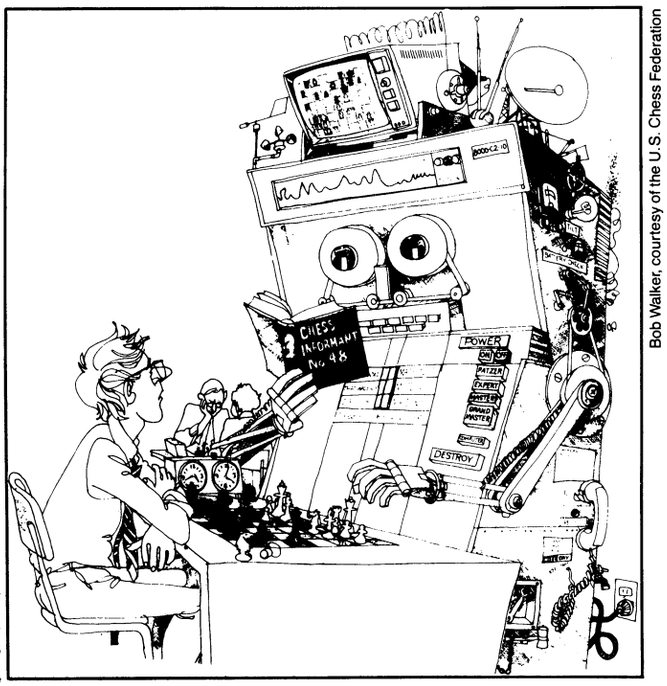
Playing Chess Bit by Bit

This month's world computer chess tournament will show how much chess-playing computers have improved their level of play



Bob Walker, courtesy of the U.S. Chess Federation

By IVARS PETERSON

Belle is playing better than ever. The chess-playing computer's circuits and chips were recently refurbished in the hope of halting a decline in Belle's chess rating. Since then, the computer has reestablished its position as one of the world's best chess players.

Two months ago, at the U.S. Open chess tournament in Los Angeles, Belle scored well enough in games against human players to raise its rating to the master level, just one step below grandmaster. This is the highest level that a computer chess program or a machine specially built to play chess has ever achieved.

Later this month, Belle will defend the title it won three years ago at the World Computer Chess Tournament in Linz, Austria. Twenty-two teams from eight countries will meet in New York to compete in this year's championship. Belle will face tough competition from programs like NUCHESS and CRAY BLITZ. One missing entry will be the Soviet Union's KAISSA, victorious in the first world tournament held in 1974 but now sadly outdated.

Observers expect a high level of play this year. Like superb racing cars, each of the chess programs has been fine-tuned to run as fast as possible. Some programs are designed to take advantage of special features built into the world's fastest computers. Several, like Belle, are high-speed machines in which chess instructions are wired into circuits or etched onto chips. Many now have extensive libraries of standard opening moves and other aids for saving time. Programmers have also tried to incorporate increasingly sophisticated chess knowledge to help computers make better decisions.

Ken Thompson of Bell Laboratories in Murray Hill, N.J., the creative force behind Belle, says, "I think speed is still most important, but [speed and chess knowledge] go hand in hand. The faster machines also can handle chess knowledge better." Yet the chess skills built into a program are generally very simple concepts that any amateur player would know. These concepts combined with speed, however, create computers that play chess better than their human programmers.

Thompson says, "I play chess, pit myself against the computer, as a barometer of where I am." He adds, "One gets a fresh point of view. They [the computers] are always original. They're not enslaved by what's been done in the past."

Just a few months ago, Belle was making embarrassing mistakes in its play. People were beginning to learn how Belle reasons and started exploiting its quirks. Belle's fumble-fingered play finally induced Thompson to delve into his machine's hardware to find the glitches in the circuitry. During a microscopic examination of the computer's circuit chips, he found tiny flaws that had "great global consequences," which affected the machine's chess ability. These problems are now fixed, but Belle still has some weaknesses. "It's willing to give up too much for a pawn," says Thompson.

