Master's Work – Massively Parallel PSO and DE algorithms

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Outline

- Presentation of the Project
- Deliverables
- Deadlines

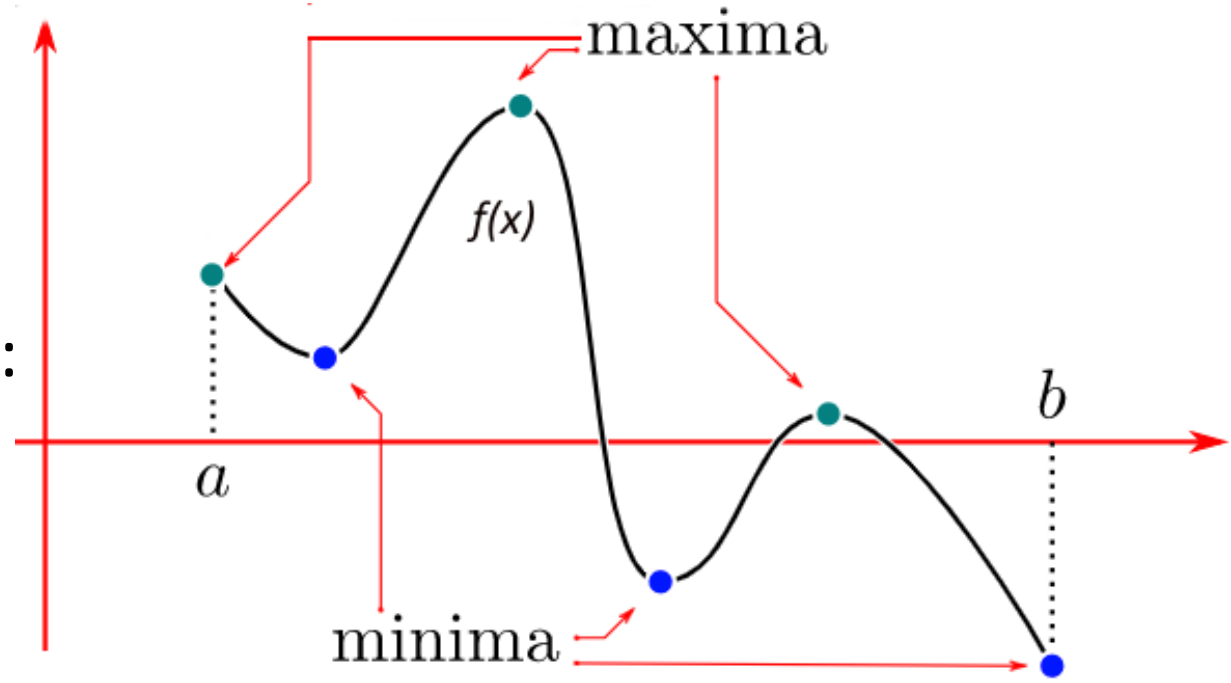
Presentation of the project

Global optimization problem

$$\min_{x \in S \subseteq \mathbb{R}^n} f(x)$$

We seek to find a global solution, such that:

$$x^* = \arg\min f(x) : f(x^*) \leq f(x) \; \forall \; x \in S$$



To solve this problem, we propose in this master project to study and compare the implementation of two massively parallel metaheuristics: **Particle Swarm Optimisation** and **Differential Evolution**.

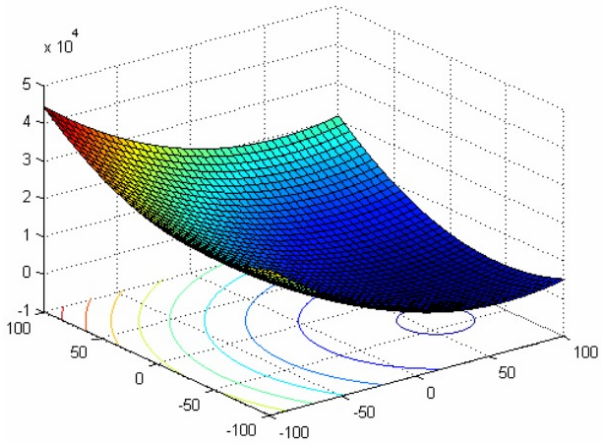
Dimensionality

- optimization can be done on multi-dimensional spaces

2D Shifted Sphere's function

$$\sum_{i=1}^{D} z_i^2 + f\_bias_1 \,,\ \mathbf{z} = \mathbf{x} - \mathbf{o} \,,\ \mathbf{x} = [x_1, x_2, ..., x_D]$$

