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Implementation Of Fuzzy Logic In Prediction Of Traffic Accidents In Bangladesh

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Abstract:
Predicting traffic events is vital for improving road safety. Models for predicting traffic accidents can be used to pinpoint accident causes and lower accident rates. Creating a fuzzy logic model for forecasting traffic accidents in Bangladesh is the goal of this work. The annual average daily traffic (AADT), the road width (RW), the speed (SP), which is measured in distance per unit time, and the roadside market (RM) are the four input variables used in this model. Annual All Accidents (AAA), the model's output, is determined as the total number of accidents that happen on a road in a day for every kilometer of road. This model is used in Bangladesh on the Dhaka-Mymenshingh highway. MATLAB's fuzzy logic toolbox is used here.
We aim to apply fuzzy logic to analyze and reduce traffic accidents in Bangladesh. This will involve collecting data on the number of vehicles on the road, the speed of the vehicles, and road conditions, and then using Mamdani fuzzy logic to find the specific factors for road accidents. In order to find out the number of predictions of accidents, we used a few variables like AADT(Annual Average Daily Traffic), SP(Speed), RW(Road Width), RM(Roadside Market), AAA(Annual All Accidents) and We applied these variables into a program called MATLAB to illustrate the results.
Key Word*: Fuzzy Logic; Mamdani Fuzzy Logic; Fuzzy Classification.*

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I. Introduction

Bangladesh is one of the most densely populated countries in the world. It has one of the highest rates of road accidents, with thousands of accidents occurring every year. This high incidence of road accidents results in significant loss of life and property and poses a major public health and safety concern. Leading to numerous social and economic problems. Despite the high incidence of road accidents in Bangladesh, there is a lack of comprehensive road safety strategies and policies that effectively address the root causes of accidents. At least 6,749 accidents took place in 2022. At least 641 people were killed and 1,364 injured in 528 road accidents across the country in May, according to Road Safety Foundation. The increasing number of road accidents in Bangladesh has led to a growing demand for effective road safety measures, including improved infrastructure, stricter enforcement of traffic laws, and more advanced technologies for accident prevention.

Research on road accidents in Bangladesh can help to fill this gap by providing evidence-based insights into the causes of accidents and effective measures for prevention.

Road accidents are complex events that are influenced by many factors, including weather conditions, road conditions, driver behavior, and vehicle characteristics. Mamdani Fuzzy Logic provides a flexible and powerful approach for modeling complex systems and allows for the incorporation of multiple input variables that may interact in non-linear ways. Many of the factors that contribute to road accidents are uncertain or vague, such as driver behavior or road conditions. Mamdani Fuzzy Logic provides a framework for handling uncertainty and vagueness and allows for the representation of knowledge in the form of fuzzy rules that reflect the expert's experience and judgment. The Mamdani Fuzzy Logic system can provide accurate predictions based on the input data, and allows for the quantification of the degree of membership of each input variable to different fuzzy sets, leading to more refined and nuanced predictions. By providing accurate predictions about the likelihood of road accidents, Mamdani Fuzzy Logic has the potential to improve road safety by informing the development of effective road safety strategies and policies, and by providing real-time information to drivers and other stakeholders to help prevent accidents.

Overall, the use of Mamdani Fuzzy Logic in this research will provide a powerful tool for modeling complex and multifaceted systems, handling uncertainty and vagueness, and providing accurate predictions that can inform the development of effective road safety measures and improve road safety in our country.

II. Material And Methods

We implemented the collected data in MATLAB software to do **MAMDANI** Fuzzy Classification and visualize the output. Here we put the value of **AADT, SP, RW, RM and AAA. Mamdani** fuzzy classification is an effective way to find out or predicting the number of accidents that can occurs based on the inputted variables.

Fuzzy logic: Fuzzy logic is a control method for solving system problems that can be used with a wide range of systems, including general systems, small systems, embedded systems, PC networks, and multichannel or workstation-based data acquisition and control systems. This technique can be applied to either hardware or software by itself or to both. More specifically, fuzzy logic is a branch of multivalued logic that focuses on approximation rather than precision in reasoning.

