Game Tree Searching by Min / Max Approximation

The paper introduces a new technique for searching min/max game trees and compares it to minimax search with alpha-beta pruning. The goals of the paper are to improve the searching mechanism.

The technique used in the paper combines a Penalty-based iterative search method and approximations of the min and max operators using generalized mean rather than min and max functions in order to get a better result.

The paper explains that the major reason for using generalized means, is that, generalized means are more suitable for Sensitivity analysis. Since, the min and max functions are discrete, it is not possible to get an estimate of the sensitivity, but, where when using the generalized means and taking the derivate of the generalized means, we can get a continuous behavior.
By using generalized mean values to approximate the min and max functions, it is possible to identify which leaf the root depends on most strongly.

Iterative heuristics works by growing the search tree one step a time. At each step, a leaf node or tip is picked and then the successors are added to it. At this point, the values provided by the evaluator function, are backed up to the ancestors of this tip.
The main problem is the question of picking the right tip for expansion. The paper provides a new answer to this question. The paper presents a method for picking the tip for expansion. This method is explained next.

The method used for picking the tip works by assigning a non-negative penalty weight for every edge in the game tree, such that bad moves are penalized more than good moves. The penalty of tip is the sum of all the penalties of all edges between the root node and the tip. The sum is calculated for all the tips and the tip with the least penalty is picked.

The min/max approximation technique presented in the paper is a special case of penalty-based search method, where the penalties are described using derivatives of the approximating generalized mean functions. The derivatives of the approximation functions measure the sensitivity of the root node to changes in the tip. The paper describes that the root heavily depends on the tip with least penalty.

The paper then describes the method followed for computing the generalized means. Since, the computation of the generalize means is very complex, the paper presents a new idea of reverse approximation. In the reverse approximation method, the computation of generalized mean values is skipped and the approximate min and max values are used instead. The paper explains that, since, the generalized mean values are used for the approximation of the min and max values, using the approximate min and max values anyway is fine and may not introduce much error.

The paper then presents the results of the proposed methods compares them to the minimax search with alpha-beta pruning for over 1000 games of Connect-four.
The results of the paper show that the number of moves performed by the proposed method are much less than the latter. The results show that the technique proposed is superior to minimax search with alpha-beta pruning when time is not a constraint. However, the minimax search with alpha-beta pruning in still superior when time is a concern.