Fuzzy Logic Based Intelligent Question Paper Generator

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Abstract*— Examinations play a vital role in deciding the quality of students. Generating an effective question paper is a task of great importance for any educational institute. Conventionally question papers are developed manually. In this paper, a fuzzy logic based model is proposed for autonomous paper generation, using MATLAB®. Comparative analysis with classical method is done and fuzzy model is found to be more reliable, fast and logical.

Keywords*— Fuzzy logic, IQPGS, Classical Method, A/D, E/M/D.

I. INTRODUCTION

Education is the backbone of society and examination is of great importance, so the system has to be designed and administered in a systematic manner. The examination system i.e. , being followed in most of the educational institutions is conventional and is unable to access the knowledge gained by the student. The predominant methodology is that, a certain predetermined number of faculties are handed over a syllabus and allocated the task of framing a question paper out of it. One of so developed question papers is picked up randomly and used for the purpose and this method is stated as Classical Method. This system suffers from the following disadvantages: dependency on intelligence of single person might raise the probability of error, due consideration might not be given to important part of syllabi, secrecy may get compromised and full utilization of resources might not be possible, hence raising the cost. According to the need, an autonomous system named as Intelligent Question Paper Generation System (IQPGS) is proposed, so as to make the system more efficient, reliable, improve its quality, and also to reduce the time taken by instructor in setting the question papers manually. It can also help to solve some critical issues like duplicity, storage of previous data and above all secrecy of question papers. Framing of a question paper requires a number of parameters to be considered; like difficulty level, numerical and theoretical content of the paper, weightage of questions according to marks etc. Although these parameters are matter of approximate reasoning because while deciding the paper manually, there are no such hard and fast rules for every subject to follow some common terminology. Every subject has a different approach. So, precise rules cannot be made about the numerical and theoretical content, difficulty etc. of the paper. Defining separate rules for each subject of every discipline is not a feasible option and is quite illogical. Humans are good in approximate reasoning but not in precise one, converse is true for machines. We can have advantage of both types of reasoning for computation. Fuzzy Logic can utilize human reasoning effectively [4]. In this paper a Fuzzy logic based approach is implemented for logical selection of these parameters while framing question paper for every subject irrespective of its discipline. System decides the parameters itself by taking some inputs from the users. All independent and dependent parameters are categorized based upon some logic so that system can easily be acquainted with them. A question paper can be categorized in two ways: Content of the paper (subcategory: Analytical (A), Descriptive (D)) and Difficulty Level of the paper (subcategory: Easy (E), Medium (M), Difficult (D)). Both the analytical and descriptive questions can be of any difficulty level, so both A/D and E/M/D parameters are considered as independent of each other.

Following this introduction a brief background of the work based on fuzzy logic and data used is presented in section 2. The proposed fuzzy based model and its various phases of analysis is described in section 3. Analysis and explanation of the results is presented in section 5. Section 6 concludes the work done and suggests future directions for further improvements.

II. BACKGROUND

A. Fuzzy Logic

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

In 1965, Zadeh proposed a complete theory of fuzzy sets to represent and manipulate ill-defined concepts and according to Zadeh " in contrast to traditional hard computing, soft computing exploits the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, low

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solution-cost, and better rapport with reality" [4]. Fuzzy logic is a method to formalize the human capacity of imprecise or approximate reasoning. Such reasoning represents the human ability to reason approximately and judge under uncertainty. In fuzzy logic, all truths are partial or approximate [7]. It uses a multi-valued membership function to denote membership of an object in a class rather than the classical binary true or false values. Fuzzy set is described by a membership function (μ) that maps a set of objects onto the interval of real numbers between 0 and 1. In standard set theory, an object is either a member of a set or not a member of the set. In fuzzy set, the transition from membership to non-membership is gradual rather than abrupt because there are non-distinguishable boundaries [6].

