CHESS BY COMPUTER

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ABSTRACT

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1. History

Chess playing machines are not solely a product of the computer revolution, but have a long and colourful history. Perhaps best known is Mr. Turk, developed by Baron von Kempelen in the late 19th century, which in various forms and copies toured Europe and America for about one hundred years. Mr. Turk's popularity testifies to the interest in mechanized chess, but it needed a hidden operator to manipulate the controls. On the other hand, a machine built by the Spanish engineer Torres y Quevedo, and displayed at the Paris exhibition of 1914, was a genuine mechanical player for king-and-rook against king endgames. Two interesting books dealing with such historical matters and more recent developments are "The Machine Plays Chess?" and "Chess and Computers" [1,2]. Despite the success of Quevedo's electromechanical device, further advances on chess automata did not come until the 1940s. In that decade, several leading mathematicians and engineers saw the possibility of applying to chess the newly evolving power of the computer: Alan Turing in England, Adrian de Groot in the Netherlands, Tihamer Nemes in Hungary, and Konrad Zuse a German designer of computer hardware, for example. In 1949, Claude Shannon of the Bell Telephone Laboratories (known for his work on Information Theory) presented a landmark paper on computer chess [3]. That paper had great influence on chess programmers and, even after the developments of the intervening years, is still worth reading.

By the mid 1960s the science of computer programming was sufficiently advanced to allow John McCarthy (formerly of MIT) to arrange a series of telephone chess matches with a program developed at the Institute for Theoretical and Experimental Physics (ITEP) in Moscow. The ITEP program, under the guidance of the well-known mathematician Georgi Adelson-Velskiy, won the match, and the scientists involved went on to develop *Kaissa*, which eventually became the first world computer chess champion. In 1967 there emerged from MIT another program, *Mac Hack Six*, which boosted substantially the Artificial Intelligence interest in computer chess, being demonstrably superior not only to all previous programs but also to most casual chess players. By 1970 there was enough interest in computer chess for Monroe Newborn, now at McGill University, to organize a computer chess competition in New York that attracted eight participants. Due mainly to Newborn's energetic planning and organization, this event continues today as the ACM North American Computer Chess Championship. Reports on these early competitions are contained in his book "Computer Chess" [4]. In 1974 the first World Computer Chess Championship was held at the International Federation of Information Processing Conference in Stockholm. Succeeding world championships have been held every third year - in Toronto, Linz and New York - under the auspices of the International Computer Chess Association, and the next will be in Cologne in June 1986. So far a new champion has emerged on each occasion; first the *Kaissa* program, then *Chess 4.6* (Northwestern University), *Belle* (Bell Telephone Labs.) and currently *Cray Blitz* (sponsored by Cray Research).

These computer chess competitions are important, and not only because they have forged a strong international network amongst scientists working on a common problem. They have also provided fifteen years of continuing experimental data about the effective speed of computers and their software, and they afford a public testing ground of new algorithms and data structures for speeding the traversal of game trees. One might ask whether such a problem as chess programming is worth all the cost and effort that goes into it, since chess is, after all, only a game. Donald Michie, a noted researcher in Artificial Intelligence, believes that computer chess serves as the "*Drosophila melanogaster* [fruit fly] of machine intelligence". Certainly the problem has all the properties of an ideal experimental medium. It is complex, yet regular and well defined; it is amenable to solution in different ways, and it can serve as a test bed for new ideas on automated learning. When one considers some of the emerging uses of computers in important decision-making processes, the chess problem is particularly relevant. If computers cannot even solve a decision making problem in an area of perfect knowledge, like chess, then how can we be sure that they make better decisions than humans in other complex domains, especially those not governed by rules, or those exhibiting high levels of uncertainty? For chess the rightness of the decisions can be measured objectively, through both the Elo rating scale and standard tests. Another aspect of decision-making modelled by computer chess is man-machine cooperation - the possibility that a human working with the help of a machine can make better decisions than either alone. Preliminary experiments have shown that computers provide a steadying influence and protects against human errors introduced, say, by impulsive short-cuts.

2. Anatomy of a Chess Program

Most chess programs work by considering all the available moves in a position (typically about forty). Responses to responses are considered, and this process continues until some maximum depth of search (a horizon) is reached. At a typical three-move-deep horizon (that is, after six "ply" or plays by the two sides) there are 40^6 positions to be examined. The searching process is such that most of these are cut-off or pruned, since it can be proved that they are of no consequence. Even so, at least a million positions would be considered, and this may still be too many to assess within the target time of three minutes. Thus, while computer chess is mathematically trivial, as a practical matter perfect play is impossible. What is surprising is that some chess programs play so well, considering they know almost nothing about the game beyond how moves are made. They can evaluate exchanges, recognize desirable pawn formations, have some notion of king safety and mobility and so on, but each move is considered on its own merits and not as part of some long term plan or goal. That is to say, they have none of the strategy or goal seeking skills associated with human intellect. Further, most programs are plagued with problems. Still feared is the "horizon effect", in which the program delays any inevitable loss of material beyond its viewing horizon by yielding some lesser loss. The excellent book "Chess Skill in Man and Machine" consists of a collection of articles that give more complete details of this and other properties of chess programs [5]. It shows that even the best programs have their bad days. Consider the following position (*Belle - Chaos*, ACM Detroit, 1979):

```
     : :      : :      : :      : :     Chaos
: :      : :   Kb   : :      : :   KW
     : :     Nb        : :      : :
: :      : :      Bw       : :
     : :      : :      : :  Pw  : :
: :      : :      : :      : :
Pb   : :      : :      : :      Pw
: :      : :      : :      : :          Belle

White's Move 59.
```