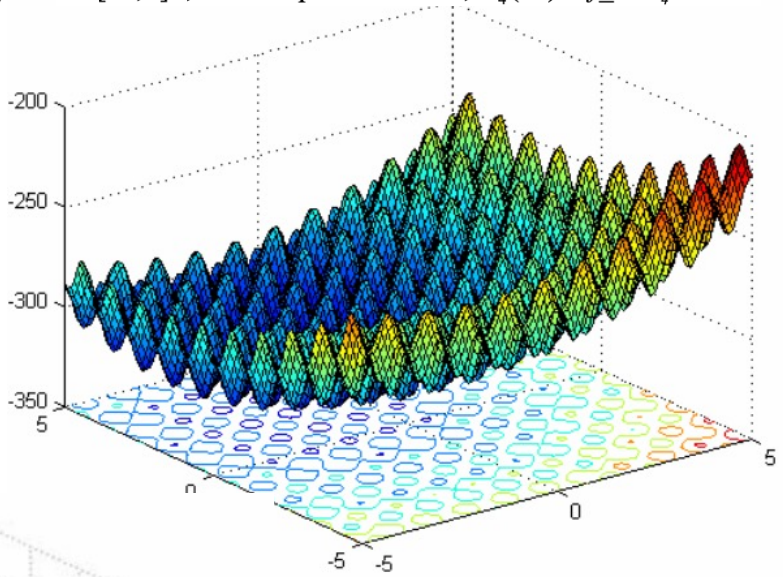
$\mathbf{x} \in [-100,100]^D$, Global optimum: $\mathbf{x}^* = \mathbf{o}$, $F_1(\mathbf{x}^*) = f\_bias_1 = -450$



2D Shifted Rastrigin's function

$$\sum_{i=1}^{D} (z_i^2 - 10\cos(2\pi z_i) + 10) + f\_bias_4,\ \mathbf{z} = \mathbf{x} - \mathbf{o},\ \mathbf{x} = [x_1, x_2, ..., x_D]$$

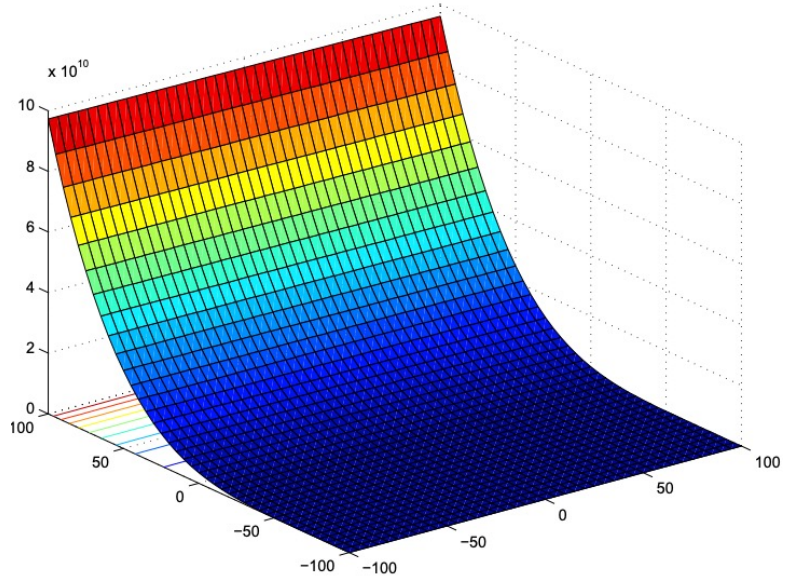
$\mathbf{x} \in [-5,5]^D$, Global optimum $\mathbf{x}^* = \mathbf{o}$, $F_4(\mathbf{x}^*) = f\_bias_4 = -330$

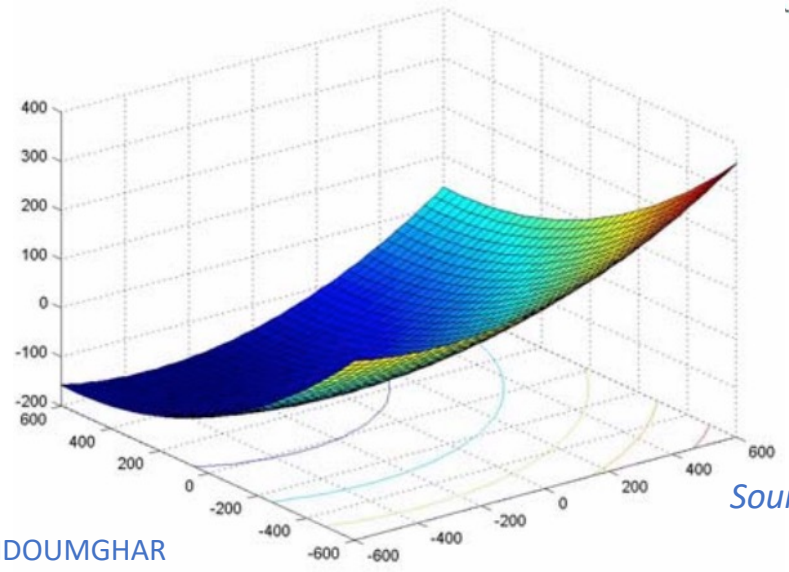


2D Shifted Rosenbrock's function

$$\sum_{i=1}^{D-1} (100(z_i^2 - z_{i+1})^2 + (z_i - 1)^2) + f\_bias_3,\ \mathbf{z} = \mathbf{x} - \mathbf{o} + 1,\ \mathbf{x} = [x_1, x_2, ..., x_D]$$

