REVIEW

GAMES IN AI RESEARCH

H.J. van den Herik
H. Iida
(editors)

Published by
Universiteit Maastricht
in cooperation with
University of Shizuoka
286 pp, Dfl. 75.- US$ 30.-
ISBN 90-621-6416-1

Reviewed by Dap Hartmann[1]

This book contains a total of 18 papers from two different workshops held in 1997: *Game-Tree Search in the Past, Present, and Future* (Princeton, NJ, August 5) and *Computer Games: Using Games as an Experimental Testbed for AI Research* (Nagoya, Japan, August 24-25).

When you think about it, computer chess has come a long way in a relatively short time. Barely 50 years after von Neumann and Morgenstern proposed *MiniMax* as an algorithm to find the best move, human world champion Garry Kasparov was beaten in a six-game match against a computer program that used *MiniMax* at the core of its move decision making. Marsland and Björnsson outline the current technology behind today's chess programs, how it has developed, and where it may go in future. Another paper by these authors discusses selective depth-first search methods. By identifying desirable characteristics of pruning heuristics, the authors attempt to understand the shortcomings of existing techniques, and acquire insights to enable improvements. "Pruning heuristics should be concerned with the question: What is the likelihood of making an erroneous pruning decision, and if an erroneous decision is made, how likely is it to affect the principal variation?"

Four search innovations in CHINOOK are the topic of one of two papers contributed by Jonathan Schaeffer. CHINOOK, of course, was the first program to win a world championship against a human in any game. Now that the program has retired, the main innovative techniques used are revealed. "Although none of the ideas is in itself a major contribution to our understanding of game-playing programs, each played a significant role in creating a world championship program." In another paper, Junghanns and Schaeffer present their efforts in constructing a program that can solve Sokoban puzzles. This one-player game, which originated in Japan, is quite challenging, and highly addictive. Those readers who are unfamiliar with these puzzles are encouraged to check out http://xsokoban.lcs.mit.edu/xsokoban.html, where 'the standard suite' of 90 Sokoban problems is available. But temporary loss of productivity in other areas may be the serious consequence of doing so. The complexity of these single-agent search problems is much greater than for comparatively 'simple' problem domains such as sliding-tiles puzzles or Rubik's Cube. Only three of the 90 problems have a solution of less than 100 moves, while the solution to problem #39 requires 674 moves. "Clearly, being able to search this deep without getting lost in the exponential complexity of the search is a daunting task." At the time when this paper was presented at the conference, ROLLING STONE (the authors' Sokoban solving program) could find the optimal solution of only 12 of the 90 problems. But since then, considerable progress was made. In a postscript, the authors claim that the program can presently solve 58 problems. Most of this progress was achieved by incorporating the ideas presented in the section 'Enhancing the current program'.

[1] Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands. Email: dap@strw.leidenuniv.nl.

The only other paper in this book on single-agent problems is by Richard Korf, whose program found the first optimal solutions to random instances of Rubik's Cube. "The key idea, due to Culberson and Schaeffer (1996), is to take a subset of the goals of the original problem, and precompute and store the exact number of moves needed to solve these subgoals from all possible initial states." The median optimal solution length appears to be 18 moves. An experimental test suite of ten problems was constructed by carrying out 100 random moves starting from the initial (solved) state. One problem was solved in 16 moves, three required 17 moves, and the remaining six problems were 18 moves away from the initial state. Korf's program generates 700K nodes per second, at which speed a complete depth-18 search requires about four weeks of CPU time. A very impressive result, considering the complexity of the problem: 43×10^{18} different states for a 3×3×3 Rubik's Cube.

M. Buro contributes two papers on Othello. The first one deals with the construction of opening books by means of learning from mistakes made in previous games. In the second paper, he describes a new evaluation function for Othello, and introduces a generalized selective search heuristic. The combined effect results in an increased playing strength equivalent to a speed-up by more than a factor of ten.

