CSCI 3202: Intro to Artificial Intelligence

Lecture 18: Optimization, Local Search, & Genetic Algorithms

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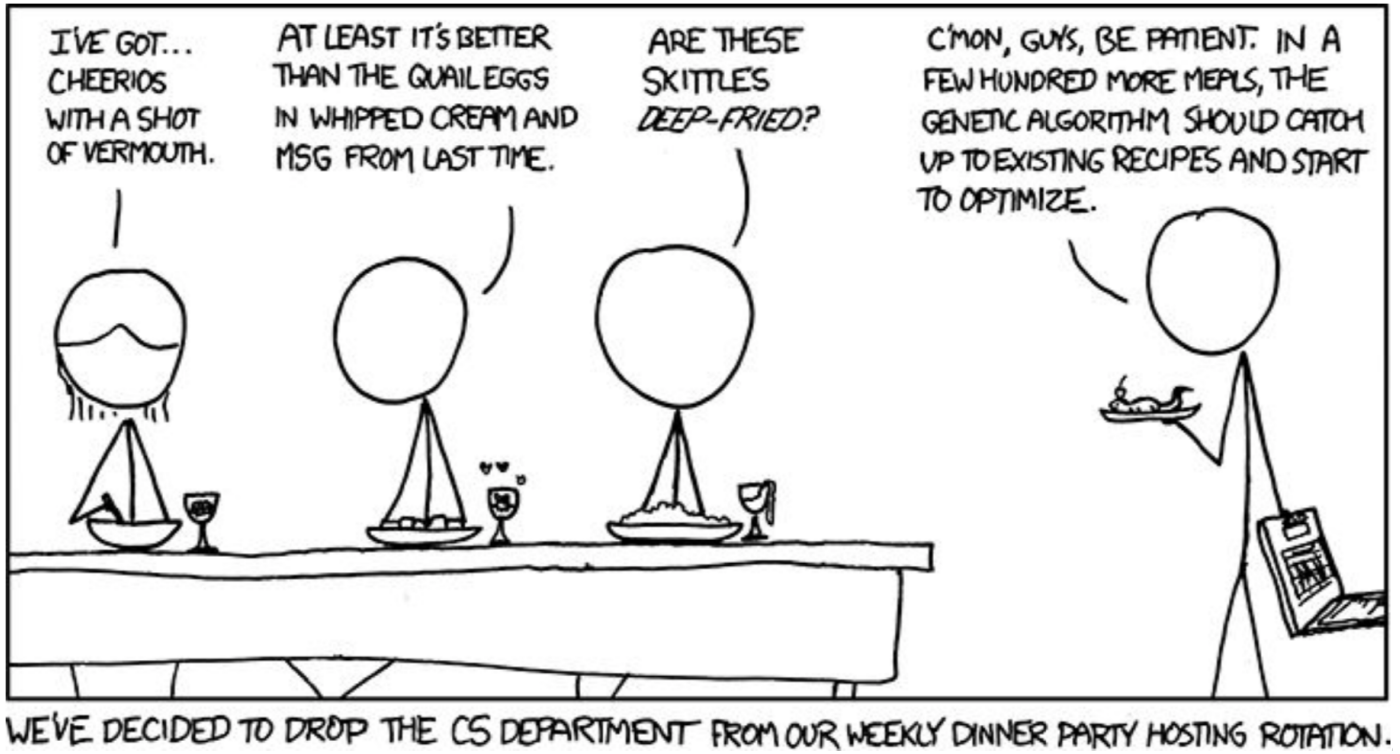
Remote Exam - Gradescope
- do the upload question first #10

