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Using a fuzzy expert system as a decision support system to decrease time consumption in the UAST development process: A case study

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Abstract

Always the decision of the government to the private sector is faced with the challenges and high level of importance, because these decisions should be taken at the meeting of standards and functional requirements to overcome investors' interests. These decisions include education, and due to the governance nature of education and the governments' strategies in this area, the private sectors who act in it, have been affected by the consequences of different decisions. In this paper, our motivation is to propose a system to decide on how to develop applied academic educations at the Applied Science Education Centers (ASEC's) which are supervised by the University of Applied Science and Technology (UAST) in Iran. The method used is the Fuzzy Inference System (FIS) to reach this goal. The model performed in this study consists of a two-part FIS for two purposes straight ahead. The first concerns the quantitative development of higher applied education, including the number of Course Request (CR) for each ASEC with 4 inputs and 242 rules. The latter, is related to the qualitative development of higher applied education, including the assessment of the capability and competence of each ASEC for specific CR with the course and student admission background, specialty, committee's and councils opinion, and frequency of course in city or province with 9 inputs, 350 rules, and an output. Each section has its inputs and rules that are determined and used by experts in this domain.
Our results show that using this method, provides some cost and time savings. This model analyzes in less than 2 minutes, while in practice it could be gain within 1650 person /hours work in different committees that all of them have their costs. Also, results are very close to reality with the advantage that there is no way to apply personal preferences, which largely meets the needs of research.

Keywords: Fuzzy inference system, higher education development, university of applied science and technology

1 Introduction

One of the most sensitive and significant tasks in the University of Applied Science and Technology (UAST) Deployment Office is to manage the Course Request (CR) process, which in it the Applied Science Education Centers (ASECs) request some courses to execute, and it should be approved before they could do it. This process is done twice a year in September and January to student admission. The process of requesting and verifying is sensitive and challenging and there are always dissatisfactions in how it is done from ASECs. They always claiming severely that they could execute some courses which it did not approve for them.

Over the years, there have been many improvements and updates that take place to make this process intelligible, clear, and more precise. There are as follows:

1- Establishing a Management Information System (MIS) through which the following actions can be performed:

- Record all information about ASECs, such as; educational experiences, educational environments, office, and teaching staffs, etc.

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- Submit the CRs by ASECs.
- Insert the opinions of the various identities involved in this process.
- Status of each CR
- Provide various reports.

2- Use spreadsheet software to show happenings in sessions.

3- Organizing different sessions to provide a more accurate process.

4- Preparation of regulations, guidelines, and various standards.

However, there are always some mistakes in the process, although their quantity is very low, existing dissatisfactions will lead to further problems. Therefore, we decided to use the expert fuzzy system to standardize the decision results and reduce the human mistakes in the process as much as possible. Further studies on higher education development models are presented as follow:

Fazli et al. emphasize the review of provincial budgeting and its impact on education, economic development, and welfare indicators using mathematical modeling and model solving [17]. Mateu et al. providing a framework to help public education development policies and technology in middle-income countries with an emphasis on general education using the Delphi model and to conclude that the main challenge of future training is more than technology, social and cultural factors [12]. Zhu et al. discuss the influence of higher education scale and quality to economic growth and proof that the higher education development scale applies a significant positive effect on economic growth in central China; however, the contribution of higher education quality to economic growth is not considerable [29].

Discussion in key national and international forces transforming the higher education and strategies adopted to modernize and improve higher education in state universities in Sri Lanka is done and the governing bodies of the state university education, donor agencies, and strategies adopted for the development of higher education in the country during the last two decades to present have been reviewed [21].

A study was done in Austrian Universities of Applied Sciences' trends and challenges, the foundation of these kinds of education, autonomy and governance, UAS student numbers, academic staff, range of study programs, and the context of UAS development of these kinds of universities [18]. Lo [24] focused on the influence of local politics on higher education development in Singapore and Hong Kong.

Remittance has a critical role in higher education development. Imtiaz et al. [3] studied on relationship between remittances and the development of higher education in eight middle-income group remittance recipient countries namely Bangladesh, India, China, Egypt, Pakistan, Philippine, Nigeria & Mexico to examine the relationship between payment and education development and show the considerable impact of remittances on primary education and the occasion for higher education. Also, many studies emphasized the positive relation of remittances and school education [5], [7], [14].

According to Xuyang and Shanming [23] studies on Marxism and its emphasis on fairness or equity in China's higher education institutions, they note that these institutions should move from the traditional rule of bureaucratic management to rule of law. Developing higher education through this thinking, a new type of cooperation between governments, institutions, students, and society could be created. In this model, all contributors find their appropriate role with the full potential to activate and enhance the innovative capacity of higher education.