A description of his Othello-playing program KEYANO is presented by Mark Brockington, one of the many researchers in the field of computer games from the University of Alberta. "[...] most first attempts at writing an Othello program are significantly flawed", according to the author. The revealing of the innards of KEYANO, which routinely finished in the top six in 21 computer Othello tournaments, will therefore be much appreciated by aspiring Othello programmers. One distinguishing feature of the program is that databases of games were used to tune parameters in the openings book, in the search routine, and in the midgame evaluation function. "Training from top-quality Othello games, is vital to the success of any Othello program."

There are two papers on Shogi, and perhaps the only blemish on this very well-edited book is that a different style of diagrams is used in each. In Grimbergen and Matsubara's contribution on the use pattern recognition for candidate move selection, *kanji* characters are used, whereas the paper on the automatic composition of Shogi mating problems by Watanabe, Iida, and Uiterwijk employs chess symbols, with the pieces of the white player printed upside-down. Neither method is very enlightening to those who are unfamiliar with Shogi. Perhaps a new set of symbols should be agreed upon, whereby different pieces are more easily distinguishable, and in which it is clear at a glance which pieces belong to which side.

Even though the preface of this book claims that there are two papers on computer Bridge, there is, in fact, only one. Smith and Nau compare two competing approaches to computer Bridge, namely planning and brute force, but fail to come to any particular conclusion. If I had been a referee for this paper, I would not have accepted it for publication, because the relevant contents is very close to zero.

Frank, Basin, and Matsubara investigated games with imperfect information by applying Monte-Carlo simulations to the unknown (hidden) pieces of information. But, unfortunately, as depth increases, the observed error rapidly approaches 100%. This is probably the second paper on Bridge in the editors' opinion. Certainly, Frank and Basin have published papers on computer Bridge before, but this paper addresses the general class of games with imperfect information. "The experience with Bridge suggests that a measure is needed for imperfect information games that describe game properties that have a bearing on the difficulty of solving the game with a Monte-carlo approach."

The paper by Iida, Uiterwijk, and Van den Herik explores cooperative strategies for so-called 'pair-playing', in which two pairs of players alternate moves (without any communication) in a two-person game with perfect information. A distinction is made between cases in which the players have exhaustive knowledge or only partial knowledge of their partner's strategy. Furthermore, it is also assumed that each pair consists of players of different strength. "[...] the performance of a cooperative search strategy [...] is better than that of a non-cooperative strategy when a player has exhaustive knowledge of the partner's strategy."

