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

$P(0) \longleftarrow initialise()$;
FOR $t \longleftarrow 1$ TO g DO
    $P(t) \longleftarrow shuffle(P(t-1))$;
    FOR $i \longleftarrow 0$ TO $\mu/2 - 1$ DO
        $p_1 \longleftarrow a_{2i+1}(t)$;
        $p_2 \longleftarrow a_{2i+2}(t)$;
        $\{c_1, c_2\} \longleftarrow recombine(p_1, p_2)$;
        $c_1' \longleftarrow mutate(c_1)$;
        $c_2' \longleftarrow mutate(c_2)$;
        IF $[d(p_1, c_1') + d(p_2, c_2')] \leq [d(p_1, c_2') + d(p_2, c_1')]$ THEN
            IF $f(c_1') > f(p_1)$ THEN $a_{2i+1}(t) \longleftarrow c_1'$ FI;
            IF $f(c_2') > f(p_2)$ THEN $a_{2i+2}(t) \longleftarrow c_2'$ FI;
        ELSE
            IF $f(c_2') > f(p_1)$ THEN $a_{2i+1}(t) \longleftarrow c_2'$ FI;
            IF $f(c_1') > f(p_2)$ THEN $a_{2i+2}(t) \longleftarrow c_1'$ 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

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.

# 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.

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 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,

$$f_i^{share} = \frac{f_i^{raw}}{\|S_j\|}, \quad i \in S_j, \quad j = 0, 1, \cdots, k-1$$

- 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

- T. Back, D. B. Fogel, and Z. Michalewicz (eds.), Handbook of Evolutionary Computation, IOP Publ. Co. & Oxford University Press, 1997. Section C6.1 and Section C6.2. (In the school library)