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The utilization of levelled fuzzy logic for more precision results

The utilization of levelled fuzzy logic for more precision results

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Abstract. The use of Fuzzy logic in the forecasting process, problem analysis, and decision making of the process is often used. The development of this fuzzy logic by widening the foot of the membership function as interval fuzzy type 2, fuzzy signature or carried out a hybrid between fuzzy logic and other artificial intelligence systems or a hybrid algorithm has also got quite good results. At this time, a multilevel fuzzy logic method is proposed. This multilevel Fuzzy Logic is interesting behind the input of a process in fuzzy logic, which is the output of the previous fuzzy logic or the output of a fuzzy logic analysis is input into the next stage of fuzzy logic. This multilevel fuzzy logic can be done up to several levels of depth according to the variables to be analysed. If the final analysis has the equation X(i) + Y(i) = Z(i), then the value of X (i) can be the result of A(i-1), where A(i-1) is the result of the Fuzzy Logic B(i-1) + C(i-1). by performing multilevel fuzzy logic is expected to have the value of forecasting errors or problem analysis and decision making better and more precise.

Introduction

Fuzzy logic was first introduced by professor Zadeh (California University) in 1965. By describing mathematical calculations based on set theory to describe obscurity in the form of linguistic variables, fuzzy logic theory develops Boolean set theory (0 and 1) into a set that has a membership value that is obscure (between 0 and 1) so that fuzzy logic is also called fuzzy or fuzzy logic [1,2]. Using this logic, the set between 0 and 1 will be read so that the results of the analysis will be more precise — for example, an analysis of the electric current required by a lamp. If the analysis is carried out when the light is on or when the light is off, then the value of the current that comes out is when the light is on and when the light is off. Although when the light is off, and the light is on, there is a process of changing the current value. At the position of the change of flow, the analysis process will be carried out [3].

This fuzzy logic application can also be used to analyse other things, such as forecasting, calculation of the amount of production, analysis of production processes, and so on [4,5]. All of these things are related to the use of artificial intelligence. 'In this era artificial intelligence dominates life. This increase in precision is a problem nowadays. By increasing the level of precision, fuzzy logic can solve all problems related to artificial intelligence. This multilevel fuzzy using in intelligent robots, smart cars, intelligent washing machines, etc. appear. In the field of forecasting, it will also be more precise to use good artificial intelligence.

In this paper, the authors conducted a study of the use of multilevel Fuzzy Logic. Multilevel Fuzzy Logic is the result of fuzzy logic processes in fuzzy logic again. The output of a fuzzy logic process will be the input of the next fuzzy logic process. The Fuzzy output is expected to produce more precise results compared to using only one stage of the fuzzy logic process.

2. Experimental method

2.1. Data input mapping

The process of mapping the set of crisp input data into the membership level, which has boundaries to become a fuzzy set is called fuzzification or membership function. There are several types of membership function models, one of which is [4,6]:

Triangle Membership Function /Trimf, as shown at figure 1.

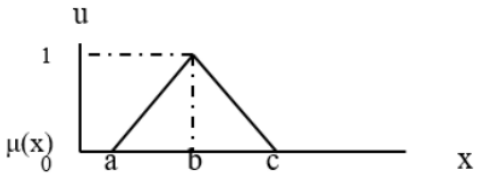

Figure 1. Triangle membership function.

The triangle membership function can be defined by the following equation:

$$f\ (x,a,b,c) = \begin{Bmatrix} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ \frac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{Bmatrix} \quad \text{.....(1)}$$

or can be defined as follows:

$$f(x,a,b,c) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right) \quad \text{.....(2)}$$

The x parameter is the input of crisp, a and c represent the toe of the triangle, while b represents the peak of the triangle. In addition to the triangle membership function that is used, also the Trapezoid shape and other forms can also be used. Fuzzy Logic Process is known as the Fuzzy Inference System (FIS).

2.2. Fuzzy inference system

Fuzzy inference that is doing reasoning using fuzzy input and fuzzy rules that have been determined to produce fuzzy output. The main structure of the Fuzzy Inference System is as follows [7,8]:

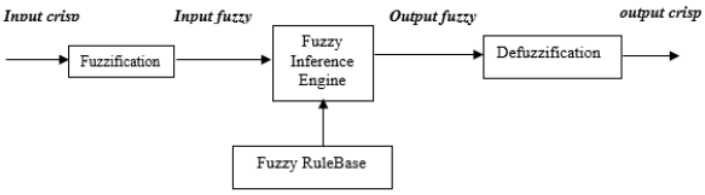

Figure 2. Fuzzy inference system structure.

