Paper chosen: Deep Blue

Goals and Techniques introduced

This paper introduces many techniques around game tree searching that helped the system evolve into beating the then reigning chess grandmaster Gary Kasparov. There were a few techniques that were also in the video lectures:

1. Quiescent searches
2. Iterative deepening
3. Pruning
4. Evaluation functions
5. Chess specific optimizations (as described in course, AI is all about finding the hacks)

New techniques introduced to improve the above:

1. **Dual credit with delayed extensions.** This was the form of selective search that was new to Deep Blue II in which it was important to calculate chains of moves where one side has delaying moves to an obvious threat but the other side has sacrifices which can result in a quicker checkmate. Since the moves are meaningless by themselves, the search needs to be done through the chain and only applied when the chain has enough credit (i.e. delay extension) and the credit needs to be computed for each side since the expectation depends on a pair of moves (ex: white doesn't make a sacrifice to get a quicker checkmate AND black plays a delaying move).
2. **Human knowledge.** The system was fed with opening game and end move playbooks taken from previous grandmaster games and evaluated with how many times a grandmaster played that move, strength of the grandmaster (Kasparov vs. level 1 grandmasters), etc. This allowed the system to have available moves when the game tree search doesn't return a singular good move or in cases where the time is running out.
3. **Panic time control.** In our implementation of Isolation game agent, we had a static timeout. In the game of tournament chess, you have 2 hours to make the first 40 moves. While a simple mechanism would be to divide 120 minutes / 40 moves = 3 mins/ move calculation, Deep Blue II used other factors such as leaving more time for the end in case of a system issue, spending more time on a move if its towards the end game, spending more time on a move if the score calculation relative to previous move drops more than threshold, etc. In our example of isolation, this could be applied as well for things like leaving more time for end game moves or doing a deeper search if the player is starting to get blocked towards the edge of the board etc.

New technologies:

1. **Massively Parallel using custom system architecture.** The system contained of 30 nodes (1 master and 29 slaves) each with 16 chess chips to compute functions. The job of the master is to calculate the root node and assign leafs to Tier 1 nodes (evaluate good moves) and Tier 2 nodes (evaluate bad moves) and then act as the boundary to the software evaluation function.
2. **Splitting search functions between hardware and software.** This allowed base features to be calculated extremely fast by the hardware chip and more experimental features to be calculated slowly but with more flexibility.

Results Summary

Deep Blue II (system which beat Gary Kasparov in 1997) was a superset of the abilities created in previous machines (Deep Blue I, Deep Thought, ChipTest). This superset was not only bigger hardware (480 processor vs 216 in previous generation, bigger RAM) but also in the software (feature groups in evaluation function). This resulted in 30% more efficiency in deep forcing sequence moves and 75% more efficiency in quieter positions and resulted in Deep Blue II defeating Gary Kasparov 3.5-2.5, Larry Christiansen 1.5-0.5, and Michael Rohde 1.5-0.5 whereas its previous generation lost to Gary Kasparov 2-4, drew Patrick Wolff 1-1, and lost to Joel Benjamin 0-2.