SCHWARZMAN VERSUS MAXIMUS
A MAN-MACHINE MATCH IN INTERNATIONAL DRAUGHTS

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ABSTRACT

This report describes the match of former World Champion Alexander Schwarzman against computer draughts program *Maximus*. An introduction is given to international draughts, computer draughts, Man-Machine battles in mind sports, and *Maximus*. The outcome of the match, a 7-5 win for Schwarzman, is described and analyzed from a computer science point of view.

1. INTRODUCTION

From April 9-14 2012, a Man-Machine battle in international draughts took place in Heerhugowaard, The Netherlands, as a side-event to the Dutch National championship in international draughts. A match with, on one side of the board, Alexander Schwarzman from Russia, and on the other side *Maximus*, a computer draughts program from The Netherlands.

International or *Polish* draughts (see box) is a board game of strategy and tactics, which can be compared to checkers (or *English* draughts), which has similar rules but is played on the smaller 8x8 board, and chess. It is mainly played in parts of Western Europe, the former USSR countries and Africa, and more recently it is gaining popularity in South America (Brazil) and Asia (China).

Let's first look at draughts tactics. A famous combination is Sijbrands vs. Sheoratan (Paramaribo 1969), see diagram 1. White to move can force getting a king – on an *occupied* square! Black is able to catch the king but in the end loses a man (see diagram 2) and the game.

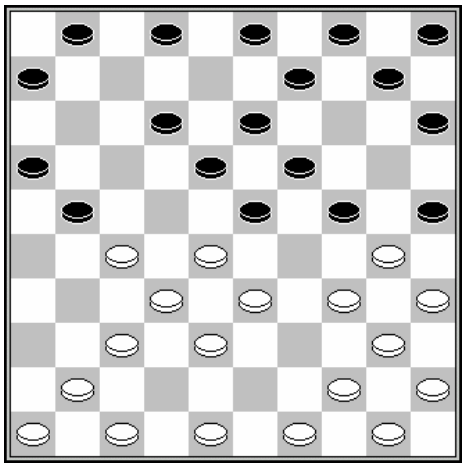

Diagram 1. After 11…20-25?

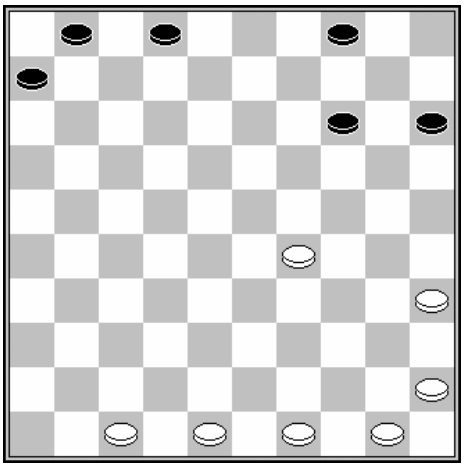

Diagram 2. After 21…5x14

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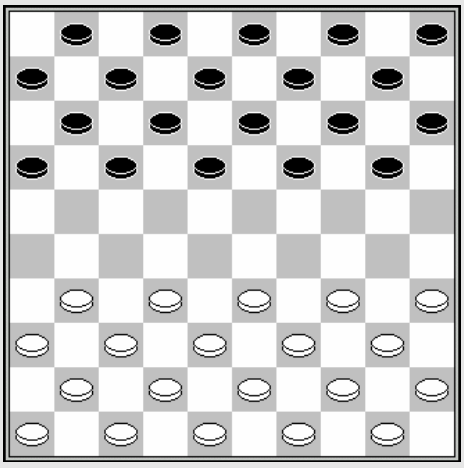
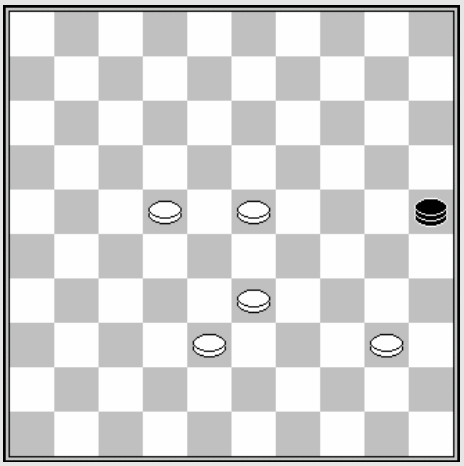
INTERNATIONAL DRAUGHTS RULES

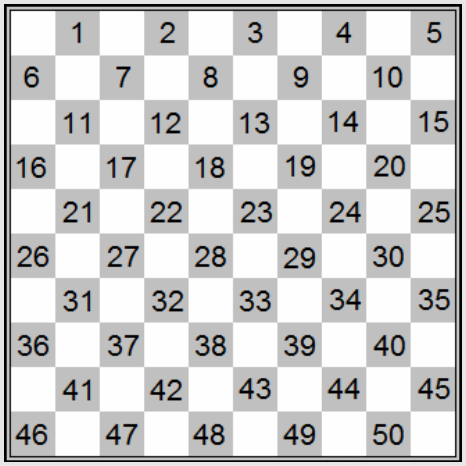
The game of international draughts is played on a 10x10 board with alternating light and dark squares. Only the dark squares are used. The game is played by two players, white and black, who sit on opposite sides of the board such that the bottom left square is a dark one. Both players start with 20 pieces (*men*), placed as follows.



The players move in turn, white to begin. A normal move consists of moving a man one square diagonally forward to an empty square. A capture move consists of jumping diagonally forward *or backwards* over an enemy piece on an adjacent square to an empty square immediately behind that, and removing the captured piece. It is possible to capture multiple pieces in one move with the same piece. However, the captured pieces are only removed *after* the moving piece has arrived at its destination square, and it is not allowed to jump *twice* over the same enemy piece. Capturing is mandatory; one always has to choose a (or *the*) move capturing *the most* pieces (men or kings). When a man reaches the other side of the board on completion of a move, it is crowned a *king* by placing a second piece on top of it. A king moves and captures like a man, except that it can also *move backwards* and it can move to *any* empty square on a diagonal. The following example, a *Coup Turc*, illustrates the above.



White to move



Notation square numbers

White plays **40-34**! Then black has only one legal move: his king must capture **25x43x27x18x29**, removing the white men at 34, 38, 22 and 23. After which white captures the black king with his only piece left: **33x24**.

The player who cannot move on his turn, because all his pieces are captured or blocked, loses the game. If neither player can win –or if both players agree so– the game is a draw. The result of a game can be 2-0 (white won), 0-2 (black won) or 1-1 (draw).

From diagram 1 the combination goes as follows, where forced moves (no choice) are underlined: **12.27-22! 18x27 13.33-29 24x33x42x31 14.44-39! 27x38 15.41-37 23x32x41 16.46x37x26x17x8 3x12 17.39-33 38x29 18.34x23x14x3 25x34**. White sacrificed three men to get a king, and now has a choice in capturing one of two black men, taking into account that his king will be caught. After **19.3x26** …, black's best option is a counter combination to catch the king. **19…10-14 20.40x29 16-21 21.26x8x19x10 5x14** (diagram 2). Black lost a man without compensation and in the game resigned after a few more moves.

For human players this combination is very challenging. One has to be able to calculate 20 plies ahead and correctly assess the position after 23 pieces disappeared from the board! For computer programs, on the other hand, this is the easy part. Observing that 12 out of 20 moves are forced suggests to extend the search (by 1 ply) in these cases. (It also makes sense to extend the search by 1 ply if there is a capture choice in a leaf of the tree.) Now a minimax search of *only 8* extended ply (*eply*) suffices to find this combination. Using standard techniques like alpha-beta pruning and a transposition table, a draughts program will see this in a fraction of a second. This means that even without good positional heuristics draughts programs are very dangerous opponents, especially in blitz games. One of the charms of draughts is that in almost every position a combination might be lurking, which can completely reverse the chances.

Now let's look at draughts *strategy*. Another charm of draughts variants, compared to e.g. chess, is that one cannot move back-and-forth, at least until one has a king. With most draughts games lasting between 40 and 60 moves (80 and 120 ply), any move can have very long-term consequences – and there is no way back. Human grandmasters are highly skilled in long-term strategy, e.g. delaying choices and switching game types. They strike when their opponent makes a mistake. For computer programs, on the other hand, this is the hard part. A particularly difficult subject is the positional sacrifice. Sacrificing a man for a long-term positional advantage is a rare event in draughts. (Except when getting a king, this is often worth sacrificing two men.) An example is the following fragment from the game Kalk vs. Georgiev (Dutch Team Championship, 2012.02.11).

