

the first 100 games was 5.88 points captured per game with average length 35.22. At game 200 the cumulative averages were 7.11 and 36.90 respectively. At game 300, 7.66 and 38.33. At game 400, 7.67 and 37.53 (after a rough spell). At game 500, 8.00 and 37.81. At game 578, 8.24 and 37.64.

There was a lot of interest shown by people observing the demo. For instance, we received over 25 requests for further literature. One observer noted that by the second day Morph had developed "a good sense of the position" and the games appeared "reasonable".

An exciting additional highlight of the Indianapolis demo was the interaction of Morph with novice-level chess-players. In seven games with children at various ages, Morph drew two games and won two. Against chess novice Emily Hollinberger of Indianapolis Morph went 2-1-1 and against her higher rated brother Drew, Morph lost two well-contested games. These games were played with a 1-ply search coupled with a database we had brought with us that had been produced in 4000 games of training by a Morph reaching 10.75 cumulative captured-piece average.

Playing its trainer

The following is a draw against GnuChess achieved by this database searching 1-ply in which Morph (White) overlooks a mate-in-2 (lacking the proper pattern):

1. e4 e5 2. Nc3 Nf6 3. d3 d5 4. Bd2 Bc5 5. Nf3 Nc6 6. Be2 0-0 7. Rf1 Be6 8. Ng5 Nd4 9. Bf3 Nxf3+ 10. Qxf3 Bg4 11. Qg3 dxe4 12. Ncxe4 Qd4 13. Nxf6+ gxf6 14. Nxh7 Kxh7 15. Be3 Qb4+ 16. Bd2 Qa4 17. Qh4+ Kg8 18. Qxf6 Rae8 19. Qg5+ Kh8 20. Qh6+ Kg8 21. Qg5+ Kh8 22. Qh6+ Kg8 23. Qg5+

The next immediate changes we plan for the Morph system will be to include additional refinements for Morph's new selective-search system, a new rote-learning mechanism for recollection of previously seen chess positions, and a major integration of Morph with the Peirce Conceptual Graphs Workbench that is currently being developed by a collaborative group of more than 80 researchers worldwide. It is expected that by this summer Morph will be defeating GnuChess on a consistent basis and will be strong enough to compete against rated human players.

IBM DEEP BLUE IN COPENHAGEN

February 24-28, 1993

Feng-hsiung Hsu

IBM T.J. Watson Research Center

Some time in late 1992, IBM Denmark talked with us about arranging chess exhibition matches, possibly in conjunction with IBM Sweden. At some point, there was talk about playing Swedish GMs as well, but the final arrangement was to play only in Copenhagen and only against Danish players.

Two separate official matches were scheduled, a 4-game match against GM Bent Larsen and a 4-game match against the Danish national team, with the last game against Larsen also counted as part of the team match. So, there are actually only seven official games. Five additional exhibition one-hour sudden-death games were also scheduled during the weekdays. The Copenhagen Chess Union co-sponsored the matches along with IBM Denmark.

The games officially started on February 24 (Wednesday). We arrived early on Friday February 19 in order to participate in a publicity event the next day with the human World Chess Champion Garry Kasparov. We had dinner with Kasparov and the organizers on Friday eve. During the dinner, we first learned about how well prepared the Danes were. Jens Nielsen, who created the Nielsen test set for chess computers (cf. *ICCA Journal*, Vol. 14, No. 1, pp. 33-37), had made a book for the Danish players containing the Deep Thought games,

various relevant articles, pointers about machines' weaknesses, and so on. We were concerned, but the machine could not be set up for match preparation over the weekend because of the prescheduled weekend events.

We started setting up the machine on the match site Monday, February 22. The machine room was not adequately cooled (no air conditioning) and one of the processors overheated and died after a few hours. The ventilation was improved Tuesday and a test game was played without further mishap.

The machine was referred to as Nordic Deep Blue by the organizers. It is actually a Deep Blue simulation running on Deep Thought II hardware. The host computer was an IBM RS/6000 550 workstation, and 14 custom chess processors were housed in a separate box communicating with the host via a VXI cable. It searches 4-5 million nodes/sec at peak speed. The total cost of all the chess-specific processors is about \$24,000.

