

Research Review of Deep Blue by Carlos Arreaza - Apr 2018

<https://pdfs.semanticscholar.org/ad2c/1effcd7c3b7106e507396bdaa5fe00fa597.pdf>

The first part of the paper gives an ample background of the different achievements obtained before getting to Deep Blue (or Deep Blue II). The different types of progress were specified on both hardware and software.

### **A brief summary of the paper's goals or techniques introduced**

- Hybrid software/hardware search: they do a combination of search using a software search, compiled in C code which gives the flexibility to change and adapt new heuristics or weights. And a hardware search, which is extremely fast as it is encoded in a silicon chip (called a chess chip). This gives the flexibility to change whenever needed, but have the speed of the hardware chip.
- Evaluation function: composed of a fast evaluation and a slow evaluation. This is done to make the search more efficient, as sometimes the slow evaluation function is not needed, so the fast is implemented instead. The fast evaluation function takes into account all the easily computer major evaluation terms with high values: sum of basic pieces, positional features ("pawn-can-run"). On the other hand, the slow evaluation function scans the chess board one column at a time doing: square control, pins, X-rays, king safety, pawn structure, passed pawns, ray control, outposts, pawn majority, and more.
- Massive parallel search: they integrated a large scale parallel search (with over 500 processors available) with selective search mechanisms.
- Search control: null-window alpha beta searches with the addition of a repetition detector. The detector contains a 32-entry circular buffer of the last 32 ply (or single moves) to detect repeated moves and bound the score appropriately.
- Software search details: the software search is the most complicated part of the algorithm. The paper reviews some of the principles like: extend forcing/forced pairs (ffp's) of moves, fractional extensions (to limit fully extending all ffp's), delayed extensions (to accumulate credit on a ffp, and only extend it when enough 'credit' has been cashed in), dual credit (regarding the credit problem before), and preserving the search envelope to prevent search oscillation.
- Hardware search details: there were a lot of parameters considered for the hardware search. Some of these are: depth of search, depth of offset searches, number of mating checks allowed for each side in the quiescence search, flags for different enabling criteria regarding one-ply extension searches.
- An opening and closing book are used during the beginning of the game and during endgame, respectively.

### **A brief summary of the paper's results**

The success of Deep Blue II was due to all the variables stated above, with the addition of the endgame databases, extended book, and evaluation function tuning. There wasn't one single contributor to the success of the algorithm, but rather the combination of all the functions summarized above. Deep Blue finally beat Garry Kasparov in a 6-game match in 1997.