Universiti Malaysia PAHANG
Engineering • Technology • Creativity

Intelligent Control

Artificial Neural Network (5)

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Chapter Description

At the end of this topic , student should be able to:-

- Understand the concept of Genetic algorithm and analyse using the algorithm.

Contents

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BASIC CONCEPT

5.1

Introduction

1960s by I. **Rechenberg** in his work "***Evolution strategies***"

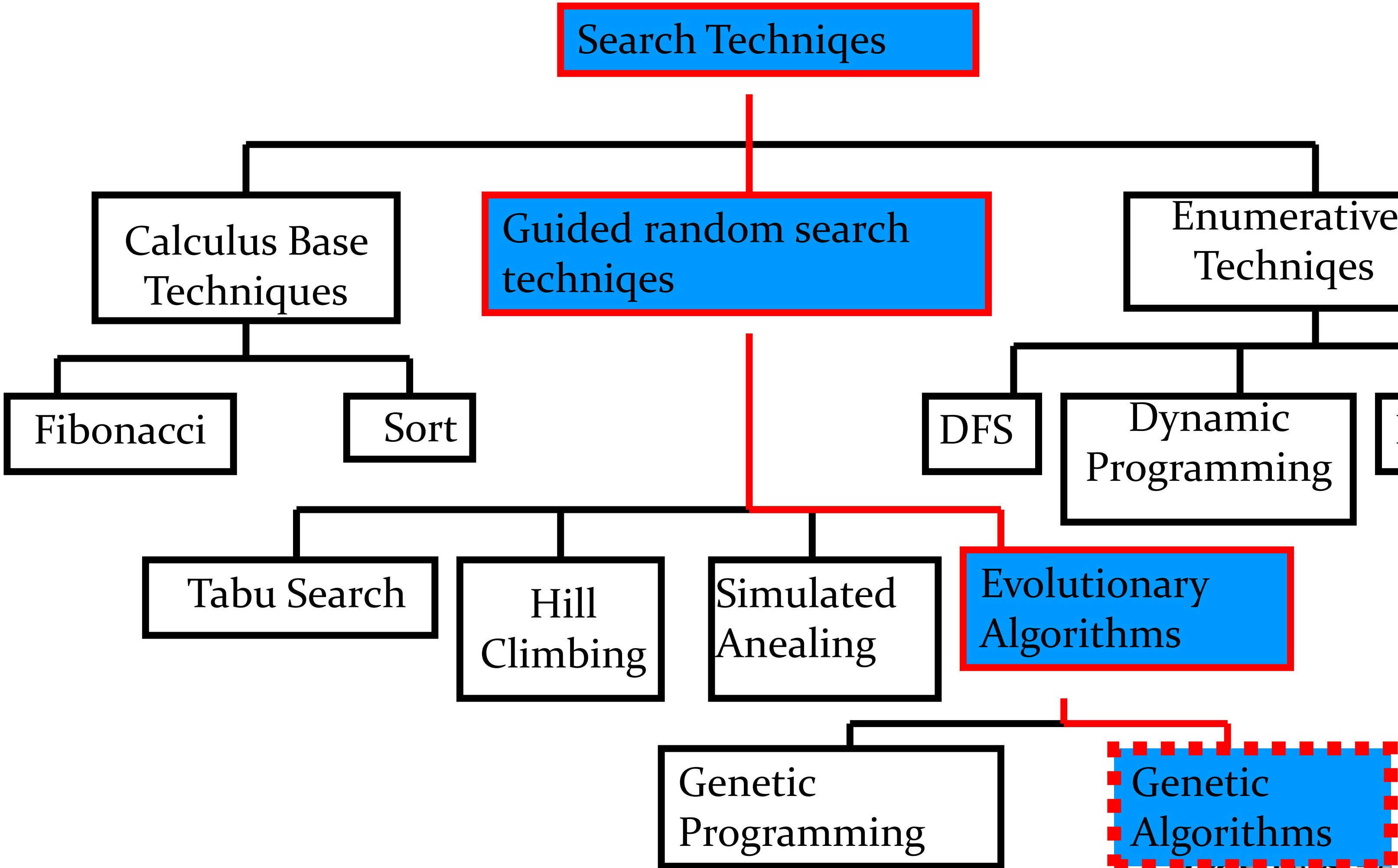
1975, Genetic Algorithms (GAs) by John **Holland**

