Deep blue (research review)

The goal of this document is to summarize advancements in the field of Artificial Intelligence (AI) while building chess machine able to defeat human chess grandmasters. Document is split in multiple topics as they were described by the reasearch paper.

Hardware

Deep Blue is parallel system with focus on searching through chess game trees. It is composed from 30 processor units and 480 single-chip chess search engines, which were able to quickly search through game tree.

System is built in three layers - one master processor which works as a supervisor while the rest function as slave nodes. Each slave node has control over multiple search engine chips. Thanks to this design, game tree (or at least its parts) could be searched in parallel, resulting in great increase in performance. Search (as well as initial search) is conducted by master node, which is delegating work among slave nodes.

The result of this design is high performance search and possibility to implement hybrid software/hardware search. Thanks to this, developers were able to have quick search using optimized hardware-based evaluation function and use much more complex, software-based evaluation function when needed.

Evaluation function

Deep Blue team implemented complex software evaluation function with over 8000 different features. Most of them were implemented and tuned by hand and automatic analysis tools were used to fine-tune evaluation function performance - one was used for detecting noisy features or features clusters and second was used to tune evaluation function weights.

Opening book

Deep Blue uses opening book created by multiple chess grandmasters. Alongside this, Deep Blue has also access to Extended book, which is a large database of past games. An ad hoc search function was implemented and used to search through this database. The weights were set in a way, which allowed Deep Blue to play moves without conducting search, if board state was found in the database.

Endgame database

Large endgame database was also used for moves with 5 pieces or less. This could help to make more informed decisions but haven't proved to be critical in practice. Interesting design decisions had to be made because of size of the database. Database was split into two parts - each chess chip stored its own copy of important moves and everything else has been stored to external storage.

Time limits

Deep Blue did the search only in predefined time-frames. There were two time targets set before each search. First one was used in standard states and the second was used when the didn't work out well. There was also "time buffer" for handling technical difficulties and possible "sudden death" phase.

Summary

The goal of Deep Blue was to win match against World Chess Champion Garry Kasparov in 1997 and it was ultimately achieved as a result of multiple iterations of hardware and software development cycles. The large searching capability, non-uniform search, and complex evaluation function were all critical. However, Deep Blue creators admit a lot of improvements could be made to further improve the performance. Amongst them, parallel search efficiency and hardware improvements were mentioned. From software perspective, algorithm optimalizations (search tree pruning) and fine-tuned evaluation function could also help in terms of overall performance.