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SENSTIVITY ANALYSIS OF PROJECT SCHEDULING USING FUZZY SET THEORY

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ABSTRACT: - *This paper describes an application of fuzzy logic in analysis of delays in construction projects using Fuzzy set linguistic values as well as membership values. There are wide range of factor which effect construction project. In this paper we use the fuzzy logic to estimate delay by using weather good(g), medium(m), bad(b) and labor experience high(h), medium(m), low(l). we know that project scheduling use either probabilistic method or deterministic method for measuring schedule duration time. These membership values help us in determining the total effect on the duration of project due to different reason in construction project. This method helps us to understand the total delay through critical path method and program evaluation and review technique. One of the main advantages of the proposed technique is that it can be easily implemented in existing computer programs for project scheduling. We know that some of the activity are delay due to some external factor, which are considered by the software earlier using critical path method using fuzzy logic.*

***Keywords*: -** Linguistic Values, Fuzzy logic.

1. INTRODUCTION

The Fuzzy set theory has been studying nearly the past 55 years. Most of an early interest in fuzzy set theory pertained to representing uncertainty in human cognitive processes according Zadeh (1965)). Fuzzy set theory is now used to minimize problems in engineering, business, medical and related health sciences, and the natural sciences. In an effort to gain a better understanding of the use of fuzzy set theory in construction industry management research and to provide a basis for future research, a literature review of fuzzy set theory in construction industry management has been conducted. While similar survey efforts have been undertaken for other topical areas, there is a need in construction industry management for the same. Over the years there are successful applications and implementations of fuzzy set theory in construction industry management. Fuzzy set theory has been recognized as an important problem modeling and solution technique. A summary of the findings of fuzzy set theory in construction industry management research may benefit researchers in the construction industry and management field.

In 1956, the critical path method (CPM) was implemented on a computer to schedule construction project. In 1957, a technique implements called the program evaluation review technique (PERT) has developed to integrate the coordinate contractor working on a single project. Recently a method called graphical evaluation and review techniques (GERT) was developed. It is the simplest method to say the dovetailed in the construction industry. It is useful when performance of all the operations is not necessary for the completion of projects.

All these methods have been broadly divided into two groups deterministic and probabilistic. When the information is used for a particular method and which is known during the analysis is called as deterministic and most of the information is used in this method is non deterministic in nature. Using CPM this method can be used. In the probabilistic method every parameter is generally expressing in terms of mean, coefficient of variation, standard deviation etc. PERT and GERT can be classified as a probabilistic method.

2. LITERATURE REVIEW

For solving the problems using fuzzy logic different paper or different literature are studied for solving the problem of delay duration in construction industry. These literature helps me to find out the reasons behind the delay duration and the use of fuzzy logic in the construction industry.

Bilal M. Ayyab and Achintya Haldar

"The Project Scheduling Using Fuzzy Set Concepts" this paper analyzed the project scheduling method using fuzzy set which helps us to find out the delay duration in any completed project. In this paper author use the linguistic function along with membership function to find out the delay duration in any project. one of the important use of this technique is that it can be easily implemented in existing computer programs for project scheduling.

Pandey M.K, Dandotiya A, Trivedi M.K, Bhadoriya S.S, Ramasesh G.R.

"Delay Computation Using Fuzzy Logic Approach" the author use the fuzzy logic set theory, which helps the author to find out the total delay duration on the construction site. Initially the research is basedon the real project executed in Gwalior (mp), and find the delay duration due to shortage of materials and lack of operators. after that the author apply the fuzzy set theory on project with linguistic and membership values. The writer gets the nearly same value in his research

O Brien J.J

"CPM In Construction Management" this paper analyzed that construction have many techniques, with varying degrees of complexity to maintain the construction project. bar charts is important tool of project scheduling, it used in simulation, value engineering, statistical quality, time and motion studies etc. and the other use of CPM in construction management. In 1956 the CPM is first implemented on computer to schedule construction project.

Shruti singh, dr. M.K trivedi

"Application of Fuzzy Logic in Delay Analysis in Construction" this paper represents the application of fuzzy logic in analysis of delays in construction industry using fuzzy toolbox of MATLAB program software. The author takes the different factor of delay labor related, project related, consultant related, contractor related, external factor, owner related, material related, environment related, design related, equipment related etc. a case study and an interview was done by an author in housing project in Gwalior, to determine causes of delay with a help of questionnaire survey. The value of factor ranging from 1 to 100 as a probability of schedule delay (01 for very low and 100 for very high).