1992, John Koza evolved GA to 'Genetic Programming'

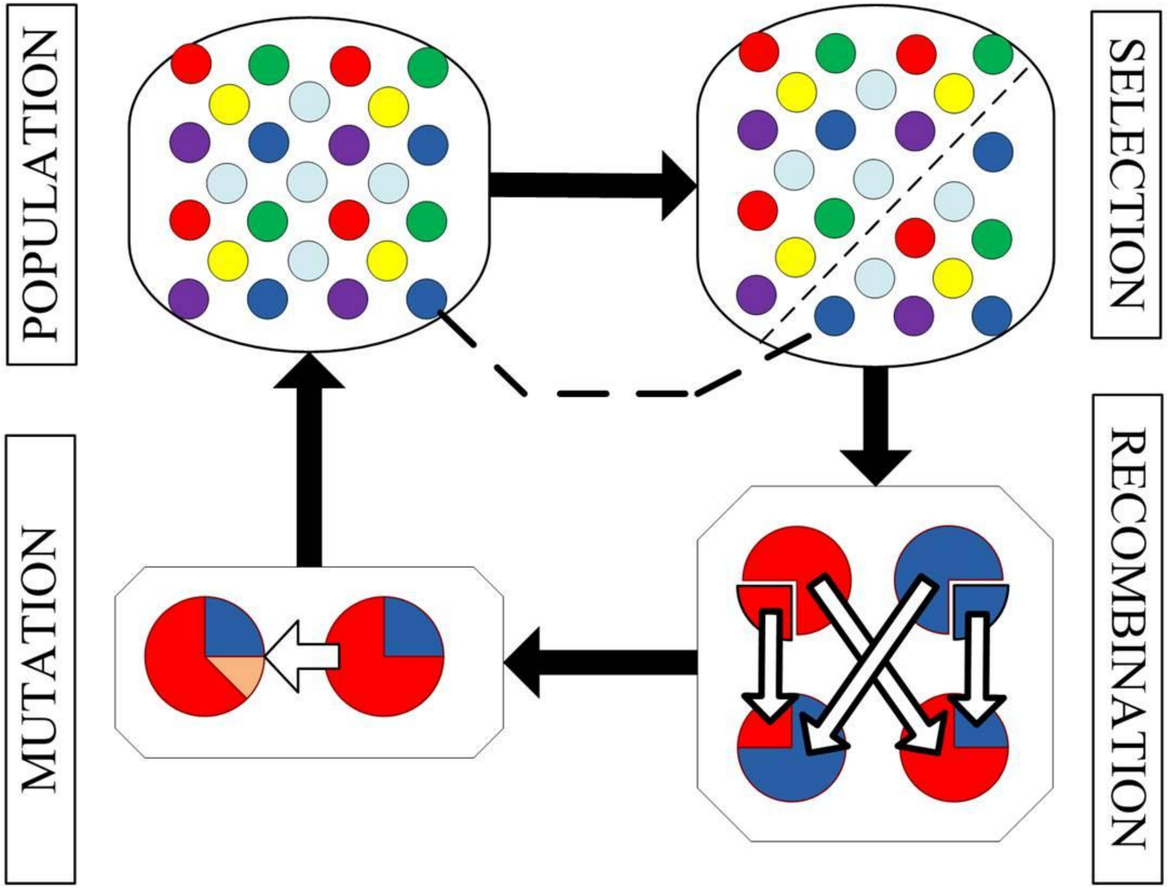
Genetic Algorithm

5.2

Introduction to GA

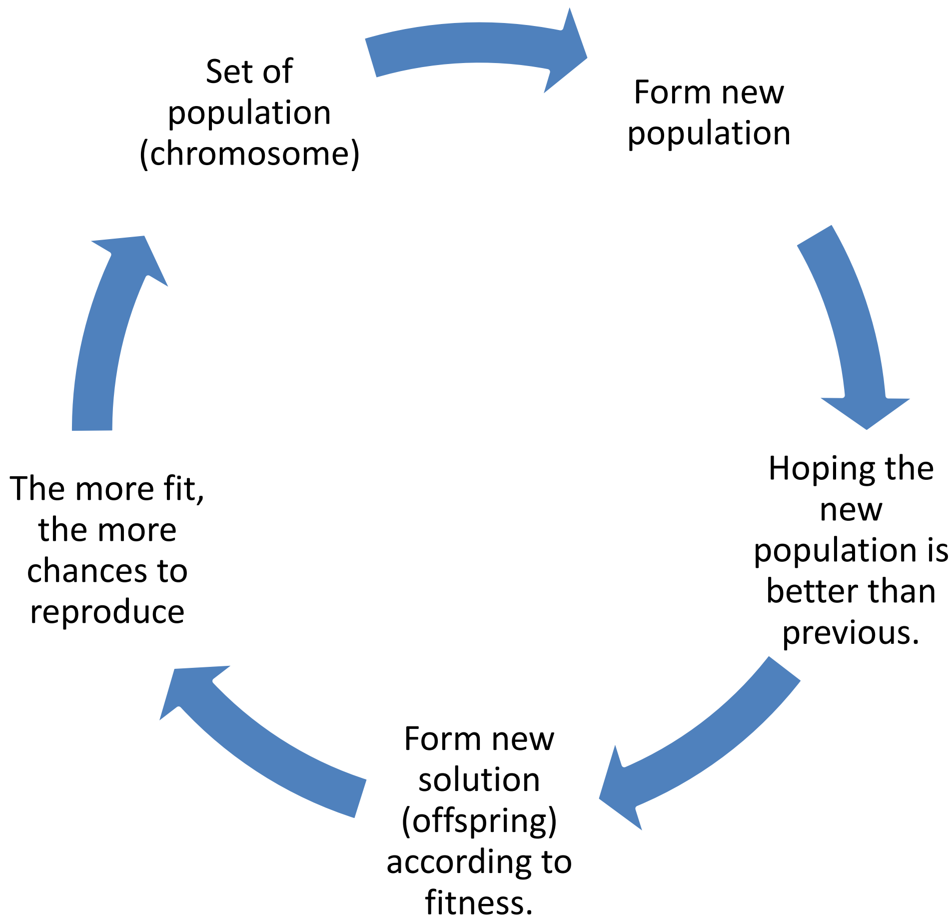


GA Components

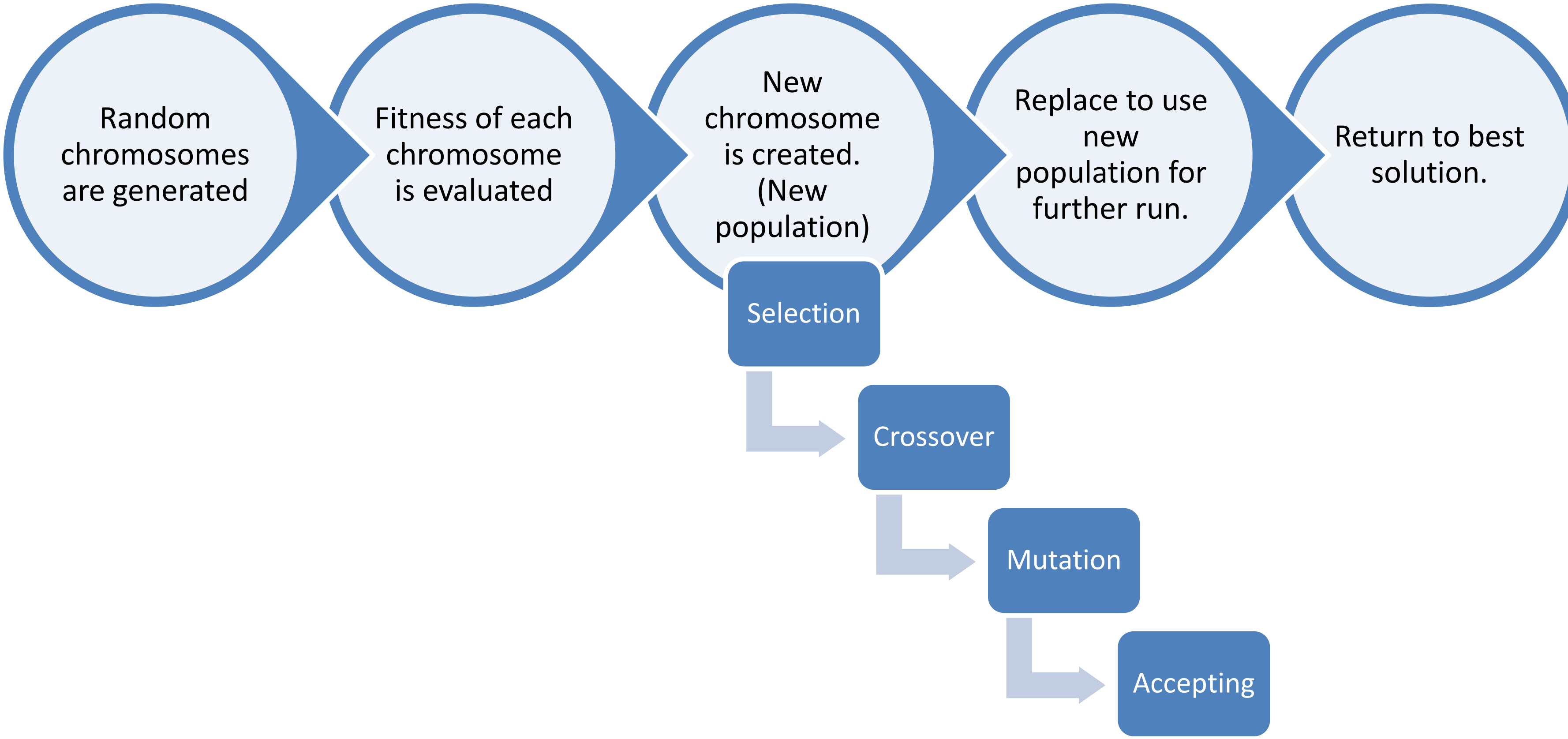


Source: http://www.engineering.lancs.ac.uk

GA Algorithm



Set up GA


Random chromosomes are generated
Fitness of each chromosome is evaluated
New chromosome is created. (New population)
Replace to use new population for further run.
Return to best solution.
Selection
Crossover
Mutation
Accepting

