Pakistan Journal of Engineering Technology and Science (PJETS)
Volume 12. Issue.02, PP. 01-13, December 2024
https://doi.org/10.22555/pjets.v12I2.1127
E-ISSN 2224-2333
P-ISSN 2222-9930

A Comparison of Different Defuzzification Methods on Road Traffic Accidents Data of Khuzdar Region of Balochistan Province of Pakistan

Zubair Ahmed [1], Shabbar Naqvi [2], Nooruddin [2], Mansoor Ahmed Khuhro [3] ,Naseer Ahmed [1], Afrasiyab Khan [4*]
[1] Department of Computer Science, Balochistan University of Engineering & Technology, Khuzdar, Pakistan
[2]Department of Computer System Engineering & Science, Balochistan University of Engineering & Technology, Khuzdar, Pakistan

[3]Department of Artificial Intelligence and Mathematical Sciences, Sindh Madresatul Islam University, Karachi, Pakistan
[4]Department of Software Engineering, Balochistan University of Engineering & Technology, Khuzdar, Pakistan

[*]Corresponding Author: afrasiiyabkhan@gmail.com

Abstract:

Road Traffic Accidents (RTAs) are an alarming cause of many deaths and injuries. It is considered a major public health issue. Multiple families have been engraved due to RTAs. Researchers from all over the world are focusing on RTAs because it is a challenging issue. In developed countries, RTAs have been minimized and are being controlled via modern methods of computer science. Similarly, people in Pakistan are facing RTA as their major issue gulping hundreds of lives every day and thousands yearly. In the Balochistan province of southern Pakistan, the National Highway 25 (N-25) called the Regional Cooperation for Development (RCD) road faces severe RTA issues. According to the Medical Emergency Response Center (MERC), overall 25,033 accidents have been recorded from Oct-2019 to Oct-2022 with 33,726 injuries and 653 deaths. This shows the alarming condition of the N-25 for the public and also serious challenges for the traffic controlling authorities. In the Khuzdar area, every year more than five thousand RTAs happen resulting in 250-300 lives and two hundred injuries having 500 to 600 accidents in disabled persons (ADPs). In this research, a Fuzzy Inferencing System (FIS) has been presented for investigating the RTAs with a case study specific to the Khuzdar area from Baghbana to Pir Umar. A comparison of five defuzzification methods, namely centroid, bisector, Smallest of Maximum (SOM), Large of Maximum (LOM), and Medium of Maximum (MOM) was made. The results indicated that the Large of Maximum (LOM) method can provide a scalable output that is better at reflecting the ambiguities of the related variables, their membership functions, and associated rules.

Keywords: *Artificial Intelligence, Road Traffic Accidents, Fuzzy Logic, RCD Road, Fuzzy Defuzzification Methods.*

I. INTRODUCTION

An accident is defined as “an unfortunate incident that happens unexpectedly and unintentionally, typically resulting in damage or injury” [1]. Accidents occurring on the road, involving pedestrians and/or vehicles, are defined as road traffic accidents (RTAs)[2]. RTA is one of the top ten leading causes of death worldwide and its incidence is higher in developing countries[3]. The number of accidents and deaths by road traffic has increased around the world [4]. Internationally, research studies show that India is leading China in the number of road accidents. One road accident occurs every minute and 16 people die in one hour and 384 in a day. 40% of road accidents occur due to truck and two-wheeler traffic [5]. On the other hand, according to the World Health Organization’s global estimate report 1.25 million road

traffic deaths occur in a year, and one-fifth of those deaths occur in China[6]. In Malaysia, road accidents have been identified as the fourth principal cause of death after cerebrovascular, pneumonia, and Ischemic heart diseases [7]. In the Gulf region, Saudi Arabia ranks second in road traffic accidents [8]. A study from Saudi Arabia states that 67% of RTAs occur due to human factors, only 29% happen due to road conditions and just 4% of road traffic accidents follow the reason of vehicle maintenance[9]. Mostly road traffic accidents occur due to human factors such as over-speed, careless driving, and use of devices during driving are fundamental factors. While other factors include, broken roads, lighting issues, break failures, poor spare parts, and weather issues[10]. Unfit transports should not be allowed to be driven on motorways and highways. Authorities should discourage underage, unskilled driving and speed [11]. Vehicle factors include no maintenance of the vehicle, sudden faults in physical spare parts, mechanical maintenance issues, and vehicle design issues [12].

Researchers in Bangladesh transportation are busy finding solutions for road traffic accidents. They suggest implementing a pre-accident traffic control system and driver vigilance system to prevent incidents. The Artificial Intelligence-based system provides alerts to drivers on speed limit by the comparison of speed with speed limit sign boards placed on roadsides and also devised a scheme for drivers' vigilance by heartbeat anomaly (HBA) with PPG device to analyze the heartbeat rate of the driver on Neuro-Fuzzy controller to integrate these inputs and logarithm calculation generates an emergency message either alarms for an emergency break by the detecting drowsiness, irregular heartbeat hi-speed. The use of the Convolution Neural Network (CNN) algorithm detects over-speed by GPS and front camera to avoid RTAs and suggests that this scheme needs to be implemented by transport authorities [13].

In Australia, a smart and intelligent traffic system (ITS) needs predictive models to make the transport system smart and intelligent. They developed an object detection neural network model (NNM) with the use of a time-lag recurrent network (TLRN) and have succeeded in predicting vehicle speed for 5 minutes in the future with 90-94 percent accuracy. They also predicted travel time of up to 15 minutes with the use of speed and flow as input to the network with the same accuracy as speed and for flow it has a 68% accuracy rate [14]. Under the umbrella of the global sustainable goal of UN Charter 11.2, the UN 2030 will improve road safety to expand public transport for all especially for people living in vulnerable conditions like women, children, and persons with disabilities and old age [15]. Smart technology works on mathematical calculations to conduct activities and to predict the users' upcoming future activities with accurate possibilities. The fuzzy logic-based model was used to predict road traffic accidents in Albania. This fuzzy logic interference model is useful in dealing with uncertain factors of RTAs like vehicle, human, and environmental causes of road traffic accidents. This study aims to investigate at investigating the fundamental environmental factors and utilize them as input variables of the fuzzy logic model in which road and traffic conditions are two effective factors fuzzy logic model is introduced to reduce the number of RTA [16].

