

CLOP: Confident Local Optimization for Noisy Black-Box Parameter Tuning

Rémi Coulom



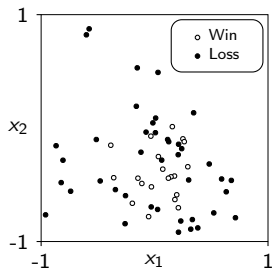
November, 2011

Advances in Computer Games 13

Noisy Black-Box Optimization

Problem: Optimizing a game-playing Program

- Heuristic parameters: evaluation, search, ...
- Observation: game outcomes (win or loss (or draw))
- Objective: maximize probability of winning



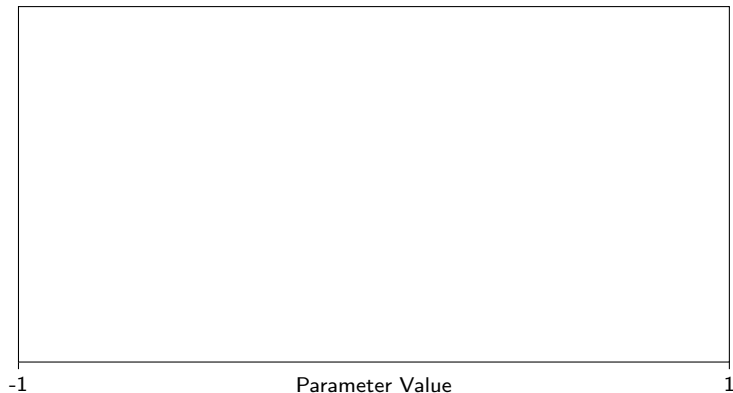
Two sub-problems

- 1 Estimate optimal \vec{x}
- 2 Choose next \vec{x}

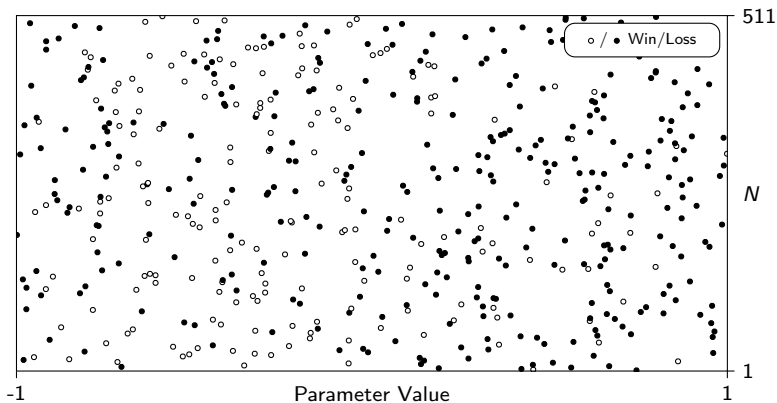
