# Evolutionary Algorithms (2)

## 1 WORK DURING THE LAB

1. Implement an **evolutionary algorithm** to find the optimum of the *Sphere function*.
    a. Population initialization for real codification
    b. Crossover operator
    c. Mutation operator
    d. Fitness function
2. Test the algorithm for different parameter settings.

Points for the work during the lab: **25p**

## 2 ASSIGNMENT A6

1. Implement and test an **evolutionary algorithm** for the *Sphere* function and *one other function* from the list below.
2. Compare **at least 2 different selection strategies** for parent selection.
3. Compare **at least 2 different crossover** operators.
4. Compare **at least 2 different mutation** operators.

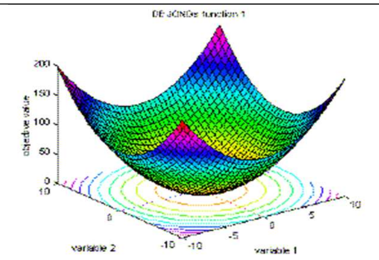
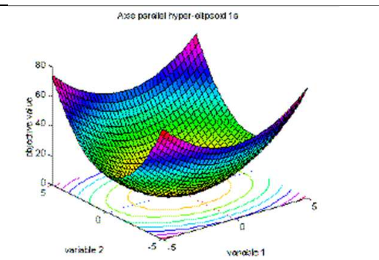
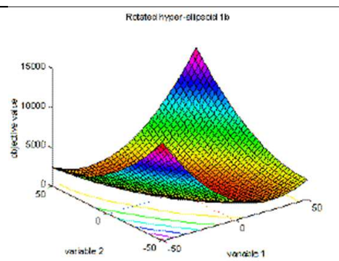
Deadline to submit A6: **Lab 7**

Points for A6: **25p**

## 3 REQUIREMENTS

1. Source code (notebook) needs to be documented.
2. Algorithms have to be tested for several parameter values (sufficient to clearly determine performance).
3. Experiments must be performed for all available problem instances and results compared for diferent parameter settings.
4. Results of the experiments need to be saved in output files, indicating solution quality, parameter values used, number of runs.
5. A report should capture the following: problem definition, algorithm used (name, steps/pseudocode), parameter setting, comparative results of experiments, discussion of results.

# 4 LIST OF FUNCTIONS

| f | Name | Plot | Formula | Global optimum | Characteristics |
|---|---|---|---|---|---|
| 1 | **Sphere Function** (aka De Jong's function 1) |  | $f_1(x)=\sum_{i=1}^{n} x_i^2 \qquad -5.12 \le x_i \le 5.12$ | `f(x)=0, x(i)=0, i=1:n.` | It is continuos, convex and unimodal. Number of local minima: no local minimum except the global one. |
| 2 | Weighted Sphere Model (Axis parallel hyper-ellipsoid) |  | $f_{1a}(x)=\sum_{i=1}^{n} i \cdot x_i^2 \qquad -5.12 \le x_i \le 5.12$ | `f(x)=0; x(i)= 0, i=1:n.` | It is continuos, convex and unimodal. |
| 3 | Schwefel 1 (Rotated hyper-ellipsoid function) |  | $f_{1b}(x)=\sum_{i=1}^{n}\left(\sum_{j=1}^{i} x_j\right)^2$ <br> $-65.536 \le x_i \le 65.536$ | `f(x)=0; x(i)=0, i=1:n.` | It is continuos, convex and unimodal. |

