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# Implementing a New Intelligent Adaptive Nero Fuzzy Inference System (ANFIS) based on Identifying and Predicting Road Accidents (Case study: Haraz road)

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***Abstract:*** *Nowadays, the number of road accidents in our country is increasing and since the financial, life, psychological and social damage in some cases are irreparable it is necessary to prevent traffic accidents damages the effective factors identify and effective solutions to be implemented. The main purpose of this research, is study of various (natural and human) causes of road accidents on the road of Haraz and providing a method for identifying incidental factors based on(FMEA) method and eventually predict events Risk Priority Number (RPN) based on the Adaptive Neural Fuzzy Inference System (ANFIS) using MATLAB software. The results of the failure analysis method (failure modes & effects analysis) (FMEA) show that the two factors of mucus and the consumption of narcotics and alcoholic beverages are the most effective factors in the accidents of Haraz road and also due to the negligibility of predictive error values, Mean Squared Error (MSE) and Root Mean Square Error (RMSE) the accuracy of the prediction by the adaptive neural -fuzzy inference system is confirmed. The result of this prediction system (ANFIS) can be effective to predict the number of road accidents risk and providing solutions to reduce the road accidents.*

***Keywords:*** *Road accidents, (FMEA) Method, Adaptive Neural Fuzzy Inference (ANFIS), Haraz road.*

## INTRODUCTION

Undoubtedly the effects and consequences of road accidents if it leads to the loss of human beings, it is irreparable. Traffic accidents are one of the most important causes of mortality and severe physical and financial losses and its heavy social, cultural and economic effects threatens human societies very much. According to the WHO 2002 report More than a million and two hundred thousand people were killed every year on road accidents and more than 50 million people are seriously injured (Zahed and Rezaei Arjoodi, 2006). Beside this kind of damage high costs caused by road accidents also disturbs the development process partially. Accidents economic costs in the World was first investigated for the first time in England and then in the United States. It investigated for the first time in Iran in 2001 which is equal to 6170.6 billion rials (Ayati, Ghadirian and Ahadi, 2008). Jabbari et al. (2014) investigated road accidents involving hazardous ones in Iran. The result of this research show that the incidence rate has increased significantly in these years and the need to improve safety measures in this area is felt more and more. Soori et al. (2012) in a

study, evaluated the new traffic law in point of view of the traffic users. The results of this research show that the new traffic laws of the country has created valuable opportunities for reducing infringement, injuries and deaths caused by traffic accidents.

Affecting factors that involve these accidents are divided in three general terms of normal, human and technical and managerial, which includes various sections for these factors. According this, the Haraz road which is one of the most important mountainous roads in the country that connects Tehran province to Mazandaran province. This article follow an investigation of the most important factors affecting the occurrence of road accidents in Haraz road and predict it using adaptive neural fuzzy system simulation (ANFIS) by this introduction.

## Theoretical Basics

### Identification and analysis of incidental factors

In general, effective factors are involved in the occurrence of road accidents that the most important of them include human, natural and environmental, road and management factors.

#### A. Human factors:

Today, in most studies in this area the humans, are called the most important factor in the occurrence of such events. Many problems related to transportation and traffic in our country cause by user behavior that the main reason for this is the lack of awareness, not enough training and a no-brainer to social conscience toward the rights of other users (Salmani et al., 2008).

#### B. Natural and environmental factors:

Natural factors along with human factors is one of the effective factors in road traffic accidents. Among the natural factors,

Climate factors play a more important role (Kashani et al., 2005).

#### C. Road factor

Historically the road has played a major role in the creation and development of civilizations. Freight and passenger transportation and the increasing expansion of vehicles on land roads regenerate the road accidents. Based on the latest information there are about 80,000 km of main roads 9 and sub 10 in Iran, that's 75 percent of the traffic in just 15,000 kilometers and the rest of the 25% of the traffic is at 65,000 kilometers. High death toll in Iran is also due to inadequacy of these roads. 73% of accidents resulted in death is due to the low width of these roads so that is 8 (Kashani et al., 2005).

