BACKGROUND

The notion that chess might be played by some mechanical or artificial device goes back several hundred years. Just why man has been intrigued for so long by this possibility requires some explanation. Over the centuries, thousands of books in numerous languages have been published on how chess should be played. Chess has always been accepted as a game whose rules are easy enough to learn, but as a game which is difficult to master. It is clear from the chess literature that the corpus of chess knowledge has made great advances (particularly during the past century). Hundreds of books exist on how to play specific opening moves, often with analysis running well beyond 20 moves of play into the middlegame. There are manuals on middlegame and endgame techniques, ploys, tactics, as well as how to handle specific configurations. It is generally accepted that the level of play at the international tournament has advanced beyond that of any previous time. Nonetheless, although chess is a finite game (there are an estimated $25 \times 10^{15}$ possible board positions) it remains for all practical purposes infinite. There are today, in spite of advances in technology, pace of lifestyle, and in computer chess, more chess professionals and aspiring professionals than ever before. The world of chess is highly organized, with numerous publications around the world. In short, the Royal Game remains highly visible and popular, to both serious devotees and amateurs. And yet, we cannot answer with certainty the simple question, What is the best first move for White? We may have a pretty good intuition as to the answer to this question, but the next natural question, What is Black’s best reply to White’s best first move(s)? is even more difficult to answer. Answers can only be subjective based on empirical results, fashion, or taste. There are of course chess positions which are discretely analyzable and we can state unequivocally that a particular move is the best. However, most positions in the problem space of chess are subject to the combinatorial explosion. Therefore the game of chess combines aspects of science, sport, art, and psychology, among others. It was believed that if we could get a computer to play chess at the master level, then we would have struck the core of human intellectual endeavors. Depending on your point of view, the primarily brute force methods which have been employed to achieve master level play, may or may not give support to the above contention. It is worthwhile noting that as computers achieve tasks which had been deemed challenging, once the techniques by which the task has been accomplished become explicated we are quick to belittle that achievement. However, it also has been believed that creative activity in a few special domains such as chess, music, and mathematics is unique to humans. Thus, if we can get a computer to play chess at the grandmaster level (the highest echelon level of human players, which may well be achieved by the turn of the century) then we have in essence digitized an artistic endeavor which was believed to be reserved for humans. Similar achievements in other domains may well follow.

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HISTORY OF MECHANICAL CHESS-PLAYING DEVICES

The Turk
Interest in the creation of a computer program to play chess was no doubt enhanced by the colorful but somewhat dubious history of mechanical chess-playing devices during the past two centuries. This began on an eve in 1770 at the court of the Empress Maria Theresa at the Habsburg Royal Palace in Vienna. There the 36-year-old Counsellor on Mechanics to the Royal Chamber, the Baron Wolfgang von Kempelen, first exhibited his amazing Automaton Chessplayer. The Turk, as it was called, consisted of the upper body of a larger than life-sized replica of a glowering, mustachioed Ottoman sultan. He was seated atop a bulky chest which was four feet wide and two feet long, and garbed in furry flowing Oriental robes with a turban, while hovering over a chessboard. The natural inclination was for spectators to suspect a small human being to be hidden somewhere in the chest. These doubts were somewhat dispelled when the door aside, a cabinet full of wheels, levers, and cylinders was opened to their view. The illusion of the Terrible Turk continued to confound audiences in Europe and North America for some 70 years. After Von Kempelen’s death in 1804, the Turk’s new owner, Johann Nepomucene Maelzel, a famous inventor of musical instruments, enjoyed many years of great financial success touring with it. Maelzel endured working relationships with a number of chess masters who acted as “directors” of the automaton, winning most of its matches against many of the leading masters of the first half of the nineteenth century. An exhibition tour to Havana proved to be Maelzel’s last, and the Turk found its final resting place in 1840 in Philadelphia’s Chinese Museum, where it remained secluded behind a glass case until July 5, 1854 when a fire destroyed the museum completely.

THE AJEEB AND MEPHISTO
During the 19th century, interest in the love of mechanical chess-playing devices continued via the exploits of the Ajeeb and Mephisto.

Theoretical Complexity
It is quite possible that herein lies the secret to man’s continuous fascination with the game of chess and to the desire to solve it by “mechanical,” “algorithmic,” or “computational” methods. Chess may fall into the domain of “hard” problems [1], e.g., problems which due to their intrinsic difficulty may never be solved by any terrestrial computing system regardless of advances in technology, advances in human knowledge, or the resources allocated. Or chess may be “semihard” as Michie (1983) suggests. That is, there may algorithmic-type solution programs which are nonetheless time-infeasible; that is, we may have to wait an unacceptably long time (e.g., more than a lifetime) for their execution to be completed. However, there may exist solutions which are heuristically adequate to embody the knowledge-content of the specific domain in question. Such solutions would be based on representations of knowledge which enable a trade of storage space for execution time.

The very nature of chess, its play on a board of 64 squares, 32 white and 32 black, with 16 pieces whose movements are well defined, suggests finiteness and the ability for exact calculation, but the kinds of thought processes used by humans and the terms employed to describe them, suggest inexact reasoning for problems of a probabilistic nature. These are akin to problems in the management of a complex business whereby the allocation resources in a most efficient manner must be determined. In either case, rules of thumb, heu-
ristics, which work most of the time, as opposed to steadfast rules, are employed. For these reasons, it was originally felt that chess posed an excellent problem domain for artificial intelligence, the branch of computer science which tries to find efficient and practical solutions to problems which when solved by humans require some thought (i.e., problems which Michie calls semihard) as opposed to standard problems which are regularly solved by conventional programming techniques.

**The Turing–Shannon Paradigm: Minimax, Alpha–Beta Chess, Computational Complexity, Programs, Expert Systems**

The idea that a computer program might be able to play chess well was first put forth by the great British mathematician Alan Turing (1950). He and Claude Shannon, the father of information science established what has been known as the Turing–Shannon paradigm. That is, a two-person, zero-sum game of perfect information such as chess can best be approached by exploring alternatives from a given board position as far ahead as possible for both sides to grow a search tree. After building such a tree of future board configurations a computation called an *evaluation function* can be applied to determine the relative merits of positions which occur at terminal nodes (leaves) of the search tree. The scores obtained at the terminal nodes are then “backed up” to determine the best move at the original board position for the side to move. Such an algorithm is called *minimax*. Nonetheless, exhaustive trees for looking ahead beyond a few moves by each side quickly becomes subject to the exponential growth known as the *combinatorial explosion*. For example, assuming that there are on the average 30 legal moves for each side in a chess position, an exhaustive search tree of 7 half moves (or ply) be each side quickly gets us to $30^7$ or close to $2.2 \times 10^{10}$ positions (nodes).

The alpha–beta algorithm, a concept attributed to John McCarthy, one of the founding figures of AI, can reduce this figure by 99% under ideal conditions, and typically by 99.5%. The underlying principle is that once a move has been deemed to be better or worse than others from minimax scores, then there is no need to determine just how good or bad the move is. This can result in immense savings in terms of the size of the trees which need to be established. Henceforth, running of superfast computers and special-purpose hardware, the leading chess programs today are able to grow search trees as large as 30 million nodes.

**Knowledge Versus Search**

The undercurrent of all work in computer chess and to a large extent, AI, is the issue of knowledge versus search. That is, complex problems are often tackled from two opposing extremes. One extreme is computationally intensive (e.g., number crunching for problems in the physical sciences) requiring a small memory while the other extreme is memory intensive and requires little computation (e.g., a database which contains an exhaustive enumeration). Figure 1, known as Clarke’s diagram, illustrates this axis.

Solutions to problems in complex task domains may fall anywhere along this axis. Professor Donald Michie has developed the notion of a “human window” which defines solutions after scrutiny according to the following:

1. The “computational efficiency” of representations (i.e., efficiency with regard to processor time and machine memory). What do such representations look like?
2. The “cognitive efficiency” of representations (i.e., computational efficiency with respect to the “brain machine”). What do “brain-oriented” representations look like?
3. How different machine representations for the computation of similar functions compare with regard to 1 and 2 above, that is, (i) Do they look the same? If not then, (ii) What does an efficient machine representation of type 2 look like when converted into human-readable form [2]?

AI programs will necessarily fall outside of either extreme, and may be evaluated according to their ability to meet the above prerequisites for a human window solution. Early efforts in computer chess (through 1975) indicated that a nonexhaustive selective search with more knowledge in the form of heuristics (rules of thumb) proved to be less fruitful than hoped for. Due to improvements in hardware with advancements in microchip technology and due to more efficient tree-searching techniques, exhaustive searches of up to 8 ply and beyond have become possible. This coupled with the use of special-purpose chess hardware and in some cases parallel processing has enabled a few chess programs to break through the master level barrier (on a rating scale known as the ELO system which runs from 1000 points for absolute beginner to 2800 for world champions, the master level starts at 2200). Nonetheless, all the leading chess programs embody considerable chess knowledge in the form of heuristics, often well beyond that of their programmers. In this sense, the team effort resembles that of a classic expert system. A domain specialist is consulted to provide knowledge in the form of heuristics and a knowledge engineer organizes the rules of the domain specialist into a form which can be easily incorporated into a program. Some of the most successful and versatile expert systems which have been developed in such a manner over a number of years include: MYCIN, to diagnose bacterial infections and make recommendations for antibiotic therapy, DENDRAL, to generate plausible structural representations of organic molecules from mass spectrogram data, CADUCEUS, which is able to synthesize a broad overview of a patient's condition incorporating evidence from causal relationships. Although no general expert system program to play chess has as yet been developed, there have been programs developed to solve problems in specific aspects or phases of play, both revising and extending our knowledge about them.

Chess programs began to appear in the late 1960s and early 1970s. The Greenblatt Chess Program [3] was the first to compete at the average U.S. Tournament player level achieving a rating in the 1600s. At that time, not many people had had to take the entry of
programs into tournaments very seriously. They were viewed primarily as a curiosity and slight bother. Invariably, the terminals on which the computers played elicited noises which were disturbing to other participants. Hence special arrangements, such as provision of separate rooms or tables, had to be made for computer programs in tournaments. However, with the exception of a few vociferous opponents to computers in chess tournaments, most people felt the machines provided an interesting addition or sideshow to chess tournaments. Albeit relatively weak, computers did already tend to score a few points against humans in chess tournaments in the 1970s. In other words, there were already a few people who were “hurt” by these programs. A simple example could be a five-round weekend tournament where a program rated 1600 would score 2.5 points against an average field of opponents rated 1600. This simply means that three players’ tournaments had been adversely affected by the program’s participation.

It may be noteworthy that in the early 1970s lower-rated players did not expect to win big prizes from chess tournaments (no more than $100) and most people were content with a trophy or plaque signifying their success.