L.A Zadeh

"Fuzzy Sets Information and Control "The author LA Zadeh introduced the concept of fuzzy in 1965 first time in the history of construction. And represent the non-control methodology of partial set memberships function other than crisp set membership function or non-memberships function. He tells that each object has it own membership value which determine the degree, through which object related to the fuzzy set. also determine the use of fuzzy in different sector other than construction industry.

H.N.Ahuja

"Construction Performance Control by Network" The author suggests after CPM the another technique program evaluation and review technique (PERT) is introduced to coordinate contractors working on the project. the PERT is enables works of project without knowledge of probability of occurrence of events. after some time, new method is developed called Graphical Evaluation and review Techniques which helps in a relative operation in construction projects.

Adriana V. Ordonez Oliveros and Aminah Robinson Fayek

"Fuzzy logic approach for Activity Delay Analysis and Schedule updating" the research aims to make a fuzzy logic model for modifying activity durations and the model integrates daily site reporting of activity progress and delays with a schedule updating and forecasting system for construction project monitoring and control.

These are some important paper which helps me in understanding the problem related to the fuzzy logic and with the help of these paper we find out the delay durations.

3. PROBLEM DESCRIPTION

The construction industry plays an important role in the developed country. The construction project divided into different activity and all are present in the form of network. for completion of these activity we need the

certain amount of resources like labor, time money and material. The objective given staff person which are working on the construction site is to reduce the total cost laying on the different activity and they are also mention that the work can be completed on given time. For estimating the time of each activity using CPM, PERT the probability distribution and parameters of duration can be measures. There are many factors which effect the duration of activity are labor, weather, client, consumer, transportation and other factor but we are consider on two factor labor and weather. Weather can be divide into different level good, medium, bad but the labor can be divide in different categories labor are based on level of experience. In the construction project the project engineers estimate the duration of activity on the bases of judgment and experience, finally the judgment effect in completion of project.

In this paper the quality of the activity duration to any of these factors is measured in the linguistic terms. The linguistic values can be converted into the mathematical measures by fuzzy set and system theory. Here we are using the different membership values and find out the effect of these changes on the duration of activity, which helps us to find out the delay before starts the project.

4. ELEMENT OF FUZZY SET THEORY

Let X is a subset of element, and A is the subset of X each value of X is related to the membership value to the subset of A.

μA(x). So membership function is given by

μA(x) = 1 if X belong to 'A'

0 if X not belongs to 'A'

There are two possible values of element X either being a member of A μa(x)=1 or not a member of A. μa(x) =0. Therefore, a have a sharp boundary, on the other hand if the membership function is between (0,1) is called a fuzzy set. Now A has not a sharp boundary. Let "X" is be the level of experience of labor. It is excellent experience i.e. x=1.0 and low experience means x=0.1, A has a linguistic variable,

x 1=1.0, μA(x1)=0.0 x 2=0.9, μA(x2)=0.0 x3=0.8, μA(x3)=0.0 x4=0.7, μA(x4)=0.0

x5=0.6, μA(x5) =0.0 x6=0.5, μA(x6)=0.0 x7=0.4, μA(x7)=0.2 x8=0.3, μA(x8)=0.6

x9=0.2, μA(x9)=0.8 x10=0.1, μA(x10)=0.9 x11=0.0, μA(x11)=1.0

For short experience,

{A= 0.4|0.1, 0.3|0.4, 0.2|0.6,0.1|0.8, 0.0|0.9}

The value of X are 0.4,0.3,0.2,0.1,0.0 and corresponding membership values are 0.1,0.4,0.6,0.8,0.9 .

For long experience,

{B=1.0|0.9,0.9|0.8,0.8|0.7,0.7|0.1,0.6|0.1}.

5. EXAMPLE

In this example a procedure is presented for estimating the probability mass function of the duration of an activity, which is the basis of any probabilistic project scheduling method. There are many factor which affect the duration of an activity, as we know. There are mostly two factors which affect the duration of construction activity.

