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Road Accidents Prediction with Multilayer Perceptron MLP modelling (Case Study: Roads of Qazvin, Zanjan and Hamadan)

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ABSTRACT

Demand growth this has increased the incidence of road accidents and the resulting casualties, including injuries and deaths. In this study, six of the rural two lane roads were selected as the study area and crash data was collected in the roads for 2013-2016 years. In this study, multi-layered perceptron model was used for modeling crashes for different roads. The purpose of the multi-layered perceptron model training is to find the optimal value of weights and biases in such a way as to minimize network error. With this view, multi-layered perceptron modeling is an optimization issue with a number of specific parameters. Based on the collected data, the studied roads included Hamadan to Avaj, Hamedan to Qorveh, Hamadan to Malayer and Hamadan to Bijar in the area of the protection of Hamadan province, as well as Abhar to Qeydar in the area of protection of Zanjan province and the old road to Abeek to Qazvin, in Qazvin province. An appropriate model for the roads of Qazvin, Zanjan and Hamadan was architecture. Approximately good results were obtained from the network. The value of the r2 statistic that was calculated was 0.83. The value of the MSE parameter equals to 0.59, which indicates the accuracy of the results in the training phase. For the roads of the Qazvin region, the value of r2 was 0.94. The value of the MSE parameter was also 0.33, which was very good, and showed the accuracy of the results in the training phase.

Key words: Safety improvement, Accident modeling, Multilayer Perceptron MLP.