No longer are programs assumed to rank in the middle or lower end of a tournament. Some programs like DEEP THOUGHT, HITECH, MEPHISTO, and FIDELITY’s products have proven they pose threats even to the highest rated players. Furthermore, the lower-rated players are able to compete for quite significant prizes (of several thousand dollars) in a number of tournaments. Some may question the correctness of this practice, but it is not a matter to be dwelled upon here. However, the participation of computer chess programs in human chess tournaments has become a rather serious problem which needs to be resolved. Again, this is not our purpose here.

The fascination with trying to develop a computer program to play very good chess has stemmed from the belief that if you can get a program to play chess well, then there may be no boundary which separates man’s creative abilities from those of machines [4]. Thus chessplaying by computer was an early preoccupation of researchers in AI. However, two schools of thought have evolved within the AI community, both driving research and progress in their own ways. One is performance driven [5] and the other is competence or methodologically driven. Computer chess has, in terms of performance, been successful for many years now; that is, in terms of success with regard to the Elo rating system [6]. By and large, the Elo rating system has been a reliable measurement of the chess strength of both humans and programs. This has been both fortunate and unfortunate for computer chess. Since 1975, when CHESS 4.7 became the first program to break the expert (2000) level, it has been demonstrated that improvements in playing strength are virtually linear with increases in the depth of tree searches (see Table 1). This increase in strength with ply depth does slow down as ratings exceed over 2200, since the rating system does become logarithmic from there on. Sad, however, is that very little is specifically known about how a top program finally decides on a move beyond the power of the alpha-beta minimax algorithm [7]. Yes, the programs do know something about king safety, pawn structure, piece activity (mobility), center control, and especially about the absolute value of pieces and pawns. Some programs will know more about certain chess concepts than others, depending on the chess strength of the programmers and chess consultants. Various refined techniques are employed to make the search more efficient including parallel algorithms [7] and singular extensions [8], however, due to the competitive priorities of most programs there is very little revealed about how a program finally does chose one move over another. The foregoing discussion is aimed at explaining why computer chess has appeared to advance primarily as a competitive sport rather than as a science.
Source: Based on Thompson [15] and Levy and Newborn [25].


5. Hitech: Gary Biddle plays at middle level Master strength, examining 10,000,000 nodes/move.

4. Biddle becomes first Master in 1983, examining 25,000,000 nodes/move.


2. KALSA (USSR) wins first world championship in 1974, plays about 1700 level chess and examines 100,000 nodes/move.


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**Landmarks:**

- **1961**
- **1978**
- **1983**
- **1990**
- **2000**
- **2020**

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**Table 1: Importance of Computer Speed**

<table>
<thead>
<tr>
<th>Year</th>
<th>Importance of Computer Speed</th>
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<tbody>
<tr>
<td>1900</td>
<td>Player</td>
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<tr>
<td>1920</td>
<td>Average Club</td>
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<tr>
<td>1940</td>
<td>Expert</td>
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<tr>
<td>1960</td>
<td>Master</td>
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<tr>
<td>1980</td>
<td>Grandmaster</td>
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<tr>
<td>2000</td>
<td>World Champion</td>
</tr>
<tr>
<td>2020</td>
<td>ELO</td>
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This article presents and reviews the major events in man–machine chess play leading to the state of the art in computer chess and its future possibilities. Early events (prior to 1985) will be summarized with emphasis on the state of the art, while later events will be presented in more detail. Our initial concentration will be on contributions and results of man–machine play involving endgame databases. Then the major advances in computer chess play will be reviewed including: the victory of CHESS 4.6 over U.S. Champion Walter Browne in a simultaneous exhibition (1978), the achievements of Ken Thompson and Joe Condon’s BELLE, the matches of IM David Levy against CHESS 4.7 in 1978 and later against CRAY BLITZ (1984); the domination of Berliner team’s HITECH from 1985 to 1988, the progress of commercial programs in the MEPHISTO and FIDELITY series, and finally the emergence of DEEP THOUGHT [9] as the world’s strongest program leading to its matches against World Champion Gary Kasparov and David Levy in late 1989.

The 1970s in the world of computer chess were highlighted by the reign of the CHESS series of programs at Northwestern University and authored by David Slate, Larry Atkin, and Keith Gorlen. A program from that series won every north American Computer Chess Championship (NACCC) through the 1970s except in 1974 (RIBBIT won) and 1978, when BELLE made its appearance. In 1978, CHESS 4.7 was rated 2040 and won the the Twin Cities Open in Minnesota with perfect 5–0 score. It performed like a very competent expert and scoring regularly against human experts. The successes of CHESS 4.7, its predecessors and successors, are well documented in Frey [4].

The dominant human player in the United States in the 1970s was Grandmaster Walter Browne. In 1977, Browne had won the U.S. Invitational Championship three years in a row and was rated 2560. At this time, Browne was full of energy and brimming with the success of a nationwide tour involving a series of 17 exhibitions where he had only lost two games and drawn six. So it was only natural that CHESS 4.6 should be one of Browne’s opponents in a 44-board simultaneous exhibition in Minneapolis. That now famous encounter is fully annotated elsewhere [10], but it is so exemplary of the state of the art of computer chess play in 1978 that we provide the score again here with light notes.

CHESS 4.6 was running on the huge and fast Cyber 176 computer, seeing over 2.5 million positions in 3 minutes of think time. Browne took his computer opponent very seriously in this game, and it should not be overlooked that the handicap of playing 44 opponents certainly did much to equalize the strength of Browne and CHESS 4.6 in this game. CHESS 4.6 does play a few of the famed “computer moves” of the 1970s, moves (often with the king) in a perfectly normal position which are completely inexplicable and probably due to the computer’s inability to find another move which it believes could improve its position. Although at this time computers were reputed to be very weak in the endgame, CHESS 4.6 weathers the technical difficulties of the endgame through its tactical abilities somewhat disguising its lack of special-purpose knowledge.

White: B.M. Walter Browne (2560)
Black: CHESS 4.6/Cyber 176 (2070)
English Opening (By transposition)

1. d4 Nf6 2.c4 c5 3. Nf3 cd 4. Nxd4 e5 5. Nb5 Bc5 6. Nc3 (this variation was fairly popular at the time; the text move, however, took CHESS 4.6 out of its book) O–O 7.e3 d6 8. Be2 a6 9. Na3 Nc6 10. Nc2 Bf5 11. O–O Qd7 12. b3 Kh8 13. Bd2 Rg8 (Black’s 12th and 13th moves are the famed “computer moves”) 14. Na4 Ba7 15. Bc3 h6 (Browne always tries to find active continuations and at the same time is trying to trade of the passive N on c2.
This is because Browne, as a GM, always tries to find the “correct” move in a position. Had he better understood his opponent in this game he would have made a waiting move when CHESS 4.6 may well have weakened itself with ...g5) 16. Rc1 Rad8 17. Nb4 Nxb4 18. Bxb4 Qc7 19. Qe1 Bc5 20. Bf3?! Bd3 21. Bxc5 dxc5 22. Be2 Bf5 23. f3 e4 24. f4 Bd7 25. Nc3 Qa5 26. Qh4 Bc6 27. Rc2 b5 28. g4 b4 29. Nd1 Rd6! (Demonstrating the soundness of Black’s last three moves) 30. Nf2 Rgd8 31. Rd1 Rxd1+ 32. Bxd1 Rd6! (At this point CHESS 4.6 had used 2 hr 44 min of computation time to Browne’s 22 min) 33. Qg3 Qd8 (Now CHESS 4.6 correctly predicts Browne’s next 11 moves) 34. Rc1 Rd2 35. g5 h6 36. fg Nh7 37. g6 fg 38. Qxg6 Qh4! (Now White is in great difficulty. Browne spent a long time thinking for the endgame after 39. Qg3 Qxg3 40. hxg3 would be hopeless for White) 39. Qf5 Bd7 (Leading to a won ending but even stronger was 39. ...Ng5!) 40. Qf4 Qxf4 41. exf4 e3 42. Ne4 e2 43. Bxe2 Rxe2 44. Nxc5 Bc8 (Lacking special-purpose endgame knowledge CHESS 4.6 gets into a little trouble. More lethal-minded was 44. ...Bh3!? with ideas of mate) 45. Rd1 Re8 46. a3?! ba 47. Ra1 g5?! (A dubious move because it offers to trade more pawns. Better was 47. ...Rf8 or 47. ...Re2) 48. fg Re5 49. b4?! (49. Nxa6 Bxa6 50. Rxa3 would lead to the ending R+B+N vs. R which is a theoretical win, but here the White Q-side pawns might cause problems and it is questionable whether CHESS 4.6 would have the technique required in any case) 49. ...a5!? 50. Nd3 Rgx5+ 51. Kf2 ab 52. Nxb4 Ra5 53. Ke3 Be6 54. Kd4 Ng5! (This piece ends up playing a vital role) 55. Nc2 (Browne offered a draw here which the Northwestern camp turned down in the “interest of science”) a2 56. Nb4 Ra4! 57. Kc5 Ne4+! 58. Kb5 Bd7+! 59. Nc6 Nc3+! 60. Kc5 Bxc6 61. Kxc6 Rxc4+ 62. Kd6 Rd4+ 63. Ke5 Rd1 and Browne resigned (0:1).

THE POWER OF BRUTE FORCE

If there is one lasting impression left by computer chess programs in the 1970s, it is the power of brute force. Brute force tree-searching methods have already accomplished a lot more in terms of chess playing strength than many well-educated writers would have opined [11,12]. When the CHESS series reached the expert level in the late 1970s, many skeptics, including myself, were surprised. Perhaps to serious chess devotees, it was as much of a revelation as a disappointment to realize that the beauty in a forcing tactical sequence of moves comprising a combination could be reduced to nodes, to efficient tree-searching, to minimax and alpha-beta, etc. That is to say, that the creative element in chess moves can be exactly equated by a computer’s calculational abilities. The accomplishments of brute force methods did serve to make us aware of how humans play strong chess, of the importance of coming to grips with the hierarchical decision making which makes chess so appealing to us, and finally of the clear tradeoffs between knowledge and search. As the number of nodes searched by the best programs increased so did the number of surprises which resulted from exhaustive brute force searches of five and more ply.

One famous and relatively early example is from the 2nd World Computer Chess Championship (WCCC) in Toronto (1977) when Kaisa (Black) in Figure 2 played 34 ... Re8 (!) instead of the “normal” 34 ... Kg7. This left an audience of 500 including a former World Champion quite perplexed for a few minutes. What they had overlooked fell right out of Kaisa’s brute force search: if 34. ...Kg7 35. Qf8+!! Kxf8 36. Bh6+ Bg7 37. Rc8+ and mates! Hence 34. ...Re8 was Black’s best way of surviving from Figure 1.
THE CONTRIBUTIONS OF ENDGAME DATABASES

In 1977, at the same 2nd WCCC, Ken Thompson came armed with a surprising weapon— it was his database for King and Queen versus King and Rook (KQKR). In fact by a technique which employed “backing up” from terminal positions (immediately lost positions) Thompson was able to exhaustively enumerate databases for all 4-piece endings. That is, his database was able to determine whether any position is a win or a draw, and if it is a win, in how many moves with best (optimal) play by both sides.

