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Career Counseling Model for Omani High School Students using Fuzzy Logic

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***Abstract*—** *the learning performance of students in basic education is considered as an essential criterion to evaluate and measure the quality of students using the grades of their academic performance. Assisting the student in making the best professional decision in selecting a major and, as a result, the career that most suits his abilities and interests, as well as preparing for and entering it, will boost the student's prospects of success, advancement, and development. Furthermore, will achieve a state of professional compatibility, which means that the role of career guidance is to assist the student in selecting the most appropriate profession for him, one that is capable of satisfying his various needs until he is satisfied, as well as contributing to work in quantity and quality so that others are satisfied with him. Therefore, it is very important to make the right career decision at the right age to avoid the consequences of choosing the wrong career. This study highlights the use of fuzzy logic technology to guide students to the right profession track, a proposed system has been designed to guide high school students to choose the correct courses which suit with their capacity and interests. The system recommends career options to students based on their academic performance (capacity) in grades five to ten, and compare the result with their choices based on interests in grade eleven. The system was finally prototyped as a MATLAB GUI application.*

Keywords— Fuzzy logic; Career Guidance; Career Counselling

1. INTRODUCTION

Based on the Royal Decree No. 120/2004 related to the issuance of the Omani Civil Service Law, the job is defined as a set of duties and responsibilities that are determined by the competent authority and which require specific qualifications and requirements for those who perform them. (Omani Civil Service Law 120/2004). Career guidance's major goal is to assist students in developing and applying knowledge, skills, and attitudes in order to make decisions about their study or employment alternatives and life responsibilities. Career guidance and student counseling are a vast and comprehensive concept; to implement this task effectively, several factors need to be considered.

Career guidance [1], according to (OECD 2004), refers to services that assist people of all ages in making educational, training, and professional decisions and managing their careers. While interviews are still the most common method of career advising, it also includes group talks, printed and electronic information, vocational education sessions, structured experience, telephone advice, and online help (OECD 2004).

Career guidance in public schools in the Sultanate of Oman depends on the student's performance in the past ten years and personal interests. In grade 10, the student chooses the courses that he will study in classes 11 and 12. These courses enable him to select one of the two tracks. The first track is pure mathematics, which depends mainly on his performance in the past years in mathematics and science courses, which rely on comprehension, analysis, and application skills. The second track is the applied mathematics, which depends on the student memorizing talent rather than any other skills.

This study aims to guide students to the correct track by executing two phases. The first phase proposes an artificial intelligence model using fuzzy logic algorithm in Matlab software. This method is done by collecting grades of 1000 in three introductory courses, mathematics, science, and the average of the rest basic subjects through levels from five to ten, these subjects are, Islamic, Arabic, English and Social Studies. Then calculating the average of these grades to use it as inputs for the proposed model. Simultaneously, the second phase compares the output of the proposed model and the actual grades for every student in level eleven to evaluate the proposed model's accuracy. Ultimately, the proposed model can infer if the student selected the track based on his capacities (proposed method) or his interests (academic performance).

2. LITRATURE REVIEW

2.1 Related Work

Fuzzy logic [2] emerged in the twentieth century, and by the beginning of the twenty-first, it was expected to be widely used in a variety of fields. The measuring and evaluation in educational environments is one of the implementations of fuzzy logic (Altrock, 1995). The proposed system that can consequently offer career guidance has been created. This new system is a web-based fuzzy logic system. The aim is to facilitate the process of career selection. In this system, understudies' earlier academic successes and instructors' perspectives were coordinated in a way which made it conceivable to distinguish the understudies' professional interests and capacities. The system predicts vocation school understudies' passion as to Accounting, Information Technology, Electronics and Automotive. Promising outcomes were acquired with respect to 300 fair ninth grade understudies as far as situating them towards a proper profession. In reference [3] a fuzzy expert system has built to recommend various successful career possibilities to students based on various aspects of the student given as input. To assist students, evaluate their interests, talents, and abilities, the method included aptitude and performance evaluations. The user can utilize the app to look into numerous job options and their potential. Allow the user to take exams and receive a thorough report on the appropriate vocations in order of preference. Finally, a list of well-known institutes for the suggested careers is displayed.