In Pakistan, RTAs have become a challenging issue with an astonishing increase in the number of RTAs. In Pakistan Road traffic accidents cause very high unnatural fatalities and it is very important to investigate them to take measures to decrease the number of RTA fatalities [17]. According to the Pakistan Bureau of Statistics (PBS), road accidents have increased drastically all over the country ever recorded [18]. This rampant explosion of vehicle population has created a burden on the current road system, which has marked traffic accidents as a serious threat to human life. The infrastructure of the country's road systems has remained unchanged for the past few decades. In December 2020, car sales have increased by 13.6%[19]. Car sales have jumped up to 46% in January 2021[20] and a 31% increase in the sale of vehicles was recorded in February 2021[21]. The country has penned down the National Road Safety Strategy Program (NRSSP) 2030 but unfortunately, no achievement has been made yet it might be beneficial to build safety foundations to make the roads safer for future generations if practical implementation is preferred [22].

In this regard, the Provincial Vehicle Ordinance, of 1965 states in fitness certificate rules that every vehicle should be given a fitness certificate by the concerned authority this can be issued for six months to three years. Unfortunately, the fitness certificate rule is ignored and remains unpracticed. Among the above-mentioned factors the human factor is the most common factor behind road traffic accidents [23] Traffic Accidents have several causes mechanical breakdown of spare parts like brake failure, steering issues, tire blowouts, lack of drivers' attention, use of the mobile phone during driving, eating and drinking while driving and over speed [24]. Geographical and environmental issues also cause road traffic accidents. Construction, broken roads, and single roads with heavy traffic, sharp road curves, snow, ice, fog, heavy rain, hilly areas, ups and downs, and zigzag turns. Environmental factors like fog 34%, severe coldness 21%,

heat conditions 20% and rainfall 25% are directly related to RTAs [25]. In Peshawar, KP (Khyber Pakhtunkhwa), car accidents have increased in the past few years because the road infrastructure remained the same and most of the roads lacked traffic control signals[26].

N-25 has many Zigzag irregular curves and deep slops with ups and downs. The N-25 highway is geographically located from 400 to 1200 meters above sea level. This project has almost 45% mountainous areas. The presence of these steep gradients and sharp curves is confirmed and creates serious bottlenecks for traffic to pass through [27].

Road Traffic Accidents in Balochistan are soaring day by day. Every day hundreds of lives are guzzled in by RTAs. There are multiple factors of road accidents in Balochistan. Research has revealed the main causes of Road Traffic Accidents on the coastal highway Makran, the Use of drugs while driving earned 83% answers of respondents, Rash Driving 56%, Lack of awareness 59%, and No awareness of traffic rules 93%. In this regard, 79% of people termed the role of government in controlling road traffic accidents as poor [28].

High-speed and over-taking are the leading cause of road traffic accidents. In this regard, highway authorities placed signboards with a speed limit of 100 km/h. As per the initial project limit of N-25 in flat areas speed limit is 100 km/h and 80 km/h in hilly areas. "Balochistan the largest province by area has a comparatively high rate of road traffic accidents. The geographical location of Balochistan marks it as very important in terms of transportation as N-25 is the busiest route connecting Karachi with Quetta and Chaman with the rash of traffic. The statistics from Jan-2015 to Feb-2017 show that due to road traffic accidents, there have been 158 recorded accidents on N-25. In these RTAs, 175 passengers lost their lives and 436 were seriously injured. People choose public transport on this route because it is inexpensive. In this route, most of the public transport are buses and wagons. The Overspeed of buses is very famous with a speed of 145 to 160 km/h[29].

Another study was conducted in Albania. This study also termed road and traffic as the main factor of road traffic accidents. Road crash studies of fuzzy logic interference models are very effective in the analysis of road safety models. Due to urbanization, Albania faced the highest rate of road traffic accidents in Southeast Eastern European Countries. Migration of people to urban areas, irregular urbanization, absence of urban planning, and very low road safety culture raised the number of RTAs. To reduce these accidents in the country the Mamdani fuzzy interference system was used to provide an AI-based fuzzy scheme for the prediction of accidents [30].

Khuzdar, on the route of N-25, is the 2nd most populous city and 3rd biggest city in the province. On N-25, most road traffic accidents take place in the Khuzdar area within the range of 40-50 kilometers from Baghbana Union Cunion Council of Khuzdar to Pir Umar Khuzdar. The data collected from MERC show Khuzdar/Baghbana with the 2nd largest number of injuries and in number of RTAs as 3rd and the death toll showing Baghbana and Tiyaro equally as 2nd. In Khuzdar 4,825 road accidents have been recorded with 7,133 injuries and 195 deaths from October, 2019 to December, 2022. In this era of technology, the high ratio of road traffic accidents is astonishing and needs our special attention. Technology nowadays is at the zenith of its advancement and IT experts can resolve all such issues. In Pakistan, the public traffic system is running without technology control. In this matter, policy should be made that no Public Service Vehicle (PSV) should be given a route permit and fitness certificate unless the technological controlling devices are used in it. This research is aimed at investigating the factors of RTA from Baghbana to Pir Umar Khuzdar to minimize the RTAs through designing an easy and reliable fuzzy system by comparing different de-fuzzification methods to find the method best suited for such kind of system.

The most common factors of RTAs are road environmental factors, human factors, and vehicle factors. The road environmental factors are further subdivided into lighting issues, road maintenance issues, construction or engineering issues, and signage issues. The human factors like unskilled drivers, lack of awareness about road and traffic rules, use of drugs while driving, traffic rules violations, speed-related issues, negligence of drivers, human errors, and the age factor.

