Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 12, December - 2019

Prediction of Road Accidents using Fuzzy Logic

Elda Maraj[1]
[1] Department of Mathematic Engineering, Mathematical Engineering and Physics Engineering Faculty, Polytechnic University of Tirana, Albania
e.maraj@fimif.edu.al

Shkelqim Kuka[2]
[2] Department of Mathematic Engineering, Mathematical Engineering and Physics Engineering Faculty, Polytechnic University of Tirana, Albania
sh.kuka@fimif.edu.al

***Abstract*— Road accidents prediction plays an important role in human life and improving the road safety. Traffic accidents represent a major problem in peoples's lives and their health. Road accidents prediction models may help to reduce the number of accidents.**
Albania has experienced many road accidents during the transition peiod. This has happened for several reasons, for instance large demographic movements towards major urban centers, irregular urbanization, lack of urban plans, the low level of road safety culture etc. Road safety indicators represent an improvement from 2009 associated by a decrease in the number of deaths. However, Albania has the highest number of death in the Southeast European Region.
The purpose of this paper is to develop a fuzzy logic model for prediction of road accidents in Albania. Here fuzzy logic toolbox of MATLAB is used.

Keywords*— Road accidents, Prediction model, Fuzzy logic toolbox.

I. INTRODUCTION

Accidents cause injuries and death for many people all over the world causing many social and economic problems. In this paper, a fuzzy model is developed for the prediction of accidents in Albania as a case study. Traffic conditions and roadway are two major factors that affect traffic accidents. By studying these factors, the number of accidents may be reduced. Crash prediction models are proved to be effective in the road safety analysis.
Road accidents problem was solved using fuzzy logic by Driss et al. [1] who defined the accident's risk by using road accident prediction system based on fuzzy logic.
Xiao et al. [2] established two fuzzy logic models to predict the risk of accidents that occurred on wet pavements.
Meng et al. [3] used fuzzy model for studying road accidents with different traffic and road conditions. They defined 41 rules for building their model and they discovered that the model is reliable when applying to the study area. Saravanan et al. [4] used fuzzy logic for predicting accidents risk on road network. They developed a new model for accident involvement risk studies.
Zaied [5] solved the problem of accidents at intersection by using fuzzy logic. They built a fuzzy logic traffic system for isolated signalized intersections that is able for changing signal timings according to situation level.
Accidents happen as a result of combination of various factors that are often caused by several factor. To explain why accidents happen, it is more appropriate to use the concept of risk increasing factors [6]. According to the World Health Organization's (WHO's), road traffic injuries are defined as "fatal or non-fatal injuries caused as a result of a road traffic crash" [7].
Road accident is most unwanted thing that can happen to a road user. Main cause of accidents and crashes are thanks to human errors. Some of the common behaviour of humans which results in accident are: Over Speeding, Drunken Driving, Distractions to Driver, Red Light Jumping, Avoiding Safety Gears like Seat belts and Helmets, Non-adherence to lane driving and overtaking in a wrong manner. Some negative effects of traffic on environment are: safety, noise, land consumption, air pollution, and degrading the aesthetics. Some preventive measures for accidents are: education and awareness about road safety, strict enforcement of law, engineering (vehicle design and road infrastructure) etc [8].

There are some advice to prevent road accidents such as, speed control when driving a car, not to use mobile phones, preventing of sleepiness while driving, not to use alcohol, medicines and drugs, following of seat belt regulations [9].
Road safety depends on how societies choose for managing transport systems, and urban development in relation to their health and safety objectives and how they are balanced with economic, social and environmental considerations. Nationally and internationally, it is accepted that preventing road safety problems is a problem of stopping serious and fatal injury in road crashes. Therefore, road users have been held responsible for the safety of the road transport system. Consequently, preventive strategies have been directed at improving users' behaviour, mostly through education, information and enforcement [10].

In this paper, annual average daily traffic (AADT), lane width (LW), velocity (V) and traffic load (TL, calculated by volume/capacity), are taken as inputs to the model. The accidents per kilometer per year (AF) is the output.

