Research Review

Deep Blue

The aim of the paper is to explain the operation of the Deep Blue system, a chess computer famous for defeating Garry Kasparov, the world champion at the time. The creators offer a short history of the machine and describe how it works, as well as its strengths and shortcomings. There were two versions of Deep Blue. The first one did not manage to defeat the chess champion, but the second one won through improvements to its hardware and software. The Deep Blue machines evolved from earlier iterations of chess computers developed at Carnegie Mellon University in the 1980s (Deep Thought and ChipTest).

Deep Blue uses many of the techniques and ideas developed for earlier chess programs such as: quiescence search, iterative deepening, transposition tables and NegaScout. The machine is organised in layers. One master processor searches the top levels of the game tree and then distributes leaf positions to other worker processors. System speed varied greatly when using this implementation.

The authors offer some insight into what made Deep Blue different. While these developments undoubtedly created some new challenges, they probably are also what allowed the machine to win:

1. Large searching capacity. The ability to search through more chess positions allowed them to create a stronger player even though they admit they do not know what the absolute best way to take advantage of this power is. They chose to create a highly non-uniform search and to provide insurance against simple errors.
2. Hardware evaluation. The evaluation function was implemented directly into the hardware, allowing for a fixed execution time.
3. Hybrid software/hardware search. They chose to use both a software search written in C as well as a fixed hardware search.
4. Massively parallel search. They had over 500 processors available to participate in the search, and used them in parallel to improve search times.

Other factors that contributed to performance were:

1. A complex evaluation function which recognised about 8000 different “patterns” an assigned each of them a value.
2. Effective use of a Grandmaster game database
3. A single-chip search engine
4. A strong emphasis on search extensions

Some possible improvements to the system are also suggested. In the words of the authors: “It is clear, however, that there were many areas where improvements could have been made. With additional effort, the parallel search efficiency could have been increased. The hardware search and evaluation could have been made more efficient and flexible with the addition of an external FPGA. Current research suggests that the addition of pruning mechanisms to Deep Blue might have significantly improved the search. Evaluation function tuning, both automatic and manual, was far from complete.”

Concluding, this paper offers a detailed explanation of how one of the most famous AI agents was developed, as well as what allowed it to become stronger than humans at chess.