MECA0027-1
Structural and multidisciplinary optimization
Academic year 2025-2026

Computer work 1: Unconstrained optimization

1 Objectives

The goal of this first computer work is to familiarize students with unconstrained optimization and the practical implementation of various methods introduced in theoretical lectures. To this end, it is asked to minimize two different functions, f_1 and f_2, defined as:

$$f_1(x, y) = 4x^2 + 5xy + 3y^2 + 4x - 3y + 5 \tag{1}$$
$$f_2(x, y) = 0.5(x^2 + y^2) - 2\cos(x)y - 10\sin(y) - 0.5xy \tag{2}$$

using the methods listed hereafter:

1. Steepest descend method;
2. Conjugate gradients method with Fletcher-Reeves update rule;
3. BFGS Quasi-Newton method.

2 Analysis

Following the developments of the different methods, **a thorough and critical analysis** is expected. It must be organized into two parts and include, **at a minimum** the following information.

First, analyze and compare the methods on each of the two functions based on:

1. two or more different starting points within the domain ([-15, 15]x[-15, 15]), with justification for their selection;
2. the stopping criteria (motivate the choice);
3. the number of iterations to convergence, the evolution of the objective function value, number of function/gradient/hessian evaluations, the "behavior" (solution path) of the algorithm.

Discuss the differences observed between the results obtained for the two functions and conclude with the strengths and weaknesses of the different methods.

In the second part, analyze the line search method(s) you used.

3 Organization and grading

This work is to be carried out in groups of 2 students, which must be formed no later than October 8. Note that the groups will remain identical for the second computer work. Each group must submit its Matlab/Octave/python files and a short report (max 12 pages) of its analysis within a .zip or .rar archive file named as "student1_student2".

The deadline for submission is October 24, 2025. The documents should be sent by email to Louis.Dehaybe@uliege.be.

The final grade will take into account the quality of the report (content, design, figures, text, tables etc.), the results (implementation of the methods) and most of all the analyses.

4 In practice

You decide whether you implement your code in Matlab/Octave or python. You should start by editing the file `getObjFVal` to define the functions $f1$ and $f2$. Then, define routines computing the gradient and hessian matrix of those functions in the same fashion. When done, edit the file `HW1` (while keeping the notation of the code) and add your implementation of the methods in the zone ADD YOUR CODE and comment it. You should also implement a function `getAlpha` that returns the step length.

Don't forget to use the provided file `plotOptimizationPath` to visualize your optimization path as it can be useful for debugging and performing analyses.

Notice that the following convention is used for the variables:

- x contains the pair of coordinates during the optimization

$$x = \begin{bmatrix} x_0 & x_1 & \dots & x_n \\ y_0 & y_1 & \dots & y_n \end{bmatrix}; \tag{3}$$

- "functionID" values are either 1 or 2 depending on which function you want to work with.