

# Populating Genomes in a Dynamic Grid

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## 1 A Dynamic Grid Environment

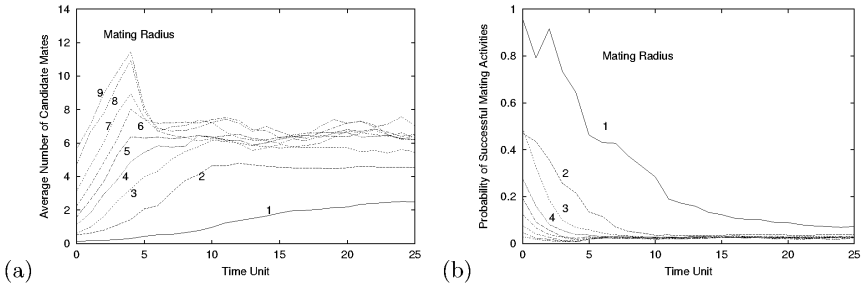
We study the behavior of a spatially distributed GA (Collins and Jefferson 1991) that has several unique features. First, individuals are allowed to move within a two dimensional grid over time. Such movement results in a continual change in the local environment in which each individual interacts. Second, selection is directly based on an individual's energy value and indirectly based on fitness. The fitness of an individual determines its initial energy level, but an individual's energy level at any point during a run reflects a combination of its fitness and its interactions in the environment. Third, the population size can change dynamically throughout a run.

We study the mating radius of the individuals, and the energy-based selection which results in noisy selection. We investigate the impact of these two aspects on the selection pressure among individuals.

## 2 Experiments and Analysis of Results

We use the Hierarchical-if-and-only-if(H-IFF) function as the test bed to study the behavior of this grid environment. We test different mating radii ranging between one and nine grids. Results indicate that the mating radius has significant impact on the performance of this GA. A GA with a mating radius of one has the highest probability of finding solutions. GAs with larger mating radii achieve competitive results in the 16-bit function, but performance degrades quickly as problem size increases. Experiments also show that, in cases where the GA finds an optimal solution, a large mating radius improves the search efficiency. The larger the mating radius, the fewer fitness evaluations necessary to find a solution.

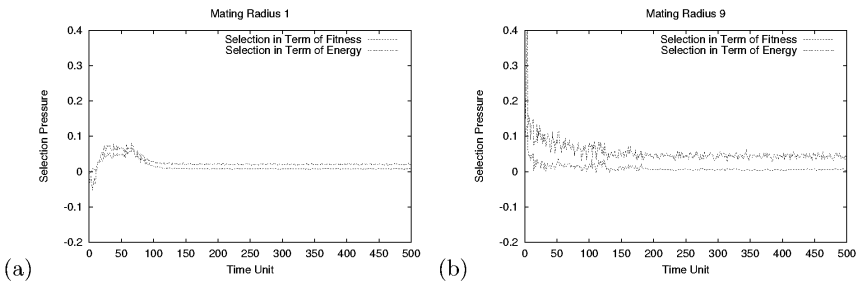
Further analysis, with the results shown in Figure 1, reveals that although a large mating radius gives individuals the chance to find more candidate mates, the probability of a successful mating is very low due to high competition among the individuals within a neighborhood. As a result, fewer offspring are created in each time unit than when a small mating radius is used. A large mating radius also encourages the GA to converge quickly to a single solution, which is not desirable for domains with large or rugged search spaces. Slower convergence allows a GA to have more complete coverage of search space. This explanation is consistent to the experimental results on the H-IFF function, where a GA



**Fig. 1.** (a) Average number of candidate mates in the early period of typical runs using different mating radii (b) Probability of successful mating activities in the early period of the same runs.

with a mating radius of nine is the fastest to solve the smaller 16-bit function but performs much worse on larger functions.

A distinguishing feature of our GA is that selection among individuals is based on their energy values. The energy of an individual is initialized as its fitness and fluctuates throughout the individual’s lifetime. As a result, the energy-based selection introduces “noise” in the selection scheme. Figure 2 shows that noise in our selection method helps to reduce the selection pressure as compared to traditional fitness-based selection. As the energy does not truly reflect the fitness of an individual, the noise provides more chance for low fitness individuals to succeed in mating. This phenomenon is more noticeable in a highly converged population as both good and bad individuals have nearly equal chance of mating.



**Fig. 2.** The selection pressure for mating among individuals with (a) mating radius of 1 (b) mating radius of 9.

## References

- Collins, R. J., Jefferson, D. R.: Selection in massively parallel genetic algorithms. In: Proc. of the Fourth International Conference on Genetic Algorithms, Morgan Kaufmann (1991) 249-256