(01) weather: -Good (G), Medium (M), Bad (B).

(02) labor experience: - High (H), Medium (M) Low (L)

The frequency of occurrence is called "F", for a preceding factor and adverse consequence "C" on the duration of an activity are estimated in linguistic term.

Now we estimate the duration of a activity and the impact of these factor on the duration.

QUENTITATIVE DESCRIPTION OF FEQUENCY OF OCCURANCE AND CONNSEQUENCE

S .no	Factor	Frequency of occurrence (f)	Adverse consequence of duration (C)
01	Weather bad	Small	Large
02	Weather medium	Medium	Medium
03	Weather good	Medium	Very small
04	Labor low	Large	Medium
05	Labor medium	Medium	Quite small
06	Labor high	Quite small	Very small

The membership value of each project is different at each place of different project. the following translation of linguistic variable into fuzzy subset are assumed as follow.

Now combining the frequency of occurrence "F" and the adverse consequence "C" for each factor , i = 1....6 by using previsions technique .

(**01**) Now, we apply a all fuzzy operation, fuzzy relation on different linguistic value as on increasing the value by 10% =

Large = { 0.8|0.6, 0.9|1.0, 01|1.0}

medium = { 0.3|0.3, 0.4|0.9, 0.5|1.0, 0.6|0.9, 0.7|0.3}

small = { 0.0|1.0, 0.1|1.0, 0.2|0.6}

quite small= (small) ^1.25 = { 0.0|1.0, 0.1|1.0, 0.2|0.54}

Very small= (small) ^ 2 = { 0.0|1.0, 0.1|1.0, 0.2|0.36}

Very large= (large) ^2 = {0.8|0.36, 0.9|1.0, 01|1.0}

consequences large

F1*C1 frequency small	0.8	0.9	1.0
0.0	0.6	1.0	1.0
0.1	0.6	1.0	1.0
0.2	0.6	0.6	0.6

consequences medium

F2*C2 frequency medium	0.3	0.4	0.5	0.6	0.7
0.3	0.3	0.3	0.3	0.3	0.3
0.4	0.3	0.9	0.9	0.9	0.3
0.5	0.3	0.9	1.0	0.9	0.3
0.6	0.3	0.9	0.9	0.9	0.3
0.7	0.3	0.3	0.3	0.3	0.3

consequences very small

F3*C3 frequency medium	0.0	0.1	0.2
0.3	0.3	0.3	0.3
0.4	0.9	0.9	0.36
0.5	1.0	1.0	0.36
0.6	0.9	0.9	0.36
0.7	0.3	0.3	0.3

consequences medium

F4*C4 frequency large	0.3	0.4	0.5	0.6	0.7
0.8	0.3	0.6	0.6	0.6	0.3
0.9	0.3	0.9	1.0	0.9	0.3
1.0	0.3	0.9	1.0	0.9	0.3

consequences quite small

F5*C5 frequency medium	0.0	0.1	0.2
0.3	0.3	0.3	0.3
0.4	0.9	0.9	0.54
0.5	1.0	1.0	0.54
0.6	0.9	0.9	0.54
0.7	0.3	0.3	0.3

consequences very small

F6*C6 frequency quite small	0.0	0.1	0.2
0.0	1.0	1.0	0.36
0.1	1.0	1.0	0.36
0.2	0.54	0.54	0.36

the total effect of all factor on activity duration is obtained by UNION operation method.

So total effect, T=(f1*c1)υ(f2*c2)υ.....(f6*c6)

FREQUENCY*CONSEQUENCES

	0.0	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**
0.0	1.0	1.0	0.36	0.0	0.0	0.0	0.0	0.0	0.6	1.0	1.0
0.1	1.0	1.0	0.36	0.0	0.0	0.0	0.0	0.0	0.6	1.0	1.0
0.2	0.54	0.54	0.36	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.6
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0
0.4	0.9	0.9	0.54	0.3	0.9	0.9	0.9	0.3	0.0	0.0	0.0
0.5	1.0	1.0	0.54	0.3	0.9	1.0	0.9	0.3	0.0	0.0	0.0
0.6	0.9	0.9	0.54	0.3	0.9	0.9	0.9	0.3	0.0	0.0	0.0
0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0
0.8	0.0	0.0	0.0	0.3	0.6	0.6	0.6	0.3	0.0	0.0	0.0
0.9	0.0	0.0	0.0	0.3	0.9	1.0	0.9	0.3	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.3	0.9	1.0	0.9	0.3	0.0	0.0	0.0

We establish a fuzzy relation R (c, da) between the fuzzy subse-t of consequence "C" and the fuzzy subset of duration of the activity in days (da).