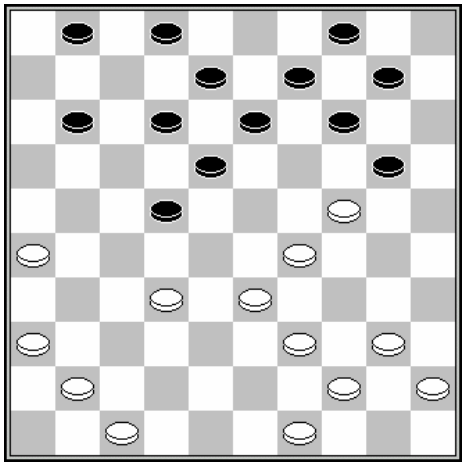


Diagram 3. After 25.30-24…

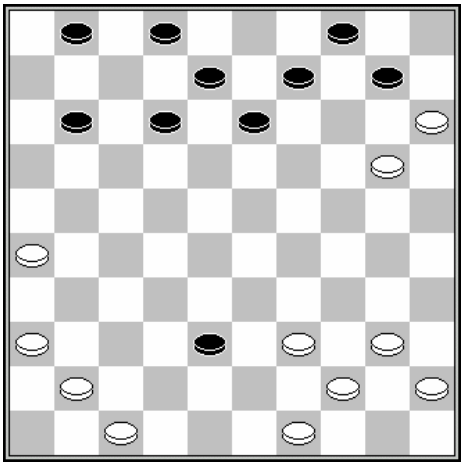


Diagram 4. After 28…18x29x38

In diagram 3, World Champion Alexander Georgiev played **25...14-19!?! 26.24x15 19-24 27.29x20 22-28 28.32x23 18x29x38**, see diagram 4. A bold sacrifice. Note that, as opposed to checkers, in draughts it is allowed to capture backwards, and thus the black outpost on 38 is potentially threatened from behind by 40-34-29 and 39-33. In the game, white decided (later) to return the piece and lost. The game was analyzed by Dutch draughts publicist Eric van Dusseldorp using the world's strongest draughts program *Kingsrow International*, concluding that the sacrifice is not correct and that black should lose. Georgiev himself replied on the World Draughts Forum:

> *"Do not believe the computer so much!* [...] *There are no concrete variants in this position – too many variations.* […] *Given analysis cannot prove anything."*
> (Forum, Nationale Competitie 2011-2012, pp. 29)

If this is indeed a winning sacrifice, this may only prove to be so (for an evaluation function) after say 20 moves (40 plies) – and this is far beyond the search depth of even the fastest programs today. So unless programs learn to master sacrifices like this, and strategic play in general, they may not be able to surpass the World Champion.

2. COMPUTER DRAUGHTS & MAN-MACHINE BATTLES

The first computer programs for international draughts were created in the late 1970's. Since then over a hundred draughts programs have been developed, the majority of which has played in one or more computer tournaments. The first computer draughts tournaments were organized in 1987 in The Netherlands (and every year since!), two years later followed by a draughts tournament at the first ICGA Computer Olympiad, London 1989. Since 1999 computer draughts tournaments are also organized in France (Nagels, Web).

From 1990-1995 computer draughts was dominated by *Truus*, a strong program written by Stef Keetman of The Netherlands. In the 1990's, *Truus* was allowed to play in a number of human tournaments. In Toulon 1992, *Truus* proved to be one of the best 10 blitz players in the world, beating World Champion Alexei Tsjizjov and not losing a single game (Keetman 1993). *Truus* also played very well in a number of open tournaments (IJmuiden 1992, 2nd place; Geleen 1996, 3rd place; Minsk 1997 Open Group, 1st place). In 1993/4, *Truus* ranked about 40th in the world (Allis 1994, pp. 170). *Truus* retired from active play in 1997, and is commercially available.

From 1996 on the strongest program was *Flits* (Adri Vermeulen, Netherlands), around 2000 joined by *Buggy* (Nicolas Guibert, France). In the years 2001-2004 these programs played a number of Man-Machine matches against some of the strongest human players (Guibert, Web; Wesselink, Web):

2001	*Buggy*	vs.	N'Diaga Samb, GMI	11–15	+0 –2 =11	
2002	*Flits*	vs.	Johan Krajenbrink, GMI	13– 7	+3 –0 = 7	
2003	*Buggy*	vs.	N'Diaga Samb, GMI	9–3	+3 –0 = 3	
2003	*Flits*	vs.	Guntis Valneris, GMI	7–7	+0 –0 = 7	
2004	*Flits*	vs.	Jeroen van den Akker	4–2	+1 –0 = 2	rapid

Johan Krajenbrink (Netherlands) finished third in the 2001 World Championship and N'Diaga Samb (Senegal) was ranked number eight in the world in 2003. Their defeat caused quite a stir in the draughts world. The 2003 match of *Flits* against Guntis Valneris (Latvia), the 1994 World Champion, is the closest thing to a "Draughts World Man-Machine Championship" thus far – and the result is undecided. *Buggy* retired in 2003, *Flits* in 2004. *Flits* is also commercially available.

In 2005, tenfold World Champion Alexei Tsjizjov (Russia) was asked in an interview if he should play the strongest computer program. His answer was:

> *"Why should I? I won't lose, but I can't win because computer defends phenomenally. He sees all my threats many moves before. And to play blitz games against computer has no sense, he will never make a serious mistake and certainly will win. Draughts players with self respect use computer as database and sparring partner, first of all for studying of end games. Nobody is planning* [to] *fight him."*
> (Translation by Alexander Presman; Forum, Who wins a match between the world champion and a computer?)

CHECKERS, CHESS & DRAUGHTS

The complexity of international draughts lies between that of checkers and chess. Allis (1994) gives the following estimates for the game-tree complexity: checkers 10^{31}, draughts 10^{54} and chess 10^{123}. Because Man-Machine matches were previously played in all three mind sports, it is interesting to compare them with respect to Artificial Intelligence progress.

Checkers (8x8)
Checkers was (weakly) solved in 2007 by Jonathan Schaeffer and his team of the University of Alberta, Canada, after 18 years of computations on multiple computers. Before that, their checkers program *Chinook* won the 1994 World Man-Machine Championship (by forfeit) in a match against checkers legend Marion Tinsley (1927-1995), who had won the previous match in 1992. In the following years *Chinook* proved to be the best checkers player in the world until its retirement in 1997 (Schaeffer 2009). Modern checkers programs like *Cake* and *KingsRow* are virtually unbeatable. They search to see a database draw right after leaving the large opening book (Wikipedia, KingsRow).

Chess
In 1997, IBM chess computer *Deep Blue* beat World Champion Garry Kasparov by 3½-2½ in a famous six-game match, after the first match in 1996 was won by Kasparov (4-2). By using a parallel supercomputer and special chess hardware *Deep Blue* was able to search 200 million positions per second. In 2006, chess program *Deep Fritz* beat World Champion Vladimir Kramnik by 4-2. *Deep Fritz* was running on a personal computer and was able to search 8 million positions per second (Wikipedia, Human-computer chess matches). Chess programs continued to improve and it can be said that today they play on a superhuman level.

Draughts (10x10)
Compared to checkers and chess, there has been less research and development in international draughts, and also less Man-Machine events. Draughts program *Truus* beat World Champion Alexei Tsjizjov in a blitz game in 1992. After that, programs *Buggy* and *Flits* have beaten strong grandmasters and tied a match against former World Champion Guntis Valneris in 2002/3 (see text), all running on desktop PC's. Draughts programs have not (yet) played, let alone beat, the reigning World Champion in a serious match.

Nevertheless the development of computer draughts continued, with new or updated programs utilizing the increasing power of desktop computers, namely 64-bit architectures, multi-core processors, more RAM, and bigger and faster hard disks. Larger databases were built. Also the development of new algorithms such as MTD-f did not go unnoticed in the computer draughts world.

It has been some years now since all the strongest programs played together in one tournament. If we look at the tournaments played from 2004-2011, we see no less than ten different winners, often in absence of strong rivals. There is an unofficial computer draughts rating list, but today the relative strength of draughts programs is mainly determined through playing large numbers of (blitz) games in automated matches. This gives a more reliable picture than computer tournaments, where programs play only a small number of games.

Today, *Kingsrow International*, the international draughts version of the strong checkers program *KingsRow* by Ed Gilbert (USA), is generally accepted as being the strongest draughts program in the world. It has a parallel search and an endgame database of 2-8 pieces plus 5 vs. 4 men (total 400 GB, compressed). Before that, the standard was 2-6 pieces (1.5 GB), which today easily fits into RAM. In international draughts, larger endgame databases do not contribute much to practical playing strength, but they are of great value when analyzing endgames. Gilbert reported the following results for *Kingsrow*: a 64.5% score vs. *Truus* (948 games) and a 60.1% score vs. *Flits* (idem) using 3:1 search threads (Forum, Internet engine matches). *Kingsrow International* is commercially available.

