Population at time t

The many choices in Evolutionary Algorithms

Parent selection:
- Fitness proportionate
- Rank based
- Tournament

Recombination:
- Normal crossover
- Intermediate recomb
- Simple arithmetic crossover
- Partially mapped crossover
- Edge recombination
- Order crossover
- Cycle crossover

Mutation:
- Bit-flipping
- Bit-flipping with "creeping"
- Random resetting
- Uniform mutation
- Non-uniform mutation

Survivor selection:
- Elitism
- (μ, λ)-selection
- $(\mu + \lambda)$-selection

Population at time t+1

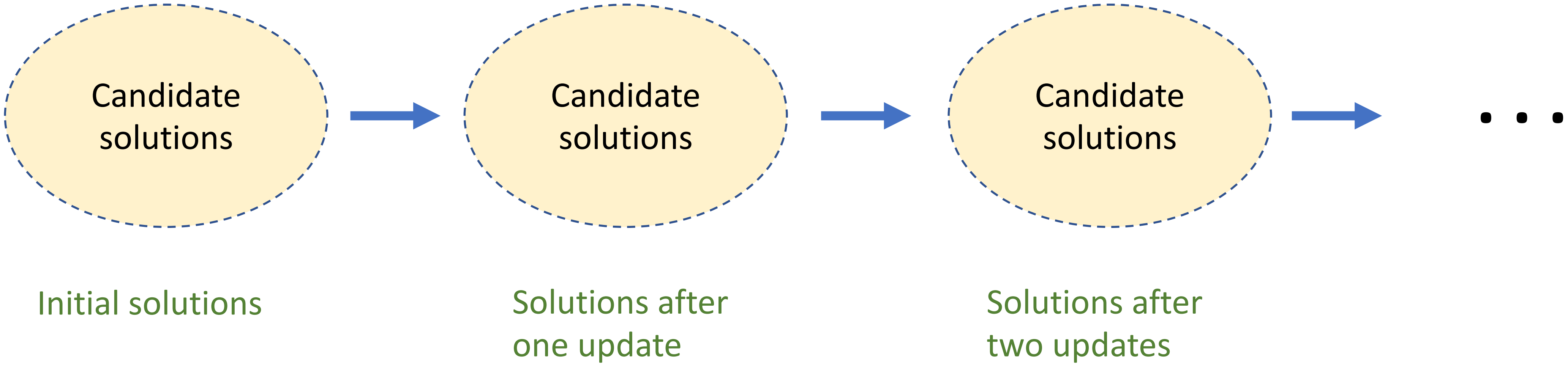
Diversity preservation:
- Fitness sharing
- Crowding
- Speciation tags
- Island model

Hybridisation
- Local search with greedy ascent
- Local search with steepest ascent
- Lamarckian evolution
- Lamarckian/Baldwinian evolution

Multiobjective optimization:
- Weighted sum
- Pareto optimality
- NSGA-II

Are we always moving towards better solutions?

From a bird's perspective, an EA looks like this:



All updates involve <u>random decisions</u> (random parent selection, random permutations, random recombination). Are we guaranteed to always move toward better and better solutions (on individual level and/or population level)?

Selection

One might wonder why we need two types of selection in each cycle.

A: What happens if I skip parent selection and instead choose parents completely at random?

B: What happens if I skip survival selection and instead make a random choice among the offspring?

C: And finally, what happens if I skip both of the above?

Selection

D: In your experience, are some problems requiring more selection pressure that other problems?

E: Ok, so I want to tune the selection pressure up or down.
How do you recommend that I do that?

Parent selection

This is usually random, and some common choices are:

- **Fitness-proportionate** selection

  → selection probability ~ fitness (f1, f2, f3, ...)

- **Rank-based** selection

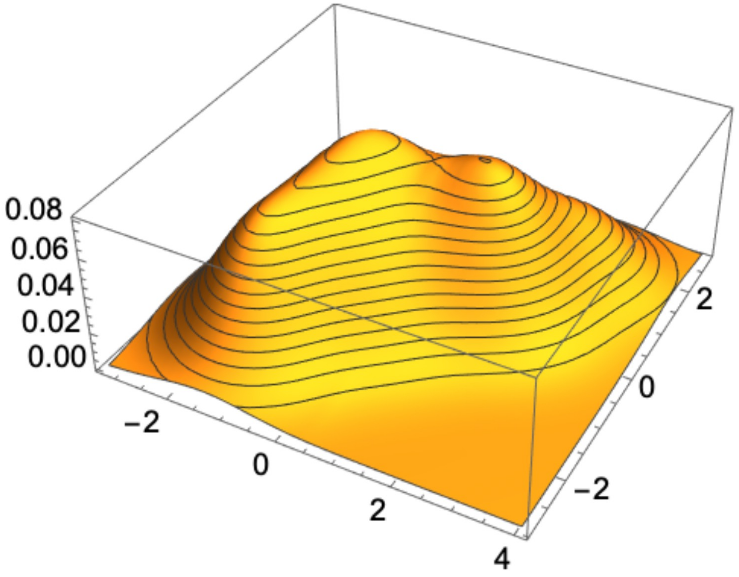
  → selection probability ~ fitness rank (1, 2, 3, ...)