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1. INTRODUCTION

Norway is one of the few countries in the world with the lowest mortality rates from road accidents and accidents worldwide. The official statistics of the Norwegian traffic organization show that since the 1970's, thanks to better cars, safer roads and road safety indicators, road traffic deaths in Norway have been driven by a downward trend Has experienced a total of 560 road deaths in the 1970s to 210 in the 2013 population (1, 2). In the past years, the National Highway Traffic Safety Administration (NHTSA) has released information on road accidents in the United States by collecting data. The organization recently released a 2017 report that shows that, in addition to 2016, the United States has been the world's most leading road accident in 2017 (3). In the following, the number of casualties and causes of accidents are discussed. 1) The death of 42,000 Americans in road accidents: The US National Highway Traffic Safety Administration announced in its latest update that in 2017, 42,000 Americans died in road accidents. According to the organization's statistics in 2016, 37,461 Americans were killed in road accidents; from 2007 onwards, 2017 and 2016, it is the record number of road accident casualties in the United States. 2) 37 thousand and 423 deaths in road accidents in 2015. Primary data from the National Highway Traffic Safety Administration show that in 2014, about 35,200 people died on an accident due to an accident, up from 7.7 percent in 2015, about 37,423 the mortality rate has been reported since 2008 (4, 5). 3) Increasing people's drive is an important factor in accidents. According to the Federal Highway Bureau, in 2015 2015, at least 107 million and 200 million miles were driven by American car drivers, but by 2016, and only in the first half of the year, which is still not before the new year holiday, is about 50 billion and 500 million miles were driven by American drivers, which represents an increase of 3.3% in road traffic. In 2017, the figure dropped to 60 billion miles and hit the record high on road traffic (6). 4) Alcohol consumption is a major cause of accidents. The Federal Highway Administration has reported that more than 15,000 road deaths in 2017 are attributable to alcohol consumption and abnormal driving patterns (4). 13,000 dead due to unauthorized speed. The statistics show that 13,000 people died just because of unauthorized speed. 5) The death of 3,000 children under the age of 16 in 2017. Available data shows that 3,000 children and teenagers under the age of 16 died in last year's incidents. 6) Increasing in the mortality of cyclists and pedestrians. According to official statistics, in 2017, at least 17% of deaths for cyclists, 15% for pedestrians and 14% for motorcycle riders, increased by almost 12% in 2016, according to official statistics, has encountered (7). 6) The highlight of human factors in road accidents. Human factors, such as driving in abnormal conditions, non-observance of permitted speed and not wearing seat belts, considerably increase the amount of road deaths. Iran, having about 18,000 road accident casualties per year (150 times as much as Norway), is statistically one of the highest road casualties in the world. The main reasons for this are the human factors such as high speed, driver's dismay and lack of attention Driving guidelines (driving culture) and technical and environmental factors such as worn out vehicles, low levels of safety of vehicles, shortcomings in quality control of existing cars, low quality and non-standard road quality. In Iran, as in many developing countries with a young population, there is a death toll on the road. East Asian countries like South Korea have faced this problem during the years of development. In order to solve the problem, due to the fact that it was not able to compete with the world's most prominent automakers, the country was able to reduce road accidents by establishing new laws and rebuilding roads, and currently there are fewer than 12,000 people killed per year. Given the annual road crashes leading to the death of a million and 300,000 people, the United Nations Roadmap for Road Safety has been presented as a roadmap for road safety cooperation, improving road and vehicle safety, improving driver's manner and individuals Pedestrians and emergency services (8, 9). The World Bank has said in its report that Iran is currently facing road accidents more than 20 times more industrialized countries and 5 times more than its own countries such as Egypt and Turkey. According to the World Bank, the Iranian government is well aware of the shortcomings and shortcomings of its transportation system, but road conditions in many parts of the country are not as interesting as the current road safety situation in Iran One of the worst of its kind is that it has had various consequences on the population and the economy of the country (10, 11). Modeling crash prediction is one of the important strategies for determining the importance of each variable in increasing or reducing accidents and improving road safety. One of the most important and widely used methods to predict crashes are statistical methods. The most common indicators used as outputs of accident prediction models are the number of registered accidents per year, as well as the number of accidents per million vehicle-kilometers (recorded accident rate over the distance traveled). Therefore, due to the high safety problems in Iran and the high number of accidents, it is necessary to predict the number of accidents and provide solutions to reduce them so that future plans can be arranged and implemented in order to prevent an increase in this number of accidents (12). Kang et al., in 2003, examined the status of road safety and the spots black character analysis of the number of accidents along the communication highways between cities. The results of this study show that most accidents in the range of 10 to 30 kilometers from the booth Complications occur (13). In 2003, William Cassiglio and colleagues explored the effects of mobile phones on driver response time and braking. The results of their research indicated that the use of mobile phones leads to an increase in the reaction time of the driver. They also compared the increase in reaction time of using mobile phones with other activities such as talking to travelers, listening to music, etc. (14). Ansari et al. (2000) examined the impact of age, seat belts, time of day, and type of vehicle in road accidents and their relevance to the severity and severity of road accidents in a statistical manner that includes accidents in the city entrance area it can also be checked (15). Zakeri et al. (2015) examined some human factors and their role in road accidents and case study of Semnan province. In this study, we tried the role of human factors in the accidents road be reviewed, including the specification can include Zyrasharh desire driver, judgment motion, driver error, error performance, illusions and perception, lack of skill and speed percent the crash caused by the above factors is observed in this research. The human factor plays a major role in traffic accidents (16). Chen, in 2016, investigated distraction factors in reducing safety and increasing road deaths. In this paper, they reviewed the causes of distraction within the vehicle and proposed ways to minimize these factors while driving, which increases safety and reduces road accidents (17). In 2016, Badawy and his colleagues examined the role of fatigue and drowsiness in road accidents. Usually in these accidents, the driver Sleepy direct path to the side of the road or the car in front diverted due to high speed, inability of the driver to avoid accidents and even failure of the driver to brake often these accidents result in death or serious injury to be In this study, to evaluate fatigue and drowsiness at random, study, library research, advanced countries have been investigated and the results of this study provide guidelines for the prevention of traffic accidents caused by drowsiness including the creation of rest side road works , Increased lighting and increased path beauty (18). Roadside elements are one of the most important drivers attribute for road safety. Zeng and Schrock in 2013 examined the effects of different shoulders on the route in the winter and other seasons for the safety factor. They developed a crash correction factor (CMF) using cross-sectional methods. The results of this study have shown that the wider shoulder blades and the wider height in winter have a lesser impact on safety, but have been more effective in other seasons (19). Found that doing so would cut about 21 percent of 5 Turners and Friends in 2012 by installing a shaky strip of total crashes and about 40 percent of crashes that occurred due to an exit from the line. These results are the result of the study in 13 different regions (20). Turner and his friends in their five studies in 2009 showed that the installation of the shaking tape reduced 23% of the accidental accidents (21). Miaw and Lum, as well as Jushu and Garber, in their study of the Poisson model and least squares, showed the inappropriateness of the least squares methods for modeling accidents and recommended the use of Poisson distribution, but the Poisson distribution has a significant limitation, in other words, in this Average distribution and variance should be equal (22). Abdul Eti et al. Have used a potential neural network to predict crashes on the Orlando Interurban Corridor 1. The analysis of the results has shown that at least 70% of accidents can be predicted correctly or the probabilistic neural network model (23). Chang used two models of artificial neural networks and negative binomial in modeling road accidents in Taiwan. By comparing the efficiency of the two models, it has been concluded that the artificial neural network model is a robust and powerful alternative to the Crash analysis (24).

