Johns Hopkins Engineering

Applied Machine Learning for Mechanical Engineers

Optimization, Part 2, A

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Introduction to Linear Optimization Programming Packages

- By the end of this lecture, you will be able to:
  - Address linear optimization problems such to be compatible with Python and MATLAB optimization packages
  - Describe “scipy.optimize.linprog” package in Python
  - Describe ‘linprog” package in MATLAB

Introduction to Linear Optimization Programming Packages

- Formal linear optimization problem with one objective function

$$\begin{gathered} minimize\ f(\boldsymbol{x}) \\ subject\ to \begin{cases} g_j(\boldsymbol{x}) \leq 0 & j \in \{1, 2, \dots, J\} \\ h_k(\boldsymbol{x}) = 0 & k \in \{1, 2, \dots, K\} \end{cases} \end{gathered} \qquad (2-1)$$

where $\boldsymbol{x} = [x_1, x_2, \dots, x_N]$ include the optimization variables (solution), $f(\boldsymbol{x})$, $g_j(\boldsymbol{x})$, and $h_k(\boldsymbol{x})$ are a linear objective function, linear inequality constraints, and linear equality constraints, respectively, and the rest is similar to Eq. 1-1.

Introduction to Linear Optimization Programming Packages

- Programming packages for linear programming

$$minimize\ \boldsymbol{C}.\boldsymbol{x}^T$$
$$subject\ to\ \begin{cases} \boldsymbol{G}.\boldsymbol{x} \leq \boldsymbol{A} \\ \boldsymbol{H}.\boldsymbol{x} = \boldsymbol{B} \\ \boldsymbol{L} \leq \boldsymbol{x} \leq \boldsymbol{U} \end{cases} \qquad (2-2)$$

where $\boldsymbol{C}$ is the N-dimensional row vector of multipliers of N optimization variables in objective function, $\boldsymbol{G}$ is a J by N matrix of multipliers of N optimization variables in J inequality constraints, $\boldsymbol{A}$ is a J-dimensional column vector of equality constants, $\boldsymbol{H}$ is a K by N matrix of multipliers of N optimization variables in K inequality constraints, $\boldsymbol{B}$ is a K-dimensional column vector of equality constants, $\boldsymbol{L}$ is an N-dimensional row vector of lower bounds of N optimization variables, and $\boldsymbol{U}$ is an N-dimensional row vector of upper bounds of N optimization variables.

Introduction to Linear Optimization Programming Packages

- Programming packages for linear programming
  - Different annotations

$$
\begin{aligned}
\min_{x} \ & c^T x \\
\text{such that } & A_{ub} x \leq b_{ub}, \\
& A_{eq} x = b_{eq}, \\
& l \leq x \leq u,
\end{aligned}
$$

Figure 2-1 Annotations used to address linear optimization problems at
https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.linprog.html

Introduction to Linear Optimization Programming Packages

- Programming packages for linear programming
  - Python: “scipy.optimize.linprog” at

    https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.linprog.html

  - MATLAB: “linprog” at

    https://www.mathworks.com/help/optim/ug/linprog.html

Introduction to Linear Optimization Programming Packages

- Python: “scipy.optimize.linprog”

SciPy.org

SciPy.org | Docs | SciPy v1.4.1 Reference Guide | Optimization and Root Finding (scipy.optimize) | index | modules | next | previous

scipy.optimize.linprog¶

scipy.optimize.linprog(*c, A_ub=None, b_ub=None, A_eq=None, b_eq=None, bounds=None, method='interior-point', callback=None, options=None, x0=None*) [source]

Linear programming: minimize a linear objective function subject to linear equality and inequality constraints.

Linear programming solves problems of the following form:

$$\begin{aligned} \min_x \ & c^T x \\ \text{such that } & A_{ub} x \leq b_{ub}, \\ & A_{eq} x = b_{eq}, \\ & l \leq x \leq u, \end{aligned}$$

where x is a vector of decision variables; c, b_{ub}, b_{eq}, l, and u are vectors; and A_{ub} and A_{eq} are matrices.

