Fuzzy Approach for Scheduling of Timetable Problem

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Abstract. The construction of timetable with all constrained is very difficult task. Timetable is the problem in which we assign teachers to respective course, time slots and rooms with some constraints. In this paper we apply fuzzy algorithm which satisfy all constrains by using one example.

Keyword: Fuzzy logic, Fuzzy Membership, Timetable problem

1. Introduction:

In every educational institution class time table is very important activity. In timetable problem faculties, subjects, timeslots, rooms, number of classes are important factors involved\textsuperscript{4}. Time table problem is deal with maximum utilization\textsuperscript{2}. There are several papers deal with finding solutions to time tabling problem using various algorithms\textsuperscript{6}. In this paper, we tried to give best solution by using algorithm in which priorities of faculties for the different subjects taught by them are considered using fuzzy membership functions\textsuperscript{1}.

Classical sets are used when there are only absolute values. But our life is having some uncertainties. Whenever there are some ambiguity or vague statements like short, tall, low, medium, we use the concept of Fuzzy logic.

1.1 Basic definition:

Fuzzy logic: Fuzzy logic is determined as a set of mathematical principles for knowledge representation based on degrees of membership rather than on crisp membership of classical binary logic. This powerful tool to tackle imprecision and uncertainty was initially introduced by\textsuperscript{1} to improved tractability, robustness and low-cost solutions for real world problems.

Fuzzy Set: It is a set with fuzzy boundaries. Defined fuzzy for each variable which allows intermediate grades of membership in them, implies each set could have elements that belongs partially to it; the degree of belonging is called membership functions ranging from 0 to 1. If X is the Universal set and its elements are denoted as $x$, in contrast with crisp set, then the fuzzy set A of X has characteristics function associated to it.

The fuzzy set is represented by a characteristic function, defined as follows:

$$\mu_A : X \rightarrow [0,1]$$
The value 0 corresponds to the absolute non-membership and the value 1 corresponds to the full membership. Therefore, a fuzzy membership function \( \mu_A(X) \) indicates the degree of belonging some element \( x \) of the universal set \( X \).

2. Problem description:

The problem is discussed for faculties of Mathematics Department of Engineering College. In this problem we assume the following constraints.

We have to allocate time slots for 48 hours in a week.

1. We assume that the number of semesters is two.
2. One subject is to be taught by every teacher for each semester.
3. Each subject should be taught for three hours in a week.
4. Classes are held for eight hours from Monday to Saturday.

We note that the department requires totally five teachers for teaching all the subjects and we have to allocate time slots for 48 hours in a week.

3. Fuzzy approach:

In this algorithm, we assigned a membership functions to timeslots given by a faculties. In this time table problem, we consider that there are five faculties F1, F2, F3, F4, F5 who teach for two semesters Sem1, Sem2 and every semester having 15 classes. Each Faculty Fi teaches a subject for semester Semj for three lectures in a week.

Suppose \((Fi, Semj, tk) = h\). This means the degree to which faculty Fi takes lecture for semester Semj at timeslot tk is high. We can always find an \( r \) such that \( 8(r - 1) < k \leq 8r \).

Then for any \( q \neq j \) following conditions should hold good.

(1) \((Fi, Semj, tk) = 0\) (i ≠ i) (Here we have more five i’s corresponding to other 5 faculties for the class \( S_j \)).
(2) \((Fi, Semj, tk) = 0\) (it corresponds to same slot for same faculty).
(3) \((Fi, Semj, tk-1) = 1\) (1<k and k not congruent to 1(mod 8)).
Which implies that. As faculty can take lecture on first time slot of a day and last slot of
the previous day that does not means \((F_i, \text{Sem}_j, t_8) = 1\).

4. \((F_i, \text{Sem}_j, t_{k+1}) = 1 \ (k \leq 47 \text{ and } k \text{ is not congruent to } 0 \text{ mod } 8)\ i.e \ k \text{ is not multiple of } 8\ \text{ implies } 8(r-1) < k < 8r\).

5. \((F_i, \text{Sem}_j, t_{k-2}) = m \ (2 < k, k \neq 2 \text{ mod } 8 \ & \ k \neq 1 \text{ mod } 8 \ k \neq 9,10,17,18,25,26,33,34,41,42\).

