Research Review

Game Tree Searching by Min / Max Approximation

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Abstract and conclusion: The paper introduces a then-new technique for searching game tree based on the idea of approximating the min and max functions with a generalized mean-value function. The approximation is used to select which leaf node to expand. The author claims that the approximations allow efficient selection of leaf nodes whose values have the highest impact on the value of the root node. The method was tested on 1000 games of Connect-Four, and the results suggest superior performance compared to minimax search with alpha-beta pruning.

The main idea: A selective iterative technique, different from iterative deepening (ID), is used to expand the search tree. At each level of search tree, a node that is calculated to have the highest impact on the root node, is chosen and expanded. Then the new values taken from the evaluation function are used to re-evaluate the values of the nodes ancestors. As a results the tree does not expand uniformly. On the selection of which nodes to choose, a penalty based scheme in which a penalty is associated with each edge, is introduced. The total penalty up to each node is defined as the sum of the edge penalties from the root to each node. The total penalty is used to decide which node/tip to be explored next. The method allows retracting from a deep level to a level closer to the root and expansion of a node that has lower penalty. The scheme and the exploration continues till the allocated time is up.

Discussion: a) The introduced penalty based scheme requires storing the expanded tree and all the associated values, and as a result it may not perform well if memory resources are scarce. b) It requires exploring all the children of a node for the purpose selecting the best, unlike the alphabet pruning that can ignore some when appropriate. c) The scheme requires searching all the un-explored nodes at all different depth to choose the next node/tip to explore, and this is not efficient as compared with depth search first. d) At each depth, the penalty based scheme does not spend time evaluating non-optimized leaves, which may turn out to be better choices at deeper levels.

Issues and open questions - 1: The paper introduces a heuristic method, but the questions of what functions for the mean-value approximation and penalty shall be used are left open to be explored. *2:* Author suggests that the efficiency of depth first search in minimax and alphabeta pruning may be combined with this penalty based scheme to produce superb performance. *3:* The introduced method may not work well in cases that sacrifices can produce later advantageous positions!