Over the official 7 games of the matches, the machine scored 4 to 3. The average rating of the opponents is around 2510-2530. The performance is therefore around 2560-2590 FIDE. Given the well-done preparation by the opponents and the winning chances it had in some of the drawn games, I have to say that the overall result is very encouraging. With the new hardware coming up this summer, things should get interesting.

Day 1 (February 24, Wednesday)

This was a disastrous day for us. It was also the first time we fully realized how serious our own lack of preparation was and how well prepared the opposition was. Frantic work followed after the games.

Larsen adopted a very simple strategy that worked surprisingly well in the first match game. He traded off all the machine's Knights, allowing the machine to have the bishop pair but without an open position to realize the potential of the bishop pair. This really should not have worked if the machine had been told explicitly to trade off some Pawns to increase the scope of the bishop pair. This diagnosis, however, came a little bit late, as you will see later. Black's opening preparation was also too superficial.

GM Bent Larsen - Nordic Deep Blue (NicKey KP 3.3)

Copenhagen, Denmark, 02/24/93 [40/2, 20/1, SD/30min]

Larsen match, game 1

1. e4 e5 2. Nf3 Nc6 3. Nc3 Nf6 4. Bb5 Bb4 5. 0-0 0-0 6. Bxc6 dxc6 7. d3 Qe7 8. Ne2 Bg4 9. Ng3 Nh5 10. h3 Nxc3 11. fxg3 Bc5+ 12. Kh2 Bc8 13. g4 Be6 14. Qe2 f6 15. Be3 Bxe3 16. Qxe3 h6 17. a4 Qb4 18. b3 b6 19. Rf2 c5 20. Kg3 Qa5 21. h4 Qc3 22. Raf1 Rad8 23. g5 Bxb3 24. cxb3 Rxd3 25. Qe2 hxg5 26. hxg5 fxg5 27. Rd1 Re3 28. Qb2 Qxb3 29. Qxb3+ Rxb3 30. Rd5 Ra3 31. Rxe5 g4 32. Kxg4 c4 33. Rd2 Rxa4 34. Rd7 Rc8 35. Ng5 Ra2 36. Rxc7 Ra8 37. g3 Rf2 38. Ree7 Kh8 39. Rxg7 Rh2 40. e5 Rd8 41. Rh7+ Rxh7 42. Nxc7 Rg8+ 43. Ng5 1-0

After the first Larsen game, there were two exhibition SD/1 games against IM Bjarke Kristensen and IM Jens Kristiansen; both again ended in disasters. The machine wrongly went after BR on a8, neglected its own king safety and regretted it two plies later in the game against Bjarke. Jens played an excellent anti-computer game, although our own opening preparation again has something to do with the bad play by the computer.

Day 2 (February 25, Thursday)

The night before, a few modifications were made to the program. One of them concerned removing the equivalent of surgical-knife-left-in-the-stomach from the machine's search-extensions code.

Three more SD/1 exhibition games were played during the day against Bjarke, Jens and IM Svend Hamann respectively. It drew Bjarke, beat Jens and lost to Svend from a completely winning position. The loss against Svend had a position that is quite interesting. The machine needed 43 seconds to see the move that it played loses, but had only 37 seconds allocated. We tried the same position on various commercial programs, and none of them saw the problem in reasonable time.

The Danish team was probably using the exhibition games to look for additional weaknesses of the program. We were using them to catch up on our preparations.

The second serious game and the first of the team match was played in the evening. Danielsen was surprised by several sharp moves by the machine, and after 15. Rab1?! was greeted with the unpleasant Bf5. 16. h3? without restraining the d5 Pawn first was probably the losing move, as 16. ... d4 wins material. Although had the machine been too greedy and grabbed the a2 Pawn with 18. ... Qa2, White would have adequate counter play. We slept a little easier this night.

