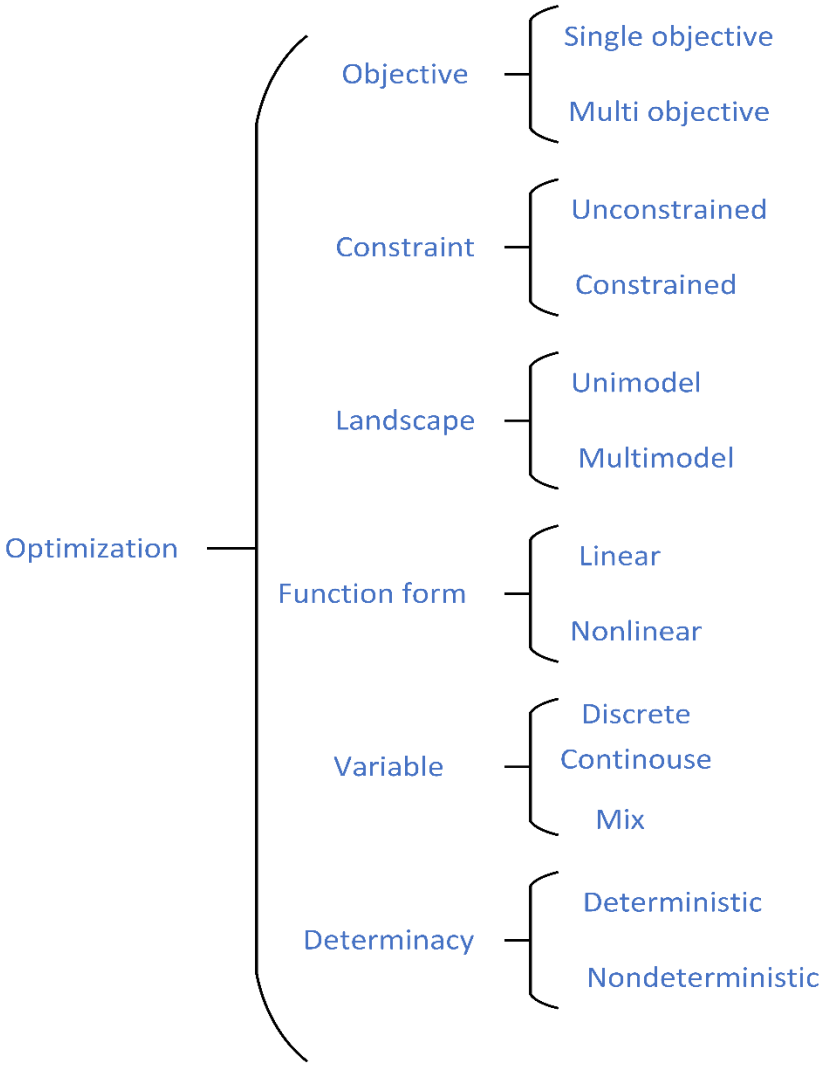
Introduction to Genetic Algorithm (GA)

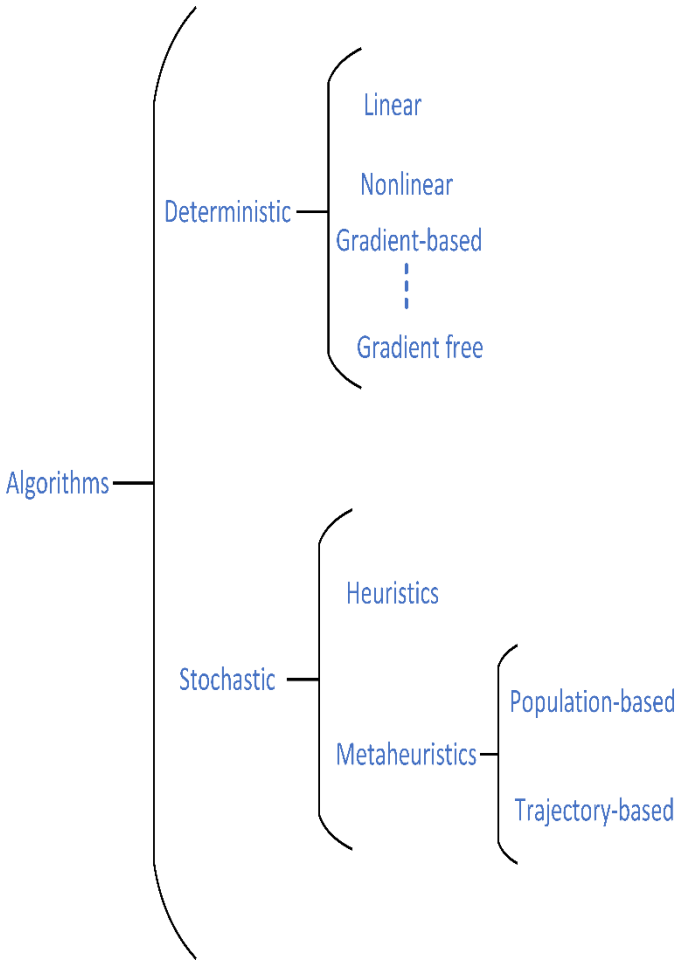
Introduction to optimization (2/13)

