CS 344 - Guide 2

* 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.