A Fuzzy Logic Approach for Predicting and Evaluating Learner's Category in E-learning System

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Abstract:
The present work focused on designing, developing and modelling of soft computing decision making model for solving real life problems in education system. E-learning is the emerging trend in this digital era and empowerment of this e-learning trend is necessary. Fuzzy Inference System (FIS) and prediction using FIS plays vital role in fuzzy environmental model for prediction of category of learners which is helpful in developing and decision making in education system.

***Keywords: Fuzzy Inference System; MATLAB; Bloom Taxonomy*.**

I. INTRODUCTION:

Result of any exam is considered in decision making of learners career. In traditional result analysis monopoly of Grading is used which does not give the justice to all the learners depending upon there capability. So in result process some parameters should be considered like How much time is utilized by learner to solve the questions?, On which type of Questions he/she concentrated? etc. Rather than this also consider parameters like from which culture/ area/ environment learners belongs, what are human values learner have. Literally all these parameters impact on the students result and ultimately on career.

II. Data Set:

For this research model there is need of some data for analysis. So for data collection TEST-1 was conducted of 30 marks and 30 minutes duration. For further analysis data was classified as input and output for FIS in following way. Two Inputs are used for FIS first input is ***Time*** and second input is ***Grade***. For Input ***Time*** five linguistic variables are used which are ***Very Less***, ***Less***, ***Average***, ***More*** and ***Extensive more***. Table I shows the range of Input ***Time*** which is referred between minimum times to maximum time utilised to solve questions in TEST-1

Table I: Input Variable ***Time***.

Range Of Time (in sec.)		Linguistic terms
182	447	Very less time
447	712	Less time
712	977	Average time
977	1242	More time
1242	1507	Extensive more time

As shown in Table-I, 182 seconds is the minimum time and 1507 second is the maximum time utilized by student for solving TEST-1. In general minimum and maximum seconds required to complete the TEST-1 are later on divided with equal interval of time to determine linguistic terms.
Another input variable is **Grade**. Grade is divided in five linguistic terms such as A, B, C, D, E where A for – Excellent score, B for- Satisfactory score, C for – Average score, D for - Weak score and E for -Poor score.

TableII shows the range of Input Grade which is between minimum mark scored and maximum mark scored in that TEST-1.

Table II: Input Variable ***Grade.***.

Range of Marks From	To	Grades
16	18	A
13	16	B
10	13	C
7	10	D
5	7	E

As shown in Table II the minimum marks is 5 and 18 is the maximum marks scored by student in TEST-1. We divided the obtained score in equal interval to different Grades.
The Output Variable is ***Remark***. Remark is divided into five linguistic variablesusing membership function.

Remark Terminologies Used in TEST-1 are:

WL: Weak Learner: Students those who utilizes more and extensive more time for solving questions and score poor marks that is below passing criteria that is grade E in respective exam.
SL: Slow Learner: Those students who uses more time to solve the question and has weak score marks like the grade D or students who uses extensive more time but score C grade mark in respective exam.
AL: Average Learner: Those students who uses average time to solve the question and score average mark like grade Dor students who uses more or extensive more time but score marks of C and B grade in respective exam.
SAT_L: Satisfactory Learner: Those students who use less time or average time and scores mark of C grade or more time to solve the questions and score more marks like grade B in respective exam.
FL: Fast Learner: Those students who use less time and very less time to solve the questions and score good marks like Grade B And C grade respectively in respective exam.
EOL: Extra Ordinary Learner: Those students who use very less time to solve the questions and score excellent marks in any difficulty level questions. Table III shows the mapping rules of two inputs ***Time*** and ***Grade*** which obtains ***Remark*** as a Output

Table III: Output Variable ***Remark***

Grade / Time	**A**	**B**	**C**	**D**	**E**
VL	EOL	EOL	FL	SATL	AL
Less	EOL	FL	SATL	AL	SL
Average	FL	FL	SATL	AL	SL
More	FL	SATL	AL	SL	WL
Extensive More	STAL	AL	SL	WL	WL

To obtain output of variable ***Remark*** *using* **FIS,** rules are defined these rules are depicts in **Table IV.**