- Optimization can include a wide range of problems with the aim of searching for certain optimality. Subsequently, there are many different ways of naming and classifying optimization problems, and typically the optimization techniques can also vary significantly from problem to problem.

- Generally speaking, classification can be carried out in terms of the number of objectives, number of constraints, function forms, landscape of the objective functions, type of design variables, uncertainty in values, and computational effort

Introduction to optimization (3/13)





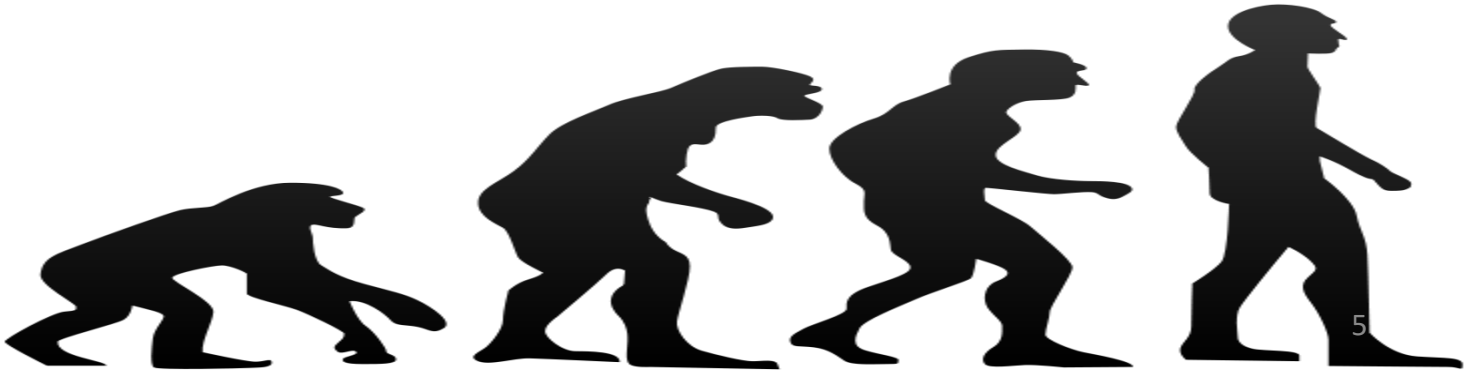
GA (4/13)

- **Introduction**
  - Based on Darwin's theory of evolution
  - Rapidly growing area of artificial intelligence
  - Used to solve optimization-based problems
  - Techniques inspired by evolutionary biology
    - Inheritance
    - Mutation
    - Selection
    - Crossover
- **History**
  - Evolutionary computing evolved in the 1960's by I.Rechenberg
  - GA's were invented by John Holland in the mid-70's.

