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AIND Project 2: Advanced Game Playing
February 20, 2017

Deep Blue

Artificial Intelligence 134 (2002) 57–83
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Summary

Deep Blue is the culmination of a multi-year effort to build a world-class chess machine. It all started at Carnegie Mellon University in the 1980s, where a team of researchers worked on Deep Blue's predecessors *ChipTest* and *Deep Thought*. In 1989, part of the Deep Thought team moved to the IBM T.J. Watson Research Center, where Deep Blue was developed.

There are two distinct versions of Deep Blue, one which lost to Garry Kasparov in 1996 (Deep Blue I) and the one which defeated him in 1997 (Deep Blue II). After the defeat, the team worked on implementing a series of changes in preparation for the rematch. The most notable improvements include:

1. An improved, single-chip chess search engine

A significantly enhanced chess chip was designed for Deep Blue II. The new chess chip had a completely redesigned evaluation function, hardware repetition detection, a number of specialized move generation modes, and improved search speeds. In addition, the number of chips in the whole system doubled, and tools for debugging and evaluation tuning were introduced.

2. Multilevel parallel search system

Deep Blue is organized in three layers. One of the processors is designated as the master, and the others as workers. The master searches the top levels of the game tree, and then distributes leaf positions to the workers. The workers carry out a few levels of additional search and then distribute their leaf positions to the chess chips, which search the last few levels of the tree.

The hardware search that takes place on the chips is fast but relatively simple. To strike a balance between the speed of the hardware search and the efficiency and complexity of the software search, the chess chips are limited to carry out only shallow searches.

3. Search extensions

The software search was designed with a strong emphasis on search extensions. One of the goals behind this approach is to avoid a search explosion when extending forcing/forced pairs of moves (ffp). One method of addressing this problem is to allow fractional extensions, where an ffp does not get a full 2-ply extension, but a smaller amount, say 1.75 ply. The less forcing the ffp, the less the extension. Another notable technique implemented is allowing ffp's to accumulate "credit", and only when sufficient credit is available can it be "cashed in" for an extension.

4. Complex evaluation function

The Deep Blue evaluation function is essentially a sum of feature values. The chess chip recognizes about 8000 different patterns, and each is assigned a value. The initialization of the feature values is done by the "evaluation function generator", a sub-program running on the master node. The evaluation generator makes these abstractions, dictating relationships between groups of related feature values rather than setting them independently.

5. A Grandmaster game database

An Opening book and an Extended book (to be used in the absence of opening book information) were created for Deep Blue. The openings were chosen to emphasize positions that the agent played well. A particular repertoire was selected before a game started. An Endgame database was also included but did not play a critical role in the matches against Kasparov.

The introduction of the described improvements resulted in a historic victory for Deep Blue, the first AI agent to win a chess match against a grandmaster and reigning world champion under regular time controls.