

Optimization Techniques

Laboratory 1

Grid search, Random search, Nelder-Mead and Powell



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Evaluation of the laboratories

- Concisely note down your observations for each lab.
- You can take notes inside the notebooks, or in separate PDFs.
- Be ready to show the work you putted into each lab, including the experiments and the learning outcomes.
- **During the exam, you will be asked to show your notes for some of the labs at random with a brief discussion on its content.**

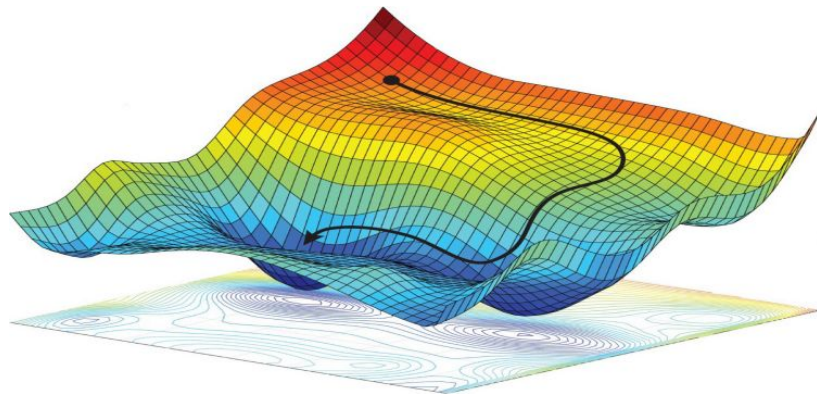
Quick recap on optimization

No free lunch

no algorithm can outperform all others across all possible problems

Different categorizations

- Exact vs Approximate
- Deterministic vs Stochastic
- Local vs Global
- Constrained vs Unconstrained



Grid search and Random Search

Grid

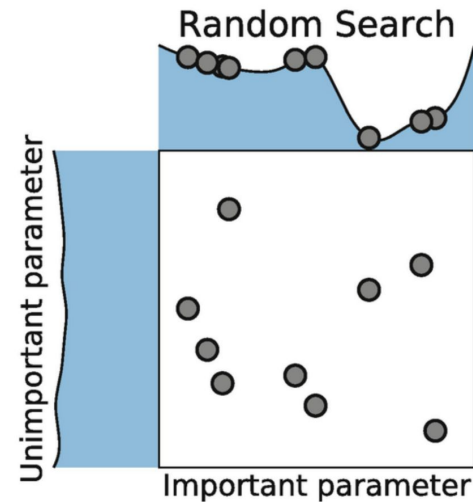
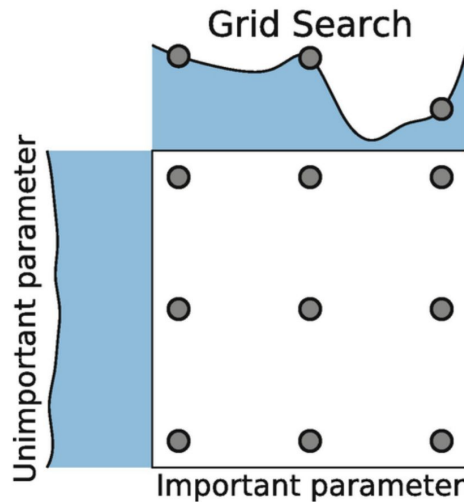
Set of values for all parameters -> try every combination

- Pros: parallelizable, simple to implement
- Cons: easy to miss good regions, expensive, combinatorial explosion

Random

Try random values based on some distribution (uniform)

