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Predicting Traffic Crashes using Multilayer Perceptron MLP Modeling (Qazvin, Zanjan, and Hamadan Roads as a Case Study)

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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 wayas 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 Qeydarin the area of protection of Zanjan province and the old road to Abeek to Qazvin, in Qazvin province. An appropriate modelfor 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. Thevalue 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.

1. INTRODUCTION

Norway is one of the few countries in the worldwith the lowest mortality rates from road accidents and accidents worldwide. The official statistics of the Norwegian traffic organization show thatsince the 1970's, thanks to better cars, safer roads and roadsafety indicators, road traffic deaths in Norway have beendriven by a downward trend Has experienced a total of 560road 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. Theorganization recently released a 2017 report that showsthat, in addition to 2016, the United States has been theworld's most leading road accident in 2017 (3). In thefollowing, the number of casualties and causes of accidents are discussed. 1) The death of 42,000 Americans in roadaccidents: 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 and2016, 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 mortalityrate has been reported since 2008 (4, 5). 3) Increasingpeople'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 teenagersunder 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'sdismay 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 Iraniangovernment is well aware of the shortcomings andshortcomings 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 statistical approaches are used to forecast crashes. The annual accident tally and the accident rate per million vehicle-kilometers traveled are two of the most popular indicators utilized in the output of accident prediction models. Therefore, it is important to estimate the number of accidents and give ways to minimize them owing to the high safety difficulties in Iran and the high number of accidents in order to create and implement future plans to prevent a growth in this number (12). In 2003, Kang et al. analyzed the frequency of accidents along intercity communication routes using a spots black character analysis to determine the current state of road safety. The majority of accidents, according to this study, happen within 10-30 kilometers of the booth (13). Driver reaction time and stopping distance were studied by William Cassiglio and colleagues in 2003. They found that drivers whose reactions were measured while using a mobile device had longer reaction times. They compared the response time boost from using a cell phone to that of doing other things, such chatting with strangers, listening to music, etc. (14). The severity and frequency of road accidents, and the role that factors like age, seat belt use, time of day, and vehicle type play in each, were studied statistically by Ansari et al. (2000) (15). Human variables in road accidents were investigated by Zakeri et al. (2015), who also conducted a case study in Semnan province. We aimed to review the literature on the impact of human error on road accidents, accounting for such variables as Zyrasharh driver desire, judgment motion, driver error, error performance, illusions and perception, inexperience, and speed as explanatory variables. The majority of car crashes may be attributed to human error (16). Chen studied the role of distractions in causing accidents and fatalities on the road in 2016. In this research, the authors (17) examined what may go wrong when a driver is distracted in the car and what can be done to fix the problem. In 2016, Badawy and coworkers investigated how sleepiness and exhaustion contribute to car crashes. Often, fatalities and severe injuries occur when a motorist loses consciousness while driving and veers off the road or into oncoming traffic because of speed, inability to avoid accidents, or failure to brake. Results from this study provide guidelines for the prevention of traffic accidents caused by drowsiness, such as the creation of rest side road works, Increased lighting, and increased path beauty (18), based on an evaluation of random studies, library research, and advanced countries. In terms of motorist safety, roadside features are among the most crucial factors. The impacts of various shoulders on the path in were studied by Zeng and Schrock in 2013.

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

The characteristics that impact the occurrence of accidents have been established, allowing for the development of a model for crash prediction. Multilayer Perceptron (MLP) will be used to model crashes using its optimized settings. Modern systems and computer techniques rely on ANN networks, or artificial neural networks, for machine learning, knowledge representation, and the application of learned skills to complex systems' most dominant outcomes. These networks' central concept is largely motivated by the biological nervous system, which similarly processes data and information for the purposes of learning and knowledge construction. The core of this concept is the development of novel data-processing architectures. Neurons, which are the system's processing parts, are highly linked, and they collaborate to solve problems and share information via synapses (electrical impulses). If one cell in such a network is compromised, the others can step in to help repair it, and vice versa. The networks can pick up new information over time. Irritation of tactile neural cells, for instance, can train cells to avoid the body and instruct this system to remedy its mistake using an algorithm. These systems are able to modify their learning to new situations by altering the synapse's weight in response to previously unseen stimuli. Recent years have seen the development of road accident prediction models utilizing a variety of analytical methodologies, however when a large number of variables are employed in the modeling stage, it can be difficult to put these models to use. Lawn width, average speed, number of heavy vehicles per 10 km, the vertical arc radius per 10 km, and traffic volume were utilized as independent variables, and the pathways analyzed were used as a case study. The number of accidents that occurred during the course of the study's three-year timeframe serves as both a dependent and an output variable.

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 inHamadan 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.

