CSE/ECE 848 Introduction to Evolutionary Computation

Module 2, Lecture 8, Part 1b
Introduction to Schema Theory

Erik D. Goodman, Executive Director
BEACON Center for the Study of Evolution in Action
Professor, ECE, ME, and CSE

How Do Schemata Propagate? Proportional Selection Favors "Better" Schemata

- Select the INTERMEDIATE population, the "parents" of the next generation, via *fitness-proportional selection*
- So if *M(H,t)* is number of instances (samples) of schema H in the population at time t, then *fitness-proportional selection* yields an *expectation* of:

$$M(H,t+intermed) = M(H,t)\frac{f(H,t)}{\overline{f}}$$

- In an example, the actual number of instances of schemata (next page) in the intermediate generation tracked the expected number pretty well, in spite of small pop size

Expected vs. Observed # Schemata in Example Intermediate (Breeding) Population

Schemata and Fitness Values									
Schema	Mean	Count	Expect	Obs	Schema	Mean	Count	Expect	Obs
101*...*	1.70	2	3.4	3	*0**...*	0.991	11	10.9	9
111*...*	1.70	2	3.4	4	00**...*	0.967	6	5.8	4
1*1*...*	1.70	4	6.8	7	0***...*	0.933	12	11.2	10
01...*	1.38	5	6.9	6	011*...*	0.900	3	2.7	4
**1*...*	1.30	10	13.0	14	010*...*	0.900	3	2.7	2
11...*	1.22	5	6.1	8	01**...*	0.900	6	5.4	6
11**...*	1.175	4	4.7	6	0*0*...*	0.833	6	5.0	3
001*...*	1.166	3	3.5	3	*10*...*	0.800	5	4.0	4
1***...*	1.089	9	9.8	11	000*...*	0.767	3	2.3	1
0*1*...*	1.033	6	6.2	7	**0*...*	0.727	11	8.0	7
10**...*	1.020	5	5.1	5	*00*...*	0.667	6	4.0	3
*1**...*	1.010	10	10.1	12	110*...*	0.650	2	1.3	2
****...*	1.000	21	21.0	21	1*0*...*	0.600	5	3.0	4
					100*...*	0.566	3	1.70	2

Results of example run (Whitley) showing that observed numbers of instances of schemata track expected numbers pretty well. "Count" is # instances of schema in pop, "Expect" is exp. # of instances in offspring pop, "Obs" is actual # observed in in offspring

Figure from Whitley, A Genetic Algorithm Tutorial,https://www.cs.colostate.edu/~genitor/MiscPubs/tutorial.pdf

Crossover Effect on Schemata

- One-point Crossover Schema Disruption Examples

  11******** and 1********1

  ^ 1/(L-1) ^(L-1)/(L-1) = 100%

- Two-point Crossover Schema Disruption Examples

  11******** and 1********1 are SAME, viewed as a ring:

  1 1

  0 0

  0 0

  0 0

  0 0

  same probability of disruption, $2/L - 1/L^2$

- The closer together loci are, the less likely to be disrupted by crossover, right? One-pt xover USUALLY breaks up schemata with large defining lengths, while two-pt xover is more forgiving, reducing the probability of disrupting a schema, and makes that probability *independent* of position on the chromosome.

Linkage and Defining Length

- Linkage -- "coadapted alleles"
- Argument that probability of disruption of schema H of length Δ(H) by one-point crossover is:

  $$\Delta(H)/(L-1)$$

  (= possible places to *disrupt* schema /

  all possible places to do one-pt crossover)
- Example:

  11******** and 1********1

  1/(L-1) 1