UNIVERSITAT ROVIRA i VIRGILI

Assignment 3: Fuzzy Expert Systems

Planning and Approximate Reasoning Practical Exercise (MAI)

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1 Introduction

In the world of publishing, it is crucial for editorial departments to be able to accurately predict the number of sales for a new book. This allows them to print and distribute the appropriate number of copies, avoiding excess inventory and ensuring that there are enough books to meet demand. In this work, we will introduce a fuzzy expert system that uses four key variables - author visibility, publisher prestige, previous sales, and publishing period of year - to calculate the number of books to print. By using fuzzy logic to model these variables and a set of rules to make predictions, this system can help editors make more informed decisions and improve the efficiency of their operations. The fuzzy expert system uses membership functions to determine the degree to which a given value belongs to each fuzzy set for each variable, and the fuzzy inference engine uses this information to calculate the output value for the "number of books to print" variable. This approach allows the system to make probabilistic predictions based on uncertain and imprecise data, making it a valuable tool for editorial departments in the publishing industry.

2 Fuzzy Expert System

A fuzzy expert system is a type of artificial intelligence system that uses fuzzy logic to process and analyze data. Fuzzy logic is a mathematical system that allows for the representation of uncertainty and imprecision in reasoning. In a fuzzy expert system, the system uses fuzzy rules to make decisions and provide recommendations based on input data.

To solve a fuzzy expert system, the following steps can be followed:

- Define the problem and identify the objectives of the system. This involves understanding the context in which the system will be used and the goals it is intended to achieve.
- Identify the input and output variables of the system. Input variables are the data that the system will use as input, while output variables are the results that the system will produce.
- Develop a set of fuzzy rules that capture the expert knowledge of the domain. These rules should be based on the input and output variables and should represent the expert's knowledge of the problem.
- Develop a fuzzy inference engine that can process the input data and apply the fuzzy rules to produce output results. This engine should be able to process the fuzzy input data and apply the fuzzy rules to generate output results.
- Test and validate the system to ensure that it is accurate and reliable. This involves using test data to evaluate the performance of the system and making any necessary adjustments to improve its accuracy.

Overall, solving a fuzzy expert system involves defining the problem, identifying the input and output variables, developing a set of fuzzy rules, creating a fuzzy inference engine, testing and validating the system, and implementing it in a real-world setting

2.1 Analysis of the problem

Editorials must be able to predict the number of sales of new books in order to accurately print and distribute them. Four factors that can affect sales are the visibility of the author, the prestige of the publisher, the book's previous sales, and the time of year it is published. We can use a fuzzy expert system to calculate the appropriate number of books to print based on these variables.

To design this system, the following steps can be followed:

- Define the problem and identify the objectives of the system. In this case, the problem is to determine the appropriate number of books to print based on the values of the four variables:

author visibility, publisher prestige, previous sales, and publishing period of year. The objective of the system is to provide a recommendation for the number of books to print that is based on the values of these variables.

- Identify the input and output variables of the system. In this case, the input variables are the four variables listed above (author visibility, publisher prestige, previous sales, and publishing period of year), and the output variable is the number of books to print.
- Develop a set of fuzzy rules that capture the expert knowledge of the domain. These rules should be based on the input and output variables and should represent the expert's knowledge of the problem. For example, the rule "IF author visibility is high AND publisher prestige is high AND previous sales are high AND publishing period is good, THEN number of books to print is high" could be used to represent the expert's knowledge that in cases where all of the input variables are favorable, the appropriate number of books to print would be high.
- Develop a fuzzy inference engine that can process the input data and apply the fuzzy rules to produce output results. This engine should be able to process the fuzzy input data and apply the fuzzy rules to generate output results.

Overall, designing a fuzzy expert system to calculate the number of books to print based on the values of four variables involves defining the problem, identifying the input and output variables, developing a set of fuzzy rules, creating a fuzzy inference engine and testing and validating the system.

2.2 Goal specification:

Overall, the goal of this system is to use fuzzy logic to make predictions or recommendations about book sales based on a set of input variables. By combining the input values and the rules of the system, the system can provide insights and guidance that can help editorials make informed decisions about book sales and printing.

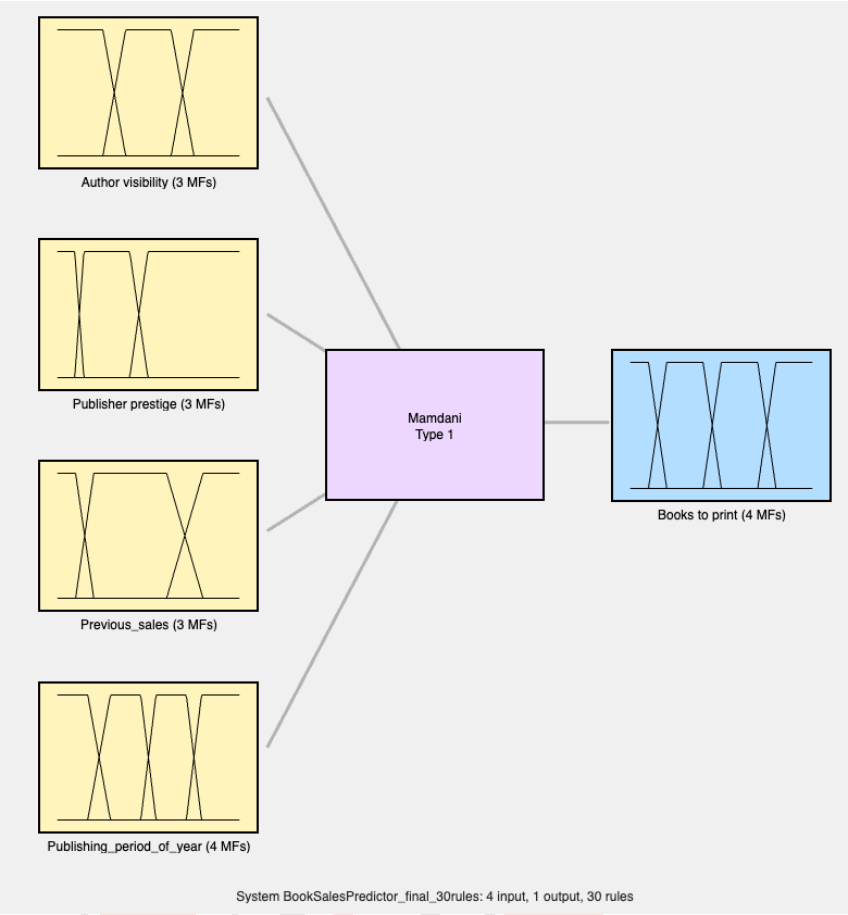

Figure 1 – -
Book sales predictor

3 TASK 1: Definition of linguistic variables

The input linguistic variables for this problem are the four factors that can affect book sales: author visibility, publisher prestige, previous sales, and publishing period of year. These variables can take on different levels of membership in fuzzy sets, such as "high", "medium", and "low".