Presentation Outline

- CLOP algorithm
- Experiments on artificial data

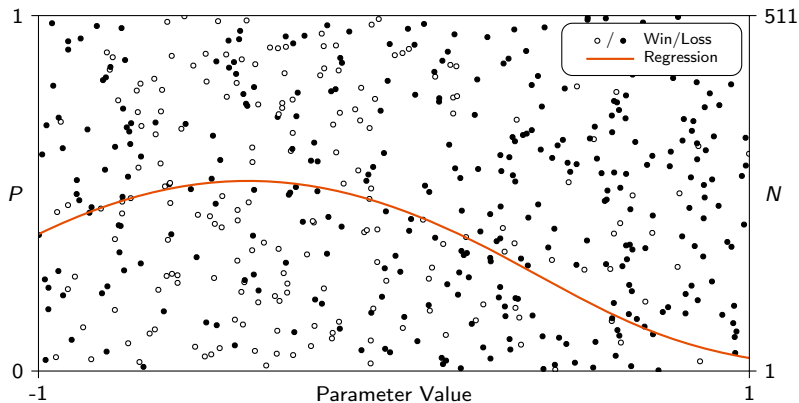
CLOP: Method for Optimum Estimation



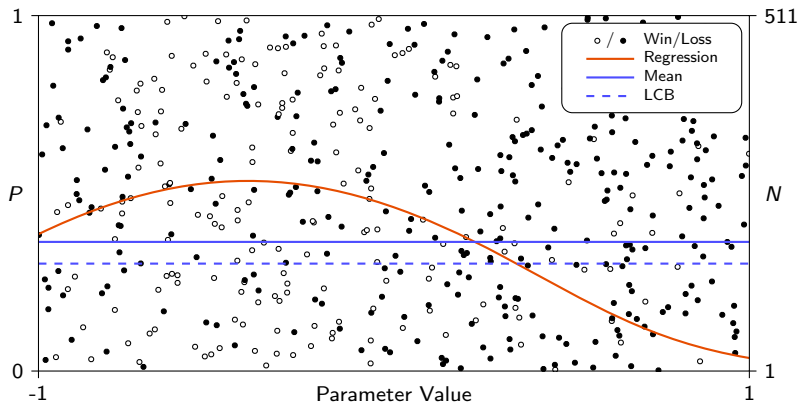
Step 1: Data



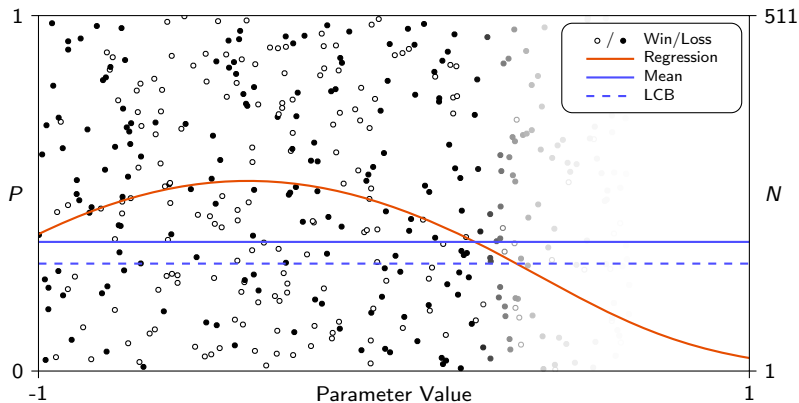
Step 2: Quadratic Logistic Regression



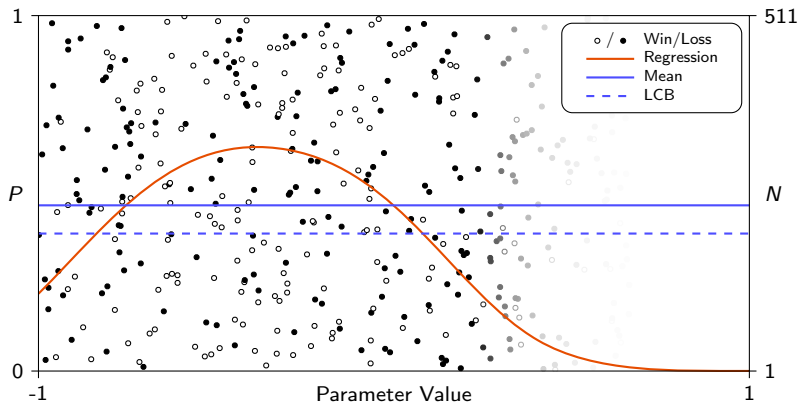
Step 3: Lower Confidence Bound



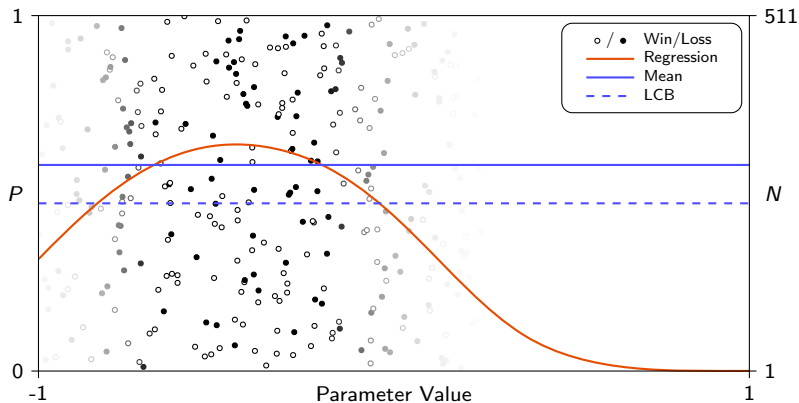
Step 4: Discard Samples Below LCB = $\mu - H\sigma$



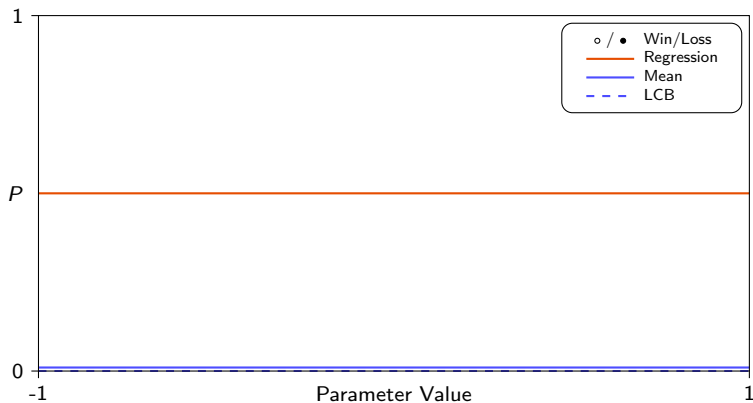
Step 5: Re-compute Regression with Remaining Samples



