APPLICATION ON HEPTAGONAL FUZZY NUMBER IN NUERAL NETWORK [GENETIC ALGORITHM]

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ABSTRACT

In this paper,we find out the efficient pesticides using the crossover operation of Genetic algorithm.

KEYWORDS

Fuzzy sets**,** Fuzzy number, heptagonal fuzzy number, neural network, genetic algorithm.

1. INTRODUCTION

In 1965, Zadeh Introduced the Fuzzy sets to represent and information possessing non-statistical certainties. However, the story of fuzzy logic started much earlier. The rotation of an infinite valued logic was "Fuzzy Set" where he described the mathematics of fuzzy set theory, and by extension fuzzy logic. Many operarations were carried out using fuzzy numbers. Fuzzy neural networks are usually based on neural network architecture with fuzzification of inputs, outputs, weights, or rules that are applied using fuzzy system.

2. PRELIMINARIES

2.1 Definition: Fuzzy Number

A fuzzy number A is a fuzzy set on the real line R, must satisfy the following conditions;

i) $\mu_{\tilde{A}}(x_0)$ is piecewise continuous
ii) There exist at least one $x_0 \in R$ with $\mu_{\tilde{A}}(x_0) = 1$
iii) $\mu_{\tilde{A}}$ must be normal and convex.

2.2 Types of fuzzy numbers:

There are many types of fuzzy numbers they are

1. Triangular Fuzzy Number
2. Trapezoidal Fuzzy Number
3. Pentagonal Fuzzy Number
4. Hexagonal Fuzzy Number
5. Heptagonal Fuzzy Number
6. Octagonal Fuzzy Number

In this section Genetic algorithm of neural network is used to solve heptagonal fuzzy number

Definition2.3 (Triangular fuzzy number). Triangular fuzzy number is defined as $\bar{A} = \{a, b, c\}$ where all a, b, c are real numbers and its membership function is given below

$$\mu_{\bar{A}}(x_0) = \begin{cases} \frac{(x-a)}{(b-a)}, & \text{for } a \le x \le b \\ \frac{(c-x)}{(c-b)}, & \text{for } b \le x \le c \\ 0, & \text{otherwise.} \end{cases}$$

Definition 2.4 (Pentagonal fuzzy number). A pentagonal fuzzy number of a fuzzy set P is defined as P = {a, b, c, d, e} and its membership functions is given by

$$\mu_P(x) = \begin{cases} 0, & \text{for } x < a \\ \frac{(x-a)}{(b-a)} & \text{for } a \le x \le b \\ \frac{(x-b)}{(c-a)} & \text{for } b \le x \le c \\ 1, & \text{for } x = c \\ \frac{(d-x)}{(d-c)} & \text{for } c \le x \le d \\ \frac{(e-x)}{(e-d)} & \text{for } d \le x \le e \\ 0, & \text{for } x > e \end{cases}$$

Definition 2.5 (Hexagonal Fuzzy number). A fuzzy number $\bar{A}_h$ is a hexagonal fuzzy number denoted by $\bar{A}_h = (a_1, a_2, a_3, a_4, a_5, a_6)$ are real numbers satisfying $a_2 - a_1 \le a_3 - a_2$ and $a_5 - a_4 \le a_6 - a_5$, if its membership function $\mu_{\bar{A}h}(x)$ is given by,

$$\mu_{\bar{A}h}(x) = \begin{cases} 0, & \text{for } x < a_1 \\ \frac{1(x-a_1)}{2(a_2-a_1)}, & \text{for } a_1 \le x \le a_2 \\ \frac{1}{2} + \frac{1(x-a_2)}{2(a_3-a_2)}, & \text{for } a_2 \le x \le a_3 \\ 1, & \text{for } a_3 \le x \le a_4 \\ 1 - \frac{1(x-a_4)}{2(a_5-a_4)}, & \text{for } a_4 \le x \le a_5 \\ \frac{1(a_6-x)}{2(a_6-a_5)}, & \text{for } a_5 \le x \le a_6 \\ 0, & \text{for } x > a_6 \end{cases}$$