II. FUZZY LOGIC

The Fuzzy Logic was introduced in 1965 by Lotfi Zadeh, and is a mathematical tool for dealing with uncertainty. It provides a technique for dealing with imprecision and information quality. The fuzzy theory provides a mechanism to represent linguistic constructs such as “many,” “low,” “medium,” “often,” “few.” The fuzzy logic provides an inference structure that allows appropriate human reasoning capabilities.
The theory of fuzzy logic is based in the notion of relative graded membership. It is important to notice that there is an connection between Fuzziness and Complexity. As the complexity of a problem, exceeds a certain threshold, the system must necessarily become fuzzy in nature. Real world problems are too complex, and the complexity involves the degree of uncertainty – as uncertainty increases, thus does the complexity of the problem. Traditional system modeling and analysis techniques are too precise for such problems. Fuzzy systems theory is similar to other engineering theories, because almost all of them characterize the real world in an approximate manner [11].
In real life, much of the information is not so crispy but involves some degree of fuzziness. The truth value can range between the completely true value and the completely false value, leading to a partial truth. The basic idea in fuzzy systems is to provide a partial truth that can be numerically described by a membership function that takes values between 0 and 1. Fuzzy logic approachs translate imprecise linguistic information sets in computer usable numerical language. Nevertheless, they can not learn well from the data. In general, fuzzy logic systems are limited to fields where expert knowledge is available and the number of input variables is small [12].
A Fuzzy rule is represented by Figure 1. It consists of four main components:

1. Fuzzification: that converts non-fuzzy inputs of fuzzy system into fuzzy inputs for inferencing mechanism.
2. Knowledge base: that consists of two parts: database that defines fuzzy sets, and rule base that represents the mapping of fuzzy input set into a fuzzy output set. Rules are fuzzy conditional statements that may be specified using the knowledge of experts directly or by available data. Also, they may have to be constructed simply from data.
3. Decision logic: that simulates human decision making based on fuzzy concepts. Conclusion of certain condition is obtained by decision making logic.

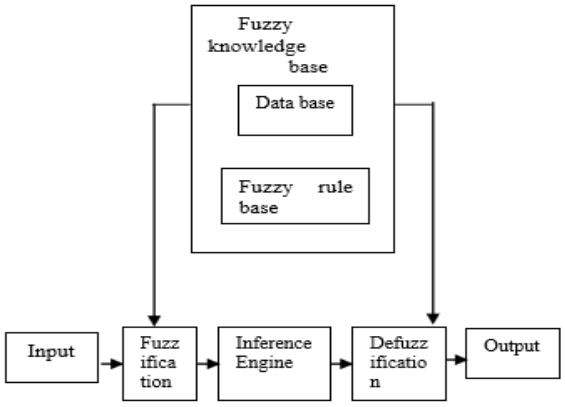

Figure 1: Structure of a fuzzy logic system.

4. Defuzzification: that converts fuzzy outputs in numeracal values [13].

III. STUDY AREA

The Tirana-Elbasan Highway is a highway in central Albania. The total length of the road is 27 kilometres. The road consists of two independent carriageways. Each carriageway contains two lanes of movement and one emergency lane.
The Krraba tunnel is part of this road which consists of two Tubes. The left tube has a length of 2.32 kilometres, and the right tube has a length of 2.58 kilometres.
The road is divided into three segments:

- The first segment (Tirana – Entry to the Krraba tunnel)
- The second segment (The Krraba tunnel)
- The third segment (The exit of Tunnel – Elbasan)

Figure 2: Map of Tirana-Elbasan Highway

Figure 3: View from Tirana-Elbasan Highway

IV. DESIGN STEPS

A. *Fuzzy Inference System*

We have used the "Mamdani Fuzzy Inference System" for our system.

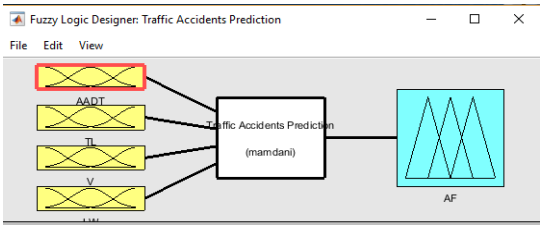

Figure 4: Mamdani FIS Model

The above figure shows the inputs and output of our system. They are explained below in detail.

B. *Input*

We have applied annual average daily traffic (AADT), lane width (LW), velocity (V) and traffic load (TL) as input variables to the model. AADT is fuzzified into three fuzzy sets: low, medium and high. Lane width is fuzzified into three sets: narrow, medium and wide. Velocity (V) has low and high two fuzzy sets. Traffic load (TL) is fuzzified into low, medium, high and extremely high. Membership functions of inputs are shown as Fig.5, Fig.6, Fig.7 and Fig.8 [3].

