Lab 1

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CS471 - Optimization

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Fifteen 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, and Schekel's Foxhole. All of the functions are dimension-wise scalable, except for f_{15}, limited by dimension $n = 10$. Functions f_2 and f_3 are unimodal, the rest of the functions are multimodal.

Table 1 presents functions together with global optima coordinates and 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:

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

2. 1st De Jong's function:

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

3. Rosenbrock

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

4. Rastrigin

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

1

5. Griewangk

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

6. Sine Envelope Sine Wave

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

7. Stretched V Sine Wave

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

8. Ackley's One

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

9. Ackley's Two

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

10. Egg Holder

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

11. Rana

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

2

Table 1: Experiments

	Name	Global Optimum x^*	$f(x^*)$	Dimensions	Range
f_1	Schwefel	$(420.9687, 420.9687, \ldots, 420.9687)$	$-418.9829n$	10,20,30	$[-512, 512]^n$
f_2	De Jong 1	**o**	0	10,20,30	$[-100, 100]^n$
f_3	Rosenbrock's Saddle	$(1, 1, \ldots, 1)$	0	10,20,30	$[-100, 100]^n$
f_4	Rastrigin	**o**	$-200n$	10,20,30	$[-30, 30]^n$
f_5	Griewangk	**o**	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	**o**	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	**o**	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	**o**	$1 - n$	10,20,30	$[-30, 30]^n$
f_{15}	Shekel's Foxhole	$-$	$-$	10	$[0, 10]^n$

12. Pathological

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

13. Michalewicz

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

14. Masters Cosine Wave

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

15. Shekel's Foxholes

$$f_{15}(x) = -\sum_{i=1}^{m} \frac{1}{c_j + \sum_{j=1}^{n}(x_j - a_{i,j})^2} \tag{15}$$

Recommended value of parameter $m = 30$, $c_j; j = 1, \ldots, m$ and $a_{i,j}; i = 1, \ldots, m; j = 1, \ldots, n$ are constant numbers fixed in advance, recommended values can be found in the external file `Shekel's_Foxholes_Data.txt`.

Experiment

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

Submission

The student must submit the following separate files to canvas:

1. source codes for the problems

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 midnight October 7, 2016. The penalty for late submission is 10% for 1 day, 20% for 2 day, after which it will be zero. 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