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Game Playing

I HAVE ALREADY MENTIONED ATTEMPTS TO PROGRAM COMPUTERS TO PLAY BOARD games, such as chess and checkers. The most successful of these was Arthur Samuel's checker-playing program. In 1967, Samuel published a paper describing an improved version of his program.[1] He had refined the program's search procedure and incorporated better "book-learning" capabilities, and instead of calculating the estimated value of a position by adding up weighted feature values, he used hierarchically organized tables. According to Richard Sutton, "This version learned to play much better than the 1959 program, though still not at a master level."[2]

Between 1959 and 1962, a group of MIT students, advised by John McCarthy, developed a chess-playing program. It was based on earlier programs for the IBM 704 written by McCarthy. One of the group members, Alan Kotok (1941–2006) described the program in his MIT bachelor's thesis.[3] The program was written in a combination of FORTRAN and machine (assembly) code and ran on the IBM 7090 computer at MIT. It used the alpha–beta procedure (as discussed earlier) to avoid generating branches of the search tree that could be eliminated without altering the final result. Kotok claimed that his program did not complete any games but "played four long game fragments in which it played chess comparable to an amateur with about 100 games experience.... Most of the machine's moves are neither brilliant nor stupid. It must be admitted that it occasionally blunders."[4] When McCarthy moved to Stanford, he took the program along with him and continued to work on it.

In the meantime, a computer chess program was being developed by Georgi Adelson-Velskiy and colleagues in Alexander Kronrod's laboratory at the Institute for Theoretical and Experimental Physics (ITEP) in Moscow.[5] During a visit to the Soviet Union in 1965, McCarthy accepted a challenge to have the Kotok–McCarthy program play the Soviet program. Beginning on November 22, 1967, and continuing for about nine months, the Kotok–McCarthy program (running on a DEC PDP-6 at Stanford) played the Russian program (running on the Russian M-20 computer at ITEP) – the first match to be played by a computer against a computer. In each of the first two games, the Stanford program eked out a draw (by surviving until the agreed-upon limit of 40 moves) against a weak version of the Russian program. However, it lost the last two games against a stronger version of the ITEP program. McCarthy later claimed that, although Stanford had the better computer, ITEP had the better programs.[6] The ITEP program was the forerunner of the much improved Kaissa program developed later by Misha Donskoy, Vladimir Arlazarov, and Alexander Ushkov at the Institute of Control Science in Moscow.

Richard Greenblatt, an expert programmer at the AI Lab at MIT, thought he could improve on Kotok's chess program. His work on computer chess eventually led to a program he called MAC HACK VI.[7] Being an expert chess player himself, he was able to incorporate a number of excellent heuristics for choosing moves and for evaluating moves in his program. Running on the AI Lab's DEC PDP-6 and written in efficient machine code, MAC HACK VI was the first program to play in tournaments against human chess players. In an April 1967 tournament, it won two games and drew two, achieving a rating of 1450 on the U.S. Chess Federation rating scale, about the level of an amateur human player. (According to the international rating system for human chess players, the highest level is that of Grand Masters. Then come International Masters, National Masters, Experts, Class A, Class B, and so on. MAC HACK VI played at the high Class C to low Class B level, which is still quite far from master play.) It became an honorary member of the U.S. Chess Federation and of the Massachusetts Chess Association. In a famous match at MIT in 1967,[8] Greenblatt's program beat Hubert Dreyfus (1929–), an AI critic who had earlier observed that "no chess program could play even amateur chess."[9] Although Dreyfus's observation was probably true in 1965, Greenblatt's MAC HACK VI was playing at the amateur level two years later.

Perhaps encouraged by MAC HACK's ability, in 1968 Donald Michie and John McCarthy made a bet of £250 each with David Levy (1945–), a Scottish International Master, that a computer would be able to beat him within ten years. (The following year Seymour Papert joined in, and in 1971 Ed Kozdrowicki of the University of California at Davis did also, bringing the total bet to £1000. In 1974, Donald Michie raised the total to £1250.) In 1978, Levy collected on his bet – as we shall see later.[10]

Around 1970, three students at Northwestern University in Illinois, David Slate, Larry Atkin, and Keith Gorlen, began writing a series of chess programs. The first of these, CHESS 3.0, running on a CDC 6400 computer, won the first Association for Computing Machinery's computer chess tournament (computers against computers) in New York in 1970. There were six entries – MAC HACK VI not among them. According to David Levy, "CHESS 3.0 evaluated approximately 100 positions per second and played at the 1400 level on the U.S. Chess Federation rating scale." Subsequent Northwestern programs, up through CHESS 4.6, achieved strings of wins at this annual event. Meanwhile, however, CHESS 4.2 was beaten in an early round of the first World Computer Chess Championship tournament held at the International Federation of Information Processing Societies (IFIPS) meeting in Stockholm in 1974. The Russian program, Kaissa, won all four games in that tournament, thereby becoming the world computer chess champion.[11]

