CSE/ECE 848 Introduction to Evolutionary Computation

Module 2, Lecture 7, Part 1b
Example – the Eight Queens Problem

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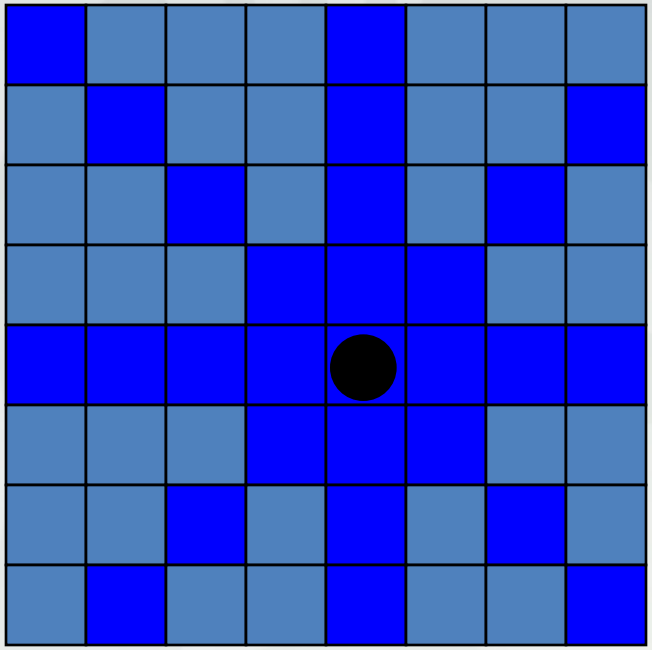
Example: the Eight Queens Problem



Place 8 queens on an 8x8 chessboard such that they are not attacking each other

Enumerative

How about your basic enumerative algorithm?

positionSet = set(1-64)

- for q1 in positionSet:
  - for q2 in positionSet-q1:
    - for q3 in positionSet-q1-q2:
      - …

64*63*62*61*60*59*58*57 = 178,462,987,637,760 => ouch!

If every op took 1 nanosecond (not likely), how long?

A little smarter? (but not much…)

Only check the rows?

- for q1 in row 1:
  - for q2 in row 2:
    - for q3 in row 3:
      - …

8^8 = 16,777,216 => doable!

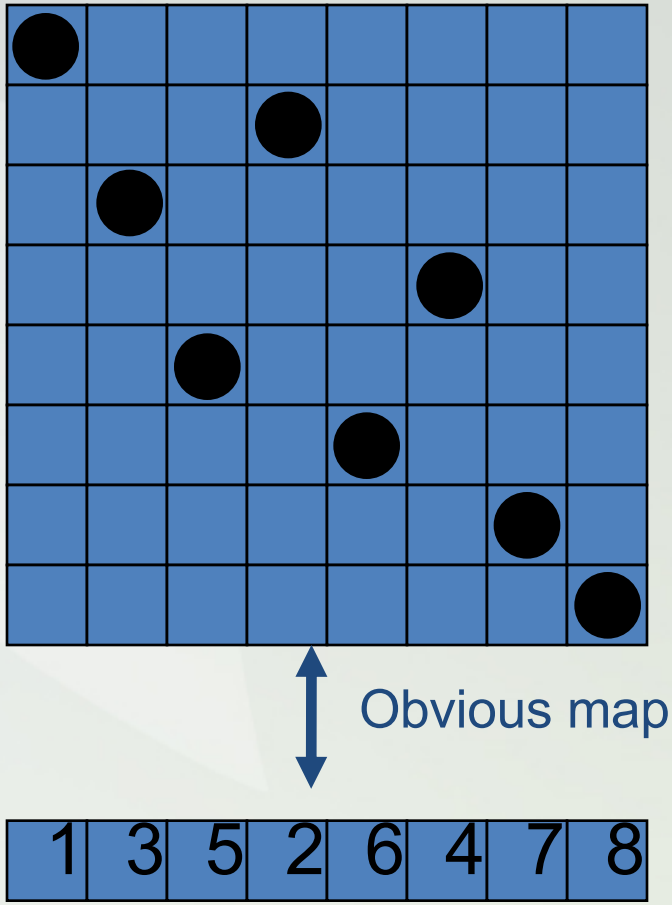
Again, if every op took 1 nanosecond, how long?

OK, how about an EA?