Table IV: If-Then Rules

IF	**Time**	Grade	Then Remark
Rule 1	VL	A	EOL
Rule 2	VL	B	EOL
Rule 3	VL	C	FL
Rule 4	VL	D	SAT_L
Rule 5	VL	E	AL
Rule 6	L	A	EOL
Rule 7	L	B	FL
Rule 8	L	C	SAT_L

Rule 9	L	D	AL
Rule 10	L	E	SL
Rule 11	A	A	FL
Rule 12	A	B	FL
Rule 13	A	C	SAT_L
Rule 14	A	D	AL
Rule 15	A	E	SL
Rule 16	M	A	FL
Rule 17	M	B	SAT_L
Rule 18	M	C	AL
Rule 19	M	D	SL
Rule 20	M	E	WL
Rule 21	EM	A	SAT_L
Rule 22	EM	B	AL
Rule 23	EM	C	SL
Rule 24	EM	D	WL
Rule 25	EM	E	WL

Where in time VL-Very Less, L- Less, A-Average, M-More, EM-Extensive More
In order to design a user friendly environment model for evaluating student learning capability while considering more input factors other than obtained score researcher proposes following algorithm.

III. RESEARCH METHODOLOGY

Proposed Algorithm

Step 1: According to algorithm in the proposed work two parameter are used as input which are TIME &GRADE and one output which is RESULT.

Step 2: Each input parameter is categorised in 5 linguistic variables and output parameter is categorised in 6 linguistic variables.

Step 3: On the basis of these 2 inputs and 5 linguistic variables in each inputs, 25 ($5^2 = 25$) linguistic strings are created. These are nothing but 25 if-then fuzzy rules which are required for taking decision and prediction.

Step 4: Fuzzy utility sets are created for each output linguistic variable for its lower bound value and upper bound value.

Step 5: Optimal fuzzy set is developed from intersection of respective upper bound and lower bound set of each output linguistic variable.

Step 6: The Best optimal set is developed by taking largest value from each optimal set of output linguistic variable of output parameter.

Step 7: Calculate total degree of match for given input values using triangular membership function for input parameter time and grade, this is denoted by $D_{MT} = [\min(D_{M1}, D_{M2})]$

Step 8:For given input apply the fuzzy if-then rules for prediction and degree of best optimal i.e. D_{BO} is calculated for the predicted output

Step 9: Calculate Degree of match that is difference as $D = |D_{MT} - D_{BO}|$

Step 10: As per NULL hypothesis when difference is near to zero i.e. less than 0.5 then our **prediction is right or satisfied otherwise prediction is wrong or unsatisfied**.