3. MAXIMUS

Maximus is a draughts program being developed by the author of this report, and the successor to *ABCdam* (2008/9). *Maximus* is written in 100% Java and runs on a 64-bit Java virtual machine.[2] Even so, its performance is competitive compared to other draughts programs written in (compiled) C/C++, measured by *perft* (performance test), nodes per second or search depth (e.g. Forum, Perft). The object-oriented code is efficient because all objects used during the search are created at program startup time. Only for the transposition table entries no objects are used because of the high Java memory overhead per object, 24 bytes.

Maximus is a typical brute force AI program. It uses bit boards to represent the board (50 squares fitting into 64 bits) which enables fast move generation and pattern matching using bitwise operators. The search algorithm is parallel alpha-beta, with the extensions mentioned in the introduction. The parallel search is based on the YBWC implementation of the strong open source C++ chess program *Stockfish*, slightly remodeled to make it more OO. Furthermore, the following standard techniques are used: (internal) iterative deepening, transposition table (Zobrist hashing, clustered lockless hash table), History Heuristic, forward pruning (based on the mechanism of checkers program *Chinook*), and pondering (on the expected move). Each algorithm having some parameters, it takes careful tuning to obtain a good overall result. Some optimization techniques were added to speed up parts of the search.

Writing an evaluation function (for draughts) is not an easy task. The programmer needs at least some understanding of the principles of the game and has to come up with some magic formula that reduces a position to a single number. It is clear that just counting pieces will not do the trick. One of the problems is that the side to move may have a (winning) combination in an otherwise "bad" position. One technique to deal with this is (automatic learning and) application of *tactical patterns* (Keetman 1994), first implemented in *Truus* and later also in other programs. *Maximus* does not use this technique. It relies on a deep search and like other modern programs it searches much deeper than *Truus* and *Flits*. The evaluation function attempts to quickly assess the position based on key draughts principles, e.g. development, centre control, locks. The weight factors of the evaluation terms were tuned by hand, after studying draughts literature and observing many test games.

Special care is given to detecting *runaways*, men that cannot be stopped from becoming kings. For this, a 'breakthrough table' (160 MB) was built, containing all possible combinations of one white man and 0-20 black men on the opposite half of the board (25 squares). For use by black, the position is reversed. (See also game 2.)

Keetman (1993) reports that *Truus*' evaluation function consists of >5000 lines of code, containing ±2000 positional patterns (and ±1000 tactical patterns). For *Maximus*, these numbers are "only" <2000 lines of code, containing <100 positional patterns (and no tactical patterns). This is not by design; working on the evaluation function is an ongoing task which by no means is finished.

Finally, *Maximus* has an opening book of ±100,000 positions (generated from a database with games by strong players) and an endgame database of 2-6 pieces (generated by M. Grimminck & H. Jetten). For checkers programs these are two vital ingredients, but in international draughts this is not the case:

Maximus without opening book	vs. *Maximus*	+7 –7 =144	50.0%
Maximus without endgame database	vs. *Maximus*	+6 –15 =137	47.2%

These matches were played with 5 seconds per move (fixed) and two search threads each. Using an endgame database gives a slightly better result (about 20 ELO points), while the only advantage of an opening book seems to be saving time. The playing strength of a draughts program mainly depends on the quality of the evaluation function and the search (depth), and how well these work together.

[2] The first 64-bit Java-to-native compiler is expected in 2013.

Maximus won both computer tournaments it competed in so far, the 2011 Dutch Open Computers Rapid (score +5 –0 =4) and the 2011 Computer Olympiad (score +6 –0 =5), on an Intel Quad Core i7-2600K 3.4 GHz. Without the strong(er) competition of *Kingsrow*, *Damage*, *Damy* and (perhaps) *Dragon*, but ahead of former tournament winners *DIOS*, *Sjende Blyn*, *TD King*, *Tornado* and *Dam 2.2* (Tournament base, Web). Also it won two test games against human players of candidate master level. *Maximus*' positional play was characterized as *ijzersterk* ("strong as iron") in a newspaper article by Dutch master Tjalling Goedemoed (*Friesch Dagblad*, 2011.11.02) — but is it a match for Alexander Schwarzman, one of the best draughts players in the world?

4. THE MATCH

In the summer of 2011, I requested that *Maximus* was allowed to play in the Amersfoort Open, a yearly international tournament organized by my draughts club ADG. With players ranging from grandmaster to second class, it is an interesting test for *Maximus*. Unfortunately, it was voted against by the strong players. However, to my surprise an email from Alexander Schwarzman (one of the players) was forwarded to me, in which he stated he was prepared to play a match against the computer! Of course it took some time to organize and to find a sponsor, but in the end a perfect solution was found: the match would be played next to the 2012 Dutch championship (SNA, Web).

We agreed to play six games, one per day, with the same playing tempo as the Dutch championship: 2 hours for 50 moves, followed by 1 hour for 25 moves and finally 20 bonus seconds per move till the end of the game. In case of a tied match, a tie-break will be played in sudden death with a time limit of 5 minutes plus 5 seconds per move (Fischer-system), with a maximum of 4 games. If the score is then still equal, the match is declared a draw. Until then, *Maximus* was playing with a fixed amount of time per move. For the match, I implemented the abovementioned time controls, and a variable time per move, depending on the stability of the search (best move and score). This also seemed the right time to buy a new computer, an Intel Core i7-3930K 3.2 GHz 32GB RAM, a 6-core with hyper-threading.

Did I consider *Maximus* up to the task? It had started to win 158-game blitz matches by a small margin against *Truus* (51.6%) and *Flits* (50.6%) using 3 search threads. And more computing power means a stronger game.

Maximus 6 threads vs. *Flits*	+18 –6 =134	53.8%	5 minutes/75 moves
Maximus 6 threads vs. *Flits*	+ 1 –0 = 17	52.8%	45 minutes/75 moves

To be fair, *Flits* was running on a (slower) Intel Core i7-920 2.8 GHz in these two matches. On the other hand, although the draw percentage is high, *Maximus* had the better chances in most games.[3] In two matches against *Kingsrow 1.52*, *Maximus* achieved a more modest result. Both using three (non-hyper) search threads and pondering.

Maximus vs. *Kingsrow* 6 piece db	+1 –30 =127	40.8%	5 minutes/75 moves
Maximus vs. *Kingsrow* 8/9 piece db	+1 –32 =125	40.2%	idem

So *Maximus* can be beaten – but it takes a (very) strong opponent to do so. However, a good result against other programs, achieved by increasing search depth alone, does not necessarily mean an equally good result against strong human players. In the meantime, the discussion on the game Kalk-Georgiev on the World Draughts Forum (see Introduction) led to the suggestion of a match Georgiev-*Kingsrow*. The World Champion comments:

[3] The question remains how much stronger *Flits* is (and *Truus*, for that matter) when running on modern hardware, compared to 2002-4. Even though it is a 32-bit program and has no parallel search. In automated matches it lacks the opening book of its original (*Turbo Dambase*), but can nevertheless benefit from running on a faster computer.

> *"Kingsrow is a very good program, but I do not think it is stronger than the best human player.* [...] *Of course I would like to play a match against the computer. In draughts, human has more chances against the computer than in chess. In chess, concrete playing begins from the first moves, and even in these cases, the computer may give an incorrect evaluation sometimes, for instance, after positional sacrifices. And in draughts, concrete playing often begins in the second half of the game, so there is a chance to make advantage in the first half... But this is all only a theory. Really interesting to see how it will go in practice!"*
> (Forum, Nationale Competitie 2011-2012, pp. 29)

On the World Draughts Forum, some predictions were made by fellow programmers – and every possible outcome was predicted (Forum, Maximus vs. Schwarzman draughts match). Aware of some of the weaknesses of *Maximus*, and knowing that Schwarzman seldom makes mistakes, my own expectation was a –hopefully– small loss. (Only after the match, I learned that Alexander Schwarzman was psychologically prepared to lose too, based on the current situation in chess.)

The games were played on a digital draughts board. The board was connected directly to *Maximus*, so that the moves made by Schwarzman were transmitted automatically to the program, and the games could be broadcasted live on the internet (SNA, Web). *Maximus* settings for the match were: 12 search threads (10 for pondering) and a hash table of 128M entries. The Java process uses 6.5 GB RAM in total. At tournament conditions, *Maximus* is able to search more than 23 million positions per second, with an average search depth of 24 *eply*. Will it be enough?

THE PLAYERS

Alexander Schwarzman (1967) is a Russian draughts player, international grandmaster (GMI) and three times World Champion in international draughts (1998-2000, 2007-2009 and 2009-2011). He also was European Champion (2002) and many times National Champion of Russia (and the USSR). He is currently ranked 2nd on the rating list of the World Draughts Federation FMJD, after reigning World Champion Alexander Georgiev (Russia). Schwarzman also plays other draughts variants, on the 8x8 board: Brazilian draughts and Russian checkers, in which he also won many (inter)national titles.