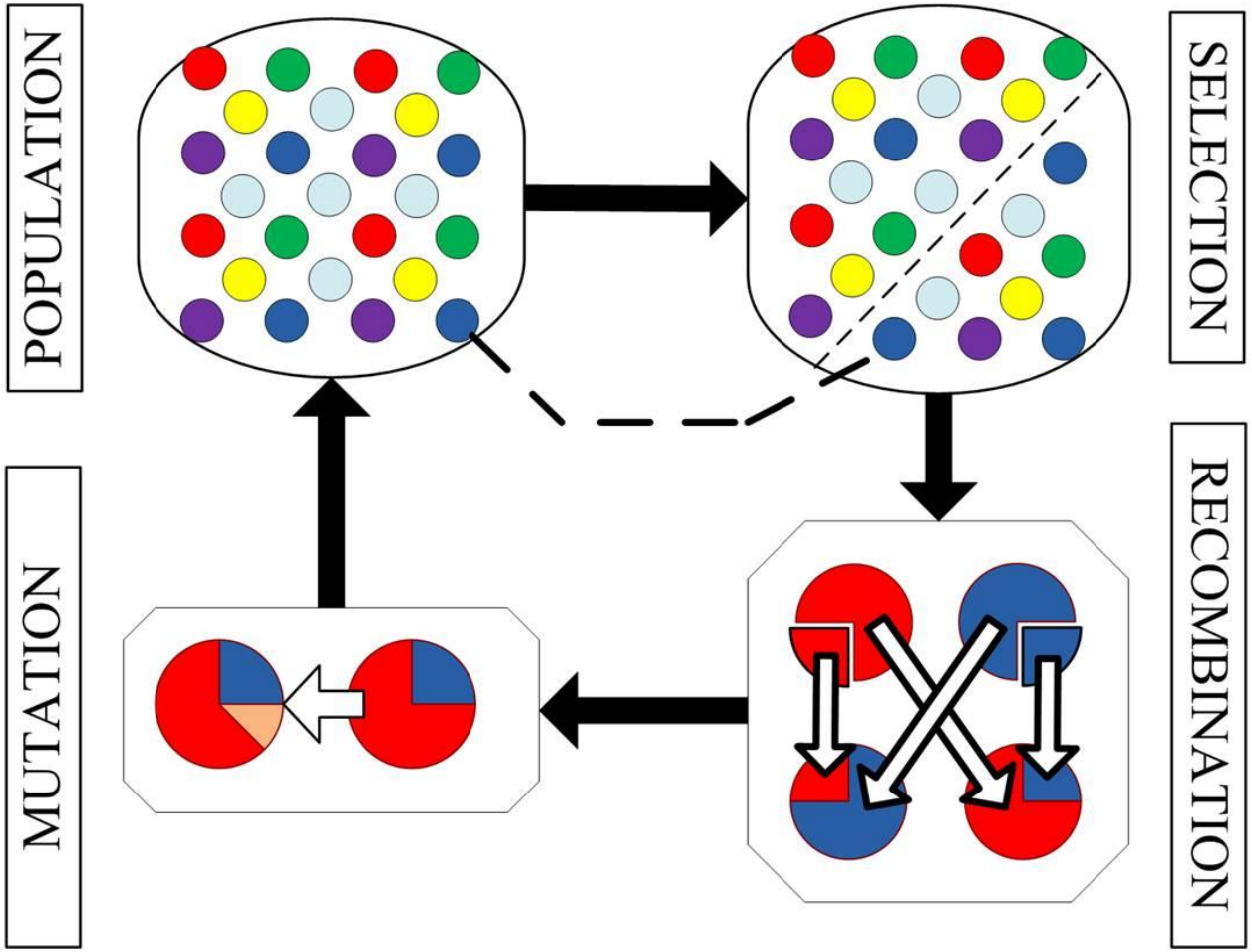
GA (5/13)

- **Natural selection**
  - Only the organisms best adapted to their environment tend to survive
  - Transmit their genetic characteristics in increasing numbers to succeeding generations
  - Those less adapted tend to be eliminated

- **GA is inspired from nature**
  - A genetic algorithm maintains
    - Population of candidate solutions for the problem
    - Makes it evolve by iteratively applying a set of stochastic operators



GA (6/13)

