CS410 Assignment 03 Report

Differential Evolution (DE) and Improved Cross Entropy Method (CEMv2) on different test functions

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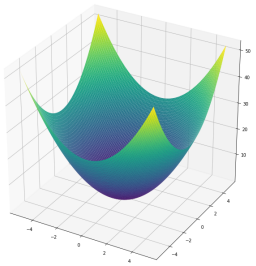
Note: Due to the large capacity of zip file, I couldn't upload it to UIT courses website . So I will only submitted the report and put the assignments folder online. This folder can be found here:

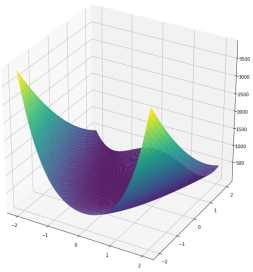
- Github
- Google Drive

1 Test function

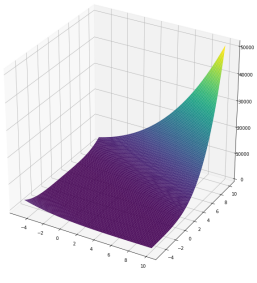
This section is a brief summary of 5 functions that I used in this assignment.



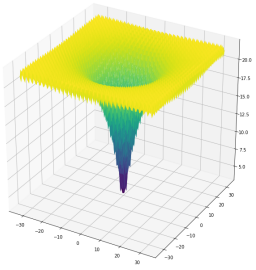
(a) Sphere



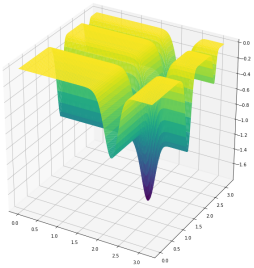
(b) Rosenbrock



(c) Zakharov



(d) Ackley



(e) Michalewicz

Figure 1: Graph of test functions

1.1 Sphere

$$f(x) = \sum_{i=1}^{d} x_i^2$$

- **where** $x_i \in [-5.12; 5.12]$
- **Global minima:** $f(x^*) = 0$, at $x^* = (0, ..., 0)$

1.2 Rosenbrock

$$f(x) = \sum_{i=1}^{d-1} \left[100 \left(x_{i+1} - x_i^2 \right)^2 + (x_i - 1)^2 \right]$$

- **where** $x_i \in [-2.048; 2.048]$
- **Global minima:** $f(x^*) = 0$, at $x^* = (1, ...1)$

1.3 Zakharov

$$f(x) = \sum_{i=1}^{d} x_i^2 + (\sum_{i=1}^{d} 0.5 i x_i)^2 + (\sum_{i=1}^{d} 0.5 i x_i)^4$$

- **where** $x_i \in [-5; 10]$
- **Global minima:** $f(x^*) = 0$, at $x^* = (0, ..., 0)$

1.4 Ackley

$$f(x) = -a \exp\left(-b \sqrt{\frac{1}{d} \sum_{i=1}^{d} x_i^2} \right) - \exp\left(\frac{1}{d} \sum_{i=1}^{d} \cos(c x_i) \right) + a + \exp(1)$$

- **where** $x_i \in [-32.768; 32.768]$
- **Global minima:** $f(x^*) = 0$, at $x^* = (0, ..., 0)$

1.5 Michalewicz

$$f(x) = -\sum_{i=1}^{d} \sin x_i \sin^{2m}\left(\frac{i x_i^2}{\pi} \right)$$

- **where** $x_i \in [0; \pi]$
- **Global minima:** $f(x^*) = 0$, at $x^* = (0, ..., 0)$

