

Research Review - AIND

Game Tree Searching by Min/Max Approximation*

This paper introduces the use of generalized mean-valued pairs as a means of identifying those nodes which have the most bearing on the outcome of a game. Additionally, this novel method is superior (albeit having more computational overhead) to minimax search with alpha-beta pruning for the same number of calls to the move operator.

Overview

The “min/max approximation” technique introduced in this paper builds on the assertion that “A method is needed that will always expand the node that is expected to have the largest effect on the value”. This is achieved using approximation of “min” and “max” operators with generalized mean-value operators which allows us to expand that node, on whose value the root depends most heavily. Generalized means used in this technique provide a good approximation to max or min values and are more suitable for “sensitivity analysis”, due to the continuous nature of derivatives.

Considering a two-person zero-sum perfect information “non-pathological” game, the associated game tree assumes non-trivial proportions rather quickly. With time being a limiting factor, minimax with alpha-beta pruning allows us to explore a small fraction of the game tree and yet produce optimal play. However, for interesting games with even larger game trees, good heuristic approximations are needed. The heuristic proposed in this paper requires a *single static evaluator* that is applied to each node as the tree is traversed iteratively, finally “backing up” the values to the root. The main crux of this technique is the *penalty-based* iterative search method to choose an optimal node which is expanded to form the *partial game tree*. A generic penalty-based scheme involved assigning a nonnegative penalty to every edge in the game tree such that tip nodes with the least penalty are expanded. The “min/max approximation” heuristic extends this and defines the penalties in terms of derivatives of the approximating functions. Implementing such a scheme has a large computation cost, owing to the number of powers and roots involved, and thus this paper introduces the “reverse approximation” technique which uses logarithms that can be computed via table-lookups (since the static evaluation functions returns integers within some range).

Results

The experimental results (using a game of *Connect-Four*) show that this approach can produce play superior to minimax search with alpha-beta pruning when calls to the “move” operator are the main consideration. The number of distinct positions considered by alpha-beta was approximately three times larger than that considered by min/max when a time bound was in effect. However, when we base the comparison on CPU time, minimax search with alpha-beta pruning outperforms the min/max approximation.

Though penalty-based schemes have an inherently larger memory requirement, the “min/max approximation” heuristic is found to allocate resources sensibly by searching shallowly in unpromising parts of the tree and deeper in promising sections. With further development and optimization, competitiveness of this technique can be improved further.