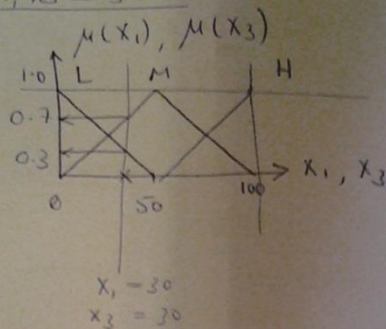


Model Answer of Final Exam Jan 2012 2011  
Genetic Algorithms

(1)

① Step 1: Fuzzification

$x_1, x_3 = 30$

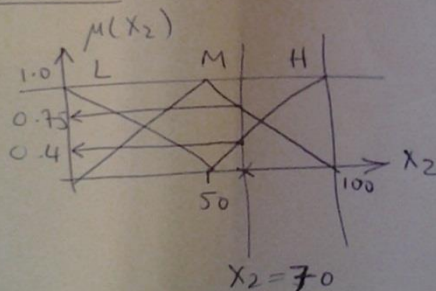


$$\mu_L(x_1=30) = 0.3$$

$$\mu_H(x_1=30) = 0.7$$

$$\mu_H(x_2=30) = 0$$

$x_2 = 70$



$$\mu_L(x_2=70) = 0$$

$$\mu_H(x_2=70) = 0.75$$

$$\mu_H(x_2=70) = 0.4$$

step 2 Inference

DB1

$$R_1, w_1 = \min(\mu_L(x_1=30), \mu_L(x_2=70)) \\ = \min(0.3, 0) = 0 \text{ L}$$

$$R_2, w_2 = \min(\mu_M(x_1=30), \mu_H(x_2=70)) \\ = \min(0.7, 0.4) = 0.4 \text{ H}$$

DB2

(2)

$$\begin{aligned} R_1 / w_1 &= \min(\mu_L(x_3=30), \mu_L(Y)) \\ &= \min(0.3, 0) = 0B \end{aligned}$$

$$\begin{aligned} R_2 / w_2 &= \min(\mu_M(x_3=30), \mu_H(Y)) \\ &= \min(0.7, 0.4) = 0.4M \end{aligned}$$

step 3 Defuzzification

$$D_{\text{Predicted}} = \frac{0B + 0.4M}{0 + 0.4} = \frac{\cancel{0} / 4M}{\cancel{0.4}} = \underline{\underline{M}}$$

Malignant

② In generational GA, chromosomes are mated to generate enough individuals to replace whole population. So, the possibility of "survival of the fittest" is Low.



③ No Crossover  $P_c = 1$ .

i.e. only mutation,

In Low population size

There is still a possibility of finding a good solution — but survival of the fittest is low.

High population size

good probability of finding optimal solution but with a lowered performance of GA.

Crossover always  $P_c = 1$ .

a- low population size

Low possibility of finding optimal solution.

b- High population

Higher probability of finding optimal with crossover —  
Higher variability.

c- Elitism :

avoids possibility of destruction of best-so-far by repeated Xover.

④ frequency does not change, as the crossover does not change the value of the allele in a particular position.

④

⑤ This is the problem of Symbolic Regression  
Solved by Genetic Programming.

⑤

Minimize  $E = \sum (f(x_i) - y_i)^2$

Objective function

where  $E = \text{error}$ .

