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Preferences Based Decision Making Mathematical Model for Faculty Course Assignment using Linear and Exponential Membership Functions

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Abstract- This paper gives a general model for the faculty course assignment problem that is a zero–one nonlinear multiobjective programming problem. Because of the nonconvexity of the problem, linear membership function and exponential membership function are used to find optimal solutions. The model with fuzzy methods provides a more satisfactory solution to a course assignment problem than assigning with arbitrary weights.
Keywords- Preferences based decision makers, zero–one multiobjective programming, faculty course problem; scalarization.

I. INTRODUCTION

The employee assignment problem is becoming more intricate now a day. Specially schools, colleges, industries, organizations, etc are facing scheduling problem for assigning task. For example, scheduling or assigning work means matching people, places, time slots, and facilities. Further it is very difficult to solve problems having so many constraints. Generally, constraint is two types hard and soft. The problem of faculty course assignment means to satisfy all the constraints like one subject to one teacher only, teacher preference to teach course, not exceeding load, all course is distributed according to preferences of teachers as well as administrator. So many researchers have carried out research in the field of assigning courses to faculty.

Timetable construction bibliography was given by Schmidt and Strohlein [2]. Timetable or Scheduling problem by different heuristic techniques such as tabu search, genetic algorithms, and expert systems were examined by Costa [4], Erben and Keppler [6], Guyette et al. [5] and Hertz [3]. Two-stage optimization model to maximize faculty course preferences in assigning faculty members to courses (stage 1) and then maximize faculty time preferences by allocating courses to time blocks (stage 2). These constraints, which are computationally more complex than the others, are recovered during the second stage, and a number of sub-problems, one for each day of the week, are solved for local optima by Badri [7]. Bloomfield and McShary [1] also considered faculty preferences in their heuristic approach. Kara and Ozdemir [8] developed a minimax approach to the faculty course assignment problem by considering faculty preferences. Asratian and Werra [13] considered a theoretical model which extends the basic class teacher model of timetabling. This model corresponds to some situations which occur frequently in the basic training programs of universities and schools. It has been shown that this problem is NP complete when founded in some sufficient conditions for the existence of a timetable. Kara and Ozdemir presented a min–max approach to the faculty course assignment problem by considering faculty preferences. This study is a continuation and generalization of the faculty–course assignment problem considered earlier by Ozdemir and Gasimov [14]. They constructed a multi objective 0-1 nonlinear model for the problem, considering participants' average preferences and explained an effective way for its solution.

To optimal fuzzy classification of students, Amintoosi & Haddadnia [18] has used a fuzzy function to solve university course timetable by genetic programming problem. A hybrid fuzzy evolutionary algorithm has been presented by Rachmawati & Srinivasan [20] to multi objective resource allocation problem which was a student's project allocation problem. Here, the student project allocation must satisfy a number of soft purposes in a sequence of some points. This algorithm uses a fuzzy inductive system to model and collect purposes. Fuzzy system considers some priorities to decide on an agreement among purposes by which the direction of the search path toward attractive regions within purpose space is performed. To solve timetable problem, Asmuni, Burke, & Garibaldi [19] has presented a fuzzy multiple heuristic sorting method where the sorting of events has been done through a simultaneous considering of

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three distinct heuristics by using fuzzy methods. The sequential combination of three heuristics is sorted as first the highest degree, second is saturation degree and third is submission degree. Fuzzy weight of an event is also used to represent that event has what problem to be scheduled. Chaudhuri & Kajal [21] has presented a fuzzy genetic heuristic idea to solve university course timetable problem where the genetic algorithm has been applied by using an indirect representation based on integration events, features and the fuzzy set model is also to evaluate the violation of soft constraints in objective function according to uncertainties o real world data. The applied fuzzy logic within this approach is also used to evaluate the violation of soft constraints in objective function due to facing with uncertainty in real world data. However, Shatnawi, Rababah, & Bani-Ismail [22] has used a novel clustering technique based on FP-Tree to solve university course timetable problem where the given technique is done to classify students based on their selective courses who submitted for the next semester. However, a fuzzy genetic algorithm has been presented by Shahvali Kohshori, Saniee Abadeh, & Sajedi [23] accompanied with local search to solve university course timetable problem where the fuzzy genetic algorithm with a local search algorithm uses inductive search to solve the combined problem and applied local search which has the ability of improving efficiency within genetic algorithm.

In this study, a model is developed, and it combines fuzzy multiobjective programming to solve problem of course assigning. This model cannot only satisfy more of the actual requirements of the integral system but is also more flexible. Furthermore, it can offer more information to the decision maker (DM) for reference, and then it can raise the quality for decision-making. The multi-objective problem model is presented and solved using fuzzy programming technique with linear membership function and exponential membership functions.

The paper outline is as follow. In Section 2 we construct the mathematical model of the faculty-course assignment problem. In Section 3 provide steps to solve mathematical model. Section 4 is the case study to solve 6 faculty and 15 courses assigning problem. To solve course assigning we take preference of faculty, faculty results for each courses and administrative preferences. Using the fuzzy membership function we get optimum value of course assigning of the faculty. In Section 5 result is discussed and later on conclusion is given.