- Could make it even smarter and solve 8 queens easily by enumeration.
- BUT what if it's the 100 queens problem (on a 100x100 chessboard)… let's find a solution that scales better than enumeration!
- What would you use to represent the problem?
- How would you evaluate fitness?
- What operations might you use?

The 8 queens problem: an obvious representation

Phenotype:
a board configuration



Genotype:
a permutation of
the numbers 1 - 8

8 Queens Problem: Fitness evaluation

- Penalty of one queen: the number of queens she is attacking
- Penalty of a configuration: the sum of the penalties of all queens
- Note: penalty is to be minimized
- Fitness of a configuration: multiplicative inverse of the penalty to be maximized (1. / TotalAttacked)

For 8 queens permutation rep: Mutation

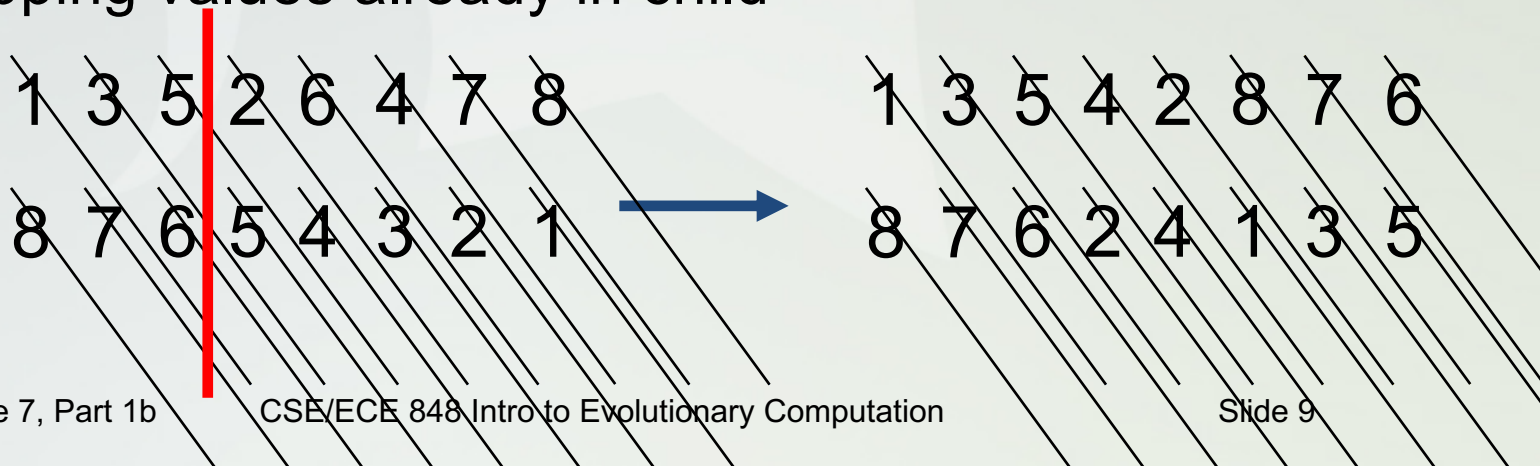
Small variation in one permutation, e.g.:

- swapping values of two randomly chosen positions
- (this is a typical mutation operation with permutation representations)

For 8-queens permutation rep: Recombination

Want it to combine two permutations into two new permutations, so a LEGAL permutation results: Many operators work, but each preserves different properties! Ex:

- choose random crossover point
- copy first parts into children
- create second part by inserting values from other parent:
  - in the order they appear there
  - beginning after crossover point
  - skipping values already in child



The 8 queens problem: Selection—examples:

- Parent selection (one of many ways!):
  - Pick 5 parents and take fittest two to undergo crossover (tournament—with fairly strong selection pressure)
- Survivor selection (replacement) (one of many ways!):
  - When inserting a new child into the population, choose an existing member to replace by:
    - sorting the whole population by decreasing fitness
    - enumerating this list from high to low
    - replacing the first with a fitness lower than the given child

8 Queens Problem: Summary Tableau (example!)

Representation	Permutations
Recombination	"Cut-and-crossfill" crossover
Recombination probability	100%
Mutation	Swap
Mutation probability	80%
Parent selection	Best 2 out of random 5
Survival selection	Replace worst
Population size	100
Number of Offspring	2
Initialisation	Random
Termination condition	Solution or 10,000 fitness evaluation

- Note that this is *only one possible* set of choices of operators and parameters
- You'll get a chance to try your own choices in an upcoming homework assignment