NUCHESS, a computer program written in a modified version of the computer language FORTRAN, recently made the move to a new host, a CRAY 1 computer at the Los Alamos National Laboratory in New Mexico. For many computer chess enthusiasts, the CRAY 1, one of the world's fastest computers, is the ideal chess machine. Among several advantages, its "words" consist of 64-bit strings of 1s and 0s, coincidentally equal to the number of squares on a chessboard.

Dave Slate of Northwestern University in Evanston, Ill., is NUCHESS's principal caretaker. He is busy adapting NUCHESS to take advantage of the CRAY's special features in time for the world championship. Slate refers to his program as "a patchwork quilt" of ideas. He is pessimistic about its chances in the tournament. "NUCHESS may finish no better than somewhere in the upper half," says Slate.

Slate is much more enthusiastic about a new version of NUCHESS that he is developing specifically for the CRAY. He regrets it will not be ready in time for the competition. One of the features he is hoping to build into the program is an ability to learn from mistakes, especially while playing speed chess with severe time limits on moves. Although the scheme will be somewhat crude, Slate says, it should be effective enough for the program to learn a variety of simple opening traps. "All you have to do is spring a trap on the program once, and the next time it will not fall into the trap [although it could still fall into it in a more roundabout way]," Slate says.

Bob Hyatt's CRAY BLITZ, a program specifically tailored to the CRAY from the beginning, has been undergoing a rigorous training schedule for months. Last year, computer scientist Hyatt, based at the University of Southern Mississippi in Hattiesburg, worked with Harry Nelson of the Lawrence Livermore Laboratory in Livermore, Calif., to eliminate "hot spots" where the program was spending too much time. Now the program runs about five times faster than ever before. This gives it time to do more complicated analyses of the play. As a result, the program also plays more intelligently, says Hyatt.

Hyatt gives an example: "Most computer programs don't recognize the difference between a 'good' and a 'bad' bishop. In the game of chess, a 'good' bishop is one whose movements are not impeded by its own pawns. A 'bad' bishop is one that is restricted in the moves it can make be-

cause its own pawns are on the same color square it is, thus blocking it. If the program can recognize this situation, it can either avoid or correct it. Until now, CRAY BLITZ couldn't do that. By adding a simple check to determine the potential for this situation, problems can now be avoided."

Fundamentally, all the chess programs and machines are alike in that they depend largely on a systematic, exhaustive search. A computer looks ahead from its current position along a branching tree of possibilities. The program assigns a value to the end of each branch according to its strategic strength or weakness. These values are then compared, and the computer finally decides how to move. Various pruning tricks shorten the process so that not all the possibilities have to be examined. Belle, for example, looks at about 100,000 positions per second or perhaps 30 million possibilities in a tree. This allows it to look forward about four moves.

The weakness of such a scheme is that the program is oblivious to all events that may occur beyond its "lookahead horizon." A human observer, for instance, may see that the computer is in such a bad position that it will inevitably lose. The computer, however, will foolishly sacrifice pieces to delay a loss it cannot avert. The computer may also forfeit an eventual large gain in favor of small immediate advantages. This makes computer chess play seem "materialistic."

A chess computer's speed and patience generally make up for its limitations. What makes a computer chess tournament exciting is that individual chess programs reflect the styles of their programmers. "They're very different," says Slate. "They depend on the individual programmer's concepts of what's going on, what he's comfortable with and what it's feasible to work with." Slate adds, "Part of the problem is that you're dealing with an enormous programming task. A lot of the things you have to do are only peripherally related to chess."

Monroe Newborn of McGill University in Montreal, organizer of the world tournament, comments, "I think people are finding that a computer is an exciting tool and want to compete with this tool. Chess is about as good a ground on which to compete as anything." He says, "In the long run, the game is going to be to program the computers." Newborn himself is entering a chess program that runs on eight Data General computers tied together, where each computer shares in the search.