Chess books tend to allude to the technical difficulties involved in winning with the Queen against a good defender of the Rook’s side. For example, Fine (1941) states: “This is a win, but from the general position the process is rather complicated.” The stronger side tries to force a zugzwang position (one in which a side must move against its will relinquishing material or ground) whereby the rook must move away from the vicinity of its king.

The only advice generally given to the defender is to “keep the king and rook together” so as to avoid any skewers or forks which might pick up the rook. So understandably International Masters Hans Berliner (1968 World Correspondence Chess Champion) and Lawrence Day (then Canadian Champion) were quite perturbed when after about 20 minutes or so of trying with the Queen’s side they were unable to win against Thompson’s database. Furthermore, the database employed defensive techniques which were inexplicable, especially when it separated its King and Rook, almost seeming to defy the human masters to find a forcing tactical sequence, which of course did not exist. This has been referred to by Professor Donald Michie as “The Strange Case of Thompson’s Table” [11].

Ken Thompson was so convinced of the difficulties involved in winning KQKR (the longest positions involving 31 optimal moves) that he sought to test it against the strongest players. Grandmaster Robert Byrne declined, but once again Walter Browne thrust himself into the thick of things by agreeing to a bet for $100 to win with the Queen’s side against Thompson’s database with a time limit of 2.5 hours for up 50 moves, which the laws of chess allow for this ending. The match was played over the telephone lines between Belle in Murray Hill, NJ, and Browne’s home in Berkeley, CA. From Figure 3, a 31-move position, the play went as follows:


Notes: Move 1. lost 1 moves; 17. lost 6 moves; 18. lost 2 moves (20 to mate); 21. lost 2 moves; 25. 17 moves to mate; 27. 14 moves to mate; 32. 17 moves to mate; 34. 17 moves to mate.

Browne’s fighting spirit and ego were challenged by this experience. He very carefully studied the computer’s play and learned a great deal about KQKR from his experience against it. A few weeks later Browne, ever the competitor, played a rematch against BELLE in this ending from another 31-move position with the chance to win back his $100. He succeeded in doing this, but exactly on move 50! (Actually Browne was allowed 5 extra moves in the rematch.)

In Figure 4, White: (Browne) Black: (BELLE) White-to-Move (WTM).
The number of moves to mate is indicated in parentheses.


Up to here Browne has been playing very accurately and making steady progress.


Browne errs on moves 16, 17, and 19. Ken Thompson has found that lower rated players have trouble from a distance of 14 to 16 moves from the win. Usually the WK is trying to cross the “barrier” on the 3rd or (as in this case) 4th rank. The books don’t help here either.
27. Qa3 Rf4 (15) 28. Qh3+ Kg5 (16) 29. Qg3+ Rg4 (15) 30. Qe5+ Kh4 31. Qh2+ Kg5 32. Ke5 Kg6 (14) 33. Qh8 Rg5+ (14) 34. Ke6 Rg4 (14) Browne has been somewhat stuck since move 26. He can only lose two moves now: 35. Qg8+ Kh5 36. Qh7+ Kg5 37. Ke5 Rg3 38. Qg7+ Kh4 39. Qh6+ Kg4 (9). Browne was now making steady progress but he is still on a tightrope: 40. Ke4 Rg2 41. Qg6+ Kh3 42. Qh5+ Kg3 43. Ke3 Rg1 44. Qg5+ Kh2 45. Qh4+ Kg2 46. Ke2 Ra1 (4). Now 47. Qg5+ 48. Qh6+ 49. Qg7+ and 50. Qxa1 wins. Browne finds another way: 47. Qe4+ Kh3 48. Qh7+ Kg3 49. Qg7+ Kh3 50. Qxa1 (1:0). Browne just makes it within the normal rules and wins back his money.

Despite the apparent tension, a little known fact is that the last 24 moves went exactly according to Browne’s home analysis (personal communication, 1990).

As an addendum to this story, it should be mentioned that a book appeared in 1895 authored by “Euclid” and edited by E. Freeborough entitled Analysis of the Chess Ending King and Queen Against King and Rook published by Kegan Paul, Trench, Trubner & Co., which had exactly the same kind of analysis as done by Thompson’s program with the same conclusions: the longest win takes 31 moves. A quote from the long out of print book, with existing copies, providing 144 pages of analysis and 191 diagrams, reads:

The view commonly held and expressed that there could be no practical difficulty in winning with Queen against a Rook was ...... discarded as illusory (pp. iv–v).

Clearly the book by “Euclid” has been somewhat overlooked by both the chess and computer chess worlds! Sources for these details on KQKR and Walter Browne are articles by Warren Stenberg and Edward Conway published in the Chess Voice (April/May 1979).

Another four-piece endgame for which there already existed databases in the 1970s was King and Rook vs. King and Knight (KRKN). T. Strohlein developed such a database for his Ph.D. thesis [13]. At the Machine Intelligence Research Unit, University of Edinburgh, Scotland, particularly between 1976 and 1979, there was considerable investigation into this endgame. Experiments with humans determined that it requires a master strength player to hold a draw in drawn positions with the weak side (N side) and that it also requires
a master level player to win won positions with the strong side (R side) [14]. This research, combined with the KRKN database, helped uncover a number of errors in Fine's *Basic Chess Endings* (1941). A benchmark of 24 interesting KRKN positions was developed, many of which required counterintuitive separating moves between the BK and BN to hold a draw. This was contrary to the standard advice from endgame texts to "keep the BK and BN as close together as possible."

The longest win in KRKN is 27 moves, and it was interesting to determine whether strong human players can find those 27 optimal moves. John Roycroft, an endgame study specialist with such a task in mind, was given three 24-move wins in KRKN and a week to study them. The challenge for Roycroft was to learn the optimal 24-move wins in these positions and produce them under serious tournament time conditions (i.e., 16 moves per hour). In these tasks Roycroft performed remarkably well. We reproduce the optimal sequence played by Roycroft from Figure 5 (White: K/d6, R/h5; Black: K/f7 N/c3, WTM).


In 1979 International Master Craig Pritchett was also tested from Figure 5 under tournament time conditions. He had never been shown or studied positions in KRKN where optimal move sequences were required. Yet he also was able to find the optimal 24 move sequence to win from the diagrammed position.

Possibilities for 4-piece endings such as KRKN arise at the highest level of play more often than one might suspect. In the Lloyd's Bank Master's tournament (August 1978) after 120 moves and three adjournments, the game between GM Balinas and then untitled (now GM) 13-year-old Joel Benjamin had reached Figure 6 (White: K/f7, R/h8, P/h6; Black: K/g5, N/f4, WTM). GM Balinas, the exchange up for many moves, had made the win difficult by cramping his Rook with the advance of the a-pawn. He came to the analysis room believing the position was now drawn. Having been very involved with this ending and having owed him a favor, the author showed Balinas the only win which seems to exist in the
position: 1. h7 Kh6 2. Ra8 Kxh7 3. Kf6! Now if 3. ...Nh5+ 4. Kg5 Ng7. (We have a basic position from the ancient game of Chaturanga where Knights and Rooks moved just as in chess.) Ironically, the continuation from this position was incorrectly analyzed by Fine (1941) as a draw or if 3. ...Ng6 4. Ra4! wins, i.e. (a) 4. ...Nh8 (the N in the corner always loses in these positions) 5. Ra7+ Kg8 (or 5. ...Kh6 6. Rg7) 6. Rb7++ (b) 4. ...Kh6 5. Rg4+- (c) 4. ...Nf8 5. Kf7 Ng6 6. Re4 Nh8+ 7. Kf6 Ng6 8. Rg4 Nf8 9. Kf7++. After resumption of play Benjamin was forced to resign on move 130.

More recently, Ken Thompson has extended this work to include all 5-piece endings [15]. This work has had great consequences for the game of chess as a number of special cases requiring more than 50 moves to win have been identified as a result of the database. Particularly these include: KBB vs. KN, 66 moves; KQ vs. KNN, 63 moves; KQ vs. KBB, 71 moves; and KRB vs. KR, 59 moves. Thompson also made significant contributions to the knowledge about the endgame KQP versus KQ determining that in many cases more than 50 moves are required with best play. The few practical tests there have been involving these 5-piece endings and the databases for them indicate that the one order of magnitude increase in computational complexity in going from four to five pieces comprises a jump in complexity which passes the threshold of human scrutability. In these cases, accounting for symmetries, rotations, and reflections, we are concerned with a jump from about 3 million possible configurations (for 4-piece endings) to over 100 million possible configurations (for 5-piece endings). Clearly this is not an area in which humans can learn easily and efforts to "decrypt" the databases into recognizable goal patterns or configurations promise no guarantee of success [16]. Roycroft's difficulties in trying to make progress with the KBBKN database give further evidence for this. The trouble is that Thompson's program is the supreme example of a brute force program—it cannot explain how it reaches a decision. It just provides moves and their corresponding numbers—the depth of win or draw involved. Missing from the databases is some form of insight as to how humans might learn how to recognize critical patterns in these endgames.

One 5-piece ending which could certainly use some decoding is KRB vs. KR (KRBKR). It occurs relatively often at the international level [17] and the optimal play in the 59-move sequence has hardly been studied. A few basic winning and drawing positions have been known for several centuries, but very little has been done to relate the database's moves to these known positions. The world chess governing organization (FIDE) has re-
acted to these findings for optimal move sequences in peculiar ways. First, the number of moves in which the defender could suffer in KRBR was increased to 100; then decreased to 75; and now it's not quite clear what FIDE intends to do. Surveying the international games of a year picked out at random Ken Thompson was able to discover many examples of KRKR where IMs and GMs had gone wrong. Here is an example which cost a strong player a half point against DEEP THOUGHT. DEEP THOUGHT did not have the KRKR database, but seeing ahead 10 moves at times, it may hardly need it. Winning this game helped DEEP THOUGHT tie for first in the Software Toolworks Open 1988 with 6.5 points out of a possible 8. We start at Figure 7 (White: DEEP THOUGHT; Black: Alex Fishbein).

60. Ke4 Rb5 61. Be3 Rh5 62. Bd4 Rg5 63. Be5 Kb6 64. Kd5 Kb5 65. Rc8 Rg6? (Not losing, but the wrong idea. Black draws relatively easily by maintaining the pin on the bishop with Rh5 — the basic Cochran Position) 66. Rc5+ Kb6 67. Rc2 Rh6? (Now this is losing. Rg5 keeps the draw in hand) 68. Rb2+ Ka6 69. Bd6 Rh5+ 70. Kc6 Rg5 71. Rb3 (all part of the final phase of the winning database technique (also known by Philidor several hundred years ago) which DEEP THOUGHT finds on its own) Rh5 72. Rb1 Rg5 73. Rb2 Rh5 74. Rb8 Rh7 75. Bf8! Ka7 76. Rb3 Ka8 77. Re3 Rb7 78. Re4! Rf7 79. Re8+ Ka7 80. Bc5+ Ka6 (1-0).