The variable authorVisibility describes the the public's interest in an author, it captures the overall fame and visibility. The Variable publisherPrestige captures the publisher's distribution power and marketing. The variable previousSales describes the previous sales of all books written by an author. finally the variable publishingPeriodOfYear captures the book sales distribution for seoson of the year.

The linguistic labels for each variable, as well as their value range and membership functions are described and justified in the following subsections.

3.1 Input Variables

Input	Range	Number of MFs
Author visibility	0 to 2000	3
Publisher prestige	1 to 200	3
Previous sales	0 to 10000	3
Publishing period of year	0 to 12	4

3.1.1 Author Visibility

In the context of authorship, low visibility refers to a situation where an author's work is not widely known or recognized. This can happen for a variety of reasons, such as if the author has not published many works, if their works have not received much attention or recognition, or if they are not widely known in their field or within the literary community.

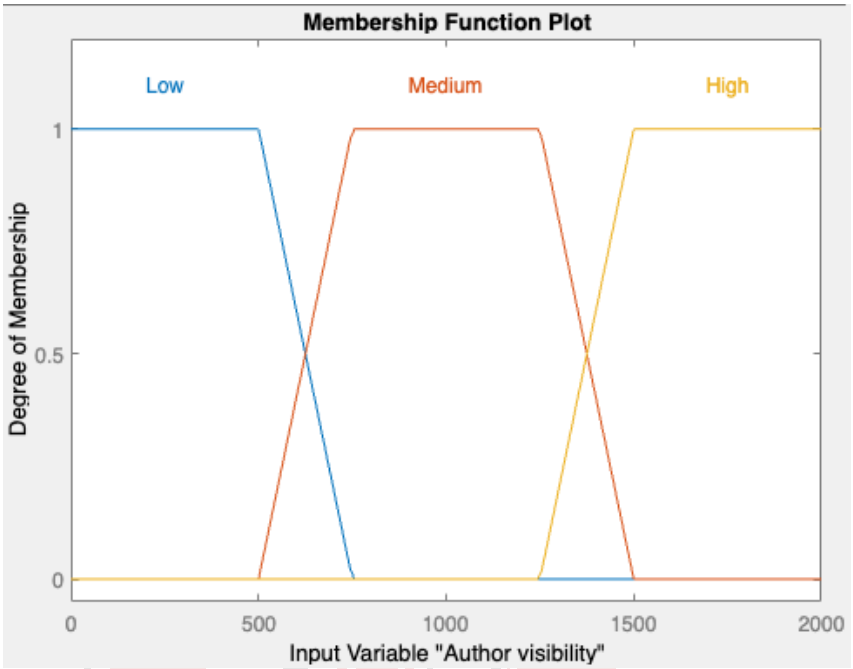

Figure 2 – -
Input Author visibility

It is difficult to provide specific thresholds for the number of views that would place an author in a certain category, as the level of visibility that is considered "low," "medium," or "high" can vary depending on the context and the individual author's goals and expectations. In general, an author with a low level of visibility based on views may have significantly fewer views than the average for their field or genre, while an author with a medium level of visibility may have a number of views that is similar to the average, and an author with a high level of visibility may have significantly more views than the average. However, these are just rough guidelines, and the specific thresholds for each category will depend on the individual author and their goals.

In general, the levels of membership for this variable could include "high visibility", "medium visibility", and "low visibility". The specific membership functions for these levels will depend on how the system is designed and the criteria used to determine an author's visibility. For example, in our case the "high visibility" level is defined based on the number of social media followers they have. Similarly, the "medium visibility" and "low visibility" levels could be defined based on a range of values for these or other relevant factors.

The authorVisibility variable describes the activeness of the user measured in days per week on a scale from 0 to 2000 with three linguistic labels: 'High', 'Medium' and 'Low'.

3.1.2 Publisher Prestige

Publisher prestige refers to the reputation and standing of a publisher within the publishing industry. A publisher with a high prestige is generally considered to be reputable and successful, while a publisher with a low prestige may be less well-known or regarded. In the context of the fuzzy expert system, the publisher prestige input variable would be used to help determine the appropriate number of copies to print and distribute for a new book release. A high prestige publisher may be more likely to have a successful book release, for example, and thus the system would recommend printing and distributing

more copies of the book.

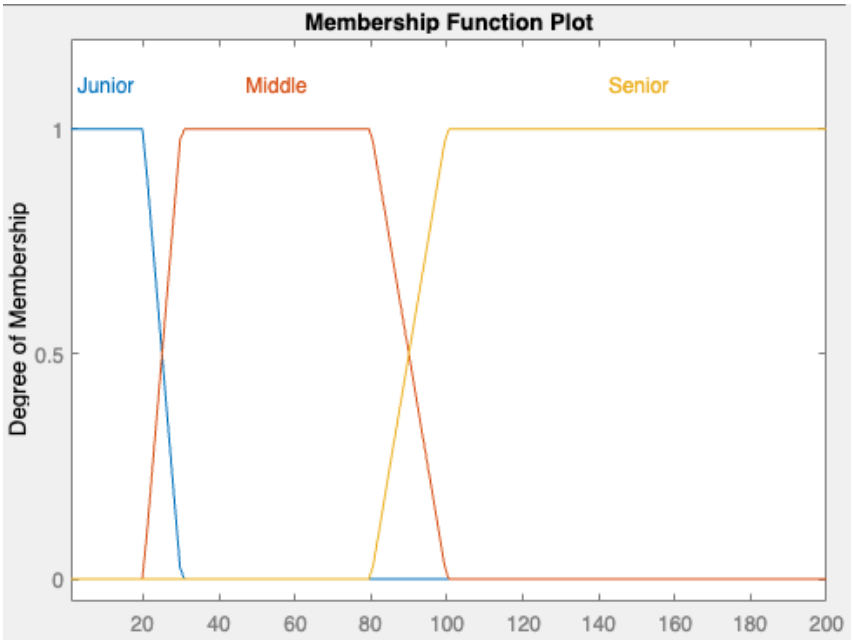

Figure 3 – -
Input Publisher prestige

In general, a fuzzy expert system would define a range of possible values for each input variable, and would then assign a membership value to each possible value within that range. For example, the membership values for the Publisher prestige input variable could range from 0 (low prestige) to 200 (high prestige), and the system could assign a specific membership value to each publisher based on its prestige

In our case, the "publisher prestige" variable is based on the number of years that a publisher has been in business. The membership functions for these fuzzy sets would determine the degree to which a given number of years belongs to each set. For example, the "junior" value might have a high degree of membership for values between 1 and 15, a moderate degree of membership for values between 15 and 25, and a low degree of membership for values between 25 and 30. The "middle" value might have a high degree of membership for values between 30 and 55, a moderate degree of membership for values between 25 and 30 and 55 and 65, and a low degree of membership for values between 0 and 25 and 65 and 80. The "senior" value might have a high degree of membership for values between 100 and 150, a moderate degree of membership for values between 75 and 100 and 150 and 175, and a low degree of membership for values between 0 and 75 and 175 and 200.