6. \((F_i, \text{Sem}_q, t_{k+2}) = m \ (k \leq 46 \ k \neq 0 \text{ mod } 8 \Rightarrow 8(r-1) < k < 8r \text{ and } (k + 1) \neq 0 \text{ mod } 8 \Rightarrow k \neq 7,15,23,31,40\).

7. \((F_i, \text{Sem}_q, t_{k-p}) = h \ (k > 3, 3 \leq p < k - 8(r-1))\).

8. \((F_i, \text{Sem}_q, t_{k+p}) = h \ (k \leq 45, k \leq 8r - 3, 3 \leq p\).

First we free the slot \((F_1, \text{Sem}_1)\) by assigning 1 in proper location. After that in each row
there should be three 1. As every faculty taking three sections for each semester then if
there is 1 three times in a semester then other entries should be zero for that semester. In
short every faculty taking only one lecture per class in a day for each semester. Therefore
some high preference converted to one satisfying the above conditions. Then final
schedule for time table generated.

Here every lecture is of one hour and classes start from 9:30 to 5:30pm on every
day i.e total 8 hours daily. Therefore there are total 48 hours. Hence \(t_1\) corresponds to
9:30am on Monday, \(t_8\) corresponds to 4:30 to 5:30pm on Monday and so on \(t_{48}\)
corresponds to 4:30pm to 5:30pm on Saturday.

Now we construct a matrix of order 30 X 48 , row corresponds to 5 faculties
teaching to two semesters, per semester 15 classes are there. In matrix first row assigned
to \((F_1, \text{Sem}_1, Cs_1, t_1)\). Second row \((F_1, \text{Sem}_1, Cs_2, t_2)\) and last row \((F_5, \text{Sem}_2, Cs_15, t_{45})\).
Whereas column assigned as \(t_1, t_2, \ldots \ldots t_{48}\). In the matrix there are six rows which
corresponds to two semester and for every semester each faculty teaching to one subject
for different sections. Hence we have total 30 row and 48 columns with entries h stands
for high, l stands for low and m stands for medium degree of priority. So if faculty \(F_1\)
teaches \(\text{Sem}_1, \text{section1}\) (i.e.Cs_1) at time \(t_1\) then degree of membership is high and we
assign it \((F_1, \text{Sem}_1, t_1) = h\).

The flow chart for above algorithm is as shown below.
Figure 2: Flow chart for algorithm
The flow chart repeats for all sections of two semesters and 5 faculties.

### 3.1 Example:

Here we are considered five faculties of Mathematics department of engineering college teach to two semesters Sem1, Sem2 and every semester is having total 15 sections Cs1, Cs2,----- Assume that faculty F1 teach to Sem1 for sections Cs1,Cs2,Cs3 and Sem2 for sections Cs1, Cs2,Cs3, F2 teach to Sem1 for sections Cs4,Cs4,Cs5 and Sem2 for sections Cs4, Cs5,Cs6 and similarly we assign for remaining faculties.

Assume faulty F1 teaches semester Sem1, section Cs1 to high priority when k takes the values 3, 10, 13, 22, 32, 41. Faculty F2 teaches semester 2 section 4 (Cs4) with high priority when k takes values 1,9,19,25,28,38. Faculty F3 teaches semester 1 section 7 (Cs7) with high priority 4, 14, 16, 24, 34, 40. Faculty 4 teaches semester 2 section 10 (cs10) with high priority 1, 10, 21, 27, 35, 47. The faculty F4 teaches semester 3 section 13 (Cs13) with high priority 2, 13, 22, 27, 38, 48.

So when F1 teaches semester 1 section1 Cs1 and k takes the value 3 enter (F1, Sem1, Cs1, t3)=h and then at the same slot for remaining faculties assign 0 so that conditions 1 and 2 satisfied.