It seems worth noting that these difficult endings will almost necessarily occur after many moves and many hours of play so that the human opponents involved will tend to be quite tired.

We conclude this section by mentioning a game between FM Rowley and none other than GM Walter Browne, which took place at the 1989 Memorial Day Classic in Los Angeles. Browne tried to win the ending KBB vs. KN resulting in a game which lasted 129 moves and nearly 12 hours of play. The game was declared a draw due to the 50-move rule, but as we know, 66 moves are required in the worst case with best defense. It seems Browne was well aware of the discoveries by Thompson's database, particularly that all positions in KBBKN are a win for the strong side, but Rowley was not. It is clear from Rowley's notes on the game in Inside Chess (June 26, 1989, p.4-5) that he did not "trust" the rumored computer results for this ending, stating: "A lot of players were saying computers have now declared two Bishops versus Knight to be a win. I just looked the ending up in Cheron's..."
book and was surprised to find King and Horwitz studies from 1851." He should see Michie and Bratko [16], and I'm sure Roycroft will have a few words to say about this ending.

There are many more examples of how endgame databases have been studied and proven useful to chess theory, but now it is time to move on and focus on the more recent history of man-machine play.

David Levy made a reputation for himself by betting on his chess skills against any machine. In this way he instigated research and progress in computer chess. His famous bet for 1250 pounds (then $2500) against four computer science professors was that no program could beat him in a match of up to six by August 1978.

In August 1978, when Levy consummated his bet against CHESS 4.7 he was simply too strong for the program. In fact, it is quite clear that he could beat it almost at will, although the final score of 3.5-1.5 somewhat belied this. In 1977 he easily beat KAISSA, the Russian program, in Montreal. Then, just three weeks before leaving England for his match against CHESS 4.7 Levy was challenged by Richard Greenblatt. His program had now been supplemented with a hardware component called CHEOPS, which could analyze legal moves and tactical possibilities at the rate of 150,000 positions per second. Levy agreed to a two-game match, the second game of which would be academic if Levy won the first game. Levy won the game against MacHack on August 23, 1978 without much difficulty. Once the opening tactics had cleared it was just a technical problem for Levy to convert his positional advantage in the endgame to victory which he accomplished without much difficulty.

The first game of the match against CHESS 4.7 produces somewhat of a surprise both for the program's ability to find a piece sacrifice for two pawns and for the outcome—a draw. It was the first time that a program had drawn an international master under tournament conditions. However, Levy provoked all the ongoing with his very passive opening play. This approach had proven successful in the past as computers never sacrificed against Levy and tended to weaken and beat themselves. CHESS 4.7 obtained a completely won game after the sacrifice but lost its way in the ensuing ending.

White: David Levy
Black: CHESS 4.7
Reversed Pirc


An excellent piece sacrifice which the program found instantly. Black gets two pawns, a continuing attack and a won game.

13. fxe3 Qg5 14. g4 Qxe3+ 15. Rf2 Bg3 16. Qe2 Qxf2+

Approximately, CHESS 4.7 trades down when material ahead.


White's first threat of the game, but Black should still win easily.

Rf3 35. Rd8 h6 36. Rxd5 Rxb3 37. Rd8 Rf3 38. Ra8 g5 39. d5 h5 40. d6 Kg7 41. Rxa7 Rf7 42. Ra5
White’s position now offers a glimmer of hope.

42. ...Kf6 43. Bc3+ Kg6 44. Re5 Rf3 45. Bb4 Rf4 46. Re7 Rf7 47. Rxe4 Rd7 48. Re7 h4 49. Kg2 g4 50. Kh2?! 

Better was 50. Bc5 preventing ...b6

50. ...b6 51. Kg2 Rd8 52. a4 Nd7 53. a5 Nf6

Better here was 53. ...bxa5 54. Bxa5 Ra8 forcing 55. Bc3.

54. axb6! Nd5 55. b7! Nxe7!

CHESS 4.7 has fallen into a lot of trouble but now appears to find the only drawing move.

56. dxe7 Rh8! 57. Bd6 Kf6 58. b8=Q Rxb8 59. Bxb8 Kxe7 60. Bf4 Kf6 61. Bd2 Kg6 62. Be1 Kg5 63. Bf2 Kh5 64. Be1. And David Slate offered a draw on behalf of his program.

The second game was more typical of how David Levy regularly succeeded in beating computer chess programs. The basic formula was: get them out of book early, get them into positions which depend more on deep understanding than tactics, and then exploit the weaknesses they have left behind. It seems worth adding that in subsequent years computer chess programmers have completely avoided playing the White side of open variations of the Sicilian Defense.

White: CHESS 4.7  
Black: David Levy  
Sicilian Defense, Dragon Variation (by transposition)

1. Nc3 c5 2. e4 Nc6 3. f4 a6

To take the program out of book.


A typical error which programs have been making on the White side of the Sicilian Defense for many years. White relinquishes his well-placed N and strengthens Black’s center at the same time.

8. ...bxc6 9. Be2 Rb8 10. Qc1 Qa5

Black is already somewhat better.


Naturally the program goes after a pawn, but Black has plenty of compensation in the resulting awkward position of the WK.

19. ...Bxd1 20. Kxd1 Be3! (Fig. 8) 21. b3 Bxd2 22. Kxd2 Rbc8 23. Qa4 Qf2+ 24. Kd3 Qxg2
Black now has completely won game.


Levy also won Games 3 and 5, but played rather recklessly in Game 4, allowing the program to emerge victorious on the White side of a Latvian Gambit.

In the late 1970s there were several instances of computer programs defeating very strong players including Grandmasters at blitz chess. Not surprisingly, since this form of chess is primarily based on a quick and accurate tactical assessment, computers perform better here than they do in slow tournament chess. Nonetheless, the differences in overall chess understanding, especially in the endgame, rendered top humans far superior to the top programs even at blitz chess.

MASTER LEVEL AND BEYOND

The Period of Belle

The period 1979 through 1983 was marked by the dominance of the program BELLE developed by Ken Thompson and Joe Condon [18]. This program was characterized by speed and depth of search facilitated by special-purpose hardware resulting in the ability to analyze 30 million positions in three minutes of think time. In a nutshell, BELLE represented quite a powerful tactician able to exhaustively search 8–9 ply in the middlegame. In addition, BELLE had a vast opening library including all five volumes of the Encyclopedia of Chess Openings (totalling 375,000 positions), deftly typed in by Thompson himself. Belle seems to play quite well in endings through its ability to see very deeply as fewer and fewer pieces remain. BELLE won the 3rd WCCC in Cologne, West Germany, in 1980. Its rating peaked at 2203 in 1983 when it officially became the first program to achieve the title of master. A few representative examples of its play follow.

BELLE scored one of its first major successes in tournaments against humans at the 1983 U.S. Open in Pasadena, California where it scored 8.5-3.5, a solid master level performance. In the Eighth Round as White it met Leslie Ault (2196) and reached the position in Figure 9 after 27. Qa4:
White is up two pawns but Black has definite compensation in the passed pawn on b3. 27 ...Rab8 is indicated [19]. Play continued 27. ...b2?? (Instead Black plays a losing move) 28. Qc2! (All programs would never miss such a one-mover. Suddenly Black is completely lost) Rdb8 29. Qxg6+ Kd8 30. Bxb2 Nxb2 31. Qxg7 Nd3 32. Qg8+ (1:0).

In the next round BELLE crushes an even higher ranked player:

White: BELLE (2075)
Black: Harry O. Radke (2321)
Modern Defense

1. e4 d6 2. d4 Nf6 3. Nc3 g6 4. f4 Bg7 5. Nf3 c5 (A poor choice because it is very sharp, probably premature, and in BELLE’s book; safer is 0-0) 6. e5 Ng4? (Now 6. ...Nf6 is necessary to maintain the tension) 7. dxe5 (White now get an edge by straightforward means) dxe5 (Black has only a choice of bad moves — if 7. ...dxc5 8. Qxd8+ Kxd8 9. h3 Nh6 10. Be3 and White has a big edge) 8. —Qxd8+ Kxd8 9. h3 Nh6 10. fxe 5 Nd7 11. Ne4! (Keeping White’s extra pawn with more centralization) f5? (A poor move, but it is already difficult for Black to move) 12. exf6 exf6 13. Nd6 (With the threat 14. Bxh6 White already has a won game) Ke7 (If 13. ...Kc7 14. Bf4 and later 0–0–0 looks very strong) 14. Be3 b6 15. Bc4 (BELLE has proceeded with very simple and strong developing moves. Again Bxh6 and Ng7 is threatened) 15. ...g5 16. 0–0–0 bxc5 (If 16. ...Nxc5 17. Bxc5 bxc5 18. Rhe1+ Kd8 19. Nf5+ wins) 17. Bb5 (Another simple and devastating move directed against the only defender of the BK) Ne5 18. Nxe5 fxe5 19. Rhf1 (Even stronger than 19. Bxg5+ as the Bishop neatly aims at two loose pawns) 1:0. All this was a direct consequence of Black’s poor opening play.

In 1980, MIT Computer Science Professor Edward Fredkin established an incentive prize fund for the development and advancement of computer chess. His grand prize of $100,000 is to go to the first program to defeat the World Chess Champion. BELLE was awarded the prize of $5000 for becoming the first program to achieve a master rating. Every year Dr. Hans Berliner organizes Fredkin Incentive Prize Tournaments which involve computers and humans competing together. The 1983 event involved only two programs, BELLE and NUCHESS (the successor to the Northwestern CHESS series) competing with
four humans in a three-round event. The key idea of this event was to prevent humans from knowing whether they were playing programs and so four new human players were selected at each round and the games were isolated from each other. BELLE won all three of its games against expert opposition, although it was losing the third round game against John Knight (2001).

Soon, thereafter, BELLE tied for first in the 1983 New Jersey Open with a score of four wins and two draws. Here is its very respectable draw against Steve Stoyko (2345) the very experienced, highest rated player in the tournament, allowing BELLE to break the 2200 barrier.