In summary, it can be concluded that AI methods including fuzzy logic have strong potential to be explored to assist in reducing the RTAs and this research also focuses on it. The rest of the paper is divided in such a way that section II defines the methodology of the research.

II. **METHODOLOGY**

This research used both quantitative and qualitative research designs. The data pertaining to RTAs on N-25, Pir Umar

Khuzdar to Baghbana area were gathered to identify the variables of this research. This research is based on data obtained from MERC, NHA/Toll Plaza, Police and other sources of the Khuzdar area. These data sets and variables have been used to develop the fuzzy logic-based AI model to predict and control the RTAs. The flow chart of the work carried out is shown in Figure 1.

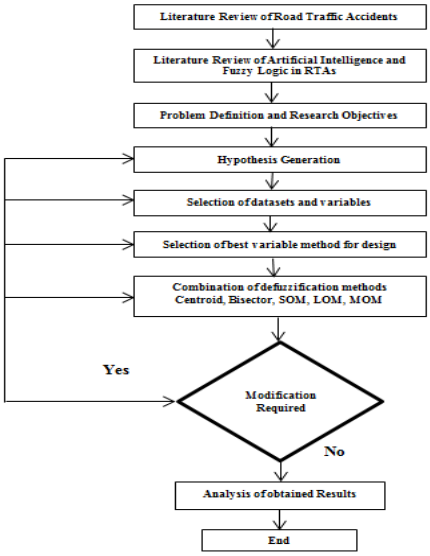

Figure 1: Research Design Flow Chart

The factors affecting the Road Traffic Accidents (RTAs) in Pakistan are unique when compared to other countries around the world. In other countries, the traffic control system is managed effectively with the help of advanced technology. No doubt this is the era of AI-based information technology. In Transportation, AI is being used by some transport companies to monitor and share information about transport speed, stay, weather conditions, distance measurement, logistic reaching, and delivery details to their consumers. They also can detect speed limits and driving faults on AI-based devices detecting results on algorithm methods. Much research has been conducted in this regard to prevent road traffic accidents and minimize the deaths and injuries of human beings. Further, AI is also being used by other companies like McDonald's, IBM, Delta, etc. for systematic and quick results for business planning [13]. However, the RTA factors in Pakistan, especially in Balochistan, are vastly different. The traffic system is in a poor state, particularly on the N-25 highway, where there are no traffic authorities to educate the drivers on the route and no technology is being used by the authorities. The highway passes through densely populated areas such as Khuzdar, where all kinds of traffic converge, and many link roads connect directly to the N-25, with no traffic authorities to control the traffic flow. Consequently, many accidents occur on this highway. Besides, this there are many dangerous curves and ups and downs of N-25 especially from Baghbana to Pir Umar without any traffic control authority where the drivers exceed the speed limit and show their negligence while driving and because of their negligence, many people lost their lives on this route. There are signboards regarding the speed limit of Heavy transport vehicles (HTVs) and Light transport vehicles (LTVs) but unfortunately, the safety instructions are ignored by drivers and many accidents occur. During the research, a physical survey was also conducted and different pictures depicting the complex areas as shown in Figure 2, Figure 3, Figure 4, and Figure 5 respectively.

The different defuzzification methods used for the factors of RTAs of N-25 especially from Baghbana to Pir Umar can also help prevent the RTAs of South Asian countries like Afghanistan, Bhutan, India, Iran, Nepal, and Sri Lanka in their narrow and winding roads. The variables related to the research problem, its importance aims, and objectives were drawn out from the literature review. In the hypothetical selection of variables, both the independent and dependent variables were selected to be used. The open-ended unstructured interview was used as a tool for data collection. The selection of unstructured questions was reliable proceeding with participants' answers to the interview and collecting

the desired data. Respondents consisted of 60 drivers interviewed and 50 public participants were selected where inter-

Figure 2: All type of traffic flow on N-25 from Khuzdar populous area

Figure 3: A view of link road which connects with N-25

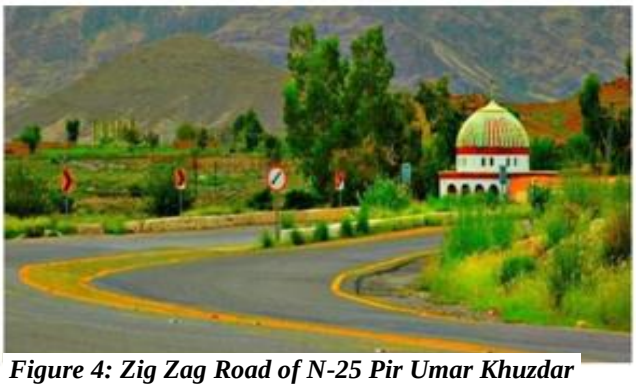

Figure 4: Zig Zag Road of N-25 Pir Umar Khuzdar

Figure 5: Irregular curves with many up and downs on N-25 Baghbana area

views consisted of 35 passengers consisting of 28 males, 5 females, and 2 children, and 15 other general people were interviewed. The questionnaire of the research is shown in Table 1. The summary of driver's interviews is shown in Table 2. whereas; the summary of answers given by public participants is shown in Table 3

Based on the literature review and from the interviews of the participants, factors were identified which relationship with RTAs related to the region under investigation. These factors have been mentioned in Table 4. After the identification of these sub-factors, ranking was done based on priority. The variables after priority-based ranking are shown in Table 5.