3.1.3 Books Previous Sales

book's previous sales refer to the number of copies of a book that have been sold in the past. The book's previous sales input variable would be used to help determine the appropriate number of copies to print and distribute for a new book release. A book with high previous sales, for example, may be more likely to have a successful new release, and thus the system would recommend printing and distributing more copies of the book. Similarly, a book with low previous sales may be less likely to have a successful new release, and the system would recommend printing and distributing fewer copies of the book.

A fuzzy expert system would define a range of possible values for each input variable, and would then assign a membership value to each possible value within that range. The membership functions for the "book sales" variable would define the degree to which a given number of sales belongs to each fuzzy set, such as "low," "medium," and "high." For example, the "low" value might have a high degree of membership for values between 0 and 1000, a moderate degree of membership for values between 1000 and 3000, and a low degree of membership for values between 3000 and 5000. The "medium" value might have a high degree of membership for values between 1000 and 5000, a moderate degree of membership for values between 500 and 1000 and 5000 and 7000, and a low degree of membership for values between

0 and 500 and 7000 and 9000. The "high" value might have a high degree of membership for values between 5000 and 9000, a moderate degree of membership for values between 2500 and 5000 and 9000 and 11000, and a low degree of membership for values between 0 and 2500 and 11000 and 13000.

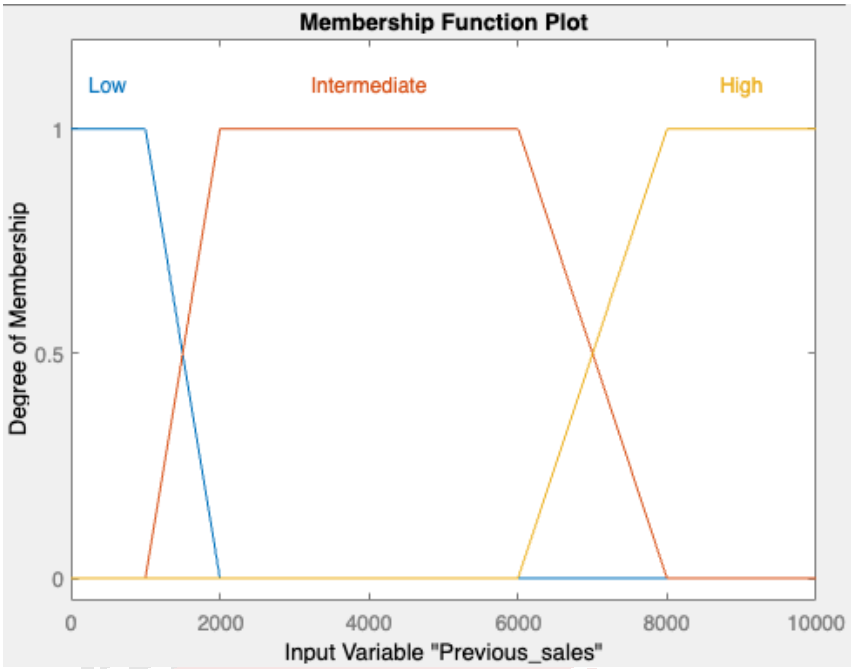

Figure 4 – -
Input Books previous sales

This membership value could be used by the system to help determine the appropriate number of copies to print and distribute for a new book release. A book with high previous sales, for example, may be more likely to have a successful new release, and thus the system would recommend printing and distributing more copies of the book.

3.1.4 Publishing period of year

The period of year it is being published refers to the specific season or period within a year in which a book is released. In the context of the fuzzy expert system mentioned in the previous answers, the time of year input variable would be used to help determine the appropriate number of copies to print and distribute for a new book release. The time of year could affect the sales of a book in various ways. For example, a book released during the holiday season may be more likely to sell well due to increased consumer spending, and thus the system would recommend printing and distributing more copies of the book. On the other hand, a book released during a slow season, such as the summer months, may be less likely to sell well, and the system would recommend printing and distributing fewer copies of the book

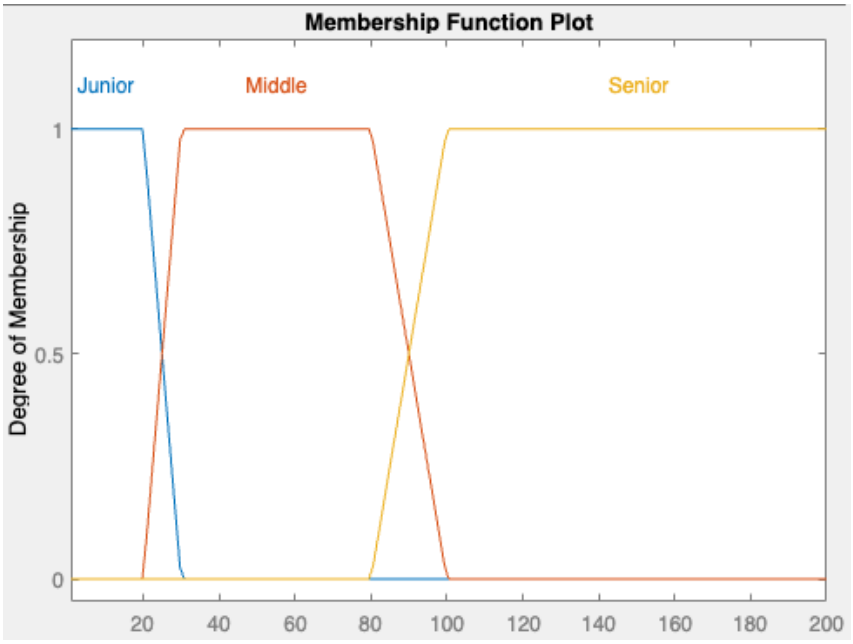

Figure 5 – -
Input Books previous sales

3.2 Output Variables

Output	Range	Number of MFs
Books to print	0 to 10000	4

The output linguistic variable is the number of books to print, which can also be represented by membership in fuzzy sets such as "many", "some", and "few". This variable will be calculated based on the values of the input linguistic variables