II. PROBLEM FORMULATION

The mathematical model involves faculty-courses, assigning using linear membership function and exponential membership function. As competition increases in educational system, it is necessary to change timetable so as to maintain quality teaching for the students. In many educational institutes faculty are recent or tenured. The problem arises due to less results in final examination by the students for specific subjects. Administrator's decided to change course preferences and give according to results preferences to increase results of each subject/courses. The model described here involves assigning courses to faculty according to result preferences by fuzzy membership functions. It's parameters, decision variables, constraints and the objectives are defined as follows

A. *Model Parameters*

Courses $I = \{1, 2, 3, ..., m\}$; $I = \cup I_j$, I_j is the set of courses that faculty j can take;

Faculty $J = \{1, 2, 3, ..., n\} = J_o \cup J_n$ for all $k < n$;

Where $J_o = \{1, 2, \ldots, k\}$ tenured faculty and $J_n = \{k+1, k+2, \ldots, n\}$ recent faculty;

h_i: total number of lecture hours for the i^{th} course in a week;

l_j and u_j: lower and upper bounds for the j^{th} faculty's weekly load;

t_{ij}: preference level of the i^{th} course by the j^{th} faculty ($t_{ij} \geq 1$, 1 indicates the most desired course);

a_{ij}: administrative preference level for the assignment of the i^{th} course to the j^{th} faculty;

b_{ij}: other preference level for the assignment of the i^{th} course to the j^{th} faculty;

B. *Model Decision Variables*

In this model the decision variable x_{ij} represents the assignment of a course to faculty and is defined as follows:

$$x_{ij} = \begin{cases} 1, & \text{if course i is assigned to faculty } j, \\ 0, & \text{otherwise.} \end{cases}$$

C. *Model Constraints*

Each course must be assigned to only one faculty: Equation (2.1) assure that a faculty-course combination is not split. In other words, since each faculty and administrator were given the opportunity to provide their preferences for each course, these constraints assure

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that only one of these preferences is selected for each faculty-course assigning. The number of these constraints will equal the number of faculty-course being offered.

$$\sum_{j=1}^{n} x_{ij} = 1, \qquad i = 1,2,3,\dots,\mathrm{m}. \tag{2.1}$$

The weekly load of each faculty must be between his/her lower and upper limits: Equation (2.2) do allocation of each faculty according to their load given. In other words, courses are assigned by calculating their lower as well as upper bound of their load limit. It is also assuring that load is distributed or assign not only by preferences but also their load capacity.

$$l_j \le \sum_{i=1}^{m} x_{ij} h_i \le u_j, \; j = 1,2,3,\dots,n. \tag{2.2}$$

The last constraint $g_t(x) \le 0, t = 1,2,\dots\dots..,r$ is used to transform the 0-1 variables to continuous ones.

D. Model Objectives

Mathematical Model of the Faculty Course Assignment using Fuzzy functions (MMFCAF) can be calculated as follows:

L_k is the average preference level of faculty per hour taught: Equation (2.3) is to calculate each faculty course assigning by their preference given. The courses assign is to be satisfied to ensure that faculty members get their required load of all courses.

$$L_k(x) = \frac{\sum_{i=1}^{m} x_{ij} h_i t_{ij}}{\sum_{i=1}^{m} x_{ij} h_i}, \qquad k = 1,2,\dots,l \text{ and } j = 1,2,\dots.,n \tag{2.3}$$

Minimize the average preference level of all faculty: Equation (2.4) minimize the average of all faculty preference level to assign the courses. Taking averages of each faculty priorities of preference are satisfy almost.

$$A_1(x) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij} h_i t_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij} h_i} \tag{2.4}$$

Minimize the administrator’s total preference level: Equation (2.5) assign courses to faculty by best choice from faculty as well as administrator preference level.

$$A_2(x) = \sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij} x_{ij} \tag{2.5}$$

Minimize the total deviation from the upper load limits of the faculty: Equation (2.6) manage load of each faculty. Otherwise all course can be assign to one faculty or some faculty are not assign any courses. So, it helps to assign course equally and according to preference given for assigning courses.

$$A_3(x) = \sum_{j \in J_n} \left(u_j - \sum_{i=1}^{m} x_{ij} h_i \right) \tag{2.6}$$

Minimize the others preference level: Equation (2.7) is also one of the administrator preferences like result analysis of faculty-courses, student preference level, etc for assigning faculty-courses.

$$A_k(x) = \sum_{i=1}^{m}\sum_{j=1}^{n} b_{ij} x_{ij}, \text{where } k = 4,5,\dots,p \tag{2.7}$$

The multi-objective mathematical model of the faculty course assignment problem: Here above objective are classifies into two group. First group for the faculty $L_1(x)$, $L_2(x)$, ..., $L_l(x)$ and second group for administrator $A_1(x)$, $A_2(x)$, …, $A_p(x)$. Thus, the multiobjective MMFCAP can be formulated as follows:

minimize $[L_1(x), L_2(x), \dots, L_l(x), A_1(x), A_2(x), \dots, A_p(x)]$

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subject to equation (2.1) to equation (2.2).