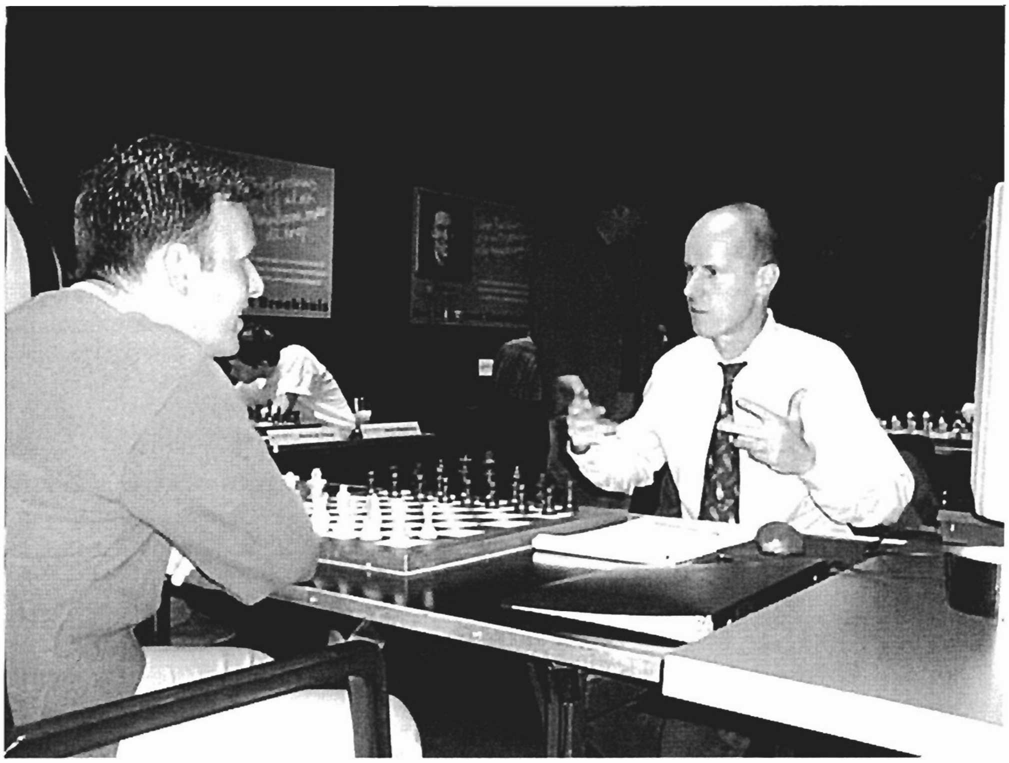
The remainder of the papers deal with computer Go. Martin Müller describes a generalized thermography applied to the game of Go, in which a 'mast value' (a measure of the score) and a 'temperature' (a measure of the urgency to move) are computed for a wide range of Go positions. In 'Flexible acquisition of various types of Go knowledge', Kojima, Ueda, and Nagano describe an algorithm to extract knowledge from Go game records. The appendix provides 18 examples of rules acquired through the use of this method. The application of the algorithm to other games is discussed briefly.

Nakamura presents two graph-theoretic approaches for estimating the number of eyes of groups in Go positions. "The first method is based on Euler's formula for connected plane graphs in which the number of minimal loops is given by the number of vertices and edges. The second method is based on labelled graphs called situation diagrams representing higher-order Go board situations and enabling the analysis of complex capturing races."

A study of the memory performance of Go players is presented by Burmeister *et al.*, more or less analogous to similar cognitive studies in chess by de Groot and Chase & Simon. Even at the highest presentation speed tested (half a second per move), Go experts had little difficulty in reproducing the games which were shown to them in this way. "[...] experts can extract significant information in less than 500 milliseconds per move."

Saito and Yoshikawa make a case for using Go as the next drosophila for studies in cognitive science. They argue that Go presents a greater challenge than chess, because it is full of unsolved problems and because perceptual-level features are closely related to higher-level plans and strategies. Even though I generally agree with the authors, my personal opinion is that the game of Go is too big a hurdle to take after the successful challenge of the human chess world champion. Sadly, there were no contributions on Amazons. This fascinating game may provide an intermediary challenge between a world-champion-level chess program and expert-level Go programs. The former goal has been achieved, while the latter one must be considered to be decades away. However, as of this writing, the strongest Amazons-playing programs are probably already outperforming the few humans who excel in this intriguing game, simply because the game does not have the long history and tradition of chess and Go. Nevertheless, like Go, the game of Amazons has a huge branching factor which creates the challenging conditions of having to abandon the deep full-width searches which underlie the world's strongest chess programs.

Most papers in *Games in AI Research* are highly accessible to anyone with 'merely' a computer-chess background. In that, it sets the perfect example of what the *ICGA Journal* has yet to prove to its readers: papers on games (and puzzles) other than chess, at a level which is non-trivial to the experts in those particular games, while being accessible to the former ICCA members, whose expertise will be predominantly in computer chess. I found that 90 percent of the papers in the present book fell in that category. Warmly recommended.



THE ACTUAL START OF WHAT CAN BE CALLED *NEW IN CHESS*.
Piket playing Fritz SSS* (Round 1, Rotterdam, May 7, 2000).

Photo by Yvette Nagel