Lab 4 - Understand the impact of control parameter(s) of selfadaptive mutators

CSE, SUSTech

Outline of This Lab

- Teaching Assistant
- How Does Self-adaptation and Parameter Control Work
- Does The Self-adaptation and Parameter Control Matter?
- Test Functions
- Illustrate The Results!

Teaching assistant

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How Does Self-adaptation and Parameter Control Work *-Part I*

1. Generate the initial population of μ individuals, each individual is a real-valued vector, (x_i, η_i) $(i = 1, . . . , \mu)$. And set $k = 1$.
2. Evaluate the fitness of each individual.
3. Each individual (x_i, η_i) $(i = 1, . . . , \mu)$ generates a single offspring (x_i', η_i') by:

   for $j = 1, \cdots, n$,

$$x_i'(j) = x_i(j) + \eta_i(j)\mathcal{N}_j(0,1), \quad (2)$$

$$\eta_i'(j) = \eta_i(j)\exp(\tau'\mathcal{N}(0,1) + \tau\mathcal{N}_j(0,1)) \quad (3)$$

where

- ✓ $x_i(j)$, $x_i'(j)$, $\eta_i(j)$ and $\eta_i'(j)$ denote the j-th components of the vectors x_i, x_i', η_i and η_i', respectively,
- ✓ $N(0, 1)$ denotes a normally distributed one-dimensional random number with mean zero and standard deviation one,
- ✓ $N_j(0, 1)$ indicates that the random number is generated anew for each value of j,
- ✓ The parameters τ and τ' have commonly been set to $\frac{1}{\sqrt{2\sqrt{n}}}$ *and* $\frac{1}{\sqrt{2n}}$.

How Does Self-adaptation and Parameter Control Work *-Part II*

4. Evaluate the fitness of each offspring.
5. Apply round robin tournament selection: For each individual, q opponents are chosen randomly from all the parents and offspring with an equal probability. For each comparison, if the individual's fitness is better than the opponent's, it receives a "win".
6. Select the μ best individuals (from 2μ) that have the most wins to be the next generation.
7. Stop if the stopping criterion is satisfied; otherwise, $k = k + 1$ and go to Step 3.

Does The Self-adaptation and Parameter Control Matter?

- Implement the above algorithm with the real-valued representstion and the Self-adaptation and Parameter Control

Test Functions
-7 unimodal benchmark functions

- Unimodal functions: f_1-f_5
- f_6 is the step function (one minimum, discontinuous).
- f_7 is a noisy quartic function, where random[0, 1) is a uniformly distributed random variable in [0, 1).

Test function	n	S	f_{min}
$f_1(\mathbf{x}) = \sum_{i=1}^{n} x_i^2$	30	$[-100, 100]^n$	0
$f_2(\mathbf{x}) = \sum_{i=1}^{n} \lvert x_i\rvert + \prod_{i=1}^{n} \lvert x_i\rvert$	30	$[-100, 100]^n$	0
$f_3(\mathbf{x}) = \sum_{i=1}^{n} (\sum_{j=1}^{i} x_j)^2$	30	$[-10, 10]^n$	0
$f_4(\mathbf{x}) = \max_i \{\lvert x_i\rvert, 1 \le i \le n\}$	30	$[-100, 100]^n$	0
$f_5(\mathbf{x}) = \sum_{i=1}^{n} [100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$	30	$[-100, 100]^n$	0
$f_6(\mathbf{x}) = \sum_{i=1}^{n} (x_i + 0.5)^2$	30	$[-30, 30]^n$	0
$f_7(\mathbf{x}) = \sum_{i=1}^{n} i x_i^4 + random[0, 1)$	30	$[-1.28, 1.28]^n$	0

Test Functions
-8 multimodal benchmark functions

Test function	n	S	f_{min}
$f_8(\mathbf{x}) = \sum_{i=1}^{n} -x_i \sin(\sqrt{\lvert x_i \rvert})$	**30**	$[-500, 500]^n$	**-12569.5**
$f_9(\mathbf{x}) = \sum_{i=1}^{n} [x_i^2 - 10\cos(2\pi x_i) + 10)]$	**30**	$[-5.12, 5.12]^n$	**0**
$f_{10}(\mathbf{x}) = -20\exp\left(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}\right) - \exp\left(\frac{1}{n}\sum_{i=1}^{n}\cos 2\pi x_i\right) +20 + e$	**30**	$[-32, 32]^n$	**0**
$f_{11}(\mathbf{x}) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n}\cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$	**30**	$[-600, 600]^n$	**0**
$f_{12}(\mathbf{x}) = \frac{\pi}{n}\left\{10\sin^2(\pi y_1) + \sum_{i=1}^{n-1}(y_i - 1)^2[1 + 10\sin^2(\pi y_{i+1})] +(y_n - 1)^2\right\} + \sum_{i=1}^{n} u(x_i, 10, 100, 4),$ $y_i = 1 + \frac{1}{4}(x_i + 1)$ $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m, & x_i > a, \\ 0, & -a \leq x_i \leq a, \\ k(-x_i - a)^m, & x_i < -a. \end{cases}$	**30**	$[-50, 50]^n$	**0**
$f_{13}(\mathbf{x}) = 0.1\left\{\sin^2(3\pi x_1) + \sum_{i=1}^{n-1}(x_i - 1)^2[1 + sin^2(3\pi x_{i+1})] +(x_n - 1)^2[1 + \sin^2(2\pi x_n)]\right\} + \sum_{i=1}^{n} u(x_i, 5, 100, 4)$	**30**	$[-50, 50]^n$	**0**
$f_{14}(\mathbf{x}) = \left[\frac{1}{500} + \sum_{j=1}^{25}\frac{1}{j+\sum_{i=1}^{2}(x_i - a_{ij})^6}\right]^{-1}$	**2**	$[-65.536, 65.536]^n$	**1**
$f_{15}(\mathbf{x}) = \sum_{i=1}^{11}\left[a_i - \frac{x_1(b_i^2 + b_i x_2)}{b_i^2 + b_i x_3 + x_4}\right]^2$	**4**	$[-5, 5]^n$	**0.0003075**

Experimental Setup

- 15 Test Minimization Functions (7 unimodal + 8 multimodal benchmark functions).
- Population size 100.
- Tournament size 10 for selection.
- Maximum function evaluation 500, 000.
- 50 independent runs for each function.

Illustrate The Results!

Plot 15 figures with one for each test function

- ✓x-axis: current generation number.
- ✓y-axis: average fitness value of the best individual of current population over 50 runs.