Definition 2.6 (Heptagonal Fuzzy Number). A Heptagonal Fuzzy number $\bar{A}hp = (a_1, a_2, a_3, a_4, a_5, a_6, a_7)$ is a subset of fuzzy number in R with following membership function,

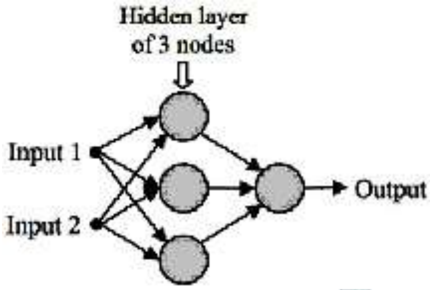
$$\mu_{\bar{A}hp}(x) = \begin{cases} \frac{1(x-a_1)}{2(a_2-a_1)}, & \text{for } a_1 \le x \le a_2 \\ \frac{1}{2}, & \text{for } a_2 \le x \le a_3 \\ \frac{1(x-a_4)}{2(a_4-a_3)} + 1, & \text{for } a_3 \le x \le a_4 \\ \frac{1(a_4-x)}{2(a_5-a_4)} + 1, & \text{for } a_4 \le x \le a_5 \\ \frac{1}{2}, & \text{for } a_5 \le x \le a_6 \\ \frac{1(a_7-x)}{2(a_7-a_6)}, & \text{for } a_6 \le x \le a_7 \\ 0, & \text{otherwise} \end{cases}$$

3. NEURAL NETWORK

An artificial neural network is an information processing system that has certain performance characteristics in common with biological neural network. Artificial neural networks have been developed as generalizations of mathematical models of human cognition or neural biology, based on the assumptions that:

i) Information processing occurs at many simple elements called neurons.
ii) Signals are passed between neurons over connection links.
iii) Each connection link has an associated weight, which multiplies the signal transmitted.
iv) Each neuron applies an activation function (Usually nonlinear) to its net input (Sum of Weighted Input Signals) to determine its Output Signals.

The following figure illustrates a fully connected two input, Single-output, feed-forward, multilayer network with a single hidden layer consisting of three nodes.



4. GENETIC ALGORITHM:

A genetic algorithm is a method for solving both constrained and non-constrained and unconstrained optimization problem based on a natural selection process that mimics biological evaluation. The algorithm repeatedly modifies a population of individual solution. Genetic Algorithms are computer programs that evolve in ways that resemble natural selection and can be applied to solve complex problems. Genetic Algorithms are inspired by Darwin's theory about evolution. Living organisms are consummate problem solver. They exhibit a versatility that puts the best computer programs to shame. This observation is especially important for computer experts, who may spend months or years of intellectual effort on an algorithm, whereas organism comes by their abilities through the apparently undirected mechanism of evolution and natural selection. Genetic Algorithm were invented by John Holland and developed by him and his student and colleagues in early 1970s. Since then they have been used extensively for problem solving. Genetic Algorithms belong to the larger class of evolutionary algorithms, which generate solution to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection and crossover.

4.6.1 Introduction to crossover operator:

The crossover operator is analogous to reproduction and biological crossover. In this more than one parent is selected and one are more off-spring are produced using genetic material of the parent. Crossover is usually applied in a genetic algorithm with a high probability.

4.6.2 Operations used on genetic algorithm:

(i) Genetic coding
(ii) Fitness function
(iii) Selection process
(iv) Crossover operator

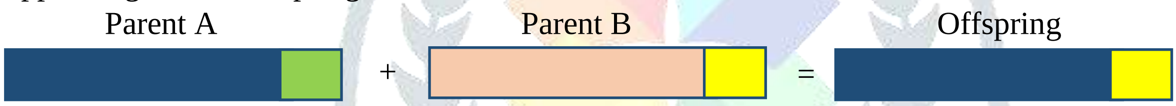
4.6.3 Types of crossover operator:

There are three types of crossover for using in genetic algorithm. There are

(i) One-point crossover
(ii) Multi-point crossover
(iii) Uniform crossover
(iv) Arithmetic crossover

(i) One-Point crossover:

In this one-point crossover, a random crossover point is selected and the tails of its two parents are swapped to get new off-spring.



