CZECH TECHNICAL UNIVERSITY IN PRAGUE
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# Coevolution

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## Coevolution and its basic types

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  - is not given by the characteristics of the individual (only), but
  - is *affected by the presence of other individuals in the population*.
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Coevolution can help in:

- dealing with increasing difficulty of the problem
- providing diversity in the system
- producing not just high-quality, but also robust solutions
- solving complex or high-dimensional problems by breaking them into nearly decomposable parts

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By the entities playing role in the relation:

- 1-population
  - intra-population
  - individuals from the same population cooperate or compete
- N-population
  - inter-population
  - individuals from distinct populations cooperate or compete

# 1-population competitve coevolution

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- successful against diverse opponents!!!

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**Solution:** Intra-population competitive coevolution

- by playing several games against other strategies in the population.
- All individuals of the same type.
- In the beginning, all are probably quite bad, but some of them are a bit better.
- The fitness (the number of games won) may not rise as expected since your opponents improve with you.

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  - Algorithm: by its ability to sort. How many sequences is it able to sort correctly? How quickly?
  - Test case: by its difficulty for the current sorting algorithms. How many algorithms did not sort it?
- Predator-prey relationship

# N-population cooperative coevolution

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Cooperation:

- symbiotic relationship
- good performance of the team $\Rightarrow$ high contribution to fitness of all members

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Principle:

- better individuals similar to others already in population are thrown away in favour of worse, but diverse individuals
- the selection process is affected by the presence of other individual in the neighborhood

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- Ideally, external fitness

- should be **static**, **deterministic** and **absolute**
- can easilly be used as internal fitness

External fitness in coevolution:

- impossible (hard) to define
- often, it is **relative**, but measured with a carefully chosen, large enough set of other individuals (**static**) sufficiently many times (almost **deterministic**)

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- Chess Elo ratings:

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# Problems with fitness assessment: 1-pop. competitive coevolution



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  - A player that beats the most other players?
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  - A player that wins by the most total points on average?
- Often, other tests are executed.
- But, do you want to spend your fitness budget
  - on evaluating current individuals more precisely, or
  - on searching further?

# 2 competitive populations (illustration)

Lotka-Volterra model (Predator-prey population dynamics):

$$\frac{dx}{dt} = \alpha x - \beta xy$$
$$\frac{dy}{dt} = -\gamma y + \delta xy$$

where $x$ is the number of prey (rabbits) and $y$ is the number of predators (wolves).

Assumptions:

1. The prey population has always food enough.
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Meaning:

- The change of the prey population ($dx/dt$) is composed of
  - increase due to the newly born individuals (proportional to the population size, $\alpha x$) and
  - decrese caused by the predation (which is proportional to the rate of predator-prey meetings, $\beta xy$).
- The change of the predator population ($dy/dt$) is composed of
  - decrease due to natural death (proportional to the population size, $\gamma y$) and
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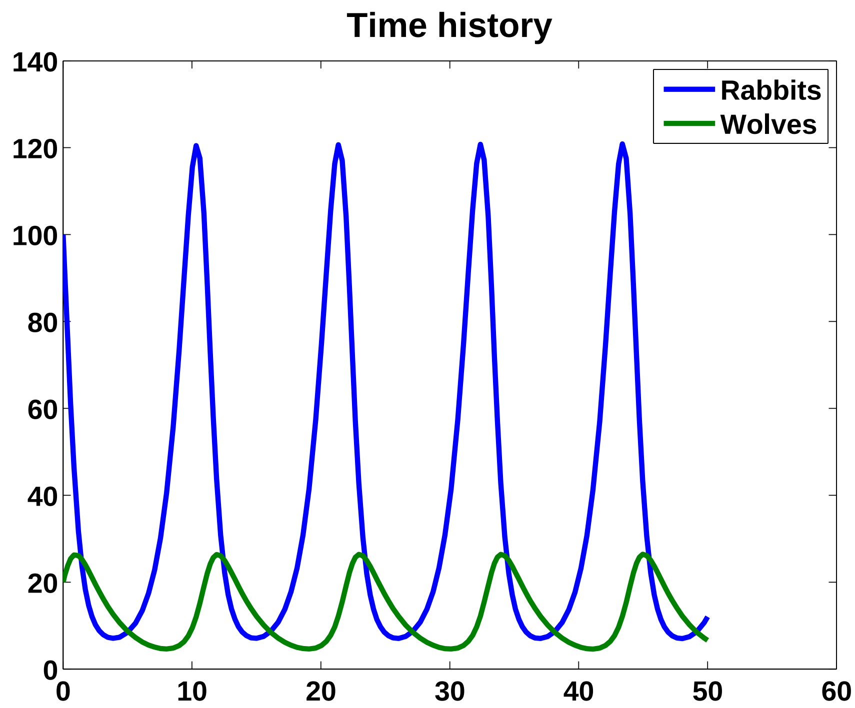

# Problems with fitness assessment: 2-pop. competitive coevolution

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- Solution:
  - detect such situation (but how?)
  - delay the evolution of the better population until the worse one catches up

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**Hijacking**

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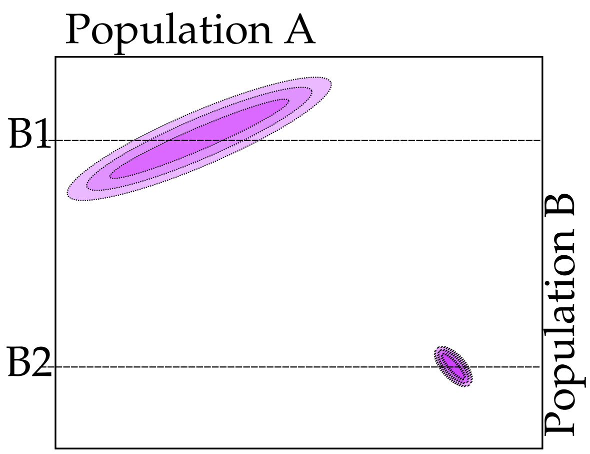
**Relative overgeneralization**

- when evaluated by average score, worse (but more robust) individual B1 will have higher score than better (but volatile) B2
- use maximum score (more tests needed)
- but again, the choice depends on what we want — a player able to get the highest score, or a player that would compare well with the most other opponents?



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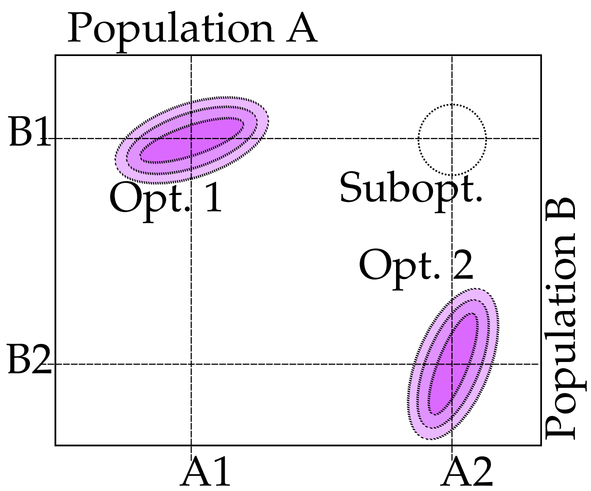
**Miscoordination**

- when the team components are not independent
- Pop. A evolved A2 (but not A1), pop. B evolved B1 (but not B2)
- Neither A2 nor B1 survives



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Appropriate when

- no explicit fitness function can be formed
- there are too many fitness cases
- the problem is modularizable (divide and conquer)