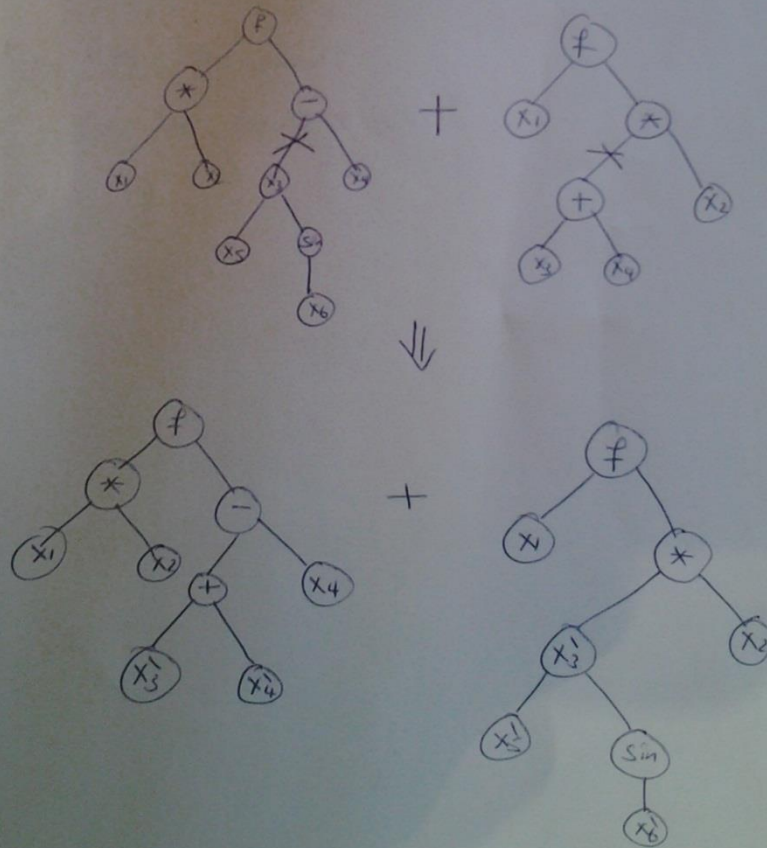
$f(x_i) = \text{function to be found}$

$y_i$  : values of 'y' for 'x's'.

Data Structure : Tree.

Operators :  $\{+, -, *, /, \sin, \cos\}$

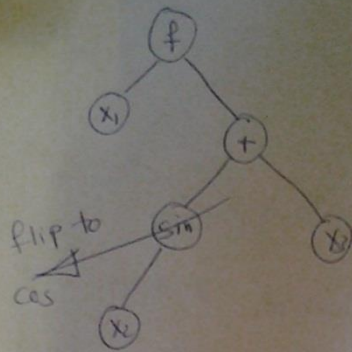
Crossover





Mutation

6

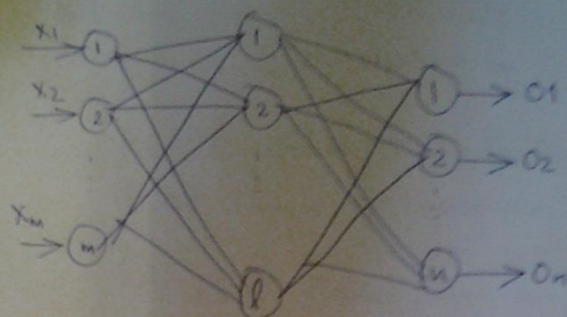


Population size thousands.

Selection Can be Roulette wheel.

⑥ FFNN

⑦

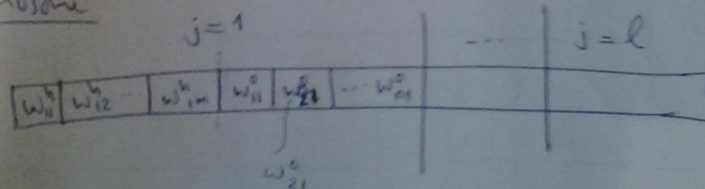


The case is determination of the number  $l$  and whether  $w_{ji}^h$  or  $w_{kj}^o$  is existent or not.

Design of chromosome

- Variable lengthed chromosome according to  $l$  entities.
- Take value of entry = MAX-INT if synapse is non-existent.

