

Laboratory 3 - additional materials

Simple Genetic Algorithm

1. Task specification for Simple Genetic Algorithm implementation

Write a program which implements Simple Genetic Algorithm (SGA) in order to optimize the function

$$f(x) = (e^x \sin(10\pi x) + 1) / x + 5$$

on the $[0.5, 2.5] \subset \mathbf{R}$ interval in which the function takes positive values. For SGA implementation please refer to your lecture notes or the lecture snapshots presented in the following figures.

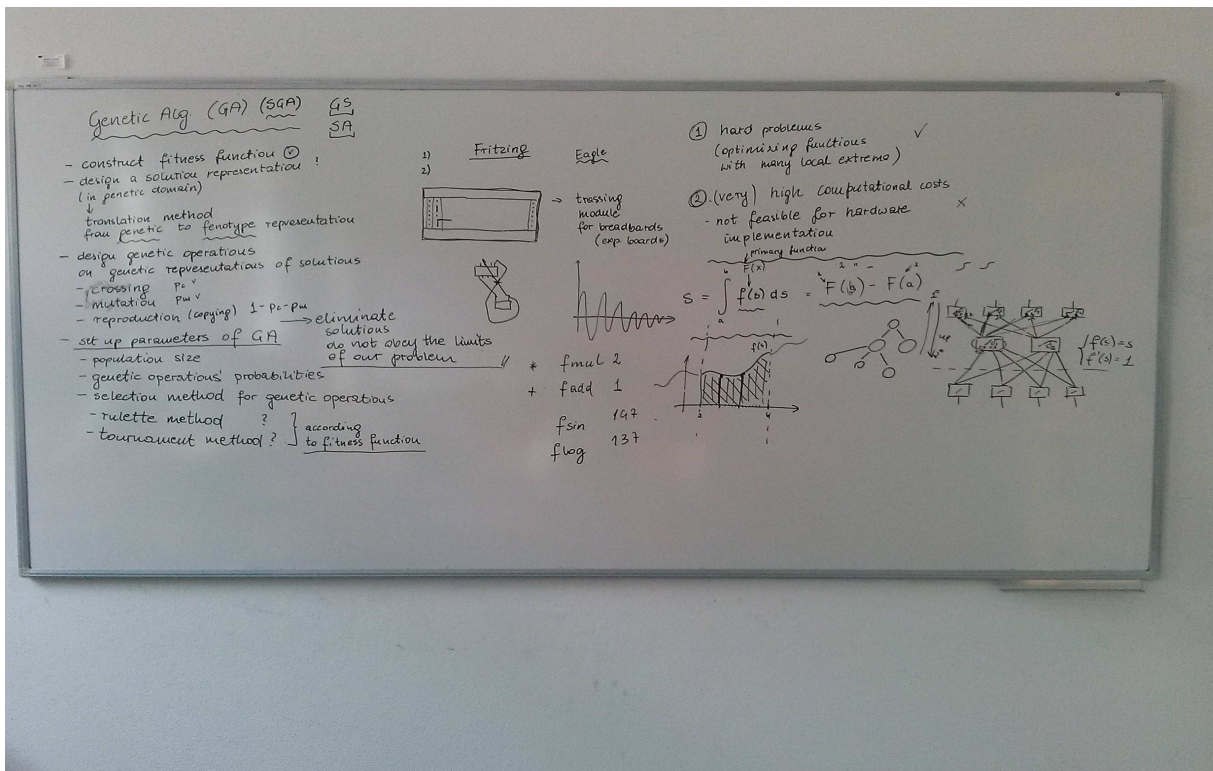


Fig. 1. Simple Genetic Algorithm - general notes

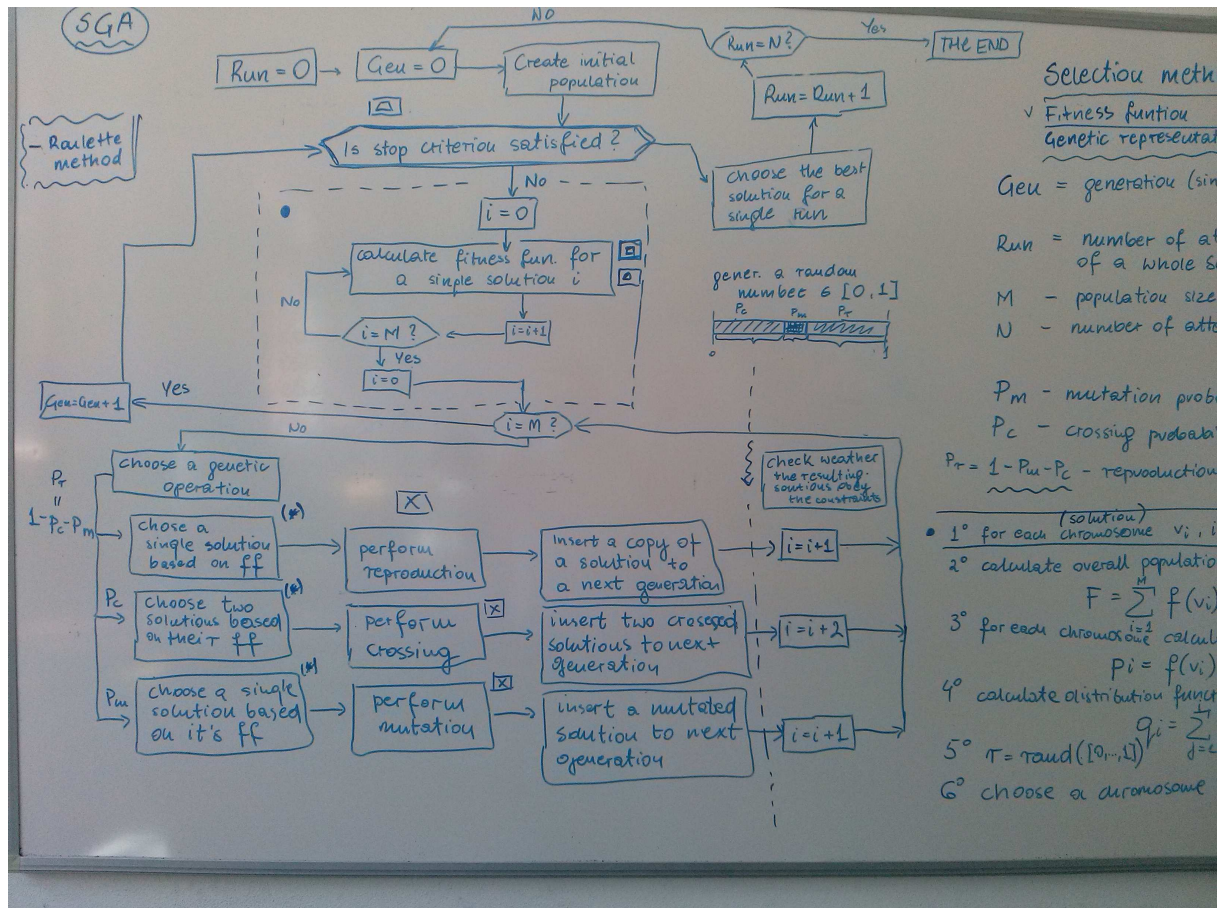


Fig. 2. Simple Genetic Algorithm - block scheme

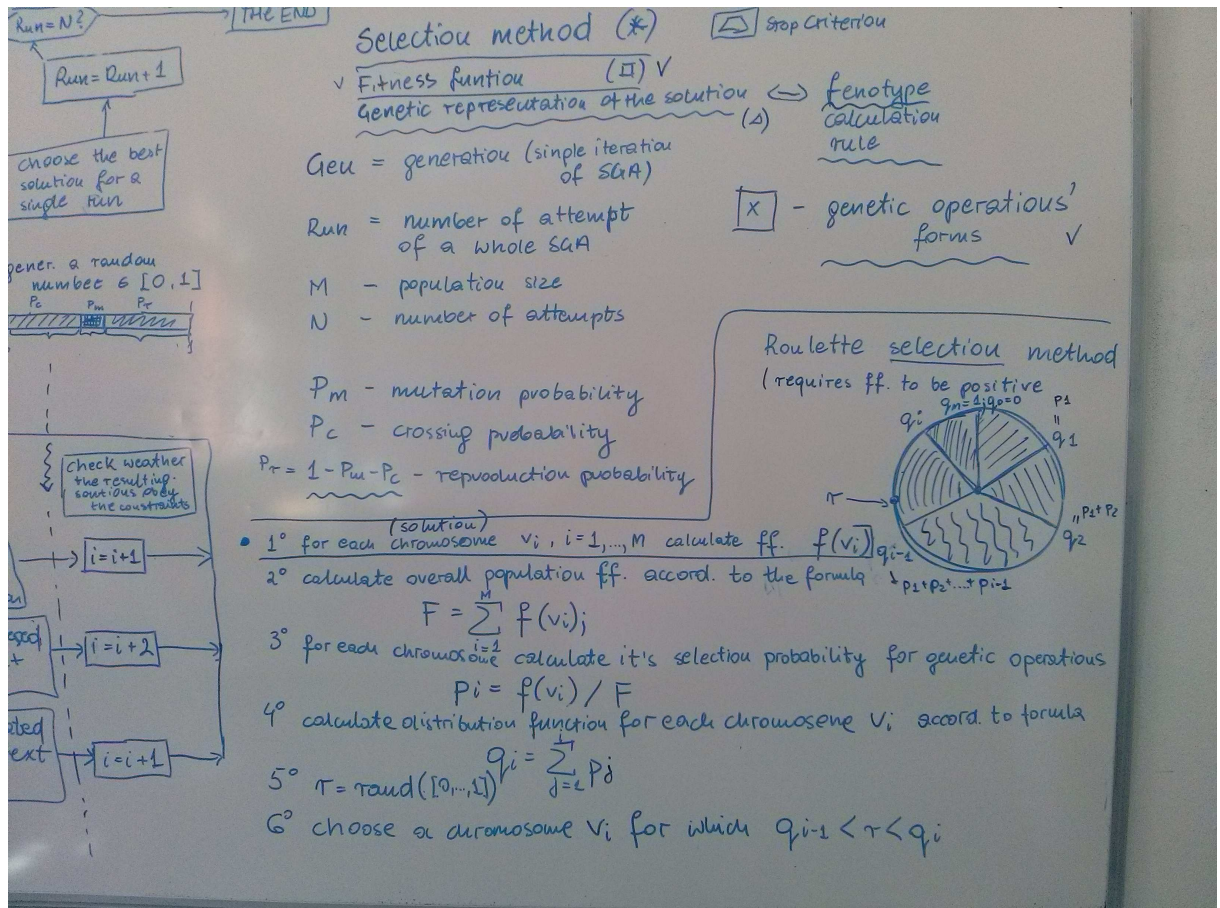


Fig. 3. Simple Genetic Algorithm - roulette selection method

General scheme of optimizing a multivariable functions using SGA.

$k=1$, $p=6$ i 10.014276