2 Results

2.1 Statistic

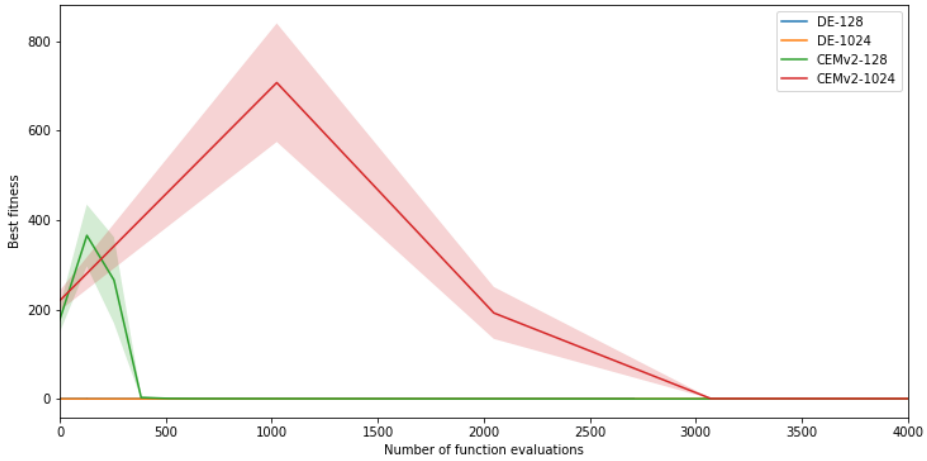
popsize N/λ	DE	CEMv2
32	0 ± 0	0.01 ± 0.01
64	0 ± 0	0.01 ± 0.01
128	0 ± 0	0.01 ± 0.0
256	0 ± 0	0.01 ± 0.0
512	0 ± 0	0.01 ± 0.0
1024	0 ± 0	0.02 ± 0.0

(a)

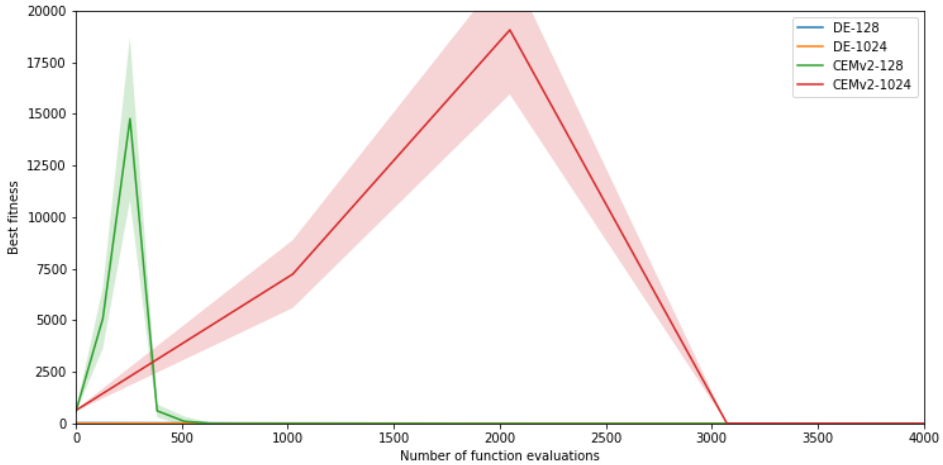
popsize N/λ	DE	CEMv2
32	0 ± 0	0.001 ± 0.0
64	0 ± 0	0.001 ± 0.0
128	0 ± 0	0 ± 0
256	0 ± 0	0 ± 0
512	0 ± 0	0 ± 0
1024	0 ± 0	0 ± 0

(b)

Table 1: Statistics on solution given by Differential Evolution and Evolution Strategies on Sphere function with 2 dimensions (a) and 10 dimensions (b)