B. Sample Data

A brief overview of complete system is given by a block

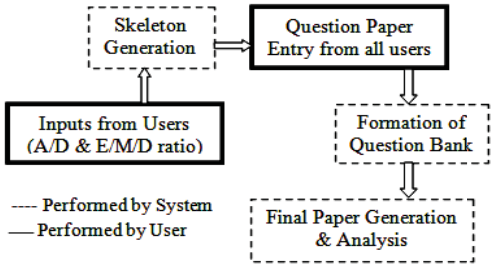

Fig. 1. Overview of Proposed System

diagram in Fig. 1. For autonomous generation of question paper, working of the whole system has been divided into three phases. In the first phase, system requires four users to enter their choices for Analytical, Descriptive and Easy, Medium, Difficult parts to provide some means for logical division of the paper according to marks. Users are allowed to choose any value for Analytical and Descriptive, both in range of 0-10 (10 being the highest value and 0 being the lowest value for analytical and vice-versa for descriptive). Users may also choose floating point numbers for A and D, irrespective of each other (Sum may or may not be 10). For E, M and D, user can give only integers values such that sum of all the three parameters must be 10, satisfying the following criteria: $1 \leq E \leq 5$, $4 \leq M \leq 10$ and $1 \leq D \leq 5$.

In the second phase, system provides a fixed skeleton (predefined) along with various parameters on the basis of inputs from all the four users. In this paper, a total of 100 marks have been divided into three parts. Part-I contains 5 questions of 2 marks each, part-II contains 3 questions of 5 marks each and part-III contains 5 questions of 15 marks each. Every time a new skeleton is generated, the E/M/D and A/D parameters get altered. This skeleton is provided to the user via an Interface to enter questions according to the given parameters. User also has to provide unit number for each question they enter. It is supposed that every subject is divided in to 10 units.

Third phase is not accessible by users/faculties; it is used at the examination end by authorized person only. System develops a question bank from all the question papers entered by all the users, using which it provides an analysis of internal process with final output as a generated question paper. Number of users, skeleton of paper and all other parameters provided here are not rigid; system is quite flexible and parameters are easy to change as per requirements.

III. Proposed System

Considering the short comings of conventional system, an eager need was felt to redesign the whole system. To develop a new examination system, system was closely observed. Some qualities and capabilities which the system should carry are, developing the question bank automatically, limiting the human intervention to raise the secrecy standards, providing more flexibility in logical selection of questions for skeleton framing and handling multiple attributes containing imprecise data to perform human-like reasoning effectively.

A brief overview of the complete system has already been given in the methodology section Skeleton generation which is up to the second phase is performed using fuzzy logic but the picking logic of questions from question bank and analysis part of paper generation process (third phase) is performed

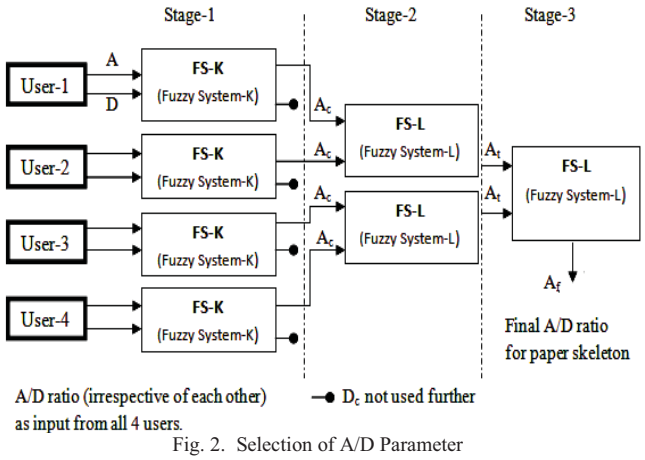

Fig. 2. Selection of A/D Parameter

using the statistical methods. Fig. 2 represents a Fuzzy Model used for deciding final A/D value by processing choices of all users. In this model two MAMDANI type FIS (Fuzzy Inference System) named as FS-K (Fuzzy System-K) and FS-L (Fuzzy System-L) are used.