Informally, that’s:

minimize:

Previous topic

root(method=’df-sane’)

Next topic

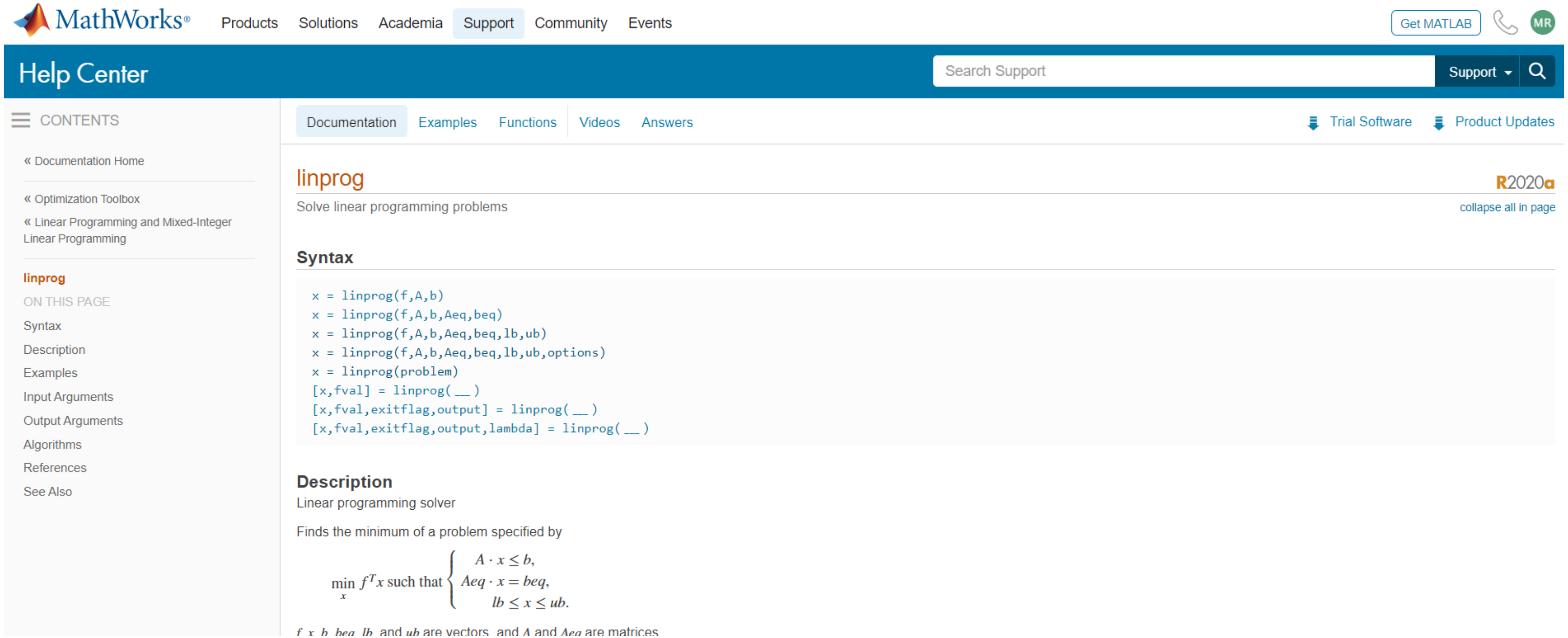
linprog(method=’simplex’)

Quick search

search

Introduction to Linear Optimization Programming Packages

- MATLAB: “linprog”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linprog

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linprog R2020a

Solve linear programming problems

collapse all in page

Syntax

```
x = linprog(f,A,b)
x = linprog(f,A,b,Aeq,beq)
x = linprog(f,A,b,Aeq,beq,lb,ub)
x = linprog(f,A,b,Aeq,beq,lb,ub,options)
x = linprog(problem)
[x,fval] = linprog( __ )
[x,fval,exitflag,output] = linprog( __ )
[x,fval,exitflag,output,lambda] = linprog( __ )
```

Description

Linear programming solver

Finds the minimum of a problem specified by

$$\min_x f^T x \text{ such that } \begin{cases} A \cdot x \le b, \\ Aeq \cdot x = beq, \\ lb \le x \le ub. \end{cases}$$

f, x, b, beq, lb, and ub are vectors, and A and Aeq are matrices.

Introduction to Linear Optimization Programming Packages

- In this lecture, you learned about:

  - General formulations of linear optimization problems in Python and MATLAB optimization packages

  - “scipy.optimize.linprog” programming package in Python

  - ‘linprog” programming package in MATLAB

- In the next lecture, we will practice these programming packages in Python and MATLAB

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