GENETIC ALGORITHM

Evolutionary Algorithms

The algorithms, which follow some biological and physical behaviours:

Biologic behaviours:

1) Genetics and Evolution – > Genetic Algorithms (GA)
2) Behaviour of ant colony – > Ant Colony Optimization (ACO)
3) Human nervous system – > Artificial Neural Network (ANN)

In addition to that there are some algorithms inspired by some physical behaviours:

Physical behaviours:

1) Annealing process – > Simulated Annealing (SA)
2) Swarming of particle – > Particle Swarming Optimization (PSO)
3) Learning – > Fuzzy Logic (FL)

Why Genetic Algorithm

Travelling Salesman Problem

Maximum destinations
Minimum Cost
Minimum Time

What are Genetic Algorithms (GAs)?

- **adaptive heuristic** search algorithms based on the evolutionary ideas of natural selection and genetics.
- represent an intelligent exploitation of a random search to solve **optimization** problems.
- exploit historical information to direct search within search space into region of better performance.
- designed to simulate processes in natural systems necessary for evolution **("survival of the fittest")**

In 1975, Holland developed this idea in **Adaptation in Natural and Artificial Systems** by applying principles of natural evolution to optimization problems.

Genetic Algorithm

It is a subset of evolutionary algorithm:

1) Ant Colony optimization
2) Swarm Particle Optimization

Models biological processes:

1) Genetics
2) Evolution

To optimize highly complex objective functions:

1) Very difficult to model mathematically
2) NP-Hard (also called combinatorial optimization) problems (which are computationally very expensive)
3) Involves large num[illegible]nuous)

So, this is the idea, this is the history behind the genetic algorithm and which we

Understanding biological terminologies

- The **genes** code the individual's characteristics.
- Genes can have different values or **alleles.** Eg. possible alleles for eye color can be black, brown, blue, green.
- **Gene Pool** is set of possible alleles present in a particular population.
- **Genome** is set of all the genes of specific species.
- Position of gene in genome is termed as **locus**.
- Genotype: set of genes of an individual.
- Phenotype: physical aspect of an individual.
- **Chromosomes** store genome and has two sets of genes (diploidy).
- Dominant one will determine phenotype.

Terminologies in GAs

GAs – based on an analogy with genetic structure and behaviour of chromosomes.

Foundations for GAs:

- Individuals in a population compete for resources and mates.
- Most successful individuals will produce more offsprings.
- Genes from good individuals propagate to produce offspring better than either of parents.
- Each successive generation will become more suited to environment.

Terminologies in GAs

Search Space: Population of individuals is maintained within search space for GA.

Individual

- refers to the possible solution to given problem.
- is coded as finite length of vector of variables generally binary {0,1}.
- is assigned a fitness score representing its ability to compete.

- Individuals are linked to chromosomes and variables to genes.
- Individuals with optimal fitness score are sought.
- GA aims for selective breeding of individuals for producing offspring better than parents.
- Offsprings are added to population and to keep the population size static old individuals are removed.
- It is expected to get the best fit solution over successive generations.

Simple Genetic Algorithm

The general GA is as follows:

Step 1: *Create a random initial state*: An initial population is created from a random selection of solutions (which are analogous to chromosomes). This is unlike the situation for symbolic AI systems, where the initial state in a problem is already given.

Step 2: *Evaluate fitness*: A value for fitness is assigned to each solution (chromosome) depending on how close it actually is to solving the problem (thus arriving to the answer of the desired problem). (These "solutions" are not to be confused with "answers" to the problem; think of them as possible characteristics that the system would employ in order to reach the answer.)

Simple Genetic Algorithm

Step 3: *Reproduce (and children mutate)*: Those chromosomes with a higher fitness value are more likely to reproduce offspring (which can mutate after reproduction). The offspring is a product of the father and mother, whose composition consists of a combination of genes from the two (this process is known as "crossingover").

