
OPTALG Documentation

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Welcome! This is the documentation for OPTALG, last updated April 26, 2016.

What is OPTALG?

OPTALG is a Python package with optimization algorithms.

License

OPTALG is released under the BSD 2-clause license.

Contact

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Documentation Contents

GETTING STARTED

This section describes how to get started with OPTALG. In particular, it covers required packages, installation, and provides a quick example showing how to use this package.

- `Numpy` ($\geq 1.8.2$)
- `Scipy` ($\geq 0.13.3$)
- `MUMPS` ($= 4.10$) (optional)

1.1 Download

The latest version of OPTALG can be downloaded from <https://github.com/ttinoco/OPTALG>.

1.2 Installation

The OPTALG Python module can be installed using:

```
> sudo python setup.py install
```

from the root directory of the package. If `MUMPS` is not available, then the option `--no_mumps` should be added to the above command.

1.3 Example

As a quick example of how to use OPTALG, consider the task of solving a quadratic program. This can be done as follows:

```
>>> coming soon
```


OPTIMIZATION SOLVERS

In OPTALG, optimization solvers are objects derived from the `OptSolver` class, and optimization problems are objects derived from the `OptProblem` class, which represents general problems of the form

$$\begin{array}{ll} \text{minimize} & \varphi(x) \\ \text{subject to} & Ax = b \quad : \lambda \\ & f(x) = 0. \quad : \nu \\ & l \leq x \leq u. \quad : \pi, \mu \end{array}$$

Before solving a `problem` with a specific solver, the solver parameters can be configured using the method `set_parameters()`. Then, the `solve()` method can be invoked with the `problem` to be solved as its argument. The status, optimal primal and optimal dual variables can be extracted using the class methods `get_status()`, `get_primal_variables()`, and `get_dual_variables()`, respectively.

2.1 NR

This solver solves problems of the form

$$\begin{array}{ll} \text{find} & x \\ \text{subject to} & Ax = b \\ & f(x) = 0. \end{array}$$

using the Newton-Raphson algorithm.

2.2 IQP

This solver, which is represented by the class `OptSolverIQP`, solves convex quadratic problems of the form

$$\begin{array}{ll} \text{minimize} & \frac{1}{2}x^T Hx + g^T x \\ \text{subject to} & Ax = b \quad : \lambda \\ & l \leq x \leq u. \quad : \pi, \mu \end{array}$$

using an interior point method. Quadratic problems solved with this solver must be objects derived from the class `QuadProblem`, which is a subclass of `OptProblem`. The following example shows how to solve the quadratic

problem

$$\begin{array}{ll}\text{minimize} & 3x_1 - 6x_2 + 5x_1^2 - 2x_1x_2 + 5x_2^2 \\ \text{subject to} & x_1 + x_2 = 1 \\ & 0.2 \leq x_1 \leq 0.8 \\ & 0.2 \leq x_2 \leq 0.8\end{array}$$

using the `OptSolverIQP` solver:

```
>>> import numpy as np
>>> from optalg.opt_solver import OptSolverIQP, QuadProblem

>>> g = np.array([3., -6.])
>>> H = np.array([[10., -2],
...              [-2., 10]])

>>> A = np.array([[1., 1.]])
>>> b = np.array([1.])

>>> u = np.array([0.8, 0.8])
>>> l = np.array([0.2, 0.2])

>>> problem = QuadProblem(H, g, A, b, l, u)

>>> solver = OptSolverIQP()

>>> solver.set_parameters({'quiet': True,
...                       'tol': 1e-6})

>>> solver.solve(problem)

>>> print solver.get_status()
solved
```

Then, the optimal primal and dual variables can be extracted, and feasibility and optimality can be checked as follows:

```
>>> x = solver.get_primal_variables()
>>> lam, nu, mu, pi = solver.get_dual_variables()

>>> print x
[ 0.20  0.80 ]

>>> print x[0] + x[1]
1.00

>>> print l <= x
[ True  True ]

>>> print x <= u
[ True  True ]

>>> print pi
[ 9.00e-01  1.80e-06 ]

>>> print mu
[ 1.80e-06  9.00e-01 ]

>>> print np.linalg.norm(g+np.dot(H,x)-np.dot(A.T,lam)+mu-pi)
1.25e-15
```

```
>>> print np.dot(mu, u-x)
2.16e-06

>>> print np.dot(pi, x-l)
2.16e-06
```

2.3 LCCP

This solver solves convex linearly-constrained problems of the form

$$\begin{array}{ll} \text{minimize} & \varphi(x) \\ \text{subject to} & Ax = b \quad : \lambda \\ & l \leq x \leq u. \quad : \pi, \mu \end{array}$$

using an interior point method.

2.4 AugL

This solver solves convex or non-convex optimization problems of the form

$$\begin{array}{ll} \text{minimize} & \varphi(x) \\ \text{subject to} & Ax = b \quad : \lambda \\ & f(x) = 0. \quad : \nu \end{array}$$

using an Augmented Lagrangian algorithm. It requires the objective function to be strongly convex.

