goa
(Global Optimization Animations)
Optimization Methods - Global Optimization Project

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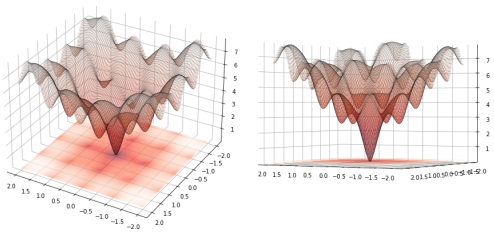
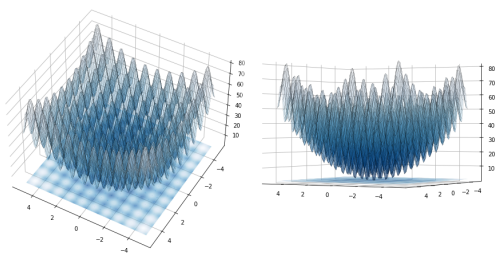
Introduction

What is **goa** (Global Optimization Animations)?

- goa is a Python package that implements:
  1. some problems (optimization test functions)
     - Ackley function



     - Rastrigin function

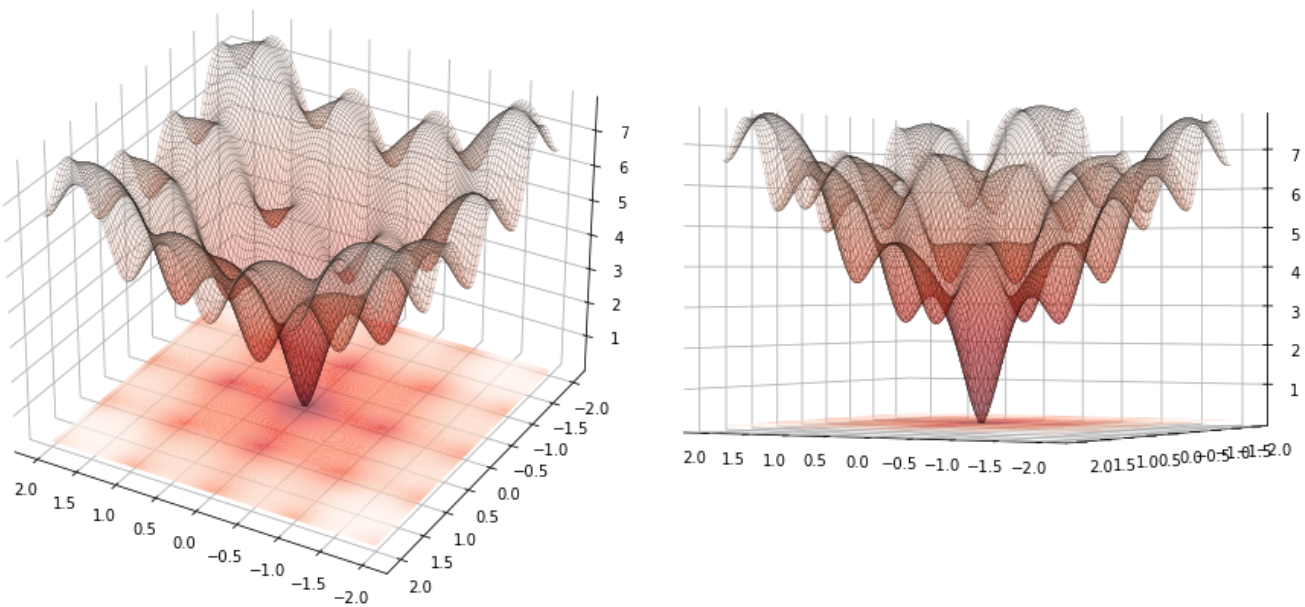


  2. some solutions (optimization algorithms)
     - Differential Evolution [1]
     - Memetic Differential Evolution [3]
     - Coordinate Method with Simple Descent Direction [5]

Definition (Ackley function)

$$f(x_1 \cdots x_n) = -20exp(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}) - exp(\frac{1}{n}\sum_{i=1}^{n} cos(2\pi x_i)) + 20 + e$$