We know that the consequence is directly proportional to duration of activity.

Let, the duration be very large if the consequence are large; let the duration be large if the consequence are medium; and let the duration be small if the consequence are small that are,

R: Da = very large = {15|0.09, 20|0.81, 25|1.0} "C "is large

R: Da = large = {15|0.3, 20|0.9, 25|1.0} "C" is medium

R: Da = small = {20|0.3, 15|0.6, 10|1.0} "C" is small

Large = {0.8|0.6, 0.9|1.0, 01|1.0}

medium = {0.3|0.3, 0.4|0.9, 0.5|1.0, 0.6|0.9, 0.7|0.3}

small = { 0.0|1.0, 0.1|1.0, 0.2|0.6}

duration very large

R1=C1*D1 consequences large	15	20	25
0.8	0.09	0.6	0.6
0.9	0.09	0.81	1.0
1.0	0.09	0.81	1.0

duration large

R2 = C2*D2 consequences medium	15	20	25
0.3	0.3	0.3	0.3
0.4	0.3	0.9	0.9
0.5	0.3	0.9	1.0
0.6	0.3	0.9	0.9
0.7	0.3	0.3	0.3

duration small

R3=C3*D3 consequences small	10	15	20
0.0	1.0	0.6	0.3
0.1	1.0	0.6	0.3
0.2	0.6	0.6	0.3

now taking a UNION matrix of rows R1 , R2 ,R3 , the relation "R" is obtain:-

CONSEQUENCES* DURATION

	10	15	20	25
0.0	1.0	0.6	0.3	0.0
0.1	1.0	0.6	0.3	0.0
0.2	0.6	0.6	0.3	0.0
0.3	0.0	0.3	0.3	0.3
0.4	0.0	0.3	0.9	0.9
0.5	0.0	0.3	0.9	1.0
0.6	0.0	0.3	0.9	0.9
0.7	0.0	0.3	0.3	0.3
0.8	0.0	0.09	0.6	0.6
0.9	0.0	0.09	0.81	1.0
1.0	0.0	0.09	0.81	1.0

A subjective estimation of the duration can be calculated by taking the composition of "T" and "R" so, ToR =

Know use a operation,

μR o S = (xi, zk) = max yj {min (xi, yj), μs (yj, zk)} ……..

The membership value of different duration: -

Fuzzy composition: - max {min (xi, yj)……}

ToR : FREQUENCY* DURATION

	10	15	20	25	Row summation
0.0	1.0	0.6	0.81	1.0	3.41
0.1	1.0	0.6	0.81	1.0	3.41
0.2	0.54	0.54	0.6	0.6	2.28
0.3	0.3	0.3	0.3	0.3	1.2
0.4	0.9	0.6	0.9	0.9	3.3
0.5	1.0	0.6	0.9	1.0	3.5
0.6	0.9	0.6	0.9	0.9	3.3
0.7	0.3	0.3	0.3	0.3	1.2
0.8	0.0	0.3	0.6	0.6	1.5
0.9	0.0	0.3	0.9	1.0	1.3
1.0	0.0	0.3	0.9	0.9	2.1

The membership values for different durations of the activity and frequencies of occurrence considering the total effect of the factors given in" quantitative description of frequency of occurrences and consequences" . According to Yao, a subset, Da can be chosen from above equation, as a fuzzy representation of the duration of the activity. The membership value for each value of the duration of the activity in Da is equal to the largest membership value in the corresponding column for that duration in equation. However, if Yao's method is used for this case, some of the information given in equation would not be considered, i.e., the frequency of occurrence of the total effect of the factors. Therefore, the writers suggest the following method: choose from equation, a row (subset) which maximizes the product of the row summation given in given equation and the corresponding frequency. So

Frequency	Row summation	Row summation* corresponding frequency
0.0	3.41	0.0
0.1	3.41	0.341
0.2	2.28	0.456
0.3	1.2	0.36
0.4	3.3	1.32
0.5	3.5	1.75
0.6	3.3	1.98
0.7	1.2	0.84
0.8	1.5	1.2
0.9	1.3	1.17
1.0	2.1	2.1

The last row of equation gives a maximum value of product of row summation to the corresponding frequency, so we can use it .