#### D. Management factor

Today, countries seek different ways to improve safety and reduce road accidents. For example Sweden has a high degree of ownership of the vehicle, 81 percent of the people own a vehicle, and the number of vehicle accidents also shows this country is in a very favorable position in terms of traffic safety, with all this Sweden is among countries which performs domain operations in extensive and comprehensive planning relative to safety education and crash reduction (Gains, 2013).

### Failure analysis method and its effects (FMEA)

Failure analysis approach and its effects is a coincidence with which form the appropriate structure to evaluate and update the design and development of the process and all policies in the organization. FMEA's primary goal is to discover and prioritize potential states by calculating the Risk Priority Number (RPN). Procedures for performing the (FMEA) method include; 1. Identify failure or failure factors 2. Assign a degree of effect severity (S) for each effect 3. Assign one degree of occurrence (O) to each pattern failure 4. Assign a degree of detection (D) for each pattern of failure 5. Calculate the Risk Priority Score (RPN) for each failure pattern (Morovati Sharif Abadi et al., 2014).

Each failure mode consists of three factors: Severity (S), occurrence (O) and diagnosis (D). Severity points to the seriousness of the potential impact. Failure is a kind of grading which is estimated for the probable

occurrence of any cause. By deleting and controlling a number of causes or mechanisms the probability of an error can be reduced. Diagnosis is the identification and discovery of a failure or cause of failure by current controls, before the design of the product or piece is approved for mass production (Morovati Sharif Abadi et al., 2014). To assign a degree of severity to each work, a 10-point range No. 1 will be used as no-number to 10 as hazardous, respectively. Also, the rate of occurrence (O) use a 10-point range from almost never to too much and finally, the recovery rate parameter (D) use a 10-point range, from 1 that is almost always equal to 10 that is the absolute uncertainty respectively (Abadian, 2011). Finally, calculating the risk priority number (RPN) for each failure mode is as follows:

$$RPN = (S) \times (O) \times (D)$$

## Adaptive Fuzzy Inference System (ANFIS)

The fuzzy systems that were established by the presentation of Dr. Asgarzadeh's paper in 1965 ,is an extension of the theory of classical collections and it comes from human behavior in response to questions and its performance in control environments. In other words, we can say that the concepts such as low, high, warm, cold, short, long, and etc. which exist in human language and thought and the boundaries that distinguish them from their contradictory concepts are flexible and imprecise, has led humans to model such behavior. Neural networks due to their specific structure, has the tremendous power of learning, adaptation, and generalization but in many cases have a high education time. On the other hand, in designing fuzzy systems it has benefited from linguistic concepts and innovative rules and these systems do not need to be trained. But choosing the best membership functions, is considered as the main problem of these systems. While no need for training eliminates their adaption ability. Therefore, the advantages and disadvantages of each of the neural networks and fuzzy systems has led to the researchers to combine them. With the goal that in this way, while having the benefits of both of them fix the shortcomings of each one through other characteristics (Christiaanse, 2007).

Neural networks that use fuzzy inputs and outputs and use fuzzy generalized rules in them to perform applying or multiplying are known as fuzzy neural networks and fuzzy systems that are trained in neural networks called neural networks. Because the neural networks (Especially multilayer perceptron neural networks) are a special case of comparative networks themselves so if in a fuzzy system the membership functions in comparative networks train using past information and adapt themselves to them, the system will result a comparative fuzzy inference system (comparative neural fuzzy network). In fact, in a fuzzy comparative system in general, the need for purely empirical selection of membership functions is eliminated although experience leads to lower training time (Bakirtzis et al., 2012).