Belle, playing white, searches deeply and convinces itself that black is threatening to support and promote its pawn, thus forcing an exchange with the white bishop. Any chess player (but not *Belle*) would know that such a ploy is faulty, since black is not left with enough force to win. Nevertheless, *Belle* played Pg5 in the hope that, by offering a pawn, it would decoy black from its primary threat. In so doing *Belle* loses sight of the promotion, which is pushed over the horizon. Black happily accepted by forking the bishop and pawn with Nf7, and the game was quickly drawn, instead of being an easy win for white.

On other occasions *Belle* has shown great originality. At Toronto in 1977, in particular, the program presented a new strategy for defending the lost ending KQ vs KR. While the ending still favours the side with the queen, precise play is required to win within 50 moves, as several chess masters were embarrassed to discover.

3. Hardware/Software Advances

Computer chess has consistently been in the forefront of the application of high technology. In New York (1983) one program (*Ostrich*) used a network of eight Data General processors, while the winner (*Cray Blitz*) had access to possibly the world's most powerful computer, a four processor Cray XMP. Some programs employed special purpose hardware (for example *Belle* and *Bebe*) and there were a few experimental versions of commercial products. Behind the scenes in the commercial world there are many developers of computer chess software. Major players are Fidelity Electronics of Miami, Hegener & Glaser of Munich, Intelligent Software of London, and Novag and SciSys of Hong Kong. Primarily for the benefit of these and other vendors, a series of restricted entry World Micro Computer Championships has been held. Unfortunately these events have been marred by disputes, because so much advertizing potential hinges on the outcome, but the competition has led to dramatic improvements in programs over the years. Today the best microprocessor-based systems can compete satisfactorily in open competition, though it is unlikely that one will ever win the title of World Computer Chess Champion. Good pocket descriptions of various chess programs and examples of their play, is given in the inexpensive paperback "Computer Chess II" [6].

While many of the programs owe their improvements to faster computers, software advances, though gradual, have been equally important. Such techniques as iterative deepening (progressively seeking longer and longer lines of play), principal variation search (analysing the main continuation more thoroughly and using it to refute all alternatives), the killer heuristic (trying previously successful moves before all others) and the use of transposition tables (special memory tables recording the outcome of positions seen before) are now in common use. Work is continuing on robust selective search methods (the retention only of moves that are consistent with some theme), and to a limited extent on plans to achieve well-defined goals. Hardware advances also continue, and there are major efforts to install chess programs on machines with thousands of processors. If successful, this could be a superb example of the benefits of distributed computation, though it is not clear that a major increase in computing power will be achieved that way.

In addition to the many public demonstrations of chess computers in over-the-board play, out of sight there is a steady flow of "automatic" games. Overnight, computers use electronic mail systems to exchange moves with other computers or humans. This quiet activity will never make the headlines, but it does illustrate the relentless "untouched by human hands" testing of programs that goes on.

4. Future

All this leads to the common question, when will a computer be the unassailed expert on chess? It is too early to make a definitive statement, since the range of opinion is too wide. For instance, in five years is a common answer by some enthusiasts. On the other hand, the optimists whose programs are currently improving suggest that they will peak "about the end of the century", while those whose programs contain radically new ideas offer, "Eventually - it is inevitable". In bleak moments I assert, "Never, or not until the limits on human skill are known", but in general I have no doubt that this problem can be solved. To provide some incentive to programmers, Edward Fredkin (MIT professor and well-known inventor) has created a special prize for computer chess. Much like the Kremer prize for man-powered flight, awards are offered in three categories. The smallest, \$5000, has already been presented to Ken Thompson and Joe Condon, when their *Belle* program achieved a US Master rating in 1983. The other awards, \$10,000 for the first Grand Master program and \$100,000 for achieving world champion status, remain unclaimed. To attract participants, each year the trustees (Carnegie-Mellon University) sponsor a match between the currently best computer program and a comparably rated human, for a \$1500 prize.

References

1. A. G. Bell, The Machine Plays Chess?, Pergamon Press, Oxford, 1978.
2. D. N. L. Levy, Chess and Computers, Batsford Press, London, 1976.
3. C. E. Shannon, "Programming a Computer for Playing Chess," *Philosophical Magazine* **41**(7), 256-275 (1950). Also in D. Levy (ed.), *Computer Chess Compendium*, Springer Verlag, 1988, 2-13.
4. M. M. Newborn, Computer Chess, Academic Press, New York, 1975.
5. P. W. F. (editor), Chess Skill in Man and Machine, Springer-Verlag, New York, 2nd Edition 1983.
6. D. E. Welsh and B. Baczynskyj, Computer Chess II, W.C. Brown Co., Dubuque, Iowa, 1985.

More technical details on computer chess are to be found in the International Computer Chess Association Journal. Subscriptions can be obtained through the editor, Dr. H.J. van den Herik, Delft Technical University, Mathematics and Informatics Dept., Julianalaan 132, 2628 BL DELFT, The Netherlands.