Another research conducted by [4] Occupation Recommendation (OCCREC), a hybrid recommendation system that combines content-based and collaborative filtering methods, was used in this study. It incorporated three pieces of data: student profiles, vocational preferences from the Holland code questionnaire, and behaviors. The student profile includes two sorts of information from Facebook: background and interests/hobbies. This system was tested on 612 students from Mongolia, Sri Lanka, Taiwan, and Thailand as part of the project. The students were also shown five vocations using five similarity measures: Euclidean, Intersection, Cosine, Jaccard, and Pearson. Finally, the study found that the hybrid recommendation with Pearson distance is appropriate for this type of data in order to recommend a profession based on student choices, behavior, and vocational interest. Universities provide elective courses in addition to compulsory courses that are required of all university students. Some students lack adequate guidance as to which courses to select. As a solution, by knowing the previous courses the student has studied, it possible to direct the student to suitable elective courses. The information from students' transcripts is evaluated in the study [5]. A link between the mandatory courses and the elective courses taken earlier by the student is established using this information. Data mining (decision tree algorithm) is used to extract the rules, and fuzzy logic is used to create an optional decision suggestion system. The experiments yielded positive results; it is worth noting that students who succeed in the compulsory courses also succeed in the related elective courses.

Further research conducted by [6] indicated, CBR and Decision Tree J-48 can correctly clarify how students select a career that exactly matches their skills and IQ tendency. When given enough data and attributes, the system appears to be able to appropriately propose majors with an accuracy of about 80%. CBR had the highest precision while Decision Tree J-48 had the lowest accuracy of the two algorithms examined.

Other reviews on the use of fuzzy logic to design an Automated Career Guidance Expert System [7] was developed in Nigeria to assist high school students in choosing career options that best suit their capacities and interests while considering their past course results. The case-base employed in this work consists of 800 training examples and 200 known testing cases. Both sorts of cases have ten attributes that indicate a student's performance in ten (10) different subjects, as well as one (1) output that represents the human counselor's suggestion to the student. The neighborhood parameter k and the similarity metric employed in the CBR algorithm were determined empirically. The CBR algorithm produced a 0 percent classification error on the test-case using Euclidean distance as the similarity metric and ten as the k- parameter.

Based on fuzzy logic approaches, the research [8] proposes a New Fuzzy Expert System for evaluating students' academic achievement. When the outputs of the fuzzy expert system are compared to the traditional and proposed fuzzy logic-based expert systems methodologies, a difference in outcomes may be detected. While the traditional approach sticks to a strict mathematical rule, fuzzy logic evaluation offers greater flexibility and reliability. The classical methodology, fuzzy-1, and fuzzy-2, as well as the new method, were compared in this work. We've seen that the proposed method (Fuzzy Expert System) is better appropriate for evaluating student performance than traditional Fuzzy Logic. Exam1, theoretical exam2, and practical exam3 are the three aspects of the suggested model for one academic course. It gets a novel method for evaluating students by using fuzzy logic based on the Mamdani methodology.

The methodologies in the research [9] used to predict student performance were grouped into three groups in this study: fuzzy logic, data mining techniques, and hybrid. The methodologies in these three categories have been examined, depending on the procedure employed, the quantity of the informative collection used, and the parameters used, among other factors. This research also uncovered the most prevalent factors affecting student success. During the research, previous data on grades is crucial in forecasting students' future academic success. Furthermore, researchers focused on the characteristics linked with the student's familial background, which have a major impact on performance.