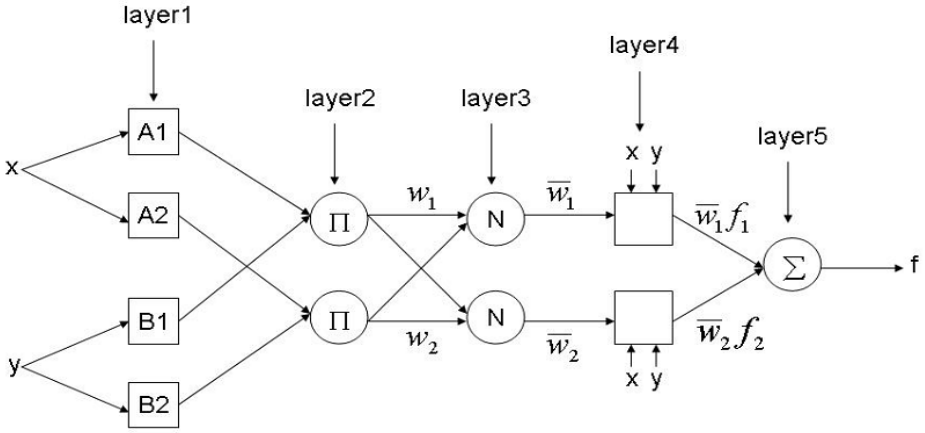


**Figure 1:** Adaptive Neural Fuzzy Inference System (ANFIS) structure (Bakirtzis et al., 2012).

As shown in Fig. 1, the structure of a system (ANFIS) consists of 5 layers including Input data, Fuzzy membership functions ,Consensus rules, Normalization and the combination of normalized weights and ultimately achieved output.

## Research Methodology

The method of this research is "practical" in In terms of purpose which can be use expected results in increasing safety and reducing road accidents. It is descriptive survey type in terms of collecting. In this research, the statistical population included 10 experts in transportation in particular road transportation. The study area covers the Haraz road. In this research, first, according to the literature review of the questionnaire and the theoretical framework of affecting factors on occurrence of road accidents identified that Include 2 categories of human and natural factors. Then, based on the failure analysis method (FMEA) the questionnaire was designed and distributed among the experts. Finally for each factor determine three parameters including severity rate (S), occurrence probability (O), and detection rate (D) and the Risk Priority Number (RPN). Finally, to simulate and predict the risk number of events (RPNs) Adaptive Neural Fuzzy Inference (ANFIS) is used.

## Reasearch Findings

### Identify and prioritize the effective factors of road accidents by FMEA method

In this section, as stated above, according to expert opinion and a review of the theoretical framework and research background 2 groups of factors affecting the occurrence of road accidents are discussed. To prioritize identified risks as previously mentioned, 10 experts view is used. First, a questionnaire was developed according to the method (FMEA) and distributed among experts. In this questionnaire the four parameters for each risk of occurrence probability (O), effect severity (S), diagnosis (D) and (RPN) number are obtained and calculated. The results of these studies are shown in Table 1, respectively.

**Table 1:** The result of the methodological review (FMEA) belongs to the effective factors of road accidents

| The factors | affecting accident Parameters | Occurrence probability (O) | Severity Effect (S) | Diagnosis (D) | (RPN) Number |
|---|---|---|---|---|---|
| natural | Avalanche fall | 4 | 5 | 8 | 160 |
| | Rock fall | 4 | 9 | 10 | 360 |
| | Frost | 3 | 10 | 7 | 210 |
| | Snow and rain | 3 | 9 | 2 | 54 |
| | Fog | 7 | 9 | 10 | 630 |
| human | Failure to comply with traffic laws | 7 | 6 | 7 | 294 |
| | Not familiar with the quality of roads | 7 | 5 | 5 | 175 |
| | Fatigue and drowsiness | 5 | 10 | 10 | 500 |
| | drug use and alcoholic beverages | 9 | 8 | 10 | 720 |
| | Hurry on the way to the destination | 8 | 9 | 7 | 504 |

According to the results of Table (1) and the average of the opinions obtained in the opinion of the experts the Fog from subset of natural factors is as the first factor and the factor of "drug use and alcoholic beverages"

from the human factor is in the first rank as the factors affecting road accidents according to FMEA methodology and expert opinion.