"Belle," world computer chess champion, and developers Joseph London (left) and Kenneth Thompson.

AT&T Bell Laboratories

Chess programs also turn out to be ideal testing boards for checking out new programming concepts that may eventually prove useful in other applications. One scientist has said chess programs have the same role in developing machine intelligence that fruit flies have in genetic research.

Hans Berliner of Carnegie-Mellon University in Pittsburgh, former world correspondence chess champion, is working on one promising idea: "chunking." Instead of looking at moves by individual pieces, Berliner's program treats logically related groups of pieces as units. CHUNKER, as the program is called, then reasons about positions that involve these units as they come up during a search. It relies extensively on a large library that lists each chunk type and its properties. As a result, CHUNKER can perform certain kinds of searches very quickly. An analysis that may take weeks of computer time to perform using a standard method takes only minutes using CHUNKER.

To Berliner, the chunking concept comes closer to the way people think about and play chess than the brute search methods generally used in computer chess programs. So far, CHUNKER has been applied to a thorough study of a chess "end game" in which both players are left with a king and three pawns each. Murray Campbell, the graduate student who worked on CHUNKER, says, "It has found errors in positions that have been studied for over 300 years by human masters, and it regularly beats its authors from both sides of positions," playing either white or black.

Berliner proudly says, "Within its domain, CHUNKER is an expert, playing the positions with a speed and accuracy that no present human or machine can come close to matching."

Berliner is fascinated by games that humans play against chess computers. They offer more surprises than games in which computers play computers, he says. "Every computer is basically using the same algorithm. The ones that can search deeper almost always win against the ones that don't search as deeply," Berliner says. "But while searching a little deeper is a great advantage against another program, it may not be much of an advantage against a human being."

At the recent National Conference on Artificial Intelligence held in Washington, D.C., Berliner organized a tournament that featured Belle, NUCHESS and four human players on each of three nights. Each night, two games pitted a computer against a human being, while the other game pitted two human players against each other. The identities of the players were hidden from one another and from the audience who watched the games on giant boards set up in a meeting room. The fun was in trying to guess which players were human and which were computers.

Belle won all three of its games, although in the third game it was in a tough battle until its human opponent ran out of time and, in his rush, started to make careless mistakes. NUCHESS, just barely running on the CRAY (adjustments were being made every evening), managed to win one, draw one and lose one. Surprisingly, most of the players did not correctly identify whether or not their opponents were computers. The audience did better because it had the advantage of seeing all three games at once.

Newborn says, "Certain characteristics of the game sometimes give away a computer." For example, a chess computer may make an obviously stupid move—like shifting the king one square left or right on the back row. "It'll do that about every third game for almost no reason whatsoever," says Newborn, "if it can't find anything better to do."

Slate says the better chess programs tend to be relatively resilient. "They don't get tired. They'll sit there keeping you bashing away," he says. The computer is "like a shark swimming around. It's not very bright, but once it gets a taste of blood, it's right there and goes munch, munch, crunch." A player can build up a nice attack disguised behind layers of pawns, and the computer may not suspect what's about to happen. "But if you allow any slight chink in the armor, then you suddenly find this thing coming after you," Slate says, "and all your nicely laid plans go astray."

Chess computers seem to drag their opponents into bizarre situations. "It makes for interesting chess," says Slate. "We are learning about the nature of chess and gaining insight into the way humans approach chess. We learn something about the weaknesses, foibles and even strengths of human chess play just by forcing humans to contest an organism that plays chess in a rather different way than they do."

Even when computers play computers, Slate says, "anything can happen on a given day. People don't realize that."

For the upcoming world computer chess tournament, Newborn notes, "Belle is favored, but not by much. It's going to be close—Belle, followed by NUCHESS, CRAY BLITZ and some of the microcomputers. It's a tough bunch." □