Grunzke et al.[9] presented the architecture and developments of metadata management for applied sciences. Their work could manage data safe and efficient, and make the data available to different users. They provide it to work with complex, big, and varying requirements data in a useable, efficient, and tolerable way.

Friman et al.[8] studied the effect of sustainable development in higher education institutes of Brazil (Feevale University) and Finland (Häme University of Applied Sciences (HAMK)). They studied the sustainable development steering policies' effect on higher education development, content curricula, and bachelors degree level in these two universities. They used the hermeneutic approach to analyze the relationship between society and the university.

The above researches discussed higher education and applied sciences development. they focused on the interaction of the economy, culture, and social aspects in higher education development, higher education scale, and quality to economic growth. They also analyze the trend of growth and challenges, data management, and requirements. In this paper, our purpose is to figure out some aspects of such trends like social demands, labor market needs, development potential and specialty in the private sector in each city or province, and the importance of evaluating educational performance on future development that the others didn't focus on.

In the following sections, the used methodology is introduced in section 2, and the proposed model is described in section 3. In section 4, the proposed model's application is examined in the real case, and finally, in section 5, discussed results and findings are presented.

2 Methodology

In this study, we have 6 professionals in applied science who taken part in our survey to specify membership functions for each input and output variable. The problem is divided to two parts, first: The number of courses is requested, and second: accept or reject the requested course. For each part rules for Fuzzy Inference System (FIS) have been codified based on its inputs and outputs exclusively.

One advantage of fuzzy logic is that it does not require precise mathematical models, it can work with ambiguous inputs, and it can carry out nonlinearity [25]. Fuzzy logic demonstrates the knowledge in terms of the rule-based approach, and it is robust and does not need precise and crisp inputs [13] [26] [27] [28]. FIS model has been applied in different fields of study. For example, Lin and Chen [10] used a FIS model utilizing satellite imagery to monitor ecologically sensitive ecosystems in a dynamic semiarid landscape. Chen et al. [6] proposed fuzzy inference as a powerful applicant for the analysis of structural systems under external excitations. Lin et al. [11] proposed the FIS model to risk assessment and potential hazard analysis of debris flows. Pourjavad and Shahin [16] used FIS to evaluate green supply chain management performance. Sweta and Lal [20] proposed a new method of e-learning system and used FIS to introduce a personalized adaptive learner model. Moallem et al. [15] used FIS to improve the segmentation results of the potatoes' image to classify them. Selvaganesan et al. [19] proposed a fuzzy-based fault detection and control system for switched reluctance motors using FIS.

In this paper, we decrease the uncertainty which is caused by human judgments, and we will do it in two parts. The first part's inputs are "the number of requested courses in the last few semesters, number of approved courses in the last few semesters, number of courses with more than 15 students in the last few semesters, and the learning centers space potential"and the output is "to decide the number of courses each ASEC could request".

The second part's inputs are "New or revival course, average acceptance of the field code in the last few semesters, degree of specialized field code, coordinating committee of the provinces vote, requested courses in the city with high and average specialization level for courses with an average degree of specialization, requested courses in the province with a high and average specialization level for courses with a low degree of specialization, Number of students admitted in the city, Number of students admitted in the province, and the Universities Supervisory and Evaluation Councils vote"and the output is "the decision about accepting or rejecting each CR".

Each part's input is the real inputs that are used to make a decision for those two outputs mentioned above in each semester. To evaluate the fuzzy system that was designed, we compare the results of FIS with the real results that we had in the last few semesters.

Peoples proofs can manage incorrect, obscure, and vague concepts properly. people usually cannot express their proofs and perceptions accurately, and they evaluate the experiences using statistical theories or probability. A Fuzzy system is a formal method to show and run uncertainties related to knowledge and humans perceptions and provides practical solutions to the problems that contain several variables. A Fuzzy system is a popular computing technic that uses theories of fuzzy sets, If-then fuzzy rules, and fuzzy arguments. By using the mentioned framework, argumentative traits and humans decisions can be formalized using some simple and intuitive IF (progressive) and Then (retrogressive) rules. Fuzzy systems use fuzzy logic for processing [1]. In these systems, a set of membership functions and fuzzy rules are used instead of absolute logical rules or 0 and 1, to get the inputs and conclude [22].

FIS changes the input into output using a series of operations. As it was seen, input and output of the FIS are defined as membership functions (MFs), and human-language rules are set. In this paper, we distribute the membership functions of the input of FIS to make our proposed approach more flexible and applicable to make a good decision.