Chromosome





### Algorithm

8

Initialize Population  $P_0$  randomly  
for  $i=1$  to MaxGenerations do  
begin

Evaluate fitness of individuals  $\{ \text{NN evaluation} \}$   
 $\text{fitness} = \text{Error}$

Select Parents for reproduction  $\{ \text{Roulette wheel} \}$

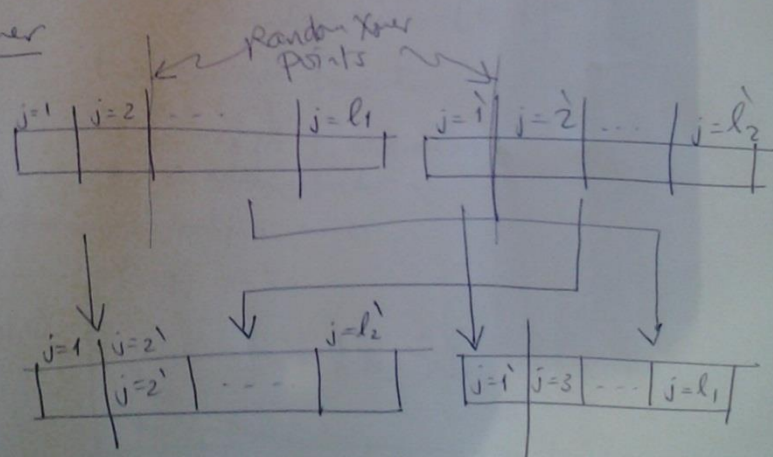
Crossover  $\{ \text{see Diagram} \}$

Mutation  $\{ \text{Floating Point Mutation} \}$

Replace old population  $P_{i-1}$  with  
new population  $P_i$

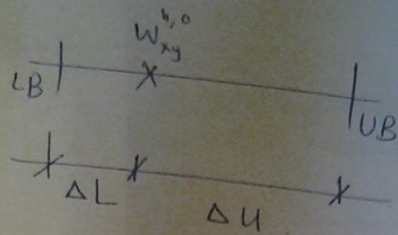
end

### Crossover



## Mutation FP Mutation

9



$$Y = \begin{cases} \Delta U & \text{random no.} > 0.5 \\ \Delta L & \text{random no.} \leq 0.5 \end{cases}$$

and  $\Delta(t, y) = y \cdot (1 - r)^{(1 - t/T)^b}$

$\Delta(t, y)$  = mutation value

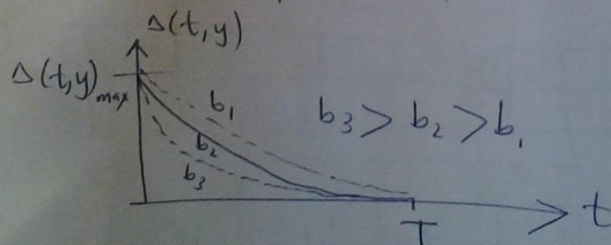
$r$  = random no.  $\in [0, 1]$

$t$  = current generation

$T$  = Max No. of generations

$b$  = dependency factor

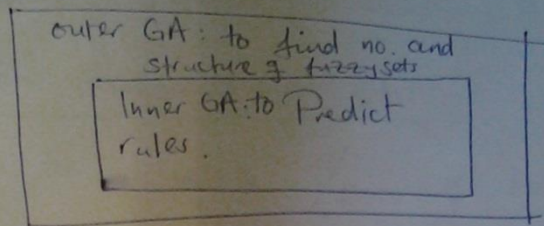
Performance Analysis curves:





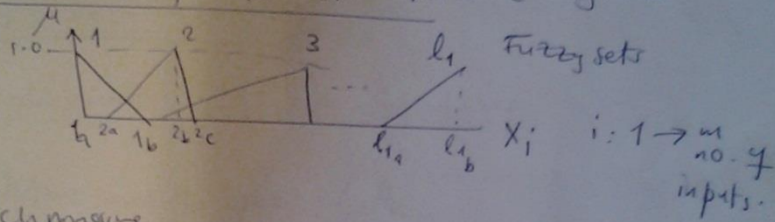
① Use 2 nested GAs

⑩

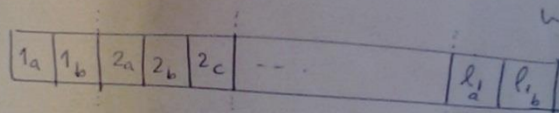


Design of chromosomes:

Chromosome of outer GA: Variable lengthed.