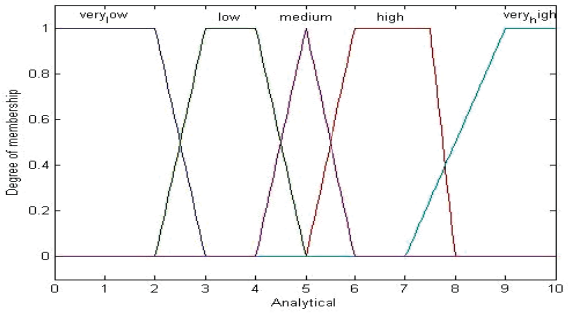

Fig. 3. Membership functions for Analytical

Fig. 3 represents membership function for first input, both the outputs of FS-K and for two inputs and one output of FS-L.

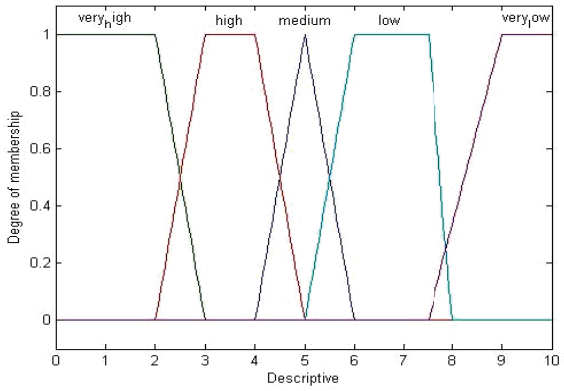

Fig. 4. Membership functions for Descriptive

Fig. 4 represents membership function of second input of the FS-K.

A. Rules and Inference

Next step in fuzzy logic model development is to decide the If-then rules. The maximum number of fuzzy rules is calculated multiplying the number of fuzzy sets of all inputs. As we have 2 inputs with 5 fuzzy sets in each input, total If-then rules will be 25. Every rule is deduced by using each possible combination of every fuzzy set of both the inputs of FS-K and then mapped on to the fuzzy set of the output by finding maximum μ value. E.g., consider A as high and D as very_high; find out the points having membership value, μ=1. In the set of high for A the candidates having μ=1 are 6, 7 (considering only integers) and for D, in the set of very_high such candidates are 0, 1 and 2. Find out the average of every possible combination of these values ({6+0}/2=3, {6+1}/2=3.5, {6+2}/2=4, {7+0}/2=3.5, {7+1}/2=4, {7+2}/2=4.5). Then these averages are taken in descending order of frequencies and are mapped on the output membership function. By tracing these values on membership function for output 1 of FSK-K, find out which points carry maximum value of μ collectively (frequency of 3.5 and 4 is 2, sum of individual μ is 2 for both and they belong to same group in output; for A out it is high and D out it is low and can be confirmed from rule no.5). Some of the rules are given below:

1. If Analytical is very_low and Descriptive is very_low then Analytical_Out is medium, Descriptive_out is medium.
2. If Analytical is low and Descriptive is very_low then Analytical_Out is high, Descriptive_out is Low.
3. If Analytical is medium and Descriptive is very_low then Analytical_Out is high, Descriptive_out is Low.
4. If Analytical is high and Descriptive is very_low then Analytical_Out is high, Descriptive_out is Low.
5. If Analytical is high and Descriptive is very_high then Analytical_Out is high, Descriptive_out is Low.

