BLM530 Doğa Esinli Algoritmalar - Nature Inspired Algorithm **Güz 2019**

Project#1 **Teslim Tarihi (Due Date): 11/11/2019**

In this project, you must implement genetic algorithms for solving two benchmark functions, namely Sphere and Rastrigin.

Sphere function (number of dimensions (*N*) is 10)

Type	minimization
Range	none
Global optima	$x_i = 0, \forall i \in \{1 \dots N\}$, $f(\mathbf{x}) = 0$
Function	$f(\mathbf{x}) = \sum_{i=1}^{N} x_i^2$

Rastrigin (number of dimensions (*N*) is 10)

Rastrigin test objective function.

Type	minimization
Range	$x_i \in [-5.12, 5.12]$
Global optima	$x_i = 0, \forall i \in \{1 \dots N\}$, $f(\mathbf{x}) = 0$
Function	$f(\mathbf{x}) = 10N + \sum_{i=1}^{N} x_i^2 - 10\cos(2\pi x_i)$

In this project, you must use two different solution representations to represent the candidate solutions: (1) Binary representation and (2) real-valued representation.

Since the decision variables are real-numbers, you should map real values on bit strings for binary representation.

Mapping real values on bit strings[1]

- Real values can be also binary coded
- $z \in [x, y] \subseteq \Re$ represented by $\{a_1,\dots,a_L\} \in \{0,1\}^L$
- $[x, y] \rightarrow \{0,1\}^L$ must be invertible (one phenotype per genotype)
- $\Gamma: \{0,1\}^L \rightarrow [x, y]$ defines the representation

$$\Gamma(a_1,\dots,a_L) = x + \frac{y-x}{2^L - 1} \cdot \left(\sum_{j=0}^{L-1} a_{L-j} \cdot 2^j\right) \in [x, y]$$

  - Only 2^L values out of infinite are represented
  - L determines possible maximum precision of solution
  - High precision → long chromosomes (slow evolution)

- **Example:**
  - $z \in [1, 10]$
  - We use 8 bits to represent real values in the domain [1, 10] , i.e., we use 256 numbers
    - 1 → 00000000 (0)
    - 10 → 11111111 (255)
  - Convert 00111100, to real value:

    $1 + (9 / 255) * [(0 * 2^0) + (0 * 2^1) + (1 * 2^2) + (1 * 2^3) + (1 * 2^4) + (1 * 2^5) + (0 * 2^6) + (0 * 2^7)] = 3.12$
  - Convert n = 3.14 to bit string:

    n = 3.14 → (3.14-1)*255/(10-1) = 60 → 0011 1100

    0011 1100 → 3.12 (better precision requires more bits)

You must use a generational genetic algorithm with population size of 100, binary tournament selection, elitism of 1. All results are averages over 20 runs with different random seeds. The maximum number of generation is 10000. The crossover and mutation operators depend on the representation.

1. Binary Representation
    a. One-point crossover with crossover probability of 0.9
    b. Bit flip mutation with mutation probability of 1/n (n is the number of genes)

[1] http://webpages.iust.ac.ir/yaghini/Courses/AOR_872/Genetic%20Algorithms_03.pdf

2. Real-valued Representation
    a. Arithmetic Recombination with crossover probability of 0.8
    b. Gaussian mutation with mutation probability of 1/n (n is the number of genes)
    c. boundary control (mirroring)

Experimental Results

The output of the algorithm is the fitness value of the best solution found so far. Each algorithm will be run 20 times. All results are reported as the average, median and best value over 20 runs. You can draw two tables for each representation.

Representation	Mean	Median	Best
Binary	xxx	xxx	xxx
Real-valued	xxx	xxx	xxx

Presentation

You must present your project. Your presentation should contain:

1. Benchmark functions
2. Genetic Algorithm summary
3. Experimental Study
    a. Parameter Settings
    b. Results
        i. Show the effect of the representation in two benchmark functions
4. Conclusion

Good luck,
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