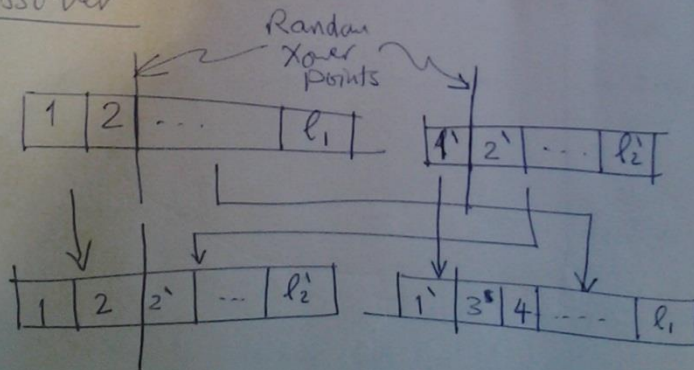


chromosome



where  $j_x$  is a FP no. on  $X_i$  axis

Crossover





## Mutation

Normal FP Mutation discussed in Ques 6.

## objective function of outer GA

Is the value of  $1/\text{error}$  of best-absolute after MaxGeneration in inner GA.

Population Size  $> 10$

Replacement: Elitist Strategy.

## Chromosome of Inner GA

Data File					Error	
	input					
	$x_1$	$x_2$	...	$x_m$	output $y$	
$r_1$	-	-		-	-	$y_1 \pm \Delta$
$r_2$	-	-		-	-	$y_2 \pm \Delta$
$\vdots$						$\vdots$
$r_p$	-	-	-	-	-	$y_p \pm \Delta$

fitness of Inner GA =  $1/\text{error}$  per Generation

Make a key

(12)

First fuzzy set : 1

not first FS = -1

2nd FS : 2

not 2nd FS = -2

last FS :  $l_j$  not last FS =  $-l_j$

0 if entry not applicable

Chromosome for 2 inputs - 1 output eg.

$R_1$			$R_2$			$R_{k_1}$		
2	1	- $l_j$ -1	4	2	7	3	0	5

Crossover

Normal Xover on variable-lengthed chromosome discussed before.

Mutation see ques. 8.

Error

- a predefined value  $\Delta$  if Regression
- an accumulation function if Classification.

Rules of restriction

- Must have an upper/lower bounds for rules
- Must have an upper/lower bounds for Fuzzy sets



⑧ for real-time evolution of Robot rules use

13

- a - Artificial Immune System (AIS) - Clonal selection.
- b - Hybrid GA - AIS.

Make a key:

right : 1

not right : -1

left : 2

not left : -2

Front : 3

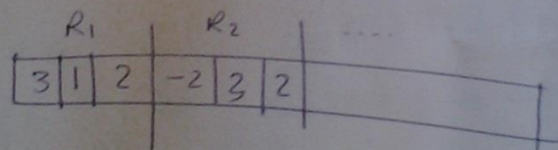
not front : -3

back : 4

not back : -4

Ø if not applicable.

Design of Antibody



Affinity evaluation of whole Plan  $\Rightarrow$  set of rules are evaluated in sequence.



## AIS Algorithm:

(14)

Initialize Set of antibodies  
for  $i = 1$  to MaxGenerations do  
begin

Evaluate Affinity of whole Plan.

Clonal Selection & Selection of absolute best.

Mutation on a % of best antibodies  
metadynamics

Replace old antibodies with new antibodies

end.

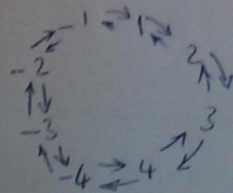
### Mutation

Generate random no.  $r \in [0, 1]$ .

if  $0 \leq r < 1/3$  add 1 to entry.

if  $1/3 \leq r < 2/3$  subtract 1 to entry.

if  $2/3 \leq r < 1$  flip entry to not



mutation cycle.

## Hybrid GA-AIS Algorithm

(15)

Initialize set  $g$  antibodies randomly.

for  $i=1$  to MaxGenerations do  
begin

Evaluate Affinity

Clonal Selection.