Fuzzy classification: Fuzzy classification analysis is usually used to classify the training data set (a data set that is used to induce the Membership function) and to predict the testing data. The training data set contains a number of examples. An example contains a value for a dependent attribute and several attribute values can be either nominal or non-nominal.

Mamdani Fuzzy Logic: Mamdani fuzzy inference was first introduced as a method to create a control system by synthesizing a set of linguistic control rules obtained from experienced human operators [1]. In a Mamdani system, the output of each rule is a fuzzy set.

Since Mamdani systems have more intuitive and easier-to-understand rule bases, they are well suited to expert system applications where the rules are created from human expert knowledge. The Max-min approach is another name for Mamdani. Ebrahim Mamdani first popularized this technique in 1975 [4].

Study Location: First, we visited the Mohakhali bus terminal and then the Gabtoli bus terminal to collect the data based on the bus. After that, we had a discussion with the highway traffic police. Then to justify the validity of the data, we separately started to count vehicles from different points (Banani, Gazipur, Chandra) of the highway. Then we considered the value of data that we collected manually from three different points.

Study Duration: November 2022 to February 2023.

Sample size: 5356800 units.

Vehicle Count:

Time Interval	Car (Weekdays/ Weekend)	Bus (Weekdays/ Weekend)	Truck (Weekdays/ Weekend)	Total Count on weekdays	Total Count on weekend
0-5 mins	75/30	13/8	12/17	100	55
60 min	900/360	156/96	144/204	1200	660
24 hours	21600/8640	3744/2304	3456/4896	28800	15840
1 month	648000/259200	112320/ 69120	103680/ 146880	864000	475200
1 year	7776000/ 3110400	1347840/ 829440	1244160/ 1762560	10368000	5702400

Sample size calculation: Total vehicle count (from Nov 2022 to Feb 2023): 5356800

Subjects & selection method: As our research topic is based on the accidents, so the main subject of our research is vehicle. We divided the vehicles into three groups: **Car**, **Bus** & **Truck**. We calculated the date based on time such as for 0-5 mins, 60 mins, 24 hrs, 1 month and 1 year. After that we inputted 3 types of speed levels and a specifically average width of road. We also considered roadside market also as accident occurs in these areas frequently.

Considering Speed: 70km/h, 80km/h, 90km/h

Considering Average Road Width: 15.48m per side/way.

Roadside Market: 60

III. Discussion

Procedure methodology:

We have inputted the data in MATLAB software to apply and do calculations of Mamdani fuzzy logic to get the result. Here are some screenshots of the software given below:

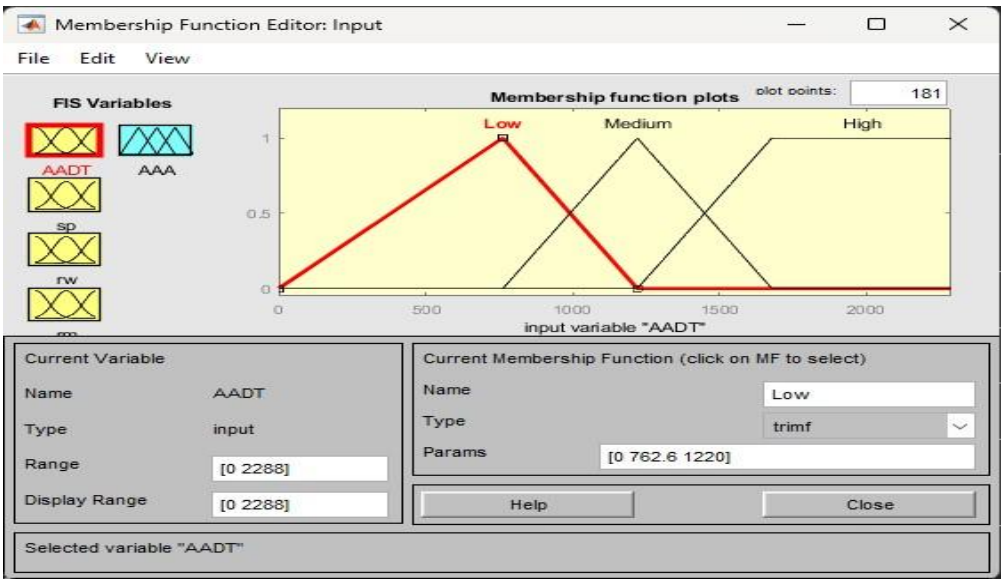

Fig 3.1: AADT

AADT stands for Annual Average Daily Traffic. In the above figure, we can see a field called range, where we have to input average data of how many vehicles travels through a specific road. We have input from 0-2288 for Dhaka – Mymensingh road as our annual average daily traffic was 2288. After Inputting the value/data a graphical representation will be shown and it also can be edited. We can see in the graphical representation that there are three triangular membership functions Low, Medium & High. We can adjust these parameters through the params field.

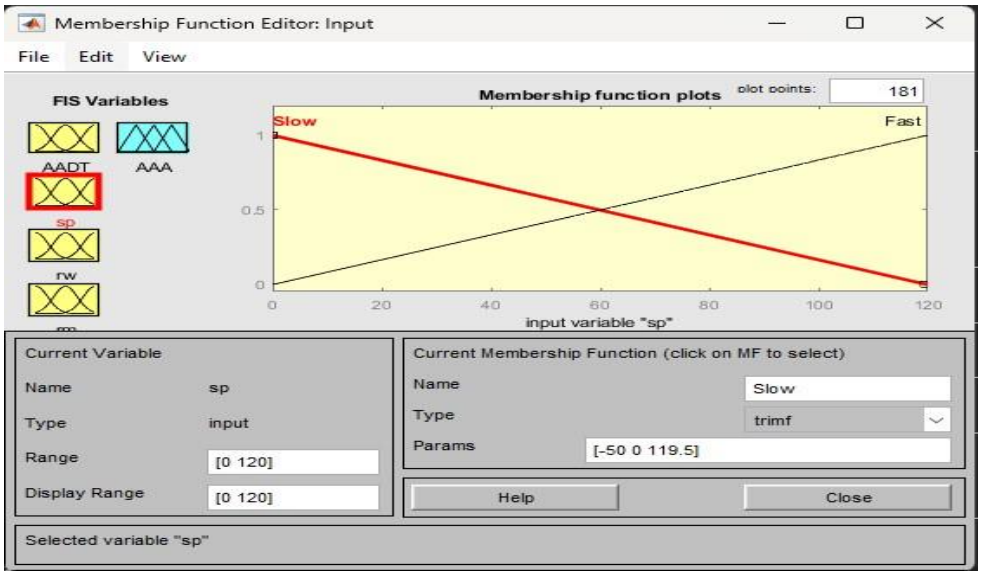

Fig 3.2: SP

SP stands for speed. Here in the range, we have to input data. We have inputted from 0-120 as we considered the highest top speed of vehicle 120. After Inputting the value/data a graphical representation will be shown and it also can be edited. In the graphical representation, we consider 0 as good and 1 as bad. When the vehicle is running so fast, the straight line is reaching 1, and when the vehicle is running slowly, another straight line is reaching 0 downward. We can adjust straight-line parameters in the params box also.