Step 4: *Next generation*: If the new generation contains a solution that produces an output that is close enough or equal to the desired answer then the problem has been solved. If this is not the case, then the new generation will go through the same process as their parents did. This will continue until a solution is reached.

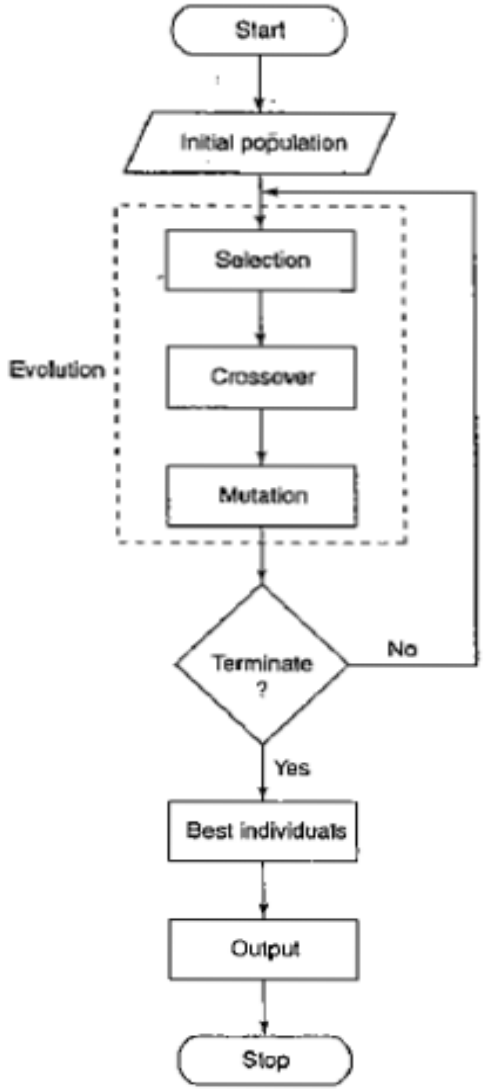


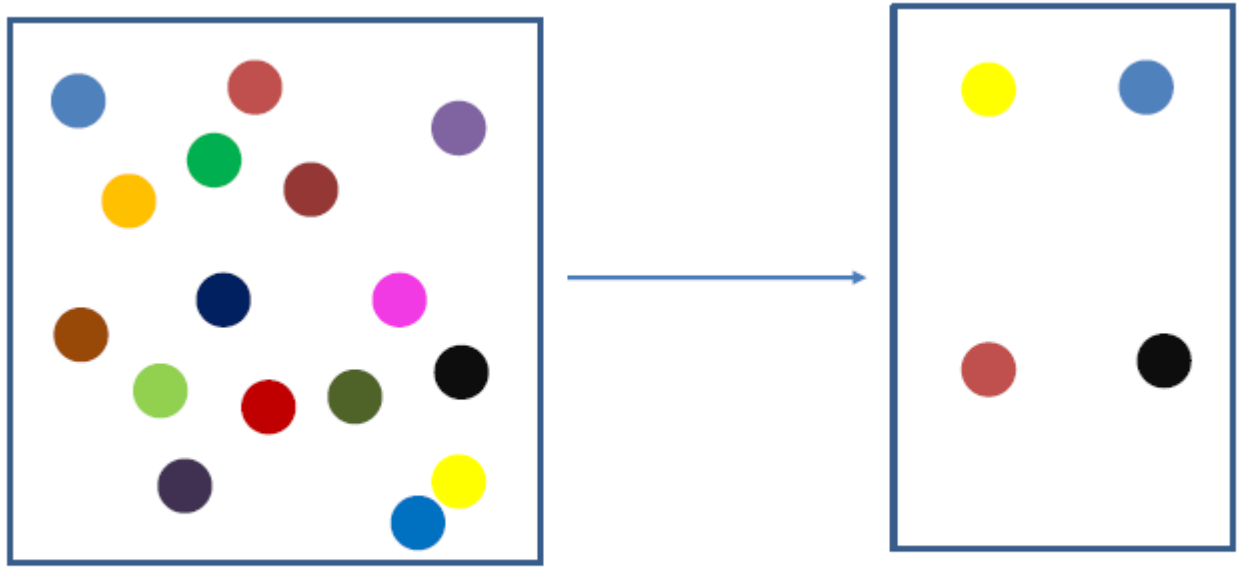
Figure 15-13 Flowchart for genetic algorithm.