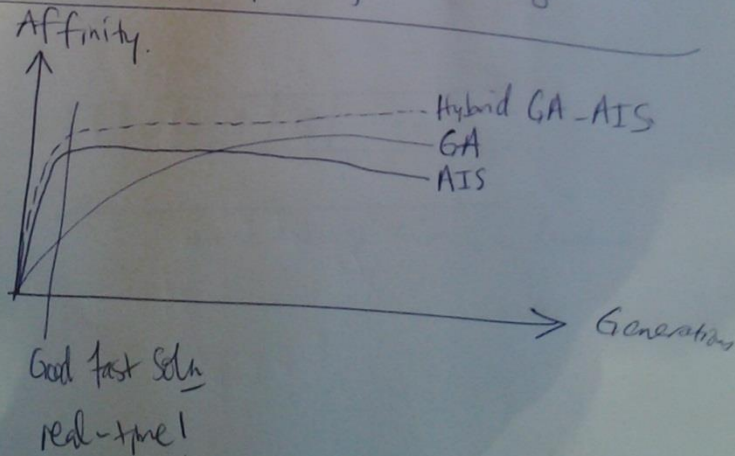
Mutation

Crossover { must be after mutation! }

metadynamics

Replace old antibodies with new antibodies  
end.

## Performance Analysis of the 2 Algorithms





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1) The problem is Feature Selection.

Each criterion represents a feature.

Each row represents a customer.  
Criteria:  $F_1, F_2, \dots, F_m$       output: regular pay or not

	$F_1$	$F_2$	...	$F_m$	$Y$
Customer <sub>1</sub>	-	-		-	-
Customer <sub>2</sub>	-	-		-	-
...					
Customer <sub>p</sub>	-	-		-	-

Algorithm normal GA.

Design of chromosome

let 1 = Feature Applicable.

0 : " not "

$F_1$	$F_2$	$F_3$	...	$F_m$
1	0	1	1	0

←  $m = \text{no. of criteria} = \text{features}$  →



Crossover normal Crossover.

(17)

Mutation ~~not~~ normal bit-string mutation.

Objective function: is the Data file with an accumulation for those rows (customers) evaluated correctly or not - evaluated by a classifier such as NN.

Fitness Use Crossvalidation - a type called LOO - Leave-one-out.

LOO algorithm

for  $i=1$  to  $p$  do

begin

~~exclude~~

exclude row  $i$

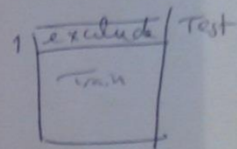
Train NN on rest.

evaluate (Test) NN on row  $i$

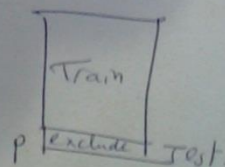
accumulation = accumulation + 1

end.

$$\text{fitness} = \frac{\sum_i \text{accumulation}}{p}$$



⋮



a- ES Algorithm

18

Begin

set  $t = 0$

Create initial point  $\{x_1^t, x_2^t, \dots, x_m^t\} \in \mathbb{R}^n$

Repeat Until (Termination Condition) do

begin

draw  $z_i$  from normal distribution.

$$y_i^t = x_i^t + z_i$$

if  $(f(\bar{x}^t) \leq f(y_i^t))$  then

$$\bar{x}^{t+1} = \bar{x}^t$$

else

$$\bar{x}^{t+1} = y_i^t$$

FI

set  $t = t + 1$

end OD

end.

b. 1/5 rule

$$\sigma = \begin{cases} \sigma/c & \text{if } p_s > 1/5 \\ \sigma \cdot c & \text{if } p_s < 1/5 \\ \sigma & \text{if } p_s = 1/5 \end{cases}$$



c- selection

(19)

~~one~~

two-membered

$(1, 1)$  select offspring.

$(1+1)$  select two offspring & parent

multi-membered

$(\mu, \lambda)$  select for  $\lambda$  offsprings.

$(\mu + \lambda)$  select for  $\mu + \lambda$  parents & offsprings.