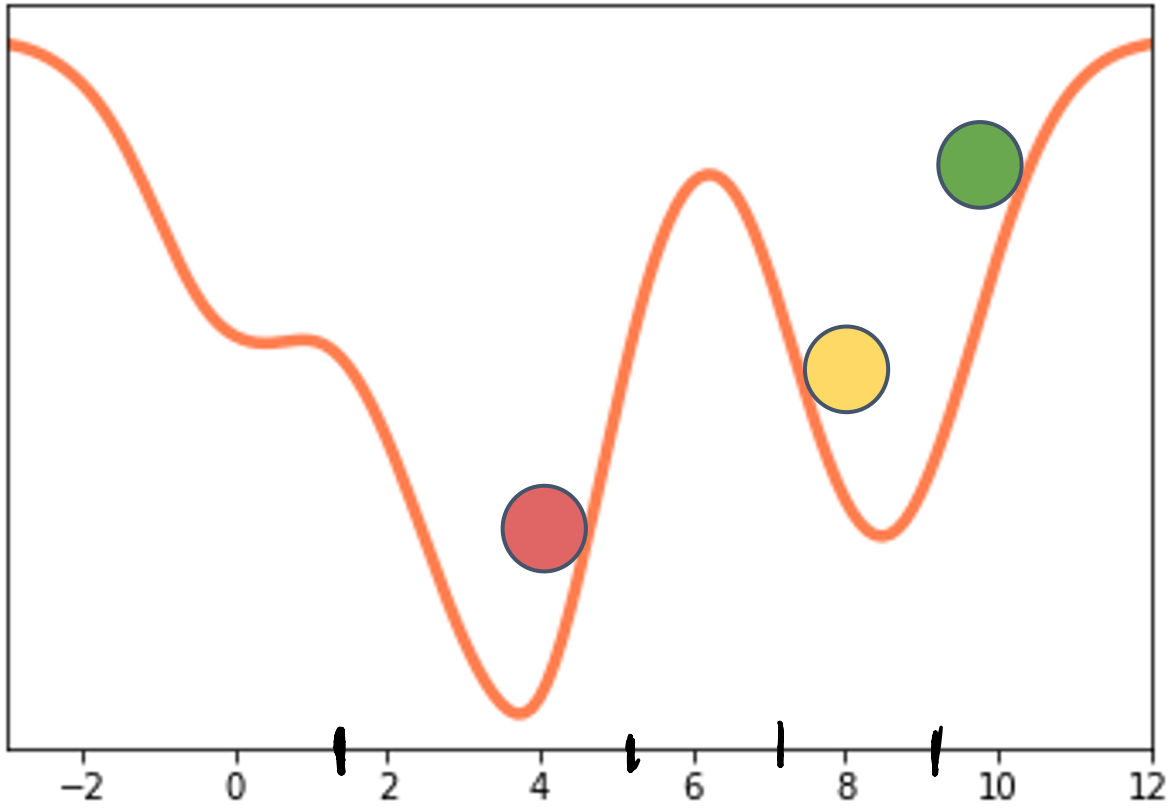


Simulated Annealing

Trying to find global **minimum** (in this case)

- Propose **random** moves
- Accept with a probability that depends on:
  1) time
  2) how "good" the move is
     - ➢ Accept move without question if it's better than our current situation
     - ➢ Accept move with some probability < 1 if it's worse

High temp - bouncing around
Low temp - hill climbing
Middle temp - hill climbing AND bouncing



