

- A problem graph, containing the start node S and the goal node G.
- A strategy, describing the manner in which the graph will be traversed to get to G.
- A fringe, which is a data structure used to store all the possible states (nodes) that you can go from the current states.
- A tree, that results while traversing to the goal node.
- A solution plan, which the sequence of nodes from S to G.

Informed Search Algorithms

Here, the algorithms have information on the goal state, which helps in more efficient searching. This information is obtained by something called a heuristic. They are:

- Greedy Search
- A* Tree Search
- A* Graph Search

Search Heuristics: In an informed search, a heuristic is a function that estimates how close a state is to the goal state. For example – Manhattan distance, Euclidean distance, etc. (Lesser the distance, closer the goal.) Different heuristics are used in different informed algorithms discussed below.

Breadth First Search

The breadth-first search (BFS) algorithm is used to search a tree or graph data structure for a node that meets a set of criteria. It starts at the tree's root or graph and searches/visits all nodes at the current depth level before moving on to the nodes at the next depth level. Breadth-first search can be used to solve many problems in graph theory.

The only catch here is, that, unlike trees, graphs may contain cycles, so we may come to the same node again. To avoid processing a node more than once, we divide the vertices into two categories: Visited and Not visited.

A Boolean visited array is used to mark the visited vertices. For simplicity, it is assumed that all vertices are reachable from the starting vertex. BFS uses a queue data structure for traversal.

Advantages of Breadth First Search:

- BFS will never get trapped exploring the useful path forever.
- If there is a solution, BFS definitely find it out.
- If there is more than one solution then BFS can find the minimal one that requires less number of steps. If there is a solution then BFS is guaranteed to find it.
- Low storage requirement: linear with depth.
- Easily programmed.

Disadvantages of Breadth First Search:

- The main drawback of BFS is its memory requirement. Since each level of the tree must be saved in order to generate the next level and the amount of memory is proportional to the number of nodes stored the space complexity of BFS is $O(bd)$. As a result, BFS is severely space-bound in practice so will exhaust the memory available on typical computers in a matter of minutes.

Depth First Search

For Negation:

P	$\neg P$
True	False
False	True

For Conjunction:

P	Q	$P \wedge Q$
True	True	True
True	False	False
False	True	False
False	False	False

For disjunction:

P	Q	$P \vee Q$
True	True	True
False	True	True
True	False	True
False	False	False

For Implication:

P	Q	$P \rightarrow Q$
True	True	True
True	False	False
False	True	True
False	False	True

Limitations of Propositional logic:

- We cannot represent relations like ALL, some, or none with propositional logic. Example:
All the girls are intelligent.
Some apples are sweet.
- Propositional logic has limited expressive power.
- In propositional logic, we cannot describe statements in terms of their properties or logical relationships.

Fuzzy Logic

The 'Fuzzy' word means the things that are not clear or are vague. Sometimes, we cannot decide in real life that the given problem or statement is either true or false. At that time, this concept provides many values between the true and false and gives the flexibility to find the best solution to that problem.

A Fitness Score is given to each individual which shows the ability of an individual to “compete”. The individual having optimal fitness score (or near optimal) are sought.

The GAs maintains the population of n individuals (chromosome/solutions) along with their fitness scores. The individuals having better fitness scores are given more chance to reproduce than others. The individuals with better fitness scores are selected who mate and produce better offspring by combining chromosomes of parents. The population size is static so the room has to be created for new arrivals. So, some individuals die and get replaced by new arrivals eventually creating new generation when all the mating opportunity of the old population is exhausted. It is hoped that over successive generations better solutions will arrive while least fit die.

Each new generation has on average more “better genes” than the individual (solution) of previous generations. Thus each new generations have better “partial solutions” than previous generations. Once the offspring produced having no significant difference from offspring produced by previous populations, the population is converged. The algorithm is said to be converged to a set of solutions for the problem.

Once the initial generation is created, the algorithm evolves the generation using following operators

- 1) Selection Operator: The idea is to give preference to the individuals with good fitness scores and allow them to pass their genes to successive generations.
- 2) Crossover Operator: This represents mating between individuals. Two individuals are selected using selection operator and crossover sites are chosen randomly. Then the genes at those crossover sites are exchanged thus creating a completely new individual (offspring).
- 3) Mutation Operator: The key idea is to insert random genes in offspring to maintain the diversity in the population to avoid premature convergence.

Fitness score is the number of characters which differ from characters in target string at a particular index. So individual having lower fitness value is given more preference.

Why use Genetic Algorithms

- They are Robust
- Provide optimisation over large space state.
- Unlike traditional AI, they do not break on slight change in input or presence of noise

Application of Genetic Algorithms

- Recurrent Neural Network
- Mutation testing
- Code breaking
- Filtering and signal processing
- Learning fuzzy rule base etc

Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a powerful meta-heuristic optimization algorithm and inspired by swarm behavior observed in nature such as fish and bird schooling. PSO is a Simulation of a simplified social system. The original intent of PSO algorithm was to graphically simulate the graceful but unpredictable choreography of a bird flock.