Fuzzy sets and systems can be considered as one of the most important implementations of fuzzy logic and set concept to outreach the variations in multi-input single-output processes. The fuzzy controllers (if-then rules) are methodically evolved considering the data gotten, rules constitute the backbone of a fuzzy control system [2].

3 Proposed system

We used FIS to make a decision support system for two goals. One, to determine the maximum number of CR for each ASEC, and two, decide which course could be held on each ASEC.

3.1 First part

Models first part Structure is shown in Figure 1. As could be seen, we have four inputs and a FIS to reach our output. The inputs are as follow:

1- **Average CR Count:** The average number of courses that ASEC's request in a few past semesters.

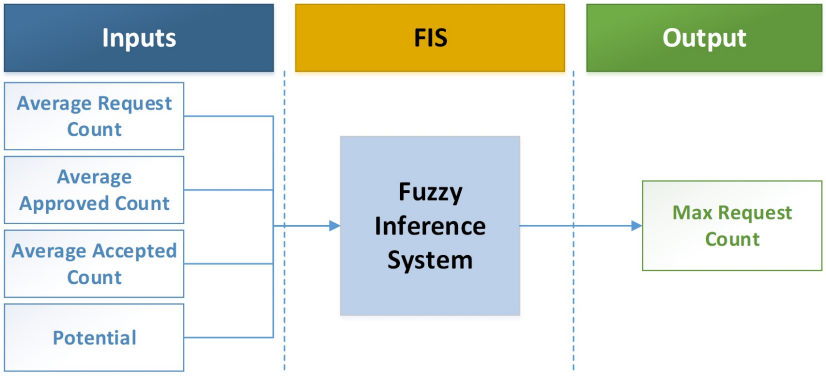


Figure 1: First part model structure

2- **Average Approved CR Count:** The average number of courses have been approved for each ASEC in a few past semesters.

3- **Average Accepted CR Count:** The average number of courses that the ASEC could have more than 15 student admission in it in a few past semesters.

4- **Potential:** The ASEC's physical capacity to hold students with assumed standards.

Our inputs are crisp, so to use the fuzzy expert system we should convert them to linguistic variables. It's done as shown in Table1. As you can see, we have 4 inputs and 1 output for the first part, and our inputs have 5 levels in different ranges; Too Low, Low, Mid, High, and Too High. Mamdani's fuzzy inference method is used in this study because it is typically used in such problems and it is the most popular method used in modeling assessment and evaluation with uncertain data [4]. In this method, the fuzzy control strategy is to map the inputs through the rules to an output [13].

Table 1: Inputs and output of the first part of the model

System					
Name	**Type**	**Version**	**Num Inputs**	**Num Outputs**	**Num Rules**
First Part	mamdani	2.0	4	1	242
	Input 1	**Input 2**	**Input 3**	**Input 4**	**Output 1**
Name	Request Count	Approved Count	Accepted Count	Potential	Max Request
Range	[0 35]	[0 35]	[0 25]	[-500 2000]	[0 30]
Num MFs	5	5	5	5	5
MF1:Too Low	[0 0 4 6]	[0 0 4 6]	[0 0 3 4]	[-3000 -3000 -300 -100]	[0 0 4 6]
MF2:Low	[4 6 10 12]	[4 6 10 12]	[3 5 9 11]	[-200 -50 0 100]	[4 6 10 12]
MF3:Med	[9 12 18 21]	[9 12 18 21]	[9 11 15 17]	[50 200 400 600]	[9 12 18 21]
MF4:High	[17 20 26 29]	[17 20 26 29]	[15 16 20 22]	[400 800 1000 1200]	[17 20 26 29]
MF5:Too High	[25 29 50 50]	[25 29 50 50]	[21 22 50 50]	[1000 1500 20000 20000]	[25 28 30 30]

To determine the number of rules for complete system description, we need to quantify the number of fuzzy sets for individual parameters. We should have:

$$N = n_1 \times n_2 \times n_3 \times n_4 = 5 \times 5 \times 5 \times 5 = 625, \tag{1}$$

rules, but because of problem conditions, some of the rules cannot happen. So we have only 242 rules for this part. Experts'knowledge is used to make these rules, and there are years and years'experience behind these rules (Figure 2). For example, if we have input 1 in high, input 2 is low, input 3 in low, and input 4 in med level, then the output would be at its low level (rule number 150). As can be seen in Table 1 and Figure 3 & Figure 4, we used a trapezoidal membership function to fuzzification the variables. In Table 1 we have the name, range, the number of MFs, and the level of MFs for 1st input in the second column, 2nd input in the third column, 3rd input in column number 4, 4th input in 5th column, and the last column we have the same data for output.

149. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is Low) and (Potential is TooHigh) then (MaxRequest is Med) (1)
150. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is Low) and (Potential is Med) then (MaxRequest is Low) (1)
151. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is Low) and (Potential is Low) then (MaxRequest is Low) (1)
152. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is Low) and (Potential is TooLow) then (MaxRequest is TooLow) (1)
153. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is TooLow) and (Potential is TooHigh) then (MaxRequest is Med) (1)
154. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is TooLow) and (Potential is High) then (MaxRequest is Med) (1)
155. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is TooLow) and (Potential is Med) then (MaxRequest is Low) (1)
156. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is TooLow) and (Potential is Low) then (MaxRequest is TooLow) (1)
157. If (RequestCoun is High) and (ApprovedCount is Low) and (AcceptedCount is TooLow) and (Potential is TooLow) then (MaxRequest is TooLow) (1)
158. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is Low) and (Potential is TooHigh) then (MaxRequest is Med) (1)
159. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is Low) and (Potential is High) then (MaxRequest is Med) (1)
160. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is Low) and (Potential is Med) then (MaxRequest is Low) (1)
161. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is Low) and (Potential is Low) then (MaxRequest is Low) (1)
162. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is Low) and (Potential is TooLow) then (MaxRequest is TooLow) (1)
163. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is TooLow) and (Potential is TooHigh) then (MaxRequest is Med) (1)
164. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is TooLow) and (Potential is High) then (MaxRequest is Low) (1)
165. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is TooLow) and (Potential is Med) then (MaxRequest is Low) (1)
166. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is TooLow) and (Potential is Low) then (MaxRequest is TooLow) (1)
167. If (RequestCoun is High) and (ApprovedCount is TooLow) and (AcceptedCount is TooLow) and (Potential is TooLow) then (MaxRequest is TooLow) (1)

Figure 2: Some of the first parts rules

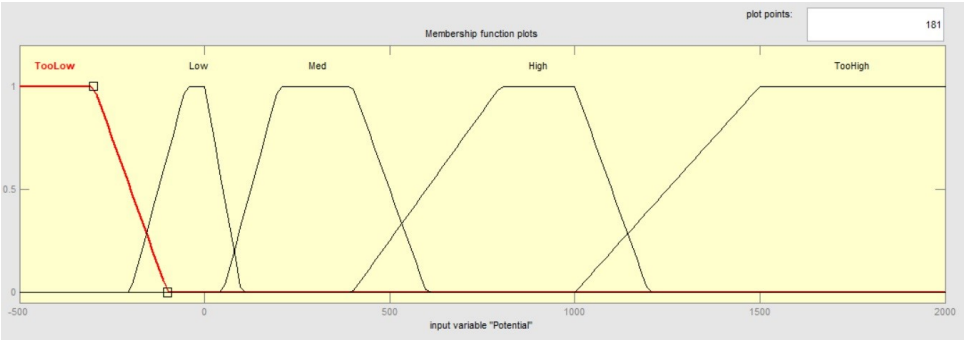


Figure 3: Fuzzy membership function for linguistic variables (Input: Potential)

Figure 3 shows the fuzzy membership function of the 4th input and its MFs. As could be seen, we have 5 trapezoidal MF with different ranges for it, which show different membership amount of each point. We have 3 fuzzy membership functions for other inputs with different ranges for MFs.

Figure 4 shows the fuzzy membership function of output –Max Request Count: the maximum courses that could be requested by each ASEC.

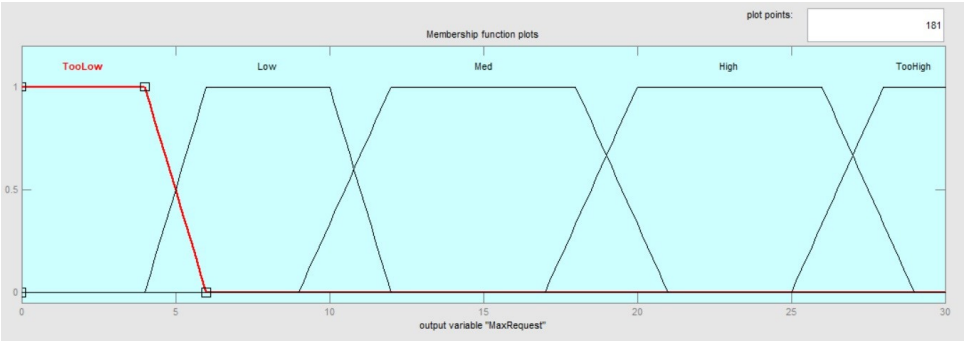


Figure 4: Fuzzy membership function for linguistic variables (Output: Max Request)

3.2 Second part

Model's second part Structure is shown in Figure 5. As could be seen, we have nine inputs and a FIS to reach our output. The inputs are as follow:

1- **Revival / New:** Should be the revival or new course for each ASEC. It means that if the ASEC holds the specific course for the first time, or it holds has held it before.