- **Tournament** selection

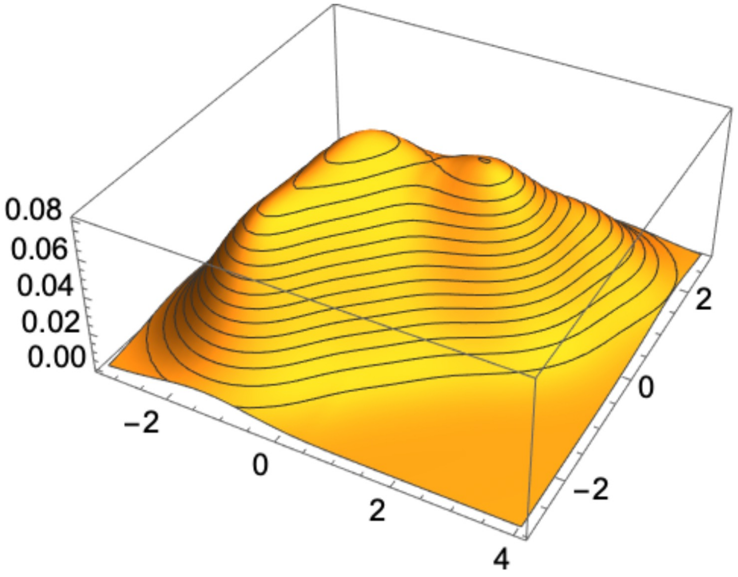
  → let k randomly selected individuals compete

Can we visualize the three different strategies?

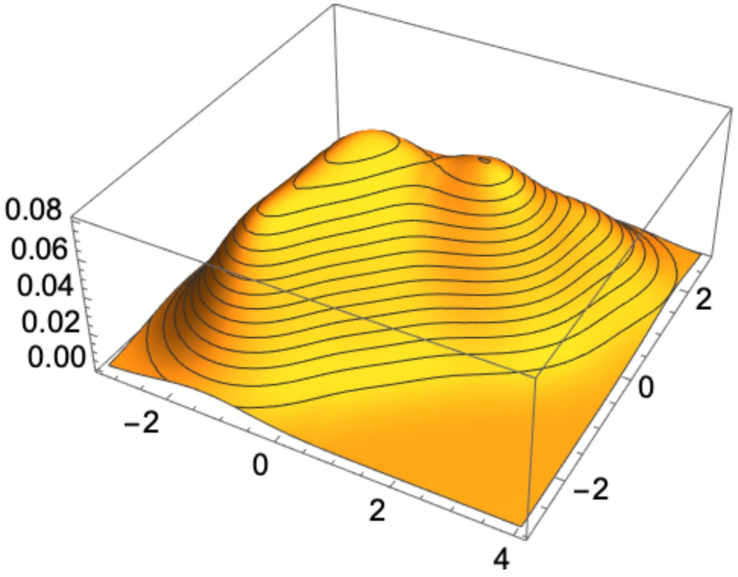
Fitness proportionate selection:



Rank-based selection:



Tournament selection:



Survivor selection (= replacement)

This is often (not always) deterministic.

Here we have to decide whether to select the new population from:

- Offspring only

→ complete generation shift

- Both offspring and the old population

→ mixed generations

The second seems more biologically realistic. Are there situations where the first is most appropriate?