**simulation of the (RPN) value by the Adaptive Neural Fuzzy Inference System (ANFIS)**

In this section, in order to design a predictive system based on input and output data it used the (ANFIS) system with the MATLAB 2015 software.

- **Research Configuration Describes and (ANFIS) System Structure**

For (ANFIS) System Design, 3 inputs includes accident severity (S), occurrence probability (O),and detection rate (D) with an Output of (RPN)Number Risk for estimation is considered. Other essential parameters to be considered are shown in Table (2).

**Table 2:** Research System Structure (ANFIS)

| Target Error | Fuzzy Network Learning Method | Number of Epochs | Fuzzy Network Creation method(FIS) | Type of Functions | Number of Membership Functions |
|---|---|---|---|---|---|
| 0 | Hybrid | 50 | Genfis1 | Guysin | 5 |

Given the determination parameters in Table 2, designed fuzzy system components along with the type and number of membership functions for input and output variables are shown in Fig. 2 and Fig. 3.

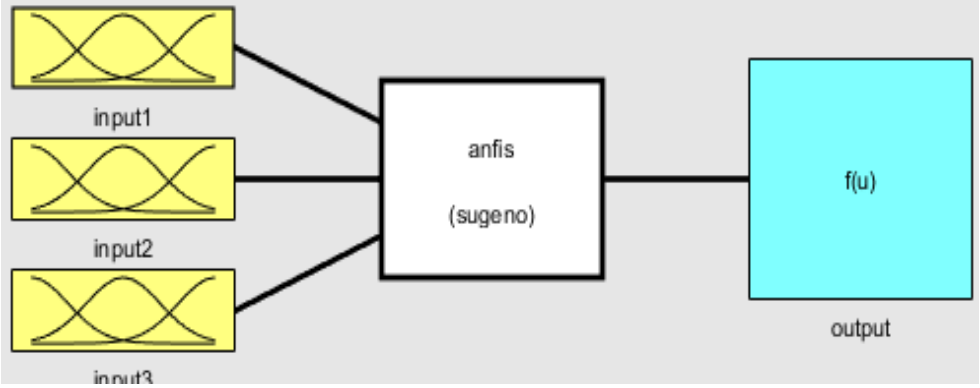


**Figure 2:** Designed Fuzzy System (FIS)

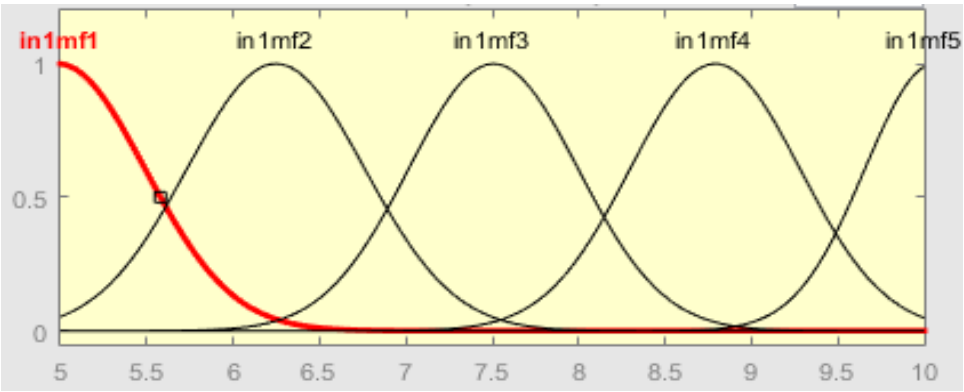


**Figure 3:** The type and number of model membership functions

After designing a fuzzy system (FIS) which is one of the major steps in the (ANFIS) system process the system should be trained by (), after the process of training the structure of the(ANFIS) system completed as

shown in Figure 4. This structure is based on the number of inputs, outputs, the number of membership functions (white color circles) and the generated rules.

