

Effective Programming Practices for Economists

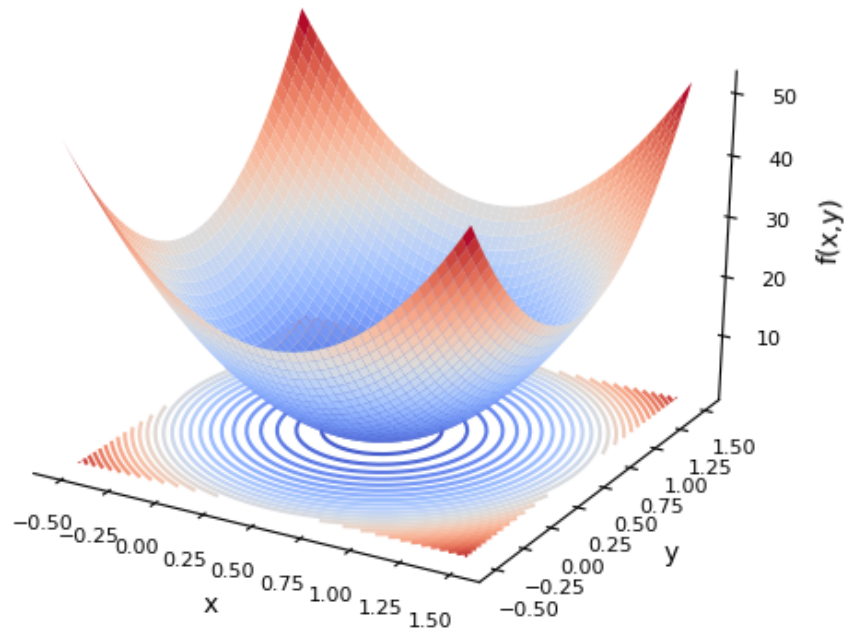
Numerical Optimization

Introduction to numerical optimization

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Example problem

- **Criterion** $f(a, b) = a^2 + b^2$
- Parameters a, b
- Want: $a^*, b^* = \operatorname{argmin} f(a, b)$
- Possible extensions:
 - Constraints
 - Bounds (a.k.a. box constraints)
- Optimum at $a^* = 0, b^* = 0,$
 $f(a^*, b^*) = 0$



Applications of numerical optimization

- Probit, many Logit models, ...
- Fitting machine learning models
- Estimating structural models
 - Maximum likelihood
 - Method of simulated moments
- Calculating optimal policies from a structural model
- Solving utility maximization problems

What is an optimization algorithm

- **Our definition:** A function that takes a criterion function and start parameters and returns a solution, possibly after a long time
- There are many different optimizers
- Picking the right one can make a huge difference but is hard
- Use a mix of theory and experimentation to get there

Libraries for optimization

- There are many optimization libraries in Python
- All are a bit different
- We will use optimagic to access all of them with a unified interface
- Optimagic development started in Bonn's Open Source Economics group!

- Using optimagic
 - Overview
 - Mechanics of minimising/maximising a function
 - Picking algorithms
 - Visualizing histories
- Intuition behind different algorithms
 - Example used throughout
 - Grid search methods
 - Derivative-based methods
 - Line search
 - Trust region
 - Derivative-free methods
 - Direct search
 - Trust region