CSE/ECE 848 Introduction to Evolutionary Computation

Module 2, Lecture 8, Part 3
Building Blocks and the Schema Theorem

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Using the Schema Theorem

Even a simple form helps balance initial selection pressure, crossover & mutation rates, etc.:

$$P(H,t+1) \geq P(H,t)\frac{f(H,t)}{\bar{f}}\left[1 - p_c\frac{\Delta(H)}{L-1} - o(H)p_m\right]$$

Say relative fitness of H is 1.2, p_c = .5, p_m = .05 and L = 20: What happens to H, if H is long? Short? High order? Low order?

Pitfalls: slow progress, random search, premature convergence, etc.

Problem with Schema Theorem – important at beginning of search, but less useful later, although Whitley's form works better…

Building Block Hypothesis

Define a *Building block* as: a short, low-order, high-fitness schema

BB Hypothesis: "Short, low-order, and highly fit schemata are sampled, recombined, and resampled to form strings of potentially higher fitness… we construct better and better strings from the best partial solutions of the past samplings."

-- David Goldberg, 1989

(GA's with CROSSOVER can be good at assembling BB's, but GA's are also useful for many problems for which BB's are not available)

Lessons – (Not Always Followed…)

For newly discovered *building blocks* to be nurtured (made available for combination with others), but not allowed to take over population (why?):

- Mutation rate should be:
  - small relative to the order of the *building block* schemata that are important to protect
  - 1/L is a frequently used default (L = number of loci)
- (but contrast that with SA, ES, (1+λ), …), which may use much higher mutation rates with different characteristics

Lessons – (Not Always Followed…) (cont.)

For newly discovered *building blocks* to be nurtured (made available for combination with others), but not allowed to take over population:

- Crossover rate should be:
  - Small enough that building blocks can multiply before being disrupted by crossover–classically, ranged from below 0.3 up to 0.7
- Selection should be able to:
  - Be strong enough to let building blocks proliferate and combine with others before crossover& mutation disrupt them

Lessons – (Not Always Followed…) (cont.)

- Population size should be (oops – what can we say about this?… so far… not much):
  - Goldberg did work considering optimal population sizes for problems with a given amount of deception (4-bit deception, etc.)
  - Some folks use as a rule of thumb to make the population size at least twice the number of loci, but that is pretty arbitrary, and certainly not provably optimal
  - Often a balancing act between how much diversity can be preserved, fighting off premature convergence, and how many generations one can afford to run in order to converge to a useful solution…