The Meaning of Computers and Chess

By Philip Ross

What Deep Junior, Deep Blue, and Garry Kasparov teach us about intelligence, human and artificial

1 March 2003—Garry Kasparov's US $1 million, six-game match in New York City last month against Deep Junior, the Israeli chess program, added yet another case to an evolving pattern: all such competitions in the past two years have been draws. Last year, Vladimir Kramnik, second on the international chess rating list, just below Kasparov, split a match with the German program Deep Fritz; then, just before the New York match, Evgeny Bareev, ranked eighth, did the same with the British program HiarcsX.

What does this pattern say about the 50-year quest for excellence in computer chess? That software is improving, that human players have still not learned to tune their play against it, and that either computers can think or chess does not involve thinking. From the purely subjective point of view—the only point of view by which intelligence can be judged, say many—the machines seem not merely sentient, but even to have a personality. The only way to tell man from machine is by man’s penchant for blunders.

In the match with Deep Junior, Kasparov was at least playing with a known entity, one that can in fact be purchased on the open market (although tweaks had been made in it before the match). That familiarity gave him a fairer chance than he’d had in 1997, when he played a version of the IBM-built machine, Deep Blue, that was fundamentally different from any that had played in public.

In the deep

What goes on under the hood of these machines remains partly veiled from the onlooker. IBM, which set the standard here, never published details about Deep Blue’s algorithms, which were largely hard-wired in a dedicated machine. The company went so far as to decommission its marvel after the match, making it impossible for anyone to see how it ticked. Kasparov seized on all the secrecy to support his accusation that IBM had cheated during the match by having some human player intervene at a critical point. Only a human master, he said, could have planned the rather involved maneuver in question—the slow preparation of an exchange of pawns.

In prepping for Deep Blue, Kasparov had noted that computers all tended to exchange pawns automatically in order to open a file (a clear path vertically on the board) for their
rooks. This tendency, also seen in humans of intermediate standing, came from assigning a positive value to a rook placed along an open file, where its mobility is enhanced. The problem is, your opponent can often feed his rooks onto the file just as fast as you can, inducing an exchange of men that prevents you from gaining an advantage. IBM got around this problem by clever programming, according to a recent account by Feng-hsiung Hsu, a key designer of Deep Blue.

In his book, Behind Deep Blue: Building the Computer that Defeated the World Chess Champion [http://pup.princeton.edu/titles/7342.html], Hsu (who left IBM in 1999) says that Grandmaster Joel Benjamin, a consultant to IBM, suggested assigning a certain value to files that were not open, but merely potentially open. That way, the computer would tend to place its rooks along the future file and thus be in a better position to dominate it when it did open. The result, to Kasparov's eyes, was a deeply conceived, strategic plan. Of course, the computer didn't have such a plan, any more than bees plan to build a perfect hexagonal cell out of wax. They do so by following a very simple algorithm:

if-this-then-that.

The original chess-playing algorithm, proposed more than 50 years ago by Claude Shannon, the electrical engineer who founded information theory, begins with the search function, which generates all possible move sequences to a certain depth, set by the computer's speed and memory. Then each end position is graded, numerically, by an evaluation function that assigns value to such aspects of chess knowledge as material (pawn = 1 point, knight = 3 points, rook = 5 points, queen = 9 points), king safety (good), piece mobility (good), doubled pawns (bad, usually), and so forth. The computer then selects the move that, given the perfect play by the opponent, leads to the position having the highest score.

The central engineering tradeoff is between search speed and the amount of chess knowledge encoded in the machine. With unlimited powers of search, a machine could play perfectly with a primitive evaluation function that merely distinguished two states: checkmate and draw. On the other hand, with godlike powers of evaluation, it could play perfectly with a search function that could not look even a single move ahead.

In practice, computers emphasize search because they do it so well. Kenneth Thompson, a pioneer of Unix and a major force in chess computing, showed in 1982 that adding a single half-move in search depth—roughly equivalent to a 10-fold speedup in hardware—increases playing strength by about 200 points on the rating scale (Kasparov's rating is 2850). The streamlining of search algorithms, organized to eliminate redundant lines of play, has allowed programmers to wring one extra half-move out of a mere five-fold speedup in hardware—the fruit of three or four years' chip-design improvements.

