

Paper chosen: Deep Blue by IBM Watson Team

The paper aims to account for and explain the success of the Deep Blue chess machine in defeating former World Chess Champion Garry Kasparov. It does this by investigating the chess chip itself, software search, hardware search, parallel search, and the implemented evaluation function, all as factors that contributed to this success. It is interesting to note that Deep Blue utilizes hardware search and software search for different functions; for example, software search does not implement quiescence search and only explores the trees near the root node while hardware search implements a complex quiescence search and explores the trees near the leaf nodes. The evaluation function was highly customized for chess games, consisting of a fast evaluation which evaluates major significant values such as positional features that can be computed quickly, and a slow evaluation which scans the chessboard slowly, evaluating scores based on chess-specific concepts such as king safety, pawn structure, and pawn majority. Software search on the Deep Thought 2, which was the foundation for the Deep Blue selective search, had certain design principles and introduced new techniques in relation to chess, including to extend forced pairs of moves, making forced moves expectation dependent to prevent non-terminating search, and dual credit, which prevents the serious problem of principal variation. On the chess chip, hardware search takes place, carrying out quiescence search and various types of search extension heuristics. The team limited searches to 4- or 5-ply searches plus quiescence in mid-game and deeper searches only in endgames to balance the speed of the hardware search with the efficiency and complexity of the software search. The hardware search is parameterized, requiring careful tuning of parameters such as depth of search, depth of offset searches, and number of 'mating' checks allowed for each side in the quiescence search. The heterogeneous architecture of the Deep Blue system influenced the parallel search algorithm to a large extent. Implementation of parallel search faced 3 main issues: load balancing, master overload, and sharing between nodes. It is to be noted here that the parallel search algorithm, which had a low observed efficiency in the 30-node Deep Blue system, was neglected in favour of improving the evaluation function following the first loss to Kasparov in 1996. The Deep Blue evaluation function is simply a sum of feature values stemming from assigning values to different 'patterns' recognized by the chess chip.

The team also listed some limitations of the Deep Blue implementation, such as the inefficiency of the parallel search, the inflexibility of the hardware search and evaluation, and the tuning of the evaluation function. Pruning mechanisms were not implemented in the Deep Blue. In conclusion, the paper states that the Deep Blue team neglected many alternative design choices during development and encourages further exploration and experimentation of game-playing artificial intelligence.