Table 1: Questionnaires

Questionnaires	N-25	Pir Umar to Baghbana
What are the primary causes of RTAs?	Over-speeding, distracted driving, fatigue, drunken driving, reckless driving	Narrow and winding roads, poor visibility, lack of safety features, increased traffic volume
What are the specific road and environmental factors contributing to RTAs?	Poor road design and maintenance, adverse weather conditions, wildlife presence	Narrow and winding roads, poor visibility, lack of safety features
How would you rank these factors in terms of their overall impact?	Poor road design and maintenance, adverse weather conditions, wildlife presence	Narrow and winding roads, poor visibility, lack of safety features

Table 2: Driver's Answers/Opinions Summary

Human Intervention Factor	58%
Road& Environmental Factor	42%

Table 3: Summary Of Answers From Other Public Participants

Accidents	Percentage
Human Intervention Factor	54%
Road & Environmental Factor	46%

Table 4: Factors Showing Minimum And Maximum Relationships With RTAs

Sr.	Factor	Relationship with RTAs	Sub-factors
1	Human Intervention Factors (HIF)	Maximum	Over-speed, overloading, un-skilled drivers, heavy vehicle
		Minimum	Careless driving, rush, increase in vehicles, animals on the road, use of cell phones and drugs while driving
2	Road Environmental Factors (REF)	Maximum	Single road tyre burst, irregular curves, ups and downs, no sign-boards
		Minimum	broken roads, rain and snowfall, no bypass

Table 5: VARIABLES AFTER PRIORITY RANKING

Sr.	Main Factor	Sub-factors	Ranking as per Priority
1	**Human Intervention Factors (HIF)**	Over-Speed (OS)	1st
		Over-Loading (OL)	2nd
		Unskilled Drivers (USKD)	3rd
		Heavy Vehicles (HV)	4th
		Animals on Road (AOR)	5th
		Use of cell Phone(UOC) while driving	6th
		Use of drugs(UOD) while driving	7th
2	**Road Environmental Factors (REF)**	Single Road (SR)	1st
		Tire Burst (TYB)	2nd
		Irregular Curves(IRC)	3rd
		Broken Roads(BR)	4th

A. Design of Fuzzy Inferencing System

For this research, Mamdani-type fuzzy Inferencing has been selected. The selection has been made as this method has been found to work well with complex levels of ambiguities. Five different defuzzification methods in this research have been compared.

- Centroid Method
- Bisector Method
- Large of Maximum Method (LOM)
- Medium of Maximum Method (MOM)
- Small of Maximum Method (SOM)

For the design, we have used Zadeh'sANDIng, ORing, and complement methods.

Where the intersection of two fuzzy sets A and B is given by:

A ∩B = Minimum (A, B)

The Union of two fuzzy sets A and B is given by

A U B = Maximum (A, B)

This research uses a fuzzy logic-based approach to investigate the factors of RTA of the Khuzdar region from Baghbana to Pir Umar by comparing different defuzzification methods to investigate which of the methods is best suited for such a system.

The complement of fuzzy Set A is given by:

Not (A) = 1 –A

The ranges of two variables for understanding have been kept from 1 to 10 where 1 shows less significance and 10 shows more significance. Figure 6 shows the structure of FIS in MATLAB.

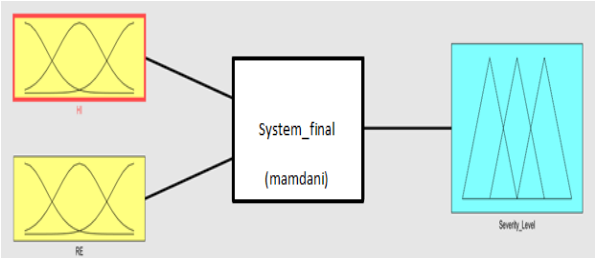

Figure 6: Basic structure of Fuzzy system.

The list of variables and their membership functions is shown in Table 6.

Table 6: Input Variables Detail

S.No	Input Variable	Membership Functions	Range
1	Human Intervention Factor (HIF)	Use of Drugs (UoD) Use of Cell Phones(UoC) Animals on Road (AoR) High Vehicle (HV) Unskilled Drivers (USKD) Over-Loading (OL) Over-Speed (OS)	1-10
2	Road Environmental Factor (REF)	Broken Roads (BR) Irregular curves (IRC) Tyre Burst (TYB) Single Road (SR)	1-10

We have used Triangular MFs for the development of the system as they are most frequently used. The output of the system is called the Severity Level. Table 7 shows the output and its related MFs with range.

Table 7: Output Variable with its Parameters

S.No	Output Variable	Membership Functions	Range
01	Severity Level	Low Middle Extreme	1-10

For the system, we have created 28 rules based on the combination of variables, interviews, and a review of the literature. Fuzzy rules are constructed based on the following principle:

IF (Antecedents) THEN (Consequents).

Figure 7 shows a view of the rule creation done in MATLAB. The input variable Human Intervention Factor (HIF) membership functions (MFs) has seven whereas, the input variable Road and Environmental Factor (REF) has four MFs. Figures 8 and Figure 9 show the footprint of the uncertainty of these variables respectively.