(a) dimension = 2



(b) dimension = 10

Figure 2: Comparision plot of Sphere functions

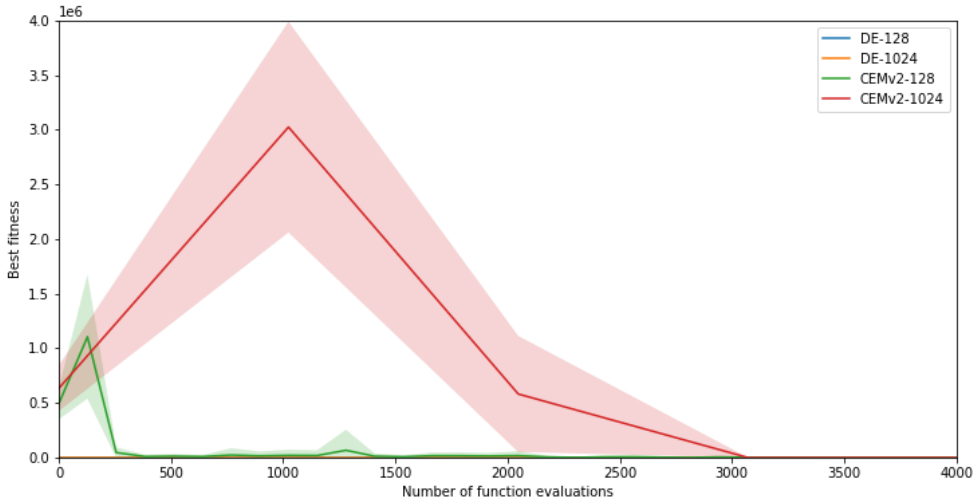
popsize N/λ	DE	CEMv2
32	0 ± 0	0 ± 0
64	0 ± 0	0 ± 0
128	0 ± 0	0 ± 0
256	0 ± 0	0 ± 0
512	0 ± 0	0 ± 0
1024	0 ± 0	0 ± 0

(a)

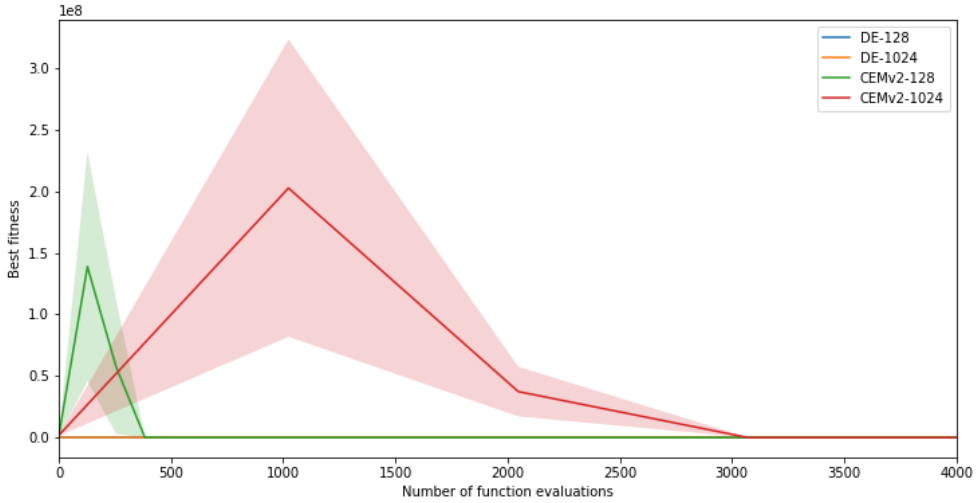
popsize N/λ	DE	CEMv2
32	0 ± 0	0.55 ± 0.08
64	0 ± 0	0.96 ± 1.57
128	0 ± 0	0.12 ± 0.03
256	0 ± 0	0.08 ± 0.02
512	0 ± 0	0.45 ± 1.19
1024	0.41 ± 0.04	0.47 ± 1.19

(b) b

Table 2: Statistics on solution given by Differential Evolution and Evolution Strategies on Rosenbrock function with 2 dimensions (a) and 10 dimensions (b)