General form of the multi-objective mathematical model of the faculty course assignment problem:

minimize $[f_1(x), f_2(x), \ldots, f_n(x)]$

subject to constraints $x \in X_0 = \{x \in X: g_t(x) \leq 0, t = 1,2, \ldots \ldots, r\}$

where $f_k(x) = L_k(x); k = 1, 2, \ldots, l, f_k(x) = A_v(x); k = l, l+1, \ldots, n$ and $v = 1, 2, \ldots, p$.

Model (i) Define linear membership function for the kth objective function as follows:

$$\mu_k(x) = \begin{cases} 1 & if\ f_k(x) \leq L_k \\ \dfrac{U_k - f_k(x)}{U_k - L_k} & if\ L_k < f_k(x) < U_k \\ 0 & if\ f_k(x) \geq U_k \end{cases} \quad (2.8)$$

Find an equivalent model by using a linear membership function for the initial fuzzy model,

$$Maximize\ \lambda,$$

$$\lambda \leq \frac{U_k - f_k(x)}{U_k - L_k} \quad (2.9)$$

Solve the model by an appropriate mathematical programming algorithm.

$$Maximize\ \lambda,$$

Subject to

$$\frac{U_k - f_k(x)}{U_k - L_k} \geq \lambda \quad (2.10)$$

Model (ii) Exponential membership function for the kth objective function and is defined as

$$\mu^E f_k(x) = \begin{cases} 1 & if\ f_k(x) \leq L_k \\ \dfrac{e^{-S\Psi_k(x)} - e^{-S}}{1 - e^{-S}} & if\ L_k < f_k(x) < U_k \\ 0 & if\ f_k(x) \geq U_k \end{cases} \quad (2.11)$$

$$where, \Psi_k(x) = \frac{f_k(x) - L_k}{U_k - L_k}, \quad k = 1,2,3,\ldots,p$$

S is a non-zero parameter, prescribed by the decision maker.

Find an equivalent model by using an Exponential membership function for the initial fuzzy model,

$$Maximize\ \lambda,$$

$$\lambda \leq \frac{e^{-S\Psi_k(x)} - e^{-S}}{1 - e^{-S}} where, \Psi_k(x) = \frac{f_k(x) - L_k}{U_k - L_k}, \quad k = 1,2,3,\ldots,p \quad (2.12)$$

Solve the model by an appropriate mathematical programming algorithm.

$$Maximize\ \lambda,$$

Subject to

$$\frac{e^{-S\Psi_k(x)} - e^{-S}}{1 - e^{-S}} \geq \lambda \quad (2.13)$$

III. STEPS FOR FINDING THE SOLUTION OF MATHEMATICAL MODEL FOR FACULTY COURSE ASSIGNING USING FUZZY (MMFCAF) MEMBERSHIP FUNCTIONS

Operation research basically used to solve organization problems arise in educational institute as well as industries like transportation, assignment, replacement theory, construction projects, inventory management, etc. Faculty-course assigning problem is well

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structured and to fit the model. Important features of operation research are decision making, scientific approach, objective, inter disciplinary team approach and finally use of computers to solve multiobjective problems. Using mathematical modelling decision makers can take more effective and efficient decision even in very complicated set of constraints. The step-wise description of the proposed model with following aspects of decision making are as follow:

Step-1 Read the real-world problem of assigning faculty-course problem.
Step-2 Find the minimum and maximum ideal for each objective function.
Step-3 Develop mathematical model for faculty course assigning (MMFCAF) problem.
Step-4 Convert multiobjective assignment problem into single objective optimization problem.
Step-5 Solve single objective optimization problem using fuzzy membership function.
Step-6 Define aspiration level of fuzzy membership function.
Step-7 Model decision variables gives assigning of course to faculty if its value is 1.
Step-8 If value is not 1 then go to step 6 for feasible solution by changing aspiration level.
Flowchart of proposed model:

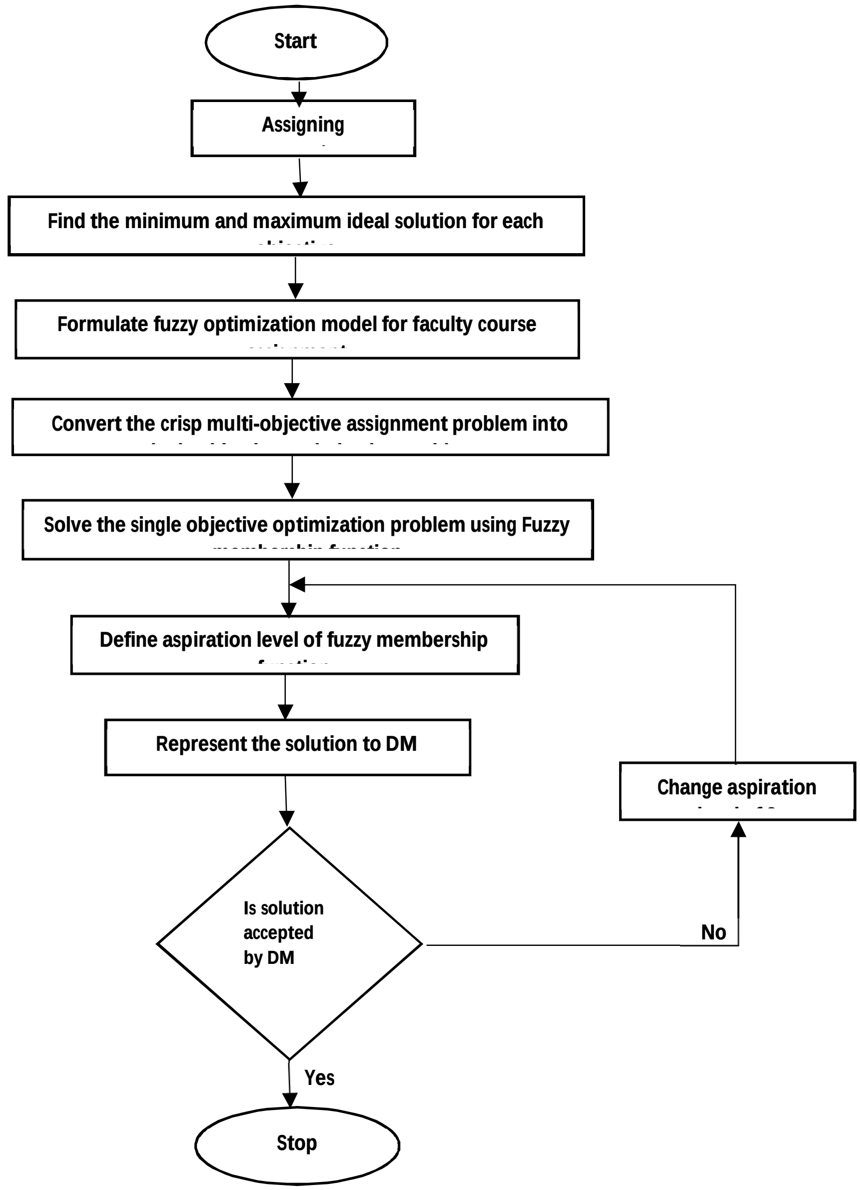

Fig 1: Flow chart of mathematical model for faculty course assigning using fuzzy membership function.

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IV. CASE STUDY

Our work on this paper was motivated by a real need of improving results as well as knowledge of the students. The assigning of courses to faculty means it must satisfied all the preference. To satisfies all preferences a mathematical model have been applied for the better result of the students. By considering 6 faculty and 15 courses. Each faculty may or may not be able to give all the courses.

$I_j \subset I$, is the set of indices showing the courses that faculty j is able to give, j = 1, 2, 3, 4, 5, 6;

P_k is the set of courses desirable to give at the k^{th} preference level; in this example we assume that k = 1, 2, 3, 4;

h_i: total number of lecture hours for the i^{th} course in a week.

l_j, u_j: lower and upper bounds respectively on the j^{th} faculty weekly load;

t_{ij}: preference level of the i^{th} course by the j^{th} faculty ($t_{ij} \geq 1$, 1 indicates the most desired course);

a_{ij}: administrative preference level for the assignment of the i^{th} course by the j^{th} faculty.

b_{ij}: previous result of the i^{th} course by the j^{th} faculty for the assigning.

The administration has some preferences in assigning courses to faculty and the faculty in turn also have preferences for these courses according to their previous result analysis. The preferences are given in tables 1,2 and 3. Table 1 contains the value of t_{ij}, for example the number 5 in the first row under P_1 indicates that $t_{51} = 1$. The numbers 2,3 in the first row under P_2 indicate that $t_{21} = t_{31} = 2$. The first row of table 4 gives the course number and the second row the number of hours required to teach that course. The first row of table 5 indicates the faculty, the second(third) row gives the upper(lower) limit on the number of hours each instructor can teach in a week.

Table 1: Faculty preference and courses

Faculty (j)	I_j; Preferred courses by the faculty	The list of un-preferred courses	P_1	P_2	P_3	P_4
1	1,2,3,4,5	---	5	2,3	4	1
2	1,2,3,6,7,8,9,10	9	6	10	7,8	1,2,3
3	6,7,11,12,13,14,15	6,7,14	15	11	13	12
4	1,2,3,10	1,2	--	3	10	--
5	11,12,13,14,15	11,12,13	--	14,15	--	--
6	8,9,11,12,13,14	11,12,14	8,9	13	--	--

Table 2: Administration preferences

Courses (I_j)	Faculty (j)					
	1	2	3	4	5	6
1,2	1	4	---	4	---	---
3	1000	4	---	1	---	---
4,5	1	---	---	---	---	---
6,7	---	1	4	---	---	---
8	---	1	---	---	---	2
9	---	1000	---	---	---	1
10	---	1000	---	1	---	---
11,12,13	---	---	1	---	4	4
14	---	---	1000	---	1	1000
15	---	---	1000	---	1	---

a_{ij} = 1, 2, 3, 4, 1000 if the administrators like the faculty to give the course less and less in increasing order of the value. a_{ij} = -- if the faculty cannot give the course.

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Table 3: Faculty course result analysis

Courses (I_j)	Faculty(j) result analysis					
	1	2	3	4	5	6
1	0.7	0.4	--	0.5	--	--
2	0.5	0.3	--	0.3	--	--
3	0.3	0.4	--	0.1	--	--
4	0.1	--	--	--	--	--
5	0.2	--	--	--	--	--
6	--	0.3	0.5	--	--	--
7	--	0.5	0.4	--	--	--
8	--	0.2	--	--	--	0.2
9	--	0.5	--	--	--	0.1
10	--	0.4	--	0.2	--	--
11	--	--	0.2	--	0.1	0.3
12	--	--	0.1	--	0.2	0.4
13	--	--	0.2	--	0.4	0.1
14	--	--	0.4	--	0.2	0.5
15	--	--	0.5	--	0.3	--

b_{ij} = 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 obtain value by minimizing the result analysis of the faculty to give the course. b_{ij} = -- if the faculty have not taught courses.

