Project 1

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CS471 - Optimization

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Eighteen selected problems are standard benchmark functions of different properties: Schwefel, De Jong 1, Rosenbrock's Saddle, Rastrigin, Griewangk, Sine Envelope Sine Wave, Stretch V Sine Wave, Ackley One, Ackley Two, Egg Holder, Rana, Pathological, Michalewicz, Master's Cosine Wave, Quartic, Levy, Step and Alpine. All of the functions are dimension-wise scalable.

Table 1 presents functions together with optimal values, in cases where global optima is known and can be reasonably expressed independent of dimension. The third column gives dimensions used in the experimentation for each function. The last column is the search and initialization range used in the experimentation.

1. Schwefel's function:

$$f_1(x) = (418.9829 \cdot n) - \sum_{i=1}^{n} -x_i \cdot sin\left(\sqrt{|x_i|}\right) \tag{1}$$

2. 1st De Jong's function:

$$f_2(x) = \sum_{i=1}^{n} x_i^2 \tag{2}$$

3. Rosenbrock

$$f_3(x) = \sum_{i=1}^{n-1} 100\left(x_i^2 - x_{i+1}\right)^2 + (1 - x_i)^2 \tag{3}$$

4. Rastrigin

$$f_4(x) = 10 \cdot n \sum_{i=1}^{n} \left(x_i^2 - 10 \cdot cos(2\pi \cdot x_i)\right) \tag{4}$$

5. Griewangk

$$f_5\left(x\right) = 1 + \sum_{i=1}^{n} \frac{x_i^2}{4000} - \prod_{i=1}^{n} cos\left(\frac{x_i}{\sqrt{i}}\right) \tag{5}$$

6. Sine Envelope Sine Wave

$$f_6\left(x\right) = -\sum_{i=1}^{n-1} 0.5 + \frac{sin\left(x_i^2 + x_{i+1}^2 - 0.5\right)^2}{\left(1 + 0.001\left(x_i^2 + x_{i+1}^2\right)\right)^2} \tag{6}$$

7. Stretched V Sine Wave

$$f_7\left(x\right) = \sum_{i=1}^{n-1} \left(\sqrt[4]{x_i^2 + x_{i+1}^2} \cdot sin\left(50\sqrt[10]{x_i^2 + x_{i+1}^2}\right)^2 + 1\right) \tag{7}$$

8. Ackley's One

$$f_8\left(x\right) = \sum_{i=1}^{n-1} \frac{1}{e^{0.2}}\sqrt{x_i^2 + x_{i+1}^2} + 3\left(cos\left(2x_i\right) + sin\left(2x_{i+1}\right)\right) \tag{8}$$

9. Ackley's Two

$$f_9\left(x\right) = \sum_{i=1}^{n-1} 20 + e - \frac{20}{e^{0.2\sqrt{\frac{x_i^2 + x_{i+1}^2}{2}}}} - e^{0.5\left(cos\left(2\pi \cdot x_i\right) + cos\left(2\pi \cdot x_{i+1}\right)\right)} \tag{9}$$

10. Egg Holder

$$\begin{aligned} f_{10}\left(x\right) = \sum_{i=1}^{n-1} & - x_i \cdot sin\left(\sqrt{|x_i - x_{i+1} - 47|}\right) \\ & - \left(x_{i+1} + 47\right) \cdot sin\left(\sqrt{|x_{i+1} + 47 + \frac{x_i}{2}|}\right) \end{aligned} \tag{10}$$

11. Rana

$$\begin{aligned} f_{11}\left(x\right) = \sum_{i=1}^{n-1} & x_i \cdot sin\left(\sqrt{|x_{i+1} - x_i + 1|}\right) \cdot cos\left(\sqrt{|x_{i+1} + x_i + 1|}\right) \\ & + \left(x_{i+1} + 1\right) \cdot cos\left(\sqrt{|x_{i+1} - x_i + 1|}\right) \cdot sin\left(\sqrt{|x_{i+1} + x_i + 1|}\right) \end{aligned} \tag{11}$$

12. Pathological

$$f_{12}(x) = \sum_{i=1}^{n-1} 0.5 + \frac{sin\left(\sqrt{100x_i^2 + x_{i+1}^2}\right)^2 - 0.5}{1 + 0.001\left(x_i^2 - 2x_i \cdot x_{i+1} + x_{i+1}^2\right)^2} \tag{12}$$