2- **Average Accepted in Location Code (LC):** It shows the average number of student admissions in that LC course in the few past semesters.

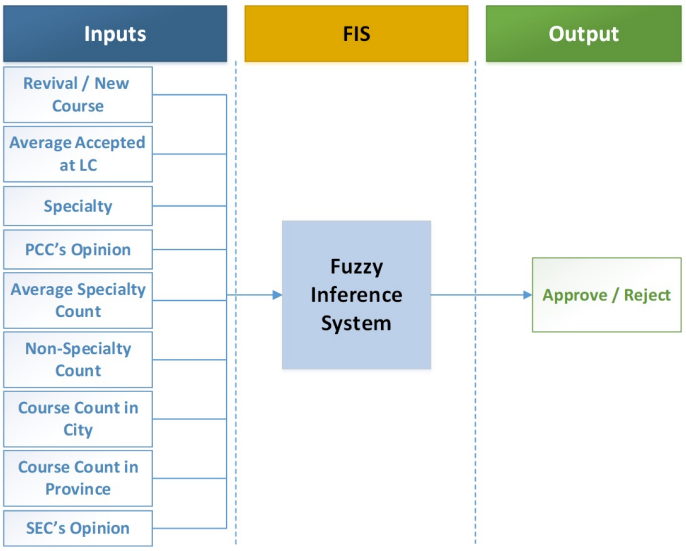


Figure 5: Second Part Model Structure

3- **Specialty:** Shows each ASEC how specialty to hold the specific course. It determines as 2: if the course was in the ASEC's specialty field, 1: if the course was somewhat related to ASEC, and 0: If the course was not related to ASEC.

4- **Provincial Coordinating Committee (PCC)'s Opinion:** PCC's opinion about the allocation of the specific course to an ASEC (each location code course).

5- **Average Specialty Count:** The number of courses with 1 specialty code in the city. Because if we did not accept a course or accepted less than its social demand in the city, we could accept it for each ASEC with a specialty code of 1.

6- **Non-Specialty Count:** The number of courses with 0 specialty codes in the province. Because if we did not accept a course or accepted less than its social demand in the province, we could accept it for each ASEC with a specialty code of 0.

7- **Course Count in City:** The number of acceptance for each course in the city.

8- **Course Count in the province:** The number of acceptance for each course in the province.

9- **Supervisory and Evaluation Council's (SEC's) Opinion:** SEC's opinion about each ASEC or the allocation of the specific course to it (each location code course).

We have 9 inputs and 1 output for the second part, as shown in Table 2, and our inputs have various levels from 2 to 5 in different ranges. To determine the number of rules for complete system description, we need to quantify the number of fuzzy sets for individual parameters. So we should have:

$$N = n_1 \times n_2 \times n_3 \times n_4 \times n_5 \times n_6 \times n_7 \times n_8 \times n_9 = 2 \times 5 \times 3 \times 2 \times 5 \times 5 \times 5 \times 5 \times 2 = 15000, \quad (2)$$

rules, but because of the problem's conditions, some of the rules cannot happen, so we have only 350 rules for this part (Figure 6). For example, if we have input 1 as new, input 2, 5, and 6 were not happening, input 3 in zero, input 4 in zero, input 7 is low, input 8 is too low and input 9 in 1, then the output would be at its low level (rule number 20). As could be seen in Table 2, 3, and Figure 7, we used the trapezoidal membership function to fuzzification the variables. In Table 2 we have the name, range, the number of MFs, and level of MFs for 1st input with two levels, 2nd input with five levels, 3rd input with three levels, 4th input with two levels, and in the last column we have the same data for input 5 with five levels and is continuous in Table 3 we have 6th input with five levels, 7th input with five levels, 8th input with five levels, 9th input with two levels, and in the last column we have our output in two levels.

Figure 7 shows the fuzzy membership function of the 7th input and its MFs. As could be seen, we have 5 trapezoidal MF with different ranges for it, which show different membership amount of each point. We have 8 fuzzy membership functions for other inputs with different ranges for MFs.