Following figure shows the flowchart of proposed algorithm working

Flow Chart

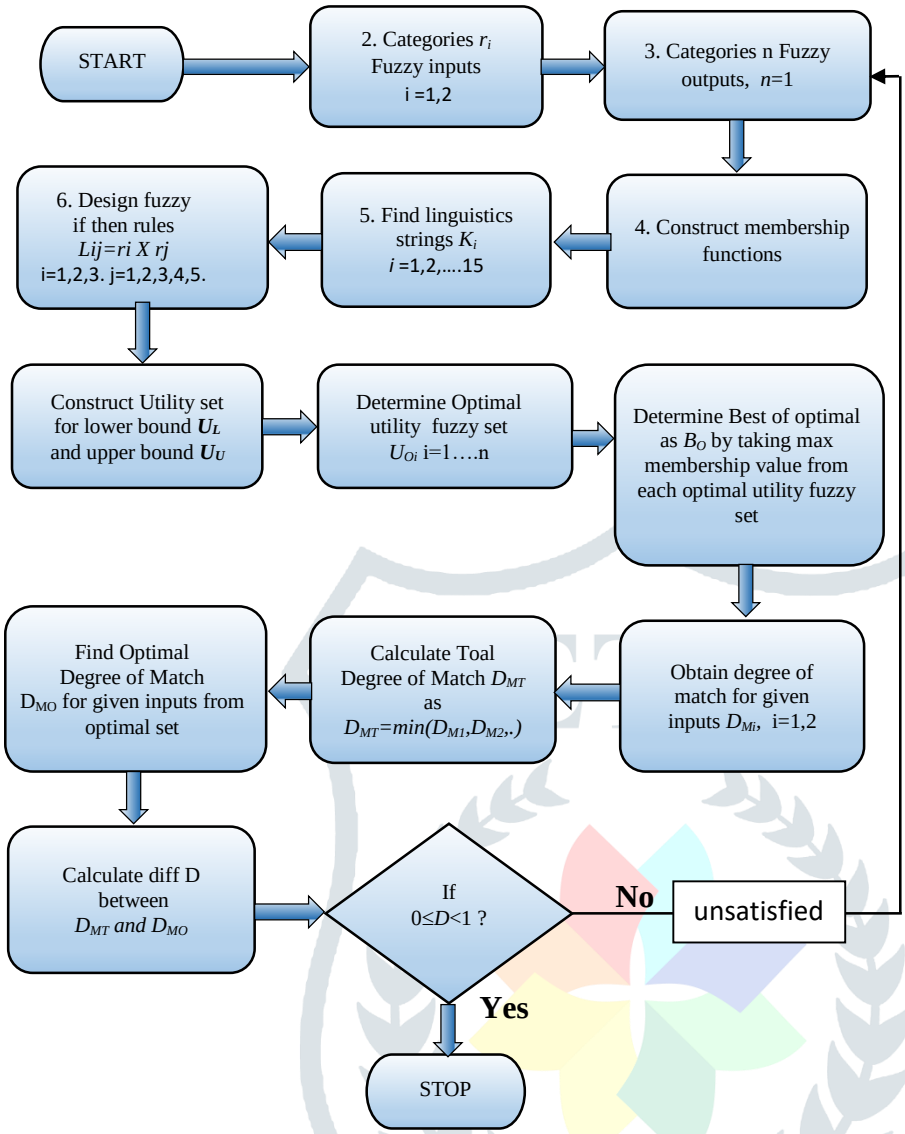

Figure 1. Flow Chart of proposed algorithm

Following table shows predicted remark for students according to input obtained.

Table V: Time and Grade of Various Case studies with predicted remark

Case study	TIME (sec.)	GRADE (mark)	Predicted Remark
1	**1300**	**6**	**WL**
2	871	18	EOL
3	400	14	EOL
4	659	14	FL
5	276	13	FL
6	246	12	FL
7	767	11	SATL
8	182	9	SATL
9	214	9	SATL
10	449	9	AL
11	581	9	AL
12	994	9	AL
13	1370	9	WL
14	773	8	AL
15	1329	8	WL

16	1507	8	WL
17	393	7	SATL
18	744	7	AL
19	839	7	AL
20	957	7	AL
21	372	6	AL
22	834	6	SL
23	699	5	SL
24	765	5	SL

IV. RESULTS AND DISCUSSION

Case Study 1

For analysing the prediction of algorithm and FIS result case study was done. Here obtain degree of match for case study 1 using the input TIME = r_i = 1300 sec. and score = r_j = 6 marks

$DM_1 = \frac{x-a}{b-a} = \frac{1300-1000}{1500-1000} = \frac{3}{5} = 0.6$ where 1000<x<1500

$DM_2 = \frac{x-a}{b-a} = \frac{6-5}{7-5} = \frac{1}{2} = 0.5$ where 5<x<7

$DM_{T=} [\min(D_{M1}, D_{M2}] = [\min(0.60, 0.50]$

$DM_{T=} 0.5$

Depend on input the learner is predicted as weak learner and hence best optimal value for weak learner is considered which is 0.266 and compared with total degree of match

$DMO_{WL=} 2 * \mu(xi) - 1$

$DB_O = DMO_{WL=} 2 * (0.266) - 1 = 0.468$

$D = |DM_T - DB_O| = |0.5 - 0.468| = 0.032$

Result of case study 1: Degree of matching means "if difference between total degree of match of input and optimal degree (Predicted) is near to zero then the level of satisfaction is increases otherwise level of satisfaction decreases".

