Application of evolutionary algorithms to solve complex problems in quantitative genetics and bioinformatics

6. Problem Representation

Making complexity out of simplicity.

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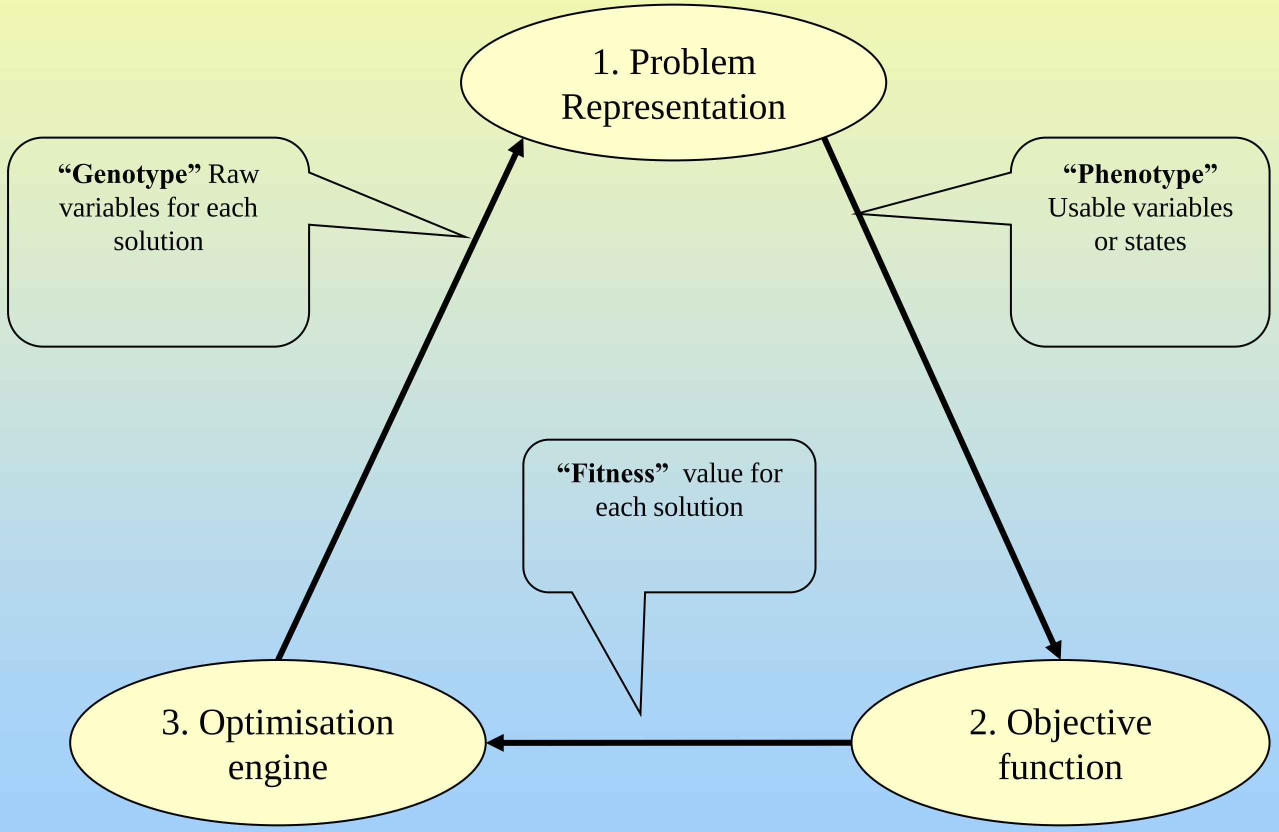
Problem Representation



Example 1: No problem representation filter needed

- In simple cases, a simple vector of real or integer parameter values can be used directly in the objective function.
- Eg. our first optimization example:

Find $\{x_1,x_2\}$ that maximizes $y = -(30 - x_1)^2 - (4 - x_2)^2$

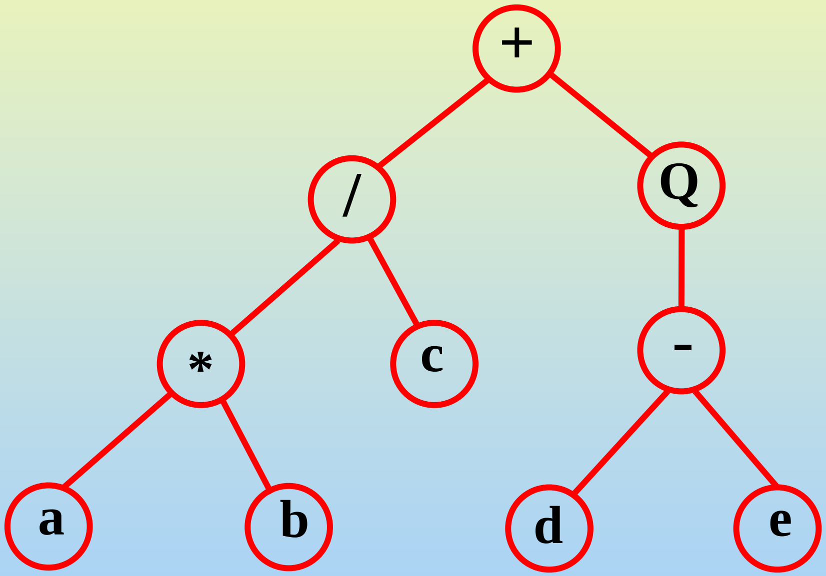
$\{x_1,x_2\}$ is a simple vector of real numbers.

Example 2: Gene expression programming

"Genotype"

"Phenotype"

+/Q*c-abde



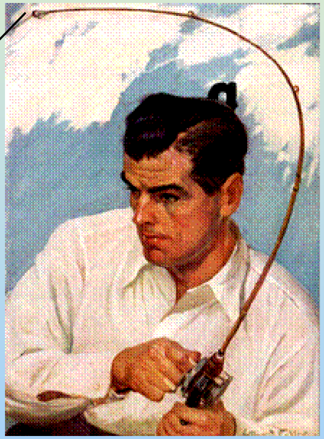
$$\frac{a*b}{c}+\sqrt{d-e}$$

Evolve - a - model …

$$y = b_0 \bigcirc b_1 x_1 \bigcirc b_2 x_2 \bigcirc b_3 x_3 \bigcirc \ldots$$

$$\underbrace{\qquad\qquad\qquad\qquad}$$

$$+ \quad * \quad ** \quad e^{?}$$



Evolve b's, operators and priors to minimise $\sum(y - \bar{y})^2$

… fishing ??

Example 3: A Mate Selection driver

- First, Selection alone ...

Vector *x*: Number of matings

(Selection only)

Source of animals	Animal#	x = Matings
Male candidates	**1**	**0**
	2	**21**
	3	**33**
	4	**0**
	5	**175**
	6	**0**
	7	**0**
	8	**0**
	…	**…**
Female candidates	**101**	**0**
	102	**1**
	103	**1**
	104	**1**
	105	**0**
	106	**0**
	107	**0**
	108	**8**
	…	**…**

Male candidates: $\sum =$ Target number of matings

Female candidates: $\sum =$ Target number of matings

A mate selection ‘driver’

			Female →	1	2	3	4 …
Male↓	**No of uses**	Ranking criterion	Rank	1	0	1	1
1	2	**5.32** **2.16**	**2** **3**			✓	✓
2	0	-	-				
3…	1	**7.64**	**1**	✓			

Parameters for mate selection

Male candidates	**1** **2** **3** **4** **…**	**2** **0** **1** **0** **…**
Female candidates	**101** **102** **103** **104** **…**	**1** **0** **1** **1** **…**
Ranking criterion	**1st male mating** **2nd male mating** **3rd male mating** **…**	**5.32** **2.16** **7.64** **…**

Parameters to be optimised

Example 4: Choosing p animals out of a group of size n

- A vector of values 0 and 1 for unselected and selected??

Animal	1	2	3	4	5	6	7	8	9	10
Selected:	0	1	0	0	1	0	1	0	1	0

- Two drawbacks here:

- We need to constrain to p animals chosen.
- The response surface is not a good shape for efficient climbing, as there are no intermediate values.