Ebrahim Mamdani first introduced the fuzzy rule method in 1975 known as the Mamdani or Max-Min method where there are five stages to get the output, namely [7]:

- Fuzzy set formation (input and output variables)
- Operational membership function
- Application function implications (implication), Min functions are generally used
- Rule composition (aggregation)
- Defuzzification

Defuzzification is a mapping process from the results of areas of fuzzy inference to non-Fuzzy regions (Crisp). In the implementation of fuzzy real-time controls, the Center of Area (COA) defuzzification process is used.

The defuzzification of the center of the area produces the center of gravity of the distribution of control actions stated in the equation:

$$z^* = \frac{\sum_{k=1}^{m} V_k \mu_v(V_k)}{\sum_{k=1}^{m} \mu_v(V_k)} \quad .....(3)$$

z^* = Output Value
m = level of quantization
V_k = element to –k
μ_V = membership degree element on fuzzy set V

The results of the defuzzification process are the result of a series of fuzzy processes.

2.3. Multilevel fuzzy logic

Multilevel fuzzy logic is combining one another fuzzy logic process results with the other fuzzy logic results, with an explanation as in figure 3:

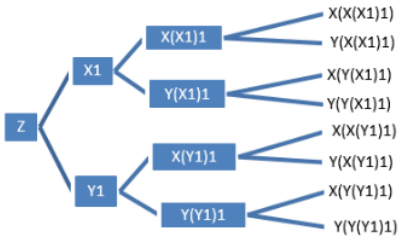

Figure 3. Multilevel fuzzy logic.

So that the settings at the lowest level of fuzzy logic processes will affect the most recent fuzzy logic process. This will get more precise results than if the process is done separately. One example of the use of fuzzy logic is: Forecasting sexual violence that will occur [9]. How likely is sexual violence if the cause occurs [9-11]. The fuzzy logic schematic as in table 1.

Table 1. Process of fuzzy logic diagrams.

NO	INPUT 1		OUTPUT 1/ INPUT 2		OUTPUT 2/ INPUT 3	OUTPUT 3
1.1.1	Friend	1.1	School environment	1	Environment	Sexual Violence
1.1.2	Teacher					
1.1.3	Educational staff					

Table 1. Cont.

NO	INPUT 1		OUTPUT 1/ INPUT 2		OUTPUT 2/ INPUT 3	OUTPUT 3
1.2.1	Slum	1.2	Home Environment			
1.2.2	How to dress					
1.2.3	Bathroom					
2.1.1	Teacher	2.1.	Dissemination of reproductive organs in schools	2	Dissemination of reproductive organs	
2.1.2	Educational staff					
2.1.3	Laboratory					
2.2.1	Parent Ability	2.2.	Dissemination of reproductive organs in home			
2.2.2	Parental Awareness					

Table 1 shows the process of inputting and inputting from one stage to another. Sexual violence has the following membership function:
1. Rarely 30 – 60; 2. Moderate 15 – 45; 3. Often 0 - 30
1 - The environment has the following membership function:
1. Good 6 – 9; 2. Moderate 4,5 – 7,5; 3.Bad 3 – 6
2 - Socialization has the membership function as follows:
Good 6 – 9; 2. Moderate 4,5 – 7,5; 3. Bad 3 – 6

Environment is the result of processing fuzzy school environment and home environment, where:
1.1 School environment, has the membership function as follows:
1. Good 6 – 9; 2. Moderate 4,5 – 7,5 ; 3. Bad 3 – 6
1.2 Home environment, has the membership function as follows:
1. Good 6 – 9; 2. Moderate 4,5 – 7,5 ; 3. Bad 3 – 6

Likewise, for the dissemination of reproductive organs, which is the result of fuzzy processing lack of socialization of reproductive organs in schools and lack of socialization of reproductive organs at home. After creating a membership function, this can be processed by using matlab or by coding to predict how much sexual violence will occur if the environmental conditions and explanation of the reproductive organs have a certain number. The Fuzzy Inference System from the example questions above can be seen in figure 4.

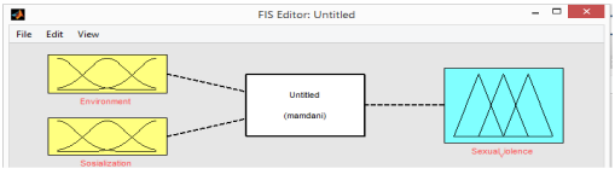

Figure 4. Fuzzy inference system.

Figure 5 and 6 shows Fuzzy Inference which consists of two inputs, namely environment and Socialization, with Sexual Violence output.

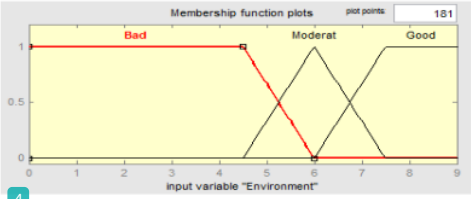

Figure 5. Membership function of environment.