11001011 + 11011111 = 11001111

Fig 1 Single Point crossover

Example:

{0, 1, 2, 3, 4, 5, 6, 7}

{7, 6, 3, 1, 4, 2, 8, 5}

Suppose we choose k = 5 then we have

{0, 1, 2, 3, **4, 2, 8, 5**}

{7, 6, 3, 1, **4, 5, 6, 7**}

(ii) Multi Point crossover:

Although single point crossover was inspired by biological processes, it has one major drawback that certain combinations of schema cannot be combined in some situations. A multipoint crossover can be used in such situations whereby the crossover is driven by a variable, i.e., number of crossover points selected, say m. As a result, the performance of generating offspring is greatly improved. Where multiple crossover points (m = 2) are randomly selected.

0	1	2	4	2	3	6	7	8	9

=>

Fig 2 Multipoint crossover

(iii) Uniform crossover:

In a uniform crossover, we don't divide the chromosome into segments; rather we treat each gene separately. In this, we essentially flip a coin for each chromosome to decide whether or not it will be include in the off-spring. We can also bias the coin to one parent, to have more genetic material in the child from that parent.

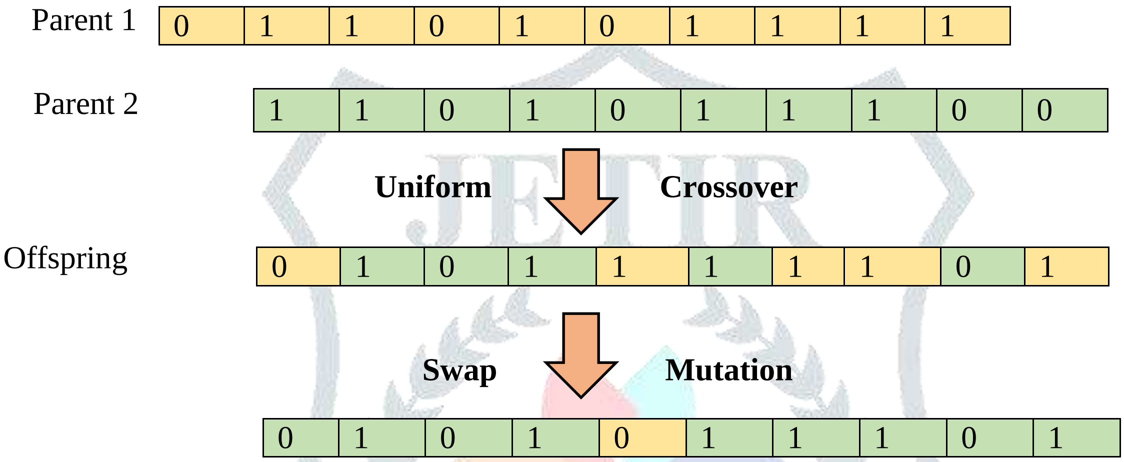


Fig 3: Uniform crossover

(iv) Arithmetic Crossover:

Some arithmetic operation is performed to make a new offspring.

11001011 + 11011111 = 11001011 (AND)

Fig. 4: Arithmetic crossover

4.6.4 Procedure for genetic algorithm

Step 1: First randomly select two machines L_1 and L_2.

Step 2: Next select another two machines L_3 and L_4.

Step 3: Convert all the elements fuzzy number into its membership function.

Step 4: Set the pentagonal fuzzy number in weights of the Machines.

Step 5: Take the values from the Machine.

Step 6: Calculate the cost matrix m = $\sum x_i y_i$

Step 7: Do the crossover operation and find maximum values of the Machine.

5. NUMERICAL EXAMPLE:

Suppose there are four types of lands L_1, L_2, L_3, and L_4. Let the possible attributes to above lands w = (a, b, c, d, e, f, g) as universal set. Where a, b, c, d, e, f, g represents the seven types of seeds like (maize, black gram, ground nut, sea same, corn, ragi, red grain) respectively. Compute the Heptagonal fuzzy number in four land L_1, L_2, L_3, and L_4 by considering completing work.

