Lab 8 - Compare niching methods for optimizing multi-modal functions

CSE, SUSTech

Outline of This Lab

- Teaching Assistant
- What is niching?
- How Do Niching Methods Work?
- Experimental Setup
- Illustrate The Results!

Teaching assistant

- Ms. Honglin Jin (12531321@mail.sustech.edu.cn)

What is Niching?

Niching refers to the formation of groups of individuals in a population. Individuals within a group are similar to each other, while individuals from different groups are very different from each other.

How Do Niching Methods Work?

Major categories of niching techniques are:

- ✓(Explicit) Fitness Sharing,
- ✓Implicit Fitness Sharing,
- ✓Fitness Sharing plus Mating Restriction (Use Distance),
- ✓Fitness Sharing plus Mating Restriction (Use Tags).

How Do Niching Methods Work?
-(Explicit) Fitness Sharing

- The shared fitness of individual *i* can be defined as

$$f_{share}(i) = \frac{f_{raw}(i)}{\sum_{j=1}^{\mu} sh(d_{i,j})},$$

where μ is the population size and $sh(d_{i,j})$ is defined as follows.

- The sharing function can be defined as

$$sh(d_{i,j}) = \begin{cases} 1 - \left(\frac{d_{i,j}}{\sigma_{share}}\right)^{\alpha}, & \textbf{if } d_{i,j} < \sigma_{share}, \\ 0, & \textbf{otherwise}, \end{cases}$$

niche count of individual i

where

- ✓ $d_{i,j}$ is the distance between individuals *i* and *j*.
- ✓ α determines the shape of sharing function.
  - ➢ The function is linear when $\alpha = 1$.
  - ➢ When increasing α, f_{share} reduces more rapidly with distance.
- ✓ σ_{share} is share radius, it decides
  - ➢ how many niches can be maintained in a population and
  - ➢ the granularity (粒度) with which different niches can be discriminated.

How Do Niching Methods Work?
-Implicit Fitness Sharing

- For each case i to be solved, do the following C times:
  1. Select a sample of λ individuals from the population.
  2. Find the individual in the sample that achieves the best performance for solving test case i.
  3. This best individual (and this one only) receives the payoff. Ties are broken evenly, i.e., payoff will be shared evenly among all best individuals if they have the same best performance.

How Do Niching Methods Work?
-Fitness Sharing plus Mating Restriction (Use Tags)

Mating Restriction: Use Tags

Each individual consists of a tag and a functional string.

# 1 # 0	10010	1010	... ...	 101

template tag functional string

- ✓Tags participate in crossover and mutation, but not fitness evaluation.
- ✓Templates can also be used.
- ✓This method has been shown to be effective for multi-modal function optimisation.
- ✓Only individuals with the same tag are allowed to mate.

How Do Niching Methods Work?
-Fitness Sharing plus Mating Restriction (Use Distance)

Mating Restriction: Use Distance

Define a threshold parameter, σ_{mate}.

✓Two individuals are allowed to mate only when their distance is smaller than σ_{mate}.

✓EAs with niching and mating restriction were found to distribute the population across the peaks better than those with sharing alone.

Mating restriction is always applied during crossover.

In order to choose a mate for an individual, their distance (in phenotypic mating restriction the Euclidean distance and in genotypic mating restriction the Hamming distance) is computed. If the distance is closer than a parameter σ_{mate}, they participate in the crossover operation; otherwise another individual is chosen at random and their distance is computed. This process is continued until a suitable mate is found or all population members are exhausted, in which case a random individual is chosen as a mate.

Experimental Setup

- The test problem is the single-variable, five-peaked function in the interval $0 \leq x \leq 1$

$$\text{maximize} \qquad 2^{-2((x-0.1)/0.8)^2} \sin^6(5\pi x)$$

- with $\sigma_{share} = \sigma_{mate} = 0.1$
- crossover rate: 0.9
- mutation rate: 0.0
- population size: 100.
- maximum generation numbers: 200

Illustrate The Results!

- Plot the landscape of the test problem.
- Implement an evolutionary algorithm with four niching methods, respectively.
- Plot 4 figures with one for each niching method, respectively.
  - ✓x-axis: variable x.
  - ✓y-axis: the distribution of 100 solutions over the landscape of the test problem.