Another research conducted by [10], proposed a system to evaluate students' academic performance using a fuzzy system. When the results are evaluated from the fuzzy system, the developed system outperforms than similar previous studies. This study has improved the student academic performance by considering important academic attributes semester, exam performance, sports activities, cultural activities, and social awareness, which are more relevant to students than targeting only semester examination-based evaluation. Student evaluation of the practical component of the various subjects in engineering institutes follows a fixed mathematical rule. Alternatively, an evaluation based on fuzzy logic can be more flexible and realistic. A model based on fuzzy logic has developed in this paper to assess the practical component (50 marks out of 150 overall) and the outcome of 20 students in action. Results were compared using the classical method. A comparison of the results showed differences between the classical logic method and the fuzzy logic method. It has found that certain-based assessment provides certain advantages, especially for low-grade students. The evaluation based on fuzzy logic is complex and needs MATLAB software. However, it is still desirable as the teacher can amend the rules at the beginning of the semester, according to his choice [11].

In research conducted by [12], a fuzzy-based conceptual framework is proposed. It consists of two parts. In the first part, the students will be analyzed for their capacities. In the second part, the available courses were suggested; the functional aspects related to their capabilities also were suggested. For the student's analysis, scores were considered on different courses in 10 + 2 criteria, and professional interest in various fields and fuzzy sets were formed. For example, fuzzy inference rules were framed for analyzing capabilities in the engineering, medical, and hospitality areas only. In the second part, the concept of forming relationships was used to suggest related courses and functions. While the study [13] done at a Malaysian university offers a fuzzy logic-driven employment suggestion system. Students benefit from the fuzzy logic technique since it makes career recommendations based on a career test. They focus just on one professional vocation, following the old technique, rather than looking for other alternative employment positions that match their skills and abilities. Implementing this technique yields superior results, and students can take part in it.

2.2 Gaps and Limitations

After studying the aforementioned proposed systems, we can see that they are all career counseling applications, though they provide guidance in different ways. Because most students have access to them, their material can be highly valuable to them. Unfortunately, these applications are restricted due to the fact that the information presented is exclusive to the nations in which they were built. Because different countries have diverse education systems and work markets, a country-specific career advising system is required. Each job requires information such as the value of education certifications, university majors, and work experience, and the number of positions available varies by country.

3. MATERIALS AND METHODS

3.1 STUDY GROUP

A random sample consists of 1000 students were used in this study from the same batch of government schools in the Sultanate of Oman. The study is based on the overall academic performance of students in Mathematics, Science, and the average of the rest basic subjects, Islamic, Arabic, English and Social Studies courses. In levels 5-10, the average student academic performance in each of the aforementioned subjects was taken to be used as an input to the proposed system.

3.2 Aim of the study

The main aim of this study is developing a proposed system using fuzzy logic approach to get a solution for the career selecting challenge. The student's performance in the previous academic years (5-10) is considered to use as inputs in the proposed system to finally get the right career path. Then, comparing the result of the proposed system with results of the classical system that already applied in schools to calculate the accuracy of the new system.

3.3 Fuzzy Logic Model

The fuzzy logic set was first introduced in 1965 as a mathematical technique of describing verbal ambiguity [16]. A technique for translating an input range to an output range is fuzzy logic. The significance of fuzzy logic stems from the reality that the majority of human thought, particularly common-sense thinking, is basically similar [17]. The usage of fuzzy sets, which are classes with non-sharp bounds and no apparent borders, is at the heart of fuzzy logic. Many systems' modeling necessitates the consideration of unknown variables. Many variables have non-statistical uncertainty associated with them. The rational framework of 'fuzzy set theory' can be used to manage this type of uncertainty. Linguistic variables and fuzzy if-then rules are two words in fuzzy logic that are important in its applications. Instead of "yes/no" or "true/false," fuzzy logic uses variables like "low" and "high." According to [18], linguistic variables are variables that represent the gradual transition from high to low, true to false, while fuzzy variables are variables that represent the progressive transition from high to low, true to false, and the fuzzy set is a set comprising these variables. The antecedent and consequent of an if-then rule are sentences comprising linguistic variables. Membership functions are used to define fuzzy sets. One of the most significant disadvantages of classical logic is that it is limited to two values: true or false; nevertheless, the advantage is that it is simple to model two-value logic systems, and we can deduce with accuracy. The physical world is analogous rather than