Case Study

5.3

Example

- Model parameters are encoded into a binary string

$$x = (1.2, 3.4, \ldots, 100) \leftarrow (0101110011 \ldots 100011)$$

- For each parameter, a minimum value, step size and encoding length has to be specified. For example two parameters x_1, x_2:

$$x_1 \in [-1 \ldots 1] \text{ and } x_2 \in [0 \ldots 3.1]$$

5-bit	x_1	x_2
Basevalue	-1	0
Stepsize	0.0625	0.1

10-bit	x_1	x_2
Basevalue	-1	0
Stepsize	0.0002	0.003

Example Cont'd

- During initialization, a population of N random models is generated.

$$
\begin{aligned}
p_1 = (0101110011) \quad &\rightarrow \quad (01011) = -1 + 26 * 0.0625 = 0.625 \\
&\qquad\; (10011) = 0 + 25 * 0.1 = 2.5 \\
p_2 = (1111010110) \quad &\rightarrow \quad (11110) = -1 + 15 * 0.0625 = -0.0625 \\
&\qquad\; (10110) = 0 + 13 * 0.1 = 1.3 \\
p_3 = (1001010001) \quad &\rightarrow \quad (10010) = -1 + 9 * 0.0625 = -0.4375 \\
&\qquad\; (10001) = 0 + 17 * 0.1 = 1.7 \\
\vdots \quad &\qquad \vdots \\
p_N = (0110100001) \quad &\rightarrow \quad (01101) = -1 + 22 * 0.0625 = 0.375 \\
&\qquad\; (00001) = 0 + 16 * 0.1 = 1.6
\end{aligned}
$$