Random Restart Hill–Climbing

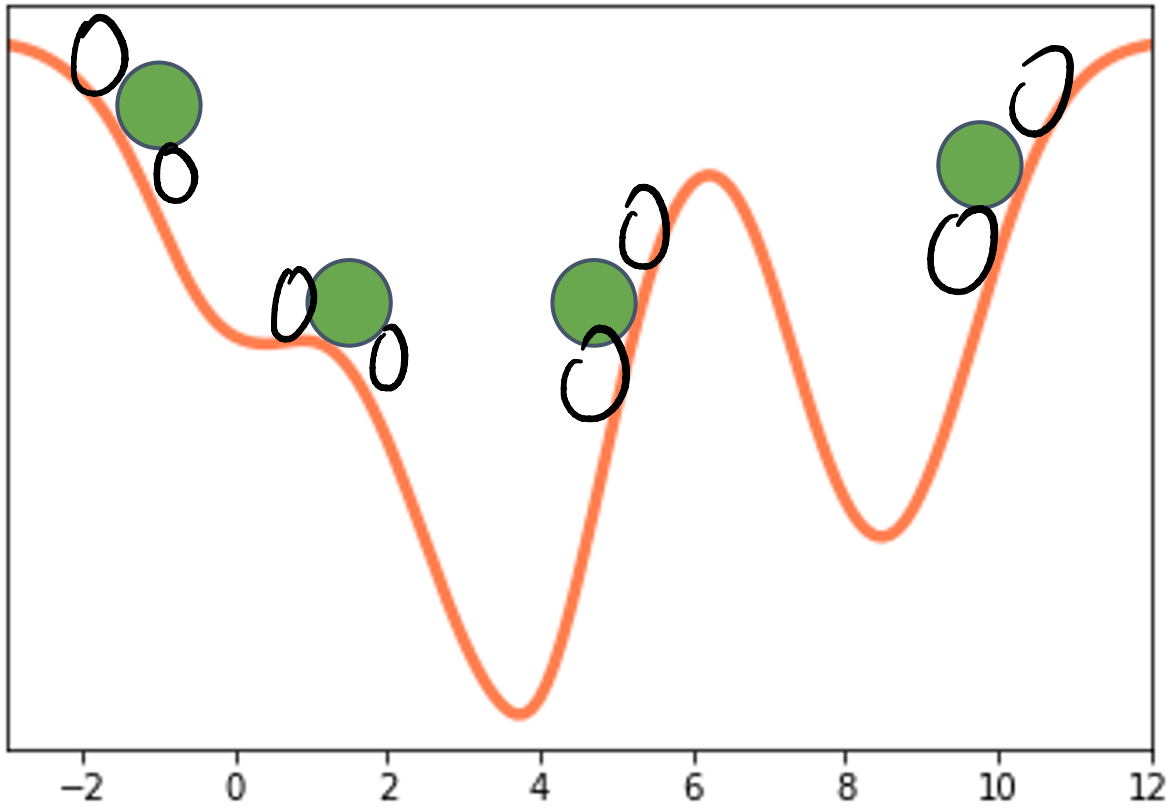
- Conduct a series of hill-climbing searches with a randomized starting point.
- If your random restart initial points end up all being close together, this method may not be any more effective than basic hill-climbing.
- You want to cover the space as much as you can.
- Cost is a constant multiple of hill-climbing - not much more expensive.

Local Beam Search

Fire off *k* states to explore

Each step:

- Propose ***all*** successors to each of the *k* states
- Pick *k* of them to keep exploring in the next step
    - Can be **best** *k*, or **random** (possibly with some performance-weighting)
- Think of these as **generations** of states…