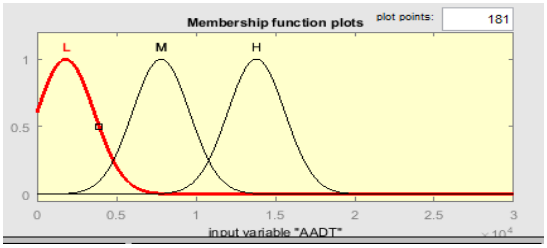

Figure 5: Membership Function of Input Variable AADT.

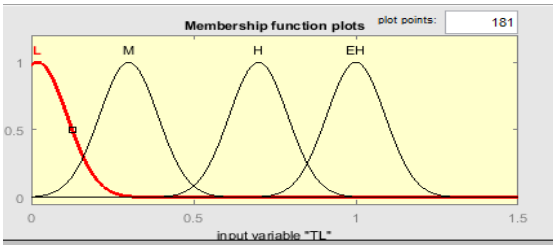

Figure 6: Membership Function of Input Variable TL.

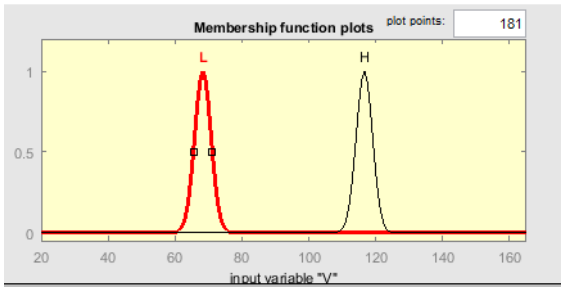

Figure 7: Membership Function of Input Variable V.

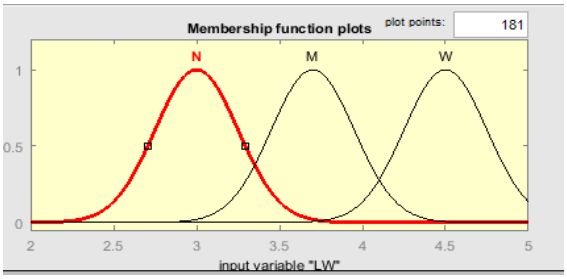

Figure 8: Membership Function of Input Variable LW.

C. *Output*

Output of our designed system is the accidents per kilometer per year (AF). The output variable is fuzzified into five sets: few, less, medium, more and many [3].

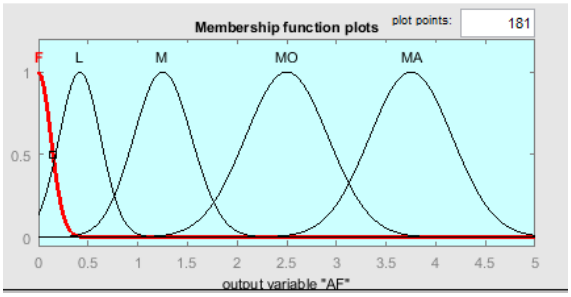

Figure 9: Membership Function of Output Variable AF.

D. *Design Rules*

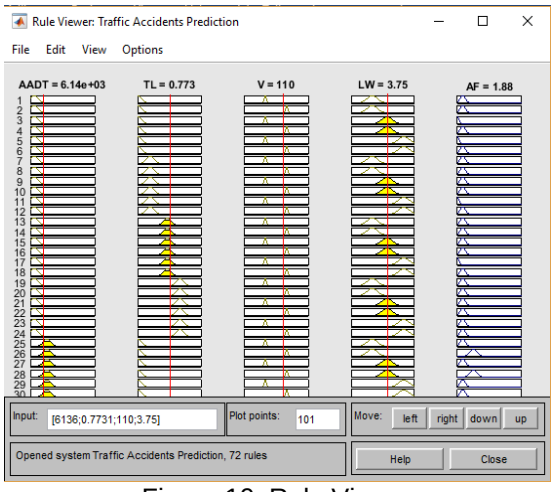

Figure 10: Rule Viewer

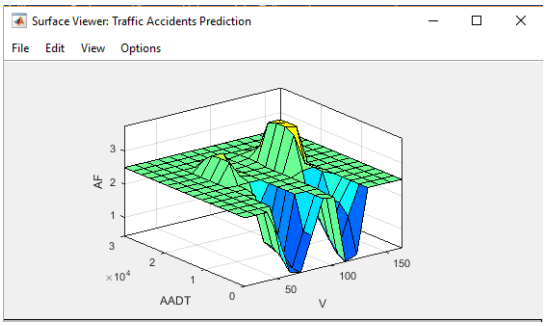

Figure 11: Surface Viewer

V. RESULTS

In this study, annual average daily traffic (AADT), lane width (LW), velocity (V), traffic load (TL) and accidents per kilometer per year (AF) are used to construct fuzzy model. These data are taken for Tirana-Elbasan Highway in Albania, and are presented in Table 1. The Fuzzy model was constructed according to Mamdani type. To develop the Mamdani FIS model are used 3x4x2x3=72 mechanical rules. Contradicting rules were omitted intuitively and the model constructed with the 41 effective rules. The fuzzy model calculations were performed using fuzzy toolbox in Matlab.