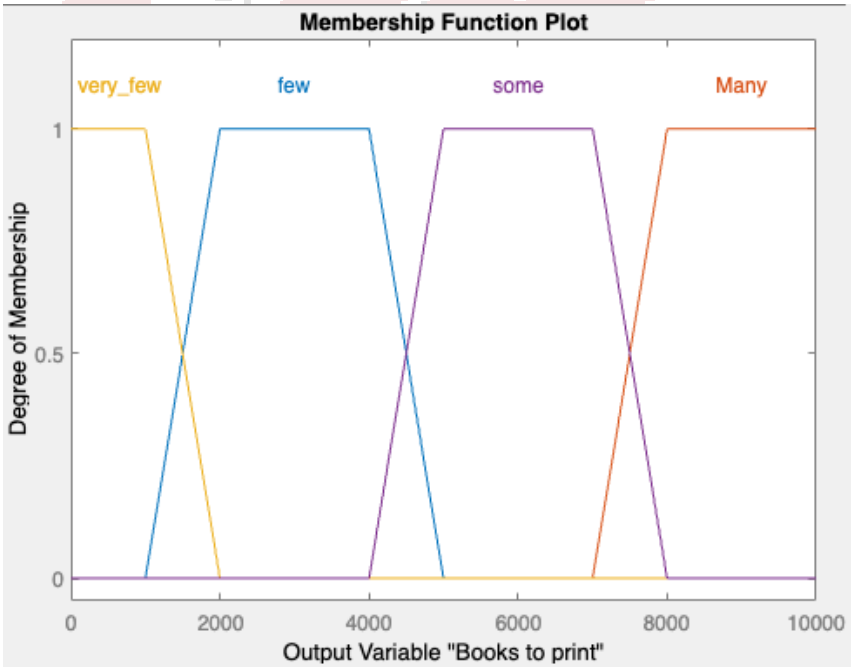

Figure 6 – -
Output Book sales prediction

4 TASK 2: Define the rules for the expert system

The fuzzy expert system has a total of 30 rules that describe the relationships between the input variables (previous sales, publishing period of year, publisher prestige, and author visibility) and the output variable (books to print). Each rule has a weight that indicates the relative importance of the rule in determining the final output.

Rule	Weight	Name
If Previous_sales is Low and Publishing_period_of_year is Summer then Books to print is very_few	1	rule1
If Previous_sales is Low and Publishing_period_of_year is Winter then Books to print is few	0.6	rule 2
If Previous_sales is Low and Publishing_period_of_year is Spring then Books to print is very_few	0.5	rule 3
If Previous_sales is Low and Publishing_period_of_year is Fall then Books to print is very_few	0.3	rule 4
If Previous_sales is Intermediate and Publishing_period_of_year is Summer then Books to print is few	1	rule 5
If Previous_sales is Intermediate and Publishing_period_of_year is Spring then Books to print is few	0.7	rule 6
If Previous_sales is Intermediate and Publishing_period_of_year is Winter then Books to print is some	1	rule 7
If Previous_sales is Intermediate and Publishing_period_of_year is Fall then Books to print is few	0.1	rule 8
If Previous_sales is High and Publishing_period_of_year is Winter then Books to print is Many	1	rule 9
If Previous_sales is High and Publishing_period_of_year is Summer then Books to print is some	1	rule 10
If Previous_sales is High and Publishing_period_of_year is Spring then Books to print is some	0.2	rule 11
If Publisher prestige is Junior and Previous_sales is Low then Books to print is very_few	1	rule 12
If Publisher prestige is Senior and Previous_sales is High and Publishing_period_of_year is Winter then Books to print is Many	1	rule 13
If Publisher prestige is Senior and Previous_sales is Intermediate then Books to print is some	1	rule 14
If Publisher prestige is Senior and Previous_sales is Low then Books to print is few	1	rule 15
If Author visibility is Low and Previous_sales is Low then Books to print is very_few	1	rule 16
If Author visibility is Low and Previous_sales is Intermediate then Books to print is few	1	rule 17
If Author visibility is Low and Previous_sales is High then Books to print is some	1	rule 18
If Author visibility is Medium and Previous_sales is Low then Books to print is few	1	rule 19
If Author visibility is Medium and Previous_sales is Intermediate then Books to print is some	1	rule 20
If Author visibility is Medium and Previous_sales is High then Books to print is Many	0.4	rule 21
If Author visibility is Low and Publisher prestige is Junior then Books to print is very_few	1	rule 22
If Author visibility is Low and Publisher prestige is Middle then Books to print is few	1	rule 23
If Author visibility is Low and Publisher prestige is Senior then Books to print is some	1	rule 24
If Author visibility is Medium and Publisher prestige is Junior then Books to print is very_few	1	rule 25
If Author visibility is Medium and Publisher prestige is Middle then Books to print is few	1	rule 26
If Author visibility is Medium and Publisher prestige is Senior then Books to print is Many	0.2	rule 27
If Author visibility is High and Publisher prestige is Junior then Books to print is some	0.7	rule 28
If Author visibility is High and Publisher prestige is Middle then Books to print is some	1	rule 29
If Author visibility is High and Publisher prestige is Senior then Books to print is Many	1	rule 30

For example, the first rule states that if the previous sales are low and the publishing period of year is summer, then the books to print should be "very few". This rule has a weight of 1, indicating that it is highly influential in determining the final output. Similarly, the third rule states that if the previous sales are low and the publishing period of year is spring, then the books to print should be "very few". This rule has a lower weight of 0.5, indicating that it is less influential than the first rule.

Overall, the set of rules and their weights provide a way for the fuzzy expert system to make predictions about the number of books to print based on the values of the input variables. The weights of the rules allow the system to take into account the relative importance of each rule in determining the final output, providing a flexible and adaptable way to make predictions.

5 TASK 3: Implement the fuzzy expert system using Matlab.

Through the implementation of the fuzzy system in Matlab with all the variables, explained in the previous chapter, some surface graphs were obtained where it is possible to observe the behavior of the system, depending on certain variables. This allows us to identify the behavior of the same system and how the same variables influence the final prediction.

Starting from the variables of previous sales and the visibility of the author, we observe in graph 7 that the behavior of the surface is that the greater the number of sales and greater visibility, we will have more predictions, likewise, we observe that the rules created give way to the surface having the desired behavior and representation.