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Figure 1. Hamadan position and selected routes

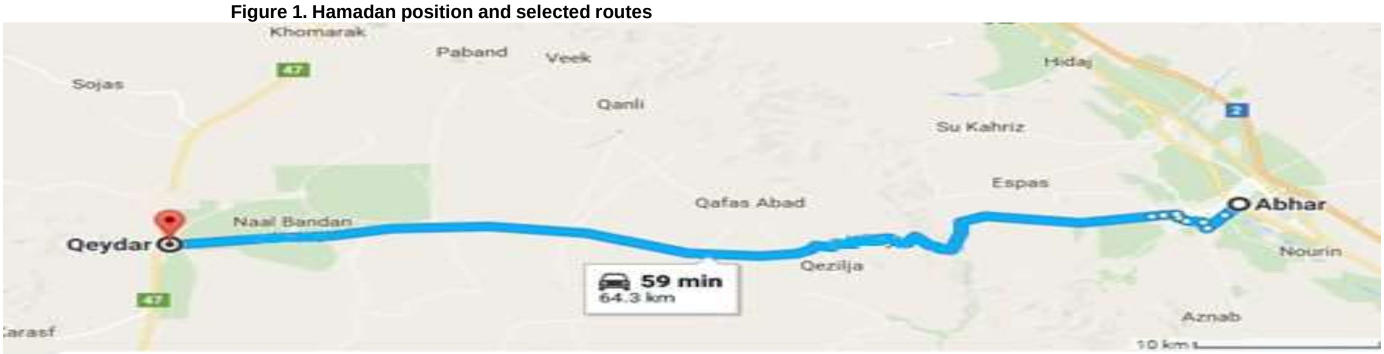

Figure 2. The position of Abhar's direction towards Qeydar and Qazvin toward Abyek

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 ofchanges 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 outputof 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).

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 Hamadanroad 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.

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 levelof 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 seenin 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

Next, the observed and predicted points were plotted along the orthogonal road to generate the two-series distribution chart shown in Figure 4; from this, it is clear that the MLP's output values are well-suited to the road. There is no statistically significant difference between the two societies' means since the estimated statistic value (-0.25) is less than the key prediction statistic at the 5% probability level (the statistic is 2,228).

Route 3.4: From Hamadan to Qorveh

Then, 9 separate segments of the road from Hamadan to Qorveh were chosen to put MLP through its paces. Figure 5 displays that the value for the model's ability to forecast regional accidents was 0.98. Crash values are simulated by the architecture neural network at every step (except for step 36) to accurately anticipate when crashes will occur.

The further research confirms that the MLP output values are reasonable for the route in question. The orthogonal route from Hamadan to Avaj yielded superior results, with a coefficient of determination of points of 97%. Regarding the aforementioned path, we ran a T-test and found that there is no difference in mean between the two societies by examining the equality of variances; the test result showed that the calculated statistic value (0.36) was less than the critical probability level at the probability level of 5% (the value of the statistic is 2,228). The final leg of Hamadan's regional inquiry was to examine the road leading from Hamadan to Bijar. Here we show the findings of an accident simulation study conducted on a subset of this road.

3.4. 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 threeroads. 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).

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 beseen 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.

3.5. Modified MLP model for selected roads in Qazvin andZanjan

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 theparameters 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.

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%. Tobetter 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

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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

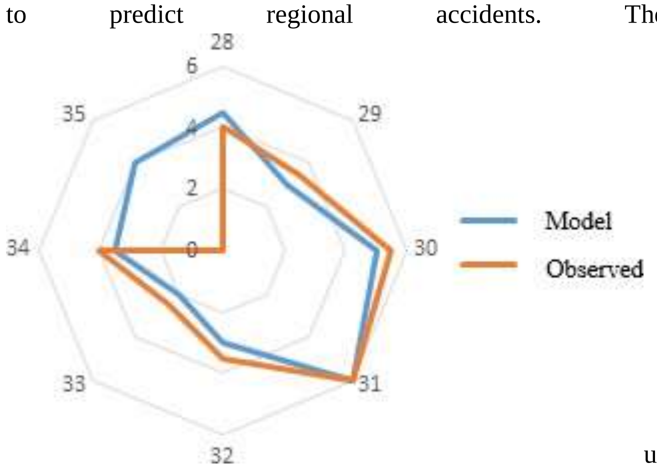
phase in predicting selected section crashes. In the training phase, after 35 steps, the network was stopped according to the setback rule, and the amount of statistics calculated was 0.93. The value of the MSE parameter was equal to 0.34, which is a very good value, showing the accuracy of the results 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

3.6. 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 sim



ulates the crash values in most sections (Figure 8).

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

Possibly because input characteristics like ADT and the number of accesses are comparable throughout different segments of the route, the accident occurred in all but segments two and five, with which we did not deal except in very little quantities. The two-series distribution diagram is elaborated upon, and it is also shown that the neural network's output values are appropriate for this axis. Qazvin Road has a satisfactory coefficient of determination of 96%. Finally, the data from the two series were compared using the t test. T-test results indicated that there is no significant difference between the two communities since the computed statistical value (-0.444) is less than the critical value (the value of the statistic is equal to 16.2), which was determined by studying and validating the equality of variances (by F-test).

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

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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

One of the leading killers, traffic accidents also result in significant material and emotional damage. The social, cultural, and economic repercussions of accidents are often just as severe, and they are profoundly impacted by human cultures. The following is an architectural representation of the revised plan for the highway connecting Qazvin, Zanjan, and Hamadan. The influence of the different pathways in terms of elevation change was removed by entering a parameter called drop-offs into the training data for the selected roads, thereby producing a form of homogeneity between the data. The network produced findings that were, on the whole, rather satisfactory. The determined value of the R2 statistic was 0.83. The MSE parameter value of 0.59 suggests that the findings from the training phase were accurate. The value of R2 was determined to be 96 for the route in the Qazvin area. The MSE parameter value of 0.33 was likewise excellent, demonstrating the reliability of the findings obtained during the training phase.

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