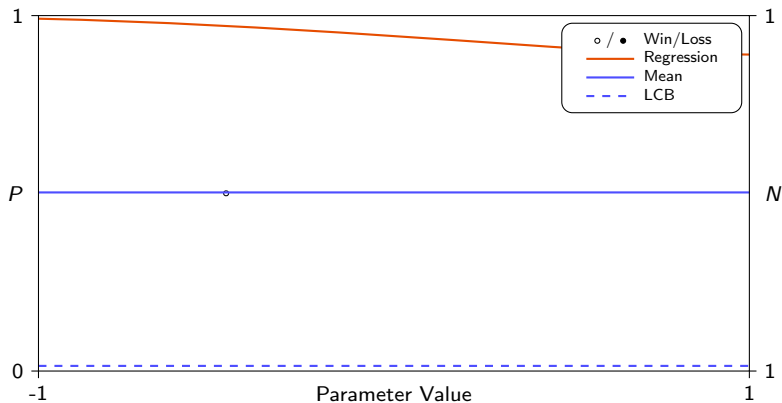
Step 6: Iterate Until Convergence



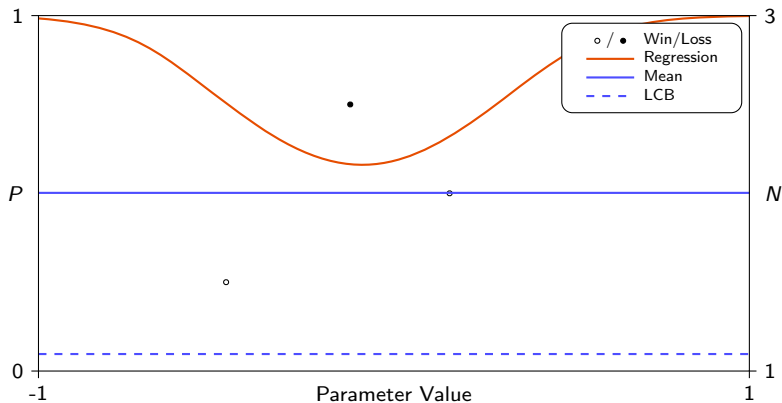
Sampling Policy: Density = Weight



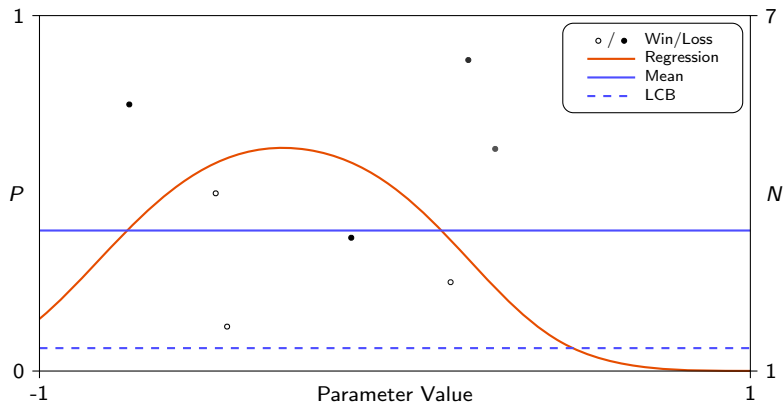
Sampling Policy: Density = Weight



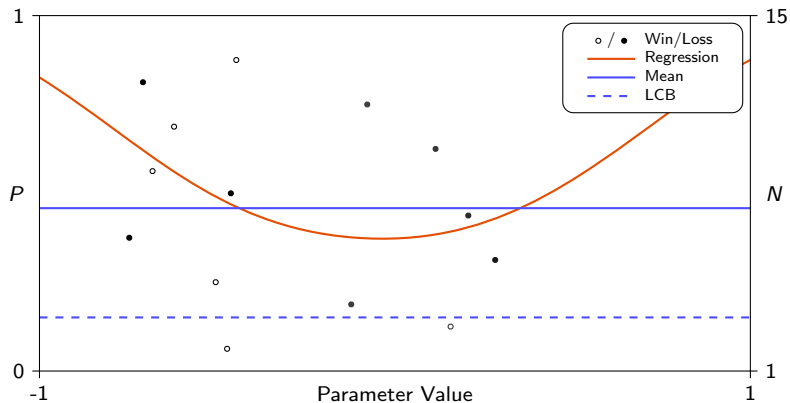
Sampling Policy: Density = Weight



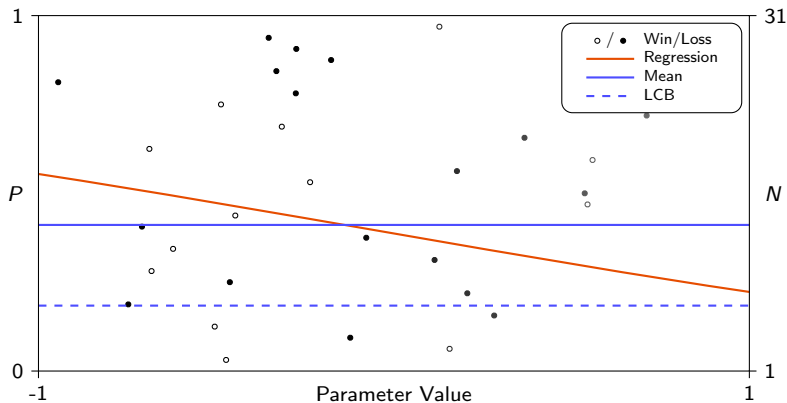
Sampling Policy: Density = Weight



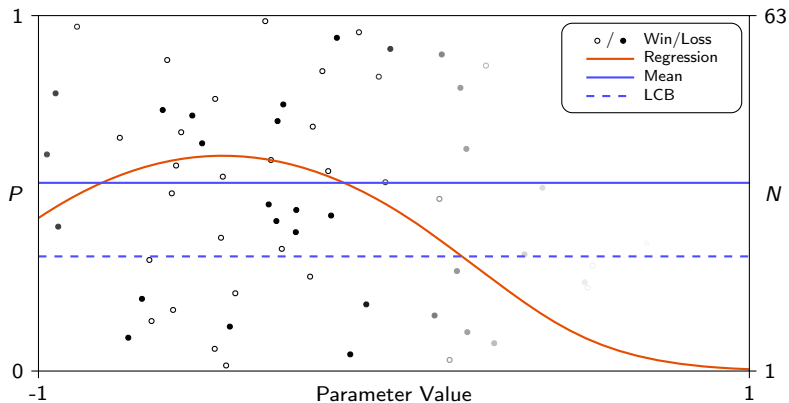
Sampling Policy: Density = Weight



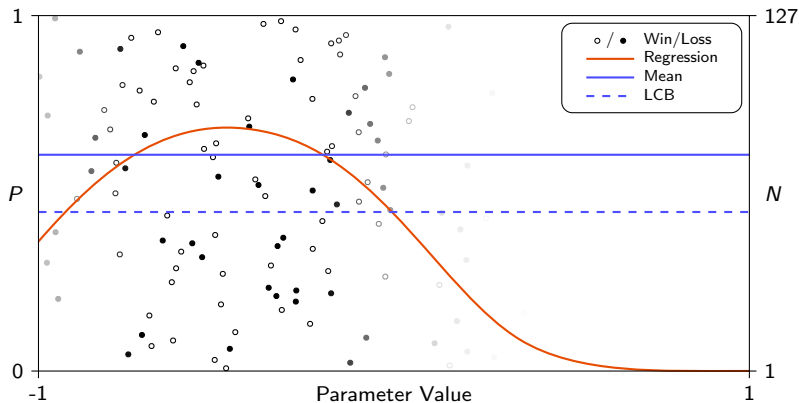
Sampling Policy: Density = Weight



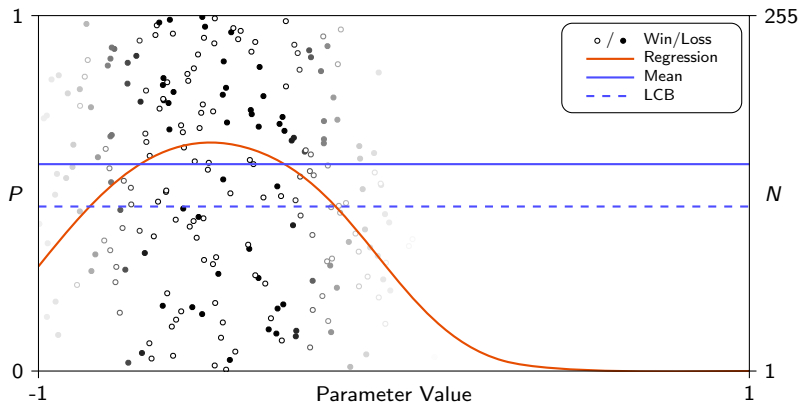
Sampling Policy: Density = Weight



