Deep Blue

Deep Blue is the chess machine that defeated world class champion Garry Kasparov in 1997. number of factors that contributed to this success, including:

- A single-chip chess search engine,
- A massively parallel system with multiple levels of parallelism,
- A strong emphasis on search extensions,
- A complex evaluation function, and
- Effective use of a Grandmaster game database.

Techniques

Search:

       Deep Blue relies on many of the ideas developed in earlier chess programs, including quiescence search, iterative deepening, transposition tables and NegaScout. For search, number of state machines were used to implement **null-window Alpha-Beta** search. As paper describes the advantages to null-window search is that it eliminates the need for a value stack and simplifies hardware design.

    i. **Hardware/ Software Search**

        The hardware search is that part of the Deep Blue search that takes place on the chess chip. A chess chip carries out a fixed-depth null-window search, which includes a quiescence search. There are also various types of search extension heuristics, both for the full-width and the quiescence portions of the search, which are described below

    ii. **Parallel Search**

        Deep Blue is a massively parallel system, with over 500 processors available to participate in the game tree search. It is composed of a 30-node RS/6000 SP computer and 480 chess chips, with 16 chips per node.

Evaluation Function:

       Evaluation functions in Deep Blue is composed of:

    i. **Fast Evaluation**

        It computes a score for a chess position in a single clock cycle, contains all the easily computed major evaluation terms with high values. The most significant part of the fast evaluation is the "piece placement" value, i.e., the sum of the basic piece values with square-based location adjustments. Positional features that can be computed quickly, such as "pawn can run", are also part of the fast evaluation.

    ii. **Slow Evaluation**

        It scans the chess board one column at a time, computing values for chess concepts such as square control, pins, X-rays, king safety, pawn structure, passed

pawns, ray control, outposts, pawn majority, rook on the 7th, blockade, restraint, color complex, trapped pieces, development, and so on.

These evaluations are standard techniques to skip computing an expensive full evaluation when an approximation is good enough.

Endgame Database:

The endgame databases in Deep Blue includes all chess positions with five or fewer pieces on the board, as well as selected positions with six pieces that included a pair of blocked pawns. Endgames were stored in the databases with one bit per position (indicating lose or doesnot-lose). If a position is reached during the search that had a known value, it received a score composed of two parts: a high-order, game theoretic value, and a low-order, tie-breaker value. The tiebreaker value is simply the value produced by the evaluation function on the position in question. If this score is sufficient to cause a cutoff, the search immediately backs up this score.

Time control:

The time control mechanism in Deep Blue is relatively straightforward. Before each search, two time targets are set. The first is the normal time target, set to be approximately the time remaining to the next time control divided by the moves remaining. In practice, a considerable time buffer is reserved, which allows for sufficient time to handle technical difficulties, as well as saving time for a possible "sudden-death" phase. The second time target is the panic time target, which is roughly one third of the remaining time.