Alexander Schwarzman www.nkdammen2012.nl

Maximus (2010) is a Dutch computer draughts program being developed by the author of this report, who is also an amateur draughts player since 2011. *Maximus* is the current Dutch Open Rapid and Olympic computer draughts champion.

Round 1, 2012.04.09. White: Maximus - Black: Alexander Schwarzman[4]

1. 32-28 17-22 2. 28x17 12x21 3. 34-30 7-12 4. 30-25 1-7 5. 40-34 11-17 6. 45-40 7-11 7. 31-26 19-23 8. 35-30 13-19 9. 40-35 9-13 10. 44-40 4-9 11. 50-45 2-7 12. 37-31 18-22 13. 31-27 22x31 14. 26x37 12-18 15. 37-31 7-12 16. 31-26 21-27 17. 41-37 27-31 18. 36x27 17-21 19. 26x17 12x41 20. 46x37 16-21 (diagram 5) 21. 37-32?! 21-26 22. 42-37 11-17 23. 34-29 23x34 24. 40x29 19-23 25. 33-28?! 23x34 26. 28-22 17x28 27. 32x12 8x17 28. 39-33 17-22 29. 30x39 20-24 30. 38-32 6-11 31. 49-44 22-27 32. 32x21 26x17 33. 45-40?! (*Schwarzman: "Typical computer move."*) 13-18 34. 43-38?! 14-20 35. 25x14 10x19 36. 47-42 9-13 37. 38-32 11-16?! 38. 32-27! (*"Already in the first game the program showed good positional feeling. […] Now the situation is equal."*) 5-10 39. 40-34 10-14 40. 37-32 15-20(!) 41. 42-37 18-23 42. 33-29 24x33 43. 39x28 20-24 44. 34-30 24-29?! 45. 48-43 13-18 46. 44-40(!) 17-21 47. 30-25 3-8 48. 40-34 29x40 49. 35x44 8-12 50. 44-39 23-29 51. 28-22 19-23 52. 22x13 23-28 53. 32x34 21x41 54. 25-20 14x25 draw. White time: 1:55, Black time: 1:57.

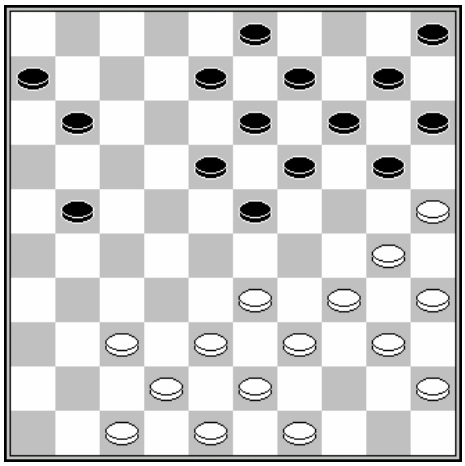


Diagram 5. After 20…16-21

An interesting start of the match! The position after 20 moves occurred before in the 1998 World Championship match Tsjizjov-Schwarzman. Schwarzman, then white, continued with 21. 38-32. As operator of *Maximus*, I was unaware of this during the game – but Schwarzman of course was not! The first 17 moves *Maximus* played from its book, then it was on its own. After some difficulties in the following phase, *Maximus* equalized the position in the second half of the game. A good start. It is always a relief if everything, software and hardware, is working as it should be.

Round 2, 2012.04.10. White: Alexander Schwarzman - Black: Maximus

1. 32-28 17-22 2. 28x17 12x21 3. 31-26 7-12 4. 26x17 12x21 5. 37-32 1-7 6. 32-27 21x32 7. 38x27 11-17 8. 43-38 18-22?! 9. 27x18 13x22 10. 36-31! 9-13 11. 41-37 8-12 12. 37-32 12-18 13. 46-41 7-12 14. 32-27(!) 17-21 15. 49-43 21x32 16. 38x27 16-21 17. 27x16 22-28 18. 33x22 18x36 19. 41-37 4-9 20. 39-33 19-23 21. 37-32 14-19 22. 43-38 10-14 23. 42-37 2-7 24. 32-27 12-17? (*Schwarzman: "Serious positional mistake."*) 25. 38-32(!) 17-21 26. 35-30!! (diagram 6)

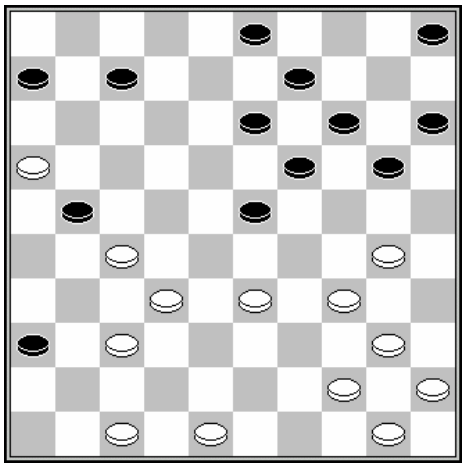


Diagram 6. After 26.35-30!!

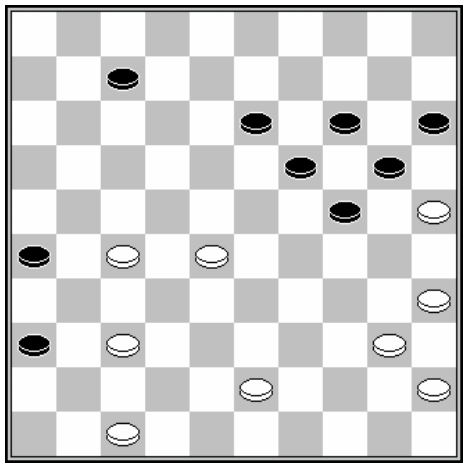


Diagram 7. After 44.32x43

[4] Annotations (! for strong moves, ? for bad moves, etc.) by Alexander Schwarzman. For a complete analysis see Schwarzman (2012).

26…3-8? (*again, a "serious positional mistake"*) 27. 30-25 5-10?! 28. 48-42(!) 13-18 29. 44-39 20-24 30. 40-35 15-20(!) 31. 33-28(!) 21-26(?) 32. 39-33(!) 8-12 33. 42-38(!) 10-15 34. 50-44(!) 9-13 35. 44-40(!) 23-29(!) 36. 34x23 18x29 37. 27-22! 6-11? ("*12-18! ... and black can get one point*") 38. 22-17! 12x21 39. 16x27 7-12 40. 27-22! 11-16 41. 32-27 12-17(!) 42. 22x11 16x7 43. 38-32(!) 29x38 44. 32x43 (diagram 7) 24-29? ("*[the] decisive mistake*") 45. 35-30 20-24 46. 40-35 13-18 47. 28-22(!) 18-23 48. 22-17! 29-33 49. 45-40?! 23-28 50. 27-21 26-31 51. 37x26 28-32 52. 43-39! 33x44 53. 40x49 32-37 54. 21-16 36-41(!) 55. 47x36 37-42 56. 49-43(!) 42-47 57. 17-11 47-33 58. 11x2 33-17?! ("*Typical computer move. 58…24-29 … is [also] winning for white*") 59. 43-38(!) 17-12 60. 2-11(!) and Black resigned. White time: 2:34, Black time: 2:40.

A very strong game by Schwarzman, that deserved an analysis in a number of Dutch newspapers. Move 26…3-8? by *Maximus* was criticized the most, as a move no human player would consider in this position. Indeed, the consequences of this move lie far beyond the search horizon. However, the position was not lost after that; the decisive mistake was made almost 20 moves later. With the difficult to find 44…13-18! black could have saved a point (Dusseldorp, Web), but *Maximus* was not able to calculate this in the given time. Still the game continued to be exciting, as Schwarzman was in time trouble. He made it to the first time limit with 9 seconds left and after that had no trouble to win.

Something interesting happened with the time distribution between moves 24-33, when Schwarzman used 83 minutes and *Maximus* only 14, making a couple of *a tempo* moves after Schwarzman thought for a long time (see figure 1). *Maximus* is programmed to play its move immediately if it guessed the opponent's move, had enough time to think already and is content with the score (unjustified in this case). On the one hand, this successfully put time pressure on Schwarzman, but on the other hand may have backfired because the position was complex enough to spend more time. By the time *Maximus* started to use more time, the position was already critical.

