Swiss (third round), perfect Swiss (fourth round and thereafter).

There were 15 second preliminary contest seeded teams. There were only five games in the first preliminary contest and five teams proceeded to the second preliminary contest. There were seven games in the second preliminary contest. We used the accelerated Swiss (supposing higher-seeded programs win in the 2nd round and draw 3rd through one round before the last round) for both preliminary contests,

2.5.3 10th through 21st WCSCs

These were three-day tournaments. The top three teams in the previous tournaments were each seeded to the final on the third day; usually, the fourth through 19th teams were seeded into the second preliminary contest on the second day.

There were 7 games in the first preliminary contests, 9 games in the second preliminary contests. There were 8 teams (10 teams at the 11th) including three seeded into the final and 24 teams in the second preliminary contests of the 10th through 21st WCSCs. We used 7-round accelerated Swiss pairing methods in the first preliminary contests and 9-round accelerated Swiss pairing methods in the second preliminary contests.

A modified accelerated Swiss pairing method was used at the 17th through 21st WCSCs.

Takenobu Takizawa modified Kakinoki's program and used Takizawa's program at the 11th through 21st WCSCs. Takizawa's program has been used for a number of Computer Go tournaments, too.

2.5.4 22nd through 25th WCSCs

Tsuyoshi Yamada, who had developed and managed the match-making server, developed and installed a pairing method into the server at the 22nd WCSC. The algorithm is the same as in Takizawa's program. Yamada's program was used for the 22nd through 25th WCSCs.

There were no final seeds and 16 second preliminary contest seeds at the 22nd through 25th WCSCs.

The tournament procedures and the pairing methods are shown in Table 2.2.

2.6 Stats of the WCSCs

Number of participation, number of wins,

Table 2.3 WCSC stats

(1) Number of Participation (20 or more)

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
1	Kakinoki Shogi	**25**	161	108	2	271	0.599	0.007
2	YSS	**24**	152	102	3	257	0.598	0.012
3	Garyu	**20**	67	104	4	175	0.392	0.023
3	Yamada Shogi	**20**	87	111	5	203	0.439	0.025

(2) Number of Wins (100 or more)

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
1	Kakinoki Shogi	25	**161**	108	2	271	0.599	0.007
2	YSS	24	**152**	102	3	257	0.598	0.012
3	Gekisashi	16	**133**	59	3	195	0.693	0.015
4	GPS Shogi	14	**101**	66	0	167	0.605	0.000

(3) Number or Losses (100 or more)

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
1	Yamada shogi	20	87	**111**	5	203	0.439	0.025
2	Kakinoki Shogi	25	161	**108**	2	271	0.599	0.007
3	scherzo	17	61	**107**	3	171	0.363	0.018
4	Garyu	20	67	**104**	4	175	0.392	0.023
5	YSS	24	152	**102**	3	257	0.598	0.012

(4) Number of draws (5 or more)

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
1	HIT Shogi	8	20	50	**7**	77	0.286	0.091
2	Yano Shogi	12	61	63	**6**	130	0.492	0.046
2	Narikin Shogi	15	38	61	**6**	105	0.384	0.057
2	Inoue shogi	3	2	11	**6**	19	0.154	0.316
5	Yamada Shogi	20	87	111	**5**	203	0.439	0.025
5	Dragon's Egg	16	87	80	**5**	172	0.521	0.029
5	Tsubakihara Shogi	15	26	72	**5**	103	0.265	0.049
5	Nazo teki Denki	11	47	60	**5**	112	0.439	0.045
5	Inaiwa Shogi	1	5	6	**5**	16	0.455	0.313

(5) Number of Games (150 or more)

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
1	Kakinoki Shogi	25	161	108	2	**271**	0.599	0.007
2	YSS	24	152	102	3	**257**	0.598	0.012
3	Yamada Shogi	20	87	111	5	**203**	0.439	0.025
4	Gekisashi	16	133	59	3	**195**	0.693	0.015
5	Garyu	20	67	104	4	**175**	0.392	0.023
6	Dragon's Egg	16	87	80	5	**172**	0.521	0.029
7	scherzo	17	61	107	3	**171**	0.363	0.018
8	GPS Shogi	14	101	66	0	**167**	0.605	0.000
9	Mattari Yuchan	13	67	93	3	**163**	0.419	0.018

(6) Win Ratio (Best 10. 50 or more games (* shows less than 50 games))

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
*	Tanase Shogi	2	27	3	0	30	**0.900**	0.000
*	Monju	1	18	5	0	23	**0.783**	0.000
1	IS Shogi	9	63	18	0	81	**0.778**	0.000
2	KCC Shogi	9	89	29	4	122	**0.754**	0.033
3	Morita Shogi	9	48	19	2	69	**0.7164**	0.029
4	ponanza	7	73	29	1	103	**0.7157**	0.010
5	NineDayFever	3	38	16	1	55	**0.704**	0.018
6	Bonanza	9	82	35	0	117	**0.701**	0.000
7	Gekisashi	16	133	59	3	195	**0.693**	0.015
8	Kanazawa Shogi	15	89	41	2	132	**0.685**	0.015
9	Puella Alpha	8	62	35	2	99	**0.639**	0.020
10	Apery	4	38	23	3	64	**0.623**	0.047

Win ratio is (number of wins)/(sum of numbers of wins and losses)

Table 2.3 WCSC stats *(continued)*

(7) Draw Ratio (Highest 10. 50 or more games (* shows less than 50 games))