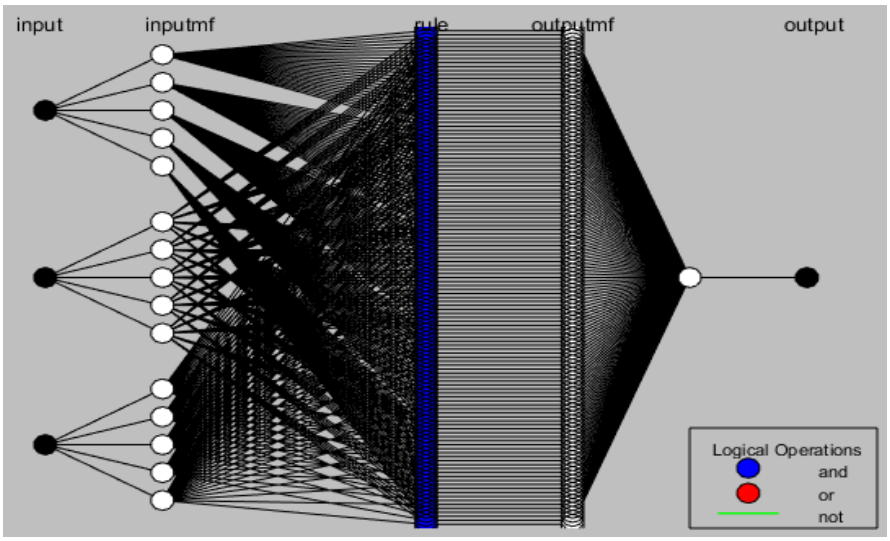


**Figure 4:** Research System Structure (ANFIS)

Finally, the designed (ANFIS) system is implemented by(MATLAB) software and includes Fuzzy System Division outputs (FIS) Including three-dimensional fuzzy diagrams based on two inputs and one output as well as outputs belonging to real model and projected data by the model .the results of this study are shown in Figures (5) and (6).

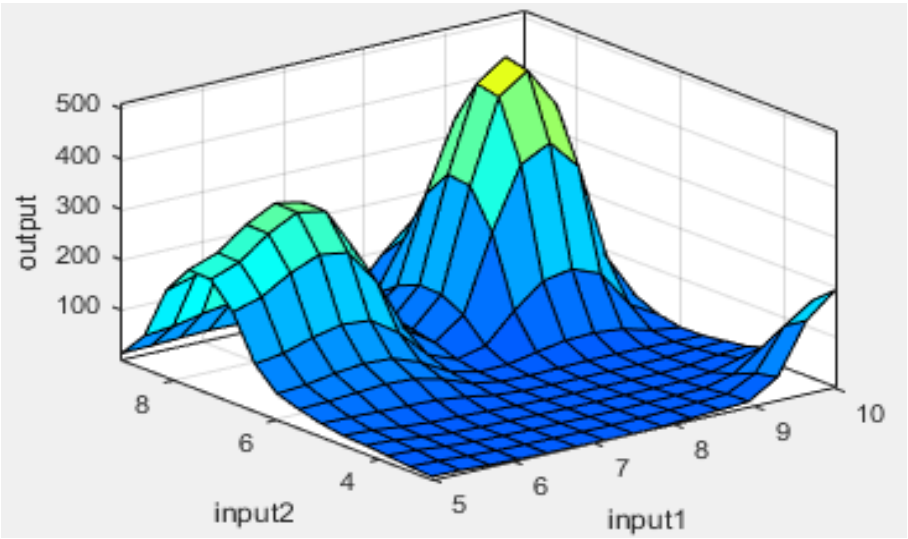


**Figure 5:** Three-dimensional diagram of the fuzzy system

As shown in Fig. 5, the 3D chart created based on the components of the fuzzy system and produced rules by this system. This chart is based on two inputs of severity of accident (s) and accident rate (o) and output of risk number (RPN). It also shows the variations in input variables and the amount of change in output variable (RPN).