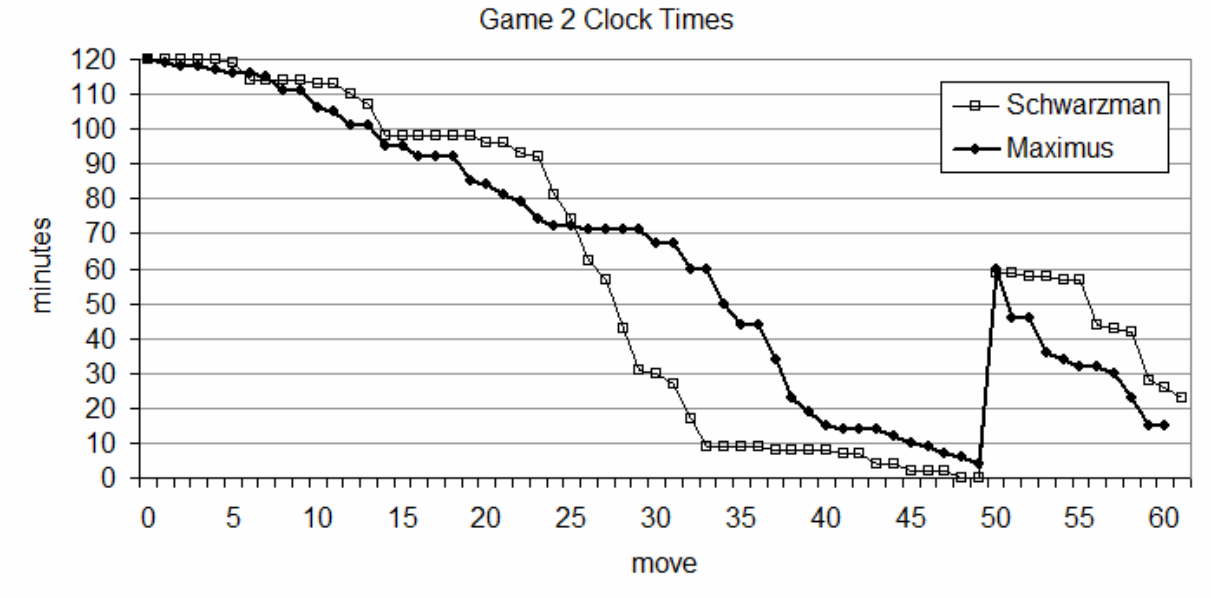


Figure 1

A spectator asked me how it is possible that, in 2012, a computer loses to a man!? Let's see. Another mistake by *Maximus* was (see diagram 8) 37...6-11? This move was played after an (incomplete) 27 *eply* search[5] (in 10'47"), with a relative search value of –0.37. When I try to reproduce this move (with an empty hash table), *Maximus* switches from 12-18 (the right move) to 6-11 (the wrong move) after 23 eply, and back again after 27 (complete) eply and beyond. This is an example of the paradox that sometimes a longer search yields a worse move. If we plot the graphs of the static evaluation and the search value and take into account the search depth, we get a clue of what went wrong (see figure 2).

[5] Maximum line depth: 49 ply. Positions with only one or two pieces left on the board!

Searching 27 eply deep from diagram 8, one of the leaf positions in the search tree is the actual game position after 27 eply (36 ply), see diagram 9.

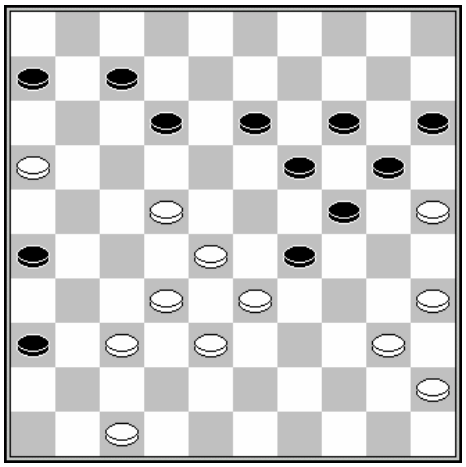


Diagram 8. After 37.27-22! *(search root)*

→ *search*

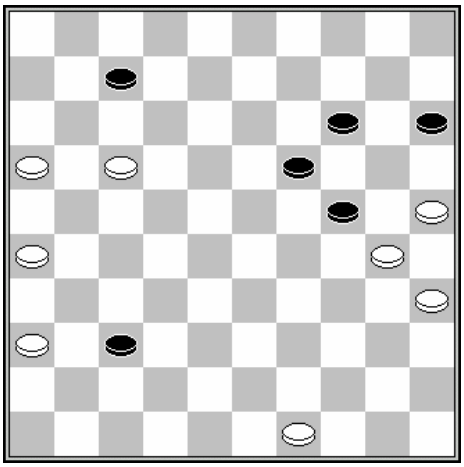


Diagram 9. After 55.47x36 *(leaf: evaluate)*

The static evaluation of the position from diagram 9 is, as we can see in figure 2, *wrong*. Black is down two men but his man (to move) at 37 is *almost a king* (this is a table lookup) and is awarded as such. Because of that, the position is evaluated as *almost equal (zero)*. It does not "see" that white will also soon get a king, let alone that the black man at 7 will be lost, that white can get a second king, etc. This is the reason that 37…6-11? is chosen (at certain depths) instead of 37…12-18(!). This is a serious shortcoming that has to be fixed (after the match).[6] We can also see that e.g. the positions between move 45 and 50 are incorrectly evaluated: a negative evaluation and a positive search value. And, less serious, over-optimistic values between move 15 and 30. All not so easy to fix. Often a deep search makes up for flaws in the static evaluation, but not this time. *Schwarzman 3 – Maximus 1!*

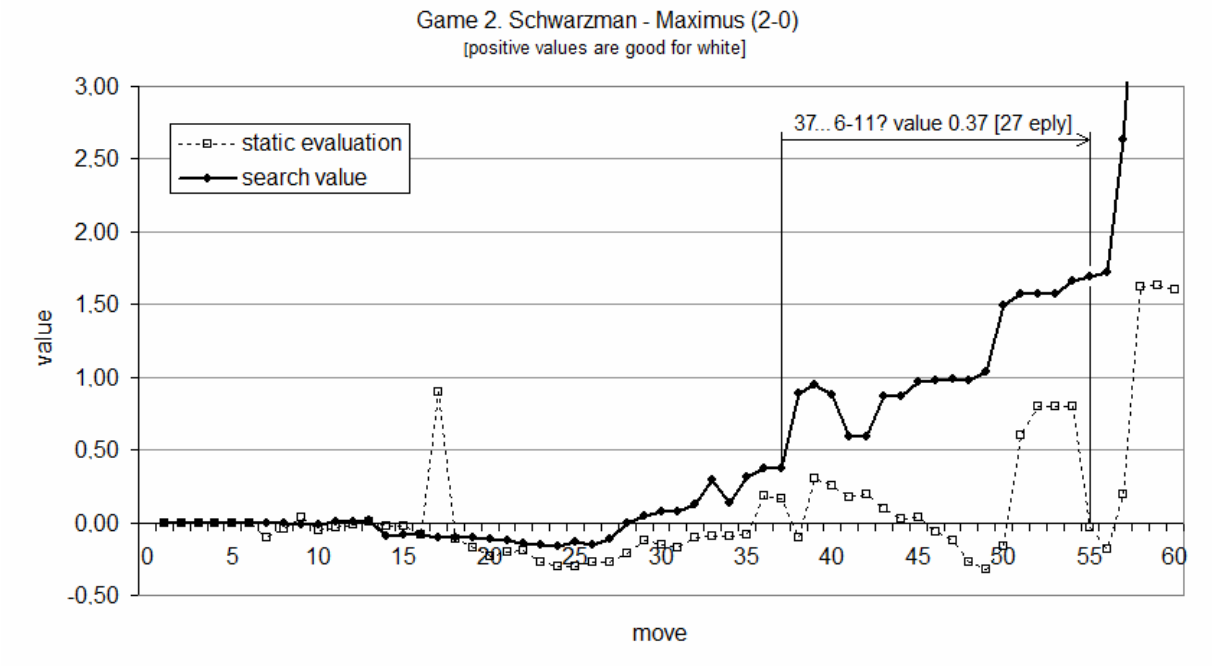


Figure 2. A value of +1 means white has an advantage worth one man.

[6] To solve problems like this (and many more complex situations), a huge partial table for *n* white men vs. *m* black men on the "opposite" half of the board was built by Michel Grimminck (Netherlands), author of *Dragon*.

Round 3, 2012.04.11. White: Maximus - Black: Alexander Schwarzman

To address the problem of Schwarzman finding a weak spot in the opening book and follow-up (like in game 2), *Maximus* was programmed to play a different first move in every game. This also gives a greater variety in the games.