numerical. Although fuzzy logic can be thought of as a continuation of multi-value logic, its goals and applications are distinct from multi-value logic because fuzzy logic is a relative reasoning logic rather than a precise multi-value logic. A fuzzy set's membership function is written as μA(x), and its membership degree is an integer between 0 and 1. μA(x) is '1' if the variable clearly belongs to set A, and '0' if it definitely does not belong to set A. Traditional sets are distinguished by a single membership function, whereas fuzzy sets are distinguished by a variety of membership functions [19]. To improve the performance and dependability of the expert system in the decision-making process, fuzzy logic might be implemented. Fuzzy reasoning is supposed to provide an alternate method of controlling various types of imprecise data, which typically represents how people think and make decisions.

3.4 The principle of Mamdani fuzzy model

Identifying inputs and outputs is the first step in applying fuzzy logic to a system. In the study [14], three input variables have been feed the system as linguistic expressions; consists of the mean of GPAs in grades 5 to 10 of Mathematics, Science, and the average of the rest basic subjects, Islamic, Arabic, English and Social Studies. The output set is made up of two fields' point values for careers. Twenty-seven rules were pushed as parameters that had an effect on the system after the membership functions of the primary parameters and low and high limits were established. The rules were determined using the Mamdani extraction tool to determine the output membership function values. For defuzzification of the fuzzy system's output variables, the Centre of Gravity (centroid) technique was used.

3.5 Design of an orientation system with regard to a fuzzy logic model

This method's mathematical equation is given in Eq (1). The data and rules were automatically loaded into the system to calculate the defuzzification process.

$$z* = \frac{\Sigma\mu(z).z}{\Sigma\mu(z)} \quad (1)$$

μ(z) was obtained as a result of the weight of membership extraction procedure, z is the output value of each rule, and z* is the defuzzified value output. In a Matlab-developed software environment, the defuzzification procedure was carried out automatically.

4. EXPERIMENTAL RESULTS AND DISCUSSIONS

There are three stages to using a fuzzy logic model:

1. Fuzzification of 3 inputs: mathematics, science and basic subjects.

2. Establishing if-then rules and a mechanism of inference

3. Defuzzification of performance value: Using a suitable defuzzification approach, calculate the final output.

Figure 1 depicts the fuzzy logic-based evaluation model, which has three inputs and two outputs. Using the online MATLAB software, the building of such a fuzzy decision-making system is simple. MATLAB is a menu-driven program that lets you to create fuzzy structures like membership functions and a database of decision rules. The software is simple to use and understand. (2006, Dweiri & Kablan) [15] It comes with a fuzzy logic toolbox that may be used to create fuzzy inference systems.