(a) dimension = 2



(b) dimension = 10

Figure 3: Comparision plot of Rosenbrock functions

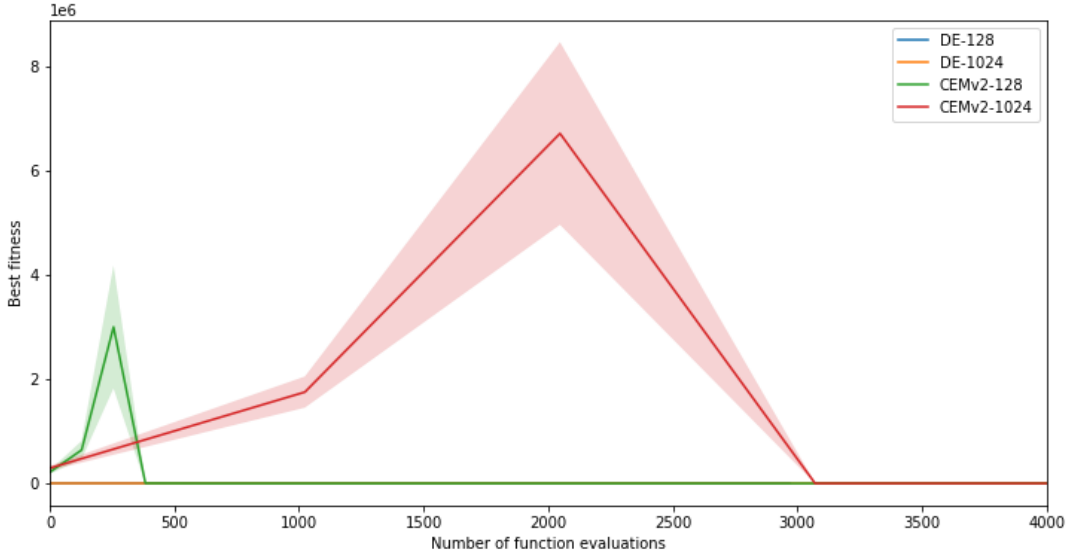
popsize N/λ	DE	CEMv2
32	0 ± 0	0 ± 0
64	0 ± 0	0 ± 0
128	0 ± 0	0 ± 0
256	0 ± 0	0 ± 0
512	0 ± 0	0 ± 0
1024	0 ± 0	0 ± 0

(a)

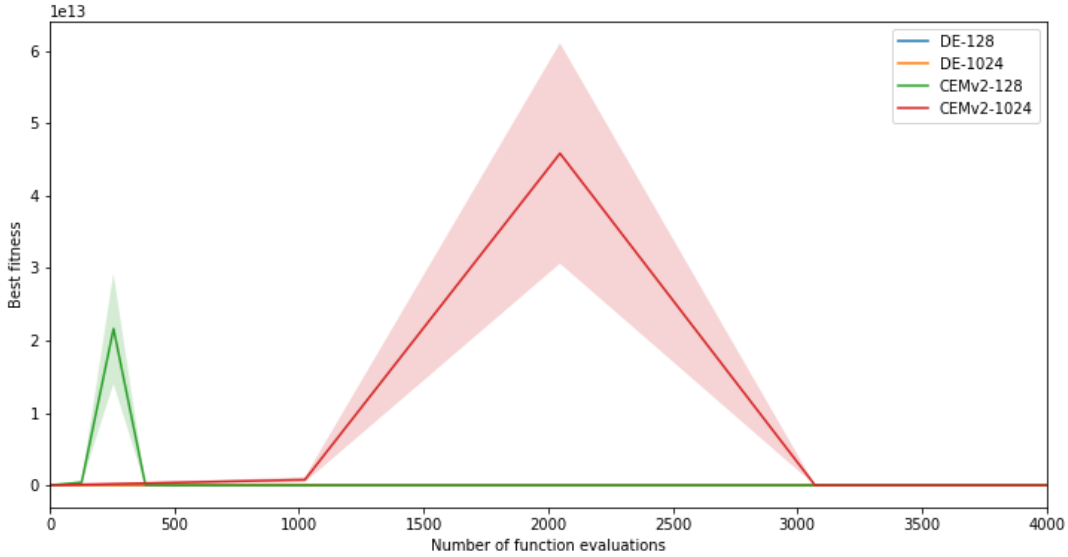
popsize N/λ	DE	CEMv2
32	0 ± 0	2.07 ± 1.14
64	0 ± 0	0.02 ± 0.001
128	0 ± 0	0.03 ± 0.00
256	0 ± 0	0 ± 0
512	0 ± 0	0 ± 0
1024	0.01 ± 0	0 ± 0