1. 33-29 18-22?! 2. 31-26 20-24?! 3. 29x20 15x24 4. 34-30 12-18 5. 37-31 18-23 6. 31-27?! 22x31 7. 26x37 7-12 8. 39-33 1-7 9. 44-39 12-18 10. 32-28(!) 23x32 11. 37x28 18-23?! 12. 50-44! 23x32 13. 38x27 13-18 14. 41-37 17-21(!) 15. 46-41(!) 21x32 16. 37x28 16-21 17. 41-37 7-12(?) 18. 43-38! (*Schwarzman: "The program played this game positional really well!"*) 11-17 19. 37-32 21-27(?) ("*Black lost the strategic fight and is going to defend.*") 20. 32x21 17x26 21. 38-32 18-22 22. 28x17 12x21 23. 49-43 8-12 24. 42-37 21-27 25. 32x21 26x17 26. 37-32 9-13 27. 33-28(!) 12-18 28. 47-42 4-9 29. 43-38 2-8 30. 39-33 14-20?! 31. 36-31 20-25?! 32. 31-27 25x34 33. 40x20 10-15(!) 34. 20-14(!) 9x20 35. 27-22?! 18x27 36. 32x12 8x17 37. 44-39 20-24(!) 38. 42-37 15-20(!) 39. 38-32 13-18 40. 32-27 (diagram 10) 20-25 ("*White has big territorial advantage–but not more.*") 41. 28-22(?) 17x28 42. 33x13 19x8 43. 27-21?! 6-11(!) 44. 21-16 11-17 45. 39-33 25-30! 46. 45-40 24-29(!) 47. 33x24 30x19 48. 37-32 8-12 49. 32-27 19-23 50. 48-42 12-18(!) 51. 42-37 23-28 52. 27-21 17x26 53. 16-11 18-22(!) 54. 11-7 22-27 55. 7-2 27-32(!) 56. 2-19 32x41 57. 19x46 3-9 draw.
White time: 2:03, Black time: 1:59.

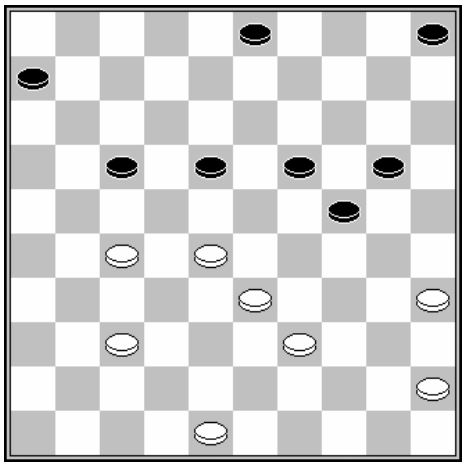


Diagram 10. After 40.32-27

In retrospect, the position from diagram 10 is the highlight of the match for *Maximus*; its 40th move was played with a search value of +0.40. (Could the program be winning?!) However, after the next few moves the score quickly dropped to a draw. Too bad! Nevertheless, this game restored my faith in *Maximus*, which was damaged in the second game.

Round 4, 2012.04.12. White: Alexander Schwarzman - Black: Maximus

1. 34-29 19-23 2. 40-34 14-19 3. 45-40 10-14 4. 50-45 5-10 5. 29-24 20x29 6. 33x24 19x30 7. 34x25 15-20 8. 38-33 13-19 9. 42-38 8-13 10. 39-34 20-24? (*Schwarzman: "A serious positional mistake. Probably [Maximus] is not able to calculate that it is not possible to keep principal point 24."*) 11. 34-29! 23x34 12. 40x20 10-15 13. 44-39 15x24 14. 45-40(!) 18-23 15. 32-28 23x32 16. 37x28 12-18 17. 47-42! 18-23 18. 42-37 23x32 19. 37x28 4-10 20. 40-34 7-12 21. 41-37(!) 2-8 22. 46-41 12-18 23. 34-29(!) 10-15 (?) ("*better 1-7 ...*") 24. 29x20 15x24 25. 39-34 24-30 26. 35x24 19x39 27. 43x34 17-22 28. 28x17 11x22 29. 34-29? 13-19! 30. 37-32 19-23! 31. 29-24 9-13!! (diagram 11) 32. 24-20(!) 1-7 33. 20x9 13x4(!) ("*After missing the combination* (see below), *I was emotionally empty and didn't believe I was able to win this position.*") 34. 49-43 8-13 35. 32-28 23x32 36. 38x27 6-11 37. 41-37 11-17 38. 37-32 13-19 39. 32-28?! 19-24(!) 40. 31-26 22x31 41. 36x27 4-9(!) 42. 43-39 24-30 43. 25x34 17-21 44. 26x17 18-23 45. 28x19 9-13 46. 19x8 3x32 47. 33-28 32x23 48. 39-33 draw. White time: 1:55, Black time: 1:39.

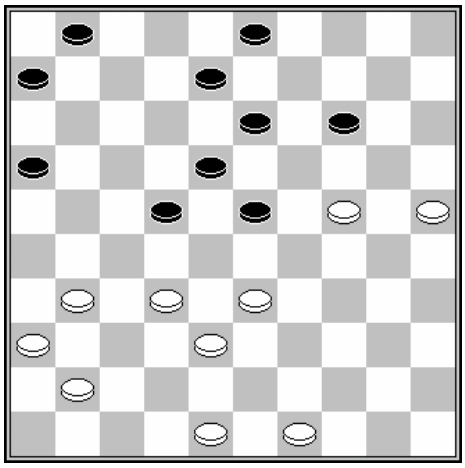


Diagram 11. After 31…9-13!!

Maximus made a serious strategic mistake in the opening (see section 5.Aftermath), but after that defended well using a surprising tactical threat. Diagram 11 even deserved a remark on Tournament Base (Web) the next day, by none other than Alexei Tsjizjov: "*31...9-13 – a nice defense of Maximus: on 32.31-27 22x31 33.36x27 13-19!! with king.*" Still, my respect for Alexander Schwarzman grew with each game – and the next game would be no exception.

Round 5, 2012.04.13. White: Maximus - Black: Alexander Schwarzman

1. 33-28 18-22 2. 38-33 12-18 3. 31-26 19-23 4. 28x19 14x23 5. 34-29(!) 23x34 6. 40x29 7-12 7. 32-28 10-14 8. 37-32 5-10 9. 45-40 13-19 10. 40-34 9-13 11. 41-37 19-23 12. 28x19 14x23 13. 35-30(!) 1-7?! 14. 42-38?! (*Schwarzman: "'computer' move"*) 10-14 15. 44-40?! 20-25 16. 30-24 14-20(!) 17. 46-41 22-27(!) 18. 32x21 16x27 19. 37-31 17-22(!) 20. 41-37 13-19(!) 21. 24x13 8x19 22. 40-35 3-9 23. 49-44?!! (*"Perfect plan!"*) 9-13 24. 44-40 20-24 25. 29x20 25x14 26. 50-45(!) (diagram 12) 22-28? (*"Even now, this exchange is a shame…"*) 27. 31x22 28x17 28. 34-29! 23x34 29. 40x29 15-20 30. 37-32 2-8 31. 45-40! 17-21(!) 32. 26x17 11x22 33. 48-42 6-11 34. 42-37 19-23(!) 35. 40-34 14-19 (*"Already after 29…15-20? I have a strange feeling – like a program begins to play, like a ...human. I mean, Maximus understands, that his position is better – and begins to play very active, with double energy!"*) 36. 47-41 22-27?! 37. 32x21 23-28 38. 33x22 18x16 39. 38-33 12-18 40. 34-30 19-24 41. 30x19 13x24 42. 43-38 11-17 43. 36-31?! 8-13(!) (*"[…] defense in worse position without real time for thinking is not easy [for black]"*) 44. 38-32(!) 17-22(!) 45. 32-28 4-9?! 46. 28x17 18-23 47. 29x18 13x11 48. 39-34 9-13(!) 49. 31-27 13-19 50. 33-28 11-17 51. 41-36 7-12 52. 27-22 20-25 53. 22x11 16x7 54. 36-31 7-11 55. 37-32 12-18 56. 31-26 11-17 57. 32-27 18-23 58. 27-22 23x32 59. 22x11 draw.
White time: 2:10, Black time: 2:10.

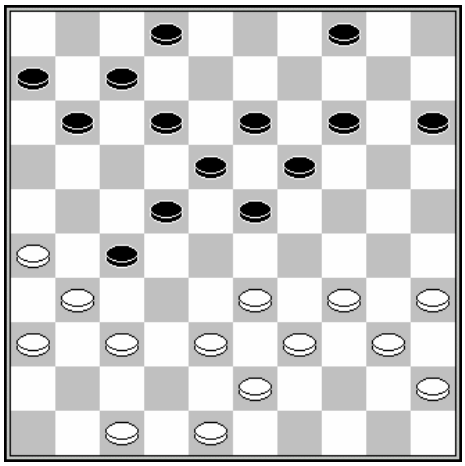


Diagram 12. After 26.50-45(!)