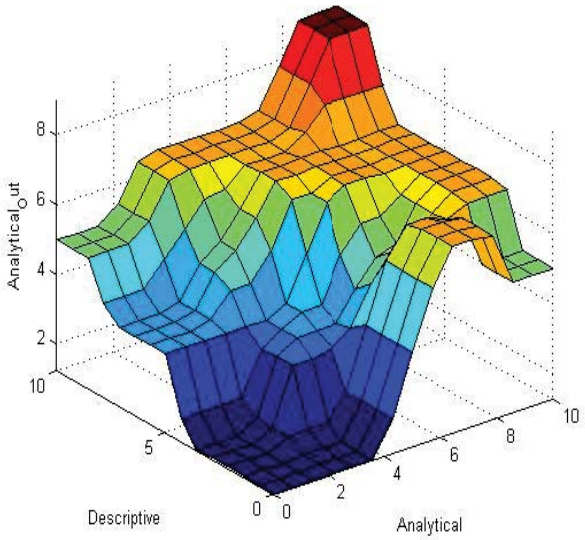

Fig. 5. Surface viewer of FS-K

Fig. 5 represents the result of FS-K system via surface plot. It shows how output is varying in accordance with input.

B. Selection of Parameters (First Phase)

In the Stage-1, FS-K requires all users to enter their input for A/D; system modifies the inputs to corrected one on the scale of 0-10 as A & D becomes counter part of each other. (For ex. User-1 enters A=9.56, D=4; D will be treated as 6 {10-4=6} in FS-K because membership functions are designed in converse nature, output of the system FS-K will be A_c=7, D_c=3). A_c/D_c are the corrected analytical and descriptive values. FS-L is a cascaded part of FS-K, in Stage-2 it receives only A_c from output of FS-K (A_c/D_c); because once A_c is known, D_c can easily be evaluated by subtracting it from 10. The four A_c values are clubbed into two groups (on the basis of weightage). These two groups are separately fed to the FS-L and two outputs are taken , then in Stage-3 again these two outputs of FS-L are taken as inputs for FS-L to give one final output as A_f (Fuzzy sets follow the Law of Associativity [4]).

A similar system like FS-L is used to evaluate the final value for E/M/D. The ranges of membership functions are different for E/M/D as compared to those in FS-L system for A/D. Clubbing the values of E from all the four users into two groups, further gives two values, one from each group on the basis of weightage. These two outputs are evaluated by the same system to obtain final value of E. In similar way all the final values are evaluated from inputs of four users. The algorithm given above describes, how to decide difficulty level (E/M/D) and content (A/D) of the every question according to the final values of parameters. Fig. 6 explains the

Algorithm for skeleton generation using flow chart. Value of 'w' is the number of questions in particular part. E.g. final values obtained from Fuzzy logics are A=7, D=3 and E=3, M=5, D=2. Value of A/D indicates that out of 100 marks,

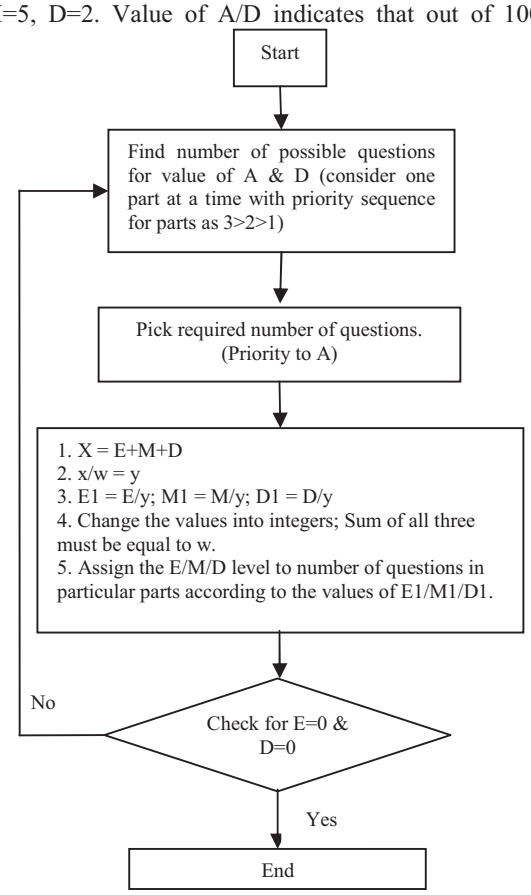

Fig. 6. Flow chart for Skeleton generation.

