Home * **Automated Tuning**

Engine Tuner [3]

Automated Tuning,
an automated adjustment of evaluation parameters or weights, and less commonly, search parameters [1], with the aim to improve the playing strength of a chess engine or game playing program. Evaluation tuning can be applied by mathematical optimization or machine learning, both fields with huge overlaps. Learning approaches are subdivided into supervised learning using labeled data, and reinforcement learning to learn from trying, facing the exploration (of uncharted territory) and exploitation (of current knowledge) dilemma. Johannes Fürnkranz gives a comprehensive overview in *Machine Learning in Games: A Survey* published in 2000 [2], covering evaluation tuning in chapter 4.

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Playing Strength

A difficulty in tuning and automated tuning of engine parameters is measuring playing strength. Using small sets of test-positions, which was quite common in former times to estimate relative strength of chess programs, lacks adequate diversity for a reliable strength predication. In particular, solving test-positions does not necessarily correlate with practical playing strength in matches against other opponents. Therefore, measuring strength requires to play many games against a reference opponent to determine the win rate with a certain confidence. The closer the strength of two opponents, the more games are necessary to determine whether changed parameters or weights in one of them are improvements or not, up to several tens of thousands. Playing many games with ultra short time controls has became de facto standard with todays strong programs, as for instance applied in Stockfish's Fishtest, using the sequential probability ratio test (SPRT) to possibly terminate a match early [4].

