Computer Chess: Belle Sweeps the Board

The next challenge is to win a $100,000 prize that has been offered for the first program to beat the human world chess champion

Bobby Fischer inspired a lot of people to take up chess in his heyday. One person who caught the chess bug, Ken Thompson, a Bell Laboratories computer researcher, has now won a world chess championship of a different sort. Last month, in Linz, Austria, Thompson and a Bell Labs colleague, Joe Condon, saw their entry, a program named Belle, win the world championship in computer chess.

This year's world championship, the third since 1974, was staged during a week-long "electronic arts festival" in Linz, an industrial city on the banks of the Danube. In earlier tournaments the ineptness of some programs drew vigorous catcalls and boos from vocal audiences. Nowadays the machines are much more capable, but the atmosphere is as noisy as ever. In the carnival air at Linz, the city fathers arranged for a chess grand master from Germany to provide a running commentary on the progress of the matches. Outside the concert hall, there were aisles filled with manufacturers' booths exhibiting the latest in commercial computer chess games, including some that talked in the language of your choice.

The 18 contestants in the match came from the United States, Canada, and Europe, including the Soviet Union. As customary, tournament organizers chose the Swiss pairing method of matching contestants, in which strong programs tend to meet only towards the end of the four rounds of competition. Thompson says he felt an uncomfortable sense of anxiety as the tournament opened because pre-competition speculation had tabbed Belle as the likely winner. "When you're the favorite, you can do no better than what is expected, and if you lose, it's disastrous," he said.

Belle has not always been the favorite. The program first rose to prominence with an upset win in the 1978 North American championships over the then-reigning world champ, Chess 4.6, which was written by researchers at Northwestern University. Last October, an upgraded Chess 4.7 regained the North American title in a tournament at Detroit.

The two programs are the leading adherents to the school of thought that says that the best way to program computers to play chess is not to try to build in a detailed knowledge of the subtleties of the game that humans acquire with years of experience (*Science*, 29 June 1979, p. 1396). What computers are good at is high-speed computation, and, so the reasoning goes, the machines should be instructed to search every conceivable move as far into the future as possible. Programs implementing such so-called brute force strategies have dominated computer chess tournaments since 1973 when David Slate and Larry Adkin of Northwestern turned away from the previously popular selective search approach. In selective search, a somewhat more sophisticated knowledge of chess enables a program to concentrate its attention on a smaller number of plausible moves. Human chess masters are said to be the most selective of all in their search, focusing on only a very few options on the basis of patterns of positions of pieces recognized from previous encounters.

As it happened, Slate and Adkin had broken up and each entered separate programs (Nuchess and Chess 4.9) at Linz. Chess 4.9 lost to an upstart Canadian entry in the first round and never recovered the lost ground. Nuchess and Belle fought to a draw in the second round in what Thompson called the best match of the tournament, but Slate's program later lost to another competitor. In the third round, Belle dispatched the Canadian program (l'Excentrique from McGill University). After the four rounds, Belle and a selective search program called Chaos from the University of Michigan were tied with $3\frac{1}{2}$ points apiece. (Chaos had been drawn by l'Excentrique.) In a play-off to break the tie, Chaos suffered some early losses of pawns and Belle raced to a quick win, thereby capturing the world title.

One of the factors that made Belle such a formidable chess player was that Thompson and Condon did not simply write a brute force chess program to run on a powerful, but standard, computer. The team put considerable effort into developing special purpose chess "hardware" whose only function was to execute certain parts of the program as rapidly as possible. By arranging things so that these hardware modules worked largely in parallel rather than serially, Thompson and Condon further enhanced the speed of execution. Belle could examine nearly 30 million positions in the three minutes allowed by tournament rules before a move had to be made. Belle may more properly be called a chess machine than a chess program.

One element limiting the progress of computer chess is that it is not a recognized field of research of the type that federal agencies can support openly. Improvements therefore tend to come only as fast as researchers can steal time to make them. Thompson, for example, is not paid by Bell Labs to write chess programs, although as a member of a computer theory group he is not rigidly prohibited from working in the area. Nonetheless, computer chess programs have now advanced to the stage where the best of them can beat some 99.5 percent of human players.

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Recently, a rather substantial prize has been instituted, and computer chess watchers hope it will focus effort in the field. The Fredkin Prize of $100,000 is to be awarded to the author of the first computer chess program to win the world chess championship, as certified by the International Chess Federation (FIDE). Anatoly Karpov of the Soviet Union is the current titleholder.

The prize has its origin in a rather fortuitous set of circumstances. Edward Fredkin, an inventor and MIT professor, had in his earlier years established a

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company that was successful enough to, as he put it, "make a little money." Inspired by the Kremer Prize, a £50,000 award put up by British industrialist Henry Kremer for the first person to fly an aircraft under his own power around a figure eight–shaped course (the prize was claimed in 1977), Fredkin had for several years been trying to interest some institution in a similar offer for a championship computer chess program, but without success.