From the opening on, *Maximus* was not very happy with its position. For 15.44-40, it used almost half an hour (27'14"), the longest time for a single move in the match. After the game, Schwarzman was not satisfied. The retreat (in diagram 12) 22-28 31x22 28x17 was too passive. After that, *Maximus* seized the initiative. A more offensive approach (a well-timed 23-28) should have offered black better chances.

Later, Schwarzman writes: *"Phew – after this game I was very glad with the result and had a feeling, that the program played very strong in the second half of the game – but… the top players could make more problems for black, for example, don't do the best strategy moves, but make alternative moves, which could be more difficult for the opponent."* This represents a known challenge for draughts programs: not all (database) draws are equal – when playing a human opponent!

Round 6, 2012.04.14. White: Alexander Schwarzman - Black: Maximus

In the last game, *Maximus* needed a win or it would lose the match. That's why I took a chance with programming the first move (16-21), a move *Maximus* would otherwise not play. In a last attempt to create complications and play for a win. *Maximus* ended up in a short wing lock (or *KVO*, the consequence) but got out as soon as it had the chance. However, Schwarzman still had the advantage…

1. 34-29 16-21?! (*Schwarzman: "I was ready [...] and even glad to play such a sharp opening"*) 2. 31-26 11-16 3. 36-31(!) 7-11 4. 41-36 1-7 5. 46-41 18-22 6. 40-34 12-18?! 7. 45-40 7-12 8. 31-27(!) 22x31 9. 36x27 19-24? 10. 50-45 14-19 11. 34-30(!) 20-25 12. 29x20 25x14 13. 40-34 18-23 14. 41-

36(!) 12-18 (*"white won the strategy fighting in opening – KVO looks very dangerous for black"*) 15. 33-28?! 14-20 16. 38-33 20-24 17. 44-40 ("*Here I had a little 'luck'. Like in all games against the program, I try to check all tactics but just too late saw a fantastic forcing for black: 17...15-20 18.30-25 18-22!??? 19.27x29 17-22! 20.25x23 22-27!, and after 21.29x20??? 27x18 22.26x17 11x44 black wins a piece!!! Only later I realized that it is possible to take 21.26x17! etc."*) 10-14 18. 30-25 14-20 19. 25x14 9x20 20. 34-30(!) 5-10(!) 21. 43-38 4-9 22. 30-25 10-14 23. 49-43 24-29 24. 33x24 20x29 25. 39-33! 14-20 26. 33x24?! (*"better don't play against the program the very sharp tactical position after 26.25x14 9x20 27.33x24 19x30!"*) 20x29 27. 40-34! 29x40 28. 45x34 2-7?! (*"This move was absolutely unexpected for me!"*) 29. 38-33 17-22 30. 26x17 22x31 31. 37x26 11x22 32. 28x17 7-11 33. 42-38 11x22 34. 32-27 22x31 35. 36x27 (*"Maximus defends this position without any problems! Why? Because the program is not a human – and never panics in a bad situation."*) 15-20! 36. 25x14 9x20 37. 48-42 3-9 38. 38-32 19-24! 39. 42-38 13-19 40. 47-42 20-25 41. 33-29 24x33 42. 38x29 8-13 43. 42-38 18-22(!) 44. 27x18 23x12 (*"I already understand that the game is going to a draw. But… many people follow this game – so, we continue!"*) 45. 43-39 12-18 46. 29-24 19x30 47. 35x24 6-11 48. 39-33 11-17 49. 32-28 9-14 50. 24-20 16-21 51. 20x9 13x4 52. 34-29(!) (*"White is trying to use the 'last chance'. But… there is no chance to win the draw ending against the program, which has a database with 6 pieces."*) 17-22!?? (*"Let me say, this is one of the… interesting points of the program – Maximus doesn't care which draw is necessary to do – the shortest or the longest and most difficult! [...] Sometimes it can make the game more interesting – like now! After the logical 52...21-27 etc., black can finish the game in a few moves."*) 53. 26x17 22x11 54. 29-23(!) 18x29 55. 33x24 4-9?! 56. 28-23(!) (diagram 13) 9-14(!) 57. 24-20(!) 25-30 58. 20x9 30-34 59. 9-4 11-17! (*"I started to spend my third hour with trying to find something winning. Who knows – maybe […] Maximus makes a fantastic mistake?!"*) 60. 4-15 34-39! 61. 38-33 39x19 (*"King against two men, still… not clear for white!!!"*) 62. 15-42 17-21! (*"Only so!"*) 63. 42-26 21-27 64. 26-8 (*"Unfortunately for white, the king is not able to take the right place at the right moment."*) 19-23 65. 8-13 27-32 draw.
White time: 2:38, Black time: 2:17.

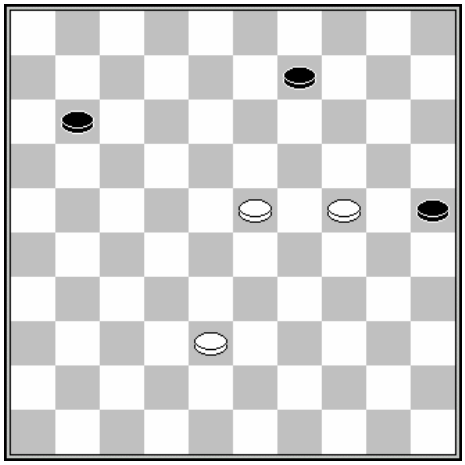


Diagram 13. After 56. 28-23(!)

The annotations by Schwarzman show that for human players these endings can be very challenging. Black can only just get a draw by making a series of unique non-losing moves. With lots of unexpected *finesses*, endgames are a weapon for the strong players, and another charm of tournament draughts and compositions. Not so in computer draughts, where games in engine matches are stopped as soon as the game result is known. For *Maximus*, diagram 13 is "just another database draw."

After agreeing to a draw I congratulated Alexander Schwarzman – he won the match!

Final Result	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Alexander Schwarzman	1	2	1	1	1	1	**7**
Maximus	1	0	1	1	1	1	**5**

5. AFTERMATH

Six games is a small number of games to draw conclusions from. However, we can do a qualitative analysis. As I am not a strong draughts player myself, I will rely on the expert opinion of those who are, for the game-technical aspects. After the match, I asked Alexander Schwarzman for his general

opinion about different aspects of *Maximus*, and later he gave me the opportunity to read his analysis of the match games (Schwarzman 2012).

- The opening (book) moves played by *Maximus* (on average 10 per game) were all right, except for 10…20-24? in game 4. This move has been played before, even by Schwarzman, but today is considered inferior. This shows a downside of using an opening book based only on the statistic success of moves. However, verifying and updating a (computer-generated) opening book is a huge task, which in addition has to be carried out by a strong player.
- The time distribution of *Maximus* did not strike Schwarzman as odd, except for some cases when the program moved surprisingly quickly (see game 2), and the (usual) cases when there is only one playable move –all other moves are losing– and the program still needs to "think".[7]
- According to Schwarzman, who has an ELO rating of 2410 FMJD (or 1559 KNDB), *Maximus* plays at grandmaster level, with an estimated rating of ±2350 FMJD (1500 KNDB). This is almost exactly equal to *Maximus*' match performance rating against Schwarzman, 2352 FMJD (1501 KNDB). This would rank *Maximus* about 25th in the world today, inactive players included.

Maximus did not quite pass the Turing test. It played a (small) number of "typical computer moves". Often these are the result of the search approaching the endgame database, trying to avoid a database draw when there is an advantage (game 3), or a database loss if the program is losing (game 2). Also it showed some "typical computer time usage". In chess, there exist anti-computer tactics such as "doing nothing" in a closed position and sacrificing material for a mating attack (Krabbé, Web). In draughts, however, these possibilities do not exist, and it is less clear how to tackle the computer.

Schwarzman writes that he had little experience with playing the computer.[8] In the past, he sometimes played blitz games against the programs at home – but never won! He did not have much time to prepare, but did give some thought to a strategy for the match: avoid complicated positions (the program calculates much better); try to get positions where the program can make a wrong positional choice; play quickly in the opening, saving time for later; don't spend much time looking for winning combinations[9] (the program won't allow them), but on the other hand be very aware of counter combinations by the computer; and finally, in the endgame it is practically not possible to beat the program if the position is a theoretical draw (every good program has an endgame database).

The match result shows that Schwarzman's strategy was successful. In the first game, he decided to play safely, without any risk. After winning the second game, his psychological condition changed. On the one hand, he still wanted to play actively and try to win games, but on the other hand he knew that not-losing meant winning the match. These two different ideas, "fighting in his mind", he holds responsible for getting some problems in games 3 and 5. *Maximus* has a different issue: it does not know how to take more risks after losing a previous game.