Parameter

Quote by Ingo Althöfer [5] [6]:

```
It is one of the best arts to find the right SMALL set of parameters
and to tune them.

Some 12 years ago I had a technical article on this ("On telescoping
linear evaluation functions") in the ICCA Journal, Vol. 16, No. 2, pp.
91-94, describing a theorem (of existence) which says that in case of
linear evaluation functions with lots of terms there is always a small
subset of the terms such that this set with the right parameters is
almost as good as the full evaluation function.
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Mathematical Optimization

Mathematical optimization methods in tuning consider the engine as a black box.

Methods

- CLOP
- Genetic Algorithms
- PBIL
- Simulated Annealing
- SPSA

Instances

- Genetic Algorithm in Falcon
- Stockfish's Tuning Method

Advantages

- Works with all engine parameters, including search
- Takes search-eval interaction into account

Disadvantages

- Time complexity issues with increasing number of weights to tune

Reinforment Learning

Reinforcement learning, in particular temporal difference learning, has a long history in tuning evaluation weights in game programming, first seeen in the late 50s by Arthur Samuel in his Checkers player [7]. In self play against a stable copy of itself, after each move, the weights of the evaluation function were adjusted in a way that the score of the root position after a quiescence search became closer to the score of the full search. This TD method was generalized and formalized by Richard Sutton in 1988 [8], who introduced the decay parameter **λ**, where proportions of the score came from the outcome of Monte Carlo simulated games, tapering between bootstrapping (λ = 0) and Monte Carlo (λ = 1). TD-λ was famously applied by Gerald Tesauro in his Backgammon program TD-Gammon [9] [10], its minimax adaption TD-Leaf was successful used in eval tuning of chess programs [11], with KnightCap [12] and CilkChess [13] as prominent samples.

Instances

- TD-λ
- TD-Leaf
- RootStrap
- TreeStrap

Engines

- CilkChess
- EXchess [14]
- FUSc#
- Green Light Chess
- KnightCap
- Meep
- NeuroChess
- SAL
- Tao
- TDChess

Supervised Learning

Move Adaption

One supervised learning method considers desired moves from a set of positions, likely from grandmaster games, and tries to adjust their evaluation weights so that for instance a one-ply search agrees with the desired move. Already pioneering in reinforcement learning some years before, move adaption was

described by Arthur Samuel in 1967 as used in the second version of his checkers player [15], where a structure of stacked linear evaluation functions was trained by computing a correlation measure based on the number of times the feature rated an alternative move higher than the desired move played by an expert [16]. In chess, move adaption was first described by Thomas Nitsche in 1982 [17], and with some extensions by Tony Marsland in 1985 [18]. Eval Tuning in Deep Thought as mentioned by Feng-hsiung Hsu et al. in 1990 [19], and later published by Andreas Nowatzyk, is also based on an extended form of move adaption [20]. Jonathan Schaeffer's and Paul Lu's efforts to make Deep Thought's approach work for Chinook in 1990 failed [21] - nothing seemed to produce results that were as good than their hand-tuned effort [22].

Value Adaption

A second supervised learning approach used to tune evaluation weights is based on regression of the desired value, i.e. using the final outcome from huge sets of positions from quality games, or other information supplied by a supervisor, i.e. in form of annotations from position evaluation symbols. Often, value adaption is reinforced by determining an expected outcome by self play [23].

Advantages

- Can modify any number of weights simultaneously - constant time complexity

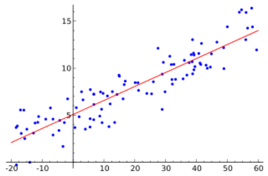
Disadvantages

- Requires a source for the labeled data
- Can only be used for evaluation weights or anything else that can be labeled
- Works not optimal when combined with search

Regression

Regression analysis is a statistical process with a substantial overlap with machine learning to predict the value of an Y variable (output), given known value pairs of the X and Y variables. Parameter estimation in regression analysis can be formulated as the minimization of a cost or loss function over a training set [24], such as mean squared error or cross-entropy error function for binary classification [25]. The minimization is implemented by iterative optimization algorithms or metaheuristics such as Iterated local search, Gauss–Newton algorithm, or conjugate gradient method.

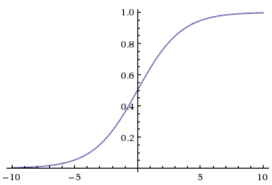
Linear Regression



Linear Regression [29]

The supervised problem of regression applied to move adaption was used by Thomas Nitsche in 1982, minimizing the mean squared error of a cost function considering the program's and a grandmaster's choice of moves, as mentioned, extended by Tony Marsland in 1985, and later by the Deep Thought team. Regression used to adapt desired values was described by Donald H. Mitchell in his 1984 masters thesis on evaluation features in Othello, cited by Michael Buro [26] [27]. Jens Christensen applied linear regression to chess in 1986 to learn point values in the domain of temporal difference learning [28].

Logistic Regression



Since the relationship between win percentage and pawn advantage is assumed to follow a logistic model, one may treat static evaluation as single-layer perceptron or single neuron ANN with the common logistic activation function, performing the perceptron algorithm to train it [30]. Logistic regression in evaluation tuning was first elaborated by Michael Buro in 1995 [31], and proved successful in the game of Othello in comparison with Fisher's linear discriminant and quadratic discriminant function for normally distributed features, and served as eponym of his Othello program *Logistello* [32]. In computer chess, logistic regression was proposed by Miguel

Logistic function [39]

A. Ballicora in a 2009 CCC post, as applied to Gaviota [33], was independently described by Amir Ban in 2012 for Junior's evaluation learning [34], and explicitly mentioned by Álvaro Begué in a January 2014 CCC discussion [35], when Peter Österlund explained Texel's Tuning Method [36], which subsequently popularized logistic regression tuning in computer chess. Vladimir Medvedev's Point Value by Regression Analysis [37] [38] experiments showed why the logistic function is appropriate, and further used cross-entropy and regularization.

Instances

- Arasan's Tuning
- Eval Tuning in Deep Thought
- Minimax Tree Optimization (MMTO or the Bonanza-Method in Shogi)
- Point Value by Regression Analysis
- RuyTune
- Texel's Tuning Method
- Winter

See also

- Dynamic Programming
- Evaluation
- Iteration
- Knowledge
- Learning
- Match Statistics
- Neural Networks
- Trial and Error

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