(b) b

Table 3: Statistics on solution given by Differential Evolution and Evolution Strategies on Zakharov function with 2 dimensions (a) and 10 dimensions (b)



(a) dimension = 2



(b) dimension = 10

Figure 4: Comparision plot of Zakharov functions

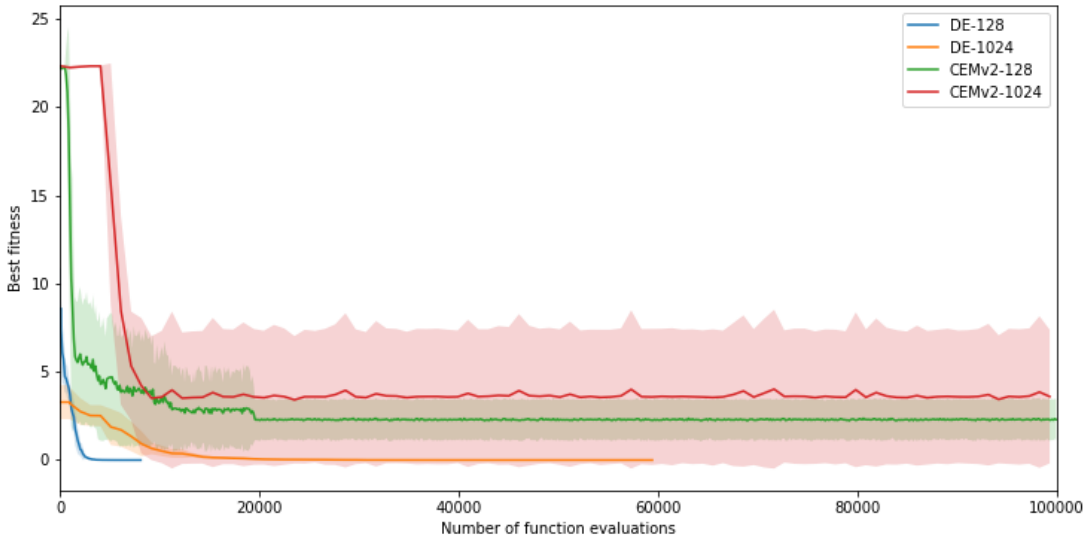
popsize N/λ	DE	CEMv2
32	0 ± 0	1.69 ± 1.71
64	0 ± 0	1.49 ± 1.53
128	0 ± 0	1.91 ± 1.28
256	0 ± 0	1.91 ± 1.28
512	0 ± 0	0.77 ± 1.18
1024	0 ± 0	1.24 ± 1.53

(a)