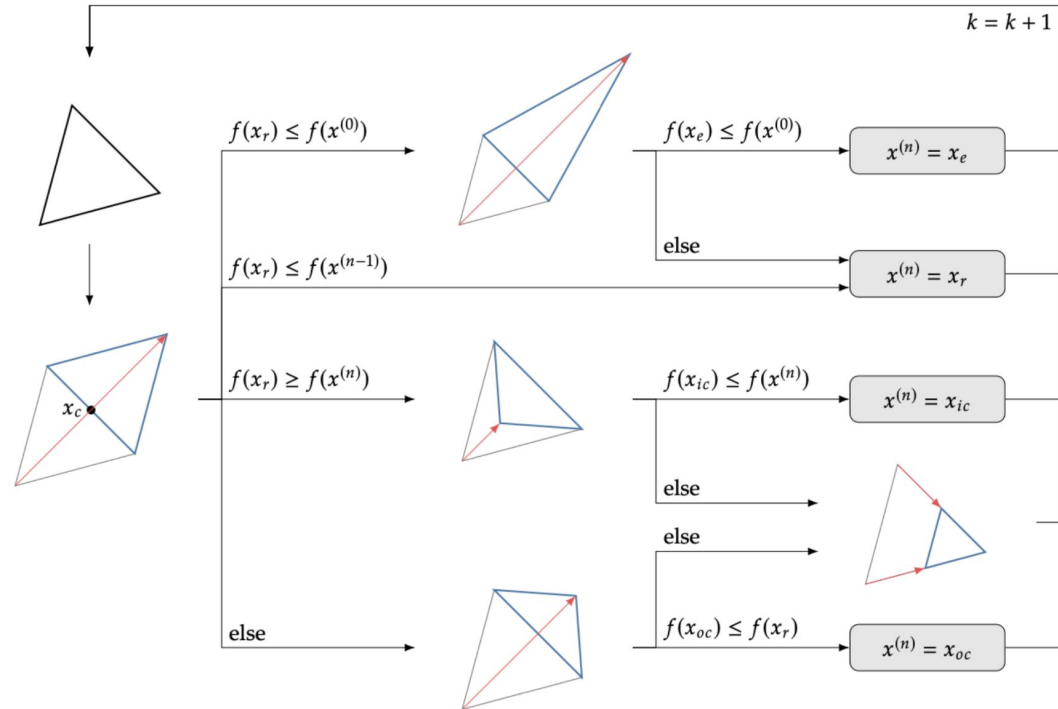
- Pros: harder to entirely miss good regions
- Cons: very expensive



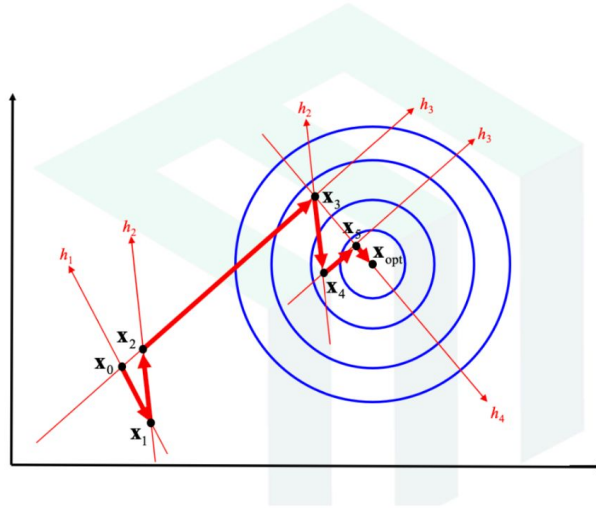
Nelder-Mead

Sequential algorithm, that can solve non-differentiable problems

- Robust to initial solutions
- Requires a lot of evaluations
- Sequential
- Not robust to noise
- Can not handle constraints



Powell



1. Pick a starting point \mathbf{x}_0 and two different starting directions h_1 and h_2 .
2. Starting at \mathbf{x}_0 , perform a 1D optimization along h_1 to find extremum \mathbf{x}_1 .
3. Starting at \mathbf{x}_1 , perform a 1D optimization along h_2 to find extremum \mathbf{x}_2 .
4. Define h_3 to be in the direction connecting \mathbf{x}_0 to \mathbf{x}_2 .
5. Starting at \mathbf{x}_2 , perform a 1D optimization along h_3 to find extremum \mathbf{x}_3 .
6. Starting at \mathbf{x}_3 , perform a 1D optimization along h_2 to find extremum \mathbf{x}_4 .
7. Starting at \mathbf{x}_4 , perform a 1D optimization along h_3 to find extremum \mathbf{x}_5 .
8. Define h_4 to be in the direction connecting \mathbf{x}_3 to \mathbf{x}_5 .
9. Starting at \mathbf{x}_5 , perform a 1D optimization along h_4 to find extremum \mathbf{x}_{opt} .

This last 1D optimization is guaranteed to find the maximum of a quadratic because Powell showed that h_3 and h_4 are both conjugate directions.