2. METHODOLOGY

Modeling for predicting crashes has been determined by determining the parameters that affect the occurrence of accidents. With the help of Multilayer Perceptron MLP, crash modeling will be done according to its effective parameters. Artificial Neural Network (ANN) networks, or more simply, the neural networks of modern systems and computing methods for machine learning, knowledge representation, and, finally, the application of the knowledge gained to overwhelming the outcomes of complex systems. The main idea behind these networks is to some extent inspired by the way the biological nervous system functions to process data and information in order to learn and create knowledge. The key element of this idea is to create new structures for the information processing system. The system consists of a large number of super-interconnected processing elements called neurons that work together to solve a problem and transmit information through synapses (electromagnetic communications). In these networks, if a cell is damaged, the rest of the cells can compensate for it and also contribute to its reconstruction. These networks are able to learn. For example, by applying irritation to tactile neural cells, cells learn to not go to the body and teach this system with an algorithm to correct its error. Learning in these systems is adaptive, that is, by using the examples, the weight of the synapse changes in such a way that, in the case of new inputs, the system produces the correct response. In recent years, road accident prediction models have been developed using various analytical techniques, but the use of these models is not easy when a large number of variables are used in the modeling stage. By selecting the studied paths as a case study, the variables used in this study were lawn width, average speed, number of heavy vehicles per 10 km, the vertical arc radius per 10 km and traffic volume as independent variables and number Accidents in a three-year study period are defined as dependent and outflow variables of the studied models.

2.1. Case study

The set of studied roads includes Hamadan to Avaj, Hamadan to Ghorveh, Hamadan to Malayer and Hamadan to Bijar in the field of protection of Hamadan province, as well as Abhar to Qeydar in the field of protection of Zanjan province and the old road to Abyek to Qazvin in Qazvin province. Figure 1 shows the selected roads in Hamadan province and Figure 2 shows selected routes in Zanjan and Qazvin provinces. These roads are considered as one of the most troubling roads of the country.