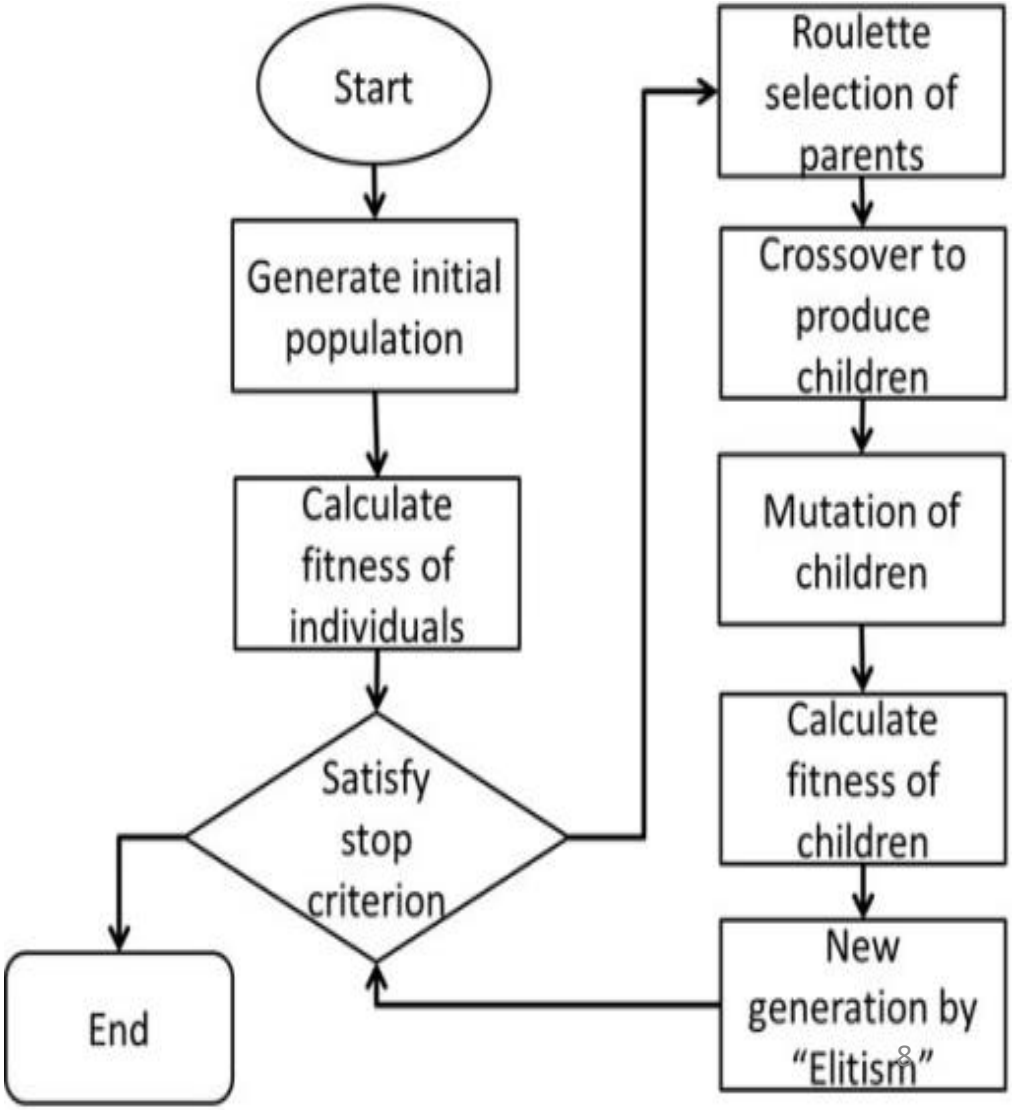


GA (7/13)

- **GA requirements**
  - A genetic representation of the solution domain (set search space)
  - A fitness function to evaluate the solution domain (objective function according to system model in case of smart grid)
- **Representation**
  - Chromosomes could be
    - Bit strings (0101 ... 1100)
    - Real numbers (43.2 -33.1 ... 0.0 89.2)
    - Permutations of element (E11 E3 E7 ... E1 E15)
    - Lists of rules (R1 R2 R3 ... R22 R23)
    - Program elements (genetic programming)
    - ... any data structure ...