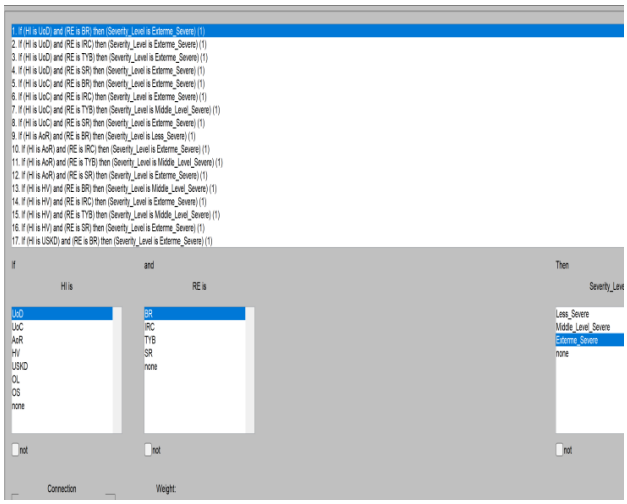

Figure 7: Rules creation in Matlab

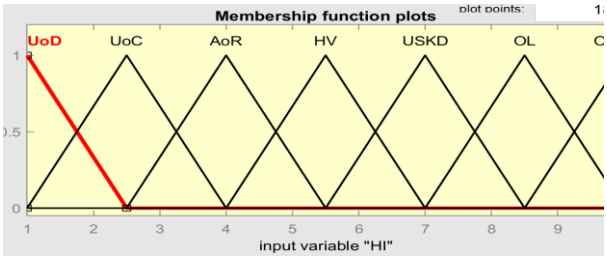

Figure 8: Membership functions of input variable Human Intervention Factor

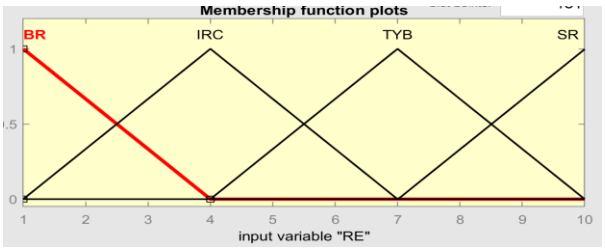

Figure 9: Membership functions of input variable Road and Environmental Factor

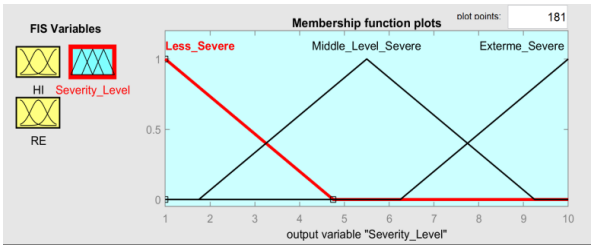

Figure 10: Output of variable severity level with Membership functions.

The output of variable severity level with membership functions is shown in Figure 10. It can be seen that the maximum output achieved on the data set is 10 whereas the minimum output achieved is 5.77. Overall minimum outputs of the five defuzzification methods are shown in Figure 21 and overall maximum values are shown in Figure 22. It can be seen from the output that three severity levels have been defined which are;

- Less Severe
- Middle-Level Severe
- Extreme Severe

These have been defined to assist the mechanism of situation handling according to the level of severity. If the severity level is less than less resources and mitigation will be required to stop accidents in the area which is from Baghbana to Pir Umar. The Extreme severity case will be an indicator that the situation has become more complex and severe steps are to be taken for accident prevention and road safety. The rest of the paper is divided in such a way that section III defines the results and discussions.

III. RESULTS AND DISCUSSIONS

A. Five Defuzzification Methods

We have used 50 data points to show the working of the Centroid Defuzzification method. The surface plot of the result is shown in Figure 11 and the output of the centroid defuzzification method on 50 data points is shown in Figure 12.

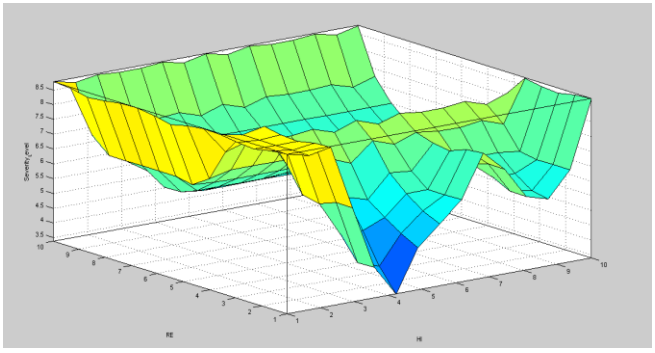

Figure 11: The surface plot of the centroid Defuzzification method

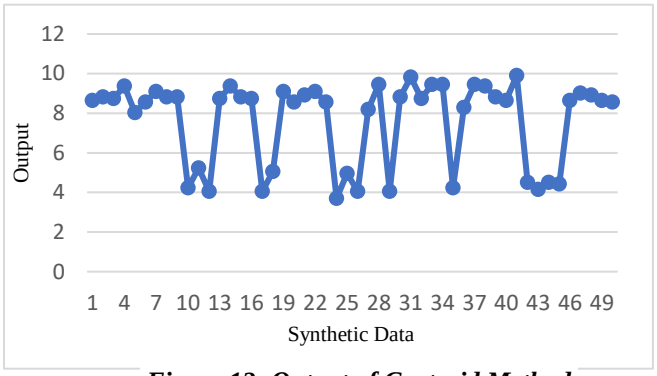

Figure 12: Output of Centroid Method

The maximum output achieved on the data set is 9.91 whereas the minimum output achieved is 3.7. The surface plot of the Bisector Defuzzification method can be seen in Figure 13, and the surface varies with the change of input. Also, it can be seen from Figure 14 that the maximum output achieved on the data set is 8.92 whereas the minimum output achieved is 5.5. The surface plot of the MOM Defuzzification method is shown in Figure 15 and the output is shown in Figure 16. The maximum output achieved on the data set is 9.91 whereas, the minimum output achieved is 3.64. The surface plot of the SOM defuzzification method and its output is shown in Figure 17 and Figure 18. The maximum output achieved on the data set is 9.82 whereas the minimum output achieved is 3.7. The surface plot of the LOM Defuzzification method is shown in Figure 19 with output plotted in Figure 20.