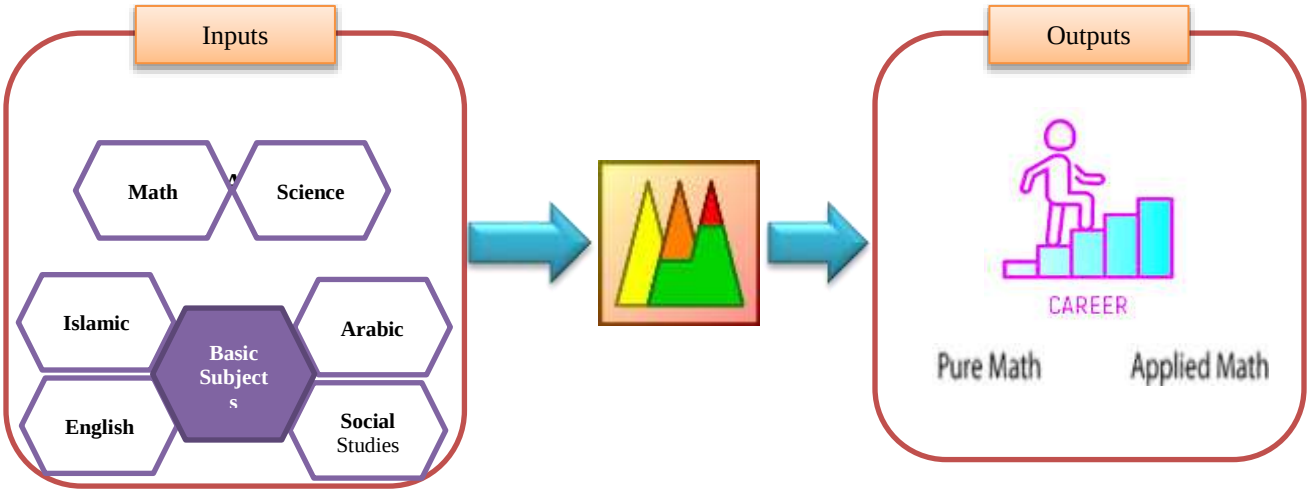

Figure 1: Student performance evaluation model based on fuzzy logic

4.1 Fuzzification of results and performance value

The results of each sub-component of the practical component were fuzzified utilizing input variables and fuzzy set membership functions. A membership function (MF) is a curve that translates each point in the input space to its corresponding membership value (or degree of membership) in the 0 to 1 range. The trapezoidal membership function (trimf) is utilized in the proposed FIS for both the input and output vectors.

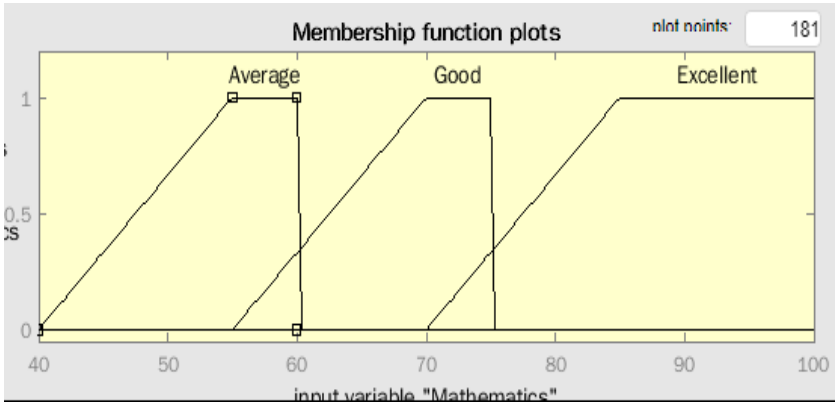

Figure 2: Membership Function for inputs and outputs.

4.2 Fuzzy Sets

The fuzzy rule set consist of three input variables named as 'Mathematics', 'Science' and 'Basic Subjects' based upon which the output variables named as 'Pure Mathematics and 'Applied Mathematics' are classified. All inputs and outputs variables are divided into three fuzzy sets i.e. Average, Good and Excellent based on the following equations:

$$\text{Average:}\quad \mu_a(x)=\begin{cases}\dfrac{x-40}{15} & for\ \ 40\le x\le 55\\ 1 & for\ \ 55<x\le 60\\ 0 & otherwise\end{cases}, \qquad (2)$$

$$\text{Good:}\quad \mu_g(x)=\begin{cases}\dfrac{x-55}{15} & for\ \ 55\le x\le 70\\ 1 & for\ \ 70<x\le 75\\ 0 & otherwise\end{cases}, \qquad (3)$$

$$\text{Excellent:}\quad \mu_e(x)=\begin{cases}\dfrac{x-70}{20} & for\ \ 70\le x\le 90\\ 1 & for\ \ x>90\\ 0 & otherwise\end{cases} \qquad (4)$$

