- ❖ Search and Optimization
  - ➢ Exhaustive search:
    - ▪ Are rarely sufficient for most real-world problems.
    - ▪ Search space (# of places to search) quickly grows to astronomical numbers.
    - ▪ Results in searches that are too slow or never completes.
  - ➢ Heuristic search: Any approach to problem solving or self-discovery that employs a practical method, not guaranteed to be optimal, perfect, logical, or rational, but instead sufficient for reaching an immediate goal.
  - ➢ Optimization search: The selection of a best element (with regard to some criterion) from some set of available alternatives.
    - ▪ Maximizing or minimizing a real function by systematically choosing input values from within an allowed set and computing the value of the function.
  - ➢ Evolutionary search: A family of algorithms for global optimization inspired by biological evolution. A family of population-based trial and error problem solvers with a meta-heuristic or stochastic optimization character.
    - ▪ A population of solutions is subjected to natural (or artificial) selection and mutation. As a result, the population will gradually evolve to increase in fitness, in this case the chosen fitness function of the algorithm.
    - ▪ Can produce highly optimized solutions in a wide range of problem settings.
- ❖ Local search
  - ➢ Hill Climbing
    - ▪ What is the hill that is being climbed here?
      - • A mathematical optimization technique which belongs to the family of local search.
      - • Iterative algorithm that starts with an arbitrary solution to a problem, then attempts to find a better solution by making an incremental change to the solution
        - ♦ If the change produces a better solution, another incremental change is made to the new solution, and so on until no further improvements can be found.
    - ▪ Compare and contrast the states from traditional search vs. those from local search.
      - • May not necessarily find the global maximum, but may instead converge on a local maximum.
      - • Local search requires complete state formulation.
    - ▪ Is hill-climbing's alternate name "greedy local search" justified?
      - • Yes, it will find a locally optimal solution that approximates a globally optimal solution in a reasonable amount of time.
    - ▪ What is a local optimum?
      - • Solutions that cannot be improved upon by any neighboring configurations.
      - • A solution that is optimal (either maximal or minimal) within a neighboring set of candidate solutions.
    - ▪ What is a random restart?
      - • A meta-algorithm built on top of the hill climbing algorithm.
      - • Iteratively does hill-climbing, each time with a random initial condition.
      - • The best x of subscript m is kept.

- ➢ Simulated annealing: probabilistic technique for approximating the global optimum of a given function. (metaheuristic to approximate global optimization in a large search space for an optimization problem)
    - ▪ SA is inspired by what process from materials science?
        - • Inspiration comes from annealing in metallurgy, a technique involving heating and controlled cooling of a material to increase the size of its crystals and reduce their defects.
    - ▪ Compare and contrast simulated annealing vs. hill climbing.
        - • Hill climbing – start with a solution to an optimization problem, often a random solution, and make a modification to that solution (a local move) and check if the new solution is better or worse than the previous one (accept if better, or keep original)
        - • Simulated annealing – similar procedure but have probability of accepting a solution that is worse than the previous one.
            - ♦ Allow algorithm to explore some paths even if they are not very good.
            - ♦ As algorithm is run, the probability of accepting a solution that is worse the previous decreases and eventually optimize at the end.
            - ♦ Start with a given "temperature" and gradually cool as run iterations, making the probability of accepting a bad solution proportional to this temperature.
- ➢ Beam search
    - ▪ Compare and contrast beam search vs. simulated annealing.
        - • Beam search – heuristic search algorithm that explores a graph by expanding the most promising node in a limited set.
        - • Optimization of best-first search that reduce its memory requirements.
        - • Greedy algorithm where only a predetermined number of best partial solutions are kept as candidates.
        - • Uses breadth-first search to build search tree.
        - • Stores predetermined number of best states at each level of the search.
        - • Not optimal (may not find best solution)
        - • May not necessarily find a solution, if one exists.
        - • Returns the first solution found.