IM Henrik Danielsen - Nordic Deep Blue (NicKey QP 6.9.1)

Copenhagen, Denmark, 02/25/93 [40/2, SD/1]

Danish team match, game 1

1. Nf3 Nf6 2. b3 g6 3. g3 Bg7 4. Bb2 0-0 5. Bg2 d6 6. d4 c5 7. 0-0 cxd4 8. Nxd4 d5 9. Na3 e5 10. Nf3 e4 11. Nd4 Nc6 12. c4 Nxd4 13. Qxd4 Bg4 14. Qe3 Qe7 15. Rab1 Bf5 16. h3 d4 17. Bxd4 Qxa3 18. Bc5 Qa5 19. Bxf8 Rxf8 20. g4 Bd7 21. Rfd1 h6 22. a4 Bc6 23. Rd6 h5 24. g5 Ne8 25. Rdd1 f5 26. b4 f4 27. bxa5 fxe3 28. fxe3 Be5 29. c5 Rf5 30. Rd8 Rxc5 31. a6 bxa6 32. h4 Rg4 33. Rc8 Bc7 34. Rb7 Bxb7 35. Rxe8+ Kf7 36. Rh8 Be5 0-1

Day 3 (February 26, Friday)

A quiet day. Both match games ended in draws.

The machine had good chances to win the second Larsen match game, but could not pull it off. This game, together with the first game, made us realize that the machine needed to be told to open up the position when it had the bishop pair. Something also needs to be done about unlike bishops endings. The machine knows that one Pawn up in bishops-of-opposite-color endings is drawish. Unfortunately, some time one extra Rook each does not change the result either.

Nordic Deep Blue - GM Bent Larsen (NicKey SI 33.12)

Copenhagen, Denmark, 02/26/93 [40/2, 20/1, SD/30min]

Larsen match, game 2

1. e4 c5 2. Nf3 g6 3. c4 Bg7 4. d4 cxd4 5. Nxd4 Nc6 6. Be3 Nf6 7. Nc3 0-0 8. Be2 d6 9. 0-0 Bd7 10. Qd2 Nxd4 11. Bxd4 Bc6 12. f3 a5 13. b3 Nd7 14. Be3 Nc5 15. Rab1 Qb6 16. Rfc1 Rfc8 17. Rc2 h5 18. Nd5 Bxd5 19. cxd5 Qb4 20. Qxb4 axb4 21. Bd2 Na6 22. Rbc1 Bd4+ 23. Kf1 Rxc2 24. Rxc2 Bc5 25. Bd3 Kf8 26. Bb5 Nc7 27. Bh6+ Kg8 28. Bd3 Ne8 29. Bd2 Nf6 30. Ke2 Kg7 31. Bb5 h4 32. h3 Rd8 33. Bg5 Rh8 34. Kd3 Rh5 35. Bf4 e5 36. dxe6 fxe6 37. Ba4 b6 38. Bc6 Kf7 39. Bd2 d5 40. exd5 exd5 41. Bf4 Rf5 42. Bc7 Nh5 43. Re2 Nf4+ 44. Bxf4 Rxf4 45. Bxd5+ Kg7 46. Be4 Rf7 47. Kc4 Rd7 48. Bd5 Re7 49. Rc2 Re1 50. Bb7 Kf6 51. Be4 Rd1 52. Kb5 g5 53. Re2 Ra1 54. Bd3 Rd1 55. Bh7 Ra1 56. Kc4 Rg1 57. Kd5 Rd1+ 58. Kc6 Rf1 59. Bd3 Rf2 1/2

Hoi got a good position in part because of an oversight in our opening preparation. Book move is 17. Qd3 instead of 17. Qe4 as in the game. Black is better after the queen trade. 20. h3?! is strange, but it is tricky. After 22. Kd2, it looks like 22. ... Ng2 wins for Black. In fact, in the analysis room, people were wondering why Hoi took so long to take the Pawn. Hoi declined the Pawn based on intuition. After the game, we checked with the machine. On 22. ... Ng2, 23. f5 gf5 and then 24. Raf1 threatens to trap the Knight, and with Rf5, Ne4 and Rg1 coming, Black might be losing.