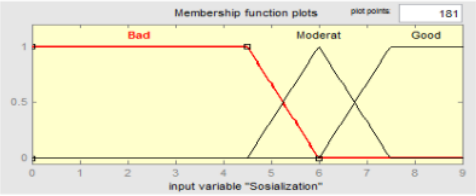

Figure 6. Membership function of sosialization.

Figures 5 and 6 show membership functions of Environment and Socialization. With trapezoidal type for Bad and Good. While moderates use the Triangle type. Crisp value in the form of environmental quality will be changed to Fuzzy value. The value of socializing the reproductive organs has also changed the value of the crisp into Fuzzy values. After the process, the output is obtained. The output results that have Fuzzy values are changed to Crisp values again.

This environment is the result of previous Fuzzy analysis. The output in the form of this Environment is a Fuzzy analysis method with input on the school environment and home environment. Likewise socialization of the reproductive organs is the output of the Fuzzy process. Input from Fuzzy process which has output value Socialization of reproductive organs in School and at home.

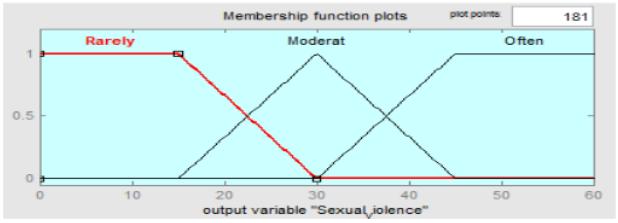

Figure 7. Membership function of sexual violence.

Figure 7 shows the membership function of Sexual Violence. The image is the output of a fuzzy analysis in the form of the number of incidents of sexual violence that occurred. This form of analysis is complemented by the provision of basic rules that can be the result of research or take from papers related to the above problems. The basic form of the rules used in this Fuzzy analysis can be seen in Figure 8.

1. If (Environment is Bad) and (Sosialization is Bad) then (Sexual_Violence is Often) (1)
2. If (Environment is Bad) and (Sosialization is Moderat) then (Sexual_Violence is Often) (1)
3. If (Environment is Bad) and (Sosialization is Good) then (Sexual_Violence is Moderat) (1)
4. If (Environment is Moderat) and (Sosialization is Bad) then (Sexual_Violence is Moderat) (1)
5. If (Environment is Moderat) and (Sosialization is Moderat) then (Sexual_Violence is Moderat) (1)
6. If (Environment is Moderat) and (Sosialization is Good) then (Sexual_Violence is Rarely) (1)
7. If (Environment is Good) and (Sosialization is Bad) then (Sexual_Violence is Moderat) (1)
8. If (Environment is Good) and (Sosialization is Moderat) then (Sexual_Violence is Moderat) (1)
9. If (Environment is Good) and (Sosialization is Good) then (Sexual_Violence is Rarely) (1)

Figure 8. Rule base of fuzzy inference system.

In figure 8, it is seen that rule based is applied to Fuzzy analysis above. Limits of crisp values that are changed to Fuzzy values at the specified membership function. Making this rule based uses the concept of min max with mathematical sentences using the "AND" logic. From the results of this analysis, the results as shown in figures 9 and 10 are obtained in the result and discussion section.

3. Results and discussion

The above analysis gives the results in the form of Rule Viewer and Surface Viewer. The Rule viewer shows the results of an analysis that can change as the input is given. The input value, which is the output of the previous fuzzy analysis, can be set on the red line (Figure 9) in the membership function environment and Socialization.

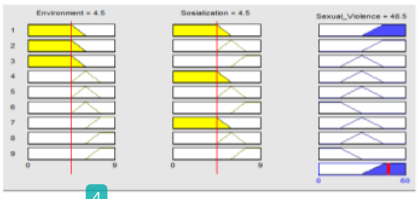

Figure 9. Rule viewer.

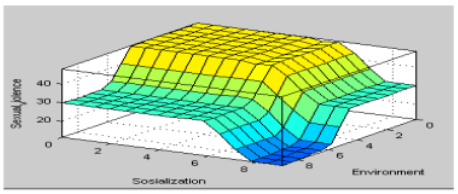

Figure 10. Surface viewer of FIS.

Whereas on the Surface Viewer, it can be seen how the relationship between 2 inputs and 1 output. In a small environment, input values and small socialization, the value of moderate sexual violence is obtained. If the Environment is high and high socialization will get the value of Sexual Violence and so on. This result will get a better value if the analysis is done by multilevel fuzzy analysis by including the previous analysis. So that the input value will be more precise if the only non-multilevel fuzzy analysis is done.

Merging multilevel analysis can be done on the matlab toolbox or coding itself, continuously. The application can be done in various fields. For forecasting, analysis of production or others.

4. Conclusion

From the explanation above, we get a conclusion that by using multilevel fuzzy logic, the direct settings done at the lowest level will be able to directly influence the output at the top level so that the analysis results will be more precise.

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