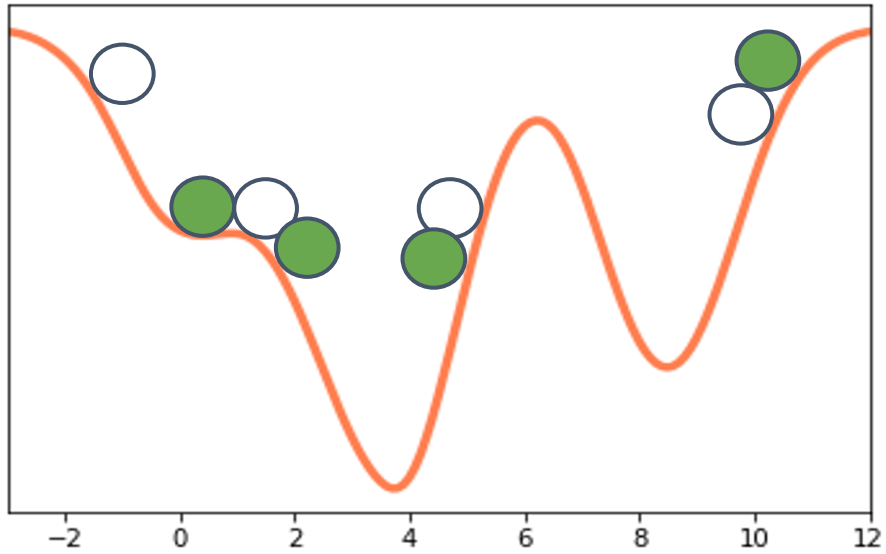


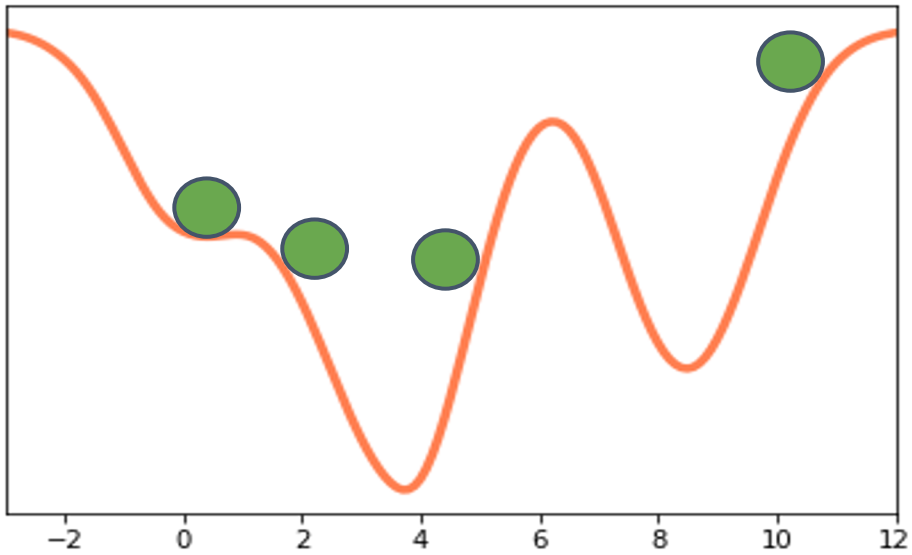
Local Beam Search

Fire off *k* states to explore

Each step:

- Propose ***all*** successors to each of the *k* states
- If any of successors is goal -> finished
- Pick *k* of them to keep exploring in the next step
    - Can be **best** *k*, or **random** (possibly with some performance-weighting)
- Think of these as **generations** of states…