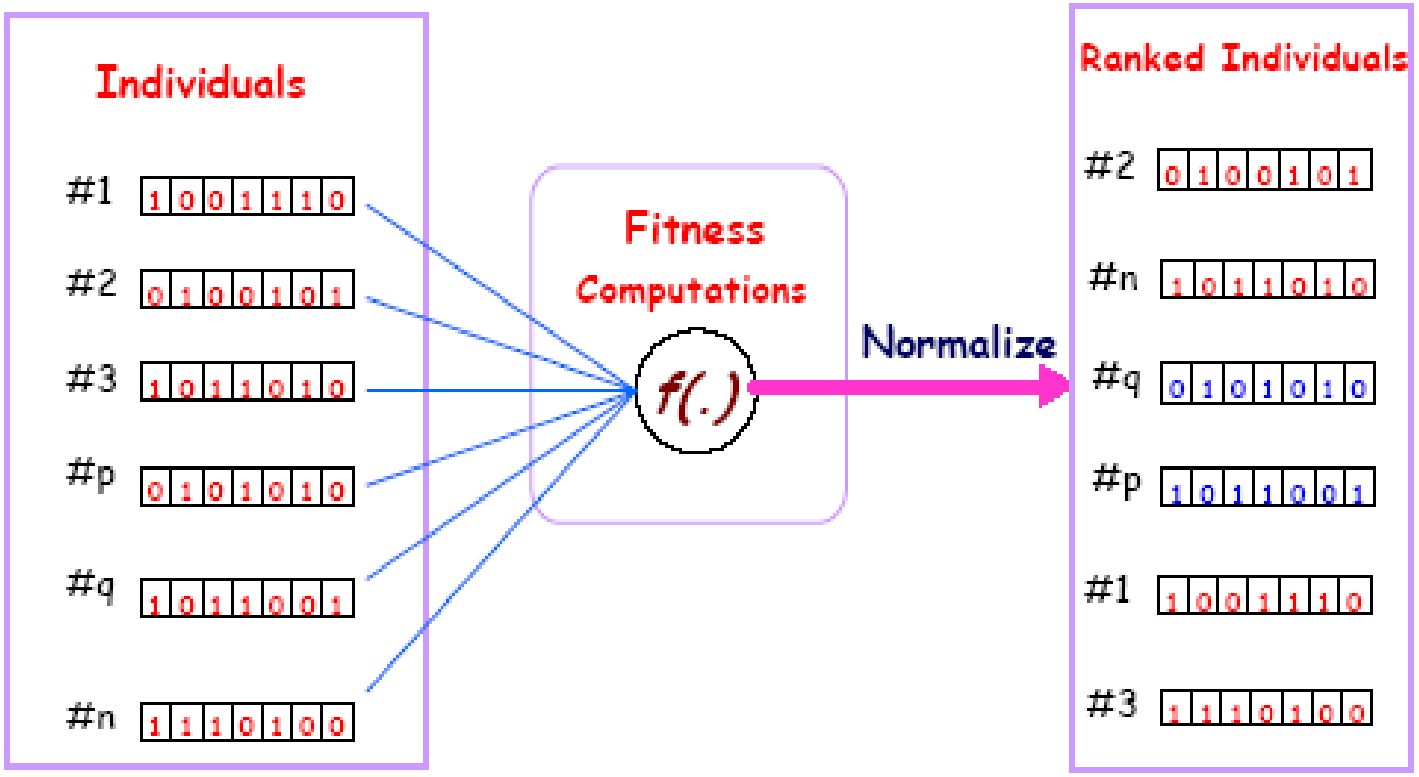
GA (8/13)

- **Algorithm**
  1. Initialization
  2. Generate population
  3. Evaluate fitness
  4. **While** gen<max_gen **do**
  5. Select two parents
  6. Crossover
  7. Mutation
  8. Evaluate fitness
  9. Elitism
  10. **End**