As the value of r is depends on k, if k is multiple of 8 i.e 8, 16, 24, 32, 40, 48 r=[k/9]+1. Otherwise, r=[k/8]+1. For above the value of k=3 , 3 is not multiple of 8. Therefore r=[3/9]+1=1. Then for sem3 other entries in matrix calculated as (F1, Sem3,1)=1 for all sections. since 1<3 and 3 ≠ 2 mod(8) so condition 3 is satisfied also (F1, sem3, t3) = 1 since 3 is not multiple of 8 i.e.0<3<8 satisfying condition 4. Accordingly (F1, Sem3, t4) = m (3 ≠ 2 mod(8) ) & 3 ≠ 1 mod(8) which satisfies condition 5. 3<46 satisfying condition 6 and as value of p is 4. Accordingly made remaining entries as m. All remaining entries made 0. Similarly repeat this for all other faculties for each semester and each section. So by using above conditions we get a matrix with entries h, m, l and 0 as shown below. Here as the rooms are different we repeated the same steps to assign timeslots for faculties F2 to F5.

### Table 1: Matrix with entries h, m, l

| Values of k   | 1 to 8 | 9 to 16 | 17 to 24 | 25 to 32 | 33 to 40 | 41 to 48 |
|--------------|--------|---------|----------|----------|----------|----------|
| (F1, Sem1, Cs1,t1) | 0mhl0m0 | 0h0l00m | 0mhl000 | 00m0l00 | 0m00lh0 | 0l0mm00m |
| (F1, Sem1, Cs2,t2) | 0ml0ml0 | 000l0m0 | hm00l00 | 00lm0h0 | hm00lm00 | 0l0mm0m  |
| (F1, Sem1, Cs3,t3) | 0m0lm00 | 000m0lm | 00lmh00 | 00lm00l | hm00lm00 | 00m0mh0m |
| (F1, Sem2,Cs1,t4) | 0ml0m00 | 00lh0l0 | 0ml00lh | 0h0lm00 | 0m00lm00 | 00m0mm0m |
| (F2, Sem2,Cs2,t5) | hm0lm00 | 0000lh0 | 0mhl000 | 00lm000 | 00m0l000 | 00mm00m  |
| (F1, Sem2,Cs3,t6) | 0m0lm00 | h0l00lm | 00ml00h | 00lm000 | 0m00lm00 | 0000m0m |
| (F2, Sem1,Cs4,t7) | 0hml0m0 | 0h0lm00 | 00mh010 | 00m0000 | 00m0000 | 00mm00m  |
| (F2, Sem1,Cs5,t8) | 0m1m00h | 0000lm0 | hm00l00 | 00lm0h0 | hm00lm00 | 00lm00m  |
| (F2, Sem1,Cs6,t9) | 0mm0lm0 | 00h0lh0 | 00mlh00 | 00lm000 | 00m0l000 | 00m0mh0m |
| (F2, Sem2,Cs4,t10) | 0m0lm00 | 000hm0l | 0m0l000h | 0hl0m00 | 00m0000 | 00mm00m  |
In the next step replace all h by 5 and m, l by 0. We get new matrix as follows.