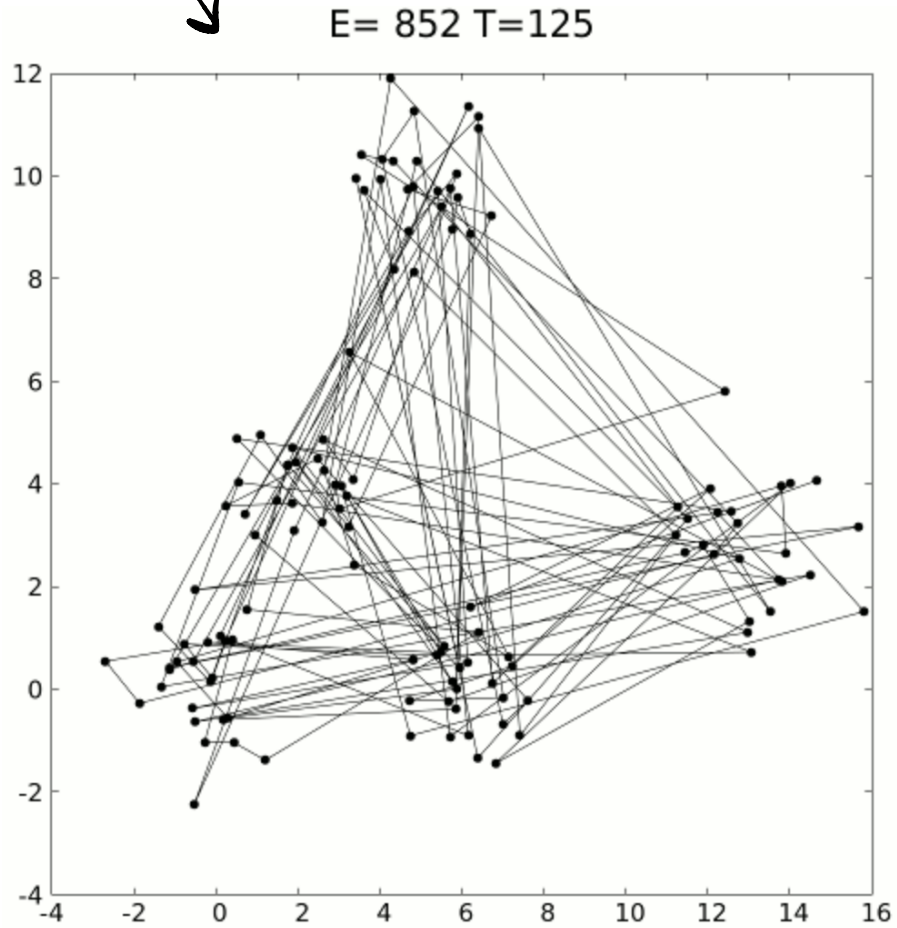


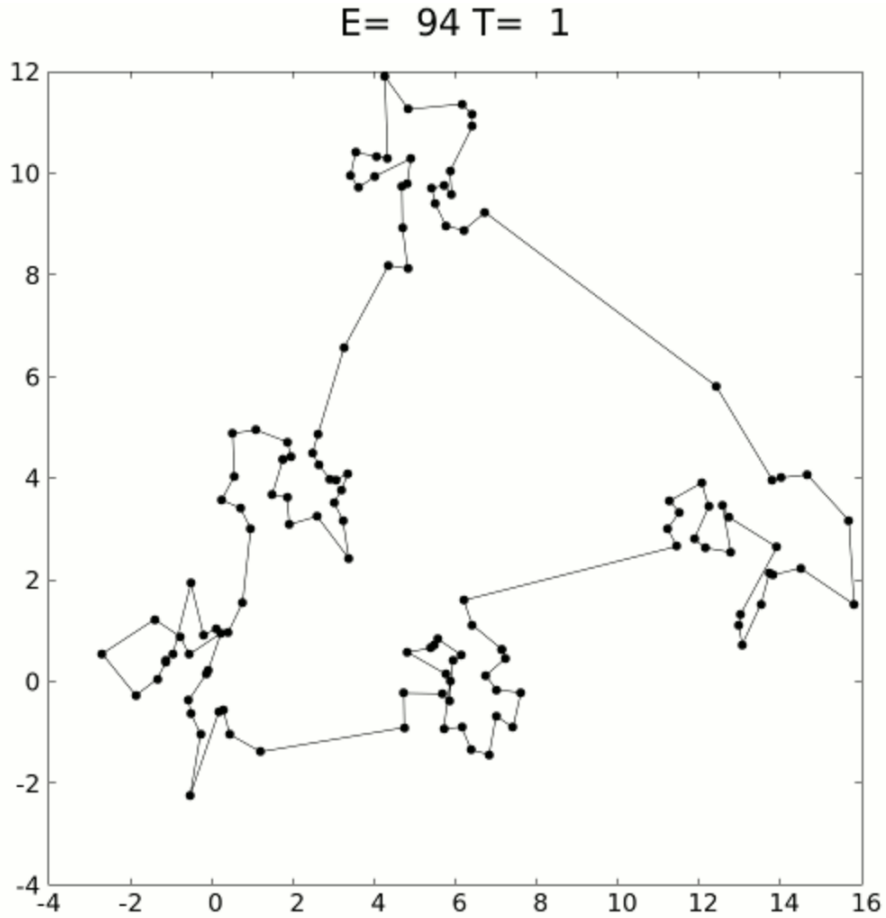


Applications

Traveling Salesman Problem - Each state is a permutation of the cities visited

- Neighbors are set of permutations produced by reversing order of any two successive cities.
- Attempt to improve solution by iteratively improving its parts.