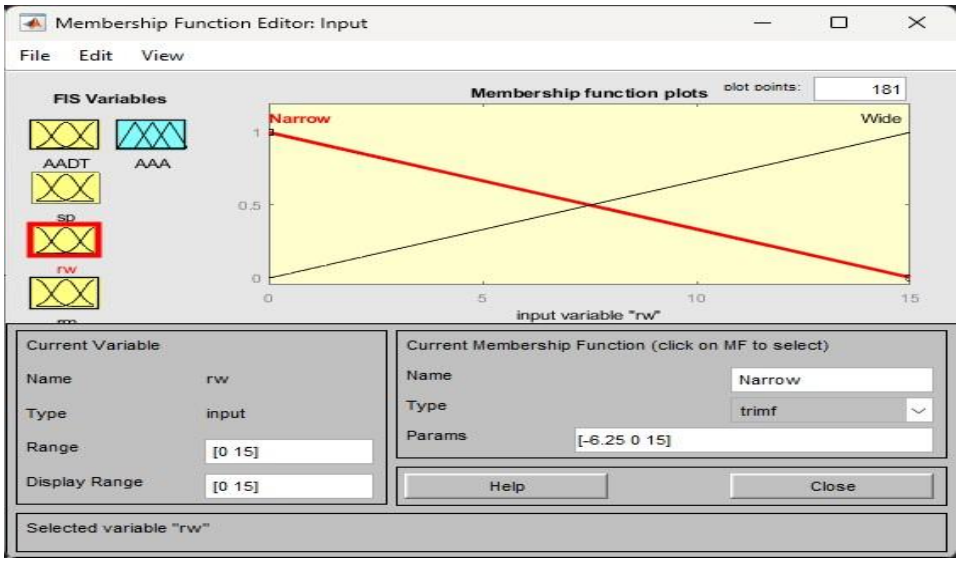

Fig 3.3: RW

RW stands for Road width. We know the width of a road may be differ based on location. As we have chosen Dhaka – Mymensingh road for our research purpose, somewhere the width was 18-20 m and somewhere 10-12 m. We considered an average width of 15.48m for our research purpose which we inputted in the range field. In the graphical representation, we can see that there are two straight lines. One is for narrow and the other is for wide. We can edit these line parameters through the params field.

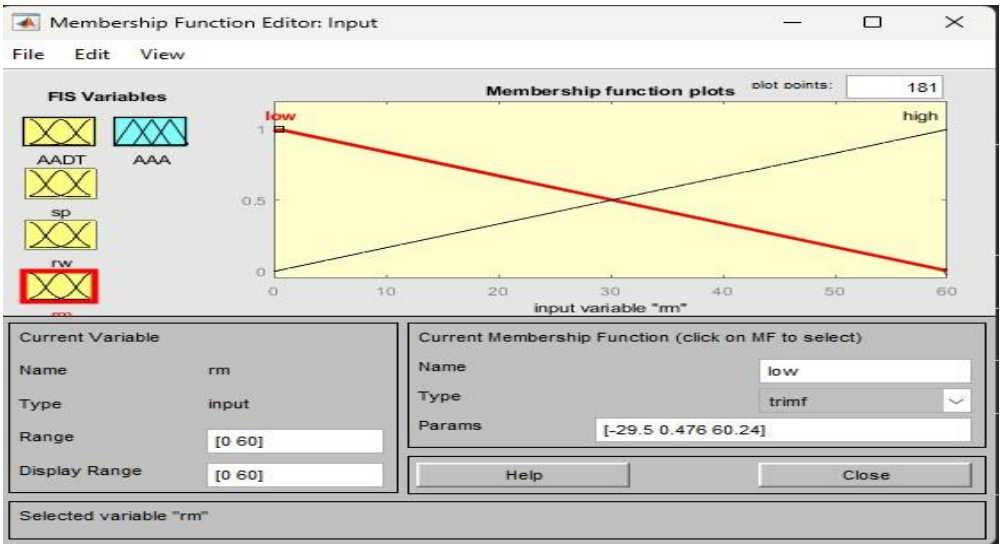

Fig 3.4: RM

RM Stands for Roadside Market. There are 60+ markets situated on the roadside starting from Dhaka to Mymensingh. We considered a round figure 60 market on average for better calculation and to get a better result. In the graphical representation, we can see two straight lines. One is for low and one is for high. Low means the number of markets is low and high means the number of markets is high in ton roadside. We can edit these lines by changing parameters from the params box.

