Evolutionary algorithms

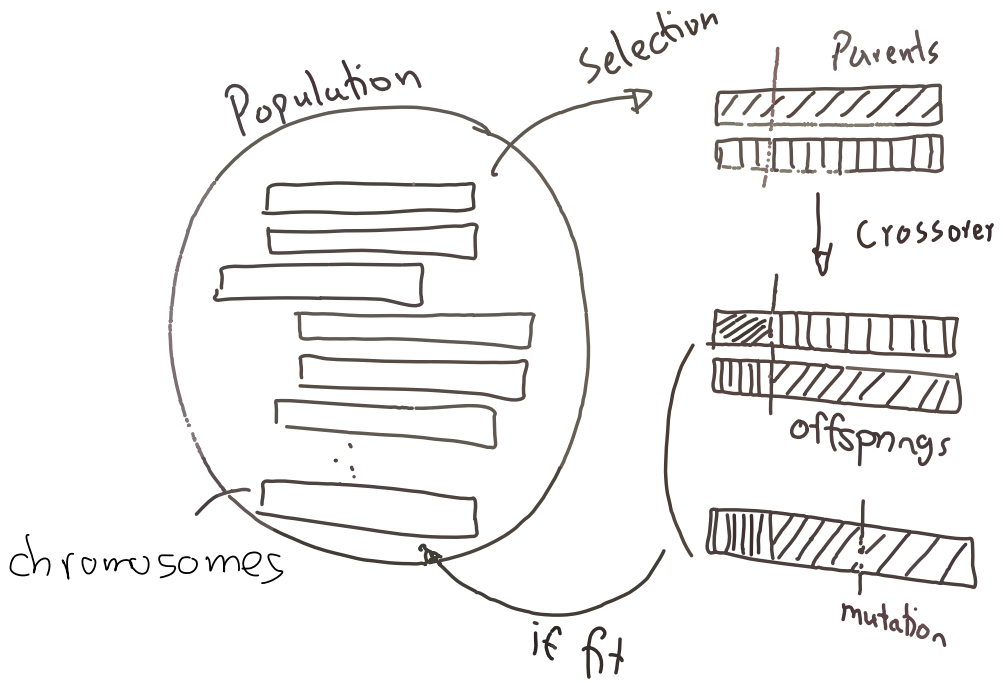
Idea : Adaptation is intelligence

↳ survival of the fittest.

Q. How do you use this idea for optimization?

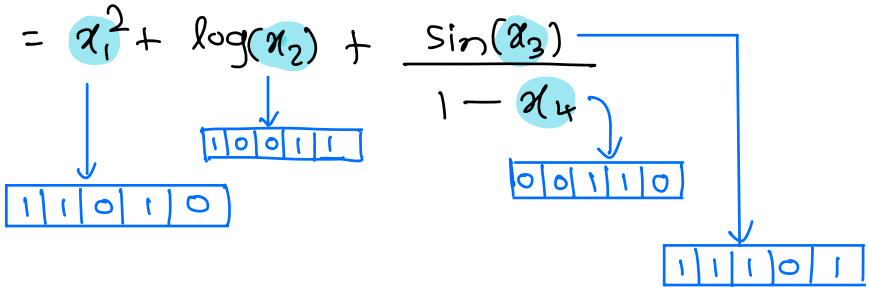
Given $f(x) = x_1^2 + \log(x_2) + \frac{\sin(x_3)}{(1 - x_4)}$

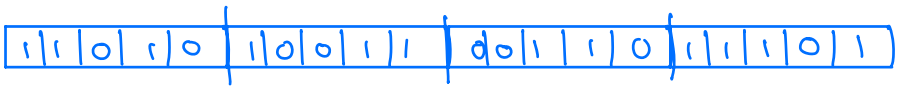
Find max(f(x)) given some contraints !



How to apply this abstract idea to the real valued optimization problem ?

$$f(x) = x_1^2 + \log(x_2) + \frac{\sin(x_3)}{1 - x_4}$$





chromsome

Simple Genetic algorithm (GA)

① Initialize population

② Calculate the fitness of your population

③ While stopping criterian not satisfied

④. Select parents

⑤ Perform crossover ⟶ offsprings

⑥ Apply mutation

⑦ Calculate total fitness

Why should we use GAs ?

- easy to code
- provide many solutions: can avoid local extrema
- Can be parallelized

What are the shotcomings of the GAs ?

- They are slow
- Fitness function may not be easily designed

↖ come from the nature of the problem

Population size ?

(How many chromosomes in one generation)

① too many: GA will be extremly sluggish.

② too few: not many possibilities for mating.

Only a part of the search space will be sampled (crossover)

Cross over frequency

① All the time (100%) : all off springs made via crossover

② Never : copy parents

Perhaps reasonable to copy "some" chromosomes to the next generation. [80% – 95%] [for some 60%]

Mutation frequency

① Never (0%) : No change in copies / offsprings

② Too often (≈50%) : Huge variability preventing convergence

③ Rarely (≈1%) : Additional diversify contributing to good solution.

for instance, $P_{mutation} = \frac{1}{1000}$ (0.1% – 0.5%)

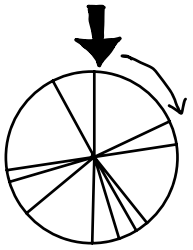
How to select parents ?

① When fitness values are very different

– Rank selection

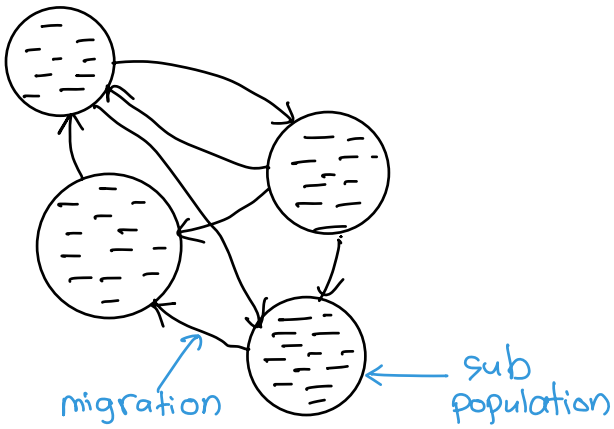
(Rank all chromosome based on their fitness value)

② fitness values are not very different
- Roulette wheel selection.



Other GA models

① Island models



How to initialize population?

① Generally random
② Could embed domain knowledge to seed the population.
③ Has to be a uniform mixture of possible values

When to stop?

① Maximum number of generation
② Look for minimum level of diversity
③ Some level of fitness

④ Certain number of generations when no significant fitness change occurs.