Genetic Algorithms

"The fact that life evolved out of nearly nothing, some 10 billion years after the universe evolved out of literally nothing, is a fact so staggering that I would be mad to attempt words to do it justice.” - Richard Dawkins

Darwinian Natural Selection: 3 key principles that must be in place for evolution to happen:

1) Heredity - process by which children receive the properties of their parents

2) Variation - Variety of traits present in population or a means with which to introduce variation

3) Selection - Some members have opportunity to pass on genetic info and some don’t; survival of the fittest

Genetic Algorithms

SETUP

Step 1: ***Initialize:*** Create a population of N elements, each with randomly generated DNA.

DRAW

Step 2: ***Selection:*** Evaluate the fitness of each element of the population and build a mating pool.

Step 3: ***Reproduction:*** Repeat N times:

a. Pick two parents with probability according to relative fitness.
b. Crossover — create a "child" by combining the DNA of these two parents.
c. Mutation — mutate the child's DNA based on a given probability.
d. Add the new child to a new population.

Step 4. Replace the old population with the new population and return to Step 2.

Genetic Algorithms

Variant of stochastic (local) beam search in which successor states are generated by combining (***breeding***) **two** predecessor (***parent***) states.

Initialization:

- Begin with **population** of *k* randomly generated states
- Each **individual** is represented as a **string** (like DNA) from some finite alphabet

Member
28439198
87932185
12197835
90271049

each number is like a "gene"

86753091

Genetic Algorithms

One generation:

- Calculate everyone's "fitness" for reproduction based on objective function values
- Yields probability of being chosen for reproduction
- Pick individuals from population for reproduction (some can be picked multiple times)
- Create new members' genes by **crossing over** parents' DNA
- Add in **mutations** with (small) independent probability

prob = 10 / 10+15+25+6

Member	Fitness	Repr. prob.	Selection	Crossover	Mutation
28439198	10	18%	12197835	12197185	13197185
87932185	15	27%	87932185	87932835	87932035
12197835	25	45%	12197835	28437835	28437835
90271049	6	10%	28439198	12199198	92199198

Genetic Algorithms

```
def genetic_algorithm(problem, some number of generations):

    for some number of generations:

        # Create a new generation by creating a same-sized population
        # of children by:

            # 1. select for reproduction
            #    a) calculate each population member's fitness for reproduction
            #    b) calculate probability of each member reproducing
            #    c) select two mates from population based on reproductive probabilities

            # 2. mate the two individuals, creating a child in the new generation
            #    a) pick where the parents' "DNA" is spliced together

            # 3. child has a gene mutated with some small probability

        # Check whether any member satisfies the fitness goal
        # a) If yes, return that member and exit
        # b) If no, continue

    # If we've reached the end (# generations), return some failure warning
```

"The Coding Train"

example evolve the word "unicorn"

- initial population: unijorm
  pancake
  aaaaaah
  popcorn

- calculate fitness score

		probability
unijorm	5	$5/(5+1+4) = .5$
pancake	1	$1/10 = .1$
aaaaaah	0	0
popcorn	4	$4/10 = .4$

members = [unijorm, pancake, aaaaaah, popcorn]

probs = [.5, .1, 0, .4]

np.random.choice(members, size=2, p=probs)

(continued)

uni/jorn

pop/corn

unicorn

popjorn

Example

"To be or not to be"

This string has 18 characters.

We are going to say there are 85 buttons on a keyboard.

guess:

"abc... ZABCD... Z, 123... 90_..."

What's the probability of generating the given string randomly?

$$P = \left(\frac{1}{85}\right)^{18}$$ is 5.36×10^{-34}

1 monkey - 1 million phrases per second since the big bang

how many phrases would this monkey have typed? $14{,}000{,}000{,}000 * 365 \times 24 \times 60 \times 60 \times 1{,}000{,}000 \approx 4.4 \times 10^{23}$ phrases

Next Time

- ~~*Games!*~~ Coding Day