Figure 1. Hamadan position and selected routes

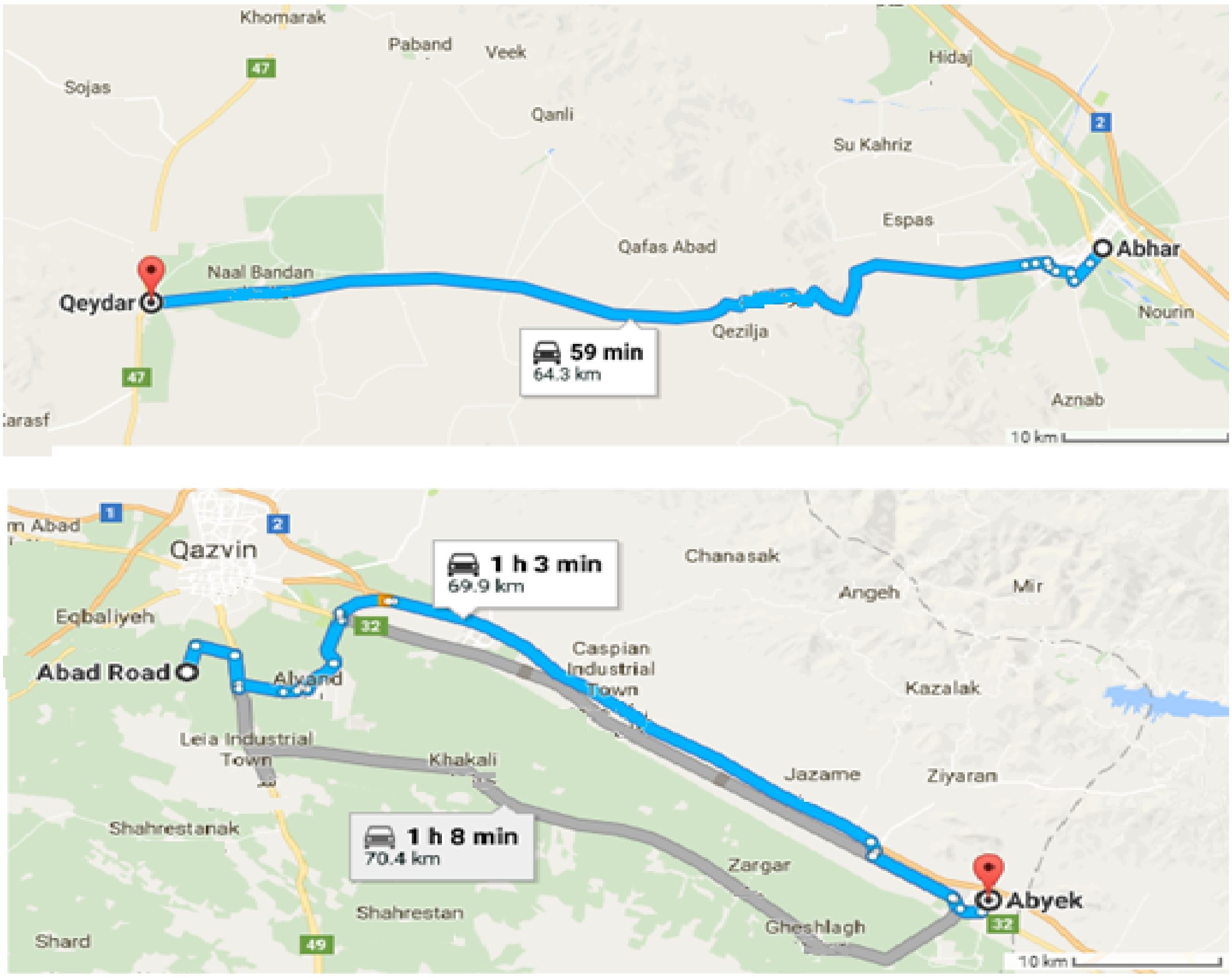

Figure 2. The position of Abhar's direction towards Qeydar and Qazvin toward Abyek

This section includes a statistical survey of crashes in selected roads. Data were analyzed in two sections. The first part of the data is based on Hamadan's four main points and the second part, including crash statistics and two-axis selected data in Qazvin. In the modeling section, the time series of the crashes will be used. Table 1 shows the selected roads and the number of corresponding pieces and encounters.

Table 1. Selected roads and number of accidents of selected segments

Province	Road Name	Number of sections studied	Number of accidents
Hamadan	Qorveh	40	185
	Avaj	37	102
	Bijar	35	56
	Malayer	40	210
Qazvin	Abyek	35	31
Qeydar	Abhar	32	91

According to the Table 1, it can be concluded that the number of crashes in Qorveh and Hamadan roads is high among the selected roads. In order to model the crashes in selected sections and also predict the future conditions of these paths, we first examined the roads using the main components analysis method, whose main objective was to reduce input variables to prediction systems of crashes and time series modeling.

2.2. Modeling Data

In this section, data collected from different roads are presented in Table 2 and Table 3. It should be noted that in the tables of this part, the variables used are defined as follows.

Table 2. Variables used in model

Variable abbreviation	Variable name
NA	Number of accidents
ADT	Average Daily Traffic Volume
W	Road width
NB	The number of lights per 10 km
ACR	Average radius of the vertical arch
AS	Average speed
NV	Number of heavy vehicles per 10 km

In Table 3, which is presented below, the parameters used for modeling in the studied roads and their measured values, the number of sectors that are indexed, along with statistical characteristics such as the mean and the range of changes are visible.