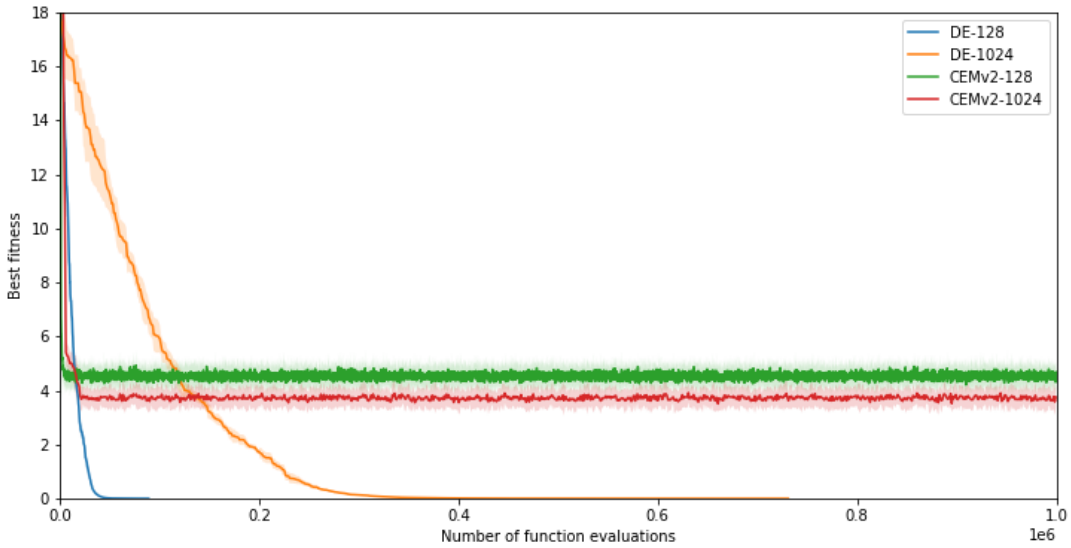
popsize N/λ	DE	CEMv2
32	0 ± 0	9.95 ± 6.25
64	0 ± 0	3.64 ± 2.81
128	0 ± 0	2.76 ± 0.37
256	0 ± 0	2.53 ± 0.67
512	0 ± 0	2.30 ± 0.53
1024	0.01 ± 0	2.23 ± 0.34

(b) b

Table 4: Statistics on solution given by Differential Evolution and Evolution Strategies on Ackley function with 2 dimensions (a) and 10 dimensions (b)



(a) dimension = 2



(b) dimension = 10

Figure 5: Comparision plot of Ackley functions

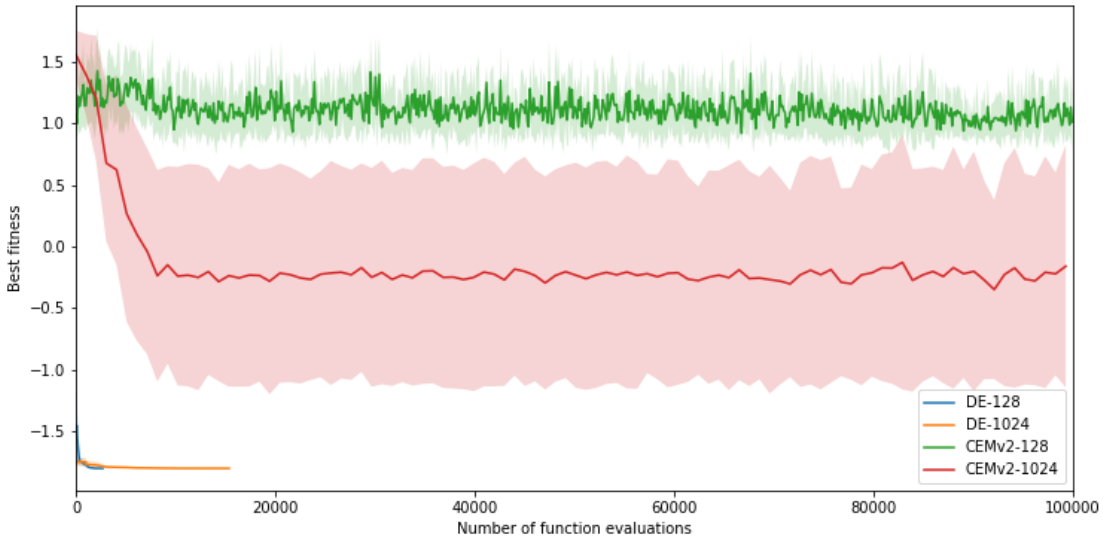
popsize N/λ	DE	CEMv2
32	-1.80 ± 0	-1.60 ± 0.18
64	-1.80 ± 0	-1.61 ± 0.22
128	-1.80 ± 0	-1.56 ± 0.26
256	-1.80 ± 0	-1.51 ± 0.24
512	-1.80 ± 0	-1.64 ± 0.32
1024	-1.80 ± 0	-1.63 ± 0.25

