Assignment 1: Bound Constrained Single Objective Numerical Optimization

1， **Overview**

The main task of this assignment is applying Evolutionary Algorithms (EAs) to optimizing several bound constrained single objective benchmark functions. This assignment has 100 marks, which will take 20% in your final mark of this course. The mark you get in this assignment depends on the your algorithm's performance on the benchmark functions, the quality of your report, program and presentation.

2， **Task**

You will implement an EA for optimizing a set of bound constrained single objective benchmark functions.

2.1, Programming aspects

Programming language: Use the programming language you like, but MATLAB and Python are preferred.

Test Functions: Test your implemented Evolutionary Algorithm by using the following 15 benchmark functions as your Test Functions.

Unimodal Functions f1-f7:

Test function	n	S	f_{min}
$f_1(\mathbf{x}) = \sum_{i=1}^{n} x_i^2$	30	$[-100, 100]^n$	0
$f_2(\mathbf{x}) = \sum_{i=1}^{n} \lvert x_i \rvert + \prod_{i=1}^{n} \lvert x_i \rvert$	30	$[-100, 100]^n$	0
$f_3(\mathbf{x}) = \sum_{i=1}^{n} (\sum_{j=1}^{i} x_j)^2$	30	$[-10, 10]^n$	0
$f_4(\mathbf{x}) = \max_i \{\lvert x_i \rvert, 1 \leq i \leq n\}$	30	$[-100, 100]^n$	0
$f_5(\mathbf{x}) = \sum_{i=1}^{n} [100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$	30	$[-100, 100]^n$	0
$f_6(\mathbf{x}) = \sum_{i=1}^{n} (x_i + 0.5)^2$	30	$[-30, 30]^n$	0
$f_7(\mathbf{x}) = \sum_{i=1}^{n} i x_i^4 + random[0, 1)$	30	$[-1.28, 1.28]^n$	0

Multimodal Functions f8-f15:

Test function	n	S	f_{min}
$f_8(\mathbf{x}) = \sum_{i=1}^{n} -x_i \sin(\sqrt{\lvert x_i \rvert})$	**30**	$[-500, 500]^n$	**-12569.5**
$f_9(\mathbf{x}) = \sum_{i=1}^{n} [x_i^2 - 10\cos(2\pi x_i) + 10)]$	**30**	$[-5.12, 5.12]^n$	**0**
$f_{10}(\mathbf{x}) = -20\exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right) - \exp\left(\frac{1}{n}\sum_{i=1}^{n} \cos 2\pi x_i\right) +20 + e$	**30**	$[-32, 32]^n$	**0**
$f_{11}(\mathbf{x}) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n} \cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$	**30**	$[-600, 600]^n$	**0**
$f_{12}(\mathbf{x}) = \frac{\pi}{n}\left\{10\sin^2(\pi y_1) + \sum_{i=1}^{n-1}(y_i - 1)^2[1 + 10\sin^2(\pi y_{i+1})] +(y_n - 1)^2\right\} + \sum_{i=1}^{n} u(x_i, 10, 100, 4)$, $y_i = 1 + \frac{1}{4}(x_i + 1)$ $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m, & x_i > a, \\ 0, & -a \leq x_i \leq a, \\ k(-x_i - a)^m, & x_i < -a. \end{cases}$	**30**	$[-50, 50]^n$	**0**
$f_{13}(\mathbf{x}) = 0.1\left\{\sin^2(3\pi x_1) + \sum_{i=1}^{n-1}(x_i - 1)^2[1 + sin^2(3\pi x_{i+1})] +(x_n - 1)^2[1 + \sin^2(2\pi x_n)]\right\} + \sum_{i=1}^{n} u(x_i, 5, 100, 4)$	**30**	$[-50, 50]^n$	**0**
$f_{14}(\mathbf{x}) = \left[\frac{1}{500} + \sum_{j=1}^{25} \frac{1}{j + \sum_{i=1}^{2}(x_i - a_{ij})^6}\right]^{-1}$	**2**	$[-65.536, 65.536]^n$	**1**
$f_{15}(\mathbf{x}) = \sum_{i=1}^{11}\left[a_i - \frac{x_1(b_i^2 + b_i x_2)}{b_i^2 + b_i x_3 + x_4}\right]^2$	**4**	$[-5, 5]^n$	**0.0003075**

2.2, Report

A report (in pdf format) must be submitted, named as report.pdf. MSWord and LaTeX templates can be found at https://www.ieee.org/conferences/publishing/templates.html. You should use these templates.

The expected structure is given below.

Abstract

Introduction

Background Introducing the benchmark & related work.

Proposed Algorithm Introducing your EA(s) and operators. Pseudo-code for all operators is required.

Experimental Results and Discussion

You will test your EA on the 15 benchmark functions. Repeat 20 times for each benchmark function, report the results and compare the performance. Statistical test is required. All parameters and corresponding values used in the evolutionary algorithm and experiments should be reported. Discussion of the results.

Conclusion and Future Work

Remark: Please be careful with the grammar, spelling and format.

2.3, Presentation

Examples of evaluation criteria are, but not limited to:

Description of the tested functions: What are they? What are their characteristics? Why they are challenging? ...

Description of the algorithm: Solution representation, different operators, ...

Results and discussion: Analysis of results, statistical test, convergence curves, performance comparison, ...

Presentation of the slides: Format, typeset, spelling, grammar, ...

Language and clearness

3， Submission

3.1, What to submit

Report and program: Each student should submit one single file for report and program, respectively.

- ✓ A program file named as assignment1-program-studentIDnumber.m if you program by using MATLAB. Example: assignment1-program-12345678.m.
- ✓ A pdf report file named as assignment1-report-studentIDnumber.pdf. Example: assignment1-report-12345678.pdf.

Presentation slides Each student should submit one single file for her/his presentation. The submitted file can be of one of the following formats:

- ✓ assignment1-presentation-studentIDnumber.ppt
- ✓ assignment1-presentation-studentIDnumber.pptx
- ✓ assignment1-presentation-studentIDnumber.pdf

3.2, Where to submit

Email your Program, Report, and Presentation files to Ms. Honglin Jin (12531321@mail.sustech.edu.cn).
The subject of the email should use the format: [CSE5012] Assignment 1
(LastName/FirstName-StudentNumber).

3.3, Important date

Please submit your Program, Report, and Presentation files by 10:20 (Beijing time) October 14 (Tuesday), 2025.
Please Note: Late submission will be penalized (25% for each day late)

4, Prohibition

You will get 0 as score for this assignment if any of the following cases happens:

- ✓ You don't respect the naming policy of files.
- ✓ The report/program submission is delayed for 3 days (72 hours) or more.
- ✓ Plagiarism.

Contact: For any question regarding this assignment, please email to Ms. Honglin Jin (12531321@mail.sustech.edu.cn). The subject of the email should respect the format: [CSE5012] Assignment 1 (LastName/FirstName-StudentNumber)
Example: [CSE5012] Assignment 1 (Jin/Honglin-12531321)