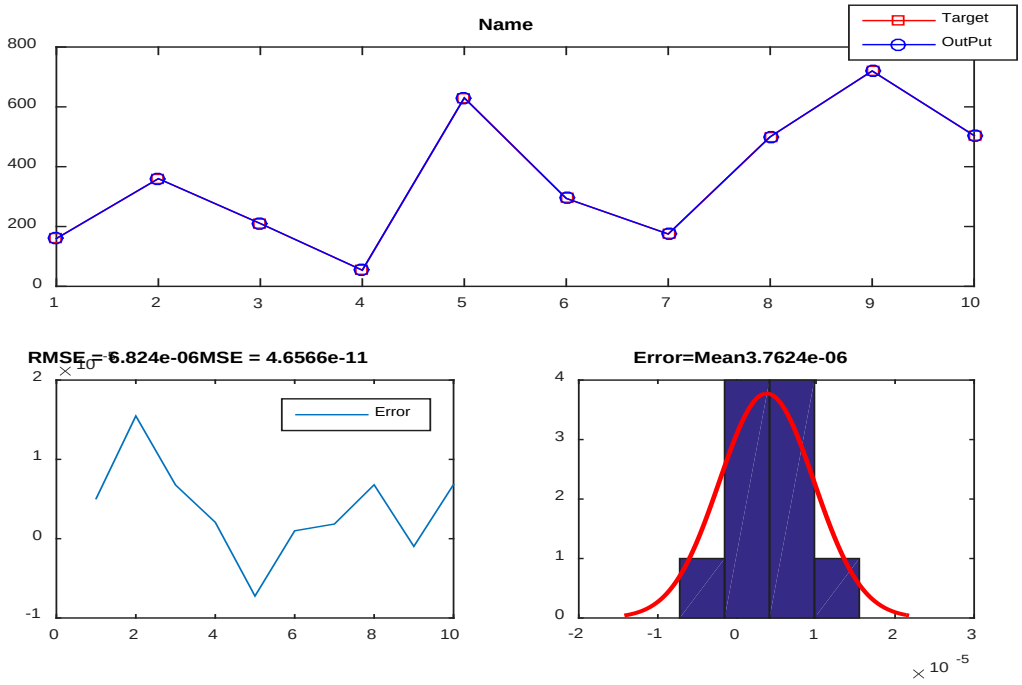


**Figure 6:** System Results (ANFIS)

The results obtained from Fig. 6,shows the model real values of the Risk Number (RPN) matches with the predicted values (output) by the model and also due to the low magnitude mean square error (MSE) and mean square error (RMSE), is equal to(4.656e-11) and (6.824e-6) respectively and aspires to zero. The designed (ANFIS) system is to be highly accurate. And the system has the ability to predict other risk-based accidents (RPNs) and there is no limit for it. The result of the comparison of the (FMEA) method and the method of the (ANFIS) system to estimate and predict the priority number of risk I n addition to the model error prediction values, is shown in Table (3).

**Table 3:** The results of the comparison of the (FMEA) method and the (ANFIS) system

| The factors | affecting accident Parameters | RPN Method Accident (FMEA) | Random Number Error | Accident Method (ANFIS) |
|---|---|---|---|---|
| natural | Avalanche fall | 160 | 5.04E-06 | 160.00000504 |
| | Rock fall | 360 | 1.54E-06 | 360.00000154 |
| | Frost | 210 | 6.76E-06 | 210.00000676 |
| | Snow and rain | 54 | 2.06E-06 | 54.00000206 |
| | Fog | 630 | -7.23E-06 | 629.99999277 |
| human | Failure to comply with traffic laws | 294 | 9.94E-06 | 294.00000994 |
| | Not familiar with the quality of roads | 175 | 1.84E-06 | 175.00000184 |
| | Fatigue and drowsiness | 500 | 6.79E-06 | 500.00000679 |
| | drug use and alcoholic beverages | 720 | -9.74E-06 | 719.99999026 |
| | Hurry on the way to the destination | 504 | 6.83E-06 | 504.00000683 |