Table 3. Parameters used for modeling in the studied roads

Variables								
NV	AS	ACR	NB	W	Number of accidents		Segment	Road
20	40	10.36	0.7	2.90	0.00	Minimum		
45	89	14.6	1.65	3.45	10.00	Maximum		
32	75	12.3	1.32	3.30	2.11	Average	37	Hamadan-Bijar
5.68	12.25	2.45	.21	0.12	8.58	Standard deviation		
15	35	9.5	0.78	3.55	0.00	Minimum		
29	78	18.41	3.25	3.55	14.00	Maximum		
21	65	14.62	1.40	3.55	3.95	Average	45	Hamadan-Qorveh
4.26	14.65	3.5	0.17	0.00	11.48	Standard deviation		
18	55	2.65	0.28	2.20	0.00	Minimum		
38	100	8.24	2.26	3.55	7.00	Maximum		
30	86	7.10	1.49	2.60	2.21	Average	31	Hamadan-Avaj
2.58	11.64	3.24	1.24	0.12	2.04	Standard deviation		
30	56	1.56	12	3.40	0.00	Minimum		
60	91	3.57	18	3.70	13.00	Maximum		
44	80	3.01	15	3.40	5.26	Average	30	Hamadan-Malayer
2.87	10.8	1.28	4.26	0.65	4.15	Standard deviation		
14	44	4.5	19	2.65	0.00	Minimum		
33	75	5.2	21.6	3.40	6.00	Maximum		
25	58	3.6	20.08	3.20	2.80	Average	35	Qeydar-Abhar
2.05	16.58	1.27	2.15	0.04	**2.36**	Standard deviation		
10	35	0	4.2	2.68	0.00	Minimum		
28	35	3.27	8.6	3.59	8.00	Maximum		
19	84	1.29	7.2	3.30	2.98	Average	46	Qazvin-Abyek
2.52	16.28	2.14	3.26	0.12	1.99	Standard deviation		

3. RESULTS AND DISCUSSION

3.1. Modified MLP model in Hamadan city

The MLP model was tested and trained for the four selected roads in Hamadan. Given that, by integrating these four roads, we should be able to see the result of the network for each roads; for the test phase, from each road, a number of sections were removed from the training phase, and then the network was executed with the remainder of these sections. Approximately the results of the grid were obtained and, in the following, Figure 3 shows the output of the test stages for each road and for the selected sections. In the training phase, after 57 steps, the network was stopped according to the setback rule, and the amount of statistics calculated was 0.84. The value of the MSE parameter was also 0.61, which indicates the accuracy of the results in the training phase (Table 4).

Table 4. Effective elements in the preparation phase of the entry axons in step 57

Variable	Value
ADT	24
W	64
NB	26
ACR	36
AS	68
NV	22

3.2. Hamadan road to Malayer

In the following, the output of the model for the Hamadan road is toward Malayer:

The value was equal to 0.98. The following diagram illustrates the ability of the model to predict regional crashes. The MLP is an architecture that simulates crash values well in all sections and predicts crash occurrence with very little difference than actual values.

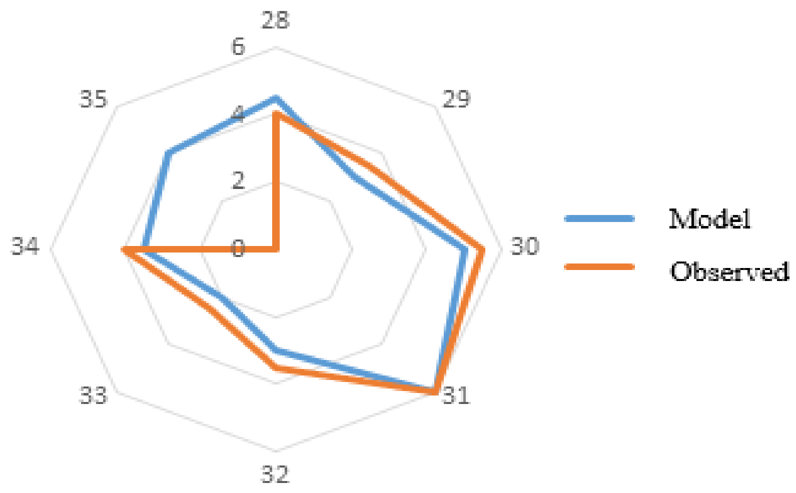

Figure 3. Neural network output at the regional testing stage for the Hamadan-Malayer axis

It can be further seen that the MLP output values are suitable for this road. The calculated statistic value (0.25) is smaller than the critical statistic at the probability level of 5% (the value of the statistic is 2.365), and therefore there is no difference between the mean of the two societies.

3.3. Hamadan road to Avaj

With the MLP test and its ability to predict the number of accidents, the value was equal to 0.95, which can be seen in the model's ability to predict regional accidents by examining the following diagram. The MLP is well-simulated, simulates crash values at all levels (except sections 35 and 37) and predicts a crash occurrence with very little difference than actual values.