These years, the late 1960s through the mid-1970s, saw computer chess programs gradually improving from beginner-level play to middle-level play. Work on computer chess during the next two decades would ultimately achieve expert-level play, as we shall see in a subsequent chapter. Despite this rapid progress, it was already becoming apparent that there was a great difference between how computers played chess and how humans played chess. As Hans Berliner, a chess expert and a chess programming expert, put it in an article in *Nature*,[12]

> [A human] uses prodigious amounts of knowledge in the pattern-recognition process [to decide on a good maneuver] and a small amount of calculation to verify the fact that the proposed solution is good in the present instance. . . . However, the computer would make the same maneuver because it found at the end of a very large search that it was the most advantageous way to proceed out of the hundreds of thousands of possibilities it looked at. CHESS 4.6 has to date made several well known maneuvers without having the slightest knowledge of the maneuver, the conditions for its applications, and so on; but only knowing that the end result of the maneuver was good.

Berliner summed up the difference by saying that "The basis of human chess strength, by contrast [with computers], is *accumulated knowledge*" (my italics). Specific knowledge about the problem being solved, as opposed to the use of massive search in solving the problem, came to be a major theme of artificial intelligence research during this period. (Later, however, massive search regained some of its importance.) Perhaps the most influential proponents of the use of knowledge in problem solving were Edward Feigenbaum and his colleagues at Stanford. I'll turn next to their seminal work.

Notes

1. Arthur L. Samuel, "Some Studies in Machine Learning Using the Game of Checkers II – Recent Progress," *IBM Journal of Research and Development*, Vol. 11, No. 6, pp. 601– 617, 1967. [193]
2. http://www.cs.ualberta.ca/~sutton/book/11/node3.html. [193]
3. Alan Kotok, "A Chess Playing Program for the IBM 7090 Computer" MIT bachelor's thesis in Electrical Engineering, June 1962. Online versions of the thesis are available at http://www.kotok.org/AK-Thesis-1962.pdf and http://www.kotok.org/AI_Memo_41.html. (The latter is an MIT memo in which Kotok pointed out that " . . . this report, while written by me, represents joint work of 'the chess group,' which consisted of me, Elwyn R. Berlekamp (for the first year), Michael Lieberman, Charles Niessen, and Robert A. Wagner (for the third year). We are all members of the MIT [undergraduate] Class of 1962.) [193]
4. The Computer History Museum has a video "oral history" of Kotok available at http://www.computerhistory.org/chess/alan_kotok.oral_history_highlight.102645440/index.php?iid=orl-433444ecc827d. [193]
5. G. M. Adelson-Velskiy, V. L. Arlazarov, A. R. Bitman, A. A. Zhivotovskii and A. V. Uskov, "Programming a Computer to Play Chess," *Russian Mathematical Surveys* 25, March–April 1970, pp. 221–262, London: Cleaver-Hume Press. (Translation of *Proceedings of the 1st Summer School on Mathematical Programming*, Vol. 2, pp. 216–252, 1969.) [193]
6. See the oral presentation about the history of computer chess at http://video.google.com/videoplay?docid=-1583888480148765375. [193]
7. Richard D. Greenblatt, Donald E. Eastlake III, and Stephen D. Crocker, "The Greenblatt Chess Program," AI Memo 174, April 1969. Available online at https://dspace.mit.edu/bitstream/1721.1/6176/2/AIM-174.pdf. [194]
8. See an account in the *SIGART Newsletter*, December 1968. [194]
9. Hubert L. Dreyfus, "Alchemy and Artificial Intelligence," RAND paper P-3244, p. 10, The RAND Corporation, Santa Monica, CA, December 1965. Available online at http://www.rand.org/pubs/papers/2006/P3244.pdf. [194]

10. For first-hand details about the bet, see David Levy, *Robots Unlimited: Life in a Virtual Age*, p. 83, Wellesley, MA: A K Peters, Ltd., 2006. [194]
11. See the Computer History Museum's exhibits on the history of computer chess at http://www.computerhistory.org/chess/index.php. For a concise timeline of computer chess history compiled by Bill Wall, visit http://www.geocities.com/SiliconValley/Lab/7378/comphis.htm. [194]
12. Hans J. Berliner, "Computer Chess," *Nature*, Vol. 274, p. 747, August 1978. [194]