DEEP BLUE SUMMARY

UDACITY RESEARCH REVIEW

I've read the Deep Blue paper by Murray Campbell, A. Joseph Hoane Jr. and Feng-hsiung Hsu. Below, I provide a brief summary of the paper, as well as overview of the research goals and overview of the Deep Blue machine design.

Summary

The paper describes how the Deep Blue, computer chess system, works. It also touches the history of development chess machines that were prerequisites to Deep Blue.
It introduces such techniques as dual credit search with delayed extensions, which is a search based on alpha-beta algorithm that was described in the course. The paper tells us about the principles that the search was designed with, such as fractional extensions, ffp's detection, delayed extension and dual credit. Also, the reader is introduced to a pruning mechanism called "no progress". For me, it was interesting to know that part of the Deep Blue search is executed on the hardware, and is done in parallel (parallel search), which increases the speed of search. On hardware side the quiescence search is run. Another fact that amazed me is that the evaluation function used in Deep Blue is incredibly complex and uses 8 000 features. Some of the features are regulated by the system in the process (dynamic values), and some are generated at the start of the game and cannot be changed thereafter (static values).

Goals

The team that was working on Deep Blue chess computer kept in mind a number of principles or characteristics that the machine should have in order to perform properly:

1. **Large Searching Capacity**, which means that the *search should be highly non-uniform* (in order to go deep enough) and *it should also provide "insurance" against simple errors*, i.e. all move sequences were explored to some reasonable minimum depth.
2. **The evaluation function should be implemented in hardware**. In my opinion this was done in order for machine to perform faster and better, because execution of evaluation function in hardware means that time to execute it is a

fixed constant. However, the fact that evaluation function is run on hardware brings some drawbacks: for example, it's not possible to modify the function and add new features to it.

3. **Massively Parallel Search**. This was done in order to improve performance of the machine, and be able to search multiple paths simoultaneously.

Design

Chess Chip

The most important part of the machine, in my opinion is the chess chip which consists of 3 parts: the move generator, the evaluation function, and the search control.

1. **Move Generator**. The move generator is implemented as an 8x8 array of combinatorial logic. It computes all the possible moves and selects one via an arbitration network.
2. **Evaluation Function**. The evaluation function consists of 2 parts: "slow evaluation" and "fast evaluation". It was done in order to skip computing full evaluation. The fast evaluation computes a score for a chess position in a single clock cycle. And the slow evaluation scans chess board one column at a time, computing values for various chess concepts.
3. **Search Control**. Used to implement null-window alpha-beta search.

Hardware Search takes place on the chess chip, and performs a fixed-depth null-window search, which includes a quiescence search.

Software Search

The software search that is used in Deep Blue is based on a depth-limited version of alpha-beta using the negamax formulation, with some logic added on top, called dual credit with delayed extensions search. **Delayed extensions** means that ffp's can accumulate credit, and when sufficient credit is available it can be "cashed in" for an extension. The **dual credit** part means that if one side accumulates sufficient credit to cash in for an extension, the other side must give up an equal amount of credit. There are also some other principles, that were the basis for the search algorithm.

Parallel Search

As the search gets deeper, jobs get allocated throughout the system. Parallel search that was used on Deep Blue is non-deterministic

Evaluation Function

The evaluation function used in Deep Blue is a sum of feature values, which account to amount of about 8000. The features that are used are either static or dynamic. Static values are set once at the beginning of the search, dynamic values are also initialised at the beginning of a search, but scaled during the search, via table lookup, based on the value and type of pieces on the board at the evaluation time. The values are generated with evaluation function generated, which was run on the master node of SP system.

Results

The Deep Blue system defeated Garry Kasparov in 1997 match. The paper showed that such improvements as tuning of evaluation function in a manual and automatic ways, better hardware (in this case, chip, which supports repetition detection; increasing the number of chips) can increase the performance of the AI agent significantly and lead to needed results.