Deep Blue by the IBM Watson Team

Introduction

This paper gave a detailed description of *Deep Blue*, the computer chess system, developed by IBM that defeated Gary Kasparov in a six game match in 1997.

Details

Many efforts were made before Deep Blue succeeded in defeating the GrandMaster and several improvements were made in the system based on the learnings from previous iterations including:

- Significantly enhanced chess chip
- Massively parallel system with multiple levels of parallelism
- Strong emphasis on search extensions
- Complex evaluation function
- Improved debugging tools
- Using the historic game database

Let's talk about each aspect in detail:

Chess Chip

The new chess chip had a completely redesigned evaluation function covering around 8000 features incorporating slow and fast evaluation. It also added hardware repetition detection, a number of specialized move generation modes and some efficiency improvements that led to searching 2-2.5 million positions per second.

System overview

Deep Blue had a massively parallel system designed for carrying out chess game tree searches. The system was composed of a 30-processor IBM RS/6000 SP computer and 480 single-chip chess search engines, with 16 chess chips per SP processor.
Deep Blue was organized as a master and workers. The master processor searched the top levels of the chess game tree, and then distributed "leaf" positions to the workers for further examination. The workers carried out a few levels of additional search, and then distributed their leaf positions to the chess chips.

Search

It relied on quiescence search, iterative deepening, transposition tables, NegaScout, large searching capacity, hardware and software searches and a massively parallel search(over 500 processors) for its working.

Software Search

A new selective search was developed which is called "*dual credit with delayed extensions*" based on principles like forcing/forced pair moves(ffp), fractional extensions and preserving the search envelopes.
Delayed extensions : Often there are a series of ffp's which are interesting. For this, "credit" was accumulated and were "cashed in" on them once sufficient amount was available. By setting this threshold appropriately, delayed extensions were encouraged.
Dual Credit : Separate credit was accumulated for both sides and if either side accumulated sufficient credit to cash in for extension, other side had to give up equal credit.

Hardware Search

Hardware search took place on the chess chip. It carried out a fixed-depth null-window search which included a quiescence search.

Evaluation Function

The Deep Blue evaluation function was essentially a sum of feature values. The chess chip recognized roughly 8000 different "patterns", and each was assigned a value. Features ranged from very simple, such as a particular piece on a particular square, to very complex. A feature value could be either static or dynamic. Static values were set once at the beginning of a search. Dynamic values were also initialized at the beginning of a search, but during the search they were scaled, via table lookup, based on the value and type of pieces on the board at evaluation time.

Using Historic Data

Data from many previous matches played was constructed and used to assist in opening moves, playing some specific moves in the midst of the game and endgame moves.

Results

Deep Blue defeated Gary Karsparov by a score of 3.5-2.5. The success was not the result of any one factor. The large searching capability, non-uniform search, and complex evaluation function were all critical. However other factors also played a role, e.g., endgame databases, the extended book, and evaluation function tuning.