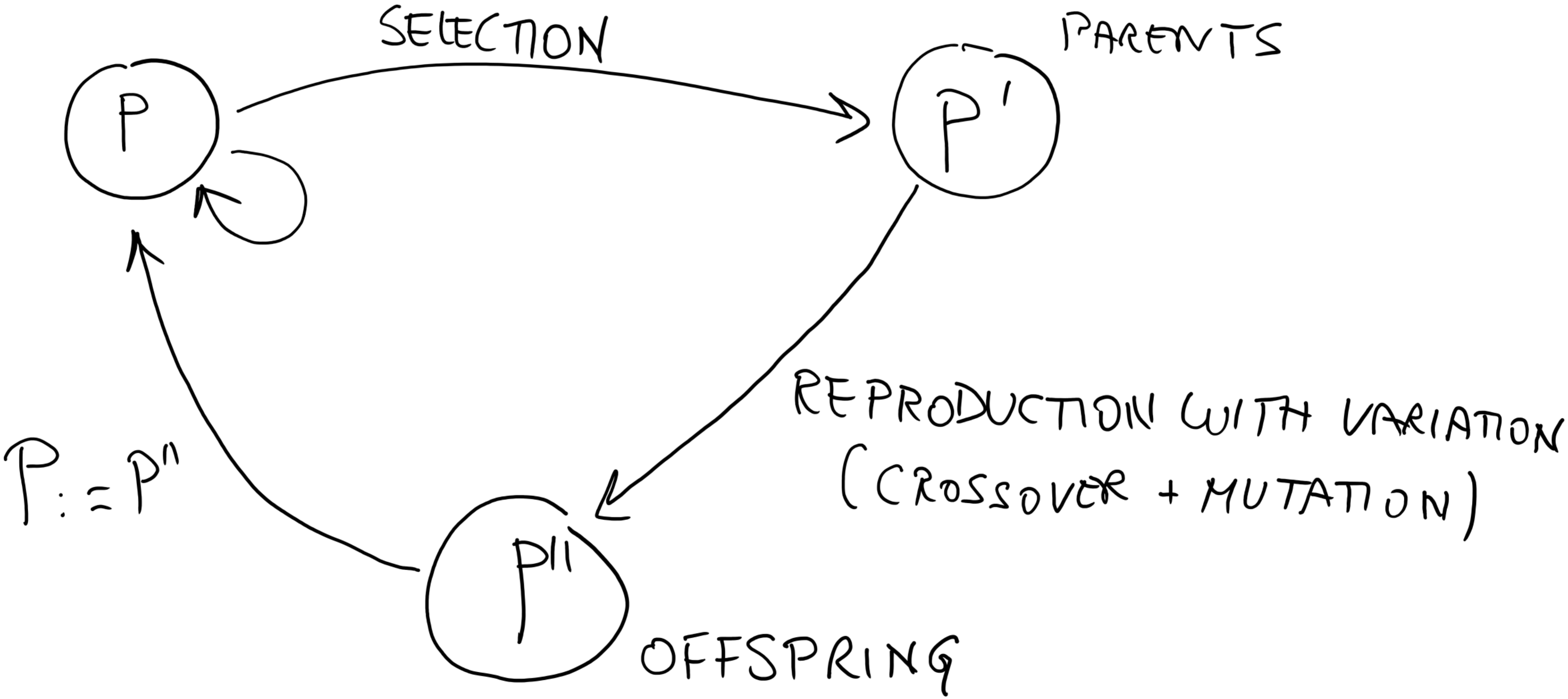
CIFO 4/4/2024

GENETIC ALGORITHMS



GENETIC ALGORITHMS

1. CREATE THE INITIAL POP P COMPOSED OF N RANDOM INDIVIDUALS
2. REPEAT UNTIL TERMINATION CONDITION
   - 2.1 CALCULATE FITNESS OF ALL INDIVS IN P (AVOIDABLE IN SOME CASES)
   - 2.2 CREATE AN EMPTY POP P'
   - 2.3 REPEAT UNTIL POP P' CONTAINS N INDIVIDUALS
     - 2.3.1. CHOOSE AN OPERATOR BETWEEN CROSSOVER (WITH PROB. p_c) OR REPLICATION (WITH PROB. $1-p_c$)
     - 2.3.2 SELECT 2 INDIVIDUALS FROM P
     - 2.3.3 APPLY THE OPERATOR IN 2.3.1 TO THE INDIVS OF IN 2.3.2.
     - 2.3.4. APPLY MUTATION TO THE INDIVIDUALS RESULTING FROM 2.3.3.
     - 2.3.5 INSERT THE INDIVIDUALS FROM 2.3.4 INTO P'
   - 2.4. P := P'
3. RETURN THE BEST INDIVIDUAL IN P

- IF N IS ODD, THERE ARE SEVERAL POSSIBILITIES
  EXAMPLES: - SELECT 1 INDIV, MUTATE IT, INSERT IT IN P'
  - FOR 1 CROSSOVER EVENT, LET ONLY ONE CHILD TO SURVIVE
  - ...