**Table 2**: Matrix after replacing h by 5, m by 0, l by 0

| Values of k | 1 to 8 | 9 to 16 | 17 to 24 | 25 to 32 | 33 to 40 | 41 to 48 |
|-------------|--------|---------|----------|----------|----------|----------|
| (F1, Sem1, Cs1,t1) | 00500000 | 00500000 | 00500000 | 00000000 | 00000050 | 00000000 |
| (F1, Sem1, Cs2,t2) | 00000050 | 00000000 | 50000000 | 00000050 | 50000000 | 00500000 |
| (F1, Sem1, Cs3,t3) | 00000000 | 00000000 | 00000500 | 00000000 | 50000000 | 00000500 |
| (F1, Sem2,Cs1,t4) | 00000000 | 00005000 | 00000005 | 05000000 | 00000000 | 00000000 |
| (F1, Sem2,Cs2,t5) | 50000000 | 00000005 | 00500000 | 00000000 | 00500000 | 00000000 |
| (F1, Sem2,Cs3,t6) | 00000000 | 50000000 | 00000005 | 00000005 | 00000000 | 00000000 |
| (F2, Sem1,Cs4,t7) | 00500000 | 05000000 | 00500000 | 00005000 | 00000000 | 00000000 |
| (F2, Sem1,Cs5,t8) | 00000005 | 00000000 | 50000000 | 00000500 | 50000000 | 00000500 |
| (F2, Sem1,Cs6,t9) | 00000000 | 00005000 | 00000005 | 05000000 | 00000000 | 00000000 |
| (F2, Sem2,Cs4,t10) | 00000000 | 00005000 | 00000005 | 05000000 | 00000000 | 00000000 |
| (F2, Sem2,Cs5,t11) | 50000000 | 00000005 | 00500000 | 00000000 | 00500000 | 00000000 |
| (F2, Sem2,Cs6,t12) | 00000000 | 50000000 | 00000005 | 00000005 | 00000000 | 00000000 |
| (F3, Sem1,Cs7,t13) | 00500000 | 05000000 | 00500000 | 00005000 | 00000000 | 00000000 |
| (F3, Sem1,Cs8,t14) | 00000005 | 00000000 | 50000000 | 00000500 | 50000000 | 00000500 |
| (F3, Sem1,Cs9,t15) | 00000000 | 00050000 | 00000500 | 00000000 | 00000500 | 00000000 |
| (F3, Sem2,Cs7,t16) | 00000000 | 00005000 | 00000005 | 05000000 | 00000000 | 00000000 |
| (F3, Sem2,Cs8,t17) | 50000000 | 00000005 | 05000000 | 00000000 | 00500000 | 00000000 |
| (F3, Sem2,Cs9,t18) | 00000000 | 50000000 | 00000005 | 00000005 | 00000000 | 00000000 |
| (F4, Sem1,Cs10,t19) | 00500000 | 05000000 | 00500000 | 00005000 | 00000000 | 00000000 |
| (F4, Sem1,Cs11,t20) | 00000500 | 00000000 | 50000000 | 00000500 | 50000000 | 00500000 |
| (F4, Sem1,Cs12,t21) | 00000000 | 00050000 | 00000500 | 00000000 | 00000500 | 00000000 |
| (F4, Sem2,Cs10,t22) | 00000000 | 00005000 | 00000005 | 05000000 | 00000000 | 00000000 |
| (F4, Sem2,Cs11,t23) | 50000000 | 00000005 | 05000000 | 00000000 | 00500000 | 00000000 |
| (F4, Sem2,Cs12,t24) | 00000000 | 50000000 | 00000005 | 00000005 | 00000000 | 00000000 |
| (F5, Sem1,Cs13,t25) | 00500000 | 05000000 | 00500000 | 00005000 | 00000000 | 00000000 |
| (F5, Sem1,Cs14,t26) | 00000050 | 00000000 | 50000000 | 00000500 | 50000000 | 00500000 |
| (F5, Sem1,Cs15,t27) | 00000000 | 00050000 | 00000500 | 00000000 | 00000500 | 00000000 |
As every section for each subject maximum 3 lectures should be there and only one lecture for every subject for the section. If these conditions are not satisfied repeat the process in section 2 so that all constraints satisfied. To indicate selection of lecture we change the entry from 5 to 2 in a row. Same time slot is not assigned for the same faculty for any section of any semester. Same slot can be assigned for different faculties for different section in different room. Then we get new matrix as below