Table 4: Weekly lecture hours of courses

Courses(i)	1,2,3	4,5	6,7,10,11,12,13,14,15	8,9
Hours(h_i)	3	2	4	6

Table 5: Upper and Lower bounds on weekly loads for instructors

Faculty (j)	1	2	3	4	5	6
Upper bound (u_j)	15	25	20	6	15	20
Lower bound (l_j)	3	8	8	0	3	8

We have ten objectives to satisfy in this particular problem. They are minimized for each of six faculty.
The average preference level L_j per hour taught:

$$L_j(x) = \frac{\sum_{i=1}^{15} x_{ij} h_i t_{ij}}{\sum_{i=1}^{15} x_{ij} h_i}, j = 1, 2, \ldots, 6 \tag{3.1}$$

Minimize the average preference level of all faculty:

$$A_1(x) = \frac{\sum_{i=1}^{15}\sum_{j=1}^{6} x_{ij} h_i t_{ij}}{\sum_{i=1}^{15}\sum_{j=1}^{6} x_{ij} h_i}, \tag{3.2}$$

Minimize the administration's total preference level:

$$A_2(x) = \sum_{i=1}^{15}\sum_{j=1}^{6} a_{ij} x_{ij} \tag{3.3}$$

Minimize the total deviation from the upper load limits of the faculty:

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$$A_3(x) = \sum_{j\in J_n}\left(u_j - \sum_{i=1}^{15} x_{ij}h_i\right) \tag{3.4}$$

Minimize the faculty result analysis for each course:

$$A_4(x) = \sum_{i=1}^{15}\sum_{j=1}^{6} b_{ij}x_{ij} \tag{3.5}$$

Our multi-objectives mathematical model now has the form
Minimize [$L_1(x)$, $L_2(x)$, $L_3(x)$, $L_4(x)$, $L_5(x)$, $L_6(x)$, $A_1(x)$, $A_2(x)$, $A_3(x)$, $A_4(x)$]
Subject to

$$\sum_{j=1}^{6} x_{ij} = 1, \qquad i = 1, 2, 3, \dots, 15. \tag{3.6}$$

$$l_j \le \sum_{i=1}^{15} x_{ij}h_i \le u_j, \quad j = 1, 2, \dots, 6. \tag{3.7}$$

For computational simplicity we have used slack variables $y_1, y_2, \dots, y_{12}$ in our solution. The slack variables are needed to reduce the inequalities in (3.7) to equalities. Thus, we can write all constraints as follows:

$g_1(x) = x_{11}+x_{12}+x_{14} - 1 = 0,$

$g_2(x) = x_{21}+x_{22}+x_{24} - 1 = 0,$

$g_3(x) = x_{31}+x_{32}+x_{34} - 1 = 0,$

$g_4(x) = x_{41} - 1 = 0,$

$g_5(x) = x_{51} - 1 = 0,$

$g_6(x) = x_{62}+x_{63} - 1 = 0,$

$g_7(x) = x_{72}+x_{73} - 1 = 0,$

$g_8(x) = x_{82}+x_{86} - 1 = 0,$

$g_9(x) = x_{92}+x_{96} - 1 = 0,$

$g_{10}(x) = x_{10,2}+x_{10,4} - 1 = 0,$

$g_{11}(x) = x_{11,3}+x_{11,5}+x_{11,6} - 1 = 0,$

$g_{12}(x) = x_{12,3}+x_{12,5}+x_{12,6} - 1 = 0,$

$g_{13}(x) = x_{13,3}+x_{13,5}+x_{13,6} - 1 = 0,$

$g_{14}(x) = x_{14,3}+x_{14,5}+x_{14,6} - 1 = 0,$

$g_{15}(x) = x_{15,3}+x_{15,5} - 1 = 0,$

$g_{16}(x) = x_{11}+x_{21}+x_{31} + y_1 - \frac{15}{3} = 0,$

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$g_{17}(x) = x_{11}+x_{21}+x_{31} - y_2 - \frac{3}{3} = 0,$

$g_{18}(x) = 3(x_{12}+x_{22}+x_{32})+ 4(x_{62}+x_{72})+ 6(x_{82}+x_{92})+4\, x_{10,2} + y_3 - 25= 0,$

$g_{19}(x) = 3(x_{12}+x_{22}+x_{32})+ 4(x_{62}+x_{72})+ 6(x_{82}+x_{92})+4\, x_{10,2} - y_4 - 8= 0,$

$g_{20}(x) = x_{63}+x_{73}+x_{11,3}+ x_{12,3}+x_{13,3}+x_{14,3}+x_{15,3} + y_5 - 5= 0,$

$g_{21}(x) = x_{63}+x_{73}+x_{11,3}+ x_{12,3}+x_{13,3}+x_{14,3}+x_{15,3} - y_6 - 2= 0,$