Average, Good and Excellent three fuzzy sets are prepared here after discussion with the research committee members. For all variables in inputs and outputs 'Average' fuzzy set is taken interval of [40 55 60 60] to present the lowest student's academic performance. While 'Good' fuzzy set is taken interval of [55 70 75 75] presenting the medium student's academic performance. The last fuzzy set is 'Excellent' and takes the interval [70 85 100 100] to present the highest student academic performance. On the other hand, output variable, which is the result of student in academic performance, has the same three membership functions.

Table 1: Fuzzy set of input and output variables result

Linguistic Variables	**Interval**
Average	[40 55 60 60]
Good	[55 70 75 75]
Excellent	[70 85 100 100]

In this research and upon of the discussion with the committee members, grade '70' is approved as a mark that qualifies the student to study either "Pure Mathematics" if greater than or equals 70 or "Applied Mathematics" if less than 70 in levels 11 and 12.

4.3 Rules and Inference

If-then rules are the next step in developing a fuzzy logic model. Multiplying the number of fuzzy sets of all inputs yields the maximum number of fuzzy rules. Because we have three inputs, each with three fuzzy sets, there will be a total of 27 If-then rules. The criteria were developed following discussions with the research committee members. The following are the rules:

1. If Mathematics is Excellent and Science is Excellent and Basic Subjects is Excellent, then Pure Mathematics is Excellent.
2. If Mathematics is Excellent and Science is Excellent and Basic Subjects is Good, then Pure Mathematics is Excellent.
3. If Mathematics is Excellent and Science is Excellent and Basic Subjects is Average then Pure Mathematicsis Good.
4. If Mathematics is Excellent and Science is Good and Basic Subjects is Excellent, then Pure Mathematics is Excellent.
5. If Mathematics is Excellent and Science is Good and Basic Subjects is Good then Pure Mathematicsis Good.
6. If Mathematics is Excellent and Science is Good and Basic Subjects is Average then Pure Mathematics is Good.
7. If Mathematics is Good and Science is Excellent and Basic Subjects is Excellent then Pure Mathematics is Excellent.
8. If Mathematics is Good and Science is Excellent and Basic Subjects is Good then Pure Mathematics is Good.
9. If Mathematics is Good and Science is Excellent and Basic Subjects is Average then Pure Mathematics is Good.
10. If Mathematics is Good and Science is Good and Basic Subjects is Excellent, then Pure Mathematics is Good.
11. If Mathematics is Good and Science is Good and Basic Subjects is Good then Pure Mathematics is Good.
12. If Mathematics is Good and Science is Good and Basic Subjects is Average then Pure Mathematics is Good.
13. If Mathematics is Average and Science is Average and Basic Subjects is Excellent then Applied Mathematics is Excellent.
14. If Mathematics is Average and Science is Average and Basic Subjects is Good then Applied Mathematics is Excellent.
15. If Mathematics is Average and Science is Average and Basic Subjects is Average then Applied Mathematics is Excellent.
16. If Mathematics is Good and Science is Average and Basic Subjects is Excellent then Applied Mathematics is Excellent.
17. If Mathematics is Good and Science is Average and Basic Subjects is Good then Applied Mathematics is Excellent.
18. If Mathematics is Good and Science is Average and Basic Subjects is Average then Applied Mathematics is Excellent.
19. If Mathematics is Average and Science is Good and Basic Subjects is Excellent then Applied Mathematics is Excellent.
20. If Mathematics is Average and Science is Good and Basic Subjects is Good then Applied Mathematics is Excellent.
21. If Mathematics is Average and Science is Good and Basic Subjects is Average then Applied Mathematics is Excellent.
22. If Mathematics is Excellent and Science is Average and Basic Subjects is Excellent then Applied Mathematics is Good.
23. If Mathematics is Excellent and Science is Average and Basic Subjects is Good then Applied Mathematics is Good.
24. If Mathematics is Excellent and Science is Average and Basic Subjects is Average then Applied Mathematics is Good.
25. If Mathematics is Average and Science is Excellent and Basic Subjects is Excellent then Applied Mathematics is Good.