## Conclusion

Today, the number of road accidents in our country is increasing and as a result the financial losses caused by them which is imposed on families and the government is very high and by noticing that the financial and psychological and social damage are irreparable in some cases ,it is necessary to prevent traffic accidents

damages implement effective strategies . The economic value of the killed people and the disadvantages of permanent disabilities, grief and mental injuries, are the negative consequences of these types of events.so this article is seeking to answer this important question that, what is the most important factor in the occurrence of road accidents in the Karaj-Chalous transportion axis? The findings show that; 1. In this axis is a combination of two natural and human factors mostly involved in accidents and according to the(FMEA) method based on the opinion of the respondents (Experts, drivers and local residents), two factors, "fog" from the natural factors and the " drug and alcohol use" from the human factor respectively, ranked first and second on natrural incidents factors on this road. 2. Based on the simulation of the Adverse Neural Fuzzy Inference System (ANFIS) the Risk Priority Value (RPN) of each of these factors simulated and predicted to take the necessary plans to reduce accidents on this road. Because of system error rate for all the events as well as the mean square error (MSE) and Root Mean Square Error (RMSE) of entire (ANFIS) system was negligible, therefore, the design of the (ANFIS) system has been implemented carefully and this system is able to predict other road accidents accurately based on the Risk Priority Number (RPN). And it can be used in risk management program compile, Road Crash Management and also be used by experts who are working in the road construction industry.

## References


1. Abadian, M., (2011). Quality Detection Quality Assessment by FMEA DEA Fuzzy. Master's Thesis, Jahaddaneshgahi Yazd University, 25.
2. Ayati, E., Ghadiriyan, F., & Ahadi, M. R. (2008). Calculate the cost of damage to vehicles in Iran road accidents in 2004. Journal of Transportation Research, 5(1), 1-13.
3. Bakirtzis, A. G., Theocharis, J. B., Kiartzis, S. J., & Satsios, K. J. (1995). Short term load forecasting using fuzzy neural networks. IEEE Transactions on Power Systems, 10(3), 1518-1524.
4. Christiaanse, W. R. (1971). Short-term load forecasting using general exponential smoothing. IEEE Transactions on Power Apparatus and Systems, (2), 900-911.
5. Gains, A., (2013). cost recovery system for speed and red light cameras – two-year pilot evaluation, Department for transport, London, 12-30.
6. Jabbari, M., Khodaparast, A., Sadri, K., Kavousi, A., and Al-Sadat Khaloo, Sh., (2014). Investigation of Road Transport Accidents of Hazardous Item in Iran. The health magazine of Iran, Volume 11, Number 5, 10-30.
7. Kashani, S., Asgari, M., and Massoud Dadashzadeh, M., (2005). Designing a Logical Model for Identifying and Analyzing Road Accident Factors in Iran. Proceedings of the First International Conference on Road and Road Accidents, University of Tehran, 20-35.
8. Morovati Sharif Abadi, A, Zanjirchi, M., and Asadian Ardakani, F., (2014). Quality Management of Productivity. Yazd University Press, 298.
9. Salmani, M., Ramadanzadeh Lasbuei, M., Derickvand, M., and Sabeti, F., (2008). The study of the most important factors affecting road accidents and providing solutions to reduce it, Case study area: Southern Khor and Biabanak rural system. Human Geographic Research, No. 65, 15-30.
10. Syori, H., Eini, A., Mehmandar, M., and Karim, KH., (2012). Assessing the new law for driving offenses against traffic users, The Journal of Rahvar, Volume 9, Number 17, 75-89.
11. Zahed, F Rezaei Arjoodi, A, (2006). Estimation of the external cost of the road section of the country on the social environment with emphasis on road traffic accidents, Quarterly Journal of Environmental Science and Technology, Volume 8, No. 3, 15-35.