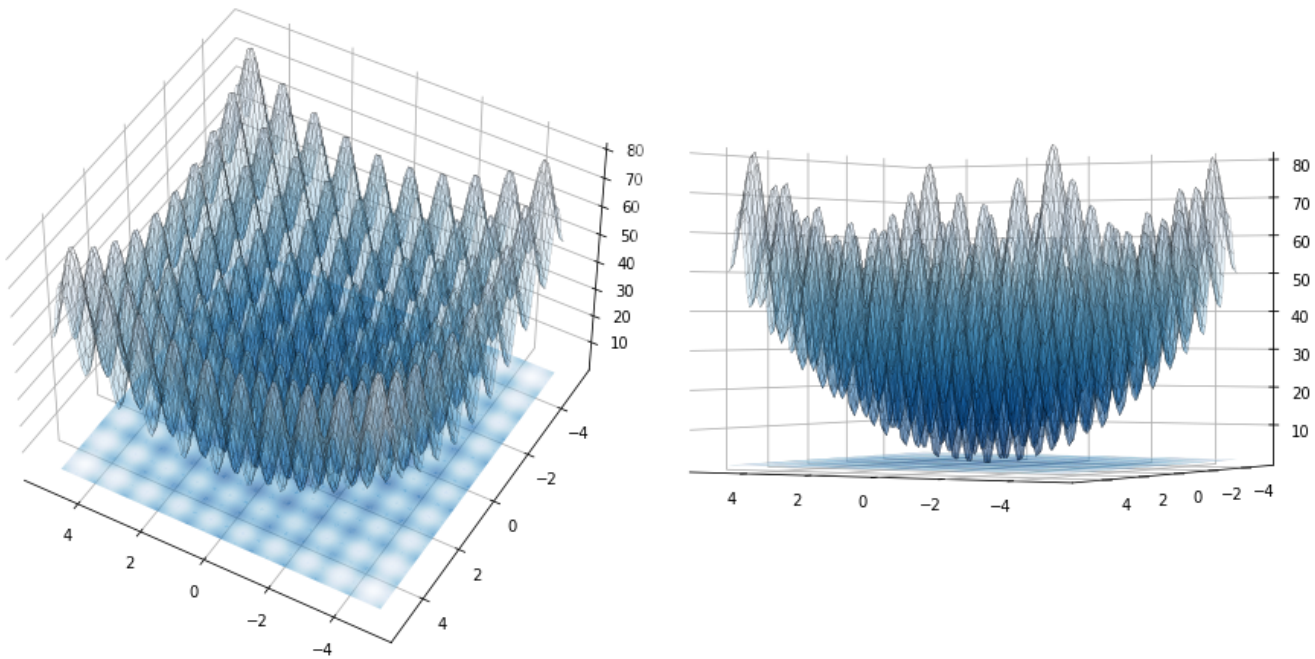
minimum at $f(0, \cdots, 0) = 0$



Definition (Rastrigin function)

$$f(x_1 \cdots x_n) = 10n + \sum_{i=1}^{n}(x_i^2 - 10cos(2\pi x_i))$$

minimum at $f(0, \cdots, 0) = 0$



Memetic Differential Evolution *vs* Differential Evolution

The two algorithms differ only by the 10^{th} code line.

```
    Data: F ∈ (0, 2), CR ∈ [0, 1]
 1  foreach i ∈ 1, . . . , p do
 2      let ii := U(1, . . . , n);
 3      randomly choose k1, k2, k3 ∈ {1, . . . , p} \ {i};
 4      let Trial := x_k1 + F(x_k2 − x_k3);
 5      for j ∈ 1, . . . , n : j ≠ ii do
 6          if U(0, 1) < CR then
 7              let Trial^(j) := x_i^(j);
 8          end
 9      end
10      let Trial := L(f, Trial);
11      if f(Trial) < f(x_i) then
12          let x_i := Trial;
13      end
14  end
```

Algorithm 1: Memetic Differential Evolution

```
    Data: F ∈ (0, 2), CR ∈ [0, 1]
 1  foreach i ∈ 1, . . . , p do
 2      let ii := U(1, . . . , n);
 3      randomly choose k1, k2, k3 ∈ {1, . . . , p} \ {i};
 4      let Trial := x_k1 + F(x_k2 − x_k3);
 5      for j ∈ 1, . . . , n : j ≠ ii do
 6          if U(0, 1) < CR then
 7              let Trial^(j) := x_i^(j);
 8          end
 9      end
10      // let Trial := L(f, Trial)
11      if f(Trial) < f(x_i) then
12          let x_i := Trial;
13      end
14  end
```

Algorithm 2: Differential Evolution

Animations - DE vs MDE on Ackley

- Left example: DE reaches convergence in 38 iterations
- Right example: MDE reaches convergence in 3 iterations

DE on Ackley

MDE on Ackley

Animations - DE vs MDE on Quadratic

- Left example: DE reaches convergence in 19 iterations
- Right example: MDE reaches convergence in 1 iteration

DE on Quadratic

MDE on Quadratic

Command line interface (CLI)

goa provides a CLI that allows to choose:

1. problem
2. problem bounds
3. optimization algorithm
4. local optimization algorithm required by memetic algorithms
5. path for an animation of the execution of the algorithm

```
(goa) → presentation git:(main) ✗ python -m goa
Select a problem (Ackley, Rastrigin, quadratic) [Ackley]:
[OPTIONAL] Change the problem bounds [(-2.5, 2.5)]:
Select an optimization algorithm (MDE, DE, CM) [DE]:
[REQUIRED only with MDE] Select a local search algorithm (CM, None) [None]:
[OPTIONAL] Want an animation? Provide a filepath .gif []: 'example.gif'
Iteration:    5 | RMSE: 0.91623379
Iteration:   10 | RMSE: 0.84967181
Iteration:   15 | RMSE: 0.74277798
Iteration:   20 | RMSE: 0.06209373
Iteration:   25 | RMSE: 0.00837453
Iteration:   30 | RMSE: 0.00156031
Iteration:   35 | RMSE: 0.00026433
Terminated at Iteration: 37
```

Conclusion

Who would need goa?

- anyone that would like to support an explanation
- anyone that would like to better understand

What could be improved?

- scalability (abstract classes for both global and local optimization algorithms)
- reproducibility (all RNGs should depend on a single random seed)

Where can the implementation be found?

- *https://github.com/deeplego/goa*

References

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Thanks for your attention!

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