

IBM Deep Blue

Abstract:

Deep Blue is the chess machine that defeated the World Chess Champion Gary Kasparov in a 6 game match in 1997. The following factors attributed to this great success,

- Single-chip chess search engine
- Multiple levels of parallelism
- Search extensions
- Complex evaluation functions
- Grandmaster game database

History:

Deep Blue I lost against Garry Kasparov in 1996. It's a single-chip chess search engine ran on a 36 node IBM RS/6000 and used 216 chess chips and the overall search speed was 50-100 million chess positions per second.

Deep Blue II:

Deep Blue II has been powered with the following enhancements compared to its predecessor,

- Enhanced chess chip
- Redesigned evaluation function(from 6400 to over 8000 features)
- Double the number of chess chips
- Set of software tools to help debug and match preparation
- Large searching capacity
- Hardware evaluation
- Hybrid software/hardware search
- Massive parallel search

Which resulted in the first ever victory by a machine against the most famous Chess master.

Chess Chip:

The Chess chip has *move generator, evaluation function and search control*. *Move generation* is responsible for generating one move at a time by computing all the possible moves based on the best first move ordering. For example, low-value pieces (Pawn) capturing high-values pieces (Queen) to high-value pieces (Rook) capturing low-valued pieces (Pawn). There are two types, *fast and slow evaluation functions*. Slow evaluation function computes the score for a chess position in a single clock cycle. For example, sum of the basic piece values with the square-based location adjustments. Slow evaluation scans the board one column at a time for chess concepts like square control, pins, X-rays, King Safety etc. *Search control* uses null-window Alpha-beta search which helps eliminate the need for a value stack but the disadvantage is to do multiple searches in some cases.

Software/Hardware search:

Deep Blue II uses both software and hardware search. It uses selective software search aka "dual credit with delayed extension". FFP stands for forcing/forced pairs. When the move is forced by the opponent,

ideally the search would extend to two ply extra. Sometimes the forced move will be at one level alone and if its “fail-low” it will not be considered ffp. But the series of ffp’s is difficult to handle and one way of handling it is, by allowing ffp’s to accumulate credit and only when sufficient credit exist against the threshold, it will be allowed to cash-in for search extension.

Hardware search takes place on the chess chip level and carries out fixed-depth null-window search which includes quiescence search. Hardware search is fast and to make it more efficient the Hardware search is limited to carry out only Shallow searches and results in 4 / 5 ply searches plus quiescence in middle game positions and somewhat deeper searches in the end game. As there are 480 chess chips with 16 chips per node, the Hardware search has the capability to do the search in parallel which results in better efficiency.

Evaluation function:

The Deep Blue II evaluation function is a sum of feature values and the chess chip recognizes roughly 8000 different patterns and each is assigned a value. Feature values are simple, complex, static and dynamic. The initialization of the feature values are done by the “evaluation function generator” from the master node. The large amount of features were created/tuned by hand whereas the automated evaluation function analysis exist too.

Open/Extended book and Endgame database:

Open-book is a book of tactical opening moves and was created manually and consisted of about 4000 positions.

Extended book on the other hand is a mechanism that allows a large Grandmaster game database to influence and direct the play in the absence of the Open-book info. The following factors influence the extended book evaluation function,

- No of times a move is played
- Relative no of times a move is played
- Strength of the player who made the move(Grand masters vs little masters)
- Recentness of the move
- Result of the move(Win/Lose)

Endgame databases include all chess positions with five or fewer pieces on the board. Will be used to identify the pattern when the game is left with less pieces. During the matches in 1997 with Gary, only one time Endgame databases were used.