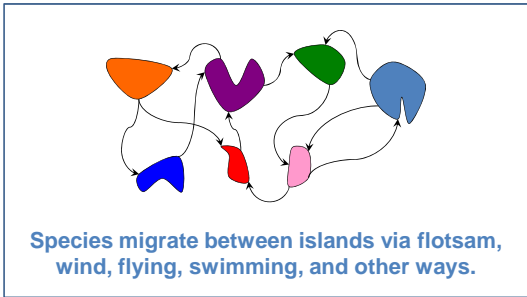


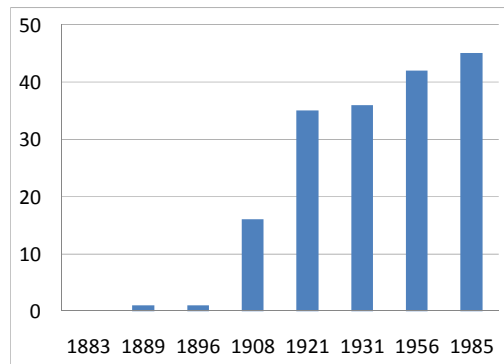
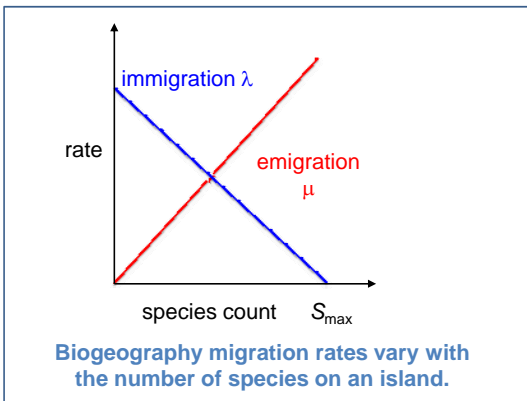
# Biogeography-Based Optimization with Blended Migration for Constrained Optimization Problems

Haiping Ma (Shaoxing University) and Dan Simon (Cleveland State University)  
Genetic and Evolutionary Computation Conference, Portland, Oregon, July 7–11, 2010

**Biogeography:** The study of the migration, speciation, and extinction of biological organisms.



**Biogeography-Based Optimization:** A new evolutionary algorithm based on the mathematics of biogeography.



For each solution  $H_i$   
 For each solution feature  $s$   
 Select solution  $H_j$  with probability  $\propto (1 - \text{fitness}_j)$   
 If  $H_j$  is selected then  
 Select  $H_k$  with probability  $\propto \text{fitness}_k$   
 If  $H_k$  is selected then  
 $H_i(s) \leftarrow \alpha H_i(s) + (1-\alpha)H_k(s)$   
 end  
 end  
 next solution feature  
 next solution

One generation of BBO; fitness normalized to  $[0, 1]$ .  $\alpha = 0$  for standard BBO, and  $\alpha > 0$  for blended BBO.

Solution  $H_1$  is considered better than  $H_2$  if:  
 (1) Both solutions are feasible, but  $H_1$  has a cost that is less than or equal to that of  $H_2$ ; or,  
 (2)  $H_1$  is feasible and  $H_2$  is not; or,  
 (3) Both solutions are infeasible, but  $H_1$  has a smaller overall constraint violation.

Kalonymoy Deb's constraint-handling rules.

| Fn. | BBO     |         |    | GA      |         |    | PSO     |         |    | Blended BBO |         |    |
|-----|---------|---------|----|---------|---------|----|---------|---------|----|-------------|---------|----|
|     | Mean    | Std Dev | NS | Mean    | Std Dev | NS | Mean    | Std Dev | NS | Mean        | Std Dev | NS |
| g01 | 1.1E-03 | 4.7E-04 | 20 | 3.5E-02 | 8.4E-03 | 15 | 2.9E-03 | 4.4E-03 | 15 | 2.7E-05     | 9.0E-06 | 30 |
| g02 | 0.00    | 0.00    | 30 | 1.3E-01 | 6.6E-01 | 10 | 1.1E-02 | 4.9E-02 | 14 | 0.00        | 0.00    | 30 |
| g03 | 3.3E-02 | 8.3E-03 | 12 | 2.7E-01 | 7.9E-02 | 10 | 2.8E-02 | 6.0E-04 | 12 | 3.1E-05     | 9.2E-05 | 30 |
| g04 | 1.3E+01 | 9.4E+00 | 0  | 3.0E+02 | 1.8E+02 | 0  | 3.9E+01 | 3.5E+01 | 0  | 2.5E+00     | 3.2E+00 | 2  |
| g05 | 5.5E-08 | 5.9E-07 | 22 | 5.0E-06 | 5.7E-05 | 18 | 2.4E-01 | 1.1E-01 | 4  | 8.5E-09     | 9.0E-09 | 30 |
| g06 | 3.0E-01 | 4.1E-01 | 16 | 9.0E+01 | 8.7E+00 | 6  | 2.1E-01 | 5.9E-02 | 18 | 1.4E-01     | 5.2E-01 | 16 |
| g07 | 2.2E+00 | 7.6E-01 | 3  | 8.5E+00 | 6.4E+00 | 2  | 9.0E+00 | 7.9E+00 | 2  | 3.5E-01     | 1.5E-01 | 8  |
| g08 | 5.8E-11 | 4.4E-12 | 30 | 1.0E-12 | 2.6E-13 | 30 | 7.5E-08 | 9.0E-08 | 30 | 7.2E-12     | 2.6E-12 | 30 |
| g09 | 0.00    | 0.00    | 30 | 3.1E+00 | 2.2E+00 | 3  | 1.7E+00 | 6.9E+00 | 10 | 0.00        | 0.00    | 30 |
| g10 | 7.4E+01 | 9.0E+00 | 5  | 9.2E+00 | 2.4E+00 | 3  | 3.9E+00 | 1.9E+00 | 5  | 5.5E+01     | 1.9E+00 | 1  |
| g11 | 0.00    | 0.00    | 30 | 0.00    | 0.00    | 30 | 1.3E-03 | 3.5E-03 | 15 | 0.00        | 0.00    | 30 |
| g12 | 3.8E-07 | 6.1E-08 | 30 | 1.4E-05 | 5.4E-06 | 15 | 7.8E-05 | 9.9E-06 | 22 | 8.5E-08     | 1.5E-08 | 30 |
| g13 | 2.9E-01 | 2.4E-02 | 7  | 9.2E+00 | 1.0E-01 | 7  | 1.8E+00 | 8.4E-01 | 7  | 5.7E-02     | 3.2E-02 | 10 |

Constrained function optimization results. Blended BBO performs the best on 10 out of 14 benchmarks. NS means "number of successes" out of 30 simulations.