

Deep Blue

Deep Blue is the chess playing machine developed by IBM Research in 1990's. Deep Blue, which was built upon series of its precedes, defeat human chess expert, Garry Kasparov, in 1997. It is the fourth version of chess playing machine, The Deep Thought, developed at Carnegie Mellon University in 1980s. Research team had continuously made improvements in each of Deep Thought's successors and finally they were able to create Deep Blue which can handle problems in chess by imitated the way human chess experts did.

Deep Blue hardware is designed to carry fast simple search in parallel. It has multiple processors with one *master processor* the top level of game tree and distributes to the rest, *worker processors*, to carry more detail search then send results to logic board chess chips in each processor for further search. Each processor control when chess chips under it start or stop search tasks.

Each chess chip has three main parts. Firstly, the move generator generates which gives fast and sequential move. Secondly, the search control where null-window alpha-beta search is implemented.

Thirdly, the evaluation function which is responsible for Deep Blue's in-game behaviour by approximate score of chess positions. This evaluation function recognizes possible patterns on chess boards, assigns value corresponding to that pattern, and modified values based on chess board at evaluation time. Research team also able to tune evaluation function to improve its performance using tools to detect and tuning evaluation function weights for chess patterns.

When Deep Blue faces opponent's tactical moves, hardware search could not effectively handle game tree search such as series of moves that lead to end game.

Search is then conducted by Deep Blue's software by Dual Credit Algorithm. *Dual Credit Algorithm* is basically alpha-beta search with *credits* for each player as an offset to modify normal alpha-beta search. *Credit* is generated from various sets of moves. This algorithm helps Deep Blue complete game tree search when it face tactical moves.

Both hardware and software search are constrained by *time control mechanism* which tells them to stop and return best move they can find within specific time period according to game rules.

Addition to hardware and software search, Deep Blue uses pre-defined knowledge banks to help it deal with search problem effectively. Human chess experts create *Opening Book* to help Deep Blue to start with moves that it plays well and *Extended Book* to shorten regular search by adding extra weight to each of chess patterns. The experts also create End Game database to help the system choose best move for when approaching end game positions.

Deep Blue is consider to be unfinished work since many improvements could be implemented. For example, hardware search could be more efficient with FPGA chess chip instead of logic-board chess chip, or overall search would be improve significantly with pruning mechanism.

Combining hardware and software search, and domain knowledge in chess game from human experts are factors behind Deep Blue success.