Junior's triumph
Deep Junior seems to have played about as well as Deep Blue, although its hardware was perhaps only 1 or 2 percent as powerful. Blue had 480 processors, each specialized totally for the generation and evaluation of chess positions; Junior had up to eight general-purpose Pentium 4 processors with up to 8 GB of RAM. Processor performance has improved enormously in the intervening years, but not enough to account for Deep Junior's matching Deep Blue's performance.

Rather, it is improved chess-playing software that mainly explains Deep Junior's success, in part because programmers, working with grandmaster advisers, have learned how to encode many aspects of chess knowledge that had previously been unmanageable. Deep Junior's handlers could not hope to match Deep Blue's search capabilities, so they concentrated on tweaking Deep Junior's evaluation function. "We have a much more stable algorithm that compensates for Deep Blue's brute force; one can say that DJ 'understands' chess much better," says Boris Alterman, an Israeli grandmaster who advised the Deep Junior team and who described his work in a question-and-answer session on the Internet Chess Club [http://www.chessclub.com]
Particularly striking was the program's very uncomputer-like willingness to sacrifice material—a piece, say, for such intangibles as freedom of movement or an attack on the opponent's king. In the fifth game of the match, the machine sacrificed a bishop for just such an attack, a very well-known maneuver that in this case seemed bad because the machine lacked immediate reinforcements. The machine could not calculate the game all the way out to the end; it merely preferred the attack to the material. Its judgment proved good—Kasparov could get no more than a draw.

(Though striking examples of computer-like play were not apparent in this match, that was partly a matter of chance. There are a number of positions, particularly in endgames, that cannot be calculated precisely, that computers misjudge horribly in ways no human beginner ever would. [For examples, see this page: http://www.worldchessrating.com/521772350.html?905145836528391].)

Thinking machines

If Garry Kasparov can consider it simply amazing that a machine, operating on simple algorithms, could slowly and methodically prepare a strategic assault on his position, then this is evidence that human-like behavior can be modeled.

Such progress must give hope to workers in artificial intelligence who have, so far, been unable to get their machines to pass a full-bore Turing Test. The test is the gold standard for AI, set by the British mathematician Alan Turing, who famously proposed that any computer whose conversation could not be distinguished from a human being's must be deemed intelligent. But the recognition of faces, the sensing of emotional states in others, the proper delivery when telling a joke—all things that now seem quintessentially human—may yet yield to a concerted programming attack.

Such, of course, has been the rationale for chess programming. Shannon’s proposal of a chess machine was explicitly made with an eye to artificial intelligence, as was the roughly concurrent effort by Turing, whose computer-designing skills helped crack the German naval code during World War II. Shannon, in an article published shortly after the war, argued that chess was the ideal grand challenge for AI because it was easy enough to specify and hard enough to pose a challenge. The latter point was important, because a perfect tic-tac-toe machine would show its inner workings all too clearly to the observer.

Interestingly, chess has, in the same period, emerged as a major test bed for cognitive psychology, in part for the same reasons. Moreover, for the psychologist, chess is interesting because skill in it varies greatly and measurably, is acquired over a long period of time, and correlates—or fails to correlate—with other, interesting traits. Unintelligent people have sometimes become quite good at chess, and, while no one has yet identified a top grandmaster who was stupid, some have clearly been unimpressive away from the chessboard.

Even so, in his book, Genius in Chess (Batsford, London: 1997), Jonathan Levitt, an English grandmaster, has cranked out a formula that equates maximum potential chess rating to 10 times a person’s IQ plus 1000. That system would suggest an IQ of about 185 for Garry Kasparov (top rating: 2850), of 121 to this writer (top rating: 2210), and a dismal 75 to the average adult who plays in rated chess tournaments (average rating: 1750).

Chess has been called the "Drosophila of cognitive psychology"—a nod to the role the fruit fly has played in genetics and a modernization of Goethe’s more poetic comparison: "Chess is the touchstone of the intellect." Yet the more we see computers play chess, the less exalted our own intellectual abilities appear.

For an analysis of a crucial situation in the third game, which Deep Junior exploited to best Kasparov, go to http://www.spectrum.ieee.org/spectrum/mar03/departments/nsili.html.