paper of 70 marks is analytical and remaining paper of 30 marks is descriptive. E/M/D ratio is maintained individually in each part. According to algorithm, first priority is for part-3 and requires 5 questions of 15 marks. To find out the possible no. of questions for A and D; divide marks for both of A and D by 15 and obtain the integer value (like, number of possible questions for A is 70/15=4, and for D is 30/15=2). It needs 5 questions for part-3 and priority is given to A; select all the 4 questions from A and the remaining one question from D. From next step x=10 (x=E+M+D). Number of questions in part-3 is 5, so w=5 and y=(x/w), so y=2 here. 'y' is the parameter used for finding the number of questions that would be easy/medium/difficult in every part and it is done by dividing the values for each of E/M/D by 'y', e.g., E1=3/2, M1=5/2, D1=2/2 gives E1=1.5, M1=2.5, D1=1. Convert these parameters into integer values according to the weightage of their floating part and sum of all the three must be equal to number of questions. In case, if two parameters have same weightage then priority is given to lower level. For next step remaining values of A=10 (4 questions are selected as A so {70-(15*4) =10}) and D=15. Check the values of A and D both, if they are zero, end the algorithm else go to step 1 again and start selecting questions for remaining parts.

C. Second-Phase (Question Bank Formation)

Skeleton generated in the first phase is considered as fixed for a particular paper and system requires all the 4 users to enter question papers with the given parameters. For question paper entry user is provided an interface. While entering questions user can't provide 2 questions from same unit in one part, system itself locks the unit number once selected, for the corresponding part only. System forms the question bank in a excel file having all 2-marks question in group-1 (g-1), all 5-marks question in group-2 (g-2), all 15-marks questions in group-3 (g-3).

D. Third-Phase (Final Paper Generation and Analysis)

In the final phase of IQPGS, one question paper will be generated from question bank which is already divided in the three groups representing different types of questions according to marks. Final interface is only for the authorized

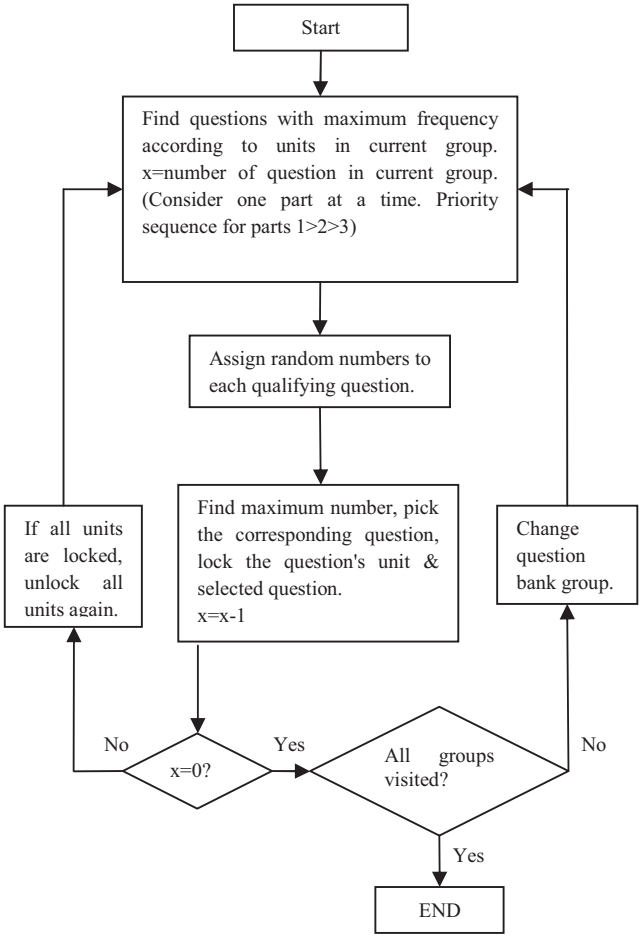

Fig. 7. Flow chart for Picking Logic

person at the examination end because of security issue. Logic for picking questions from the question bank, giving due

