**Project #1**
MTM4502-Optimization Techniques — Date: 26/04/2024
Instructors: Hale GONCE KÖÇKEN, Gökhan GÖKSU — Due Date: 24/05/2024

## Parameter Selection

Take the parameters $a$ and $b$ as the last two digits of your student number. For instance, if your student number is 18058063, take $a = 6$ and $b = 3$.

## Introduction

Objective functions plays an important role to validate and compare the performance of optimization algorithms. Many benchmark or test functions have been documented in various publications, but there isn't a universally accepted list of benchmark functions. The most effective test functions should possess a range of distinct characteristics, allowing for unbiased testing of new algorithms. In [1], a rich set of 175 benchmark functions for unconstrained optimization problems with diverse properties are presented. In the course, as you know, we made a tutorial session for

$$f_{175}(\mathbf{x}) = 0.25x_1^4 - 0.5x_1^2 + 0.1x_1 + 0.5x_2^2$$

subject to $-2 \leq x_i \leq 2$, for $i = 1, 2$, by using Newton-Raphson and Hestenes-Stiefel algorithms.

## Main Task

Write a MATLAB program to find the minimum of the function $f_{cd}(\cdot)$ where $cd = ab$ (mod50) from [2, Appendix B] by using

- Newton-Raphson,
- Hestenes-Stiefel,
- Polak-Ribière and
- Fletcher-Reeves algorithms.

You are also strongly encouraged to use another relevant algorithm from the literature, which will be rewarded with an extra 10 points. If the function is not differentiable, use an approximation proposed by yourself or an relevant approximation commonly used in the literature and write it explicitly in your report. Repeat the main steps of your algorithms until the desired accuracy is achieved, i.e.

$$\|\nabla f(\mathbf{x}_k)\| \leq \epsilon \text{ and } |f(\mathbf{x}_{k+1}) - f(\mathbf{x}_k)| \leq \epsilon.$$

Take **<u>THREE</u>** initial guess as $\mathbf{x}_0 \sim \mathcal{N}_n(0, 1)$ ($n$-dimensional vector having elements from standard normal distribution by using `randn` function of MATLAB) or $\mathbf{x}_0 \sim \mathcal{U}_n(x_{0,\min}, x_{0,\max})$ ($n$-dimensional vector having elements from uniform distribution from the closed interval $[x_{0,\min}, x_{0,\max}]$ where $x_{0,\min}$ and $x_{0,\max}$ are specified for each function in [1] by using `rand` function of MATLAB). For instance, if your problem is defined on $-2 \leq x_i \leq 2$, for $i = 1, 2$, you may consider to choose $\mathbf{x}_0 \sim \mathcal{U}_n(-2, 2)$. Take also the absolute error bound as $\epsilon = 10^{-4}$ for every algorithm.

## Instructions

Write a project report regarding to the given task by answering the following questions (please **EXPLAIN** all of them by at least two sentences):

- [3p] How many steps does it take to find the minimum of this function with all of these algorithms?
- [3p] What are the execution times of these algorithms? Does this make sense?
- [3p] Does the convergence depend on the initial conditions? Why?
- [3p] Based on the last two questions, what can be the reason for this trade-off?
- [3p] Do you expect the same number of steps and execution times, when you change the stopping criterion and the absolute error bound?

Your project report also **MUST**

- [3p] contain at least one figure (if your problem is 2-dimensional, then your figure must include the all the steps starting from **THREE** random initial points with **DIFFERENT COLORS** and all the steps corresponding to the same iteration **MUST** be plotted with the **SAME COLOR**!),
- [3p] contain at least one table for benchmark,
- [4p] be at least two pages long and be written by IEEE conference proceeding template [3]!

## Submission Information

All projects must be uploaded via `online.yildiz.edu.tr` with a **SINGLE PDF** file. Please **DO NOT UPLOAD** your codes directly. Please also **DO NOT EMBED** your codes directly into your report. If you want to share your codes, you may create a GitHub repository, share your codes to all the world and give a link in your pdf file.

**Any project submitted after the deadline will be subject to a 25-point deduction per 12 hour period**. You may work with your friends. Collaboration is strongly recommended. However, each student should be able to present his/her program, project and report.

## References


[1] M. Jamil and X.-S. Yang, "A literature survey of benchmark functions for global optimisation problems," *International Journal of Mathematical Modelling and Numerical Optimisation*, vol. 4, no. 2, pp. 150–194, 2013, `https://arxiv.org/pdf/1308.4008.pdf`.

[2] M. M. Ali, C. Khompatraporn, and Z. B. Zabinsky, "A numerical evaluation of several stochastic algorithms on selected continuous global optimization test problems," *Journal of Global Optimization*, vol. 31, no. 4, p. 635, 2005.

[3] IEEE, "Manuscript Templates for Conference Proceedings." `https://www.ieee.org/conferences/publishing/templates.html`. Accessed: 2023-05-04.