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An Amalgamated Approach of Fuzzy Logic and Genetic Algorithm forBetter Recruitment Process

[1]AnjuKhandelwal, [2]AshishAgrawal
Shri Ram MurtiSmarak College of Engineering & Technology, Bareilly
[1]dranjukhandelwal@rediffmail.com, [2]agarwal.ashish01@gmail.com

ABSTRACT

The recruitment process in any departments or organizationsis usually decided by traditional criteria. In today's scenario, every organization wants to have best employees for their work. Many organizations are used to have separate departments to solve this purpose. But sometimes the recruitment process gets affected by human perceptions, beliefs, pat experiences, feelings, personal relations etc..So, for making recruitment process more automatic and accurate, various authors have proposed their solutions with Hungarian method. In this paper, authors are proposing a method of recruitment by the use of fuzzy triangular number and genetic algorithm with Hungarian method. After performing the first stage (written test) of recruitment with fuzzy triangular number and Hungarian method, the later stages are accomplished with linguistic variables and final recruitment is performed by the use of genetic algorithm.

Keywords: Fuzzy number, Triangular Fuzzy Number, Job Recruitment, Robust Ranking Method, Hungarian method, Linguistic Variable, Genetic Algorithms.

2000AMS Subject Classification: 90C08, 91B24, 91B18

1 Introduction

The assignment problem is a special type of Linear Programming Problem in which our objective is to assign n number of jobs to n number of persons at a minimum cost/ maximum profit. Assignment may be persons to jobs, classes to rooms, operators to machines, drivers to trucks, trucks to delivery routes, or problems to research teams, etc...Thesolution of assignment problem is defined by Kuhn[1] named as Hungarian method. To find solutions to assignment problem, various another algorithms such as Neural Network [2], Genetic Algorithm [3] etc. have been developed. Over the past 50 years many variations of the classical assignment problems are proposed e.g. Generalized Assignment Problem, Quadratic Assignment Problem, and Bottleneck Assignment Problem etc. However, much of the decision making in the real world takes place in an environment where the objectives, constraints or parameter are not precise. Therefore a decision is often made on the basis of vague information or uncertain data. In 1970, Belmann and Zadeh introduced the concept of fuzzy set theory into the decision making problems involving uncertainty and imprecision. Fuzzy Assignment Problems have received great attention in recent years. Lin and Wen [4] proposed an efficient algorithm based on the labeling method for solving the Linear Fractional Programming Problem. Chen[5] discussed a fuzzy assignment model that considers all persons to have same skills. Long-Sheng Huang and Li-puZhang[6] developed a mathematical model for the fuzzy assignment problem and transformed the model as certain assignment problem with restriction of qualification.

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Linzhong Liu and XinGoa[7] considered the Genetic Algorithm for solving the fuzzy weighted equilibrium and multijob assignment problem.

GA (genetic algorithm) simulates the survival of the fittest individuals among all the individuals in the population over successive generations for solving a problem. Genes from good individuals propagate throughout the population so that two good parents will sometimes produce offspring that are better than either parent. Thus either successive generation will become more suited to their environment [16, 17].Jiuping Xu[8] developed a priority based Genetic Algorithm to a Fuzzy Vehicle Routing Assignment model with Connection Network. The total cost which includes preparing costs as the objective function and the preparing costs and the commodity flow demand is regarded as fuzzy variables. There are several papers [9-11] in the literature in which generalized fuzzy numbers are used for solving real life problems. Also Dominance of Fuzzy Numbers can be explained by many ranking methods [12-15].

2 Preliminaries

In this section, some basic definitions are discussed.

2.1 A Fuzzy Set is characterized by a membership function mapping element of a domain, space or the universe of discourse X to the unit interval [0,1] i.e. $A=\{(x,\mu_A(x);x\in X\}$. Here : $\mu_A : X \to [0,1]$ is a mapping called the degree of membership function of the fuzzy set A and $\mu_A(x)$ is called the membership value of $x\in X$ in the fuzzy set A. These membership grades are often represented by real numbers ranging from [0,1].

2.2 A Fuzzy Set $\tilde{A}$, defined on universal set of real number X, is said to be fuzzy number if,

i. $\tilde{A}$ is convex, i.e. ~ $\mu_A \sim(\lambda x_1+(1-\lambda)x_2)\geq \min(\mu_A \sim(x_2)), x_1, x_2 \in X, \lambda \in [0,1];$

ii. $\tilde{A}$ is normalized fuzzy set if there exist at least one $x_0 \in X$ with $\mu_A \sim(x_0)=1$

iii. Its membership function $\mu_A \sim(x)$ is piecewise continuous.

