

# Optimization

## Homework 3

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### 1. Problem 1

#### Results :

SciPy's minimize function (<https://docs.scipy.org>) was used to minimize a 10 dimensional RosenBrock function. Ten samples were drawn from a normal distribution with  $\mu = 1$  and  $\sigma = 2$ . For the first part of the problem, Nelder-Mead simplex algorithm was used and for the second part of the problem both Nelder-Mead and BFGS algorithm was used with different starting points and different terminating tolerances.

Table 1: Results for Nelder-Mead with tolerance at 1e-8

rel_error	x	y	y_diff
2.990	[-1.171, 1.157, 1.121, 1.112, 1.121, 1.197, 1....	25.067	25.067
-0.123	[0.02, -0.404, 0.681, 0.842, 0.924, 0.97, 0.99...	66.975	66.975
0.775	[-0.965, 0.955, 0.902, 0.844, 0.705, 0.898, 1....	46.797	46.797
-0.201	[1.025, 1.016, 0.996, 1.009, 0.977, 0.747, 0.6...	10.394	10.394
-0.632	[0.811, 0.664, 0.457, 0.2, 0.049, 0.008, 0.008...	5.996	5.996
-0.704	[0.725, 0.517, 0.231, -0.152, 0.034, 0.013, 0....	11.796	11.796
-0.919	[-0.243, 0.051, 0.041, -0.025, 0.015, -0.01, 0...	9.709	9.709
-0.355	[-0.978, 0.975, 0.944, 0.835, 0.685, 0.415, 0....	8.984	8.984
0.408	[0.5, 0.24, 0.039, 0.02, 0.004, -0.73, 1.044, ...	94.037	94.037
-0.360	[0.576, 0.34, 0.122, 0.045, 0.014, -0.148, 0.0...	98.303	98.303
Avg:	0.088	37.806	37.806
Std:	1.139	36.478	36.478

Final results for Nelder-Mead with tolerance at 1e-8:

Relative error:  $0.088 \pm 1.139$

y:  $37.806 \pm 36.478$

difference:  $37.806 \pm 36.478$

Table 2: Results for Nelder-Mead with tolerance at 1e-16

rel_error	x	y	y_diff
2.990	[-1.171, 1.157, 1.121, 1.112, 1.121, 1.197, 1....	25.067	25.066801
-0.123	[0.02, -0.404, 0.681, 0.842, 0.924, 0.97, 0.99...	66.975	66.975452
0.775	[-0.965, 0.955, 0.902, 0.844, 0.705, 0.898, 1....	46.797	46.797200
-0.201	[1.025, 1.016, 0.996, 1.009, 0.977, 0.747, 0.6...	10.394	10.394475
-0.632	[0.811, 0.664, 0.457, 0.2, 0.049, 0.008, 0.008...	5.996	5.995642
-0.704	[0.725, 0.517, 0.231, -0.152, 0.034, 0.013, 0....	11.796	11.795859
-0.919	[-0.243, 0.051, 0.041, -0.025, 0.015, -0.01, 0...	9.709	9.708681
-0.355	[-0.978, 0.975, 0.944, 0.835, 0.685, 0.415, 0....	8.984	8.984113
0.408	[0.5, 0.24, 0.039, 0.02, 0.004, -0.73, 1.044, ...	94.037	94.037039
-0.360	[0.576, 0.34, 0.122, 0.045, 0.014, -0.148, 0.0...	98.303	98.303444
Avg:	0.088	37.806	37.806
Std:	1.139	36.478	36.478

Final results for Nelder-Mead with tolerance at 1e-16:

Relative error:  $0.088 \pm 1.139$

y:  $37.806 \pm 36.478$

difference:  $37.806 \pm 36.478$

Table 3: Results for BFGS with tolerance at 1e-8

rel_error	x	y	y_diff
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
Avg:	-0.002	2.392	2.392
Std:	0.002	2.059	2.059

Final results for BFGS with tolerance at 1e-8:

Relative error:  $-0.002 \pm 0.002$

y:  $2.392 \pm 2.059$

difference:  $2.392 \pm 2.059$

Table 4: Results for BFGS with tolerance at 1e-16

rel_error	x	y	y_diff
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
-0.000	[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, ...	0.000	0.000
-0.004	[-0.993, 0.997, 0.998, 0.999, 0.999, 0.999, 0....	3.987	3.987
Avg:	-0.002	2.392	2.392
Std:	0.002	2.059	2.059

Final results for BFGS with tolerance at 1e-16:

Relative error:  $-0.002 \pm 0.002$

y:  $2.392 \pm 2.059$

difference:  $2.392 \pm 2.059$

#### Discussion :

The varying parameters did not affect the final solution. For Nelder-Mead, this is probably because it does not generalize well to higher dimension such as  $N=10$  for the Rosenbrock function. For BFGS, there was more likely loss of precision from the approximate Hessian. Overall, the BFGS performed well in comparison to Nelder-Mead, this is most likely due to using first order derivative information.