consideration to the important part of syllabi and to remove duplicity in questions has been described using an algorithm, in the Fig. 7 given below. According to the algorithm, g-1 is taken first because priority is given to the g-1 of the question bank. It consists of 5 questions of 2-marks from each user which makes a total of 20 questions of 2-marks from all. Find the frequencies of all the units i.e. which unit has been selected by more number of users and select those having maximum frequency of the questions according to unit number. Suppose from unit-5, 4 questions are in question bank and from unit-7, 4 questions are also there. In the case of maximum frequency clash, questions from both unit-7 & 5 will be considered as qualifying questions. In next step a random number (range 1-10,000) is assigned to each question. The question having maximum number will be selected as first question of 2 marks from paper. The unit number of that question and question itself will be locked. X is the number of question required in current part, part-1 corresponds to 2 marks questions so total number of question required for part-1 is 5, hence x=5. As questions are selected, x will go on decreasing by 1 i.e. x-1 until x becomes zero. If a condition occurs where x~=0 and all units are locked then all units will be unlocked again but not the selected questions. Once x=0 condition occurs, system will check that questions for all groups are selected or not. If not, then all the units will be unlocked again because group is changed. In this manner all question will be selected one by one and final generated paper will exported by the system to an excel file for further use.

IV. RESULTS

Proposed method is much faster than classical method (manual). Full utilization of resources, logical selection of questions (unbiased selection), removal of duplicity in questions, uncompromised secrecy issues, consideration of environmental concerns, emphasis on important part of syllabi and less man power are key advantages of the new system and there are lot of issues also which are solved by the system IQPGS. In case if paper is leaked then new paper can be framed in seconds by just one click while in classical method, it will require the whole process to get repeated. Fuzzy part of IQPGS also has computing advantages over classical method. Both methods have been compared for deciding the parameters (A/D and E/M/D). For comparison, all possible combinations of A and D e.g. 0, 0.5, 1, 1.5, 2, 2.5, - - - - 10 have been evaluated and found that classical method doesn't vary in range or gives fixed values (doesn't justify human reasoning well) and it always considers value of A quite higher than that in Fuzzy. If the value of one parameter is fixed and we check all combinations of it with varying values other parameter, then always there exist one or two terms here it is not able to evaluate it (refer table 1). In the same way, comparison is performed for the E/M/D system also and Fuzzy logic is found more advantageous.

TABLE I. COMPARISON OF FUZZY WITH CLASSICAL METHOD

Inputs		Fuzzy Results		Classical Result	
A	D	A	D	A	D
0	9	5	5	0	10
0	9.5	5	5	0	10
0	10	5	5	indetrmined	
0.5	10	5	5	10	0
2.5	3	2.35208	7.63776	2.63158	7.36842
2.5	2.5	2.35208	7.63776	2.5	7.5
2.5	2	1.35357	8.95245	2.38095	7.61905
2.5	1.5	1.35357	8.95245	2.27273	7.72727
3	9.5	6.61111	3.5	8.57143	1.42857
3	10	6.61111	3.5	10	0
3.5	10	6.61111	3.5	10	0
3.3	9.5	6.61111	3.5	8.75	1.25
3.5	9	6.61111	3.5	7.77778	2.2222

V. CONCLUSION.

In this paper a new fuzzy logic based IQPGS system for autonomous paper generation has been proposed. Comparison with classical method shows that the proposed system is more reliable in terms of duplicity removal, uncompromised issues, and lesser man power, logical in terms of unbiased selection and faster as the use of fuzzy logics in machines both approximate and precise reasoning are considered very well. In future, to make the system more enhanced adaptability by using feedbacks to make the system improve itself via self learning mechanism and detection of vague data entry will further be introduced.

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