Comparison between Genetic Algorithms and Particle Swarm Optimization

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Introduction

- PSO: Instead of using traditional genetic operators, each particle adjusts its direction and velocity according to its own experience and that of its companions'.
- Compare GA and PSO:
  - Not a performance evaluation.
  - Provide insights into how GAs and PSO work

GA Operators

- Selection
- Crossover
- Mutation

PSO

- A particle is analogous to a population member (chromosome) in a GA.
- Like a GA chromosome, a particle represents a candidate solution to the problem being addressed.
- Each particle is treated as a point in the D-dimensional problem space as X_I
- The best previous position (the position giving the best fitness value) of the each particle is P_I
- The index of the best particle among all the particles in the population is represented by g.
- The rate of the position change (velocity) for particle i is represented as V_I

PSO

- The particles are manipulated according to the following equations:

$$v_{id} = w * v_{id} + c_1 * rand() * (p_{id} - x_{id}) + c_2 * Rand() * (p_{gd} - x_{id})$$
$$x_{id} = x_{id} + v_{id}$$

- w: inertia weight
- Larger inertia weight facilitates global exploration.
- Smaller inertia weight tends to facilitate local exploration.

Crossover - GA

- Effects of GA crossover may vary during a run.
- At the beginning, the population members are usually randomized.
- Crossover can have significant effects, moving a chromosome a relatively large distance in problem space.
- Toward the end of a run, a population has often converged, hence, chromosomes have similar structures.
- Crossover then usually has less effect, and the resulting movements are relatively smaller.

Crossover - PSO

- PSO does not have a crossover operation.
- However, the concept of crossover is represented in PSO.
- Each particle is stochastically accelerated toward:
  - its own previous best position
  - the global best position
- These particles seem to be exploring a region that represents the geometric mean between two promising regions.

Mutation - GA

- GA mutation tends to have less impact near the beginning of a run, and more near the end.
- Initial population is randomized, so flipping a bit here and there near the beginning may not change things as dramatically as flipping bits near the end of a run, when the population has converged.

Mutation - PSO

- Because each particle has a velocity, PSO mutation-like behavior is directional.
- It is the random amount of velocity change.
- GA mutation is generally considered to be omnidirectional in that any bit in an individual can be flipped.

Selection - GA

- The effect of selection in a GA is to support the survival of the fittest.
- An elitist strategy is often used, which results in the chromosome with the highest fitness value always being copied into the next generation.
- Crossover occurs between randomly selected parents.
- The evolution of an individual chromosome typically involves exchanging genetic material with quite a few other randomly-selected individuals.

Selection - PSO

- PSO does not utilize selection.
- All particles continue as members of the population for the duration of the run.
- In PSO, a particle does not explicitly exchange material with other particles, but its trajectory is influenced by them.
- A given particle is influenced only by its own previous best position and that of the best position in the neighborhood or in the global population.

Simulated Annealing

- A high value of w at the beginning of the run facilitates global search, while a small w tends to localize the search.
- Good performance can be achieved by reducing the value of w during a run.
- The inertia weight thus appears to have characteristics that are reminiscent of the temperature parameter in simulated annealing.