3.5. Genetic Algorithms

A) Ideas Behind

1) A GA is a variant of stochastic beam search:

- local search
- more than one current states
- probabilistic in choosing the successor state

2) A GA models reproduction involving two parents:
a successor is generated by combining two states

3) A GA models evolution:

- population genetics
- survival of the fittest

✓Parent states are chosen from a set after rating with an objective function.
✓The function is called fitness function .
✓ 'Crossover' and 'Mutation' are also accommodated.

B) Major steps of a typical Genetic algorithm:

Toy example: 8-queens problem

1) Begins with an initial population, that is, set of data structures.

Suppose 4 states: a) 25348716 b) 81765432
c) 42561862 d) 31456321

2) Each individual is rated using a fitness function.

F(a) = 28-h(a) = 28-5 =23, F(b) = 13, F(c) = 22, F(d) = 17.

3) Process terminates if one individual is 'sufficiently fit'.

Say, the value to be 'sufficiently fit' is 25.

4) A parent generation is formed taking better performing individuals.

Parent generation:
Taking 15 as the threshold value, for example, we get {a, c, d}.

5) Parents are chosen randomly for ‘crossover’, and a new generation is obtained consisting of the ‘offsprings’.

Say, a and d are chosen for crossover, and 4 is the crossover point.

253|**48716** New generation: e. 253**56321**

314|**56321** f. 314**48716**

6) Each member of new generation can undergo, with a small independent probability, the process of ‘mutation’.

Mutation:

Say, [e. 25356321] $\rightarrow$ [e′: 2**6**356321].

7) Parent generation and new generation form new population for running the next cycle beginning from step 2.

New population:

{a, c, d, e′, f}

C) Important features of Crossover and Mutation:

1. Beside single point, multipoint crossovers are possible.
   In most cases, crossover points are chosen randomly.

2. Additional information like 'useful block' (genetic code) in the structure may help meaningful crossover.
   Mask or schema may be used to perform crossover considering 'useful blocks'.

3. Crossover and mutation help combine :

   - uphill tendency
   - random exploration
   - exchange of information among implicit parallel search threads

All those increase the probability of convergence avoiding local maxima.