White: Steve Stoyko (2345)
Black: BELLE
Petroff’s Defense

1. e4 e5 2. Nf3 Nf6 3. d3 (Stoyko, once a feared tactician, avoids any early tactical discussion with BELLE) Nc6 4. g3 d5 5. Nbd2 (White is steering for a King’s Indian Reversed, hoping that it might lead to strategical positions which BELLE may not handle well) Be5 6. Bg2 dxe4 7. dxe4 0-0 8. 0-0 Qe7 9. c3 a5 10. h3 Rd8 (Out of its book, BELLE has developed quite soundly and nicely) 11. Qc2 Be6?! (Now a more provocative development is 11. ...b6 and 12. ...Ba6, eyeing the d3 square) 12. Ng5 Bd7 13. Nc4 Nh5 (A neat idea, not for the threat of Nxe3 but because it forces White’s next few moves) 14. Kh2 b5 15. Na3 Bxa3 (This shattering of White’s pawn structure is what Belle had foreseen) 16. bxa3 Nf6 17. Nf3 Be6 18. Re1 Bc4 (BELLE’s bishop finds the a6-f1 diagonal anyway) 19. Bf1 Bxf1 20. RxI Qc5 21. Bg5 Rd6 (BELLE somewhat surprisingly does not snatch the loose pawn on a3. Perhaps it feared (after 21. ...Qxa3) 22. Bxf6 gxf6 23. Nh4 and 24. f4; nonetheless, White’s weak pawns will not go away and Black again threatens to infiltrate via d3) 22. Rab1 Rad8 23. Qe2 (Stoyko maintains an active policy which will assure counterplay for a pawn) Qxc3 24. Rxb5 Qxa3 25. Rb7 (White seems to have sufficient counterplay for the pawn, especially due to the pin on the N/f6 and pressure on the c-file) Re8? (too passive) 26. Kg2 Qa4 27. Bxf6 Rxf6 28. Rc1 Qa3 (Black’s pieces are simply not well coordinated in this middlegame) 29. Rcb1 a4 (Black’s back rank is too weak to play the desirable Nd4) 30. Rd1 Qe7 31. Rd5 Re8 32. Qb5 (threatening Nxe5 with a back rank combination, but also the P/a4) h6 33. Qxa4 Rd8 34. Rbb5 Rxd5 35. exd5? (Better was 34. Rxd5; now BELLE has neat drawing combination) (Fig. 10) Rfx3! 36. dxc6 e4 37. Qd4 Rf6 38. Re5 Re6 39. Rxe6 Qxe6 40. Qd8+ Kh7 41. Qxc7 e3 42. fxe3 Qxa2+ 1/2-1/2. Although there were errors by both sides, this was a legitimate draw.

The source for the BELLE game scores presented above is Welsh and Baczyński [19] and some of my notes are based on Baczyński’s comments.

In the effort to provide a balanced view of matters, we present the second game of a Fredkin Challenge Match which was played in 1981 and scores one for humanity. BELLE’s opponent, Carl Storey (2206) won both games of a two-game match for which he received $2500.

Knowing no better, BELLE played the uncalled for 11. d5?! soon drifting into an unpromising endgame after 16. Qc4 Qxc4 17. Bxc4 Nxc4 18. Bxh6 etc. BELLE did not realize that its R was misplaced on h4 for 22. Rb4 was necessary and good. Instead, in the futile effort to muster a K-side attack that R soon became trapped in that quarter after 27. ...f5. Storey should have followed with 28. ...Kf6, though after 31. ...Re1 32. Rf3 Kf6 and
Black is still better. BELLE did not play 34. Rc3 because it saw 34. ...Rxd4!. However, not knowing much about R-endings, it drifted into a lost one with 37. Bf3? (better 37. Rc3) which became clear after 38. ...Rc7 and 39. ...Rc4.

White: BELLE
Black: Storey
Pirc Defense


CRAY BLITZ VERSUS DAVID LEVY

In 1983 CRAY BLITZ won the 4th WCCC in New York City with a 4.5-.5 score. Running on the world’s fastest computer, the CRAY-XMP, and seeing over 30 million positions in 3 minutes of think time, CRAY BLITZ’s programmers Robert Hyatt and Albert Gower challenged David Levy to a match during the 4th Advances in Computer Chess Conference in London in April 1984.

For many years David Levy had been recognized as the world’s leading specialist in computer hostile play. Although he has never been rated more than 2375, it is believed that his great knowledge and experience in playing against chess programs was worth a few hundred rating points. This match was an indirect consequence of his 1968 bet. The challenge was renewed with the support of OMNI Magazine of New York, offering $5000 (including $1000 from Levy) to the first program to defeat David Levy at any time. This writer was his second there and we planned some strategies in both the opening and middlegame to befuddle the program which ran on the world’s fastest computer and searched 7 or more full
ply (half-moves). We planned openings which could lead to blocked positions and few tactics. As it turned out, CRAY BLITZ suffered from both communication and hardware problems causing it to fall into severe time trouble. David Levy played surprisingly well after a 5-year layoff from chess, capitalizing on his “do nothing but do it well” strategy to score a 4-0 shutout. The complete details of the match and the games are well described in Welsh and Baczynskyj [19], therefore we present only one position from the first game here. This game represents a great success for our overall match plans and preparation. David chooses an opening which although objectively unfavorable, proves very difficult for CRAY BLITZ. White is drawn into a position with a blocked center where positional themes in the subcenter and wings become critical. CRAY BLITZ makes a number of serious strategic errors and the following position (Fig. 11) arises:

20. c3? (White’s position has been steadily declining and the threat was simply 20. ...
c3. Best for White is probably 20. Nd1. Instead after the text the WN/b2 never gets back into play and White’s position literally becomes split into two halves) Bxf3!! (Levy initiates an ideal pawn sacrifice. White’s K-side pawn structure is permanently shattered, Black obtains long-term positional compensation and an initiative which naturally the program finds very difficult to evaluate properly) 21. gxf3 Nf5! (The \(P/a6\) could not be defended anyway and Black’s K-side initiative is about to begin) 22. Rxa6 Rxa6 23. Rxa6 Qb7 24. Ra5 Qxf3 25. Rxb5? (This is the culmination of the combination which began with 20. ...Bxf3!! Levy knew that CRAY BLITZ would continue its greedy ways) h6 26. Bf4 Qh3 27. Bg3 h5 28. Rc5 Ra8 29. Qc1? (29. Ra5 was the only defense) h4 30. Bf4? Qf3! 31. h3+ Qxh3 32. Rxc4? Qf3 33. Bh2 h3 34. Qf1 Ra1! 35. Nd1 Rxal 36. Rc8+ Kh7 37. Rh8 Kxh8 38. Qxd1 Qg2 mate (0:1).

The Reign of HITECH
In April 1984 Hans Berliner gave a talk at the Advances in Computer Chess 4 Conference in London. Berliner's talk was impressive because, in considerable detail, he outlined his “Five Year Plan for Computer Chess at Carnegie Mellon University” [20]. He talked about plans to design the fastest-ever VLSI move generator by then graduate student Carl Ebeling, the “chunking” work that Murray Campbell and he were doing. And the extensions of the B* algorithm in Andrew Palay’s dissertation. The notion of the 8000 “ever possible” moves
to every square on the chess board employing 64 VLSI customized chips (by Andre Palay) was also a very powerful idea.

Berliner's approach seemed a very sensible hybrid of the brute force and knowledge-based approaches to computer chess. He recognized the need for a powerful and deep exhaustive search, but he also advocated the development of a large incremental store of pattern-based chess knowledge. Essentially, he had a very clear plan for what had to be done, a few very powerful methods to accomplish his goals, and a team on which he could rely and work with. This writer has always been of the opinion that a really successful approach to computer chess requires such a diversified team effort. Many were a bit skeptical, because since beginning his research in computer chess around 1970, Berliner had never developed a strong program and seemed even to discontinue his work in the area several times. His program PATSOC was relatively new and did not perform particularly well at the 1983 WCCC in New York City.

Any remaining skepticism was completely dissolved in November 1985 when HITECH (by Ebeling, Berliner, Goetsch, Palay, Campbell, and Slomer) won the 16th North American Computer Chess Championship with a perfect 4-0 score and was quickly rising well into the master class. Between 1985 and mid-1988 HITECH was clearly the world's best program and in 1988 became the first program to achieve a senior master rating.

HITECH has won the Pennsylvania State Championship three years in a row (1987, 1988, and 1989) and is ranked among the top 150 players in the United States at 2413. At the 21st North American Computer Chess Championship in New York City (November 1990), HITECH soundly defeated DEEP THOUGHT after three previous defeats at the hands of DEEP THOUGHT in serious tournament competition. More details about HITECH and its performance can be found in Berliner and Ebeling [21] and Berliner [20, 22]. We now present some major highlights of HITECH's career and are grateful to Dr. Berliner for providing the game scores.

White: HITECH
Black: Mark Unico (1677)
Gateway Open, Pittsburgh, PA 1985

Here is an early brilliance where HITECH finds a known idea in a novel setting:


HITECH has a vastly positive score against masters (2200–2400) since its maturing in 1987 with debugged software and more pattern recognizers. It is also widely accepted that HITECH plays the most human-like chess of the strong programs. Here is an example of the kind of technique and sound, solid play which has enabled it to perform so well against players rated below it.

White: Kimball Nedved (2242)
Black: HITECH
Gateway Open, October 1985
Ruy Lopez

1. e4 e5 2. Nf3 Nc6 3. Bb5 a6 4. Ba4 Nf6 5. Qe2 (The Wormald Variation, which is old, but not particularly dangerous or popular. HITECH plays as it normally would on
(Normally this kind of pawn structure is quite promising for White with chances of
Rf2 c4 (Black’s effective counterplay on the Q-side and in the center initiated by this
move suggests that White may have sought improvements earlier with moves like b4
to try to relocate the bishop on b3) 16. d4 exd4 17. exd4 Rc7! (Black’s successful
defense stems from piling up on White’s e-pawn while preventing its advance) 18.
Re1 Re7 19. e5 dxe5 20. Nxe5 Nd7! (Black’s straightforward defense proves very
effective) 21. Qf1 Nxe5 22. Rxe5 Rxe5 23. dxe5 Bd5 (Now White has an isolated
e-pawn and a somewhat passively placed Q) 24. Nf3 Nc6 (A human might fear the
pin with 25. Rd2 but HITECH sees that Nxe5 defends and attacks, e.g. 26. Qd1 Nxf3+ 27.
gx f3 Qg5+ etc.) 25. Re2 g6 26. a4 Bxf3 27. Qxf3 Nxe5 (The strategic battle
having been won, HITECH mops up like a seasoned master) 28. Qe4 Re6 29. ab5
Nd3! 30. Qf3 Ne1 31. Qf2 Rxe2 32. Qxe2 Nxc2 33. bxa6 Qb6+ 34. Qf2 Ne3 35.
Qf3 Nf5+ (0:1)

The following game represents the highest rated player that HITECH has scored against and
represented quite an upset at the time. The play is quite wild with chances for both sides and
illustrates what resourceful defenders the top programs like HITECH and DEEP
THOUGHT can be.