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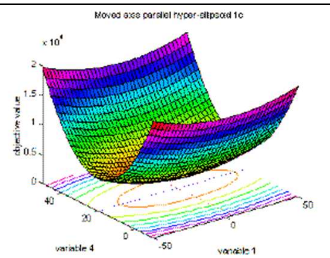
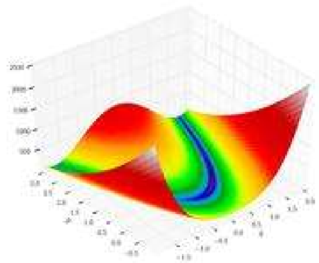
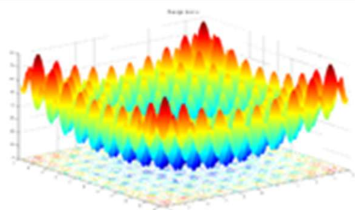
| 4 | Moved axis parallel hyper-ellipsoid function |  | $f_{1c}(x) = \sum_{i=1}^{n} 5i \cdot x_i^2$<br><br>$-5.12 \le x_i \le 5.12$ | `f(x)=0;`<br>`x(i)= 5*i,`<br>`i=1:n.` | Derivata din axis parallel hyper-ellipsoid (1a) – cu alt minim |
| 5 | Rosenbrock's valley (aka Banana function)<br>(aka De Jong's function 2) |  | $f_2(x) = \sum_{i=1}^{n-1} 100 \cdot (x_{i+1} - x_i^2)^2 + (1 - x_i)^2$<br><br>$-2.048 \le x_i \le 2.048$ | `f(x)=0;`<br>`x(i)=1,`<br>`i=1:n.` | The global optimum is inside a long, narrow, parabolic shaped flat valley. |
| 6 | Rastrigin Function |  | $f_6(x) = 10 \cdot n + \sum_{i=1}^{n} (x_i^2 - 10 \cdot \cos(2 \cdot \pi \cdot x_i))$<br><br>$-5.12 \le x_i \le 5.12$ | `f(x)=0;`<br>`x(i)=0,`<br>`i=1:n.` | Based on function 1 with the addition of cosine modulation to produce many local minima. Thus, the test function is highly multimodal. However, the location of the minima are regularly distributed. |

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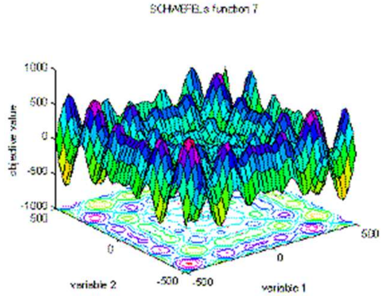
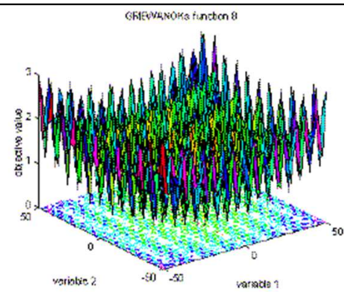
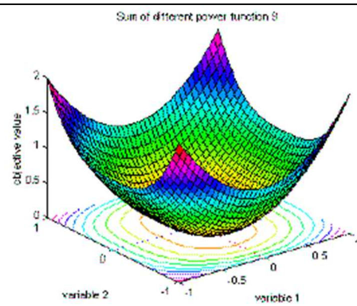
| 7 | Schwefel Function |  | $f_7(x) = \sum_{i=1}^{n} -x_i \cdot \sin\left(\sqrt{\lvert x_i \rvert}\right)$<br><br>$-500 \le x_i \le 500$ | `f(x)=-n·418.9829; x(i)=420.9687, i=1:n.` | Deceptive function in that the global minimum is geometrically distant, over the parameter space, from the next best local minima. |
| 8 | Griewank Function |  | $f(\mathbf{x}) = \sum_{i=1}^{d} \frac{x_i^2}{4000} - \prod_{i=1}^{d} \cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$<br><br>$x_i \in [-600, 600]$, i = 1, …, d. | `f(x)=0; x(i)=0, i=1:d.` | Similar to Rastrigin's function. It has many widespread local minima. However, the location of the minima are regularly distributed. |
| 9 | Sum of different powers function |  | $f(\mathbf{x}) = \sum_{i=1}^{d} \lvert x_i \rvert^{i+1}$<br><br>$x_i \in [-1, 1]$, i = 1, …, d. | `f(x)=0; x(i)=0, i=1:d.` | Unimodal test function. |

