RESEARCH REVIEW

Game Tree Searching by Min Max Approximation

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‘Game Tree Searching by Min Max Approximation’ is a report which looks into using generalised mean operators to approximate the ‘min’ and ‘max’ values in a game tree. Their new technique aims to reduce the strain on the limiting factor of game tree searching - the computational time.

Throughout the report, techniques to search a game tree are discussed; such as alpha-beta, pruning which aims to reduce the number of branches the search needs to evaluate; and iterative deepening, which only allows the game tree to be searched to a set number of levels.

The minimax approximation heuristic is an altered version of the penalty-based search method. The penalty-based search method penalises edge nodes of the game tree which represent a bad move, more than an edge node which represents a good move. It then uses these penalty values to decide which leaf node should be expanded. In minimax approximation, the penalties are defined in terms of the derivatives of the approximating functions. The approximation approach swaps out the standard way of calculating the min max operators for a generalised p-mean function. The reason for the use of this function is that is it “more suitable for a ‘sensitivity analysis’ than the min or max functions” and the derivative of the min max values provides us with no extra information.

The paper states that implementing a generalised p-mean function is computationally expensive and therefore they use a ‘reverse approximation’ method instead. The generalised mean would give a ‘sensitivity weight’ to each parent and child in the tree. This is instead achieved by using the weighting equation

$$w(c) = log(n) + (p - 1) \cdot (log(v_e(d)) \cdot log(v_e(c)))$$

which provides them with a weight based on the depth and accuracy of the approximation.

The paper presents 2 sets of test results where the limiting factor is different. Set 1 limits the player based on CPU time, whereas set 2 limits the player based on calls to the ‘move’ operator. Due to the additional computational time required for a penalty based approach, the results of their testing (using the game of Connect Four) shows that their method of min max approximation is superior to Alpha Beta implementations except when CPU time is the limiting factor, in which case Alpha Beta pruning is still proves to be better.

In conclusion, this means that where the agent is limited to a number of calls to the ‘move’ operator, instead of by CPU time, min max approximation will outperform Alpha Beta pruning. The paper suggests that their implementation could perform better on special-purpose hardware.