2.3 For a Triangular Fuzzy Number A(X), it can be represented by A(a,b,c;1) with membership function μ_x given by

$$\mu(x)=\begin{cases} l(x)=\dfrac{x-a}{b-a}, & a\le x\le b \\ 1, & x=b \\ r(x)=\dfrac{c-x}{c-b}, & b\le x\le c \\ 0, & \text{otherwise} \end{cases}$$

Where $\mu\sim 1(x)$ and $\mu\sim r(x)$ are the left membership function and right membership function of the fuzzy set.

2.4 A Triangular Fuzzy Number $A = (a,b,c;1)$ is said to be non-negative if and only if $a \geq 0$.

2.5 **α-Cut:** The α-Cut of a fuzzy number $A(x)$ is defined as $A(\alpha) = \{x / \mu(x) \geq \alpha, \alpha \in [0,1]$.

2.6 **Genetic Algorithm**:The basic idea behind the genetic algorithm is to manage and maintain a population of chromosomes (collection of genes) and to search for a solution until a nearest

optimum solution is found. GAs has got a great measure of success in search and optimization problems. Some major terms of Genetic algorithm are-

- Fitness Function-The fitness function used in this paper is –

$$\text{Fitness Function} = \left(\sum_{i=1}^{n} Chromosome's\ \text{Gene Value} - 1\right)$$

- Arithmetic Crossover-The basic formula for performing arithmetic crossover is-

Offspring 1: a*parent1+ (1-a)*parent2
Offspring 2: (1-a)*parent1+ (a)*parent2

- **Boundary Mutation-**For performing boundary mutation, the range is 0-26 and 26 was selected to replace the middle gene.

2.7 Fuzzy Assignment Problem

In everyday life corresponding to each physical structure there is some mathematical phenomena. Here we describe mathematical model of assignment problem in the fuzzy theory for delegation of post in recruitment process.

Assume that there are n jobs and n persons.The assignment cost influenced by different parameters in real life and therefore assignment cost coefficients are usually uncertain value and will change respectively in different time frames. In this paper we consider assignment cost as a fuzzy number and defined by $\tilde{c} = (\underline{c} / c / \overline{c})$ where c represent the most possible assignment cost, c the most optimistic assignment cost and c the most pessimistic assignment cost. Obviously if cost coefficients are fuzzy numbers, then the total assignment cost becomes fuzzy as well.Now, the fuzzy assignment problem is written as,

$$Min.\ \tilde{z} = \sum_{i=1}^{n}\sum_{j=1}^{n} \tilde{c}_{ij}\ x_{ij}$$

Subject to

$$\sum_{i=1}^{n} x_{ij} = 1,\ j = 1,2,3,\ldots\ldots\ldots\ldots,n$$

$$\sum_{j=1}^{n} x_{ij} = 1,\ i = 1,2,3,\ldots\ldots\ldots\ldots,n$$

$$x_{ij} \in \{0,1\} \text{ for } i, j = 1,2,\ldots\ldots\ldots\ldots,n$$

2.8 Robust's Ranking Method

In this paper we defined the fuzzy cost coefficient into crisp ones by a fuzzy number ranking method. For this we use Robust's ranking method which satisfies compensation, linearity, and additive property and provide results which are consistent with human intuition.

If $\overline{c}$ is a fuzzy number then the Robust's ranking is defined by

$$\tilde{R}(c) = \int_0^1 0.5(c_l, c_u)\, d\alpha$$

Where (c_l, c_u) is the alpha level cut of the fuzzy number.

3 Problem Statement

In every organization, employee hiring is a vital and huge task which sometimes becomes tough row o hoe. Suppose , in an organization A, hiring process is going on for four job designations- TM(Technical Manager), HRM(Human Resource Manager), FM(Financial Manager)and PDM(Post Development

Manager). For the TM designation there are 2 vacancies, for HRM there are 4 vacancies, for FM there are 3 vacancies and for PDM there is 1 vacancy. It means, they have to hire total 10 people. After calling for resume, total 50 candidates applied for this recruitment. Now the problem is to hire the most suitable candidate for the defined designations, and another main task is to make this process faster and more accurate.