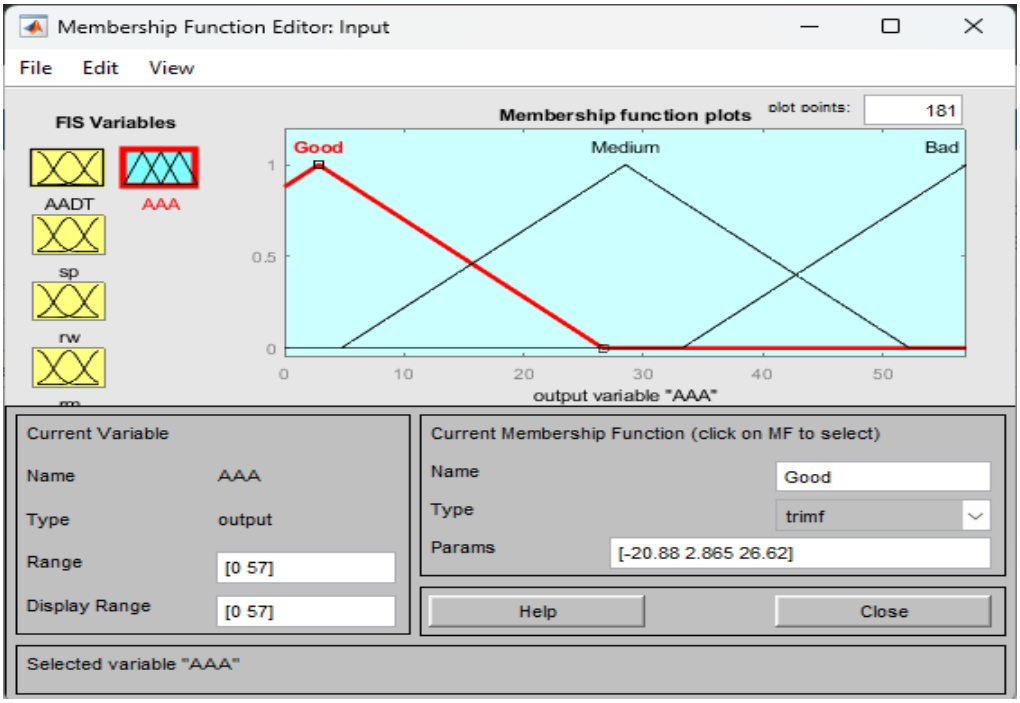

Fig 3.5: AAA

AAA stands for Annual Average Accidents. Annually nearly 60 accidents occur each year. It can differ over the years. So, we considered 57 accidents yearly for our research purpose. We can see their triangle membership function as good, medium, and high. These functions' parameters can be edited through the param box.

Fig 3.6: Output

In the rule's viewer, we can see that there are 3*2*2*2 = 24 rules that have been implemented to develop Mamdani FIS Model. There are 3 types of **AADT** which are Low, Medium, and High. There are 2 types of **SP** we have considered and they are Slow and Fast. Again, there are 2 types of **RW** they are Narrow and Wide then there are 2 types of **RM** and they are Low and High lastly there are 3 types of **AAA** which are Good, Medium, and Bad. These are membership functions for **AAA**.

IV. Result

In this study, to construct a fuzzy model are used: the annual average daily traffic (AADT), road width (RW), speed (SP), roadside market(RM), and the annual all accidents (AAA). The data have been collected in one-month duration for Dhaka-Mymensingh Road and are presented in Table 1. To develop the Mamdani FIS model are used 3x2x2x2 = 24 mechanical rules.

Table 1

Month	January
AADT	2288
Speed	70-90
Road Width	15.48m
Roadside Market	60
AAA	57

Applied these rules on the Dhaka-Tangail highway. The applied values are given below

Table. 2.

Month	January
AADT	1508
SP	84
RW	11.7
RM	20.8
AAA Predicted	28
AAA Observed	13
Absolute Error	15

V. Conclusion

In conclusion, this research aimed to investigate the use of Mamdani-type fuzzy inference systems in predicting road accidents in Bangladesh. The study analyzed various factors that contribute to road accidents in Bangladesh and used a Mamdani-type fuzzy inference system to make predictions about the likelihood of accidents occurring in different conditions.

The results of the study showed that Mamdani-type fuzzy inference systems can be effectively used to predict road accidents in Bangladesh, and that the system was able to provide accurate and reliable predictions based on the input data.

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