	Name	#Participation	#Wins	#Losses	#Draws	#Games	Win Ratio	Draw Ratio
*	Inoue Shogi	3	2	11	6	19	0.154	**0.316**
*	Inaniwa Shogi	1	5	6	5	16	0.455	**0.313**
1	HIT Shogi	8	20	50	7	77	0.286	**0.091**
2	Hakusha Shogi	9	23	36	4	63	0.390	**0.063**
3	Narikin Shogi	15	38	61	6	105	0.384	**0.057**
4	Tsubakihara Shogi	15	26	72	5	103	0.265	**0.049**
5	Apery	4	38	23	3	64	0.623	**0.047**
6	Yano Shogi	12	61	63	6	130	0.492	**0.046**
7	Nazoteki Denki	11	47	60	5	112	0.439	**0.045**
8	Sexy Aichan	14	40	65	4	109	0.381	**0.037**
9	Hyper Shogi	11	54	54	4	112	0.500	**0.036**
9	Daemon Shogi	8	19	35	2	56	0.352	**0.036**

Draw ratio is (number of draws)/(number of games)

win ratio and other stats are shown in Tables 2.3(1) through 2.3(7).

3. The Art of Computer Shogi

Computer Shogi uses an alpha-beta tree pruning method with some ideas from computer chess and other completely new shogi-based ideas.

3.1 Basic Technology

Many computer shogi programs use PVS (principal variation search), quiescence search, aspiration search, null move (forward) pruning, futility pruning, killer heuristic, history heuristic, iterative deepening, transposition hash tables, and singular extension, adopted from chess programs.

3.2 Realization Probability Algorithm

Before playing, professional players' moves are collected and categorized, then probabilities calculated, such as recapturing or capturing and gaining material, promoting a rook and gaining material, checking and gaining material, and so on. When playing, the programmer must evaluate the nodes if the probability (multiplied) is less than the threshold; otherwise, he or she must search more deeply.

Yoshimasa Tsuruoka proposed this algorithm in 2002 and implemented it in the shogi program Gekisashi, winning the championships in 2002, 2005, 2008, and 2010.

3.3 Bonanza Method

Before playing, the programmer gathers professional players' move records in the form of textbooks. The subsequent steps are as follows: Prepare a linear evaluation function and decide the initial coefficients of

the function. Give many positions and find the best move for each, then compare it with the move in the textbooks. Count the number of moves for which the program moves and the textbook moves are identical and calculate the ratio of identical moves. If the ratio is high, then the coefficients are probably right, but if the ratio is low, then the coefficients are probably wrong. To adjust the coefficients, a numerical iterative method such as that used to solve partial differential equations is used. When playing, the program just uses the evaluation function.

Kunihito Hoki proposed this algorithm in 2006 and implemented it in the shogi program Bonanza, winning the championships in 2006 and 2013.

By 2006, about thirty thousand coefficients had been adjusted. Now, more than forty million coefficients have been adjusted and this method has been further extended to nonlinear evaluation functions.

3.4 Other Ideas

3.4.1 Consultation Algorithm

A consultation algorithm was first implemented in Monju in 2009 by Takuya Obata, as follows: Give the root position to independent computers and receive the best move each (voting phase), and then decide the move by a given algorithm, such as move

with the best score, or just by majority (decision phase).

3.4.2 Loosely Coupled Multi-Processor System with Parallel Search

The first computer shogi program using a multi-processor system was Super Shogi, by Hisayasu Kuroda, in 1997. This was an eight-computer system.

The first computer shogi using a loosely coupled multi-processor system with parallel search was GPS Shogi by Tetsuro Tanaka, Tomoyuki Kaneko, et al., in 2000. This system used 320 processors (666 cores).

GPS Shogi won the 22nd WCSC in 2012 and won against Miura 9-dan in the second Den-O-Sen, in 2013, using such a system.

3.4.3 Df-pn (depth-first proof number search) Algorithm

This derives from studying tsume-shogi (mating) problems. Unlike the case of chess, the number of possible moves in the endgame of shogi is the same as the number of possible moves in the middle game, so a good algorithm for searching and/or tree is needed for solving tsume-shogi problems. Ayumu Nagai proposed this algorithm and implemented it in a tsume-shogi solver, succeeding in solving many problems.

4. Conclusion

The top computer shogi programs have already come close to the top human-player level. Yoshiharu Habu Meijin predicted about ten years ago that the top programs would be close to the top human-player level in ten years. His words were prophetic. Many professional players understand how strong top computer programs have become, as do many other people after watching the recent championship.

Computer shogi programs have become the helpful partners of professional players, who now use computer shogi for verifying their studies, for example. Daisuke Nakagawa 8-dan observed the 18th WCSC and also the exhibition between Tanase Shogi (the runner-up) and top amateur player Yukio Kato. Tanase Shogi won the game. Nakagawa studied this game and won his next three professional games, including the one versus Akira Watanabe.

Toshiyuki Moriuchi 9-dan studied ponanza's moves and used them at the Meijin match versus Yoshiharu Habu in 2013, winning the game and the match.

Professional players now make a careful study of moves such as GPS's attacking move against Miura 9-dan and YSS's king move against Toyoshima 7-dan.

The human chess game is still active, but computer chess programs are now stronger than the strongest human player. The relation between human shogi players and computer shogi programs will be the same as that between human chess players and computer chess programs in five years' time. But problems remain. Among them, for example, many of the winning ways of shogi are still to be solved.

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