**Table 3**: Matrix after replacing 5 by 2

| Values of k | 1 to 8 | 9 to 16 | 17 to 24 | 25 to 32 | 33 to 40 | 41 to 48 | Total classes |
|-------------|--------|---------|----------|----------|----------|----------|---------------|
| (F1, Sem1, Cs1,t1) | 00200000 | 00200000 | 00200000 | 00000000 | 00000200 | 00000000 | 4 |
| (F1, Sem1, Cs2,t2) | 00000200 | 00000000 | 20000000 | 00000200 | 20000000 | 00200000 | 5 |
| (F1, Sem1, Cs3,t3) | 00000000 | 00000000 | 00000200 | 00000000 | 20000000 | 00000200 | 3 |
| (F1, Sem2,Cs1,t4) | 00000000 | 00000200 | 00000002 | 02000000 | 00000000 | 00000000 | 3 |
| (F1, Sem2,Cs2,t5) | 20000000 | 00000002 | 02000000 | 00000000 | 00200000 | 00000000 | 4 |
| (F1, Sem2,Cs3,t6) | 00000000 | 20000000 | 00000200 | 00000002 | 00000000 | 00000000 | 3 |
| (F2, Sem1,Cs4,t7) | 00200000 | 02000000 | 00200000 | 00002000 | 20000000 | 00200000 | 5 |
| (F2, Sem1,Cs5,t8) | 00000020 | 00000000 | 20000000 | 00000200 | 20000000 | 00200000 | 3 |
| (F2, Sem1,Cs6,t9) | 00000000 | 00020000 | 00000200 | 00000000 | 00000000 | 00000200 | 3 |
| (F2, Sem2,Cs4,t10) | 00000000 | 00020000 | 00000200 | 02000000 | 00000000 | 00000000 | 4 |
| (F2, Sem2,Cs5,t11) | 20000000 | 00000002 | 02000000 | 00000000 | 00200000 | 00000000 | 3 |
| (F2, Sem2,Cs6,t12) | 00000000 | 20000000 | 00000002 | 00000200 | 00000000 | 00000000 | 4 |
| (F3, Sem1,Cs7,t13) | 00200000 | 02000000 | 00200000 | 00002000 | 20000000 | 00200000 | 5 |
| (F3, Sem1,Cs8,t14) | 00000020 | 00000000 | 20000000 | 00000200 | 20000000 | 00200000 | 3 |
| (F3, Sem1,Cs9,t15) | 00000000 | 00020000 | 00000200 | 00000000 | 00000000 | 00000200 | 3 |
| (F3, Sem2,Cs7,t16) | 00000000 | 00020000 | 00000002 | 02000000 | 00000000 | 00000000 | 3 |
Since for every subject total lectures are maximum three, if this condition is not satisfied replace $h$ and $m$ in such rows by 0. For above in row 1, 2, 5, ---. Once again we generate the matrix.

**Table 4:** Final slots selected

| Values of $k$ | 1 to 8 | 9 to 16 | 17 to 24 | 25 to 32 | 33 to 40 | 41 to 48 | Total classes |
|--------------|--------|---------|----------|----------|----------|----------|---------------|
| (F1, Sem1, Cs1,t1) | 00200000 | 00200000 | 00000000 | 00000000 | 00000020 | 00000000 | 3 |
| (F1, Sem1, Cs2,t2) | 00000000 | 00000000 | 20000000 | 00002000 | 00000000 | 00200000 | 3 |
| (F1, Sem1, Cs3,t3) | 00000000 | 00000000 | 00002000 | 00000000 | 20000000 | 00000000 | 3 |
| (F1, Sem2, Cs1,t4) | 00000000 | 00002000 | 00000000 | 00000000 | 00200000 | 00000000 | 3 |
| (F1, Sem2, Cs2,t5) | 20000000 | 00000000 | 00000000 | 00000000 | 00002000 | 00000000 | 3 |
| (F1, Sem2, Cs3,t6) | 00200000 | 20000000 | 00000000 | 00000000 | 00000002 | 00000000 | 3 |
| (F2, Sem1, Cs4,t7) | 00200000 | 02000000 | 00000000 | 00000000 | 00000000 | 00000000 | 3 |
| Assignment | Values |
|------------|--------|
| (F2, Sem1, Cs5, t8) | 00000020 00000000 20000000 00000200 00000000 00000000 3 |
| (F2, Sem1, Cs6, t9) | 00000000 00020000 00000200 00000000 00000000 00000000 3 |
| (F2, Sem2, Cs4, t10) | 00000000 00000002 00200000 00000000 00200000 00000000 3 |
| (F2, Sem2, Cs5, t11) | 00000000 00000002 00200000 00000000 00200000 00000000 3 |
| (F2, Sem2, Cs6, t12) | 00000000 20000000 00000000 00000000 00000000 00000000 3 |
| (F3, Sem1, Cs7, t13) | 00200000 02000000 00200000 00000000 00200000 00000000 3 |
| (F3, Sem1, Cs8, t14) | 00000000 00020000 20000000 00000200 00000000 00000000 3 |
| (F3, Sem1, Cs9, t15) | 00000000 00020000 00000000 00000000 00000000 00000000 3 |
| (F3, Sem2, Cs7, t16) | 00000000 00000002 02000000 00000000 00200000 00000000 3 |
| (F3, Sem2, Cs8, t17) | 00000000 00000002 00200000 00000000 00200000 00000000 3 |
| (F3, Sem2, Cs9, t18) | 00000000 20000000 00000002 00000000 00000000 00000000 3 |
| (F4, Sem1, Cs10, t19) | 02000000 02000000 00200000 00000000 00000000 00000000 3 |
| (F4, Sem1, Cs11, t20) | 00000020 00000000 20000000 00000200 00000000 00000000 3 |
| (F4, Sem1, Cs12, t21) | 00000000 00020000 00000200 00000000 00000000 00000000 3 |
| (F4, Sem2, Cs10, t22) | 00000000 00020000 00000002 02000000 00000000 00000000 3 |
| (F4, Sem2, Cs11, t23) | 00000000 00000002 02000000 00000000 00200000 00000000 3 |
| (F4, Sem2, Cs12, t24) | 00000000 20000000 00000002 00000000 00000000 00000000 3 |
| (F5, Sem1, Cs13, t25) | 02000000 02000000 00200000 00000200 00000000 00000000 3 |
| (F5, Sem1, Cs14, t26) | 00000020 00000000 20000000 00000200 00000000 00000000 3 |
| (F5, Sem1, Cs15, t27) | 00000000 00020000 00000200 00000000 00000000 00000000 3 |
| (F5, Sem2, Cs13, t28) | 00000000 00002000 00000002 02000000 00000000 00000000 3 |
| (F5, Sem2, Cs14, t29) | 00000000 20000000 00000002 00200000 00000000 00200000 00000000 3 |
| (F5, Sem2, Cs15, t30) | 00000000 20000000 00000002 00000000 00000000 00000000 3 |
Final time table for Faculty 1 for two semesters and all sections

