More on Niching and Speciation: Crowding
Previous lecture

1. Review of fitness sharing
   (a) Fitness sharing changes the raw fitness.
   (b) (Explicit) fitness sharing relies on a similarity or distance metric.
   (c) Implicit fitness sharing does not use a similarity measure.

2. Today: Crowding, speciation and mating restriction
What Is Crowding

- Crowding techniques insert new individuals into the population by replacing similar individuals.
- Crowding techniques strive to maintain the pre-existing diversity of a population.
- Crowding techniques do not modify fitness.
Deterministic Crowding

\(P(0) \leftarrow initialise();\)

\textbf{FOR} \(t \leftarrow 1\) \textbf{TO} \(g\) \textbf{DO}

\(P(t) \leftarrow shuffle(P(t - 1));\)

\textbf{FOR} \(i \leftarrow 0\) \textbf{TO} \(\mu/2 - 1\) \textbf{DO}

\(p_1 \leftarrow a_{2i+1}(t);\)
\(p_2 \leftarrow a_{2i+2}(t);\)
\(\{c_1, c_2\} \leftarrow recombine(p_1, p_2);\)
\(c_1' \leftarrow mutate(c_1);\)
\(c_2' \leftarrow mutate(c_2);\)

\textbf{IF} \([d(p_1, c_1') + d(p_2, c_2')] \leq [d(p_1, c_2') + d(p_2, c_1')]\) \textbf{THEN}

\(\text{IF} \ f(c_1') > f(p_1) \ \text{THEN} \ a_{2i+1}(t) \leftarrow c_1' \ \text{FI};\)
\(\text{IF} \ f(c_2') > f(p_2) \ \text{THEN} \ a_{2i+2}(t) \leftarrow c_2' \ \text{FI};\)

\textbf{ELSE}

\(\text{IF} \ f(c_2') > f(p_1) \ \text{THEN} \ a_{2i+1}(t) \leftarrow c_2' \ \text{FI};\)
\(\text{IF} \ f(c_1') > f(p_2) \ \text{THEN} \ a_{2i+2}(t) \leftarrow c_1' \ \text{FI};\)
Discussions

• Capable of niching, i.e., locating and maintaining peaks.

• Minimal replacement error (the error of replacing an individual of one class by another from a different class).

• Few parameters to tune.

• Fast because of no distance calculations.

• Population size must be large enough.

• Should use full crossover, i.e., crossover rate = 1.0.
Speciation in a narrow sense focuses search within a peak.

- A speciation method restricts **mating to similar individuals** and discourages mating of individuals from different species.

- In order to apply such a speciation method, individuals representing each species must be found first. The speciation method **cannot** be used independently.

- Niching and speciation are complementary.

- Similarity can be measured at either genotypic or phenotypic levels.
Mating Restriction: Use Tags

Each individual consists of a tag and a functional string.

<table>
<thead>
<tr>
<th>template</th>
<th>tag</th>
<th>functional string</th>
</tr>
</thead>
<tbody>
<tr>
<td># 1 # 0</td>
<td>10010</td>
<td>1010 ... ...</td>
</tr>
</tbody>
</table>

- 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.
Mating Restriction: Use Distance

- Define a threshold parameter, $\sigma_{\text{mate}}$.
- Two individuals are allowed to mate only when their distance is smaller than $\sigma_{\text{mate}}$.
- 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 recombination.*
Fitness Sharing by Speciation

- Use tags to identify species (peaks).
- For a given problem, let \( k \) be the number of different tags. Let \( \{S_0, S_1, \ldots, S_{k-1}\} \) be \( k \) species of individuals and \( \| \cdot \| \) be the cardinality of a set. Then,
  
  \[ f_{share}^i = \frac{f_{raw}^i}{\|S_j\|}, \quad i \in S_j, \quad j = 0, 1, \ldots, k - 1 \]

- Recombination occurs only among individuals with the same tag.
- A tag can be mutated.
- No distance is used here.
- This is actually sharing plus mating restriction.
Summary of Niching and Speciation

**Fitness Sharing** modifies fitness.
- (explicit) fitness sharing
- implicit fitness sharing
- fitness sharing with mating restriction

**Crowding** is about replacement strategies.
- deterministic crowding

**Speciation** in a narrow sense occurs during recombination. It is all about mating restriction.
- by tags
- by distances
Other Niching & Speciation Methods

do exist.

- Sequential niching
- Parallel Eas
- etc.

Reference