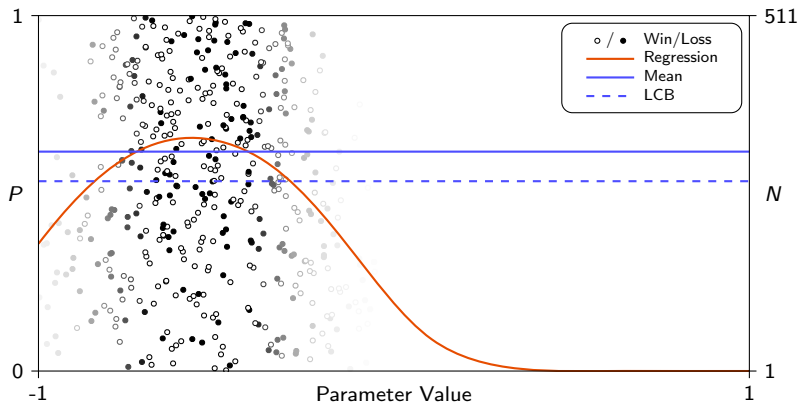
Sampling Policy: Density = Weight



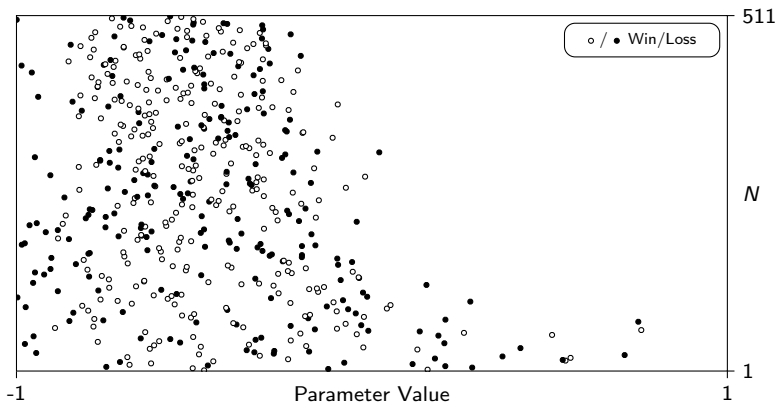
Sampling Policy: Density = Weight



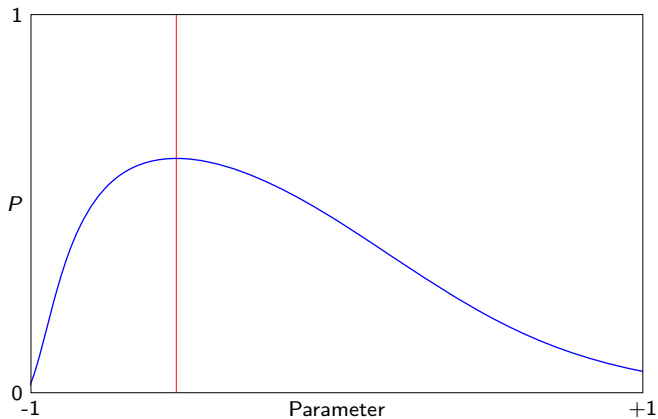
Sampling Policy: Density = Weight



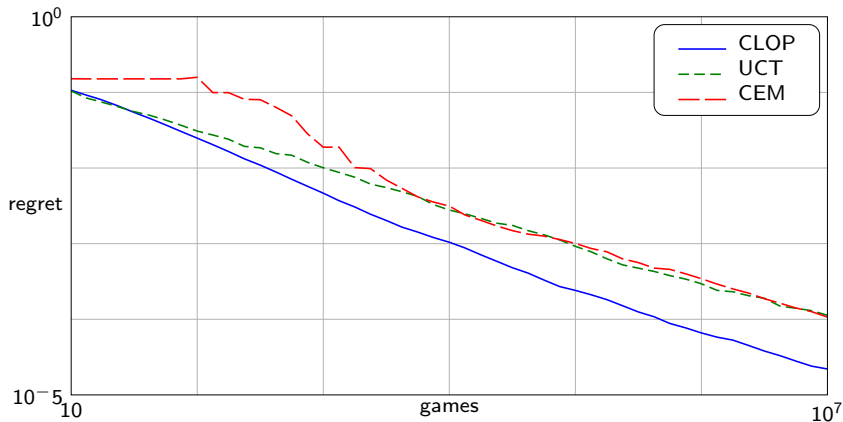
Sampling Policy: Density = Weight



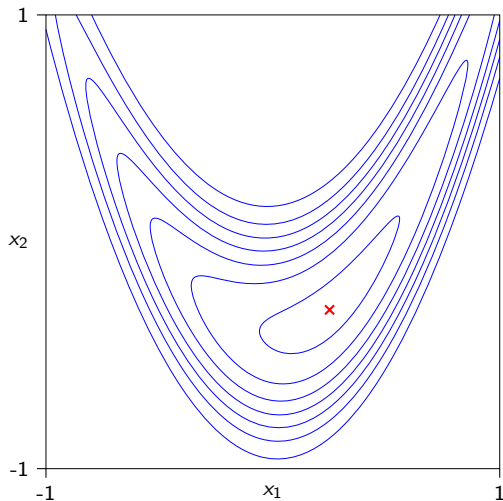
Smooth 1D function



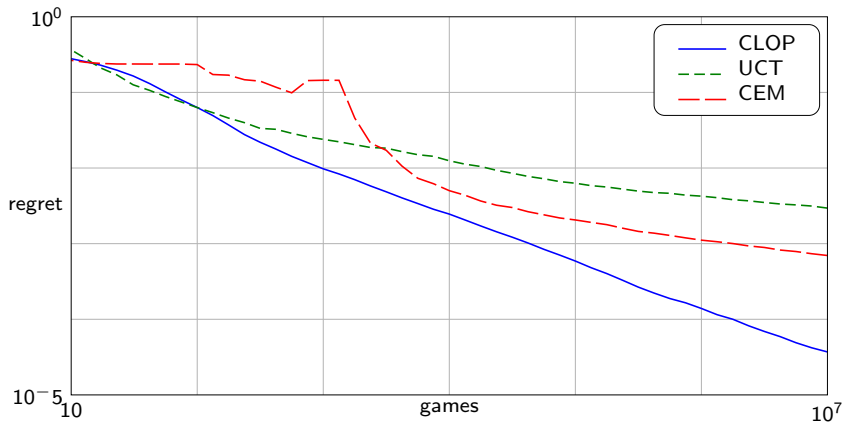
Smooth 1D function



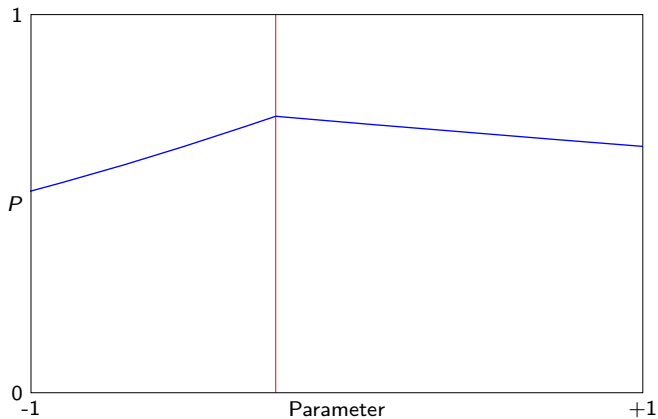
Rosenbrock



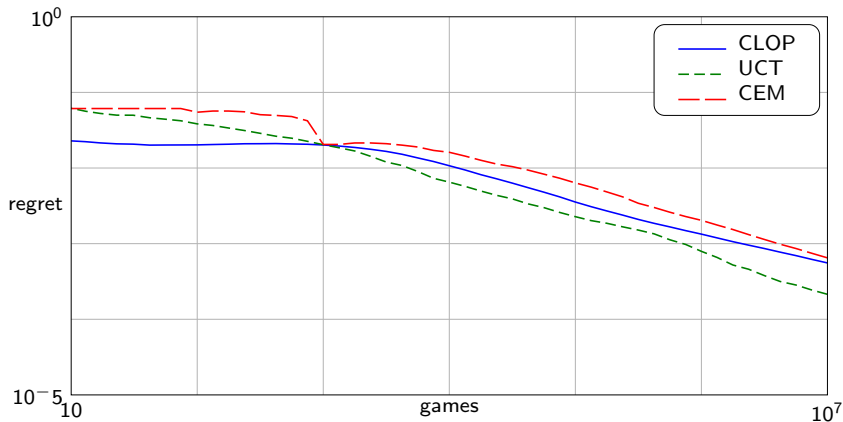
Rosenbrock



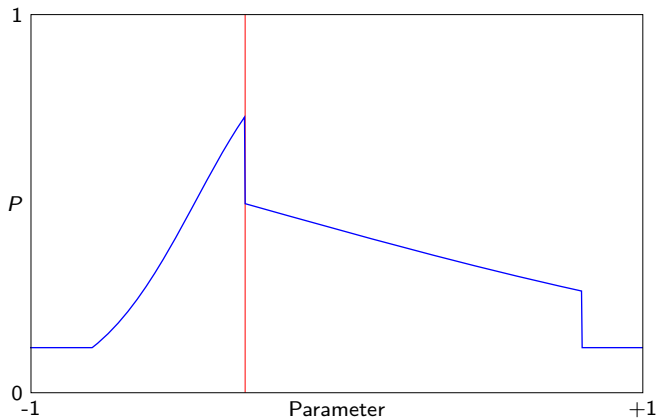
Angle



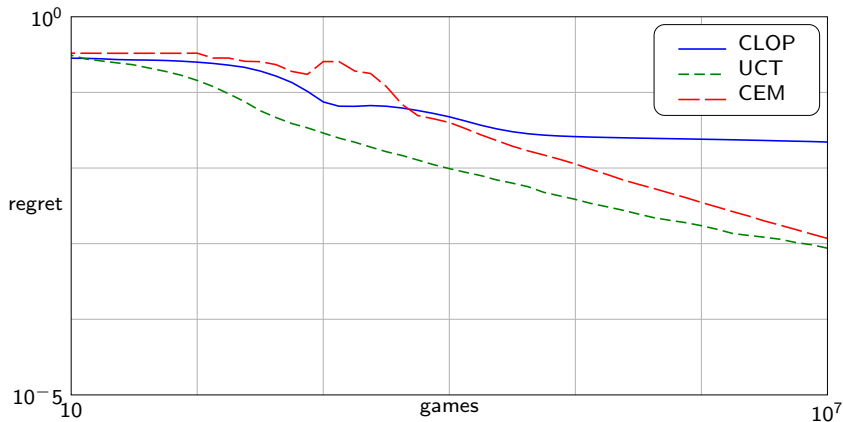
