Research Review for the paper 'Deep Blue'

(Paper: Murray Campbell, A. Joseph Hoane Jr., Feng-hsiung Hsu, "Deep Blue")

Summary:

'Deep Blue' is a chess game machine developed by IBM Research which defeated the then-world chess champion 'Garry Kasparov' in a six-game match in 1997.

Details:

This paper describes the history (Deep Thought, Deep Blue I) which lead to the Deep Blue System which defeated the grandmaster in 1997. It also compares the changes and improvements which lead to the success of Deep Blue System. Each version of the system leading up to the final Deep Blue System played multiple matches against various chess champions and grandmasters to analyse and improve its strategies. Many changes were made to the earlier versions of Deep Blue to achieve the final Deep Blue System revealed in 1997:

1. Chip design and speed:

   A new chess chip was designed with a better evaluation function which went around 6400 – 8000 features. The per-chip search speed was improved to 2 – 2.5 million positions per second. The chess chip included three parts: the move generator, the evaluation function, and the search control.

2. Improved search:

   The final Deep Blue System was a massively parallel system with one master and many workers model. The master processor analysed the top levels of the search tree and distributed the leaf nodes to the worker nodes for further analysis. The system relies on various techniques like quiescence search, iterative deepening, transposition tables, and NegaScout.

3. Hybrid search:

   Deep Blue combines a hardware search encoded in the chess chip with a much more flexible software search. The search was also made non-uniform. A move stack was used to keep track of moves that have been explored so far at each level of the search tree. Various software search strategies (E.g., forced moves, fractional extensions etc.) based on experience in real games with chess champions were included. A repetition detector was also included in the move stack.

4. Evaluation Function:

   The chess chip approximately recognized 8000 patterns and each was assigned a value. The evaluation function value was a sum of various feature values, where features ranged from very simple to very complex types. The Deep Blue had 54 registers and 8096 table entries

for a total of 8150 parameters in the evaluation function. The evaluation function features had both manual and automated tuning.

5. Opening moves:

   Deep Blue also had an opening book moves of around 4000 positions, hand created by Grandmaster Joel Benjamin, with assistance from Grandmasters Nick De Firmian, John Fedorowicz, and Miguel Illescas.

6. Extended Book:

   This helped to direct and influence Deep Blue System's play in the absence of opening book information. An ad hoc function that combined these factors in a nonlinear way to produce a scalar value as output was developed.

7. Endgame databases:

   Endgame databases were developed for all chess positions with five or fewer pieces on board. Various end game strategies were added to handle situations towards a win or at least a draw instead of a loss.

Many design choices were also made during the development of Deep Blue System by IBM Research. The authors also suggests future works and places of improvements to further improve the search tree pruning and the overall system. Overall, this paper gives an idea of the effort and hard work that goes into developing a successful game-changing research product.