Example 4: Choosing p animals out of a group of size n

- Rank on an ‘ arbitrary number that is evolved

Animal	1	2	3	4	5	6	7	8	9	10
Real number	6.91	7.43	3.23	1.88	8.97	3.76	6.92	4.46	8.44	2.12

- Ranking gives:

Animal	5	9	2	7	1	8	6	3	10	4
Real number	8.97	8.44	7.43	6.92	6.91	4.46	3.76	3.23	2.12	1.88

Animal 1 just misses out: If animal 1 is in the best solution, then this solution will benefit (through progeny) from its high number for ranking on.

- No constraint worries
- We can also evolve p.

- [Note that this could be a good or a bad solution – that is for the objective function to decide. All we are dealing with here is a system to produce “legal” solutions.]

Example 5: Assigning animals into groups

- This follows on simply:

Animal	5	9	2	7	1	8	6	3	10	4
Real number	8.97	8.44	7.43	6.92	6.91	4.46	3.76	3.23	2.12	1.88
Group	1	1	1	2	2	3	3	3	4	4

- "Genotype": {6.91, 7.43, 3.23, 1.88, 8.97, 3.76, 6.92, 4.46, 8.44, 2.12}
- "Phenotype": (5,9,2), (7,1), (8,6,3), (10,4)

- What if this is best solution except that "5" and "4" should be swapped? A ***big valley*** to go through.

Example 5: Assigning animals into groups

- What if this is best solution except that "5" and "4" should be swapped? A ***big valley*** to go through.

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Real number	8.97	8.44	7.43	6.92	6.91	4.46	3.76	3.23	2.12	1.88
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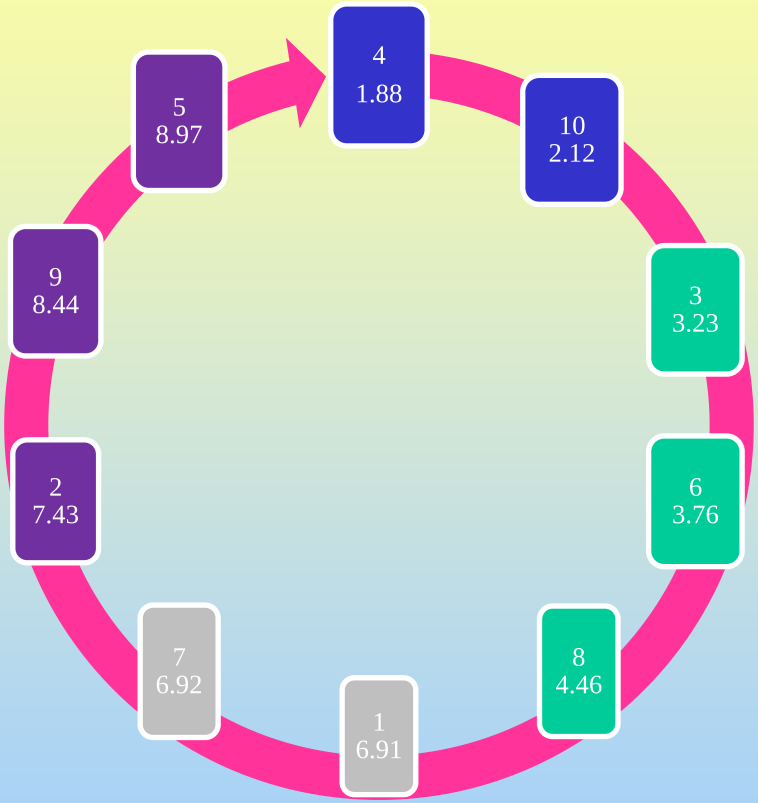
- Make smaller valleys: Order groups on an index related to objective function.
  - Eg. If groups are farms, order on pasture quality, milk yield, mean EBV, or some index of such things.

Example 5: Assigning animals into groups

- Make the vector circular …

  Transform using eg:

  $X = X \bmod 10$



- Now animals 4 and 5 can swap quite easily.