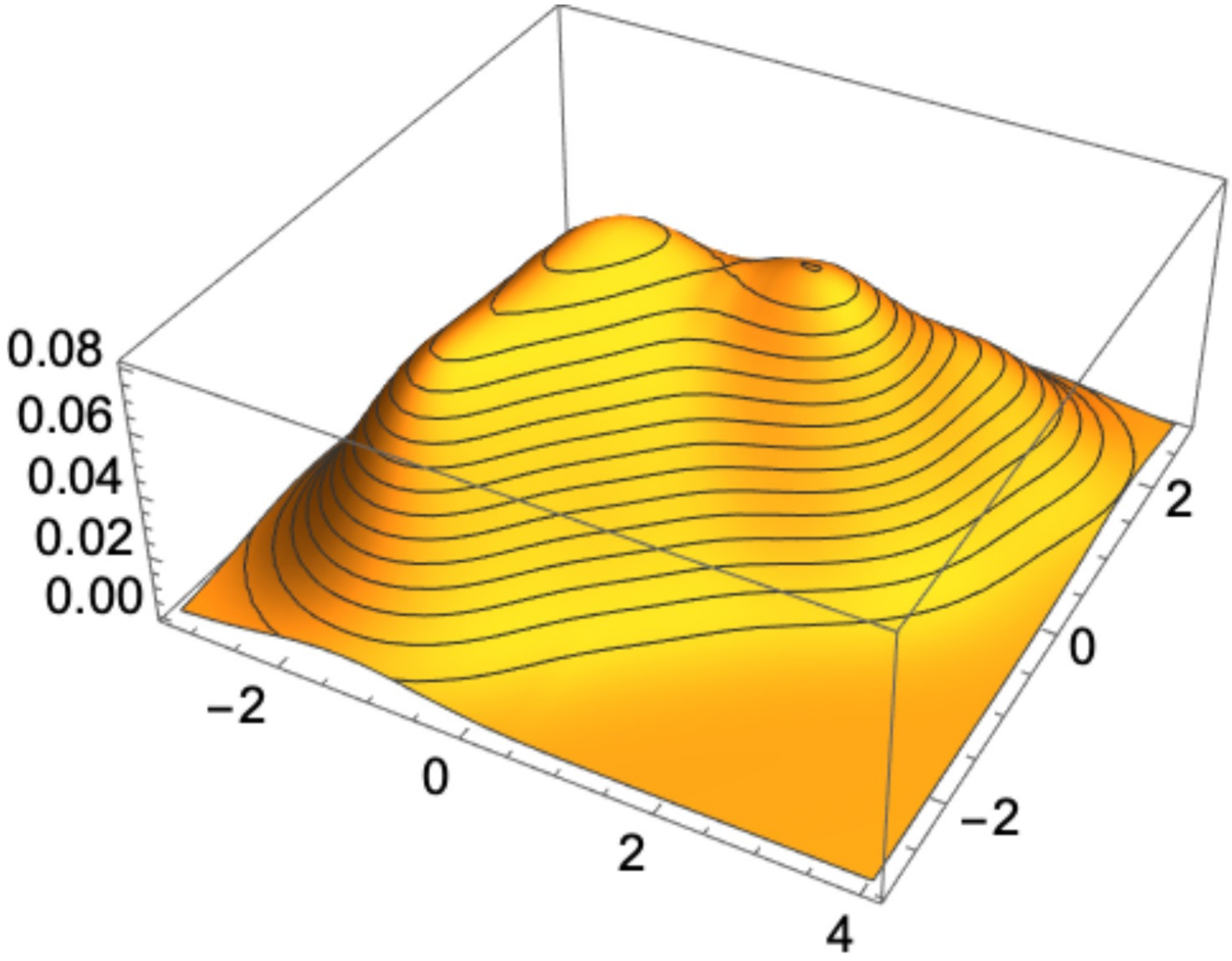
Preserving diversity

It is stressed in the lectures and the book that in evolutionary algorithms we should maintain diversity in the population over time.

- What does "preserving diversity" really mean and why is it important?

- Going back to the people-on-a-mountain picture, how would a low diversity and a high diversity population look?

- Two popular solutions to maintain diversity are fitness sharing and crowding. They both involve "niches". Could you visualize what we mean by a niche?


0.08
0.06
0.04
0.02
0.00
−2
0
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4
2
0
−2

Biological equivalent of ....

Fitness sharing:

- Each individual in a niche is less likely to be selected as parent
-

Genetically similar (i.e. related) invididuals do not mate

Crowding:

Memetic algorithms

Hybrid solutions that combine EA with other techniques (local search, problem-specific knowledge) can be much better than EA alone.

- Without going into specifics, why is this not surprising?

- According to the lectures, most recent Memetic algorithms use Lamarckian evolution (alone or in combination with other methods). Are EAs smarter than Mother Nature in this respect?

- Analogy between Baldwinian evolution and the stock market

Multiobjective optimization

When we have two or more (potentially conflicting) goals that we want to optimize simultaneously, we can use these techniques:

1) Weighted: search for solutions that are ok (though may not the best) with respect to all the goals

2) Pareto: search for solutions that are never worse than other solutions for any of the goals, and that are better for at least one goal.

How would you interpret these two approaches for the example where you want to buy a car?