API REFERENCE

3.1 Linear Solvers

`optalg.lin_solver.new_linsolver` (*name*, *prop*)

Creates a linear solver.

Parameters *name* : string

prop : string

Returns *solver* : `LinSolver`

class `optalg.lin_solver.LinSolver` (*prop*=*'unsymmetric'*)

Linear solver class.

Parameters *prop* : {`symmetric`, `unsymmetric`}

analyze (*A*)

Analyzes structure of *A*.

Parameters *A* : matrix

analyzed = `None`

Flag that specifies whether the matrix has been analyzed.

factorize (*A*)

Factorizes *A*.

Parameters *A* : matrix

factorize_and_solve (*A*, *b*)

Factorizes *A* and solves $Ax=b$.

Returns *x* : vector

is_analyzed ()

Determine whether the matrix has been analyzed.

Returns *flags* : {`True`, `False`}

prop = `None`

Linear system property {`'symmetric'`, `'unsymmetric'`}.

solve (*b*)

Solves system $Ax=b$.

Parameters *b*: vector :

Returns *x* : vector

class `optalg.lin_solver.mumps.LinSolverMUMPS` (*prop='unsymmetric'*)
Linear solver based on MUMPS.

class `optalg.lin_solver.superlu.LinSolverSUPERLU` (*prop='unsymmetric'*)
Linear solver based on SuperLU.

3.2 Optimization Solvers

class `optalg.opt_solver.OptProblem`
Class for representing general optimization problems.

A = None
Matrix for linear equality constraints

H_combined = None
Linear combination of Hessians of nonlinear constraints

Hphi = None
Objective function Hessian (lower triangular)

J = None
Jacobian of nonlinear constraints

b = None
Right-hand side for linear equality constraints

eval (*x*)
Evaluates the objective value and constraints at the give point.

f = None
Nonlinear equality constraint function

gphi = None
Objective function gradient

l = None
Lower limits

lam = None
Lagrange multipliers for linear equality constraints

mu = None
Lagrange multipliers for upper limits

nu = None
Lagrange multipliers for nonlinear equality constraints

phi = None
Objective function value

pi = None
Lagrange multipliers for lower limits

show ()
Displays information about the problem.

u = None
Upper limits

x = None
Initial point

class `optalg.opt_solver.QuadProblem` ($H, g, A, b, l, u, x=None, lam=None, mu=None, pi=None$)
 Quadratic program class.

Parameters H : symmetric matrix

g : vector

A : matrix

l : vector

u : vector

x : vector

class `optalg.opt_solver.OptSolver`
 Optimization solver class.

add_callback (c)

Adds callback function to solver.

Parameters c : Function

add_termination (t)

Adds termination condition to solver.

Parameters t : Function

callbacks = None

List of callback functions.

fdata = None

Function data container.

get_dual_variables ()

Gets dual variables.

Returns lam : vector

nu : vector

mu : vector

pi : vector

get_error_msg ()

Gets solver error message.

Returns $message$: string

get_iterations ()

Gets number of iterations.

Returns $iters$: int

get_primal_variables ()

Gets primal variables.

Returns $variables$: ndarray

get_results ()

Gets results.

Returns $results$: dictionary

get_status ()

Gets solver status.

Returns **status** : string

info_printer = None

Information printer (function).

is_status_solved ()

Determines whether the solver solved the given problem.

Returns **flag** : {True, False}

line_search (*x*, *p*, *F*, *GradF*, *func*, *smax=inf*)

Finds steplength along search direction *p* that satisfies the strong Wolfe conditions.

Parameters **x** : current point (ndarray)

p : search direction (ndarray)

F : function value at *x* (float)

GradF : gradient of function at *x* (ndarray)

func : function of *x* that returns function object with attributes *F* and *GradF* (function)

smax : maximum allowed steplength (float)

Returns **s** : steplength that satisfies the Wolfe conditions (float).

parameters = None

Parameters dictionary.

reset ()

Resets solver data.

set_error_msg (*msg*)

Sets solver error message.

Parameters **msg** : string

set_info_printer (*printer*)

Sets function for printing algorithm progress.

Parameters **printer** : Function.

set_parameters (*parameters*)

Sets solver parameters.

Parameters **parameters** : dict

set_status (*status*)

Sets solver status.

Parameters **status** : string

solve (*problem*)

Solves optimization problem.

Parameters **problem** : OptProblem

terminations = None

List of termination conditions.

class optalg.opt_solver.**OptSolverNR**

Newton-Raphson algorithm.

class optalg.opt_solver.**OptSolverIQP**

Interior-point quadratic program solver.

class `optalg.opt_solver.OptSolverLCCP`
Interior-point solver for linearly-constrained convex programs.

class `optalg.opt_solver.OptSolverAugL`
Augmented Lagrangian algorithm.

3.3 Stochastic Optimization Solvers

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