13. Michalewicz

$$f_{13}(x) = -\sum_{i=1}^{n} sin(x_i) \cdot \left(sin\left(\frac{i \cdot x_i^2}{\pi}\right)\right)^{20} \tag{13}$$

14. Masters Cosine Wave

$$\begin{aligned} f_{14}(x) = -\sum_{i=1}^{n-1} & e^{-\frac{1}{8}\left(x_i^2 + x_{i+1}^2 + 0.5x_{i+1} \cdot x_i\right)} \\ & cos\left(4\sqrt{x_i^2 + x_{i+1}^2 + 0.5x_i \cdot x_{i+1}}\right) \end{aligned} \tag{14}$$

15. Quartic

$$f_{15}(x) = \sum_{i=1}^{n} \left(i \cdot x_i^4\right) \tag{15}$$

16. Levy

$$f_{16}(x) = \sin^2(\pi w_1) + \sum_{i=1}^{n-1} (w_i - 1)^2 \left[1 + 10 \cdot \sin^2(\pi w_i + 1)\right] + (w_n - 1)^2 \left[1 + \sin^2(2\pi w_n)\right] \tag{16}$$

where: $w_i = 1 + \frac{x_i - 1}{4}$

17. Step

$$f_{17}(x) = \sum_{i=0}^{n-1} \left(|x_i| + 0.5\right)^2 \tag{17}$$

18. Alpine

$$f_{18}(x) = \sum_{i=0}^{n-1} \left|x_i \cdot sin(x_i) + 0.1 \cdot x_i\right| \tag{18}$$

Table 1: Experiments

	Name	$f(x^*)$	Dimensions	Range
f_1	Schwefel	0	10,20,30	$[-512, 512]^n$
f_2	De Jong 1	0	10,20,30	$[-100, 100]^n$
f_3	Rosenbrock's Saddle	0	10,20,30	$[-100, 100]^n$
f_4	Rastrigin	0	10,20,30	$[-30, 30]^n$
f_5	Griewangk	0	10,20,30	$[-500, 500]^n$
f_6	Sine Envelope Sine Wave	$-1.4915(n-1)$	10,20,30	$[-30, 30]^n$
f_7	Stretch V Sine Wave	0	10,20,30	$[-30, 30]^n$
f_8	Ackley One	$-7.54276 - 2.91867(n-3)$	10,20,30	$[-32, 32]^n$
f_9	Ackley Two	0	10,20,30	$[-32, 32]^n$
f_{10}	Egg Holder	–	10,20,30	$[-500, 500]^n$
f_{11}	Rana	–	10,20,30	$[-500, 500]^n$
f_{12}	Pathological	–	10,20,30	$[-100, 100]^n$
f_{13}	Michalewicz	$0.966n$	10,20,30	$[0, \pi]^n$
f_{14}	Masters' Cosine Wave	$1-n$	10,20,30	$[-30, 30]^n$
f_{15}	Quartic	0	10,20,30	$[-100, 100]^n$
f_{16}	Levy	0	10,20,30	$[-10, 100]^n$
f_{17}	Step	0	10,20,30	$[-100, 100]^n$
f_{18}	Alpine	0	10,20,30	$[-100, 100]^n$

Pseudo-random number generator

Use the **Mersenne Twister** (MT) pseudo-random number generator in your code. The MT webpage is at (`http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html`) and the different programming language codes are available at (`http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/VERSIONS/eversions.html`).

Experiment

Generate at least 30 pseudo-random solution vectors and solve for all functions in given dimensions of 10, 20 and 30. Compute statistical analysis on the obtained results for average, standard deviation, range, median and time (in millisecond).

Submission

The student must submit the following separate files to canvas:

1. source codes
2. a LaTeX typeset report on the results and its analysis

The report must contain an introduction in the problems, the full experimentation results in tabular format and condensed results with statistical analysis.

The files must be submitted through Canvas by 5PM April 5, 2019. The grading rubric is given in Table 2.

Table 2: Grading rubric

File	Aspects	Points
`Code`	Compiles and executes	35
	Explanation	15
`Report`	Results	25
	Analysis	25