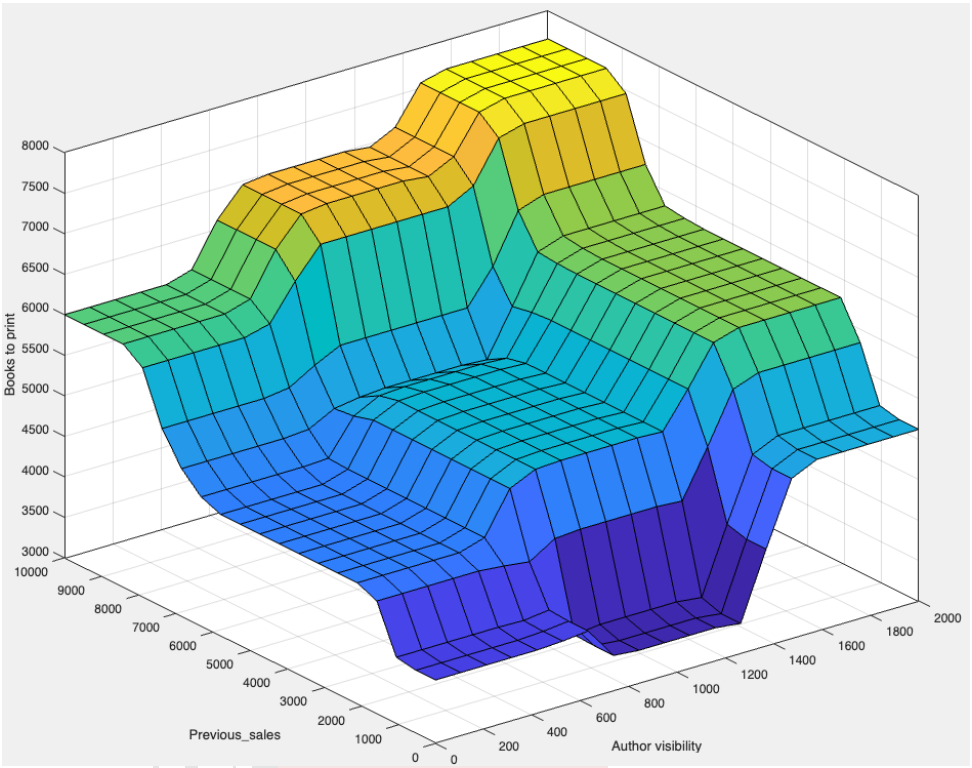

Figure 7 – Control surface fuzzy expert system - Previous sales and author visibility

For the variables of previous sales and publisher prestige, there is a behavior where the surface shows a raised part in the corner where the maximum values of each variable intersect as seen in the image 8, and it decreases with respect to the same variables. These variables present a good correlation as expected by means of the designed rules.

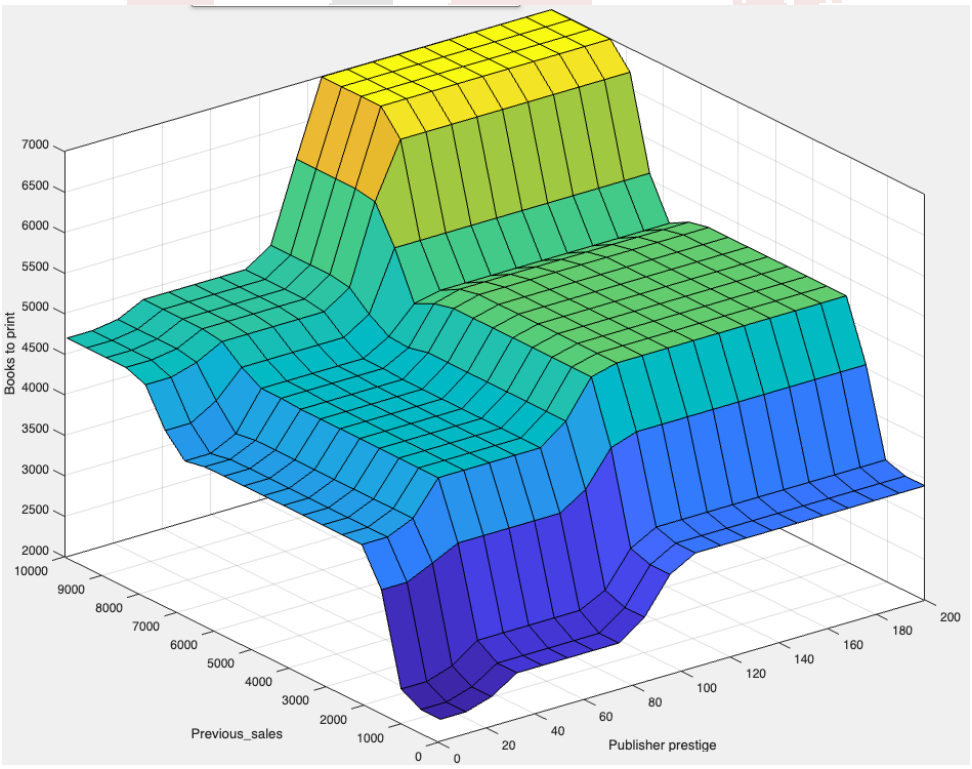

Figure 8 – Control surface fuzzy expert system - Previous sales and publisher prestige

Observing the surface plot 9 for the period of previous sales and publication of the year, it was taken into

account in the rules of the seasons in which it is more successful to publish and which are not, with which it can be seen that regardless of the number of sales, a similar behavior is observed where for the periods from January to March it is higher, while for the following months that represent spring and summer, they decrease to their minimum and rise again in autumn. Which in turn, the surfaces interact and are affected by the number of past sales.

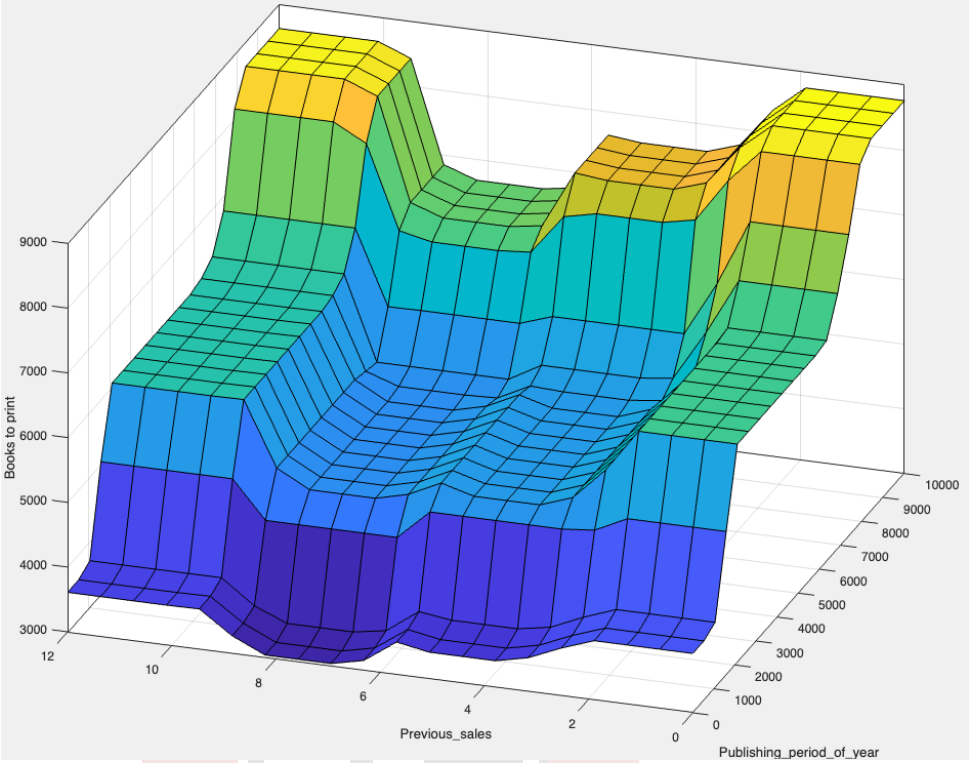

Figure 9 – Control surface fuzzy expert system - Previous sales and publishing period of year