Angle



Discontinuous Function



Discontinuous Function



Conclusion

Summary of CLOP

- Much faster black-box optimizer than state of the art in games
- Foolproof: no tricky meta-parameters
- Popular freeware: <http://remi.coulom.free.fr/CLOP/>

Future Work

- High-dimensional problems: more regularization, sparsity
- Apply to less noisy or noiseless problems (BBOB)
- Apply CLOP principle to other forms of regression
- Optimization from self-play
- Prove convergence

Extra Slide: Code

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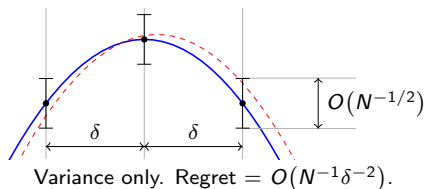
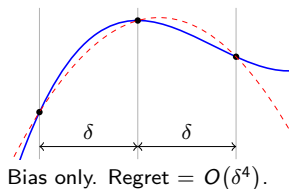
procedure QUADRATICCLOP( $H, \vec{x}_1, y_1, \dots, \vec{x}_N, y_N$ )
   $w_0 \leftarrow \lambda \vec{x}.1$  ▷ a function of  $\vec{x}$  that returns 1
   $W_0 \leftarrow N$ 
   $k \leftarrow 0$ 

  repeat
     $w \leftarrow \lambda \vec{x}. \min_{i=0}^k w_i(\vec{x})$  ▷ weight function
     $k \leftarrow k + 1$ 
     $q_k \leftarrow \text{QUADRATICLOGISTICREGRESSION}(w, \vec{x}_1, y_1, \dots, \vec{x}_N, y_N)$ 
     $\mu_k \leftarrow \text{LOGISTICMEAN}(w, \vec{x}_1, y_1, \dots, \vec{x}_N, y_N)$ 
     $\sigma_k \leftarrow \text{CONFIDENCEDEVIATION}(w, \vec{x}_1, y_1, \dots, \vec{x}_N, y_N)$ 