Example Cont'd

For each member of the population calculate the value of the objective function:

$$O(x_1, x_2) = x_1^2 + x_2^2$$

$$\begin{aligned}
p_1 &\rightarrow O(0.625, 2.5) = 6.64 \\
p_2 &\rightarrow O(-0.0625, 1.3) = 1.69 \\
p_3 &\rightarrow O(-0.4375, 1.7) = 3.08 \\
&\vdots \qquad \vdots \\
p_N &\rightarrow O(0.375, 1.6) = 2.70
\end{aligned}$$

Based on the objective function value, a probability is assigned to make it into the next generation $P(p_j) = f(O(x_i))$. In our example

$$P(p_j) = \frac{1}{\sum_i \max\{O(x_i)\} - O(x_i)} (\max\{O(x_i)\} - O(x_i))$$

In our case: $\sum_i \max\{O(x_i)\} - O(x_i) = 12.45$ this gives:

$$\begin{aligned}
P(p_1) &= \frac{6.64 - 6.64}{12.45} = 0. \\
P(p_2) &= \frac{6.64 - 1.69}{12.45} = 0.40 \\
P(p_3) &= \frac{6.64 - 3.08}{12.45} = 0.28 \\
P(p_4) &= \frac{6.64 - 2.70}{12.45} = 0.32
\end{aligned}$$

Now we can generate a new population of the same size.

Selection

Each model's chance to mate is determined by their probability.
The offsprings undergo two steps: *Crossover* and *Mutation*

Mating Cand.	Old Pos.	Prob.
m_1	p_2	0.4
m_2	p_3	0.28
m_3	p_4	0.32
m_4	p_2	0.4

Crossover

With probability P_c two members of the population exchange their genes after a randomly chosen point.

$$\begin{matrix} (000111) & & (000001) \\ & \xrightarrow{3} & \\ (110001) & & (110111) \end{matrix}$$

Typically $0.2 \leq P_c \leq 0.7$.

Mutation

With a probability P_m one bit changes its value.

$$(000111) \to (010111)$$

Typically P_m is chosen so that 80-90 percent of the population do not mutate.

Effect to reproduction

Result of selection, crossover and mutation:

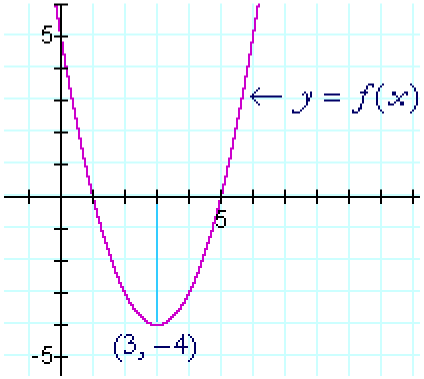
New	Father	Mother	Cross.	Mut.	Result	$O(x)$
p_1	m_1	m_2			(1111010110)	1.69
p_2	m_1	m_2			(1001010001)	2.7
p_3	m_3	m_4	4		(0110|100001) → (0110010110)	2.08
p_4	m_3	m_4	4	3	(1111|010110) → (1101100001)	3.03

The resulting genetic strings make up the new population.

Maxima and Minima

- Let's say that we have a function f(x) $= x^2 - 6x + 5$
- Find the turning point, and decide whether it is minima or maxima!
- Solution :
- Find the differential of *f(x)* = 0

$$f'(x) = 2x - 6 = 0$$
$$x = 3$$



- Substitute the value of *x*=3 to *f(x)* → $f(3) = 3^2 - 6 \cdot 3 + 5 = -4$ → ***minima***

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