Operators in GA

Three main operators are:

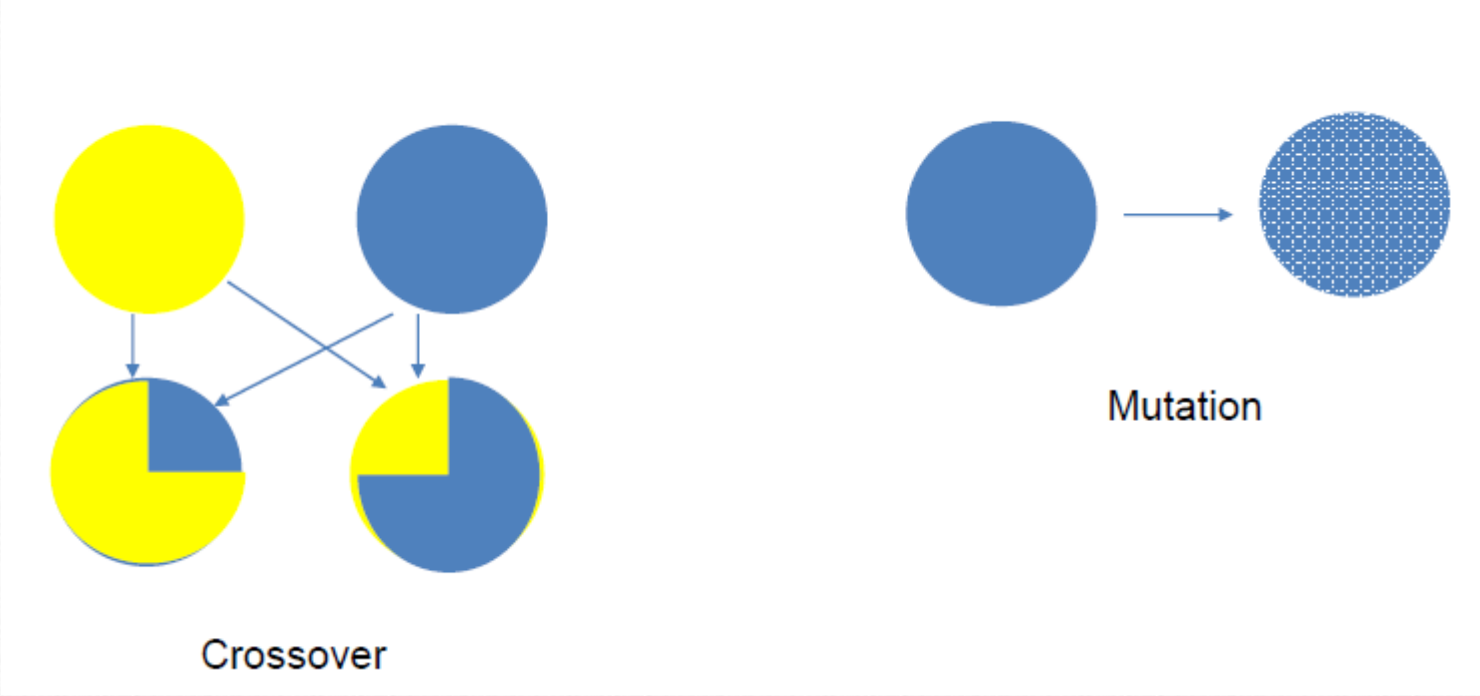
- Selection – survival of the fittest
- Crossover – mating between individuals
- Mutation – introduces random modifictions

Selection Operator



Selection based on fitness function

Crossover and Mutation Operator



Operators in GA