Da = activity duration

Da = 10|0.0,15|0.3,20|0.9,25|0.9

According to zadah, the probability mass function of the duration activity can be calculated as follow: -

P(da=10) = {0.0/0.0+0.30+0.90+0.90} = 0.0

P(da=15) = {0.30/0.0+0.30+0.90+0.90} = 0.14

P(da=20) = {0.9/0.0+0.30+0.90+0.90} = 0.42

P(da=25) = {0.9/0.0+0.3+0.9+0.9} = 0.42

Now, estimates of the mean value "d¯a" and the standard deviation of the duration σDa of the activity duration and calculated as follow :-

Activity duration,

d¯a = {10*0.0+15*0.14+20*0.42+25*0.42} = 21 days

σ^2da= {10^2*0.0+15^2*0.14+20^2*0.42+25^2*0.42}-{21^2} = 21 days

σda=(21)^1/2 = 4.58 days

CoV = σda/ d¯a = 4.58/21 = 0.21

(**02**) Now in a next case we apply a all fuzzy operation, fuzzy relation on different membership value as on decreasing the value by 10% :-

Large = 0.8|0.4, 0.9|0.8, 01|0.9

medium = 0.3|0.1, 0.4|0.7, 0.5|0.9, 0.6|0.7, 0.7|0.1

small = 0.0|0.9, 0.1|0.8, 0.2|0.4

quite small= (small) ^1.25 = 0.0|0.88, 0.1|0.72, 0.2|0.34

Very small= (small) ^2 = 0.0|0.81, 0.1|0.64, 0.2|0.16

Very large= (large) ^2 = 0.8|0.16, 0.9|0.64, 01|0.81

R: Da = very large = {15|0.01, 20|0.49, 25|0.81} "C " is large

R: Da = large = {15|0.1, 20|0.7, 25|0.9} "C" is medium

R: Da = small = {20|0.1, 15|0.4, 10|0.9} "C" is small

d¯a = 21.95 days

cov = 0.183

(03) Now in a next case we apply a all fuzzy operation, fuzzy relation on different membership value as on given by Bilal M. Ayyub

Large = 0.8|0.5, 0.9|0.9, 01|1.0

Medium=0.3|0.2,0.4|0.8,0.5|1.0,0.6|0.8, 0.7|0.2

small = 0.0|1.0, 0.1|0.9, 0.2|0.5

quite small= (small) ^1.25 = 0.0|1.0, 0.1|0.88, 0.2|0.42

Very small= (small) ^2 = 0.0|1.0, 0.1|0.81, 0.2|0.25

Very large= (large) ^2 = 0.8|0.25, 0.9|0.81, 01|1.0

R: Da = very large = {15|0.04, 18|0.64, 20|1.0} "C " is large

R: Da = large = {15|0.2, 18|0.8, 20|1.0} "C" is medium

R: Da = small = {18|0.2, 15|0.5, 10|1.0} "C" is small

$\bar{d}a$ = 18.7 days

cov = 0.083

6. RESULT

The delay duration for different membership function is different. in this paper we analysis the different delay duration using different membership function by increasing or decreasing the membership function and we get the result. in order to increase or decrease the membership function by 10%, there will be not a certain difference in delay duration. If we decrease the membership value by 10% (Bilal M. Ayyub) the delay duration will be increased by 17.3%. and in increased case, delay duration increased by 12.29%. this delay percentage is different for every membership value.

7. CONCLUSION

This paper totally deal with the different probabilistic methods with various degrees of complexity are used in the construction engineering. When we used the linguistic term other than the mathematical terms the probability theory fails so, we translated linguistic term into mathematical by fuzzy set. In this paper we find out the different delay duration due to labor experience and weather conditions with different memberships functions. This approach helps the site engineer, contractor and other to find out the delay duration before the work start on site.

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