Table 2: Inputs and output of the second part of the model

System					
Name	**Type**	**Version**	**N. Inputs**	**N. Outputs**	**N. Rules**
Second Part	mamdani	2.0	9	1	350
	Input 1	**Input 2**	**Input 3**	**Input 4**	**Input 5**
Name	Rev/New	Ave Accept	Code	State	1Num
Range	[0 1]	[0 75]	[0 2]	[0 1]	[0 30]
N. MFs	2	5	3	2	5
MF1	New:[0 0 1]	TooLow:[0 0 10 12]	Zero:[0 0 1]	Zero:[0 0 1]	TooLow:[0 0 1 2]
MF2	Rev:[0 1 1]	Low:[10 12 18 20]	One:[0 1 2]	One:[0 1 1]	Low:[1 2 3 4]
MF3	-	Med:[18 20 30 35]	Two:[1 2 2]	-	Med:[3 4 7 8]
MF4	-	High:[30 35 50 55]	-	-	High:[7 8 14 15]
MF5	-	TooHigh:[50 55 75 500]	-	-	TooHigh:[14 15 30 30]

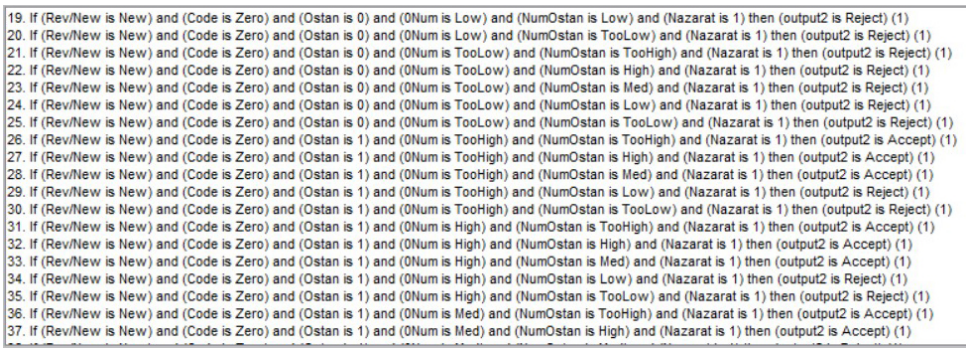


Figure 6: Some of the Second Parts Rules

Figure 8 shows the fuzzy membership function of output –Approve / Reject: The decision about allocates each course to each ASEC.

We also propose the surface graph of 2 inputs and output to show the relation between them, without other inputs in Figure 9(a). As could be seen, with the increase in input 9 we have an increase in output, also we have a sharp peak in the middle of 1st input beside the low level of input 9, and it continues with the increase in 9th input until the mid-level. We have the maximun amount of output in the upper half of input 9 and the lower half of the first input. It shows that if an ASEC held a course in the past, and the SEC agreed to continue, it would be approved regardless of other inputs.

4 Application

After proposing the model, we test it in two phases, as mentioned the model has two parts, with historical data that collect in 3 years. In the first part of the model, we want to decrease the number of requests have reliable requests, and save checking time. As could be seen in Figure 9(b), we have a 30 percent decrease and check out 2389 requests lower, which could save about 700 person-hours work.

Also, as we have shown in Figure 9(b), after engineering the requests, we have only 226 differences with the number of final approved requests, and it is shown that using this method, we have results close to reality and we discuss it in Figure 10(a). Figure 10(b) shows the histogram of the difference between request engineering results and final decision. We can see, it could help to make a better decision, because it was so close to the final decision, that made after numerous meetings and about 1650 person/hour work.

In the second part of the model, we want to check if we could have some rules which help us to decide about each CR. So we made a model, with 9 input and 350 rules. We run the model using MATLABs fuzzy toolbox with Intel(R) Core(TM) i7-2670QM CPU @ 2.20GHz, and as shown in Figure 10(a), we can say that we are successfully doing this.

As could be seen, we have Approximately 96 percent adaptation in rejecting some requests with real work, that done with the human in 11 meetings with 1650 person/hour work, within less than 2 minutes. So, if we accept a deviation of about 4 percent, we could replace these time consuming and expensive meetings with this model and make decisions in a short time.