$g_{22}(x) = 3(x_{14}+x_{24}+x_{34}) +4x_{10,4} + y_7 - 6= 0,$

$g_{23}(x) = 3(x_{14}+x_{24}+x_{34}) +4x_{10,4} - y_8 = 0,$

$g_{24}(x) = x_{11,5}+x_{12,5}+ x_{13,5}+x_{14,5}+x_{15,5} + y_9 - \frac{15}{4}= 0,$

$g_{25}(x) = x_{11,5}+x_{12,5}+ x_{13,5}+x_{14,5}+x_{15,5} - y_{10} - \frac{3}{4}= 0,$

$g_{26}(x) = 6(x_{86}+x_{96})+4(x_{11,6}+ x_{12,6}+x_{13,6}+x_{14,6}) + y_{11} - 20 = 0,$

$g_{27}(x) = 6(x_{86}+x_{96})+4(x_{11,6}+ x_{12,6}+x_{13,6}+x_{14,6}) - y_{12} - 8 = 0,$

$g_{28}(x) = \sum_{i=1}^{15} \sum_{j=1}^{6} (x_{ij} - {x_{ij}}^2)= 0.$

General form of the multi-objective mathematical model of the faculty course assignment problem:
To simplify notation, we denote the objective functions as follows:

$f_i(x) = L_i(x)$, i = 1, 2, 3, ..., 6, $f_7(x) = A_1(x)$, $f_8(x) = A_2(x)$, $f_9(x) = A_3(x)$, $f_{10}(x) = A_4(x)$.
where $L_i(x)$, i = 1, 2, 3, ..., 6, $A_1(x)$, $A_2(x)$, $A_3(x)$ and $A_4(x)$ are defined by (3.1), (3.2), (3.3), (3.4) and (3.5) respectively.

Model (i):
Find an equivalent model by using a linear membership function for the initial fuzzy model,

$$Maximize\ \lambda,$$

$$\lambda \le \frac{U_k - f_k(x)}{U_k - L_k}, k = 1, 2, \dots, 10 \tag{2.8}$$

Solve the model by an appropriate mathematical programming algorithm.

$$Maximize\ \lambda,$$

Subject to

$$\frac{U_k - f_k(x)}{U_k - L_k} \ge \lambda \tag{2.9}$$

The minimization problem at each iteration is solved here by using the package LINGO 17.0. The final results are given in tables 6 and 7.

Table 6: Computational result

f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	LMF(λ)
2.00	1.50	1.33	1.00	1.00	0.75	1.19	2026.00	29.00	4.20	0.44

Table 7: Assignment according to preference level

Variable	Optimum Value	Corresponding assignment
X_{21}	1	2nd course, 1st faculty

X_{41}	1	4th course, 1st faculty
X_{51}	1	5th course, 1st faculty
X_{62}	1	6th course, 2nd faculty
$X_{10,2}$	1	10th course, 2nd faculty
X_{73}	1	7th course, 3rd faculty
$X_{13,3}$	1	13th course, 3rd faculty
$X_{15,3}$	1	15th course, 3rd faculty
X_{14}	1	1st course, 4th faculty
X_{34}	1	3rd course, 4th faculty
$X_{11,5}$	1	11th course, 5th faculty
$X_{14,5}$	1	14th course, 5th faculty
$X_{8,6}$	1	8th course, 6th faculty
$X_{9,6}$	1	9th course, 6th faculty
$X_{12,6}$	1	12th course, 6th faculty

Model (ii):
Find an equivalent model by using an Exponential membership function for the initial fuzzy model,

$$Maximize\ \lambda,$$

$$\lambda \leq \frac{e^{-S\Psi_k(x)} - e^{-S}}{1 - e^{-S}} where, \Psi_k(x) = \frac{f_k(x) - L_k}{U_k - L_k}, k = 1, 2, 3, \ldots, 10 \qquad (2.10)$$

Solve the model by an appropriate mathematical programming algorithm.

$$Maximize\ \lambda,$$

Subject to

$$\frac{e^{-S\Psi_k(x)} - e^{-S}}{1 - e^{-S}} \geq \lambda \qquad (2.11)$$

The minimization problem at each iteration is solved here by using the package LINGO 17.0. The final results are given in tables 8 and 9.

Table 8: Computational result

S	λ	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10
0.2	0.4199	2.00	2.00	1.50	1.00	1.00	0.75	1.33	2023	29.00	4.30
0.3	0.4077	2.00	1.50	1.50	1.00	1.00	0.60	1.12	2026	29.00	4.30
0.5	0.3836	2.00	1.50	1.33	1.00	1.00	0.75	1.19	2026	29.00	4.20
1	0.3257	2.00	1.50	1.50	1.00	1.00	0.60	1.12	2026	29.00	4.30

Table 9: Assigning of course(i) to faculty(j) X_{ij} according to different aspiration level

S = 0.2	S = 0.3	S = 0.5	S = 1	Optimum Value
X_{21}	X_{21}	X_{21}	X_{21}	1
X_{41}	X_{41}	X_{41}	X_{41}	1
X_{51}	X_{51}	X_{51}	X_{51}	1
X_{62}	X_{62}	X_{62}	X_{62}	1
X_{72}	$X_{10,2}$	$X_{10,2}$	$X_{10,2}$	1
$X_{10,2}$	X_{73}	X_{73}	X_{73}	1
$X_{13,3}$	$X_{13,3}$	$X_{13,3}$	$X_{13,3}$	1

