Minimization of the Himmelblau Function

In this example we want to use AlgoPy to help compute the minimum of the non-convex multi-modal bivariate Himmelblau function

$$f(x,y) = (x^2 + y - 11)^2 + (x + y^2 - 7)^2$$

The idea is that by using AlgoPy to provide the gradient and hessian of the objective function, the nonlinear optimization procedures in scipy.optimize will more easily find the x and y values that minimize $f(x,y)$. Here is the python code:

```
"""
Minimize the Himmelblau function.

http://en.wikipedia.org/wiki/Himmelblau%27s_function
"""

import numpy

import minhelper


def himmelblau(X):
    """
    This R^2 -> R^1 function should be compatible with algopy.
    http://en.wikipedia.org/wiki/Himmelblau%27s_function
    This function has four local minima where the value of the function is 0
    """
    x = X[0]
    y = X[1]
    a = x*x + y - 11
    b = x + y*y - 7
    return a*a + b*b


def main():
    target = [3, 2]
    easy_init = [3.1, 2.1]
    hard_init = [-0.27, -0.9]
    minhelper.show_minimization_results(
            himmelblau, target, easy_init, hard_init)


if __name__ == '__main__':
    main()
```

Here is its output:

```
properties of the function at a local min:
point:
[ 3.  2.]
function value:
0.0
autodiff gradient:
[ 0.  0.]
finite differences gradient:
[ 0.  0.]
autodiff hessian:
[[ 74.  20.]
 [ 20.  34.]]
finite differences hessian:
[[ 74.  20.]
 [ 20.  34.]]

------------------------------------------------------------
searches beginning from the easier init point [ 3.1  2.1]
------------------------------------------------------------

properties of the function at the initial guess:
point:
[ 3.1  2.1]
function value:
0.7642
autodiff gradient:
[ 9.824  5.704]
finite differences gradient:
[ 9.824  5.704]
autodiff hessian:
[[ 81.72  20.8 ]
 [ 20.8   39.32]]
finite differences hessian:
[[ 81.72  20.8 ]
```

ALGOPY

Previous topic

Minimization of the Rosenbrock Function

Next topic

Minimization of Wood's Function

This Page

Show Source

Quick search

Go

Enter search terms or a module, class or function name.

```
 [ 20.8   39.32]]

strategy: default (Nelder-Mead)
options: default
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 31
         Function evaluations: 59
[ 2.99997347  2.0000045 ]

strategy: ncg
options: default
gradient: autodiff
hessian: autodiff
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 4
         Function evaluations: 5
         Gradient evaluations: 4
         Hessian evaluations: 4
[ 3.  2.]

strategy: ncg
options: default
gradient: autodiff
hessian: finite differences
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 4
         Function evaluations: 5
         Gradient evaluations: 18
         Hessian evaluations: 0
[ 3.  2.]

strategy: cg
options: default
gradient: autodiff
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 7
         Function evaluations: 18
         Gradient evaluations: 18
[ 3.00000005  1.99999991]

strategy: cg
options: default
gradient: finite differences
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 7
         Function evaluations: 72
         Gradient evaluations: 18
[ 3.00000004  1.99999991]

strategy: bfgs
options: default
gradient: autodiff
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 5
         Function evaluations: 9
         Gradient evaluations: 9
[ 2.99999993  1.99999986]

strategy: bfgs
options: default
gradient: finite differences
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 5
         Function evaluations: 36
         Gradient evaluations: 9
[ 2.99999993  1.99999986]

strategy: slsqp
options: default
gradient: autodiff
Optimization terminated successfully.    (Exit mode 0)
            Current function value: 2.68119275432e-08
            Iterations: 5
            Function evaluations: 9
            Gradient evaluations: 5
[ 2.99997095  2.00001136]

strategy: slsqp
options: default
gradient: finite differences
Optimization terminated successfully.    (Exit mode 0)
            Current function value: 2.68250888103e-08
            Iterations: 5
```

```
            Function evaluations: 24
            Gradient evaluations: 5
[ 2.99997095  2.00001136]

strategy: powell
options: default
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 5
         Function evaluations: 126
[ 3.  2.]

strategy: tnc
options: default
gradient: autodiff
(array([ 2.999999,  2.000002]), 11, 1)

strategy: tnc
options: default
gradient: finite differences
(array([ 2.99999646,  2.00000762]), 14, 1)


------------------------------------------------------------
searches beginning from the more difficult init point [-0.27 -0.9 ]
------------------------------------------------------------

properties of the function at the initial guess:
point:
[-0.27 -0.9 ]
function value:
181.61189441
autodiff gradient:
[-0.146732 -0.3982  ]
finite differences gradient:
[-0.146732 -0.3982  ]
autodiff hessian:
[[-44.7252  -4.68  ]
 [ -4.68   -17.36  ]]
finite differences hessian:
[[-44.7252  -4.68  ]
 [ -4.68   -17.36  ]]

strategy: default (Nelder-Mead)
options: default
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 54
         Function evaluations: 105
[-2.80514623  3.13132056]

strategy: ncg
options: default
gradient: autodiff
hessian: autodiff
Optimization terminated successfully.
         Current function value: 181.611894
         Iterations: 1
         Function evaluations: 5
         Gradient evaluations: 1
         Hessian evaluations: 1
[-0.26999996 -0.89999989]

strategy: ncg
options: default
gradient: autodiff
hessian: finite differences
Optimization terminated successfully.
         Current function value: 181.611894
         Iterations: 1
         Function evaluations: 5
         Gradient evaluations: 3
         Hessian evaluations: 0
[-0.26999996 -0.89999989]

strategy: cg
options: default
gradient: autodiff
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 10
         Function evaluations: 35
         Gradient evaluations: 35
[ 3.00000011  1.99999978]

strategy: cg
options: default
gradient: finite differences
Optimization terminated successfully.
         Current function value: 0.000000
```

```
         Iterations: 10
         Function evaluations: 140
         Gradient evaluations: 35
[ 3.0000001   1.99999978]

strategy: bfgs
options: default
gradient: autodiff
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 11
         Function evaluations: 29
         Gradient evaluations: 29
[ 3.          1.99999999]

strategy: bfgs
options: default
gradient: finite differences
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 11
         Function evaluations: 116
         Gradient evaluations: 29
[ 3.          1.99999999]

strategy: slsqp
options: default
gradient: autodiff
Optimization terminated successfully.    (Exit mode 0)
            Current function value: 6.19262349912e-09
            Iterations: 10
            Function evaluations: 22
            Gradient evaluations: 10
[ 2.99999684  2.00002046]

strategy: slsqp
options: default
gradient: finite differences
Optimization terminated successfully.    (Exit mode 0)
            Current function value: 6.18718154108e-09
            Iterations: 10
            Function evaluations: 52
            Gradient evaluations: 10
[ 2.99999683  2.00002045]

strategy: powell
options: default
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 6
         Function evaluations: 155
[ 3.58442834 -1.84812653]

strategy: tnc
options: default
gradient: autodiff
(array([ 3.,  2.]), 42, 1)

strategy: tnc
options: default
gradient: finite differences
(array([ 2.99999981,  1.99999997]), 39, 1)
```