1) We have a function $f: \mathbb{R}^k \rightarrow \mathbb{R}$, i.e. $f(x_1, x_2, \dots, x_n): \mathbb{R}^k \rightarrow \mathbb{R}$, $f \rightarrow$ positive for any point within its domain (because of roulette wheel method).

2) We assume that every $x_i \in D_i$, $i=1, 2, \dots, k$ i.e. D_i is an interval in which i -th variable changes.

3) We want to find a solution up to accuracy of $p \in \mathbb{N}$ significant digits (decimal digits).

1° We divide each interval D_i to $(b_i - a_i) \cdot 10^p$ equal subintervals where $D_i = [a_i, b_i]$ $i=1, \dots, k$.

2° Let $m_i \in \mathbb{N}$ be the smallest number such that $(b_i - a_i) \cdot 10^p \leq 2^{m_i} - 1$ then each of the x_i variable can be represented as $b_i \in [0, 1]$ $x_i = a_i + \text{dec}(0101\dots 01) (b_i - a_i) / (2^{m_i} - 1)$

$\text{dec}(b_{p-1} b_{p-2} b_{p-3} \dots b_2 b_1 b_0) = \sum_{i=0}^{p-1} b_i 2^i = b_0 \cdot 2^0 + b_1 \cdot 2^1 + b_2 \cdot 2^2 + \dots + b_{p-2} \cdot 2^{p-2} + b_{p-1} \cdot 2^{p-1}$

3° Each chromosome (solution) would then consist of $m = \sum_{i=1}^k m_i$ bits in which each x_i is represented by m_i bits.

ex. $x_1 - 6 \text{ bits}$ $x_2 - 7 \text{ bits}$ $x_3 - 6 \text{ bits}$ Chromosome (single solution)

I Mutation operator

- choose some random position $j \in \{0, \dots, m-1\}$ and flip a single bit on this position

II crossing operator

before

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

after

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

III stop criterion

- number of populations
- observe the average value of the fitness function for consecutive populations and stop when for chosen number of consecutive populations the average value of ff doesn't change above some given threshold

$x^{(0)} \in D = [-1, 2]$

$(b - a) \cdot 10^6 \leq 2^{m_i} - 1$

length $3 \cdot 10^6 = 3000000$ m

$2^{22} < 3000000 < 2^{23}$

$m = 22$ each chromosome (solution) should be coded bits 22 bits

II Fitness function is just directly the f function which we are maximizing.

