

Research Review of Deep Blue by IBM

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Deep Blue is the world-class computer chess system developed at IBM Research. The goal of this agent was to defeat the World Chess Champion Garry Kasparov. The success of Deep Blue has had implications for intelligence of both types - artificial and human.

There are 5 factors which contributed to the success of Deep Blue: A single-chip search engine, a massively parallel system, search extensions via iterative deepening, a complex evaluation function and the effective use of a Grandmaster game database.

Deep Blue takes advantage of 480 specially-designed "chess" computer chips. These chips are designed to support 3 specific features for processing chess games. The Deep Blue chip is responsible for move generation, processing the evaluation function, and search control (pruning). The move generator is implemented as an 8 x 8 logic array, a "silicon chessboard". Hardwired finite state machines generate moves one at a time and a move to perform a depth-limited search on is selected by a priority-based arbitration network.

The evaluation function is implemented directly on the Deep Blue chess chip. The evaluation function takes advantage of weighted feature detection which scores many predetermined patterns in a chess configuration and returns a score based on how well of a position it's in. The evaluation function can be processed in a faster "approximation" mode, where specific scores aren't necessary. The evaluation function, while implemented directly on the hardware, has several tuning parameters which allow it to be tweaked by the software search. The Deep Blue chip also manages some pruning via a null-window alpha-beta search.

Deep Blue takes advantage of a static, parallelized processor tree consisting of one SP master node, controlling 29 other SP nodes, each of which controls 16 Deep Blue chess chips. The chess chips are unable to communicate with each other (only their parent host node) providing the architecture necessary to support parallelism and synchronization under many conditions. After the first few iterations are processed on the master node, jobs begin to be allocated across each of the child SP nodes, and down to each of the Deep Blue chess chips. Jobs can be allocated preemptively to reduce the effects of communication latency between master and worker nodes.

Deep Blue takes advantage of iterative deepening to try to resolve tactical noise resulting from the horizon effect. A move's search depth will be extended by 1-ply (an extra turn) until some condition is met (to avoid search explosion).

In a game between two human players, each player will draw from experiences of games previously played. Patterns can be recognized because the players have seen the patterns before. The use of Grandmaster game databases provides this previous experience to Deep Blue. Deep Blue can recognize a chessboard configuration which matches a known configuration and moves based without any additional search.

The Deep Blue system successfully defeated the World Chess Champion in 1997. IBM confesses that further tuning of the evaluation function, and additional pruning techniques could result in huge gains for Deep Blue's performance.