Fredkin told *Science* that he thinks "prizes are a wonderful thing and there should be more of them." He cited the prize that got Lindbergh to fly across the Atlantic as an example of the positive impact that prizes can have. His interest in computer chess comes from the widely accepted assertion that computer chess is a kind of benchmark for progress in artificial intelligence research.

In times past, however, the connection between brute force searching, the method used by almost all the top chess-playing programs, and intelligence has been questioned. Years ago it was thought that a chess-playing computer would have to emulate human chess masters to qualify as intelligent. Some artificial intelligence researchers are now taking a less anthropocentric view. With the rise to dominance of brute force chess programs such as Belle, investigators have accepted the concept of a knowledge-search continuum within which computers can compensate for a lack of chess knowledge by an ability to do more searching. Fredkin puts it more bluntly. "Intelligence is having a problem and solving it," he says.

The other half of the prize story is that artificial intelligence researchers were themselves considering the establishment of several prizes for the solution of certain problems, including computer chess, whose solutions would be recognized as major advances in the still young field. According to Raj Reddy of Carnegie-Mellon University, people have yet to reach a consensus on what things when achieved would truly represent progress in artificial intelligence. One approach that leading investigators have discussed is to devise a set of problems in the spirit of the Hilbert problems in mathematics that, if solved, would be recognized as such advances. Prizes would be offered for solutions to the problems as a way to direct the attention of artificial intelligence researchers to the selected areas. When Reddy announced last year at a Tokyo meeting of the International Joint Council on Artificial Intelligence that an awards committee had been formed and foundations would be approached as sponsors, a marriage between Fredkin, who had the money, and the research community, which could administer the details, was made for the establishment of a chess prize. (There is a second large prize. Volmac, a Dutch computer software company, last year offered $50,000 to anyone who can write a chess program to defeat former world champion and international grand master Max Euwe of the Netherlands by 1 January 1984.)

The interest accrued on the prize money is being used to sponsor competition between the best computer programs and comparable human players, according to Hans Berliner of Carnegie-Mellon, who is chairman of the committee administering the Fredkin Prize. For example, Chess 4.9 and Belle, the two highest scoring entries in the most recent North American championships, are being paired with humans in the expert category. The winner of each match is to receive $1500. In fact, the first match has already been held at Stanford University last August. Chess 4.9 met Paul Benjamin, a New York City chess player. Each side won one game and thereby half the prize money. Belle is scheduled to play its match next month.

Berliner's expectation is that each year, the ratings of the human opponents will rise as the programs get better. Eventually, it is hoped, FIDE will admit a computer chess team to the international championships. At that point, it is up to the chess program to survive as best it can and perhaps one day fight its way all the way to world chess championship. Fredkin hopes this process will take about 10 years ("a good prize should last about 10 years but not much longer"), but most computer chess watchers are prepared for a much longer wait.—ARTHUR L. ROBINSON

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Prizes That Predict Nobel Winners

Mid-October is the date of that riveting annual sweepstake, the Nobel prize awards. Jimmy the Greek does not give odds, but others who follow the competition, particularly those who hand out lesser awards, like to think that they can pick the winners. Thus when Columbia University awarded its Louisa Gross Horwitz prize on 1 October, a university press release noted, "Of the 22 scientists who have won the award since it was first given in 1967, eight have subsequently won the Nobel Prize."

The Horwitz prize ($22,000) is given each year for outstanding research in biology or biochemistry. This year's winner is César Milstein, an Argentine-born molecular biologist employed by the Medical Research Council at Cambridge University, England. Along with his associate Georges Kohler, Milstein is credited with developing a method, known as the hybridoma technique, for producing monoclonal or pure antibodies.

The chairman of the committee that selected Milstein, I. Bernard Weinstein of Columbia's Cancer Research Center, said Milstein's work on hybridomas has "really revolutionized the whole field of immunology." Milstein's discovery, first announced in 1975, has made it possible to produce nearly unlimited quantities of specific mouse antibodies in the laboratory. The new technique thus offers a quantitative as well as a qualitative improvement. The hope is that this technique will make it possible to develop new means of attacking autoimmune diseases and some types of cancer.

Weinstein added that "we have had a pretty good track record" in choosing future Nobel winners; he expected Milstein would one day be among them. He also mentioned that in September Milstein had received another award with a short but impressive history, the Wolf Foundation prize. The Wolf Foundation was created in 1975 by a wealthy Israeli—Ricardo Lobo Wolf—who put up $10 million as an initial endowment. He clearly meant it to be a complement or competitor for the Nobel Foundation.

The Wolf prize of $100,000 has been given annually since 1978 in

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