Table 3: Inputs and output of the second part of the model(continue)

System					
	Input 6	**Input 7**	**Input 8**	**Input 9**	**Output 2**
Name	0Num	Num City	Num State	Nezarat	Acc./Rej.
Range	[0 30]	[0 200]	[0 200]	[0 1]	[0 1]
N.MFs	5	5	5	2	2
MF1	TooLow:[0 0 1 2]	TooLow:[0 0 15 20]	TooLow:[0 0 15 20]	Zero:[0 0 1]	Reject:[0 0 1]
MF2	Low:[1 2 3 4]	Low:[15 20 40 45]	Low:[15 20 40 45]	One:[0 1 1]	Accept:[0 1 1]
MF3	Med:[3 4 7 8]	Med:[40 45 75 80]	Med:[40 45 75 80]	-	-
MF4	High:[7 8 14 15]	High:[75 80 150 160]	High:[75 80 150 160]	-	-
MF5	TooHigh:[14 15 30 30]	TooHigh:[150 160 2000 2000]	TooHigh:[150 160 2000 2000]	-	-

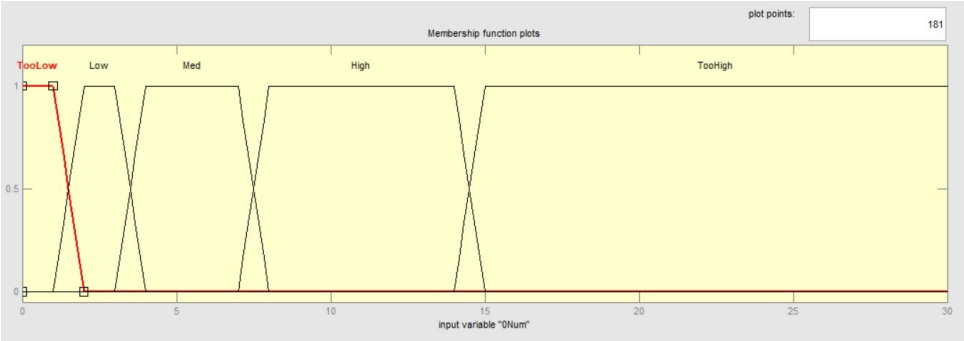


Figure 7: Fuzzy membership function for linguistic variables (Input: 0Num)

Table 4 compares the different methods of defuzzification, and as be shown, the centroid method does it better than the others.

Table 4: Compare the different defuzzification methods

Defuzzification Method	**Difference**	**Total Data**	**Adaptation Percent**
Centroid	338	7913	95.73
Bisector	339	7913	95.72
MOM	339	7913	95.72
LOM	344	7913	95.65
SOM	339	7913	95.72

In output data that we have from different defuzzification methods, the centroid, bisector, and MOM methods have smaller oscillations during steady-state compared to LOM and SOM defuzzification methods. And as showed in Table 4 the centroid method's results, was a little better than the others.

5 Discussion

In this paper, the aim is to examine the possibility of modeling the quantitative and qualitative development of applied science education in UAST. This work is always carried out through a series of meetings, which have led to a lot of time -as discussed earlier, there are about 1650 hours per semester- and money and people from different organizations and provinces of the country invited to attend these meetings. The model designed for this purpose consists of two FISs, each with its inputs, rules, and outputs. To determine the factors influencing the decision (inputs of both sections) and relevant laws, practitioners, and experts in applied science education were interviewed.

As shown in Table 5, the first part of the model, which involves the quantitative development of applied science educations, includes 4 inputs, 242 rules, and one output. The result indicates the number of CRs that each ASEC can apply for, concerning its facilities, equipment, and educational spaces and also, its previous educational records.

Also, Table5 shows the number of components in the second part of the model, which is related to the qualitative development of applied science education, includes 9 inputs, 350 laws, and one output. The result of this section