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$X_{14,3}$	X_{14}	$X_{15,3}$	X_{14}	1
X_{14}	X_{34}	X_{14}	X_{34}	1
X_{34}	$X_{11,5}$	X_{34}	$X_{11,5}$	1
$X_{11,5}$	$X_{15,5}$	$X_{11,5}$	$X_{15,5}$	1
$X_{15,5}$	$X_{8,6}$	$X_{14,5}$	$X_{8,6}$	1
$X_{8,6}$	$X_{9,6}$	$X_{8,6}$	$X_{9,6}$	1
$X_{9,6}$	$X_{12,6}$	$X_{9,6}$	$X_{12,6}$	1
$X_{12,6}$	$X_{14,6}$	$X_{12,6}$	$X_{14,6}$	1

V. DISCUSSION

The tenured ones are faculty who have less than three years work experience whereas recent have more than five years' experience of teaching courses. These priorities are used in a conic scalarization method for combining different and conflicting objectives and the scalarized problems are solved by LINGO 17.0. The administration requests to teach more hours to recent than the tenured ones. In Tables 1, 2 and 3, A1, A2 and A4 refer to the faculty total preference level on faculty–course assignments, administration's total preference level and result analysis on courses respectively. MMFCAF problem we have used two fuzzy membership functions. First linear membership function A1 is obtained as 1.19, A2 is obtained as 2026 and A4 is obtained as 4.2 as shown in table 6. The total deviation from the upper load limits of the instructors (A3) is obtained as 29 for linear membership function and exponential membership function. Second exponential membership function as shown in table 8 and table 9 we get some changes as aspiration level is change. There is no change for faculty 1st and 4th for any aspiration level and minor changes for 5th faculty. As 1st, 4th and 5th are tenured so their preference is given more priority comparing to recent 2nd, 3rd and 6th faculty for better results. Preference of assigning course to all faculty are almost satisfied. Each one has got according to their given preferences by using exponential membership function. Figure 1 which shows different value of exponential membership function λ for aspiration level S = 0.2, 0.3, 0.5 and 1. As aspiration level increased objective function value is decreased and give feasible solution for assigning faculty-courses.

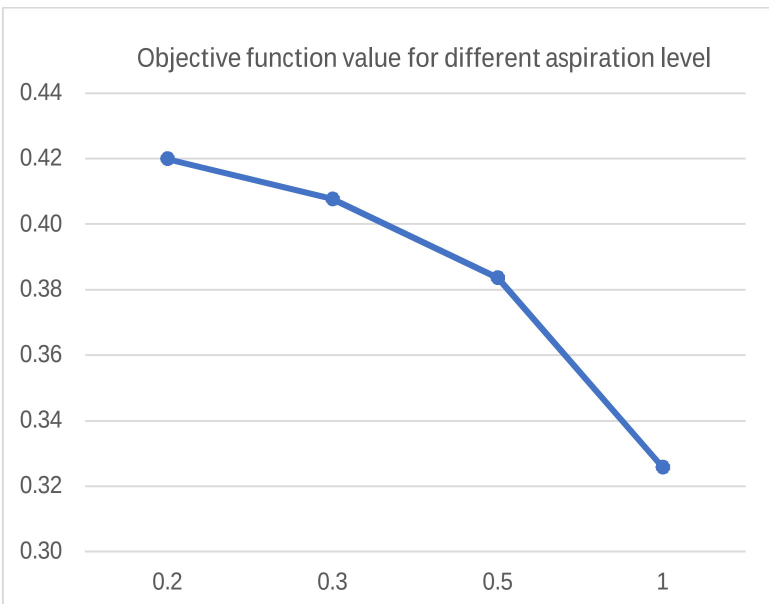

Fig 2: Optimum value of objective function using exponential membership function.

Fig 2 to Fig 5 shows objective function value for aspiration level S = 0.2 to 1 respectively. For different aspiration level assigning of courses to faculty change for recent compare to tenured. As recent are more experience, by result preferences administrator can do variation on allocation of courses to faculty 2nd ,3rd and 6th.

