Deep Blue: Chess AI who Defeated Kasparov

Artificial Intelligente Nanodegree

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Deep Blue, presented in the year of 1997, was a very successful chess playing computer which defeated Garry Kasparov, then the undisputed chess world champion, in a series of 6 matches. Deep Blue became the first AI to defeat a current world chess champion under standard chess tournament time controls. It was developed by the IBM Watson Team, with development initially starting in 1985 at Carnegie Mellon University with the ChipTest project, which later evolved in the Deep Though project at IBM as a direct predecessor for Deep Blue. Chess grandmaster Joel Benjamin worked as a part of the Deep Blue team.

Deep Blue's hardware consists of 480 processors, which are able to process about 100 to 200 million game positions per second.

The move search algorithm is based on negamax search with alpha-beta pruning. Negamax is a simplification of standard minimax search which considers the game to be a zero-sum game with score symmetry, taking advantage of the mathematical relation `max(a, b) = –min(–a, –b)`. It uses a depth-limited search whose depth can be extended under certain circumstances related to a "dual credit" system, where both sides (players) accumulates or gives up "credit" according to game circumstances, like the threat of a checkmate or when there is only one legal move at the time. Search also stops under time management circumstances, to deal with the rules regarding time on a chess championship. If dealing with a particularly complex situation, the algorithm is able to search until a certain "panic" time threshold.

The search algorithm uses parallelization. It is implemented both in software and in hardware, with a combination of both being used. Hardware search is more limited (in terms of configurability), but faster and used more to explore near tree leaves, whereas software search is more complex, is used to explore the tree near root, and takes advantage of a transposition table to take advantage of previously assessed moves that happened to be found under different tree paths.

Deep Blue's search uses a nonlinear evaluation function consisting of more than 8,000 features, whose weights were mostly tuned by hand. Features are all calculated from the current board. Examples of features include information about pinned pieces, pawn structure, and knight/rook/queen traps. The complete search function is called a "slow evaluation". A simplified version, called "fast evaluation", which can be computed in a single clock cycle, is used when the calculation of the expensive full evaluation function is not needed and an approximation of its value is good enough.

An opening book consisting of about 4,000 positions is included. Deep Blue also includes and takes advantage of a 700,000 grandmaster games database. An endgame database is also provided, with all chess positions with five or fewer pieces, and some six-pieces positions as well.

In the end, Deep Blue defeated Kasparov on a six-game match. Kasparov won game #1, Deep Blue on games #2 and #6, and games #3, #4 and #5 ended in a draw by mutual agreement.