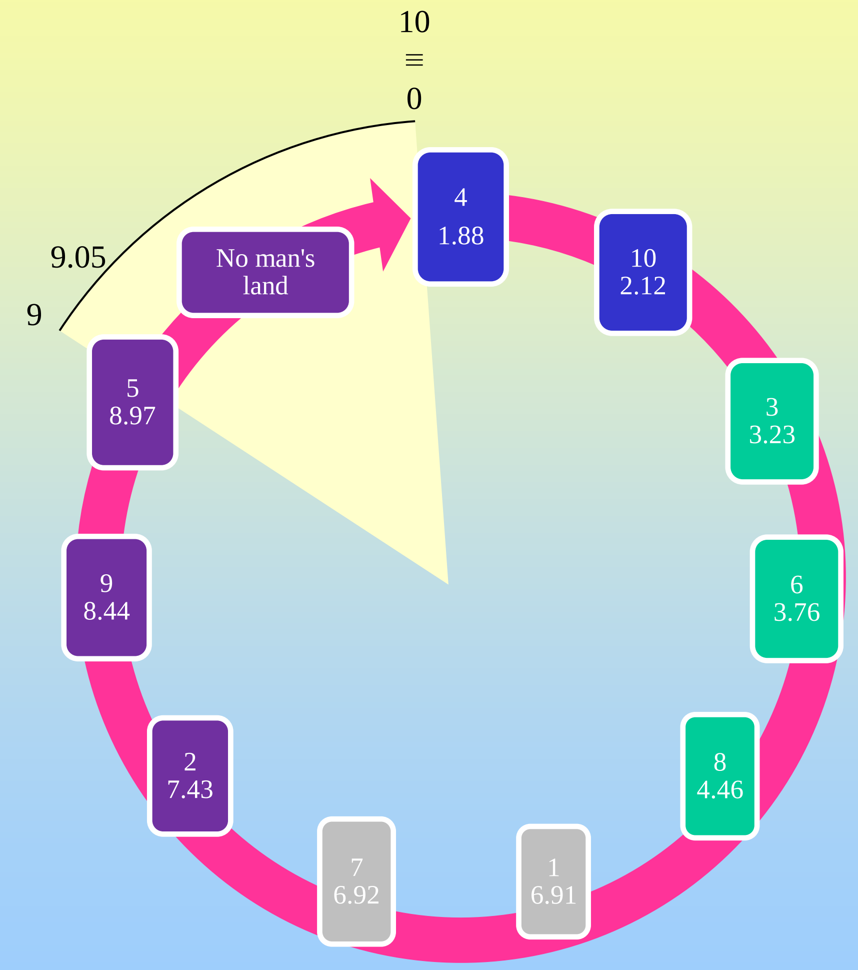
send him to the nearest group with a probability

Example 5: Assigning animals into groups

“No man’s land” example:

