Research review: **Deep Blue by Murray Campbell, A. Joseph Hoane Jr., Feng-hsiung Hsu**

The goal

The main goal of the paper is to describe the Deep Blue system, and give some of the rationale that went into the design decisions behind Deep Blue.

Historical notes

The paper provides some historical notes on a series of machines that led to Deep Blue. The early efforts in building a chess machine started in 1980s at Carnegie Mellon University, and moved to the IBM T.J. Watson Research Center at 1989.

Main ideas and techniques

The great advantage of the paper is that it describes not only the architecture of the Deep Blue, but also show a number of new challenges appeared (large searching capacity, hardware evaluation, hybrid software/hardware search, massively parallel search, etc.)

Some selected ideas, I found most interesting:

- The move generator in a chess chip is implemented as an 8 × 8 array of combinatorial logic, which is effectively a silicon chessboard. A hardwired finite state machine controls move generation.
- The evaluation function implemented in the Deep Blue chip is composed of a "fast evaluation" and a "slow evaluation".
- The chess chips optionally support the use of an external FPGA (Field Programmable Gate Array) to provide access to an external transposition table, more complicated search control, and additional terms for the evaluation function
- The mechanism of dual credit with delayed extensions search.
- The balance between hardware and software search: to strike a balance between the speed of the hardware search and the efficiency and complexity of the software search, authors limit the chess chips to carry out only shallow searches. This typically results in 4- or 5-ply searches plus quiescence in middlegame positions and somewhat deeper searches in endgames.

The paper also covers an important question of choosing evaluation function which is expectedly rather complex.

Authors also shown, that opening and ending books brought a lot of benefits.

Summary

The paper is a great high-level description of the famous chess program and can be used as a first step in researching the structure of the high quality chess programs.