Computer Chess: Algorithms and Heuristics for a Deep Look into the Future *

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Abstract. In this paper we will describe some of the basic techniques that allow computers to play chess like human grandmasters. In the first part we will give an overview about the sequential algorithms used. In the second part we will describe the parallelization that has been developed by us. The resulting parallel search algorithm has been used successfully in the chess program ZUGZWANG even on massively parallel hardware. In 1992 ZUGZWANG became Vize World Champion at the Computer Chess Championships in Madrid, Spain, running on 1024 processors. Moreover, the parallelization proves to be flexible enough to be applied successfully to the new ZUGZWANG program, although the new program uses a different sequential search algorithm and runs on a completely different hardware.

1 Introduction

The game of chess is one of the most fascinating two-person zero-sum games with complete information. Besides of being one of the oldest games of this kind it is still played by millions of people all over the world. Moreover, during the last years, chess had been put to a worldwide attention due to the interest of the people in superstars like International Grandmaster Kasparov and due to the fact that computers now start to challenge the worlds best chess players [41].

The playing strength of the top human chess players is due to their strategic planning ability, lookahead, intuition and creativity. The playing strength of the computers, however, is mainly based on their speed. It will be interesting to watch the contest between humans and computers in the future.

On the other side, strategic games like chess are considered to be excellent test environments for planning devices [39]. It is great evidence that algorithms, that enable a computer to play chess successfully, can be of use in other domains where strategic planning is required, e.g. in expert systems, motion planning in dynamic environments, or business planning [61].

The modern history of computer chess started with the work of Shannon [56] and Turing [58]. In 1974 a first Computer Chess World Championship was held in Stockholm seeing a win of the soviet program KAISSA. Software as well as hardware improvements significantly increased the playing strength of the

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computers. Most of the references given at the end of the paper are offsprings of this research in computer chess. Levy and Newborn [40, p 5] mention that the playing strength increased from 1640 ELO points [17] in 1967 to more than 2500 points nowadays. For a detailed description of the history of computer chess we refer to [40].

In this paper we will give an overview about the most important lookahead techniques used in modern chess programs. In the first part we will describe some sequential search algorithms, that enable computers to choose their move based upon a deep look into the future. We will describe the standard enhancements used to speed up the search. Then we will present two selective search algorithms allowing even further lookahead along promising lines of play at the risk of overlooking chances or threats on other lines. The first one is the Null Move Search Algorithm [8, 29, 16] that is widely used in state-of-the-art chess programs today. The second one, the so called Fail High Reduction Algorithm, is an alternative for programs using a sophisticated static evaluation function [25]. We developed it quite recently and showed its superiority to the standard algorithm in a sequence of tests. It is now used in ZUGZWANG and at least one commercially available chess program.

In the second part we will describe a parallel approach to the search algorithm allowing an even deeper lookahead. The resulting distributed algorithm has been used successfully in the chess program ZUGZWANG even on massively parallel hardware [20, 21, 22, 23, 24]. In 1992 ZUGZWANG became Vize World Champion at the Computer Chess Championships in Madrid, Spain, running on 1024 T805 processors. Moreover, the parallelization proves to be flexible enough to be applied successfully to the new ZUGZWANG program, although the new program uses a different sequential search algorithm and runs on a completely different hardware. This new program recently played successfully at the 12th AEGON Man vs. Machine tournament in Den Haag, The Netherland, running on 40 M604 processors. Our parallelization is the first one that has been applied efficiently to massively parallel hardware.

1.1 The Problem

Informally spoken, given a chess position $S$ we are interested in the best move for the side to move in $S$. Zermelo [66] formalized the notion of a theoretical win, loss or draw in two-person zero-sum games. From this the following recursive minmax function $F$ can be deviated: For a terminal position $t$

$$F(t) := \begin{cases} 1, & \text{if } t \text{ is won for the side to move in } t \\ 0, & \text{if } t \text{ is a draw} \\ -1, & \text{if } t \text{ is lost for the side to move in } t \end{cases}$$

The value of a nonterminal position $v$ with children $v_1, \ldots, v_w$ is then given as

$$F(v) := \max \{-F(v_1), \ldots, -F(v_w)\}.$$ 

If the game does not contain infinitely long sequences of moves, $F(v)$ can be computed for any position $v$. This is done by building a search tree with root