9.05 → 9 with prob=0.95

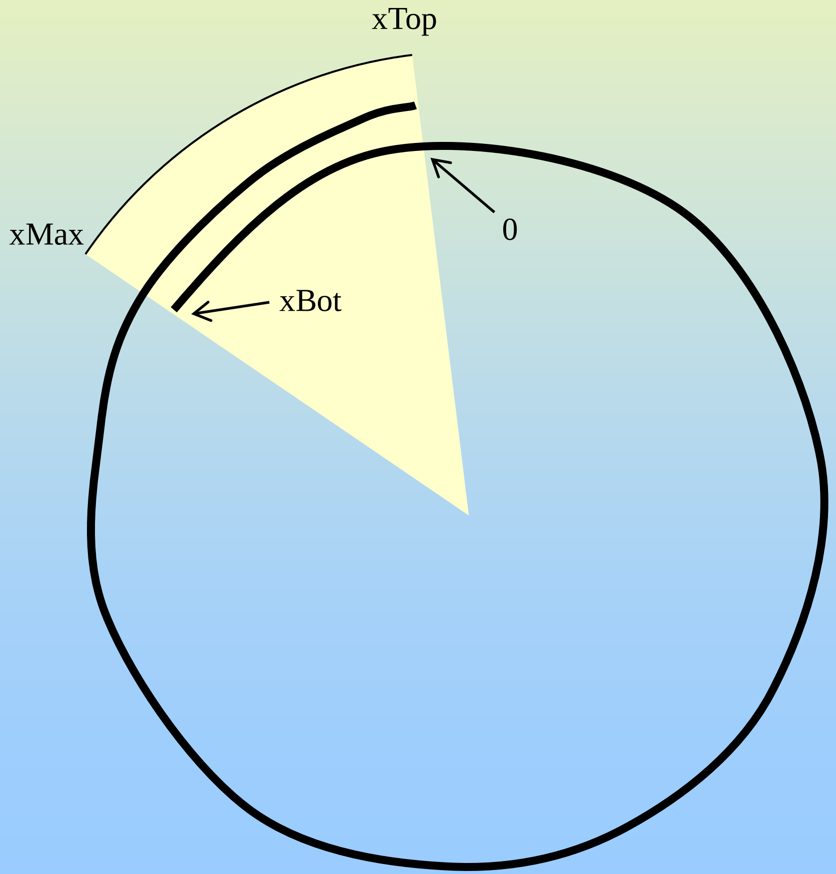
9.05 → 0 with prob=0.05



Example 5: Assigning animals into groups

```
xMax = 100000000   ! Enough to make integer weightings effectively continuous
xTop = 105000000   ! Gap to jump to go back to beginning
xBot =  -5000000   ! Gap to jump to go back to beginning
...

if (trial(j) > xTop )  trial(j) = trial(j) - xTop
if (trial(j) > xMax )  trial(j) = xMax
if (trial(j) < xBot )  trial(j) = trial(j) + xTop
if (trial(j) <   0  )  trial(j) = 0
```



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```
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...

if (trial(j) > xTop )  trial(j) = trial(j) - xTop
if (trial(j) > xMax )  then
  If((trial(j)-xMax)/(xTop-xMax) > Rnd) then
    trial(j) = 0
  else
    trial(j) = xMax
  endif
endif

if (trial(j) < xBot )  trial(j) = trial(j) + xTop
if (trial(j) <   0  )  then
  If(trial(j)/xBot > Rnd) then
    trial(j) = xMax
  else
    trial(j) = 0
  endif
endif
...
```

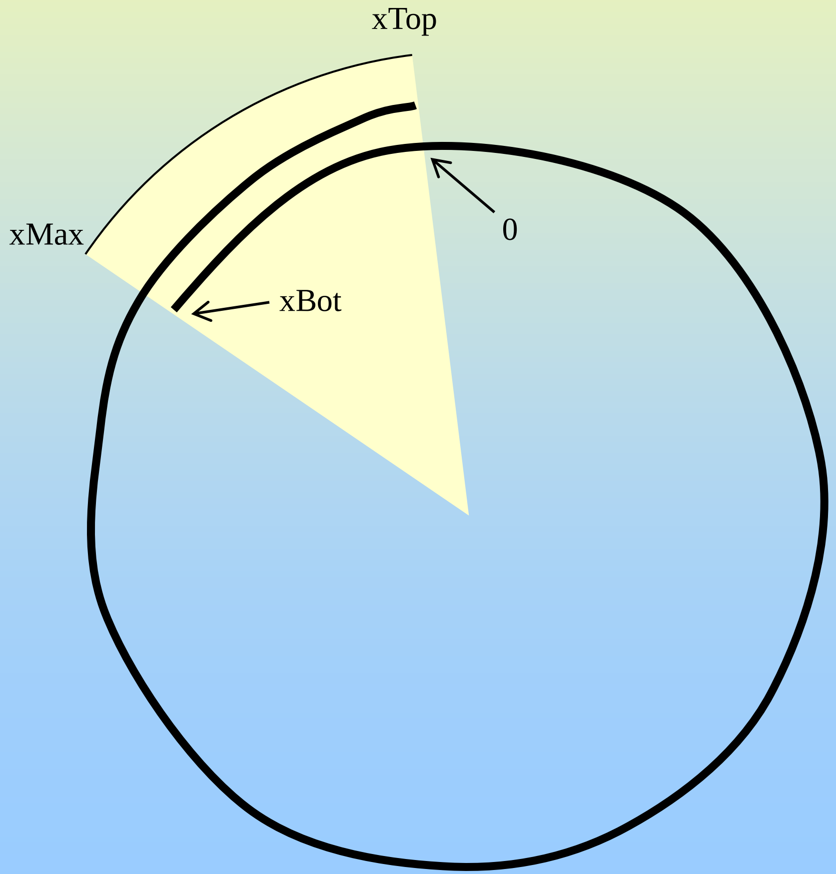

The End