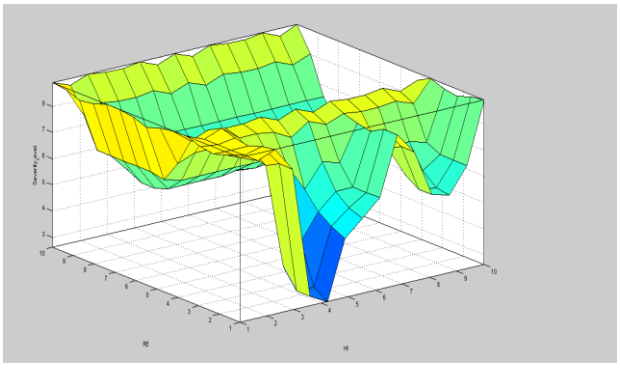

Figure 13: Surface plot of Bisector Defuzzification Method

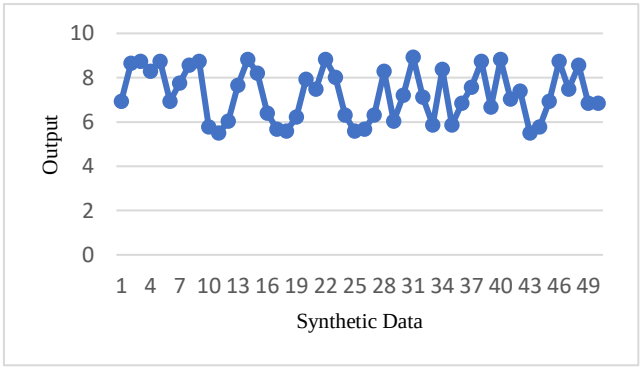

Figure 14: Output of Bisector method

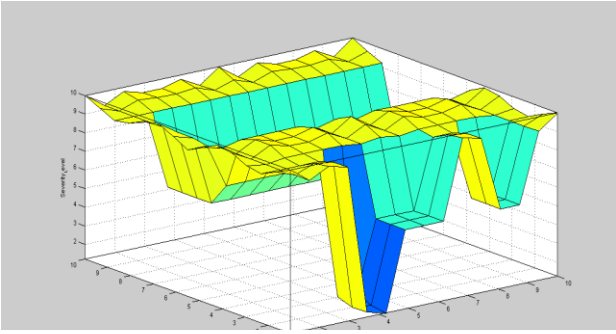

Figure 15: Surface plot of MOM Defuzzification method.

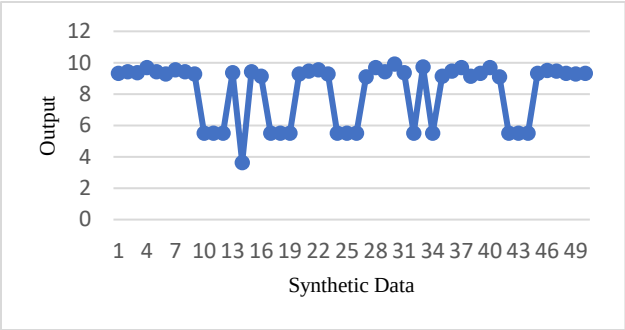

Figure 16: Output of MOM Surface

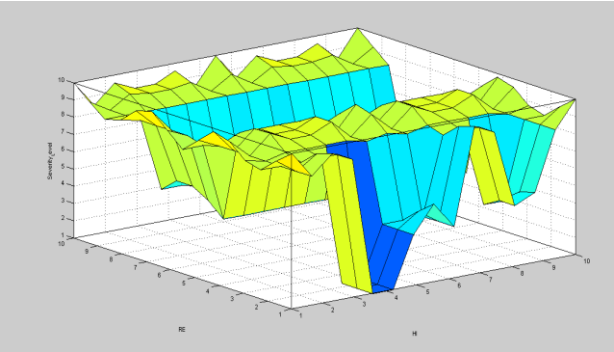

Figure 17: Surface plot of SOM Defuzzification Method.

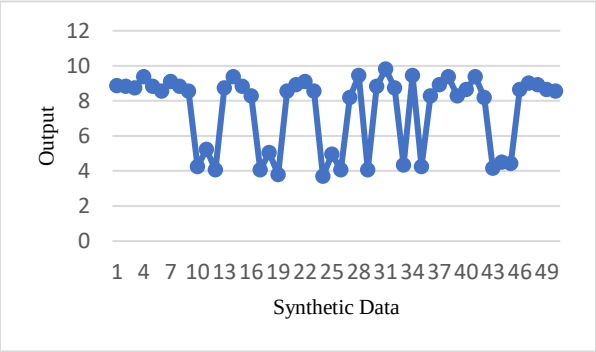

Figure 18: Output of SOM Method.

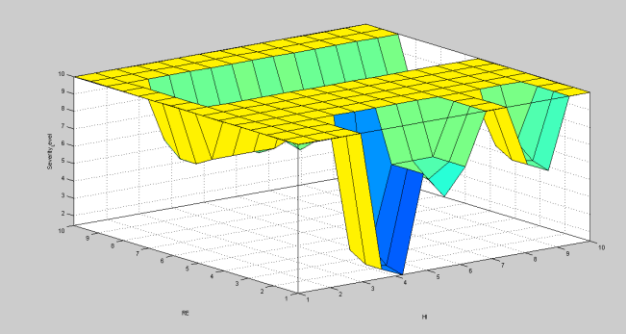

Figure 19: Surface plot of LOM Defuzzification Method.

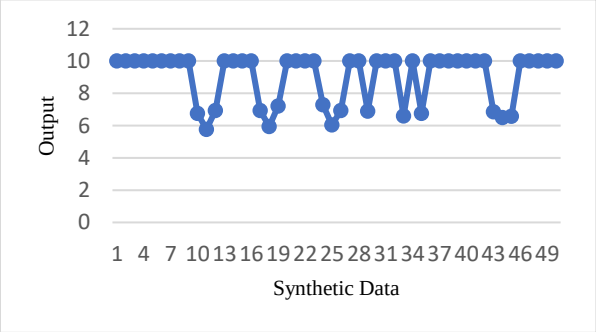

Figure 20: Output of LOM Method.

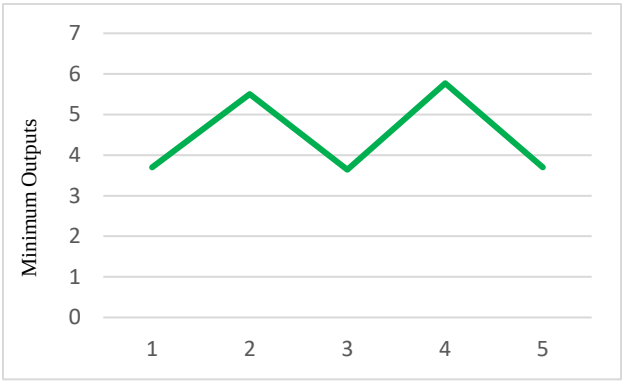

Figure 21: Output of All Minimum Defuzzification Methods.