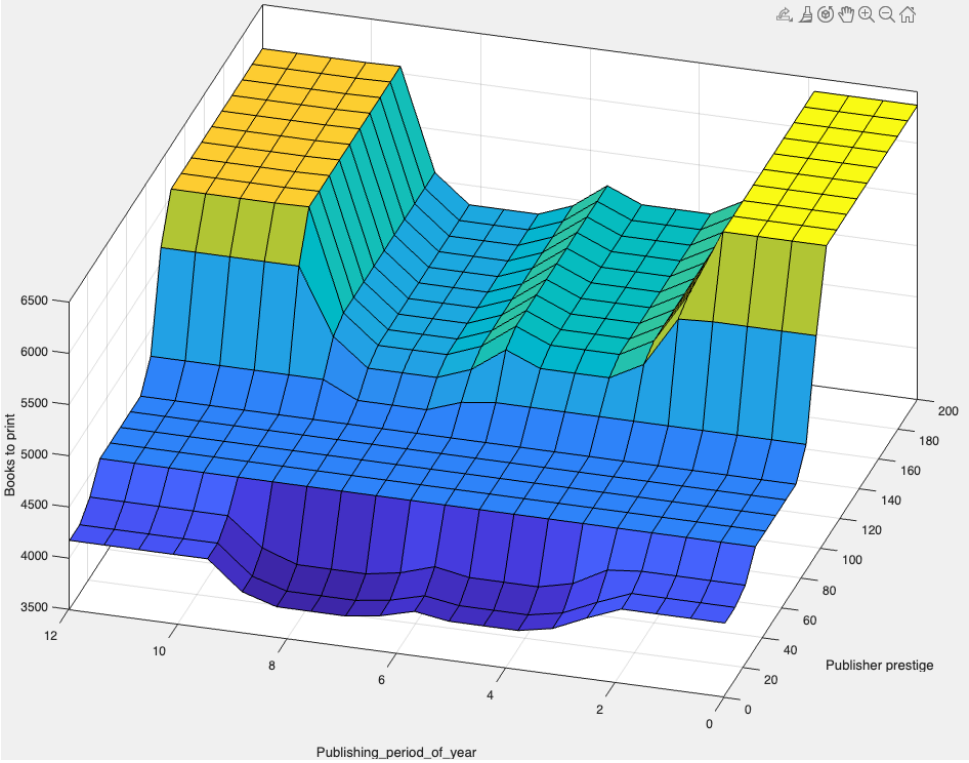

Figure 10 – Control surface fuzzy expert system - Publishing period of year and publisher prestige

In the image 10, the same behavior can be seen regarding the time of year and how this affects the predictions. However, the prestige publisher has 3 clear surfaces, and maybe it is possible to improve the medium surface, adding a rule to optimize it, it was not placed in this work, due to the limitation of rules available.

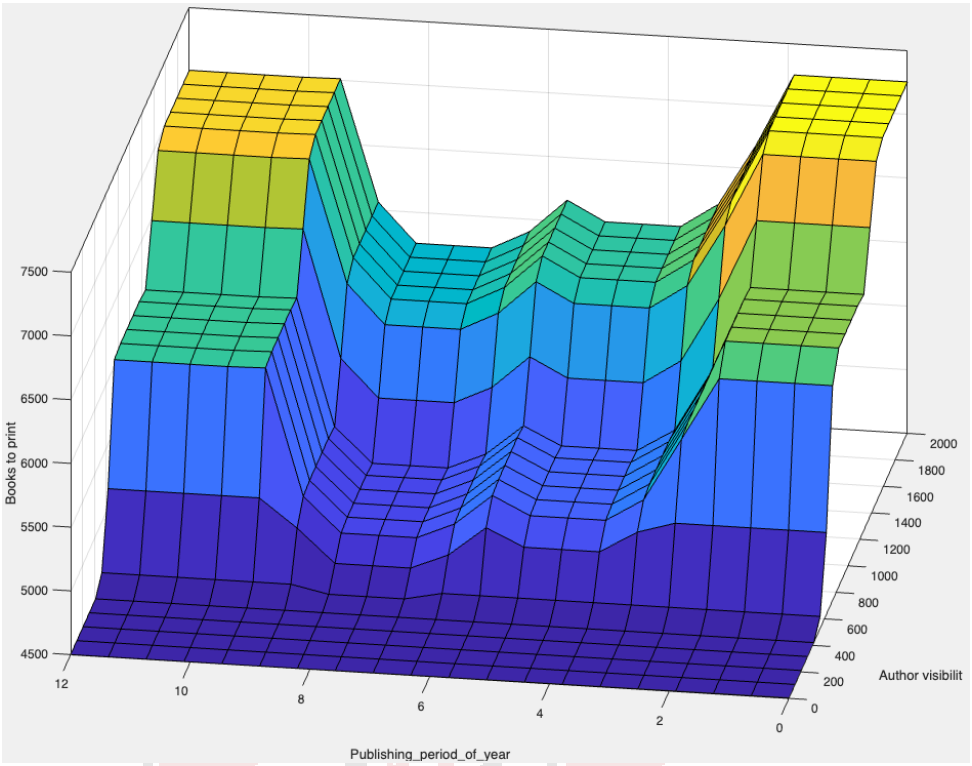

Figure 11 – Control surface fuzzy expert system - Publishing period of year and author visibility

For the last plot shown in image 11, a similar relationship is observed with respect to the period of the year, however, for the visibility of the author, 3 surfaces are observed which clearly belong to each of its variables, also You can optimize a little more, however it was not done due to the limitation of the rules.

6 TASK 4: Testing cases and execute the system.

To validate the previously created system, 4 different experiments were carried out including some cases to observe the behavior in the predictions. Some cases were developed to identify how important each input variable is for the fuzzy system and how this can affect the predictions.

As a starting point, a few variables were selected to represent one of the best and worst cases for predictions in the system. As shown in the table 1, the extremes of the ranges in each of the input variables were used to simulate the conditions that can deliver the highest and lowest predictions that the system can deliver.