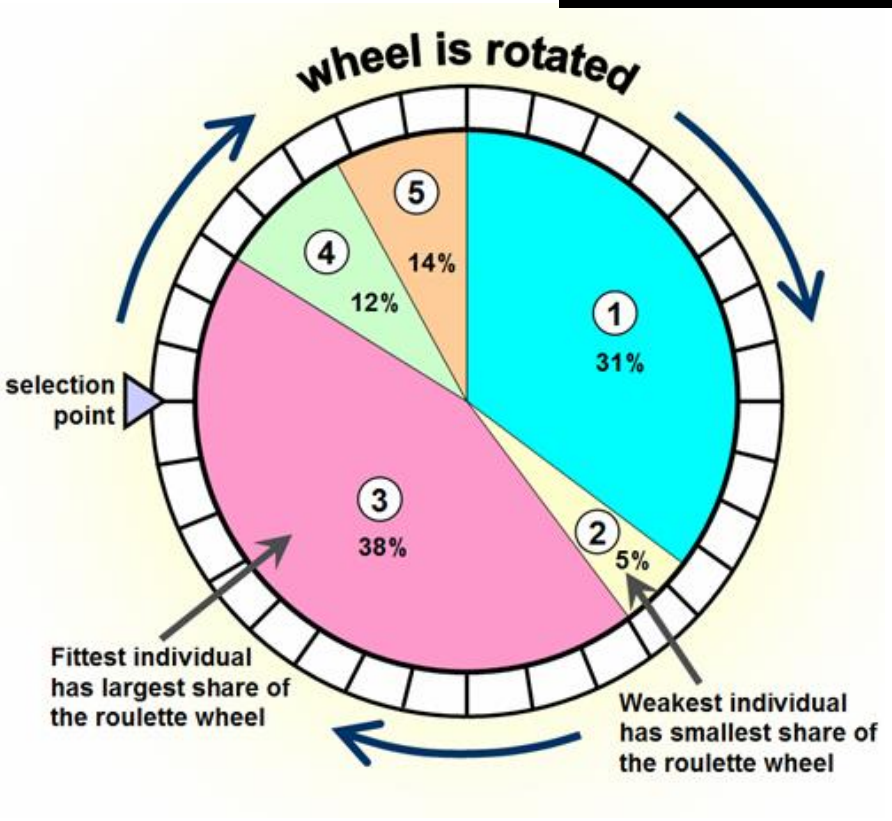


GA (9/13)

- **Fitness function**
  - The fitness function is always problem dependent
  - Assigns fitness value to the individual
  - It summarizes, how close a solution is to achieving the set aims



GA (10/13)



- **Selection**
  - Darwinian survival of fittest
  - More preference to get better guys
  - Ways to select
    - Roulette wheel
    - Tournament
    - Truncation
  - By itself, pick best
- **Roulette wheel**
  - Probability of selection is assigned to individuals based on their fitness value
  - Two parents are selected randomly from set of individuals with high selection probability
  - Selected parents are used to produce off-springs

GA (11/13)

- **Crossover**
  - Single point crossover

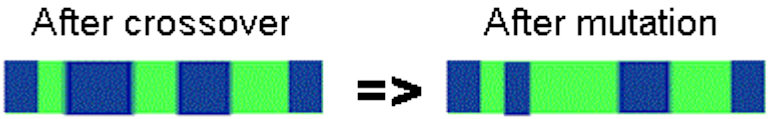
  - Two point crossover

  - Uniform crossover

GA (12/13)

- **Mutation**
  - String subjected to mutation after crossover
  - It prevents falling all solutions into local optimum
  - It alters bits of chromosomes to make the string better
  - Bit wise mutation is performed with probability of mutation Po
  - A random number ro is generated and compared with Po
  - If Po>ro , then mutation occurs

- **Types of mutation**
  - Bit inversion
  - Selected bits are inverted



11001001 => 10001001

  - Order changing
    - The number are selected and exchanged

(1 2 3 4 5 6 8 9 7) => (1 8 3 4 5 6 2 9 7)

GA (13/13)

- **Advantages of GA**
  - Concepts are easy to understand
  - Always an answer; answer gets better with time
  - Less time required for some special applications
  - Chances of getting optimal solution are more
- **Limitations**
  - The population considered for the evolution should be moderate or suitable
  - One for the problem (normally 20-30 or 50-100)
  - Crossover rate should be 80%-95%
  - Mutation rate should be low i.e. 0.5%-1% assumed as best
  - The method of selection should be appropriate
  - Writing of fitness function must be accurate