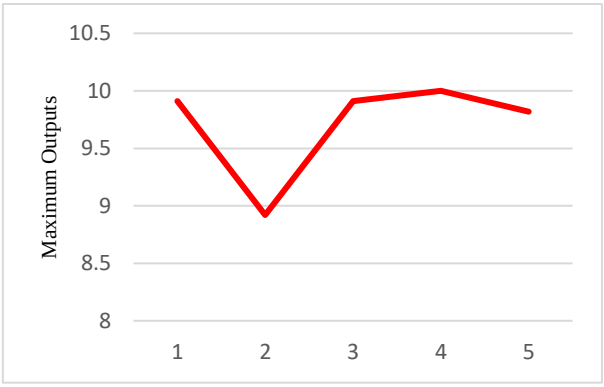

Figure 22: Output of all maximum defuzzification methods.

IV. RESULTS AND DISCUSSIONS

Now the combined plot of all the methods is shown. The LOM method was more sensitive and responsive to the data and reflected well by achieving higher values of sensitivity. It can be concluded that among all defuzzification methods, LOM is more suitable for the variables and the data set obtained after detailed research based on literature review, interviews, and analysis. However, to get more statistically significant results, more real data and statistical testing are required to make the system in real-world scenarios. However, this research provides a way forward to continue working in this area towards achieving SDG sustainable cities and communities for Pakistan in general and Balochistan in particular. Our results can help design protocols, and policies for preventing accidents in the area from Pir Umar to Baghbana. The focus of the research has been identifying key factors and their uncertainties and coping with them using fuzzy logic. Uncertainties exist because of the diversity of the area, literacy and other factors which have already been discussed in the introduction. The combined plot of all methods is shown in Figure 23.

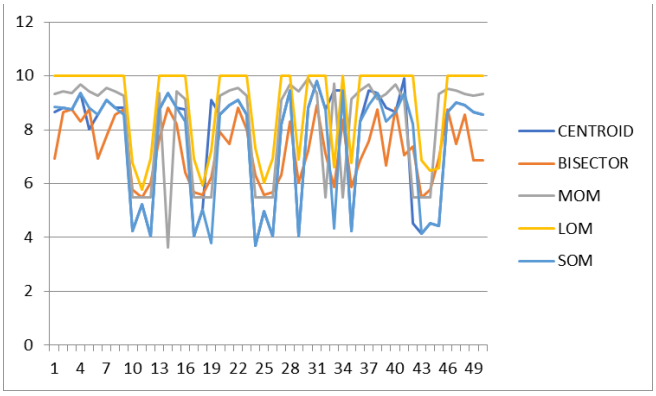

Figure 23: Combined plots of all methods.

It is a fact that this is a case study and all the applicable rules have been practically applied in this research. After the selection of the research topic, it was selected hypothesis collected the data regarding this case study and analyzed them to rectify the factual hypothesis. It was asked Unstructured questionnaires from the drivers and general passengers regarding the RTAs occurring in N-25 and then, especially within the area of Pir Umar to Baghbana which is the universe of this case study. In the data analysis, it was analyzed the data of key problems related to the topic and factual hypothesis. Finally, when the results from the analyzed data then it were obtained relationship among the hypotheses and provided suitable solutions to the problem through different de-fuzzification methods of fuzzy logic in AI.

B. Other Similar Case Studies

Some other similar case studies related to the paper are shown in Table 8.

Table 8: SIMILAR CASE STUDIES

S.No	Title	Citation
1	Environmental factors affecting the frequency of road traffic accidents: a case study of a sub-urban area of Pakistan,"	[25]
2	Analysis of Vehicle Accidents using Spatio-Temporal Tools in ArcGIS; A Case Study of Hayatabad, Peshawar	[26]
3	Causes of Road Accidents in Makran Coastal Highway Balochistan	[28]
4	Increasing Trends of Traffic Accidents in Quetta: Causes and Solutions	[29]

V. CONCLUSION AND RECOMMENDATIONS

In this research, it has been identified the factors of RTA from Baghbana to Pir Umar region of Balochistan province of Pakistan which include the Human Intervention Factor (HIF), and the Road and Environmental Factor (REF). it was developed a Mamdani-type FIS and investigated five different Defuzzification methods namely Centroid, Bisector, Large of Maximum (LOM), Medium of Maximum (MOM), and Small of Maximum (SOM). The system design was evaluated on a data set created from literature and interviews for testing purposes. The results indicated that the LOM method was found to be more useful in defining the severity level of the factors because the maximum output achieved on the data set is 10 whereas the minimum output achieved is 5.77. It shows that the LOM defuzzification method can be useful for dealing with the ambiguities of RTA. However, more investigations are required to have more confidence in the results. We shall be using more data sets from diversified RTA data sets of Pakistan and compare them with the study done in this research. It also aims at using MFs and Rules optimization techniques to create an efficient system to assist in reducing RTAs with a general focus on South Asian Countries.

REFERENCES

[1] "The Oxford English Dictionary | Oxford Languages." https://languages.oup.com/research/oxford-english-dictionary/ (accessed Jan. 20, 2023).

[2] A. Chandrasekharan, A. J. Nanavati, S. Prabhakar, and S. Prabhakar, "Factors impacting mortality in the pre-hospital period after road traffic accidents in Urban India," Trauma Mon, vol. 21, no. 3, Jul. 2016, doi: 10.5812/traumamon.22456.