White: IM Michael Rohde (2602)
Black: HITECH
World Open, 1986, Philadelphia
Grunfeld Defense

1. d4 Nf6 2. Nf3 g6 3. c4 Bg7 4. Nc3 d5 5. Qb3 dxc4 6. Qxc4 0–0 7. e4 Bg4 8. Be3
(White has more space from his big center but Black has no weaknesses) Qd7 15.
Rg3 f5! (Quite an active move which creates weaknesses but emphasizes some of the
weaknesses in White’s position) 16. Bd4 Bxd4 17. Rxd4 Kh8 18. Rd1 (It’s not so easy
to suggest how White should continue because after 18.e5!? f4 followed by 19.
...Rf5 may prove the White center pawns weak. Black starts to get some counterplay
now) f4 19. Rg1 Qh3 (This looks too offside, but Black has just adequate resources
for such a venture) 20. Nb5 Qxh2 21. Rf1 c6 22. Qc3+ Rf6 23. Nc7 Raf8 24. Ne6Ra8 25. d6! (one can sense that Rohde now feels he can win at will and he becomes just a little overconfident) Kg8 26. d7 (This should win, but perhaps 26. Qb3 first might be even stronger, virtually forcing exd6 27. Rxd6 etc.) Nxd7 27. Rxd7 Rxe6 28. Bc4 Kf7 29. Ke2!? (Again one gets the sense that White feels the game is already over. 29. Qe5 looks more effective, although after Qh3 30. Bxe6+ Qxe6 31. Bxe6+ Kxe6 32. Rxb7 Bxf3 Black has plenty of play in the ending. Instead White could play 30. Rxb7 Qh3 30. Rxb7 Rd8 (HITECH has definite counterplay for the exchange now stemming from the Bishop on h5) 31. Rb3 Rd5!! (An excellent defensive resource as the WK now becomes more of a target than the BK) 32. Ke1 Qg2 33. Bxd5 cxd5 34. Qh8 Rxe4+ (Forcing a draw which White could force in any case) 35. fxe4 Qxe4+ 36. Kd2 Qe2+ 37. Kc3 Qc4+ 38. Kd2 1/2 – 1/2

The play by HITECH in winning from the diagrammed position (Fig. 13) is a wonderful technical achievement and won the Pennsylvania State Championship (1988) for HITECH for the second year in a row.

Figure 13: White: IM Edward Formanek (2461)
Black: HITECH
Position after 28. ...Qxe5

29. Nd4 Rc3 30. Re1 Bd7 31. Qf3 Bc8 32. Kf2 f6 33. Ra1 Bb7 34. Rb1 (Black is up a solid pawn but it is not an easy position to win because the WN is powerfully posted on d4 and the bishop is bad on b7) Rc7 35. Rb6 Kf7 36. Re6 Qg5 37. Qg3 Rc2+! (Forcing further simplification into a B vs N ending which can only bring Black closer to victory) 38. Nxc2 Qxg3+ 39. Kxg3 Kxe6 40. Nd4+ Ke5 41. Kf3 h5 42. h4 g5 43. g3 Bc8 44. Nc6+ Kd6 45. Nd4 Bg4+ 46. Kf2 Ke5 47. Nb5 Bd7 48. Nd4 Ke4 49. Nc2 Bb5 50. Nd4 Ba6 51. Ne6 Bc8 52. Nd4 Bd7 (It appears the position is going around in full circle. Nonetheless Black is making steady progress in improving its position) 53. Nc2 gxh4 54. gxh4 Bg4 55. Nd4 f5 56. Ne6 f4!! (Fig. 14) (Such a wonderful move deserves another diagram. HITECH sees very deeply into the position as after 57. Nxf4 d4 58. Ng2 d3 59. Ke1 Kf3 wins) 57. Ne5+ Kf5 58. Nd3 d4!! (Transposing into the winning line described above) 59. exd4 Ke4 60. Ne5 Kxd4 (A nice point is that if 61. Nxe4 hxe4 the BK can still stop the WP) 61. Nf7 Be6 62. Ng5
FIGURE 14. (W) Formanek-HITECH After 56. ...f4!!

Bd5 63. Nh3 Ke4 64. Ng1 Kf5 65. Ne2 Kg4 66. Kg1 f3 67. Nc3 Bc6 68. Kf2 Kxh4 69. Nd1 Kg4 70. Ne3+ Kf4 71. Nf1 h4 72. Nh2 h3 73. Nf1 Bb5 74. Ng3 h2 75. Nh5+ Kg4 76. Ng3 Bf1!! (0:1) A beautifully played endgame.

The following game is the first win by a computer program over a Grandmaster. Denker's tactical style is not likely to pose problems for a computer, but here HITECH finds an excellent combination which never gives Denker a chance. HITECH won the match 3 1/2–1/2.

White: HITECH
Black: GM Arnold Denker (2396)
Match, September 1988
Sicilian Defense, c3 Variation


This section concludes with an example to give humans fair time. Bear in mind that Kudrin is a Grandmaster and one of the twenty highest rated players in the country. He also happens to specialize in the Dragon Variation of the Sicilian Defense.

White: HITECH
Black: Sergey Kudrin
National Open, Chicago 1988
Sicilian Defense, Dragon Variation

1. e4 c5 2. Nf3 Nc6 3. d4 cxd4 4. Nxd4 g6 5. Nc3 Bg7 6. Be3 Nf6 7. Bc4 0–0 8. Bb3 d6 9. f3 Bd7 10. Qd2 Re8 11. 0–0–0 Ne5 12. g4 b5 13. g5?! (In some sense this variation is an ideal choice by Black against a computer in that there is plenty of deep theory and machines are likely to grab a pawn not realizing the long-term dangers to their king. In the meantime White’s attack against the BK never gets off the ground) Nh5 14. Nxb5 Nxf3 15. Nxf3 Bxb5 16. Bxa7 Bc4 17. Qe3 Bxb3 18. Qxb3 Nf4 19. e5 Qd7 20. Bb6? Rb8 21. Qe3 Qa4 (Black has an excellent attacking position) 22.
The Master Micros

Through the 1980s manufacturers of microcomputer chess programs had been intensely pursuing the goal of developing a master level program. The major companies involved in this effort have been Fidelity International, Hegener and Glaser (manufacturer of Mephisto), and Novag (manufacturer of the Constellation series). On looking back to the 1980s the progress has been superb. In 1980 the programs were still quite weak, playing no better than Class B (1600-1800) chess. In 1985 the Fidelity Par Excellence was officially rated 2100. The transition from the 6502 to the faster 68,000 chip with its extended assembly language instruction set, was primarily responsible for enabling the Fidelity to surpass the coveted 2200 threshold in 1987 at the Software Toolworks Open. Mephisto followed suit in 1988. For this, programmers Dan and Kathe Spracklen (Fidelity) and Richard Lang (Mephisto) deserve high commendation. Their ability to compete with the best programs despite severe handicaps in memory size and CPU speed clearly attests to their superior software. At the 1986 U.S. Open Fidelity scored the first win ever over an International Master.*

White: Fidelity Experimental (Unrated)
Black: IM David Strauss (2533)
U.S. Open, Somerset, NJ, Rd.6
Center Counter Defense

1. e4 d5 2. exd5 Nf6 3. d4 Nxd5 4. c4 Nb6 5. Nf3 g6 6. Nc3 Bg7 7. h3 0-0 8. Be3 Nc6 9. Qd2 e5 10. d5 Ne7 11. g4 f5 12. 0-0-0 fg 13. Ng5 (This is all part of an extended book line prepared by Boris Baczynskyj which ends here) g3?! 14. c5 g2 15. Bxg2 Nc4 16. Qe2 Nxe3 17. Qxe3 Nf5 18. Qd2 Bh6 19. Nce4 Nh4 20. Rhg1 Bf5 21. Bh1 (A human might get tired of defending White’s position, but of course the program is unaffected by such feelings) b6 22. d6 c6 23. Qe3 bxc5? 24. Nxc5 Qb6 25. Nb3 Qa6 (Strauss probably thought he was winning here) 26. Qc3 Qxa2 27. Bxc6! (Fig. 15) (Computers know no dangers—a human would probably never dare to take this pawn) Rad8 28. Bd5+ Kh8 29. Nc5 Qb1+ 30. Kd2 (White now has a won game) Nf3+ (Black does not have enough for the piece) 31. Bxf3 Rxd6+ 32. Ke2 Rxd1 33. Rxd1 Qb2+ 34. Qxc2 Bxc2 35. Rg1 Bf5 36. h4 Rb8 37. b3 Rc8 38. Nf7+ Kg7 39. Nd6! Rf8 40. Ra1 Kh8 41. Rxa7 Bf4 42. Nf7+ Kg8 43. Bd5 Kg7 44. Ng5+ (1:0) A very efficiently played game by White.

In late October 1989, after a thrilling visit to Harvard University by World Champion Gary Kasparov, a new man-machine event was christened, called The Harvard Cup. The 4-round event, primarily sponsored by IBM and organized by Danny Edelman and Chris Chabris, pitted four Grandmasters (Boris Gulko, Michael Rohde, Lev Alburt, and Max Dlugy) against four computers (DT, CHIPTEST, HITECH, and MEPHISTO PORTO ROSE). The games were played at the time control of 30 minutes sudden death and this

*Chess 4.7’s win over David Levy was under match conditions
seemed to handicap the computers more than the humans, the final score being 14.5–1.5 in favor of the humans. In the following game we see three time US Champion Alburt entering too many tactical complications and relinquishing a half point to MEPHISTO PORTO ROSE.

White: Lev Alburt
Black: MEPHISTO PORTO ROSE
Harvard Cup, Rd. 2
Catalan Opening

Bxe5 Rd3 27. Bc3 Kf8 (White now wins a pawn but let Black out of the bind) 28. Bxa5 Bxa5 29. Nc5 Bxg2 30. Kxg2 Rd5 31. Nxe6+ Kg8 32. f4 b5 (With good technique White’s K-side pawns should win, but Albur makes the mistake of letting the game become an unclear and exciting race) 33. Re4 Bb6 34. Rfe1 Rd2+ 35. R1e2 Rfd7 36. Kf1? (Inconsequential) Rd1+ 37. Re1 Ba5 38. Rxd1 Rxd1+ 39. Kf2 Bb6 40. Kg3 Rd2 41. a4 a6 42. Kh4 Rxb2 (Somewhere in the next few moves Black should play Kf7, but the machine can’t anticipate White’s mating idea) 43. Kh5 c3 44. Kg6 (Fig. 20) Rd4! (The ending now becomes very tactical) 45. Nd4 Kf8 46. Ne6+ Kg8 (46. ...Kxe8 would be ideally complicated for Albur’s time pressure) 47. Re5 c2 48. Rd5?! (48. Rf5 looks like a better try, e.g. Bc5 49. Rxc5 Rc4 50. Rf5 Rc8 51. Rf7 etc.) c1=Q 49. Rd7 Qc3 50. Re7 (Amazingly, White still has a draw) Qc2+ 51. f5 Rxf4+ 52. hxg4 Qc6 53. Rg7+ Kh8 54. Rh7+ Kg8 55. Rg7+ Kh8 56. Rh7+ Kg8 1/2 -1/2

DEEP THOUGHT CHALLENGES MANKIND’S BEST

In less than two years it seems that DEEP THOUGHT has gone on a whirlwind tour through the world of chess. Since the summer of 1988 its series of accomplishments including a number of Grandmaster victims and tournament victories has been most remarkable. The program was developed by five graduate students at Carnegie Mellon University: Fenghsuing Hsu, Thomas Anantharaman, Murray Campbell, Andreas Nowatzyk, and Peter Jansen. Hsu, Campbell, and Nowatzyk have already graduated and are working on improvements to DEEP THOUGHT for IBM Yorktown Heights. IBM is interested in advancing the theoretical and practical merits of parallel computing. In the next few years it is hoped that such advances will enable DEEP THOUGHT to see one billion moves per second which equates to an exhaustive search of about 14 ply. The version of DEEP THOUGHT which played David Levy in December 1989 (see later) ran on four processors in parallel and searched over 700,000 positions per second, or over 100 million positions (often over 10 ply) in three minutes. DEEP THOUGHT is based on over 100 VLSI chips with the main program running off a SUN-4 workstation. Its evaluation function is tuned based on over 900 IM/GM games which it was provided to “learn” from. The program consists of 100,000 lines of code and is completely written in C. It evaluates king safety, mobility, development, etc. and employs an important concept called singular extensions [8] to recognize moves which have been deemed important enough to analyze more deeply.

