

Deep Blue - Paper Review

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Introduction

This document is a brief review of the paper “Deep Blue” which describes a chess game playing agent with that name, that defeated the human world champion in a six-game match in 1997.

This agent was the result of many years of study and development, and is the last of a family of agents, that evolved until defeating the best human player in the world.

Review

The accomplishment of winning the match was the result of many techniques used inside the agent, to make it as good as it is. There are a lot of different things that contribute to the agents decisions inside the game. The main components of the agent, that make it so good are:

- Specific hardware built to be really good to function with search algorithms
- A big parallel processing system that let you search more effectively the graph
- A really good and big game database
- Super developed evaluation functions

Faced challenges during development

This complex system had a number of challenges that needed to be solved to make it work in the best possible way.

Some of them were:

- The search capacity of the system was more powerful than any other chess playing agent at the time. The developers had to take advantage of this, but they way to go was not clear at first. Their search is build around two principles: it should be highly non-uniform, and should provide insurance against simple errors.
- The evaluation function was implemented in hardware, which had a lot of advantages and disadvantages that needed to be addressed.
- Massive parallel search, that needed to be studied in order to make the best out of this feature.

System Overview

The primary components that make this system so good are:

- Chess Chip

Deep Blue has 480 chess chips distributed in 30 processors. Each chip is capable of searching 2 to 2,5 millions chess positions per second. They have a search control mechanism that allow them to detect repeated game states during the search, to make it more efficient. They also have a combined evaluation function, that has a “fast evaluation” and a “slow evaluation”. Each one considers different kind of features to give a score. Together they avoid computing an expensive evaluation, when an approximation is good enough.

- Software Search

The selective search build for this agent, was called by their authors “dual credit with delayed extensions”. It was call that way because some of the principles of the algorithm were directly related with chess strategy.

Nevertheless the search method was a complex function that is a derived from alpha-beta.

- Hardware Search

This is the part of the Deep Blue search that takes place on the chess chip. This search is fast but is relatively simple. To get a balance between the speed of the hardware search and the complexity of the software search, the hardware search only carries out shallow searches. The host processor controlling each chip, start a search and then is free to do other work, like initiating other search in another chip. The processor then uses shallow controlled searches on various chips, and combine the information between them.

- Parallel search

Deep Blue uses a static processor tree, with one processor controlling 29 processors, which in turn control 16 chess chips each. This architecture lets the master processor allocate different types of search in different processors and they distribute this work even further on the chess chips. The master processor uses the information given by all the processor to analyze the game. Distributing the work makes possible for better search strategies.

- Evaluation function

The Deep Blue function is essentially a sum of feature values. Each chess chip recognizes around 8000 different patterns, and each is assigned a value. There are features that range between “simple” and “very complex”.

The features also divide in static and dynamic. The first kind have their values set once and the beginning of a search, the other ones are also set at the beginning, but their values can be scaled during the search (via lookup table).

The initialization of the values is done by a sub-program that runs on the master node, and although it would be beneficial, it can't be used on other nodes near the root.

Most of the features and weights were tuned by hand, but there were two instances where automated analysis tools aided in the process. One tool had the goal of identifying features that were noisy and the other had the goal of tuning the evaluation function weights.

Conclusions

The creation of the Deep Blue agent had no one particularity that make it as good as it is, it was a combination of techniques, hardware, software, hand tuning, and previous games analysis. A lot of different agents were made in the process, each time improving the last one. A lot of techniques were found while working on those other agents, and then inherited by Deep Blue.

There was a lot of AI research and implementation on this work, but also a lot of hardware development and chess knowledge was used to get the results it got.