26. If Mathematics is Average and Science is Excellent and Basic Subjects is Good then Applied Mathematics is Good.
27. If Mathematics is Average and Science is Excellent and Basic Subjects is Average then Applied Mathematics is Good.

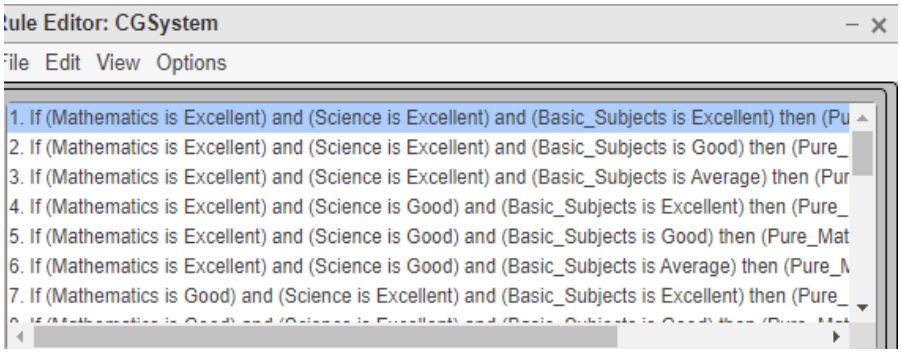

Figure 3: Rules editor in MATLAB

4.4 Defuzzification

The internal fuzzy output variable is defuzzified into a single crisp value throughout the defuzzification process. It is completed after the fuzzy inputs have been evaluated, but the final output is a single integer. The Fuzzy toolbox in MATLAB includes the centroid, bisector, middle of maximum, greatest of maximum, and smallest of maximum defuzzification algorithms. The most common defuzzification method is the centroid approach, which returns the center of the region under the curve. For defuzzification, the suggested FIS use the centroid technique. The crisp value is calculated of the formula given below:

$$Z = \frac{\int \mu_C(z) \times x \times dz}{\int \mu_C(z) \times dz} \qquad (5)$$

5. Conclusion

The proposed system is evaluated on the basis of certain values of grades of three subjects and the results were found satisfactory. In this research a large sample of 1000 students has been taken and fed their grades in three inputs and calculated the student performance. Based upon the system results, it recommended 928 students to their correct career path, thus, this result matches the results of the conventional method, while only 72 students did not choose the career path which matches their capabilities. The Accuracy of the system is calculated using the equation below.

$$\textbf{SA}= \frac{\textbf{Total Matches}}{\textbf{Total Performance Scores}} \times 100 = \frac{928}{1000} \times 100 = 92.8 \qquad (6)$$

Therefore, the accuracy of the system was found to be 92.8 percent (%). In details, the system succeeded to recommend 368/430 to "Pure Mathematics" with 86%. On the other hand, it succeeded to recommend 560/570 to "Applied Mathematics" with 98%. Based on fuzzy logic approaches, a new fuzzy logic model for evaluating students' academic achievement has been established in this study. There is a difference in outcomes between the classical and proposed fuzzy logic systems when the results of the proposed system are compared. While the present classical approach solely considers the student's interests, fuzzy logic evaluation offers a lot of flexibility and reliability. Furthermore, we contrasted the traditional method, which focuses solely on the student's interests, with the new method, which focuses on the student's academic achievement in grades five to ten. As a result, we can show that the proposed method (fuzzy logic system) is better suitable for evaluating student performance than traditional fuzzy logic. We evaluated our proposed system with the total of 1000 sample of students which gave almost 93% of accuracy.

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