Table 1 – Prediction Cases for Best and Worst Conditions

Case	**Input**				**Output**
#	**Author visibility**	**Publisher**	**Previous sales**	**Period of publication**	**Books to print**
Best	2000	200	10000	1	8758.8
Worst	0	1	700	7	751.6

As seen in table 1, in the best of cases 8758.8 books were achieved to print based on the prediction. Otherwise, for the worst case, the prediction was 751 books. Here, it can be seen that, although the previous sales were 10,000 books, some rules in the system can interfere so that this value varies and is not the same. With this, a system is thus left that is not biased towards the extremes when taking into

account all the input variables.

6.0.1 Experiment 1

Description: For the experiment 1, it was desire to test the author visibility through each season of year (period of publication), and for that it was used 1000 and 500 followers in the social media, same publisher prestige and a high previous sales.

Winter:

Table 2 – Prediction Cases with focus in Author visibility in Winter

Case	**Input**				**Output**
#	**Author visibility**	**Publisher**	**Previous sales**	**Period of publication**	**Books to print**
1	1000	200	9000	1	8758.8
2	500	200	9000	1	7256.6

It can be seen in table 2, that as expected with more visibility in the author, the predictions of books to be printed will be higher.

Spring

Table 3 – Prediction Cases with focus in Author visibility in Spring

Case	**Input**				**Output**
#	**Author visibility**	**Publisher**	**Previous sales**	**Period of publication**	**Books to print**
1	1000	200	9000	4	78312
2	500	200	9000	4	6581.3

As can be seen in table 3, it presents the same behavior as in the previous table with respect to the author's visibility variable, otherwise, for the publication period it is observed that the winter season is higher than spring.

Summer:

For the iteration in summer, it was observed in table 4 that these are probably the lowest prediction values of the system, given the conditions, in addition, the behavior of the author's visibility is preserved in this situation.

Table 4 – Prediction Cases with focus in Author visibility in Summer

Case	**Input**				**Output**
#	**Author visibility**	**Publisher**	**Previous sales**	**Period of publication**	**Books to print**
1	1000	200	9000	5	75805
2	500	200	9000	5	6000

Fall

In the table 5, it can be seen that the basis persists that the higher the author's visibility number, the more books are predicted to be printed. Likewise, it is observed that the values of books to be printed for the author variable with visibility at 1000 in summer and autumn are different due to their seasons, for visibility of 500 the prediction value is equal to 6000. This may be due to the rule that autumn will predict more books than summer, however, autumn has more prediction range than summer and that makes one different from the other.

Table 5 – Prediction Cases with focus in Author visibility in Fall

Case	Input				Output
#	Author visibility	Publisher	Previous sales	Period of publication	Books to print
1	1000	200	9000	10	8622.8
2	500	200	9000	10	6000

For the last iteration, it was observed that the prediction values increase compared to the summer season, and this is a positive aspect, considering that the system has as configuration that the most important season is winter, followed by autumn, the spring and finally summer, in the same way that each iteration showed us in the previous tables.

6.0.2 Experiment 2

Description:

For this case, we fixed the values of author visibility, previous sales, and period of publication at 1000, 8000, and 1, respectively. We then varied the value of publisher prestige, using the values 180, 90, and 10.

Results:

Table 6 – Prediction Cases with focus on Publisher prestige

Case	Input				Output
#	Author visibility	Publisher	Previous sales	Period of publication	Books to print
3	1000	180	8000	1	8758.8
4	1000	90	8000	1	6415.1
5	1000	10	8000	1	5731.7

As we can see in table 6, the number of books to print is higher when we increase the value of publisher prestige, and that is because publisher prestige can affect the number of books that a publisher chooses to print in several ways. First, a more prestigious publisher may have a larger audience and a higher demand for their books, which could lead them to print more copies. Additionally, a more prestigious publisher may have more resources and funding available, which could allow them to invest in larger print runs. Finally, a publisher with a strong reputation may be more likely to take risks on new or unknown authors, which could also lead to larger print runs for those books.

6.0.3 Experiment 3

Description:

In this case, we are considering two different scenarios. In the first scenario (cases 6, 7, 8, and 9), we fixed the value of the author visibility at 1000, the publisher prestige at 10, and the period of the year at 1, and we decreased the value of previous sales from 9000 to 1000. In the second scenario (cases 10, 11, 12, and 13), we kept the same values for author visibility, publisher prestige, and previous sales, but we changed the value for the period of the year to 5.

Results:

Table 7 – Prediction Cases with focus on previous sales and the period of the year

Case	Input				Output
#	Author visibility	Publisher	Previous sales	Period of publication	Books to print
6	1000	10	9000	1	5731.7
7	1000	10	7000	1	4920.2
8	1000	10	4000	1	4212.1
9	1000	10	1000	1	2276.7
10	1000	10	9000	5	4363.2
11	1000	10	7000	5	3951.5
12	1000	10	4000	5	3867.1
13	1000	10	1000	5	2.2767

From table 7, when comparing the output of the fuzzy expert system in these two scenarios, we can determine the effect of changing the period of the year on the number of books to print. This can provide insight into how the seasonality of book sales may affect the publisher's decision on how many copies to print. In the period 1, if the previous sales value is high, we will have the highest output value. As we decrease the value of previous sales, the output value decreases. If we compare these values with the values of period 5, we will always find that the output values for period 1 are higher.

6.0.4 Experiment 4

Description:

For this experiment, some cases are presented that are going to be classified by months, of which the author visibility variables are set at 1,000, previous sales at 4,000, editorial prestige at 90, and the period of the year that is going to be iterated, representing each month of the year. Additionally, the change of the type of sfuzzy system was implemented, having Mandani and Sugeno, with the previous intention of comparing these two.

Results:

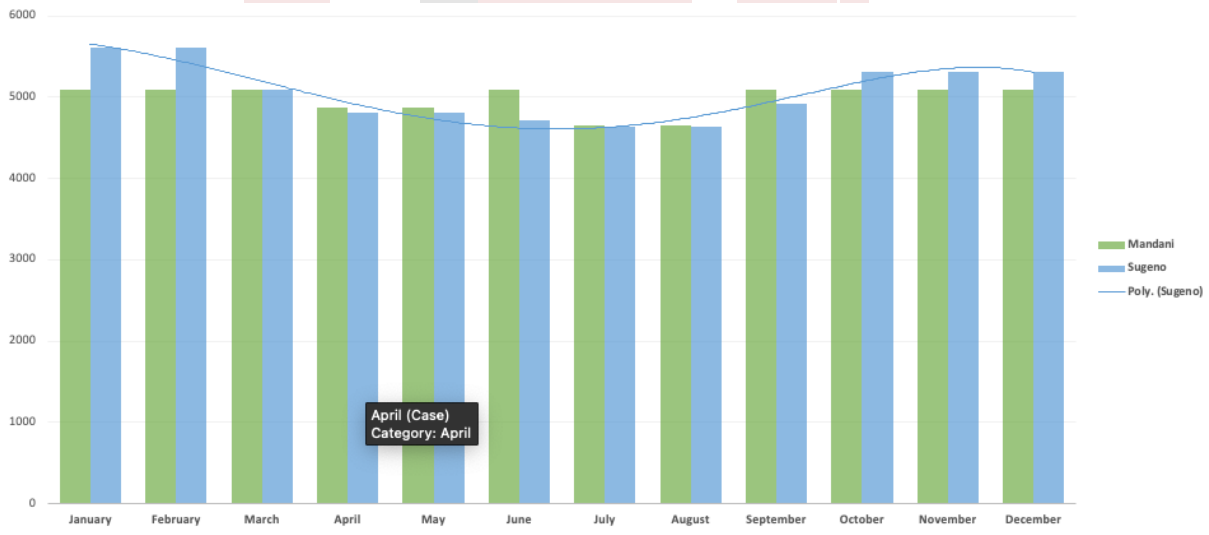

Figure 12 – Experiment 4 - Comparison of system types (Mamdani and Sugeno) through the publication period

One of the first things that can be observed in the graph 12 and table 8, is that the behavior of predictions of books to be printed varies according to what is established in the previously described rules.

On the other hand, comparing both types of systems we observe that with Mamdani we obtain a higher number of predictions than in Sugeno for the winter and fall seasons, however in spring and summer

Mamdani obtains a higher number of predictions. This leads us to deduce that sugeno is more subject to presenting more variable and extreme results compared to Mamdani.

Table 8 – Comparison Between Mamdani and Sugeno Fuzzy Inference System

Case	Type	Input				Output
		Author	Publisher	Previous sales	Period	Books to print
January	Mandani	1000	90	4000	1	5098.7
January	Sugeno	1000	90	4000	1	5605.1
February	Mandani	1000	90	4000	2	5098.7
February	Sugeno	1000	90	4000	2	5605.1
March	Mandani	1000	90	4000	3	5098.7
March	Sugeno	1000	90	4000	3	5095.1
April	Mandani	1000	90	4000	4	4875.7
April	Sugeno	1000	90	4000	4	4812.8
May	Mandani	1000	90	4000	5	4875.7
May	Sugeno	1000	90	4000	5	4812.8
June	Mandani	1000	90	4000	6	5098.7
June	Sugeno	1000	90	4000	6	4720.6
July	Mandani	1000	90	4000	7	4658.6
July	Sugeno	1000	90	4000	7	4637.4
August	Mandani	1000	90	4000	8	4658.6
August	Sugeno	1000	90	4000	8	4637.4
September	Mandani	1000	90	4000	9	5098.7
September	Sugeno	1000	90	4000	9	4915.4
October	Mandani	1000	90	4000	10	5098.7
October	Sugeno	1000	90	4000	10	5307.2
November	Mandani	1000	90	4000	11	5098.7
November	Sugeno	1000	90	4000	11	5307.2
December	Mandani	1000	90	4000	12	5098.7
December	Sugeno	1000	90	4000	12	5307.2

As one of the difference observed in this experiment is that Mandani FIS posses less flexibility in the system design and through defuzzification of rules consequent crisp result is obtained , in other hand, Sugeno FIS offer more flexible but use the weighted average of the rules of consequent crisp to obtain results.

7 Task 5 - Analysis of the results

1. **Looking at your fuzzy expert system, what is the influence of the publishing period on the number of books if the author has great visibility?**

   The influence of the publishing period on the number of books would depend on rules and membership functions defined for the fuzzy expert system. However, in general, if the author has great visibility (i.e., a high value for the "author visibility" variable), then the publishing period would likely have a moderate to strong influence on the number of books to print.

   For example, if the expert system uses the following rules:

   (a) If the author is very famous and the publishing period of the year is summer, then the number of books to print should be many.

   (b) If the author is very famous and the publishing period of the year is winter, then the number of books to print should be few.

   Then, if the input data indicates that the author has great visibility and the publishing period is summer, the fuzzy inference engine would apply the first rule and conclude that the number of books to print should be many. On the other hand, if the input data indicates that the author has great visibility and the publishing period is winter, the fuzzy inference engine would apply the second rule and conclude that the number of books to print should be few.

In this way, the publishing period would have a significant influence on the number of books to print, depending on the values of the other input variables and the specific rules and membership functions defined for the expert system.

2. **What changes should you make to the system and which are the implications in the system if you want to consider also the age of the readers to whom the book is addressed?**

   To consider the age of the readers to whom the book is addressed, we would need to add an additional input variable to the fuzzy expert system and define appropriate membership functions and rules for this variable. For example, the new input variable could be "age of readers," with possible values such as "kids," "teens," "adults," and "seniors." The membership functions for these values would define the degree to which a given value belongs to each fuzzy set, based on the age of the readers to whom the book is addressed.

   Once the membership functions for the new input variable have been defined, we would need to update the rules for the expert system to take this variable into account. For example, some possible rules could be:

   (a) If the author is very famous and the age of the readers is kids, then the number of books to print should be many.

   (b) If the author is unknown and the age of the readers is seniors, then the number of books to print should be few.

   (c) If the previous sales are high and the age of the readers is teens, then the number of books to print should be some.

   (d) If the previous sales are low and the age of the readers is adults, then the number of books to print should be few.

   These new rules would allow the expert system to take the age of the readers into account when calculating the appropriate number of books to print. The implications of adding this new input variable would be that the expert system would be able to make more refined predictions about the number of books to print, based on the age of the readers to whom the book is addressed. This could potentially improve the accuracy of the predictions and help the editorials make more informed decisions about the number of books to print

3. **If the author visibility depends on many criteria, how can we model it in this expert system?**

   If the author visibility depends on many criteria, we can model it in the expert system by using multiple input variables to represent these criteria. For example, we could add additional input variables such as "popularity on social media," "awards and accolades," "public speaking engagements," and "media appearances," each with their own membership functions and rules.

   The overall "author visibility" variable would then be calculated by the expert system using a combination of these input variables and the corresponding membership functions and rules. For example, if the author has a high degree of popularity on social media, a high number of awards and accolades, and a high number of public speaking engagements, then the expert system would conclude that the author has high visibility. On the other hand, if the author has low popularity on social media, few awards and accolades, and few public speaking engagements, then the expert system would conclude that the author has low visibility.

   In this way, the expert system would be able to model the "author visibility" variable more accurately by considering multiple criteria and using multiple input variables. This could improve the accuracy of the predictions made by the expert system and help the editorials make more informed decisions about the number of books to print.

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