- ELITISM: COPY UNCHANGED OF THE BEST INDIVIDUAL (OR SET OF INDIVIDUALS) INTO P'.

- REPLICATION: COPY UNCHANGED OF THE PARENTS

- TERMINATION CODITION: LIKE FOR THE S.A.

- WE CAN AVOID POINT 2.1 — WHEN WE USE TOURNAMENT AND WE DON'T USE ELITISM

SUGGESTIONS

PARAMETERS	HOW TO SET THEM
POPULATION SIZE	THE BIGGER THE BETTER (WITH AN UPPER BOUND)
SELECTION ALGORITHM	TRY FIRST TOURNAMENT (NEW PAR. : TOURN. SIZE)
CROSSOVER RATE p_c	LARGE (CLOSE TO 1)
MUTATION RATE p_m	SMALL (CLOSE TO 0)
MAX. NUMBER OF GENERATIONS	THE BIGGER THE BETTER WITH AN UPPER BOUND

EXAMPLE

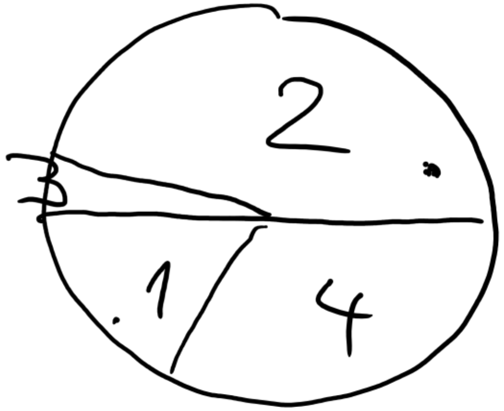
MAXIMIZE FUNCTION $f(x) = x^2$ FOR $x \in \mathbb{N}$ AND $0 \leq x \leq 31$.

REPRESENTATION : BINARY STRINGS OF LENGTH 5.

"TOY" PARAMETERS :
- POP. SIZE = 4
- $p_c = 1$, $p_m = 0$
- FITNESS PROP. SELECTION.

INITIAL POP.

			$f_i / \sum_j f_j$
1. 01101	$x = 13$	$x^2 = 169$	0.14
2. 11000	$x = 24$	$x^2 = 576$	0.49
3. 01000	$x = 8$	$x^2 = 64$	0.06
4. 10011	$x = 19$	$x^2 = 361$	0.31



FIRST TWO SELECTED INDIVS : 1 AND 2

0 1 1 0 | 1
1 1 0 0 | 0

$\times$

0 1 1 0 0
1 1 0 0 1

$\xrightarrow[p_m = 0]{\text{BECAUSE}}$ INTO P'

SECOND TWO SELECTED INDIVS : 2 AND 4

1 1 | 0 0 0
1 0 | 0 1 1

$\times$

1 1 0 1 1
1 0 0 0 0

$\longrightarrow$ P'

NEW POP.

0 1 1 0 0 $\quad x^2 = 144$
1 1 0 0 1 $\quad x^2 = 625$
1 1 0 1 1 $\quad x^2 = 729$
1 0 0 0 0 $\quad x^2 = 256$

SCHEMA

A SET OF STRINGS THAT HAVE IN COMMON THE SAME CHARACTERS IN SOME COMMON POSITIONS.

THIS CAN BE OBTAINED BY ADDING ONE MORE CHAR TO THE ALPHABET:

DON'T CARE SYMBOL (*)

$$*0000 = \{00000, 10000\}$$

$$*111* = \{01110, 01111, 11110, 11111\}$$

THE MORE * THE LARGER IS THE CARDINALITY OF THE SET

ORDER OF A SCHEMA H ($o(H)$) =
N. OF CHARACTERS $\neq$ *

LENGTH OF A SCHEMA H ($\delta(H)$) =
DISTANCE BETWEEN THE RIGHTMOST AND LEFTMOST POSITIONS CONTAINING A CHAR DIFFERENT FROM *

EXAMPLE

$o(011*1**) = 4$

$\delta(011*1**) = 5 - 1 = 4$

SCHEMA THEOREM (INFORMAL)

SCHEMATA THAT ARE :

- WITH AVG. FITNESS > AVG. OF THE POP. (SELECTION)
- SHORT (CROSSOVER)
- OF SMALL ORDER (MUTATION)

BUILDING BLOCKS

RECEIVE A NUMBER OF COPIES EXPONENTIALLY GROWING FROM 1 GENERATION TO THE NEXT

(ALL OTHER SCHEMATA EXPONENTIALLY DECREASING)

$\Downarrow$

THEOREM OF ASYMPTOTIC CONVERGENCE OF GAs

LET $i(t)$ BE THE BEST INDIV. IN P AT GEN t
AND S_{opt} THE SET OF EXISTING GLOBAL OPTIMA.

$$\boxed{\lim_{t \to \infty} P\left(i(t) \in S_{opt}\right) = 1}$$

CONSEQUENCE

SEQUENCE $[i(0), i(1), \dots, i(t), \dots]$
CONVERGES TOWARDS A SOLUTION IN S_{opt}