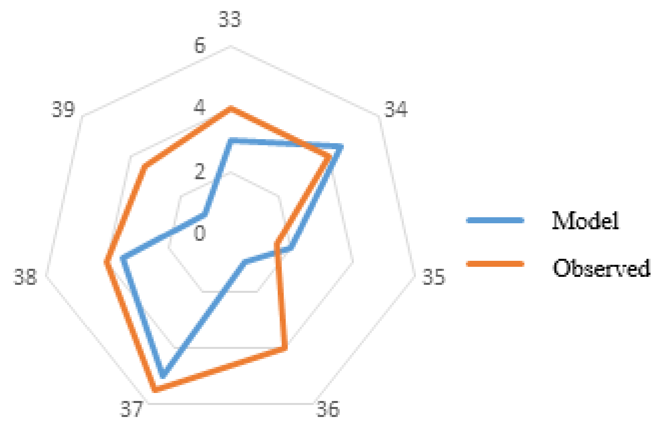

Figure 4. Neural network output at the regional testing stage for the Hamadan-Avaj axis

In the following, the two-series distribution chart was plotted by plotting the observed and predicted points in the orthogonal road (Figure 4), and it is also possible to find out that the output values of the MLP are suitable for this road. The calculated statistic value (-0.25) is smaller than the critical prediction statistic at the probability level of 5% (the statistic is 2,228), and therefore there is no difference between the mean of the two societies.

3.4. Hamadan road to Qorveh

Subsequently, MLP was tested for the Hamadan road to Qorveh by selecting 9 sections. The value was equal to 0.98, which can be seen by examining Figure 5, in the model's ability to predict regional accidents. The architectural neural network simulates the crash values at all stages (except in section No. 36) and predicts the occurrence of a crash with a very small amount of difference than actual values.

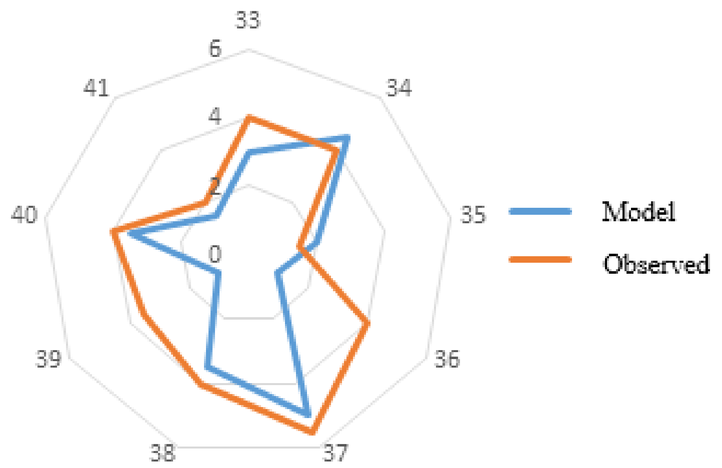

Figure 5. Neural network output at the regional testing stage for the Hamadan-Qorve axis

The next study shows that MLP output values are appropriate for this road. The coefficient of determination of points on the orthogonal road was 97%, which can be stated, more favorable results were obtained from the Hamadan road to Avaj. For the above-mentioned road, the T-test was performed and by examining the equality of variances, the result of the test showed that the calculated statistic value (0.36) was smaller than the critical probability level at the probability level of 5% (the value of the statistic is 2,228), and Therefore, there is no difference between the mean of the two societies. The Hamadan road to Bijar was tested as the last route in the regional investigation of Hamadan. In the following, the simulation results of selected sections crashes in this road are presented.

3.5. Hamadan-Bijar road

MLP was tested for this road by selecting 7 sections. The value was 0.49, which is slightly lower than the other three roads. By examining the following graph showing the observed and predicted values, we can refer to the model's ability to predict crashes in these selected sections. It can also be seen that the MLP is an architecture that simulates crash values at all levels (except sections 36 and 39) more than real values (Figure 6).