[3] N. Onyemaechi and U. Ofoma, "The public health threat of road traffic accidents in Nigeria: A call to action," Ann Med Health Sci Res, vol. 6, no. 4, p. 199, 2016, doi: 10.4103/amhsr.amhsr_452_15.

[4] B. Mishra, N. D. Sinha, S. K. Sukhla, and A. K. Sinha, "Epidemiological study of road traffic accident cases from Western Nepal," Indian Journal of Community Medicine, vol. 35, no. 1, pp. 115–121, Jan. 2010, doi: 10.4103/0970-0218.62568.

[5] C. Bannon and a. Costello, "Transport and health -- a biomedical perspective.," World Transport Policy & Practice, 1997.

[6] "Global Status Report on Road Safety 2015 Summary," 2015. [Online]. Available: www.who.int

[7] S. Bhattacharya, A. Alberini, and M. L. Cropper, "The value of mortality risk reductions in Delhi, India," J Risk Uncertain, vol. 34, no. 1, pp. 21–47, Feb. 2007, doi: 10.1007/s11166-006-9002-5.

[8] World Health Organization, Global status report on road safety 2015.

[9] M. Touahmia, "Identification of Risk Factors Influencing Road Traffic Accidents," Engineering, Technology & Applied Science Research, vol. 8, no. 1, pp. 2417–2421, Feb. 2018, https://doi.org/10.48084/etasr.1615.

[10] M. Angın & Albrka Ali: "Analysis of Factors Affecting Road Traffic Accidents in North Cyprus" Engineering, Technology & Applied Science ResearchVol. 11, No. 6, 2021, 7938-7943 https://doi.org/10.48084/etasr.4547.

[11] Detho et al.: "Proposed Remedies to Prevent Road Traffic Accidents (RTAs) on Highways in Pakistan" Engineering, Technology & Applied Science Research Vol. 8, No. 5, 2018, 3366-3368 https://doi.org/10.48084/etasr.2128.
[12] R. Morgan, M. Tziotis, B. Turner, and J. Epstein, "AGRS06-09_Guide_to_Road_Safety_Part_6_Road_Safety_Audit." [Online]. Available: www.austroads.com.au
[13] V. M. Nantulya and M. R. Reich, "The neglected epidemic: road traffic injuries in developing countries," BMJ, vol. 324, no. 7346, pp. 1139–1141, May 2002, doi: 10.1136/BMJ.324.7346.1139.
[14] R. Abduljabbar, H. Dia, S. Liyanage, and S. A. Bagloee, "Applications of artificial intelligence in transport: An overview," Sustainability (Switzerland), vol. 11, no. 1. MDPI, Jan. 02, 2019. doi: 10.3390/su11010189.
[15] U. Nations, "The 2030 Agenda and the Sustainable Development Goals An opportunity for Latin America and the Caribbean Goals, Targets and Global Indicators," 2030. [Online]. Available: www.cepal.org/en/suscripciones
[16] Dr. E. Maraj and Prof. (Dr) S. Kuka, "Application of Fuzzy Logic in Prediction of Traffic Accidents," International Journal of Innovative Research in Engineering & Management, pp. 19–23, Feb. 2022, doi: 10.55524/ijirem.2022.9.1.4.
[17] A. Khurshid, A. Sohail, M. Khurshid, M. U. Shah, and A. A. Jaffry, "Analysis of Road Traffic Accident Fatalities in Karachi, Pakistan: An Autopsy-Based Study," Cureus, Apr. 2021, doi: 10.7759/cureus.14459.
[18] "Data on Traffic Accidents Year/Month Total Number of Accidents Accident Persons Total Number of Vehicles."
[19] "Growing auto sales - Newspaper - DAWN.COM." https://www.dawn.com/news/1595468 (accessed Jan. 20, 2023).
[20] "Automobile sales jump 46% in January 2021." https://tribune.com.pk/story/2283627/automobile-sales-jump-46-in-january-2021 (accessed Jan. 20, 2023).
[21] "Pakistan records 31% increase in car sales in February." https://www.geo.tv/latest/339337-car-sales-in-february-increase-by-31 (accessed Jan. 20, 2023).
[22] "Pakistan National Road Safety Strategy 2018 2030 | PDF | Road TrafficSafetyTrafficCollision."https://www.scribd.com/document/490098823/Pakistan-National-Road-Safety-Strategy-2018-2030# (accessed Jan. 20, 2023).
[23] "The Provincial Motor Vehicles Ordinance, 1965." http://punjablaws.gov.pk/laws/189.html (accessed Jan. 20, 2023).
[24] S. Gulzar, F. Yahya, Z. Mir, and R. Zafar, "Part-II: Social Sciences and Humanities "Provincial Analysis of Traffic Accidents in Pakistan," 2012, [Online].Available: www.savap.org.pkwww.journals.savap.org.pk
[25] H. M. Hammad et al., "Environmental factors affecting the frequency of road traffic accidents: a case study of sub-urban area of Pakistan," Environmental Science and Pollution Research. Springer Verlag, 2019. doi: 10.1007/s11356-019-04752-8.
[26] M. B. Ali Rabbani, "Analysis of Vehicle Accidents using Spatio-temporal Tools in ArcGIS; A Case Study of Hayatabad, Peshawar," International Journal of Engineering Works, vol. 06, no. 12, pp. 439–444, Dec. 2019, doi: 10.34259/ijew.19.612439444.
[27] Seiji Kojima, "Basic design study report on the project for the improvement of national highway N-25 in Islamic republic of Pakistan July 2005 japan international cooperation agency grant aid management department."
[28] S. Sciences and S. Bashir, "Causes of Road Accidents in Makran Coastal Highway Balochistan," 2015.
[29] Z. Naeem Qaisrani et al., "Increasing Trends of Traffic Accidents in Quetta: Causes and Solutions," 2021. [Online]. Available: https://www.researchgate.net/publication/357752389
[30] E. Maraj and S. Kuka, "Prediction of Road Accidents using Fuzzy Logic," 2019. [Online]. Available: www.jmest.org