Optimal optimieren mit MATLAB – so geht’s

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Why Optimization?
For example

Maximize Fuel Efficiency

Minimize Risk

Maximize Efficiency in terms of e.g., Profits
Optimization Approaches in MATLAB

- **Gradient Based**
  - Finds local minima/maxima
  - Applicable for large scale problems with smooth objective function
  - Faster/fewer function evaluations

- **Global Methods**
  - No gradient information required
  - Solve problems with non-smooth, stochastic, discontinuous objective function
Gradient based Optimization Solvers

- **Nonlinear minimization**
  - `fminunc`: unconstrained
  - `fmincon`: linear and nonlinear constraints
  - Supply Gradient and Hessian functions to speed up

- **Constrained curve fitting with least squares solvers**
  - `lsqinlin`: linear least-squares subject to linear constraints
  - `lsqnonlin`: nonlinear least-squares with bound constraints

- **Linear or quadratic problems**
  - `linprog`: linear problems
  - `quadprog`: quadratic problems
Why use Global Optimization?

- What if the problem has multiple local minima
- What if the gradient is undefined
- What if the problem is stochastic
- What if some variables are binary or integer

Need a solver that can explore the solution space and not fall into local minima.
Global Optimization Solvers

- **Global Search, Multi Start**
  - Well-suited for smooth objective and constraints
  - Return the location of local and global minima

- **Genetic Algorithm, Simulated Annealing**
  - Many function evaluations to sample the search space
  - Works on both smooth and non-smooth problems

- **Pattern Search**
  - Fewer function evaluations
  - Does not rely on gradient calculation
  - Works on both smooth and non-smooth problems
Global Optimization Solvers

- Mixed-Integer Optimization using `ga`
  - Allows linear or nonlinear mixed-integer problems
  - Allows you to specify that certain variables are integer valued
  - Can have any objective function, bounds, and inequality constraints
  - Can indirectly include equality constraints
Optimization APP
Speed up Optimization using Built-in Parallel Support

1) Gradient Estimation
   - fmincon
   - fminimax
   - fgoalattain

2) Iterative sampling of local solution space
   - MultiStart
   - ga, gamultiobj
   - patternsearch
Key takeaways

1. **Solve Wide Variety of Problems**
   - Linear, quadratic, nonlinear, least squares (Optimization Toolbox)
   - Nonlinear, nonsmooth, stochastic, mixed-integer (Global Optimization Toolbox)

2. **Set-up, Run, and Monitor Optimizations**
   - Optimization App
   - Automatic code generation
   - Customizable plot functions

3. **MATLAB Environment**
   - Integrated Numeric, Graphics, Symbolic Math
   - Parallel Computing
Thank You

Any Questions?
Local Optimization

- Interior-point quadratic programming solver
  - Solves large-scale QP problems faster
  - Performance example:
    Calculate optimal power flow on the electric grid

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Optimization APP

Problem Setup and Results

Solver: fmincon - Constrained nonlinear minimization
Algorithm: SQP

Figure 1

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