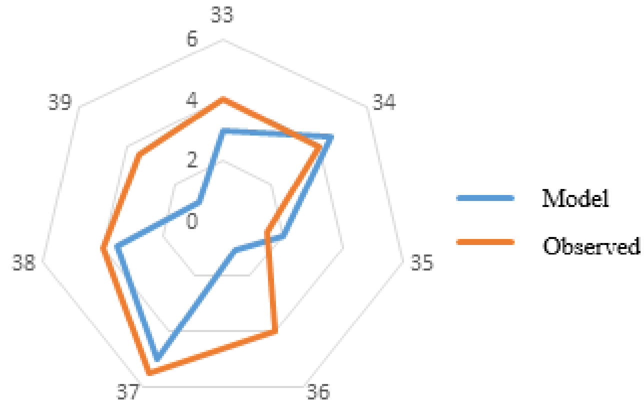

Figure 6. Neural network output at the regional testing stage for the Hamadan-Bijar axis

In the following, the distribution diagram of the two series was plotted (observational values in the horizontal axis and the values measured on the vertical axis), and it can also be seen that the output values of the neural network are suitable for this axis. The T-test was performed for Hamadan axis towards Bijar. By examining the equality of variances, the result of the test showed that the calculated statistic value (0.36) was smaller than the critical statistics in the probability level of 5% (the value of the statistic is 54.2) and so there is no difference between the two communities.

3.6. Modified MLP model for selected roads in Qazvin and Zanjan

In this section, the MLP model was constructed with three major parameters, namely riding width, average speed and ADT. The diagram depicted in Figure 7 shows the results for the Qazvin regional model by eliminating the paramount parameters in which the analysis of the parameters is correlated with each other. The architectural network has two hidden layers, each containing four elements. The network stopped after 28 steps, with an MSE statistic of 0.37.

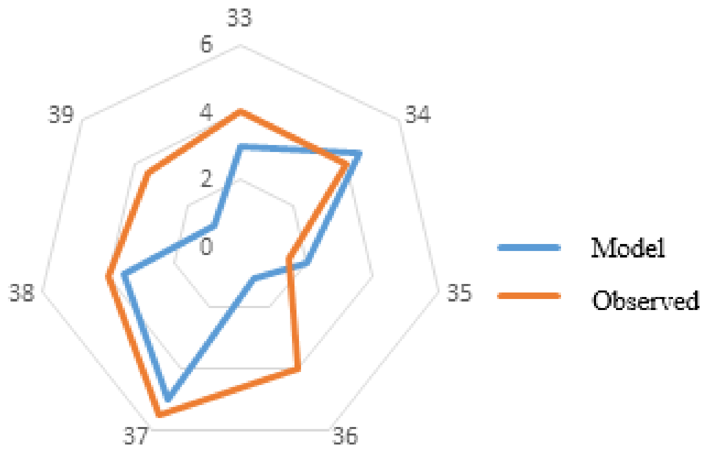

Figure 7. The output of the neural network test stage with the removal of parameters (Qazvin and Zanjan)

Based on the above diagram, it can be seen that in most of the time, the network generated appropriate results, and even models that have encountered more encountered occurrences. Except for section No. 5, in which there was no accident, the collision network predicted. The coefficient of determination of this stage was 95%. To better understand the ability of the model, the t test was used to examine the mean values of observed and modeled values. The f test for equalization of variances with a 1. 41 (less than 5.5% at 5.5%) showed that the two statistical populations are equal variances. Then, the calculated statistic in the T-test was 0.122, which is smaller than the Table 5 statistic (2.33), and therefore, there is no significant difference between the mean values. Given that, by integrating these two roads, we should be able to see the result of the network for each axis; for the test phase, from each road, a number of sections were removed from the training phase, and then the network was run with the remainder of these sections. Approximately good results were obtained from the grid, and the graphs below illustrate the model output for the neural network test phase in predicting selected section crashes. In the training phase, after 35 steps, the network was stopped according to the setback rule, and the amount of statistics calculated was 0.93. The value of the MSE parameter was equal to 0.34, which is a very good value, showing the accuracy of the results in the training phase.

Table 5. Effective elements in the preparation phase of the entry axons in step 44

Variable	*Value*
ADT	28
W	59
NB	30
ACR	38
AS	61
NV	25

3.7. The Qazvin road to Abyek

The correlation coefficient at this stage was equal to 0.96. The following diagram illustrates the ability of the model to predict regional accidents. The architectural neural network simulates the crash values in most sections (Figure 8).