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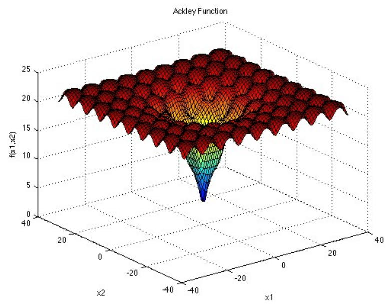
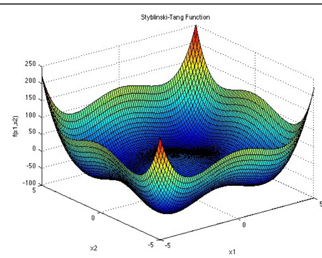
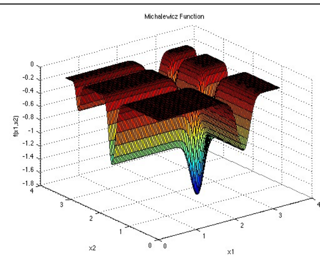
| 10 | Ackley Function |  | $$f(\mathbf{x}) = -a \exp\left(-b\sqrt{\frac{1}{d}\sum_{i=1}^{d} x_i^2}\right)$$ $$- \exp\left(\frac{1}{d}\sum_{i=1}^{d}\cos(cx_i)\right)$$ $$+ a + \exp(1)$$ a = 20, b = 0.2, c = 2π<br>$x_i \in [-32.768, 32.768]$, i = 1, …, d | `f(x)=0;`<br>`x(i)=0,`<br>`i=1:d.` | Multimodal test function. |
| 11 | Styblinski-Tang Function |  | $$f(\mathbf{x}) = \frac{1}{2}\sum_{i=1}^{d}(x_i^4 - 16x_i^2 + 5x_i)$$ $x_i \in [-5, 5]$, i = 1, …, d. | $f(\mathbf{x}^*) = -39.16599d,$<br>$\mathbf{x}^* = (-2.903534,$<br>$\ldots,$<br>$-2.903534)$ | |
| 12 | Michalewicz Function |  | $$f(\mathbf{x}) = -\sum_{i=1}^{d}\sin(x_i)\sin^{2m}\left(\frac{ix_i^2}{\pi}\right)$$ m=10<br>$x_i \in [0, \pi]$, i = 1, …, d. | `f(x)=-4.687`<br>`(d=5);`<br>`x(i)=???,`<br>`i=1:d.`<br><br>`f(x)=-9.66`<br>`(d=10);`<br>`x(i)=???,`<br>`i=1:n.` | Multimodal test function (*n*! local optima). The parameter *m* defi nes the "steepness" of the valleys or edges. |

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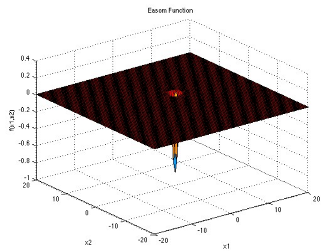
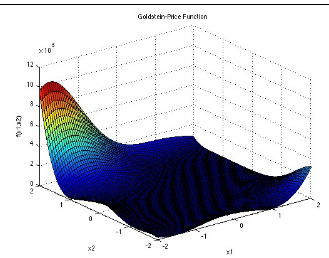
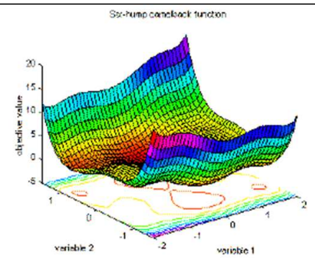
| | | | | | Larger *m* leads to more difficult search. |
| 13 | Easom Function |   | $f(\mathbf{x}) = -\cos(x_1)\cos(x_2)$ $\exp\left(-(x_1-\pi)^2-(x_2-\pi)^2\right)$ $x_i \in [-100, 100]$, $i = 1, 2$. | `f(x1,x2)=-1; (x1,x2)=(pi,pi).` | Unimodal test function, where the global minimum has a small area relative to the search space. |
| 14 | Goldstein-Price Function |   | $f(\mathbf{x}) = \left[1+(x_1+x_2+1)^2 (19-14x_1+3x_1^2-14x_2+6x_1x_2+3x_2^2)\right] \times \left[30+(2x_1-3x_2)^2 (18-32x_1+12x_1^2+48x_2-36x_1x_2+27x_2^2)\right]$ $x_i \in [-2, 2]$, $i = 1, 2$. | `f(x1,x2)=3; (x1,x2)=(0,-1)` | Global optimization test function |
| 15 | Six-hump camel back Function |   | $f(\mathbf{x}) = \left(4-2.1x_1^2+\frac{x_1^4}{3}\right)x_1^2 + x_1x_2 + (-4+4x_2^2)x_2^2$ | `f(x1,x2)=-1.0316; (x1,x2)=(-0.0898,0.7126), (0.0898,-0.7126).` | Global optimization test function. Within the bounded region are six local minima, two of them are global minima. |

http://www-optima.amp.i.kyoto-u.ac.jp/member/student/hedar/Hedar_files/TestGO_files/Page364.htm

http://www.geatbx.com/ver_3_3/fcnindex.html