Table 1. Tirana-Elbasan Highway

Year	2015	2016	2017
AADT	6075	6968	8785
TL	0.732	0.754	0.835
V (km/h)	110	110	110
LW (m)	3.75	3.75	3.75
Predicted (accidents/ km)	1.27	1.41	1.99
Observed (accidents/ km)	1.15	1.52	1.7
Absolute error	0.12	0.11	0.29

Average absolute error = 0.17

Vl. CONCLUSIONS

Road accidents occur in every country of the world. Every year they take the lives of more than a million people. The different age groups such as, the elderly, children and the disabled are particularly vulnerable. Road safety has received inadequate attention at both the international and national levels. The reasons include lack of general appreciation.

The basic objective of this paper is to develop a model that can predict the traffic accidents. Because of the random character of traffic accidents, the developed methodology will not be efficient in predicting the exact number of traffic accidents. The fuzzy logic model is practical in predicting traffic accidents. Nevertheless, there are still new researches to do to improve the efficiency of the fuzzy logic model.

ACKNOWLEDGMENT

Authors acknowledge the General Director of Road Policy in Albania, and Albanian Road Authority for supporting with real data.

REFERENCES

[1] Driss, M., Saint-Gerand, T., Bensaid, A., Benabdeli, K., & Hamadouche, M. A. (2013, May). A fuzzy logic model for identifying spatial degrees of exposure to the risk of road accidents (Case study of the Wilaya of Mascara, Northwest of Algeria). In Advanced Logistics and Transport (ICALT), 2013 International Conference on (pp, 69-74). IEEE.

[2] Xiao, J., Kulakowski, B., & El-Gindy, M. (2000). Prediction of risk of wet-pavement accidents: fuzzy logic model. Transportation Research Record: Journal of the Transportation Research Board, (1717), 28-36.

[3] MENG, X. H., ZHENG, L., & QIN, G. M. (2009). Traffic Accidents Prediction and Prominent Influencing Factors Analysis Based on Fuzzy Logic [J]. Journal of Transportation Systems Engineering and Information Technology, 2, 015.

[4] Saravanan, S., Sabari, A., & Geetha, M. (2014). Fuzzy-based approach to predict accident risk on road network. International Journal of Emerging Technology and Advanced Engineering, 4(5), 536-540.

[5] Zaied, A. N. H., & Al Othman, W. (2011). Development of a fuzzy logic traffic system for isolated signalized intersections in the State of Kuwait. Expert Systems with Applications, 38(8), 9434-9441.

[6] Third African road safety congress. (1997 (19-8-2007) http://www.worldbank.org/transport/ publicat/b28.pdf). Financing of road safety actions. Paper presented at the Third African road safety congress. from http://www.worldbank.org/transport/publicat/ b28.pdf.

[7] World Health Organization. (2007b (17-8-2007) http://www.who.int/violence_injury_prevention/road_traffic/en/). Road traffic injuries (Publication. Retrieved 17-8-2007, from World Health Organization: http://www.who.int/violence_injury_prevention/road_traffic/en/ .

[8] http://jhtransport.gov.in/causes-of-road-accidents.html.

[9] https://patient.info/doctor/accidents-and-their-prevention.

[10] Racioppi Francesca, Eriksson Lars, Tringvall Claes, Villaveces Andres, “Preventing road traffic injury: A public health perspective for Europe”, 2004.

[11] S. N. Sivanandam, S. Sumathi and S. N. Deepa, “Introduction to Fuzzy Logic using MATLAB”, 2006-2007, pp. 17 – 128.

[12] A.W. Jayawardena, “Hydro-meteorological disasters: Causes, effects and mitigation measures with special reference to early warning data driven approaches of forecasting”, 2013.

[13] Jaya Pal, Vandana Bhattacherjee: “Prediction of fine in accidents using fuzzy rule based model”, International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-1, Issue-9, December 2015.