Nordic Deep Blue - IM Carsten Hoi (NicKey PU 5.3.18)

Copenhagen, Denmark, 02/26/93 [40/2, SD/1]

Danish team match, game 2

1. e4 d6 2. d4 g6 3. Nc3 Bg7 4. f4 Nf6 5. Nf3 c5 6. Bb5+ Bd7 7. e5 Ng4 8. e6 Bxb5 9. exf7+ Kd7 10. Nxb5 Qa5+ 11. Nc3 cxd4 12. Nxd4 Bxd4 13. Qxd4 Nc6 14. Qc4 Qb6 15. Qe2 h5 16. Bd2 Nd4 17. Qe4 Nf5 18. Qa4+ Qc6 19. Qxc6+ bxc6 20. h3 Nge3 21. Bxe3 Nxe3 22. Kd2 Nc4+ 23. Ke2 Raf8 24. b3 Nb6 25. Rhf1 Rxf7 26. Rf3 h4 27. Rd1 Rhf8 28. Ke3 e6 29. a3 a5 30. Rdf1 c5 31. Ke2 Kc6 32. Kd1 Nd5 33. Nxd5 exd5 34. a4 d4 35. R1f2 d5 36. g4 hxg3ep 37. Rxc3 Rf6 38. Rfg2 Rxf4 39. Rxc6+ R8f6 40. R2g5 Rf1+ 41. Ke2 Rf2+ 42. Ke1 Rf1+ 43. Ke2 Rf2+ 44. Ke1 1/2

Day 4 (February 27, Saturday)

We did not choose the Scandinavian Defence, Danish variation, to honor our host. The 1. e4 e5 defence was busted (well, sort of), and nothing else was ready. 8. ... 0-0-0?? is a horrible mistake by the machine. Probably

the only chess-player at the match site that did not think that Larsen was winning was the machine. 13. ... Bd6! is critical. If 13. ... ed5, then Bc7! is annihilating. Larsen could have won a Pawn by 14. Bd6, but might have to give up the attack. The attack petered out into a better ending for Black, but the QN vs QB ending would probably require the like of Karpov to win it.

GM Bent Larsen - Nordic Deep Blue (NicKey SD 1.2)

Copenhagen, Denmark, 02/27/93 [40/2, 20/1, SD/30min]

Larsen match, game 3

1. e4 d5 2. exd5 Qxd5 3. Nc3 Qa5 4. Nf3 Nf6 5. d4 Bf5 6. Be2 e6 7. 0-0 Nbd7 8. a3 0-0-0 9. Bf4 Qb6 10. Nb5 Nd5 11. Bg3 a6 12. c4 axb5 13. cxd5 Bd6 14. Qb3 Bxg3 15. hxg3 Nf8 16. a4 Rxd5 17. axb5 Kd7 18. Bc4 Rd6 19. d5 Ke7 20. Rfe1 Nd7 21. Qc3 Nf6 22. Nh4 Bg4 23. Re3 Rhd8 24. dxe6 fxe6 25. Rae1 Rd1 26. Qe5 Rxe1+ 27. Rxe1 Rd2 28. Nf5+ Bxf5 29. Qxf5 Rd1 30. Qe5 Rxe1+ 31. Qxe1 Qd6 32. Qe2 h6 33. b3 Qd7 34. Qf3 b6 35. Qe2 Kf7 36. g4 Qd6 37. g3 Nd5 38. Kg2 Kf6 39. Qf3+ Ke7 40. Qe4 Nf6 41. Qg6 Kf8 42. g5 hxg5 43. Qxg5 Qd4 44. Qc1 Ke7 45. Qg5 Kf7 46. Qc1 Qe5 47. Qd2 Ke7 48. Qb4+ Kd7 49. Qd2+ Nd5 50. Qd3 g5 51. Qf3 Ke7 52. Kg1 Qd4 53. Qh5 Qg7 54. Qg4 Kd6 55. Qe4 Qa1+ 56. Kg2 Qf6 57. Qc2 Qe5 58. Qc1 Kd7 59. Kg1 Ke7 60. Kf1 Kf6 61. Qa3 Kf7 62. Qc1 Ke7 1/2

The following is probably the best game of the match by the machine. One commentator went as far as saying that the machine played like a Super Grandmaster. Lars Bo had recent successes against the 10. ... Be7 line, but said after the game that he might have to rethink the whole line. DT I used to win games against GMs by tactics. This game was won by positional play. The final coup de grace is a tactical combination, but the game was finished before that. Lars Bo criticized his own 20. Qc3 as tempo losing. Machine concurred.