The program won the 6th WCCC in Edmonton [5, 22] with a perfect 5-0 score. Its current rating is 2551 USCF and there are now only a select group of players in the world strong enough to feel confident against DEEP THOUGHT. Below we present some of DEEP THOUGHT’s major games leading to the match against David Levy in December 1989.

One of the first really strong players to fall prey to DEEP THOUGHT was IM Igor Ivanov in the 9th Round at the 1988 U.S. Open in Boston. Considering Ivanov’s strength, this game was so one-sided that it prompted him to withdraw from the tournament. DEEP THOUGHT scored a quite respectable 8.5 points of 12, and to put the quality of that score in perspective, consider that the author’s final score (Rated 2519) was 9-3.

White: DEEP THOUGHT
Black: Igor Ivanov (2596)
1988 US Open, Rd. 9
Center Counter Game
1. e4 d5  2. exd5 Nf6  3. d4 Nxd5  4. c4 Nf6  5. Nf3 Bg4  6. Be2 e6  7. Be3 Bd4+  8. Nbd2 0-0  9. a3 Be7 (Black has played a lacedasical opening, leaving White with a lot of space)  10. h3 Bh5  11. 0-0 c6  12. g4 (Not unlike the human World Champion, Garry Kasparov, DEEP THOUGHT is unprejudiced about advancing the pawns in front of its K. It works out well here)  13. Nh4 Nbd7  14. Nxe6 hxe6  15. f4 g5  16. g5 Ne8  17. Ne4 Nd6  18. Nxd6 Bxd6  19. b4! (Grabbing still more space)  20. c5 Be7  21. axb4 a6  22. Qc2 Qe7  23. Qe4 b6  24. Qb7 Rf8  25. Bxa6 (Black's position is quickly crumbling)  26. fxe5 bxc5  27. Bc4! Rab8 (Fig. 17)  28. Rxf7! Rxb7  29. Rf4+ (1:0)

DEEP THOUGHT made history and big news by tying for first at the 1988 Software Toolworks Open with GM Tony Miles, each scoring 6.5-1.5. En route it scored the first ever win by a computer over a world championship candidate, GM Bent Larsen. True, Larsen is no longer in his prime, but neither can he be deemed a slouch with his 2580 FIDE rating. Certainly, Larsen's play indicates that he was somewhat resentful of having to play a machine, which he only later learned he could have avoided by signing a list, and neither did he give DEEP THOUGHT sufficient respect.

White: Bent Larsen
Black: DEEP THOUGHT
Software Toolworks Open 1988
English Opening, Keres System


...Kxg7 31. Rxd5 etc.) or whether it is just desperation; in any case at least he is starting to fight, but it is too late) Rg6! 31. Qd2 Rd7 32. Rxd4 Rxd4 33. Ne5 Nxe3! 34. Qxd7 Nxd1+ 35. Qxd1 Rg3! 36. Qd6 Kxg7 37. Nd7 Re3 38. Qh2 Kh7 39. Nf8+ Kh8 40. h5 Qd5 41. Ng6+ fxg6 42. hxg6+ Kg7 43. Qh7+ Kf6 (0:1)

One area where DEEP THOUGHT is definitely weak is the Opening. Therefore, it is probably wrong to alter one’s style of play just to get DEEP THOUGHT out of book. That is what seems to happen in this game. GM and former candidate Robert Byrne finds that out after he chooses the inferior “Owen Defense” in order to get out of book. Overall, Byrne’s play is too passive and he makes a number of inaccuracies. DEEP THOUGHT seized the initiative with 22. Rc5! Understandably Byrne believed that Rook could be trapped, but could not find a way to prove it and instead the Rook exerted pressure. DEEP THOUGHT nicely built up the pressure until Byrne was driven to the desperate 36. ...Nxe4?! The game was fully annotated by Byrne in the New York Times on Tuesday, September 26, and in fairness to him it should be mentioned that he won the return game. Both games were played at the rate of 40 moves in two hours.

White: DEEP THOUGHT
Black: Robert Byrne
USA Sports Center Match
Owen Defense


There still are times when a very strong human player can make DEEP THOUGHT look confused. Six-time U.S. Champion Walter Browne again finds himself the center of
attention, by “upsetting” DEEP THOUGHT in the 4th Round of the 1988 Software Toolworks Open. DEEP THOUGHT makes some peculiar bishop moves and then Browne finds a deep, long-term tactical theme based on White’s weakness on the h1-a8 diagonal.

White: DEEP THOUGHT
Black: GM Walter Browne
Software Toolworks Open 1988, Round 4

1. e4 c5 2. c3 Nf6 3. e5 Nd5 4. d4 cxd4 5. Nf3 Nc6 6. Bc4 Nb6 7. Bb3 d5 8. exd6 Qxd6 9. O-O e6 10. cxd4 Be7 11. Nc3 O-O 12. Re1 Nd5! (Getting DEEP THOUGHT out of book since the normal moves in this position are 12. ...Bd7 and 12. ...Rd8 as Browne writes in Inside Chess, March 1988) 13. g3!? (Unnecessarily weakening) 13. ...Qd8! 14. a3?! Nxc3! (White is now saddled with a long-term weakness on c3) 15. bxc3 b6 16. Qd3 Bb7 17. Be2 g6 18. Bf4?! (For the three three moves DEEP THOUGHT gropes to find the right square for its QB) Rc8 19. Bh6?! (This would have been a more natural last move) Re8 20. Bd2? Na5 21. Ba4 (Fig. 19) Qd5! (Browne finds a winning idea which is simply beyond DEEP THOUGHT’s depth of analysis. Such long-term positional themes can still separate top human players from the top programs) 22. Bxe8 Rxe8 23. Kg2 Nc4 24. Bc1 g5! 25. h3 h5 26. g4 e5! (All of Black’s forces join the attack) 27. Qd1 f5! 28. gxf5 g4 29. hxg4 fxg4 30. Kg1 Qxf3 31. Qxf3 Bxh3 32. Bh6 Kh7 33. Bd2? (More futile moves with this bishop) Rf8 34. Rxe5 Nxe5 35. Re1 Nc6 (0:1)

In October, 1989, Garry Kasparov achieved the highest FIDE rating ever attained, reaching 2795 and eclipsing Bobby Fischer’s mark of 2780. Kasparov soon raised his rating even more to over 2800. At the height of his confidence he took on DEEP THOUGHT for a two-game match in New York City. Both sides played at the rate of 2 hours for all the moves. Kasparov took this challenge very seriously (as he takes all chess-related matters) and prepared carefully for the match by studying DEEP THOUGHT's games.

In the first game as Black, Kasparov essayed the Sicilian Defense and DEEP THOUGHT, as is its wont, avoided main lines with 2. c3. Kasparov played very simply and soon obtained a very solid position. After White plays c4 (e.g., on move 12 in this game) it is very hard to decide what to do with the pawn structure. DEEP THOUGHT played two ques-
tionable N moves: 10. Nb5 and 16. Nh4. The primary theme of the game is Black’s exploitation of White’s bad bishop on e3. This is caused by the slight pawn weakness on d4. After a K-side pawn expansion leaving White virtually moveless, Kasparov ultimately engineers a breakthrough on the e-file.

White: DEEP THOUGHT (2551)
Black: Garry Kasparov (2795)
Two Game Match, October 22, New York City
Game 1: Sicilian Defense, c3 Variation

1. e4 c5 2. c3 e6 3. d4 d5 4. exd5 exd5 5. Nf3 Bd6 6. Be3 (I would opt for 6. dxc5 Bxc5 7. Be2 with a blockade of Black's isolated d-pawn to follow. However the World Champion likes to play the Black side of the Tarrasch Variation of the Queen's Gambit where he accepts such a weakness and has been very successful with it) c4 (Kasparov has played this move before against Nigel Short) 7. b3 cxb3 8. axb3 Ne7 9. Na3 Nc6 10. Nb5?! Bb8 11. Bd3 Bf5 12. c4 0-0 13. Ra4 Qd7 14. Nc3 Bc7 15. Bxf5 Qxf5 16. Nh4? Qd7 17. 0-0 Rad8 18. Re1 Rfe8 19. c5 Ba5! 20. Qd3 a6 21. h3 Bxc3 22. Qxc3 Nf5 23. Nxf5 Qxf5 24. Ra2 Re6 25. Rae2 Rde8 26. Qd2 f6 27. Qc3 h5 28. B4 r8e7 29. Kh1 g5 30. Kg1 g4 31. h4 Re4 32. Qb2 Na7! 33. Qd2 R4e6 34. Qc1 Nb5 35. Qd2 Na3 36. Qd1 Kf7 37. Qb3 Nc4 38. Kh2 Re4 39. g3 Qf3 40. b5 a5 41. c6 f5 42. cxb7 Rxb7 43. Kg1 (Fig. 20) f4! 44. gxf4 g3 45. Qd1 Rbe7 46. b6 gxf2+ 47. Rxf2 Qxd1 48. Rxd1 Rxe3 49. Rg2 Nxb6 50. Rg5 a4 51. Rh5 a3 52. Rd2 Re2 (0:1) It all looks very easy, however this should not bely the virtuoso accuracy of the World Champion’s play.

In the second game Kasparov employs an opening innovation in an old variation (3.e4) which has been revived in recent years. The innovation is the temporizing 6. Nc3 rather than 6. Bf4 and White quickly gets a big game with the pawn sacrifice 10. Qd4 leading to 12. Bxc4. In deep trouble DEEP THOUGHT decides to relinquish its Q which renders the game “no contest.”
White: Garry Kasparov  
Black: DEEP THOUGHT  
Two Game Match, New York City, Oct. 22, 1989  
Game 2: Queen’s Gambit Accepted


MAN VS. MACHINE: DEEP THOUGHT VERSUS DAVID LEVY

In London, December 11-14, 1989, a match billed as “The Ultimate Challenge” paired IM David Levy against DEEP THOUGHT. The match took place at the British Computer Society in the center of London, using the computer satellite communications networks, Tymnet and Telenet to transmit moves across the Atlantic from DEEP THOUGHT’s base at Carnegie-Mellon University in Pittsburgh.