The games were also analyzed using *Kingsrow International*. Figure 3 gives an overview of all match games, plotting the search value graphs of both *Kingsrow* and *Maximus*. We see that both programs often more or less agree on the search value, except in game 3, where the 8/9-pieces database enables *Kingsrow* to see a database draw while *Maximus* still sees a big advantage for white. In general, *Kingsrow* sees big changes in the score a little earlier than *Maximus*, as a result of a greater search depth. (*Kingsrow* preferred a different move in 42% of the cases.) Now do these graphs give a good representation of a game, in terms of which side had the better position, and by how much?

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[7] *Maximus* has a (conservative) *easy move* algorithm, which produced only two "easy" moves during the match.
[8] In explaining his choice of opening for the second game, Schwarzman mentions he had a "computer adviser", Alexander Verhovih.
[9] A nice illustration is a combination that Schwarzman didn't consider in game 2: 32. 37-31?! 26x48 33. 16-11 7x16 *(6x17?? and white will capture 9 pieces later on!)* 34. 34-29 24x31 35. 39-34 48x30 36. 35x24x15x4x13x2 *(white has a king, but black can catch it)* 18-22 37. 2x24 (or ...) 14-19 38. 24x27 31x22 and black can draw.

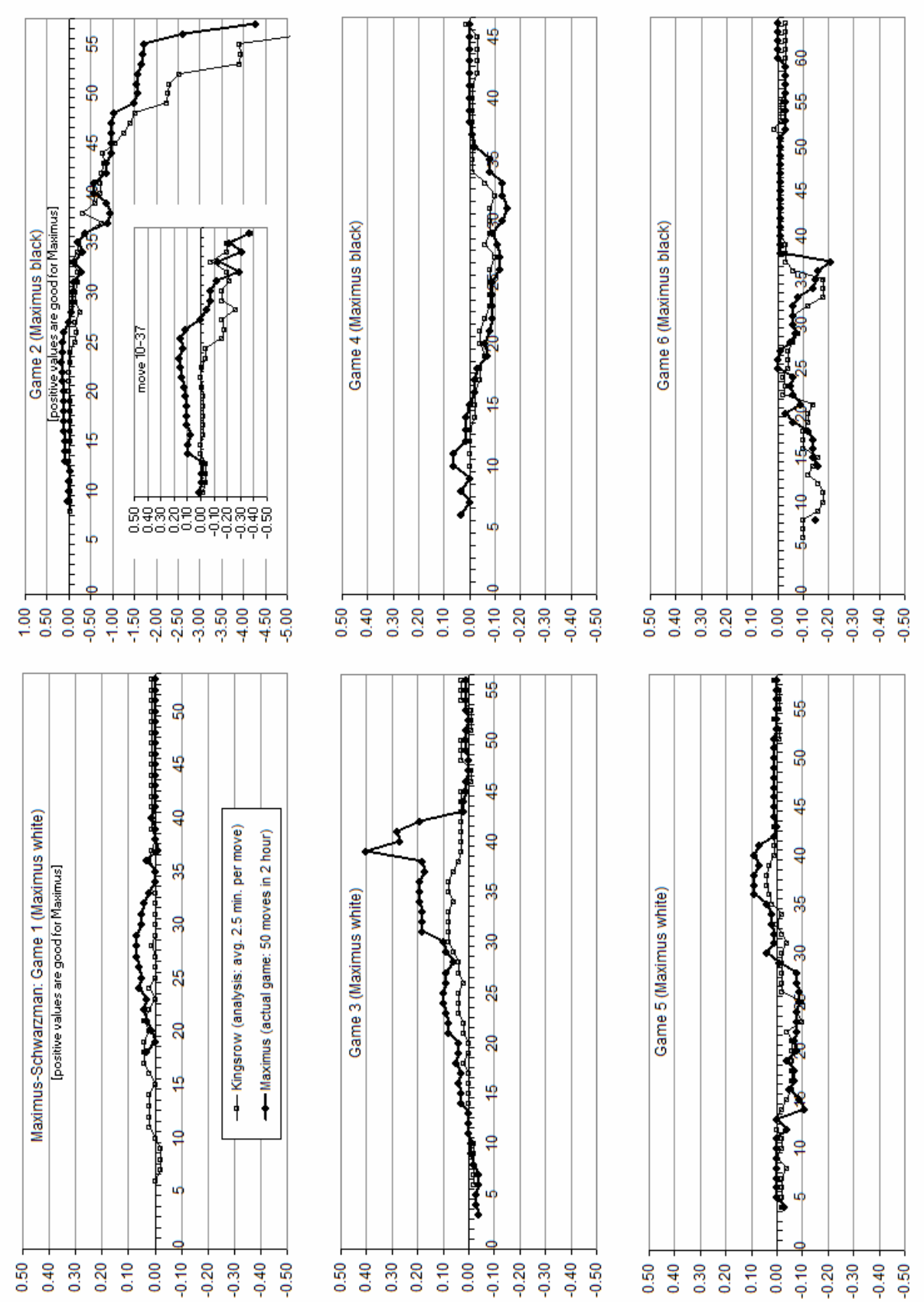
Maximus-Schwarzman: Game 1 (Maximus white)
[positive values are good for Maximus]
Kingsrow (analysis: avg. 2.5 min. per move)
Maximus (actual game: 50 moves in 2 hour)
Game 2 (Maximus black)
[positive values are good for Maximus]
move 10-37
Game 3 (Maximus white)
Game 4 (Maximus black)
Game 5 (Maximus white)
Game 6 (Maximus black)

Figure 3

To answer this question, I had the fortunate opportunity to consult my fellow club member Ton Sijbrands, former World Champion and still the player with the highest rating in the world, 2476 FMJD (1606 KNDB).

> *"I have replayed the six match games of Maximus against Schwarzman, and compared them to the graphs. And I have to say that I absolutely did not find anything 'strange' or anomalous. […] The 'descent' in game 2 seems to be completely justified. (In my opinion, that was the most exciting, colorful and – above all –* intriguing *game of the match.) And that Maximus was momentarily 'overly optimistic' in game 3 (see the phase just before the 40th move) is not so strange. At the time black was struggling with, on the one hand, a weakened or at least somewhat threatened right wing, and on the other hand, a piece lagged behind at 5. (Or, after 5-10-14 and maybe 14-20, a piece lagged behind at 15!) This didn't yield anything concrete in the game, but I* could *imagine that when the position would have been slightly different, white would have gotten good chances! In general, I think Maximus played very well against Schwarzman."*

Figure 3 shows that games 1 and 3 are *Maximus*' best games, but that it never came close to winning (judged by *Kingsrow*). In the other four games, Schwarzman proved to be the better strategic player in the first part of the game, and *Maximus* equalized in the second half of the game (except of course in game 2), even getting some chances in game 5. Especially starting with black proved to be difficult for *Maximus*. So, at least for this match, Alexander Georgiev was right: "in draughts, […] there is a chance to make advantage in the first half".

Concluding, we can say that *Maximus*' evaluation function, in conjunction with the search, is good enough to achieve grandmaster level, but not good enough against a player of this caliber. The search algorithm can also be improved, but the most important issue is (missing) knowledge. However, writing the perfect evaluation function is impossible. Even for human grandmasters, certain positions can be very hard to assess. For example, in his analysis of game 2, Schwarzman writes (after move 18): *"The question is: the corner piece on "16", is it active or passive? Will see…"*. In other words, we can not do without a (deep) search.

Today, like in chess, computer draughts programs are also used to explore new opening lines, which sometimes leads to interesting discoveries in sharp and complex lines. But for the *long-term vision*, computer programs don't have much value yet, says grandmaster and former Dutch champion Auke Scholma in Dutch newspaper *Dagblad van het Noorden* (2012.05.19). In addition, human draughts players are tough to match in other disciplines, such as when to spend the most time, and adapting to their opponent and circumstances.

So while the days of Man-Machine battles in checkers and chess are (long) gone, in international draughts they are still of interest! If we look at the relative strength of *Maximus* and *Kingsrow*, we derive a rating difference of about 70 ELO points (a 40%/60% score), based on 158 blitz games. (In tournament games with longer thinking time this may be less, because less mistakes are made. See section 4, matches *Maximus-Flits*.) This would mean that if the previous estimate of *Maximus*' rating is correct, the world's strongest draughts program *Kingsrow* does not have a higher rating ("is not stronger") than the best human players – which corroborates the above.

Given the earlier comparison with checkers and chess, this is remarkable. Future Man-Machine draughts matches, such as a possible match between World Champion Alexander Georgiev (2445 FMJD) and *Kingsrow* (2420? FMJD, of course depending on the hardware as well), or a rematch Schwarzman-*Maximus*, will certainly be exciting – and close. And no matter the results, an interesting area of future research is *long-term strategy*, or "where do I put my pieces?"

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