GM Lars Bo Hansen - Nordic Deep Blue (NicKey QO 3.6.7)

Copenhagen, Denmark, 02/27/93 [40/2, SD/1]

Danish team match, game 3

1. Nf3 Nf6 2. c4 e6 3. Nc3 d5 4. d4 Be7 5. Bf4 0-0 6. e3 c5 7. dxc5 Bxc5 8. Qc2 Nc6 9. a3 Qa5 10. Nd2 Be7 11. Bg3 Bd7 12. Be2 Qb6 13. 0-0 d4 14. Na4 Qd8 15. b4 Rc8 16. Nb2 e5 17. Nb3 dxe3 18. fxe3 Qe8 19. Rad1 Ng4 20. Qc3 Bg5 21. Bxg4 Bxg4 22. Rde1 f6 23. c5 Nd8 24. Nd2 Qc6 25. Qc2 b6 26. Ne4 Nf7 27. Nc4 bxc5 28. Nxc5 Bh5 29. e4 Nd6 30. Nxd6 Qxd6 31. Bf2 Qd2 32. Qb3+ Bf7 33. Qh3 Rfd8 34. Be3 Bxe3+ 35. Rxe3 Bc4 36. Rfe1 Rb8 37. Qg3 a5 38. Rc3 Qd4+ 39. Qe3 axb4 40. Qxd4 Rxd4 41. axb4 Rxb4 42. Kf2 Rb5 43. Na4 Ra5 44. Nb6 Ba6 45. Nd5 Bb7 46. Ne7+ Kf8 47. Nf5 Ra2+ 48. Kf3 Rdd2 49. Rc7 Rf2+ 50. Kg4 Rxc2+ 51. Ng3 Raf2 52. h4 g6 0-1

Day 5 (February 28, Sunday)

Larsen got into early trouble underestimating 14. f5. Machine probably had a winning edge at move 25, but it willingly went into another unlike-bishops ending without proper assessment. The resultant queen and bishop ending might be winnable had the Queen been traded and the KN Pawn (but not the KR Pawn) become passed. The machine, however, was trying hard to avoid trading the Queen. This time, it did not know that certain unlike-bishops endings are winnable.

Nordic Deep Blue - GM Bent Larsen (NicKey SI 14.3)

Copenhagen, Denmark, 02/28/93 [40/2, SD/1]

Larsen match and Danish team match, game 4

1. e4 c5 2. Nf3 d6 3. d4 cxd4 4. Nxd4 Nf6 5. Nc3 a6 6. a4 g6 7. Be2 Bg7 8. 0-0 0-0 9. f4 Nc6 10. Be3 Bd7 11. Nb3 Be6 12. Ra3 Rc8 13. Kh1 Re8 14. f5 Bxb3 15. Rxb3 Qd7 16. fxg6 hxg6 17. Nd5 Nxd5 18. exd5 Ne5 19. a5 Bf6 20. c3 Kg7 21. Rb4 Rh8 22. Qb3 Rc7 23. Bb6 Rcc8 24. Kg1 Rh4 25. Bd4 Rc7 26. Bxe5 dxe5 27. Rxb4 Bxb4 28. Rxf7+ Kxf7 29. d6+ Kg7 30. dxc7 Qxc7 31. Qb4 Bg5 32. Bf3 b5 33. axb6ep Be3+ 34. Kh1 Bxb6 35. Qe4 Qc5 36. Qb1 a5 37. Be4 g5 38. Bh7 Kf8 39. Bf5 Qf2 40. Bg6 Kg7 41. Bh7 Kh8 42. Bf5 Kg7 43. Bd3 Be3 44. Bh7 Kh8 45. b3 Bd2 46. c4 Be3 47. Bg6 Bd4 48. Bf5 Be5 49. Be4 Be3 50. Qd1 Kg7 51. Qa1 Bd4 52. Qc1 1/2

Final result: Larsen - Deep Blue: 2.5-1.5; Deep Blue - Danish Team: 3-1.