Fig. 4. Simple Genetic Algorithm - general, fixed decimal precision optimization scheme for multivariable positive valued functions defined on an set of intervals, snapshot 1

Remark: Note that for $k = 1$ the above method becomes a general, fixed decimal precision optimization scheme for positive valued function of one variable defined on a single closed interval, i.e. the scheme refers exactly to the laboratory task.

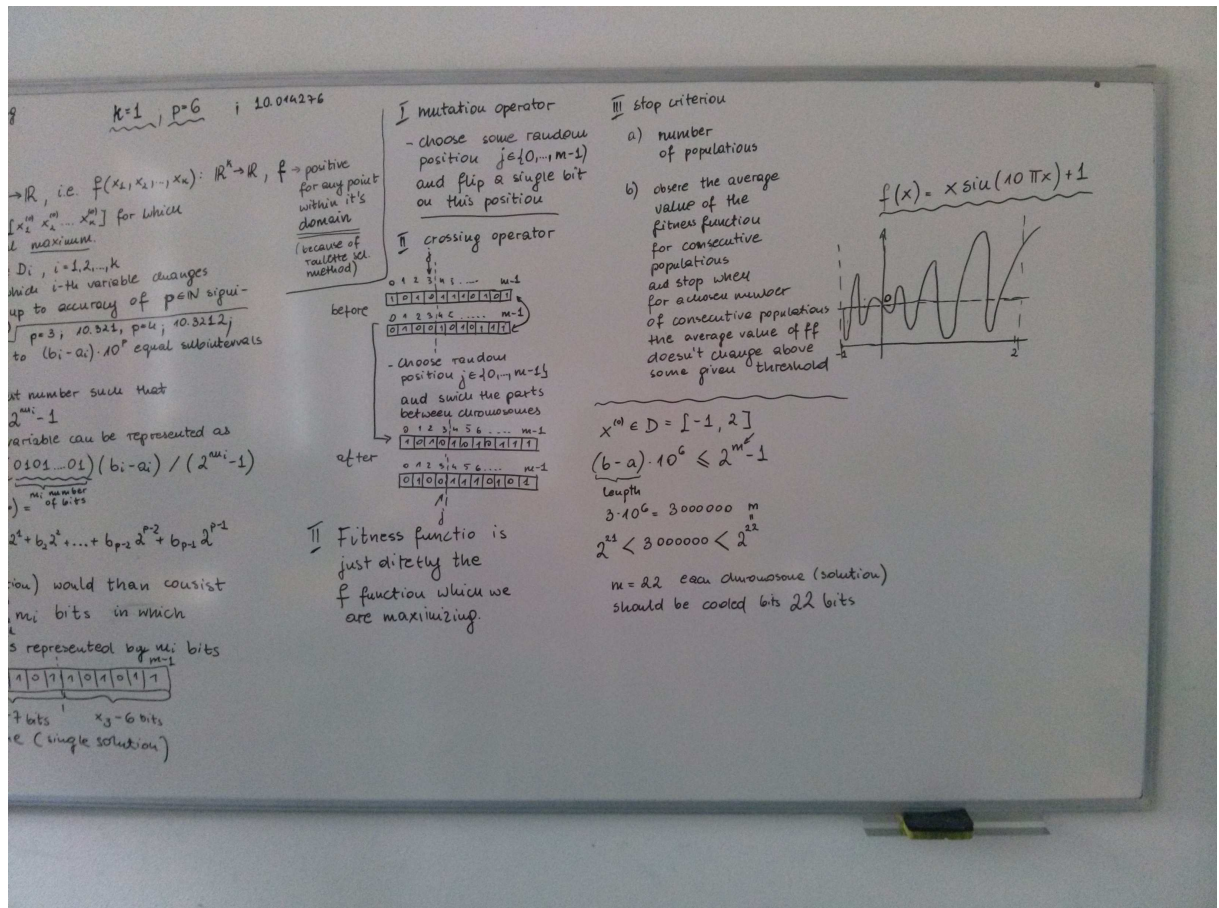


Fig. 5. Simple Genetic Algorithm - general, fixed decimal precision optimization scheme for multivariable positive valued functions defined on an set of intervals, snapshot 1