Step 1: L_1 = (28, 7, 18, 6, 5, 4, 8); L_2 = (30, 8, 9, 18, 3, 7, 11)

Step 2: L_3 = (26, 8, 20, 4, 6, 3, 7); L_4 = (31, 5, 23, 6, 7, 9, 15)

Step 3: Convert the Heptagonal fuzzy number into membership function

L_1 = (2.8, 0.7, 1.8, 0.6, 0.5, 0.4, 0.8)

L_2 = (3.0, 0.8, 0.9, 1.8, 0.3, 0.7, 1.1)

L_3 = (2.6, 0.8, 2.0, 0.4, 0.6, 0.3, 0.7)

L_4 = (3.1, 0.5, 2.3, 0.6, 0.7, 0.9, 1.5)

Step 4:

Consider the above fuzzy number is fuzzy weights Lij

L_{11} = 0.6; L_{12} = 0.7; L_{13} = 0.8, L_{14} = 0.9; L_{15} = 0.75; L_{16} = 0.85; L_{17} = 0.5

L_{21} = 0.6; L_{22} = 0.7; L_{23} = 0.8, L_{24} = 0.9; L_{25} = 0.75; L_{26} = 0.85; L_{27} = 0.5

L_{31} = 0.6; L_{32} = 0.7; L_{33} = 0.8, L_{34} = 0.9; L_{35} = 0.75; L_{36} = 0.85; L_{37} = 0.5

L_{41} = 0.6; L_{42} = 0.7; L_{43} = 0.8, L_{44} = 0.9; L_{45} = 0.75; L_{46} = 0.85; L_{47} = 0.5

Table: 1 Calculate the cost matrix for Land-1

N	2.8	0.7	1.8	0.6	0.5	0.4	0.8
0.6	1.68	0.42	1.08	0.36	0.30	0.24	0.48
0.7	1.96	0.49	1.26	0.42	0.35	0.28	0.56
0.8	2.24	0.56	1.44	0.548	0.40	0.82	0.64
0.9	**2.52**	**0.63**	**1.62**	**0.54**	**0.45**	**0.36**	**0.72**
0.75	2.1	0.525	1.35	0.45	0.37	0.3	0.6
0.85	2.38	0.595	1.53	0.51	0.425	0.34	0.68

0.5	1.4	0.35	0.9	0.3	0.25	0.2	0.4

Max = {2.52, 0.63, 1.62, 0.54, 0.45, 0.36, 0.72}

Table: 2 Calculate the cost matrix for Land-2

N	3.0	0.8	0.9	1.8	0.3	0.7	1.1
0.6	0.18	0.48	0.54	4.68	0.18	0.42	0.66
0.7	0.21	0.56	0.63	1.26	0.21	0.49	0.77
0.8	0.24	0.64	0.72	1.44	0.24	0.56	0.88
0.9	**2.7**	**0.72**	**0.81**	**1.62**	**0.27**	**0.63**	**0.99**
0.75	2.25	0.6	0.675	1.35	0.225	0.525	0.825
0.85	2.55	0.68	0.765	1.53	0.255	0.595	0.935
0.5	1.5	0.4	0.45	0.9	0.15	0.35	0.55

Max = {2.7, 0.72, 0.81, 1.62, 0.27, 0.63, 0.99}

Table: 3 Calculate the cost matrix for Land-3

N	2.6	0.8	2.0	0.4	0.6	0.3	0.7
0.6	1.56	0.48	1.2	0.24	0.36	0.18	0.42
0.7	1.82	0.56	1.4	0.28	0.42	0.21	0.49
0.8	2.08	0.64	1.6	0.32	0.48	0.24	0.56
0.9	**2.34**	**0.72**	**1.8**	**0.36**	**0.54**	**0.27**	**0.63**
0.75	1.95	0.6	1.5	0.3	0.45	0.25	0.525
0.85	2.21	0.68	1.7	0.34	0.51	0.255	0.595
0.5	1.3	0.4	1	0.2	0.3	0.15	0.35

Max = {2.34, 0.72, 1.8, 0.36, 0.54, 0.27, 0.63}

Table:4 Calculate cost matrix for Land-4

N	3.1	0.5	2.3	0.6	0.7	0.9	1.5
0.6	1.86	0.30	1.38	0.36	0.42	0.54	0.9
0.7	2.17	0.35	1.61	0.42	0.49	0.63	1.05
0.8	2.48	0.40	1.84	0.48	0.56	0.72	1.2
0.9	**2.79**	**0.45**	**2.07**	**0.54**	**0.63**	**0.81**	**1.35**
0.75	2.325	0.375	1.725	0.45	0.525	0.675	1.125
0.85	2.635	0.425	1.955	0.51	0.595	0.765	1.275
0.5	1.55	0.25	1.15	0.3	0.35	0.45	0.75

Max = {2.79, 0.45, 2.07, 0.54, 0.63, 0.81, 1.35}

Step 6: Therefore we get among the seven pesticides urea is the best.