4 Implementation

Out of total 50 candidates we made 5 groups containing 10 candidates in each

Section 1-

- Group 1-[C1 C2 C3 ……C10]
- Group 2-[C11C12C13…….C20]
- Group 3-[C21 C22C23…….C30]
- Group 4- [C31 C32 C33…….C40]
- Group 5-[C41 C42 C43…….C50]

At first stage,authors had conducted a written test, which had 25 marks questions forTM, 25 marks questions for HRM, 25 marks questions for FM, 25 marks questions for PDMs. The data in further tables (table 1- table 5) is calculated by performing the Robust Ranking method. As in table 1 for C1, the value in TM column is 12 which is calculated as, (it means C1 scores 12 marks in TM section).(Note:Scale Taken-[10-25] for marks)

Fuzzy Triangular Number-(10, 12, 14)

$$(C_k^l, C_k^u) = [2k+10, 14-2k]$$

$$=24$$

$$R(\check{C}) = \int_0^1 0.5 * 24 dk$$

$$= \left[12k\right]_0^1$$

$$=12$$

Then **at*second stage*,**after applying Hungarian method, we found 4 best candidates from each group. It means 20 candidates out of 50 were shortlisted.

Table 1: Candidates and their marks for group 1

Candidates / Designations	TM	HRM	FM	PDM
*C*1	12	18	20	15
*C*2	16	19	14	20
*C*3	22	24	15	15
*C*4	14	22	19	13
*C*5	16	18	24	21
*C*6	18	15	25	20
*C*7	16	17	12	21
*C*8	18	19	22	23
*C*9	24	11	16	15
*C*10	15	18	21	10

Table 2: Candidates and their marks for group 2

Candidates / Designations	TM	HRM	FM	PDM
*C*11	16	20	25	21
*C*12	15	22	19	16
*C*13	14	24	18	14
*C*14	22	16	20	25
*C*15	23	19	21	15
*C*16	13	20	24	21
*C*17	10	15	19	17
*C*18	14	23	16	18
*C*19	18	23	20	16
*C*20	18	21	22	23

Table 2: Candidates and their marks for group 3

Candidates / Designations	TM	HRM	FM	PDM
C21	21	22	23	16
C22	16	21	20	19
C23	18	16	18	23
C24	15	21	20	24
C25	14	16	23	21
C26	19	24	15	14
C27	24	18	15	22
C28	22	17	21	16
C29	14	15	18	25
C30	13	19	22	24

Table 4: Candidates and their marks for group 4

Candidates / Designations	TM	HRM	FM	PDM
C31	15	18	22	19
C32	21	16	24	20
C33	23	12	19	16
C34	24	19	18	20
C35	21	25	16	24
C36	13	20	17	19
C37	15	24	18	16
C38	13	20	19	17
C39	23	18	22	16
C40	20	16	12	25

Table 3: Candidates and their marks for Group 5

Candidates / Designations	TM	HRM	FM	PDM
C41	16	14	20	22
C42	18	20	21	24
C43	24	21	18	16
C44	23	16	19	14
C45	19	20	12	15
C46	12	16	21	13
C47	18	13	20	10
C48	13	14	22	12
C49	18	11	15	20
C50	24	21	15	10

Final selected 20 candidates after performing first stage (written test) and on performing Hungarian Method-

- TM: C9, C15, C27, C34, C43
- HRM: C3, C13, C26, C35, C50
- FM: C6, C11, C21, C32, C48
- PDM: C8, C14, C29, C40,C42

At *third stage*, selected candidates for each designation were gone through to an interview session which has three qualifying criteria Q1, Q2 and Q3 (which can be named as per the need of the particular designation). In this interview session, candidates were evaluated in terms of linguistic variables of fuzzy logic (table7). Then this result is converted into numeric values by referring the triangular fuzzy values for linguistic values defined in table 6[18].Then in table 8 marks or values are assigned on the basis of table 7 and their corresponding value from table 7.Table 7 and 8 shows corresponding results of this stage for TM designation. Further calculations in the following section will be performed on table 8.

Table 8: Assignment of values based on table 6

	Q1	*Q2*	*Q3*
C9	4	24	15
C15	24	26	12
C27	24	12	24
C34	21	18	26
C43	24	15	12

Table 7:Linguistic variable assignment for TM

	Q1	*Q2*	*Q3*
C9	*VL*	*H*	*M*
C15	*H*	*VH*	*LM*
C27	*H*	*LM*	*H*
C34	*LH*	*HM*	*VH*
C43	*H*	*M*	*LM*

Table 4: The Linguistic variable values

	LinguisticVariable	*TriangularFuzzyNumber*	*WholeValue*
1	*VeryLow(VL)*	(1,1,2)	4
2	*Low(L)*	(1,2,3)	6
3	*HighLow(HL)*	(2,3,4)	9
4	*LowMedium(LM)*	(3,4,5)	12
5	*Medium(M)*	(4,5,6)	15
6	*HighMedium(HM)*	(5,6,7)	18
7	*LowHigh(LH)*	(6,7,8)	21
8	*High(H)*	(7,8,9)	24
9	*VeryHigh(VH)*	(8,9,9)	26