(a)

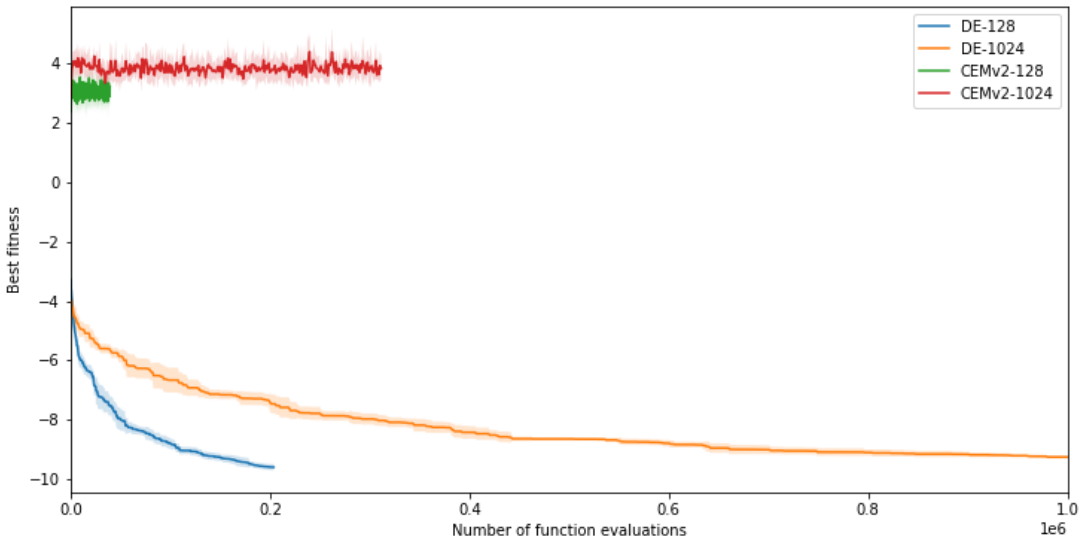
popsize N/λ	DE	CEMv2
32	-9.64 ± 0.03	-3.33 ± 0.47
64	-9.65 ± 0.01	-3.34 ± 0.49
128	-9.66 ± 0	-3.67 ± 0.40
256	-9.66 ± 0	-3.43 ± 0.37
512	-9.66 ± 0	-3.62 ± 0.44
1024	-9.24 ± 0.06	-3.60 ± 0.66

(b) b

Table 5: Statistics on solution given by Differential Evolution and Evolution Strategies on Michalewicz function with 2 dimensions (a) and 10 dimensions (b)



(a) dimension = 2



(b) dimension = 10

Figure 6: Comparision plot of Michalewicz functions

2.2 Illustration with gif

Because GIF files can't be played on a PDF file without downloading external plug-ins, I put the GIF files to a folder name "gif" inside the zip file that I submitted. Or the GIF files can be found online at this link

2.3 Brief comment

On using Differential Evolution (DE) and Improved Cross Entropy Method (CEMv2) on solving different objective functions, it is easily to consider that DE gives out a better solution with a smaller deviation compared to which CEMv2 does almost all the times . And even in challenging cases such as Ackley function or Michalewicz of 2 dimensions, CEMv2 does not converge to the global minimum at all despite the fact that DE could in huge population size case like more than 512.

In addition to results collected above, we could also analyze based on from Figure 1 to Figure 6. DE often tends to have a better fitness with a shorter convergent time in comparison with that on CEMv2 regardless of increasing difficulties in different objective function or increasing population size within each test function.

Hence, we could conclude that in the case of using 5 different objective functions with 2 and 10 dimensions and population size of 32, 64, 128, 256, 512 and 1024, DE has a better performance than CEMv2 in all aspects.