Step 7: Select the two lands L_1 and L_2 then do the crossover operation

L_1 = 2.52, 0.63, 1.62, 0.54, 045, 0.36, 0.72

L_2 = 2.7, 0.72, 0.81, 1.62, 0.27, 0.63, 0.99

Randomly choose an integer k in {0, 1, …7}

Suppose k = 1 then for L_1' and L_2'

L_1' = 2.7, 0.72, 0.81, 1.62, 0.27, 0.63, 0.99

L_2' = 2.52, 0.63, 1.62, 0.54, 045, 0.36, 0.72

k = 3

L_1' = 2.7, 0.72, 1.62, 0.54, 045, 0.36, 0.72

L_2' = 2.52, 0.63, 0.81, 1.62, 0.27, 0.63, 0.99

Suppose k = 5

L_1' = 2.7, 0.72, 0.81, 1.62, 0.45, 0.36, 0.72

L_2' = 2.52, 0.63, 1.62, 0.54, 0.27, 0.63, 0.99

Suppose k= 6

L_1'= 2.7, 0.72, 1.62, 1.62, 0.45, 0.63, 0.99

L_2'= 2.52, 0.63, 0.81, 0.54, 0.27, 0.36, 0.72

Therefore the maximum value is

{2.7, 0.72, 1.62, 1.62, 0.45, 0.63, 0.99}

Next we choose two lands L_3 and L_4 and again do the crossover operation.

L_3 = {2.34, 0.72, 1.8, 0.36, 0.54, 0.27, 0.63}

L_4 = {2.71, 0.45, 2.07, 0.54, 0.63, 0.81, 1.35}

Suppose k = 1

L_3' = {2.71, 0.45, 2.07, 0.54, 0.63, 0.81, 1.35}

L_4' = {2.34, 0.72, 1.8, 0.36, 0.54, 0.27, 0.63}

Suppose k = 2

L_3' = {2.71, 0.72, 1.8, 0.36, 0.54, 0.27, 0.65}

L_4' = {2.34, 0.45, 2.07, 0.54, 0.63, 0.81, 1.35}

Suppose k = 3

L_3' = {2.71, 0.72, 2.07, 0.54, 0.63, 0.81, 1.35}

L_4' = {2.34, 0.45, 1.8, 0.36, 0.54, 0.27, 0.63}

Maximum value is {2.71, 0.72, 2.07, 0.54, 0.63, 0.81, 1.35}

Comparing (1) and (2)

{2.7, 0.72, 1.62, 1.62, 0.45, 0.63, 0.99}

{2.79, 0.72, 2.07, 0.54, 0.63, 0.81, 1.35}

Suppose k = 3

{2.7, 0.72, 2.07, 0.54, 0.63, 0.81, 1.35}

{2.79, 0.72, 1.62, 1.62, 0.45, 0.63, 0.99}

Suppose k = 4

{2.7, 0.72, 2.07, 1.62, 0.45, 0.63, 0.99}

{2.79, 0.72, 1.62, 0.54, 0.63, 0.81, 1.35}

Suppose k = 5

{2.7, 0.72, 2.07, 1.62, 0.63, 0.81, 1.35}

{2.79, 0.72, 1.62, 0.54, 0.45, 0.63, 0.99}

Maximum value is

{2.7, 0.72, 2.07, 1.62, 0.63, 0.81, 1.35}

Finally we get the maximum.

6.CONCLUSION

In the numerical example we have compute the efficient pesticides then we took the crossover operation and compare with four lands to find out the maximum value. From those seven pesticides we found that one efficient pesticide that will be commonly used in the field of agriculture.

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