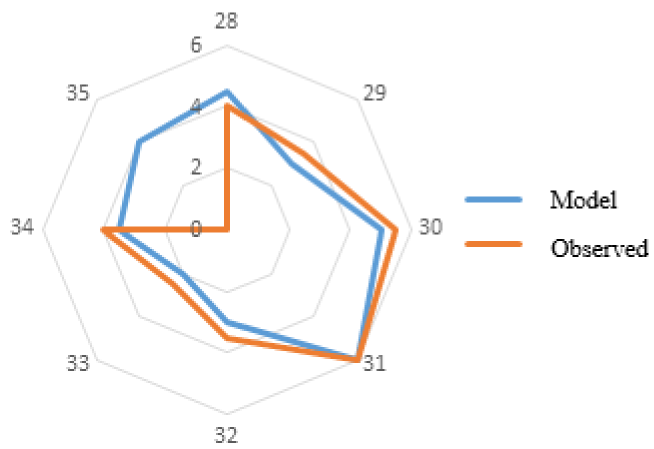

Figure 8. Neural network output at the regional testing stage for the Qazvin-Abyek axis

Except for the two sections number two and five, in which we did not deal, in very small quantities, the accident occurred, which may be due to the similarity of the input parameters, such as ADT, or the number of accesses in these sections to the other sections of the route. The two-series distribution diagram is further illustrated, and it can also be seen that the output values of the neural network are suitable for this axis. The coefficient of determination for the Qazvin road is 96%, which is an acceptable value. Finally, the t test was performed between the data of the two series. By examining and confirming the equality of variances (by F-test), the result of the T-test showed that the calculated statistical value (-0.444) is smaller than the critical value (the value of the statistic is equal to 16.2), and so there is no difference between the two communities.

3.8. Qeydar-Abhar's road

The value at this stage was equal to 0.97. By examining the diagram below, it can be seen that this parameter represents the ability of the model to predict the crash values of this road. In general, the architectural neural network simulates the magnitudes of accidents in most sections, and, with the exception of the three sections No. 35 and No. 36, which we did not deal with, a very small amount indicates an accident that could be due to the similarity of the parameters The input, such as ADT, or the number of accesses in these sections will be with other sections of this path (Figure 9).

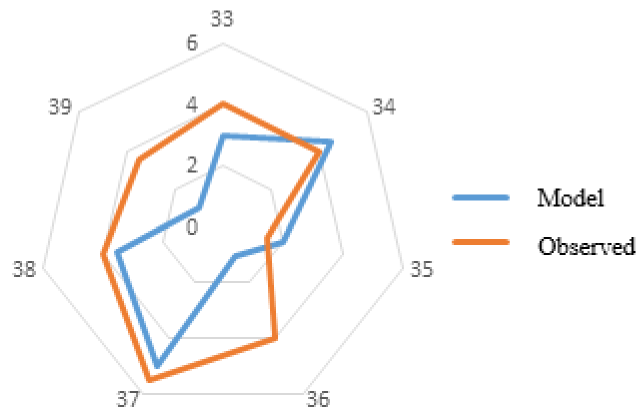

Figure 9. Neural network output at the regional testing stage for the Qeydar-Abhar axis

The two-series distribution diagram is further illustrated, and it can be concluded that the values of the neural network output (vertical axis points) and the observed crash values (horizontal axis points) are highly correlated (96%). As a result, the neural network function is suitable for this road. For this road, t-test was performed. By examining the equality of variances and confirming it by F-test, the result of the T-test showed that the calculated value of the statistical (-0.018) was smaller than the critical value statistic at the probability level of 5% 2), and so there is no difference between the two societies. Considering the above, it can be concluded that by creating an optimal network with appropriate architecture, one can predict the number of accidents in the axis of Qazvin region based on the parameters mentioned.

4. CONCLUSION

Traffic accidents are one of the most important causes of mortality and cause severe personal and financial losses. Accidents also have severe social, cultural and economic consequences, and the consequences of these are heavily influenced by human societies. In the following, the modified model for the road of Qazvin, Zanjan and Hamadan was architecture. For the selected roads, a parameter called drop-offs was entered into the training data, which was the reason for creating a kind of homogeneity between the data and eliminating the effect of the difference in paths in terms of elevation change. Approximately good results were obtained from the network. The value of the R2 statistic that was calculated was 0.83. The value of the MSE parameter equals to 0.59, which indicates the accuracy of the results in the training phase. For the road of Qazvin region, the amount of R2 calculated was equal to 96. The value of the MSE parameter was also 0.33, which was very good, and showed the accuracy of the results in the training phase.

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AUTHORS CONTRIBUTION

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CONFLICT OF INTEREST

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