Table 5: Final Time Table for Faculty 1

| Days/Time Slots | 9.30 am | 10.30 am | 11.30 am | 12.30 pm | 1.30 pm | 2.30 pm | 3.30 pm | 4.30 pm |
|-----------------|---------|----------|----------|----------|---------|---------|---------|---------|
| MON             | F1/sem2/ Csec2 | F1/sem1/ Csec1 | F1/sem2/ Csec3 |
| TUE             | F1/sem2/ Csec3 | F1/sem1/ Csec1 | F1/sem2/ Csec1 |
| WED             | F1/sem1/ Csec2 | F1/sem1/ Csec3 | F1/sem2/ Csec1 |
| THURS           | F1/sem2/ Csec1 | F1/sem1/ Csec2 | F1/sem2/ Csec3 |
| FRI             | F1/sem1/ Csec3 | F1/sem2/ Csec2 | F1/sem1/ Csec1 |
| SAT             | F1/sem1/ Csec2 | F1/sem1/ Csec3 | F1/sem1/ Csec1 |

4. Result and Discussion:

In this paper the modification of [5] is done. They have applied the algorithm for one section for two semesters with 9 teachers taught to two semesters. So they got matrix of order 18x39. Here we used the algorithm for 13 sections for two semesters taught five faculties of Mathematics of engineering college. We got a matrix of order 30x48.

Table 1 shows entries with high (h), low (l) and medium (m) priorities of faculties. Table 2 shows the entries after replacing h by 5 and m,l replacing by 0, so that we can decide time slots with higher priorities, then again we replace 5 by 2 and we count the number of in each row which shows in Table 3. If in each row 2 is not appeared exactly 3 times again we use step first for high priorities and discard entries accordingly so that every row having only three time 2, as every faculty has three lectures for every class which show in Table 4.

Finally after satisfying all constraints of time table, we generate a proper time table shows in Table 5.

5. Conclusion:

This paper consists of an algorithm to generate time table which satisfied all the condition. An algorithm which ensures at least one hour gap between two lectures for a faculty in a day. By using this algorithm we can generate a time table for Mathematics faculties teach to fifteen sections for semester one two and three with no overlapping in time slots.

In future we try to develop algorithm for course time table which includes other theory subjects and practical subjects.
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