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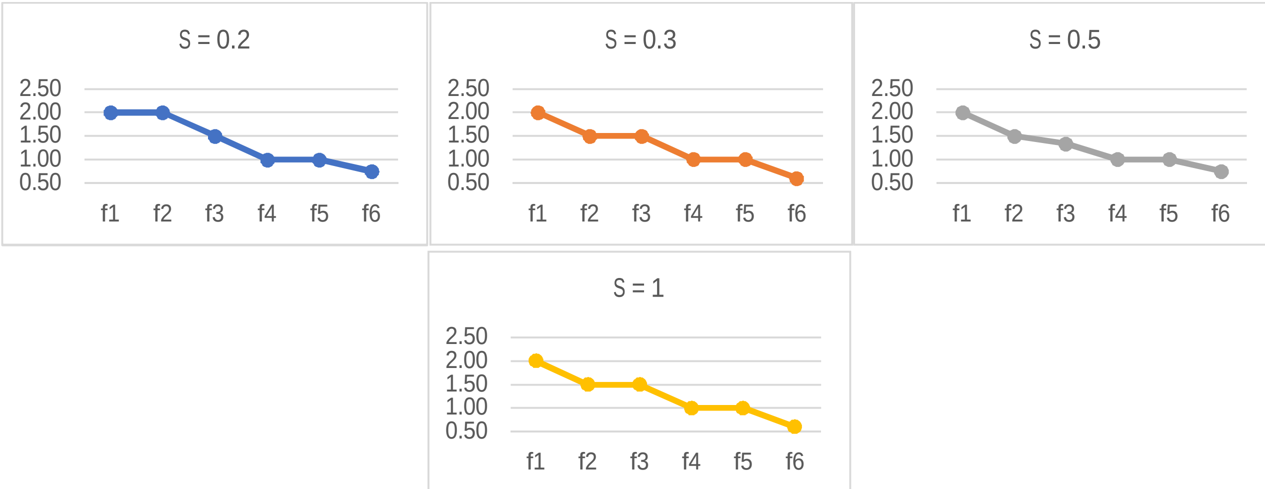

Fig 3: Different aspiration level using exponential membership function.

VI. CONCLUSION

Considering the pedagogical aspects of faculty course assignments is an important contribution for the better performance of any educational organization. This study can consider as an important stage for faculty-course assigning. By using the outcomes of this problem, educational institutions can be solved timetable problem more effectively.

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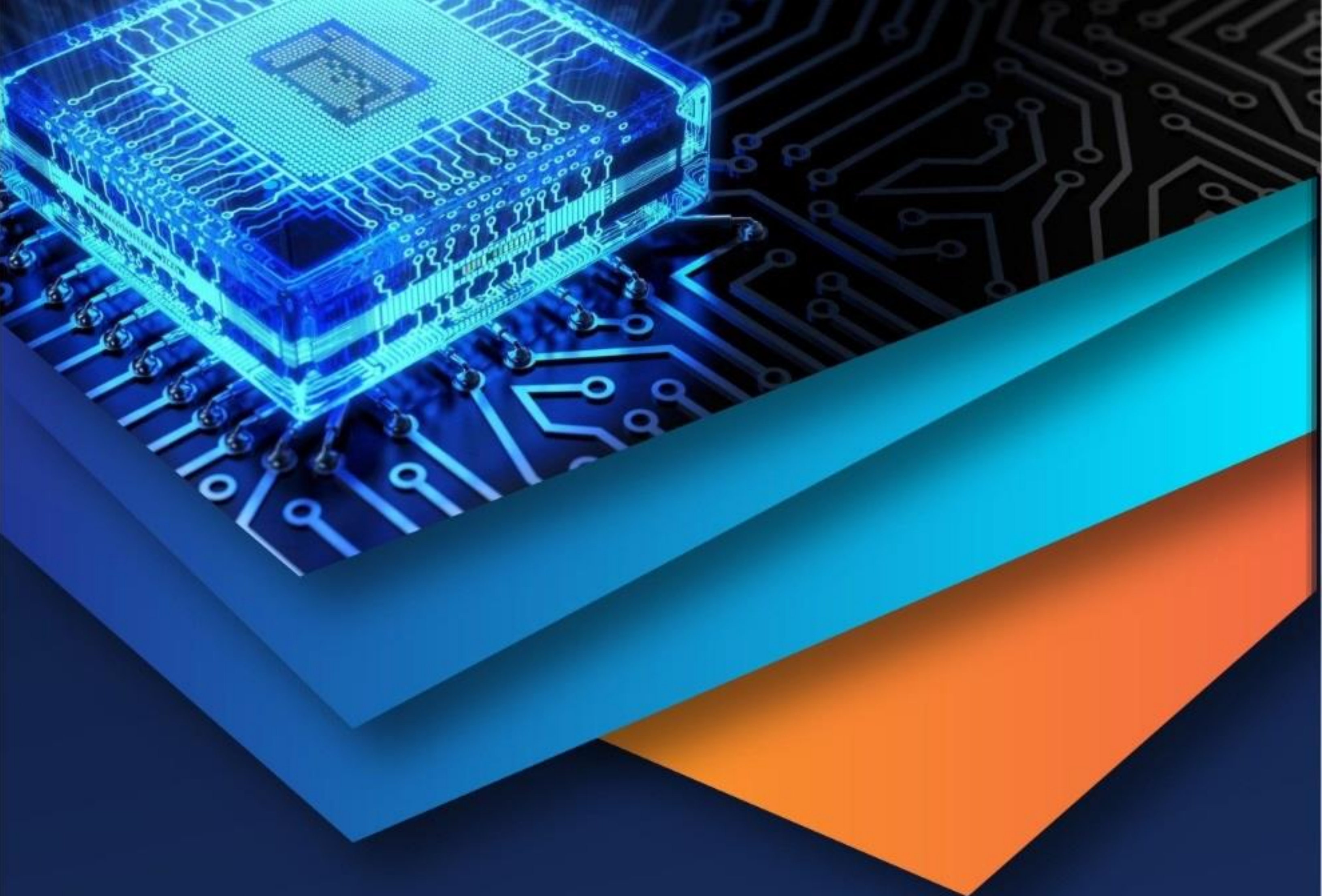

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