In above case study the difference Dwhich is near to zero. Here predicted remark for particular student is closer to optimal remark. This shows that degree of match is satisfactory. And proposed algorithm works according to our FIS rules.

Similarly for analysing Algorithm and FIS rule case studies were conducted for all 23 cases. Table VI shows result of all the case studies.

Table VI: Final Result of showing Satisfaction Level of Algorithm

Case No	**Input x (for Grade)**	**Input x (for time)**	**DM_T = Min(DM_1,DM_2)**	**D_{BO} = (2*Bo)-1**	**D= D_{MT} - D_{BO} |**	**Satisfaction Level**
1	**18**	**871**	**0.200**	**0.929**	**0.729**	**Decreased**
2	14	400	0.333	0.6	0.267	Increased
3	14	659	0.333	0.6	0.267	Increased
4	**13**	**276**	**0.000**	**0.856**	**0.856**	**Decreased**
5	12	246	0.333	0.6	0.267	Increased
6	11	767	0.333	0.32	0.013	Increased
7	9	182	0.333	0.32	0.013	Increased
8	9	214	0.333	0.32	0.013	Increased
9	9	449	0.333	0.32	0.013	Increased
10	9	581	0.011	0.32	0.309	Increased
11	9	994	0.333	0.4	0.067	Increased
12	**9**	**1370**	**0.034**	**0.632**	**0.598**	**Decreased**
13	8	773	0.333	0.116	0.217	Increased
14	8	1329	0.333	0.632	0.299	Increased
15	8	1507	0.333	0.632	0.299	Increased
16	7	393	0.333	0.32	0.013	Increased

17	7	744	0.333	0.116	0.217	Increased
18	7	839	0.042	0.116	0.074	Increased
19	7	957	0.333	0.116	0.217	Increased
20	6	372	0.333	0.116	0.217	Increased
21	6	834	0.079	0.4	0.321	Increased
22	5	699	0.000	0.4	0.400	Increased
23	5	765	0.000	0.4	0.400	Increased

In above table observe that out of 23 cases 20 cases matches the criteria which shows increased satisfaction level i.e. $D=|DM_T-DB_O|<=0.5$ and few cases shows the satisfaction level decreased as D>0.5 so only 3 cases are not matched as per decided criteria. Statistically calculated the accuracy of obtained result in which it indicate that 87% cases are matched as per prediction of proposed algorithm and 13% cases are not matched as per decided criteria.

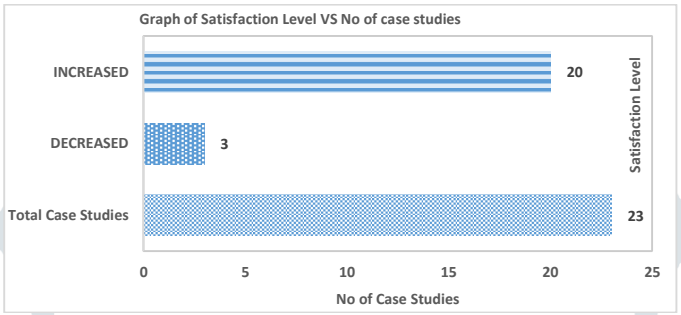

Figure 2. Graph of Satisfaction Level of Degree of match

V. CONCLUSION:

The Satisfaction criterion measured by proposed algorithm gives 87% satisfactory result. The lacuna in traditional result analysis can be overcome by proposed algorithm and FIS soft computing tool which uses different factors which effects on the result. Proposed research works on only two parameters. This research work trying to adopt new technology in traditional result analysis which will help for categorizing all the learners depending upon there capability. As the number of parameter are increased for analysis the complexity for prediction is increased. Proposed Algorithm and FIS gives best solution with easy method in complex analysis when multiple criteria are consider for evaluation.
Based on the result analysis it is cleared that proposed algorithm using FIS model is suitable for prediction of learner's category.

Future Work:
Researcher wants work on this model in future using many parameters like level of Bloom's Taxonomy such as Remembering, Understanding, Analysing, Applying, Evaluation, and Creation. Also Researcher works on FIS-Soft computing model for categorizing the learners. Which will be helpful in result analysis system.

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