Section 2-

Genetic algorithm Implementation-Here, Genetic algorithm is applied on all the designation clusters found at second stage. In further explanations, Genetic implementation for only TM designation is shown-

1. Chromosome Representation- Normally in genetic representation, binary encoding is used for representing chromosomes. But for the sake of our problem, authors had used value encoding for representing chromosomes. In value encoding, the genes of chromosomes can be represent by real numbers and sequence of values.
2. Fitness Value Calculation- Fitness value is used for deciding the suitability of a particular chromosome and to find its closeness to the optimal solution. For the calculation of fitness value, we used table 8. For calculating fitness value, a fitness function is also required. Table 9 shows the calculated fitness value for each chromosome or candidate. The fitness function used here is –

$$\text{Fitness value} = \left(\sum_{i=1}^{n} Chromosome's\ gene\ value - 1\right)$$

Table 9- Fitness Value Calculated

Chromo some Set	*Fitness Value*
$C9:4,24,15$	42
$C15:24,26,12$	61
$C27:24,12,26$	59
$C34:21,18,26$	64
$C43:24,15,12$	50

3. **Chromosome Selection Method-** For letting our solution close to optimal solution, we have to select best chromosome for further calculation. There have been many selection methods described so far. Here we used rank selection method, after calculating fitness value, chromosomes are sorted in decreasing order, and best ranked chromosomes are selected. Rank 5 is better than 1. Table 10 shows the results of rank selection method.

Table 10- Calculation of rank of each chromosome or

Chromosome Set	*Fitness Value*	*Rank*
$C34:21,18,26$	64	5
$C15:24,26,12$	61	4
$C27:24,12,24$	59	3
$C43:24,15,12$	50	2
$C9:4,24,15$	42	1

4. **Crossover-** As in this paper value encoding is used for chromosome representation, authors had decided to use arithmetic crossover operator. Arithmetic crossover operator produces two new offspring according to equation-

- Offspring 1: a*parent1+ (1-a)*parent2
- Offspring 2: (1-a)*parent1+ (a)*parent2

For performing crossover, authors have divided five chromosomes in three sets. In set A, C34 and C15 has taken, in set B C27 and C43 has taken and in set C, C9 has taken. Table 11 shows the values after

performing arithmetic crossover on set A. Similarly, crossover operator can be performed on other sets.

Table 11- Crossover Results

Before Crossover	After Crossover
C34 : 21,18, 26	C34 : 22.2, 21.2,20.4
C15 : 24,26,12	C15 : 22.8,22.8,17.6

5. **Mutation** – Mutation is used to preserve diversity in chromosome population by finding new dimensions in search space to evaluate. Here, authors used boundary mutation operator, in which upper or lower bound of range gets selected for replacing the value of selected gene. Here, the range is 0-26 and 26(upper limit) was selected to replace the middle gene. Table 12 shows the results of mutation.

Table 12- Mutation Results

Before Mutation	After Mutation
C34 : 22.2,21.220.4	C34 : 22.2,26,204
C15 : 22.8,22.817.6	C15 : 22.8,26,17.6

After performing all these stages up to one iteration value of each chromosome is calculated again and best three chromosomes (on the basis of their fitness value) get evicted from the population as best chromosomes. The best two candidates for the post of technical manager are C27 and C34. Table 13 shows these results.

Table 13- Final Results for the TM post

Chromosome (Candidate)	Fitness Value
C9	44
C15	65.4
C27	68.2
C34	67.6
C43	65.8

Similarly, the whole procedure can be performed for the posts of HRM,FM and PDM and best candidates can be selected. Table 14 shows final results (candidates selected) for all posts.

Table 14-Finally selected candidates for all posts

Post	*Candidates*	*Fitness Values*
TM	*C27, C34*	68.2,67.6
HRM	*C35, C13, C3, C50*	70.2,68.8,65.8,65.2
FM	*C32, C11, C48*	67,66,65.8
PDM	*C42*	69.6

5 Conclusion

The above process used for the delegation of job field to various candidates has been solved by Fuzzy Linguistic variables and Hungarian method using Genetic approach. This paper results in a sense that fuzzy logic with Genetic algorithm approach results in a far better and accurate way. The method used in this paper is a phased method that continuously refines the results at every phase or stage and finally gives more precise results. This approach is also useful for solving transportation problem, network flow problem etc.

6 No Conflict Declaration

The authors declare that there is no point of conflicts between authors about publishing the paper.

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