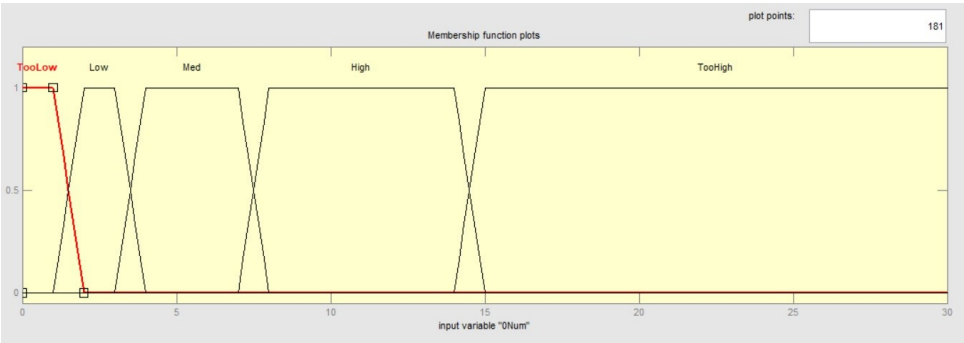
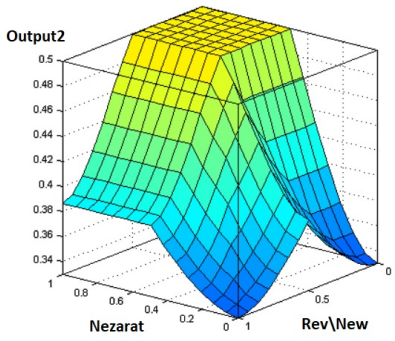
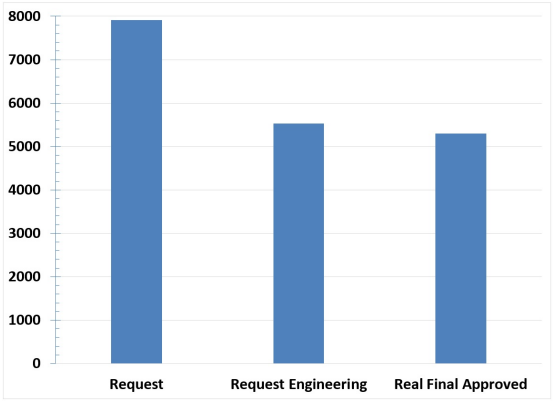


Figure 8: Fuzzy membership function for linguistic variables (Output: Accept / Reject)



(a) The surface graph between input 1 and 9 and their effect on output in the absence of other inputs



(b) Number of requested courses comparison between normal and request engineering

Figure 9:

determines that each ASEC will have the ability to execute any CR in the light of its educational history, the need for the labor market, and expertise in this field.

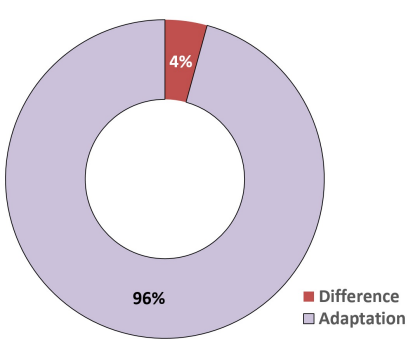
6 Conclusion

In this paper, we want to decide about the development of applied science in both aspects of quality and quantity. Usually, this decision is made by held time and cost consuming meetings, and about 1650 person/hours with attendance from different organizations and provinces.

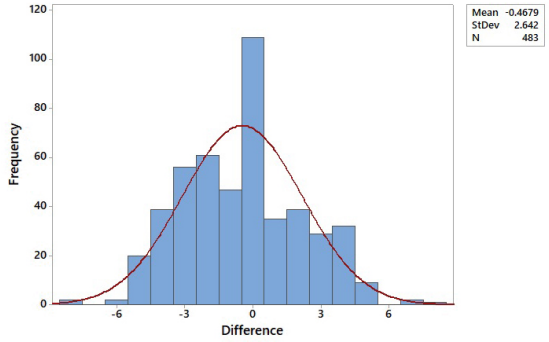
We propose a two parts model, and in each part, we built a FIS with different inputs, rules, and output. In part 1, we have a FIS with 4 inputs, 242 rules, and 1 output, and we want to decide about how many CRs could be held in each ASEC. In part two, we have a FIS with 9 inputs, 350 rules, and one output, and we aim to decide the quantitative development of each ASEC and decide about which CR could be held in it.

After comparing the results of the model with the decisions taken by the relevant committees for data over the past 3 years (6 semesters), about 96 percent of the compliance has been observed, which, is due to time and cost savings, represents a very satisfying performance of the model. Because the models response time was less than 2 minutes, this is a significant difference compared to 1650 person/hours of work and its additional costs.

We also ARE faced some limitations in our study, such as macro decisions based on Country Vision Document Development Programs, changes in development policies in these training which is communicated by the Ministry of Science, Research and Technology, opt-out some ACESs from continuing in this trainings because of meeting educational needs, restrict some ACESs because of poor quality of education, that lead to disrupting the balance of courses in some cities and provinces and it will affect the output of the model.



(a) Adaptation with human work



(b) Comparison between request engineering results and final decision

Figure 10:

Table 5: Details of the model

Model Parts	N. Inputs	N. Rules	Adaptation Percent	Goal
First	4	242	1	Quantitative Development
Second	9	350	1	Qualitative Development

7 Future research

For future studies, the use of ANFIS is recommended to extract rules closer to reality and to consider further inputs to increase the accuracy of the model's performance. Also, researchers could calculate the cost reduction that happened in this change, because of reducing time and ignoring so many meetings that should be held before using this method, that in this study we did not compute.

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