$\mathbf{x} \in [-100,100]^D$, Global optimum $\mathbf{x}^* = \mathbf{o}$, $F_3(\mathbf{x}^*) = f\_bias_3 = 390$





2D Shifted Griewank's function

$$\sum_{i=1}^{D} \frac{z_i^2}{4000} - \prod_{i=1}^{D} \cos\left(\frac{z_i}{\sqrt{i}}\right) + 1 + f\_bias_5\ ,\ \mathbf{z} = (\mathbf{x} - \mathbf{o}),\ \mathbf{x} = [x_1, x_2, ..., x_D]$$

$\mathbf{x} \in [-600,600]^D$, Global optimum $\mathbf{x}^* = \mathbf{o}$, $F_5(\mathbf{x}^*) = f\_bias_5 = -180$

Source: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.821&rep=rep1&type=pdf

The project - Instructions

1. Instruction of how to install Cuda under googlecolab.
   - http://www.mage.fst.uha.fr/idoumghar/master2/ InstructionsandcodetostudyUFAZ2022.pdf
2. Download:
   - http://www.mage.fst.uha.fr/idoumghar/master2/cudaPSO2025.zip
3. Form the groups by filling in the following link: **https://uhafr-my.sharepoint.com/:x:/g/personal/lhassane_idoumghar_uha_fr/EYbk_NNkz1ZApNEaPL84RlcBidYmP3KEvZxWPCQu5UxC-A?e=CFsxbL**
4. Each pair of students will study massively parallel version of PSO algorithm code.
5. Change PSO code to DE code described in : **https://**www.mage.fst.uha.fr/idoumghar/master2/ImprovedDE.pdf
6. The evaluation of your implementation will be done on the mathematical benchmark functions:
   Shifted Rastrigin's Function, Shifted Rosenbrock's Function, Shifted Griewank's function, Shifted Sphere's Function.
   For more details about these functions, please see:
   https://www.sfu.ca/~ssurjano/optimization.html
   http://www.cmap.polytechnique.fr/~nikolaus.hansen/Tech-Report-May-30-05.pdf
   https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.821&rep=rep1&type=pdf
7. The user can specify the dimension (Dim) of the studied problem and the population
8. Try to improve the quality of your results (try other strategies for DE, etc.).

The project

- Finally, you will need to compare your implementation with other algorithms in the literature, following this procedure:
  - Population: 50, 100, 500.
  - Dimension of each benchmark: Dim = 10, 50, 100.
  - The algorithm terminates once the maximal number of function evaluations is reached, which is set to 10^4 X Dim, e.g. for a 10D problem, the maximal number of function evaluations is 10^5.
  - Calculate the mean and standard deviation of the global minimum values obtained after 10 runs.
  - To compare your DE results, you can :
    - Implement sequential version of DE algorithm.
    - Use results presented in *An_Improved_CUDA-Based-Implementation_of_Different.pdf*
  - Use the statistical analysis (Wilcoxon and/or Kruskal-Wallis based on your results) described on the following web link: https://machinelearningmastery.com/statistical-hypothesis-tests-in-python-cheat-sheet/)

Deliverables

Final document: scientific paper

- The document to be produced will take the form of a scientific article (take inspiration from *An_Improved_CUDA-Based-Implementation_of_Different.pdf :* http://www.mage.fst.uh.fr/idoumghar/master2/ImprovedDE.pdf)
- Structure of the paper (you must use word or latex format https://www.ieee.org/conferences/publishing/templates.html):

Title
Abstract,
Keywords,
1. Introduction,
2. GPU programming
3. Differential Evolution
    3.1. Overview of sequential version of DE
    3.2 Description of Massively parallel version of DE (UML Diagrams: sequence diagrams, User Diagram, etc.)
4. Experimental results
    4.1 Setup
    4.2 Benchmark functions
    4.3 Results: experimental protocol, graphics, tables, etc (presentation of the results obtained by sequential and massively parallel versions of DE (Dim = 10, 50, 100, etc., Population Size = 50, 100, 500, Running time - curves).
5. Conclusion

Deadlines

Planning

- September 26th : composition of student groups. Please complete the following file:

https://uhafr-my.sharepoint.com/:x:/g/personal/lhassane_idoumghar_uha_fr/EYbk_NNkz1ZApNEaPL84RlcBidYmP3KEvZxWPCQu5UxC-A?e=CFsxbL

- Sept. 26th to Nov. 12th : Each pair of students will work on this project.

- Final deliverables due on XXX at 12h : presentation, paper, code, etc.

- X: in ascending order of groups, each pair of students will have a 30 min (15min presentation + 10 min questions) time slot to present their work:
  Their algorithms,
  Their specification,
  Their design and results, etc.