In preparation for the match I had accumulated a nice group of DEEP THOUGHT’s games, including a few recent losses which revealed some chinks in its armor. DEEP THOUGHT’s opening play is poor and we certainly planned to take advantage of this while avoiding tactical skirmishes which are its forte. In endgames DEEP THOUGHT is even more daunting, for we had seen a number of examples where it scored a full point from equal to inferior positions with the help of more than 20-ply searches.

As White we planned strategies to get out of book and to exploit positions with opposite wing castling, while leaving the option of a big central buildup, which we believed the computer did not understand well. As Black, based on DEEP THOUGHT’s predilection for 1. e4, we planned 1. ...d6, 2. ...g6, 3. ...Nd7 4. ...Bg7, and later ...h6, ...Ne7, ...b6 and ...Bb7 to reach positions where DEEP THOUGHT would find it hard not to play d5 or e5, after it might stumble into positions with a blocked center where strategical themes might preside over tactics. Clearly, we felt that DEEP THOUGHT was too strong an opponent to do nothing against, but were willing to cede a spatial disadvantage for a solid position.

In the end, despite my prediction of a close match and bookies bets on Levy, it was all for naught—DEEP THOUGHT was simply too strong for David Levy. The last five years away from active chess play had taken more of a toll than the previous five. Levy had trouble getting out of the openings with his rooks connected, either as White or Black and tended to revert into a caterpillar which was never able to metamorphose into a butterfly. Final score: DEEP THOUGHT 4, David Levy 0.

The match was wonderfully sponsored by INFOLINK, the largest independent provider of credit information in the United Kingdom. Professor Michie and GM Raymond Keen ably shared duties as Match Director and Organizers. Bob Wade was the arbiter and 21-year-old GM David Norwood, a history student at Oxford, served as a colorful commentator. “Champagne Norwood” as he became known, took on DEEP THOUGHT in a four-hour game after a night at the Ritz and a bottle of champagne brunch. In only drawing the game, played on Friday, December 15, Norwood lost a bet but it added to proceeds of more than 5000 pounds which went to the Royal Society for the Blind.
In addition to being pleased by the result, the DEEP THOUGHT team of Feng-hsiung Hsu, Thomas Anantharaman, Murray Campbell, Peter Jansen, and Andreas Nowatzyk was $5000 richer.

The Games

Game 1: W: David Levy  B: DEEP THOUGHT—Dutch Defense

This game portends of troubles to follow. Levy delays the strong move h4 forever, delays the developing Ne2 for too long, and weakens his position with 8. f3.


Game 2: DEEP THOUGHT versus David Levy—King’s Indian Defense

This game pretty much summarizes the match as Levy had his best chance to score (a draw) and still came up empty-handed. He obtained a position with a blocked center in which DEEP THOUGHT, despite a bid edge, lost the thread. Levy defended well from a very cramped position, but then erred to allow a big monster pawn to live on f6. This allowed DEEP THOUGHT to announce mate in 12 with 38. Ng4

1. c4 d6  2. Nc3 g6  3. d4 Bg7  4. e4 a6 (This is to get DEEP THOUGHT out of book, but our match plan was to play ...Nd7 with ...c5 or ...e5 to follow) 5. Be3 Nf6  6. Be2 0–0 (I would prefer 6. ...c5, then if 7. dc Qa5 both here and especially on the next move) 7. f4?! (throughout the match DEEP THOUGHT seemed to love to create quartets with its pawns) e6 (much too timid) 8. e5 Ne8  9. Nf3 d5  10. 0–0 Nc7 (ten moves and no pieces beyond the second rank; very discouraging for a second) 11. Rc1 e6  12. Qe1 b5? (too weakening on a wing where White also has more space. I prefer 12. ...dc  13. Bxc4 Nd7 with Nb6 and Nd5 to follow with some activity, but ceding d6 to a WN. Perhaps Black could then sac an exchange on d6 for active minor pieces) 13. cd cd  14. Nd1! Ra7  15. Nf2 Nd7  16. Qa5 (16. Bd2 is very strong) Na8  17. Qa3? (trading Queens followed by Bd2 was strong) Qb6  18. Bd2 a5  19. Qd6 b4  20. Rc6 Qd8  21. Rfc1 Bb7  22. R6c2 Nb6  23. Qxd8 Rxd8  24. Be3 Rc8 (Black appears very close to equality) 25. Rc5 Bf8  26. Bd3! Rd8  27. R5c2 Rc8  28. Rxc8 Bxc8  29. Ng4 Be7  30. Nf6+ Bxf6? (Kg7 was essential) 31. exf6 Rc7  32. Ne5 Rxcl+  33. Bxc1 Bb7 (White’s Ne5 and P/f6 are too strong) 34. a3 Nc7  35. ab ab  36. Bd2 Na4  37. Bxb4 Nxb2  38. Ng4! (DEEP THOUGHT already sees a new queen) e5 (desperation) 39. Nh6+ Kh8  40. Nxf7+ Kg8  41. Nh6+ Kh8  42. f5 1:0

Game 3: David Levy versus DEEP THOUGHT—Dutch Defense

1. d4 f5  2. Bg5 c6!? (a sort of improvement over Game 2 so that now 3...h6  4. Bh4 g5  5. e3 Qb6 is threatened. This is apparently in DEEP THOUGHT’s book. I would not
worry about such “book moves”) 3. c3 h6 4. Bf4 Nf6 5. Nd2 (all according to plans, with Qc2, e3 Bd3 and 0-0-0 to follow) d6 6. e4! (if fe 7. Nxe4 Nxe4 8. Qh5+ and 9. Qf5++; this way Levy’s sharpest move in the match and the spectators were now quite pleased that he might play a convincing game; DEEP THOUGHT was consuming plenty of time now) 6...g5 7. e5 Nh7! (a move which we all overlooked, including David, but I wouldn’t worry about it) 8. Nc4? (but our optimism had to be brief; I think that with 8. Qh5+ and 9. Nh3 (Norwood’s suggestion) White gets plenty of long range compensation for the piece; I’m sure that Kasparov would agree with me. What’s more, if White can’t play such positions, then what fun is left in chess? Instead White moves his only developed piece twice and the attack quickly peters out) 8...gxf4 9. Qh5+ Kd7 10. Qxf5+ Kc7 11. Qxf4 Be6 12. Nf3 Rg8 13. Ne3 Ng5 14. ed+ (better 14. Nd2 and 15. h4) ed 15. d5 Bxd5 16. Nxd5 cxd5 17. Nd4 Qe7+ 18. Be2 Nc6 19. Nb5+ Kb8 20. h4 Ne6 21. Qf3 Ne5 22. Qxd5 Nf4 0:1

Game 4: White: DEEP THOUGHT/Black: David Levy Sicilian Defense
(By Transposition)

1. c4 d6 2. Nc3 Nd7 3. d4 g6 4. Nf3 Bg7 5. e4 c5 6. Be2 cxd4 (finally David gets an opening along the lines we had planned and can transpose into a Dragon type position. Unfortunately, it is not a good Dragon. David’s idea was to put pressure on the P/e4 from c5 and hope that DEEP THOUGHT would not handle such positions well). 7. Nxd4 Ng6 8. Be3 0-0 9. 0-0 a6 10. f3 (Surprisingly DEEP THOUGHT solidifies its center before taking any further action) Re8 (The beginning of passive ways) 11. Qd2 Ne5 12. h3 Be7 13. f4 Nc6 14. Nf3 Qa5 15. a3 Rad8 16. b4 Qc7 17. Rac1 b6 18. Bd3 Qb7 19. Qf2 Rb8? (Again too passive. 19...b5 is indicated) 20. e5 Nh5 21. b5 axb5 22. cxb5 Nd8 23. g4 (White wins a piece) Bh8 24. gxh5 Bxh3 25. hxg6 hxg6 26. Rfd1 Qd7 27. Ng5 Bg4 28. Qh4Bg7 29. Rd2 Bh5 30. Nd5 Qa7 31. Rc7 Rb7 32. exd6 exd6 33. Rc8 Qxa3 34. Ne4! An overwhelming centralization which forces resignation (1:0)

THE FUTURE

Kasparov believes that he can “save mankind” for at least five years and probably ten. The pervading question which remains is “How much of Kasparov’s overwhelming success against DEEP THOUGHT was based on his preparation for the match and how much was based on pure ability or technique?” Kasparov believes that as computers become more of a threat to humans in the game of chess, so will humans learn new ways to exploit their weaknesses. This author agrees, but believes that the number of years where we will be dominant are limited.

Nonetheless, as the IBM team of Hsu, Campbell et al. prepares its improved, parallel, microchip, next generation DEEP THOUGHT to search over one billion nodes per second, it is very likely that the world of chess between man and computer will experience a new phenomenon. That phenomenon is namely that although, in the relatively near future, a computer program may be developed which can defeat the human World Champion in a match, it is almost certain that there will be a space (of positions) in chess which top humans will clearly understand better than the top program. Such positions will most likely be strategic in nature and will help distinguish the difference between achievements in performance versus achievements in competence [24]. In fairness, this may not seem like an
especially unique circumstance, in that there are some positions which any world chess champion does not play as well as some other grandmaster due to stylistic differences. The difference here is that this is likely to be a fairly large space which is knowledge-based, subtle and strategically oriented. In other words, although there may be a computer program which is world chess champion, this could be a unique time when humans can learn from programs and vice-versa. In the meantime there will be some very exciting battles ahead of us.

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REFERENCES

DANNY KOPEC

1990.

25.
First Computer Senior Master, ICAC 7, 11(7/3), 125-126 (June/September 1989).

24.
H. H. Beringer, "HITCHEC AGAIN Wins Pennsylvania Chess Championship: Becomes
Ship's Chess Life, 17-24 (September 1989).

23.
C. Kopce, "DEEP THOUGHT Outsearches Foes, Wins World Computer Champion-

22.
H. H. Beringer and C. Belting, "Pattern Knowledge and Search: The SUPREM Archi-
1987.

21.
H. H. Beringer, "Some Innovations by Hittech, ICAC 7, 10(3), 111-117 (September
Dubuque, IA, 1985.

20.

19.

18.
K. Thompson and J. Condon, in Belle Chess Hardware: Advances in Computer Chess
Ford University, Palo Alto, March 1988, pp. 60-61.

17.
K. Kopce, B. Libby, and C. Cook, "The Endgame King, Rook and Bishop vs. King
Endgame, ICAC 7, 10(3), 3-13 (March 1987).

16.
D. Nible and I. Bristow, "Ideas on Knowledge Synthesis Steaming from the KBKKN
(September 1986).

15.
K. Thompson, "Knowledge Analy sis of Certain Endgames," ICAC 7, 9(3), 131-139

14.
D. Kopce and I. Nible, "How Hard is the Play of the Kings-Rock-King-Knight End-

13.
T. Stoehlein, "Uberendungsueber kombinatorische Spiele, Dissertation, Fachhul