     $w_k \leftarrow \lambda \vec{x}. e^{(q_k(\vec{x}) - \mu_k) / (H \sigma_k)}$ 
     $W_k \leftarrow \sum_{i=1}^N \min(w(\vec{x}_i), w_k(\vec{x}_i))$ 
  until  $W_k > 0.99 \times W_{k-1}$ 

   $\vec{x}_{N+1} \leftarrow \text{RANDOM}(w)$  ▷ next sample, distributed like  $w$ 
   $\tilde{\vec{x}} \leftarrow \sum_{i=1}^{N+1} w(\vec{x}_i) \vec{x}_i / \sum_{i=1}^{N+1} w(\vec{x}_i)$  ▷ estimated optimal
end procedure

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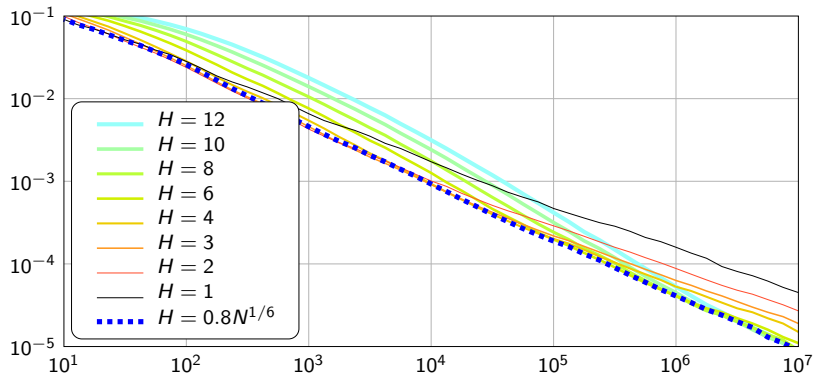
Asymptotic Rate of Convergence (Intuitively)



Optimal asymptotic bias-variance tradeoff: regret = $O(N^{-2/3})$.

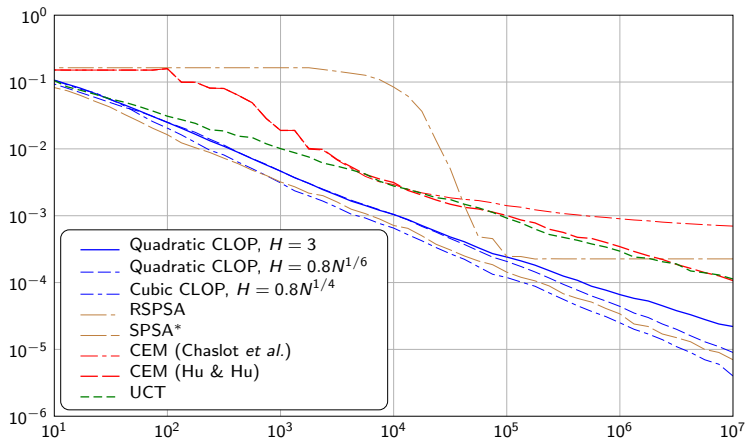
Effect of Meta-Parameter H

TODO: name of axes.

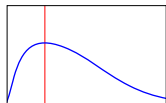


Conclusion (of many other experiments): $H = 3$ works well in practice.

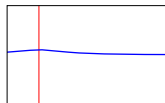
Extra Slide: Many algorithms



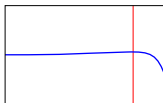
Extra Slide: 1D Problems



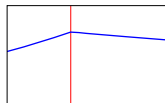
(a) LOG



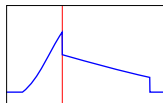
(b) FLAT



(c) POWER

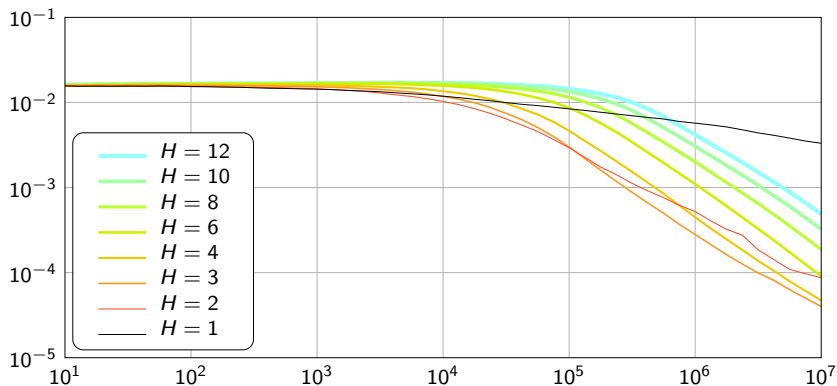


(d) ANGLE

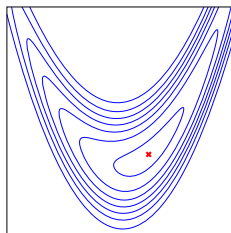


(e) STEP

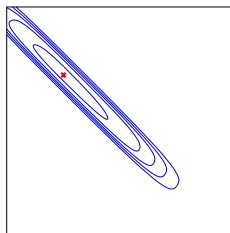
Effect of Meta-Parameter H on POWER



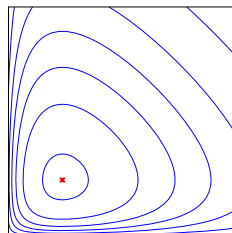
Extra Slide: 2D Problems



(f) ROSENBROCK

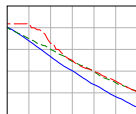


(g) CORRELATED

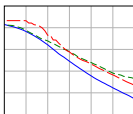


(h) LOG^2

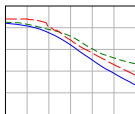
Extra Slide: Performance on many problems



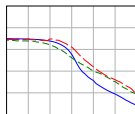
(i) LOG



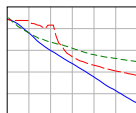
(j) LOG^2



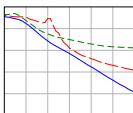
(k) LOG^5



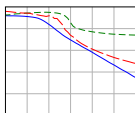
(l) FLAT



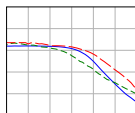
(m) ROSENBROCK



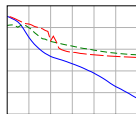
(n) ROSENBROCK^2



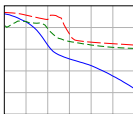
(o) ROSENBROCK^5



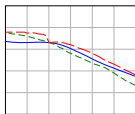
(p) POWER



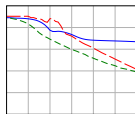
(q) CORRELATED



(r) CORRELATED^2



(s) ANGLE



(t) STEP

— Quadratic CLOP ($H = 3$), - - - UCT, - - - CEM (H_u & H_d).