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Shahrekord earthquake risk assessment by neuro-fuzzy way method using seismic evaluation of structures

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ABSTRACT: Today, the science of risk analysis and seismic improvement of structures are from the earthquake engineering branches, whose process is very long, bulky, and costly. One of the most important problems in this field is the timeliness and the high error rate, so achieving a logical result can be used by decision-makers to solve problems. The goal is to provide a method to help accelerate earthquake risk analysis through refurbishment studies using neuro-fuzzy tools.400 schools were selected from Shahrekord and suburbs schools and then evaluated their seismic risk acceptance using a quick evaluation checklist based on the Rapid Assessment Guidelines of Buildings 364 and the ATC methodology. Also, with the help of wika software, among several structural data, the most effective ones were selected based on the number of replications and the value of the selection, then Anfis software was used to design the neuro-fuzzy system. To check the accuracy of the designed model, we first compared the level of risk obtained from the neuro-fuzzy system and the actual level of risk, and in the next step, we calculated the amount of dispersion of the outputs of the system and compared with the results in the data. This implies adopting the results of the neuro-fuzziness system and the results of the qualitative assessment and proper operation of the system. One of the main advantages of this method is the modeling of uncertainties, the entry of information from the structure by qualitative and quantitative methods, and the high speed of the risk analysis process.

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1. INTRODUCTION

In this article, using neuro-fuzzy intelligent systems, risk analysis studies were carried out [1]. Shahrekord and Suburbs Schools' Improvement Data Collection was used for modeling. These specifications of the structure which are effective on the earthquake, include the maximum ground acceleration[1] in the site, the type of the structure on which it is constructed, age of the structure, structure's area, the lateral load system, type of the structural skeleton, type of roof, type of the foundation and regularity of the plan and the height of structures [2],[3],[4]. In addition to the 10 data, there is also a collection of other data that indicates the cost per square meter of structural improvements, and three groups of structures are considered as outputs of the system: economically inefficient structures (high risk), structures that have been completed due to the cost per square meter (medium risk) and those that do not need to be improved (low risk). Among the 10 selected parameters, based on the specifications in the standard 2800, the most important and most effective parameters in risk were selected through the decision tree technique and by using the method of algorithm j48 and WEKA software [5]. Based on the results of the software and Table 1, six parameters were selected with the highest score and their membership features were drawn.

Table 1. The score of the parameters in the decision tree.

Parameter	Type of structural system	Maximum acceleration of the earth
score	1125	1560
parameter	type of roof	soil type
score	730	2354
parameter	regularity status of the plan structure	lateral load system
score	1125	384
parameter	type of foundation	age of the structure
score	1125	3892
parameter	the structure's area	regularity status in the height
score	256	827

1 PGA

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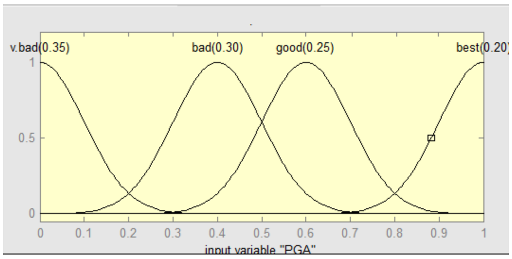

Fig. 2. PGA Fuzzy Membership Functions.

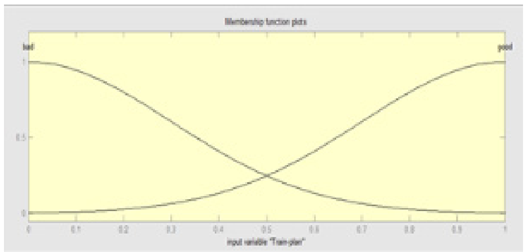

Fig. 5. Fuzzy membership functions of plan's regularity.

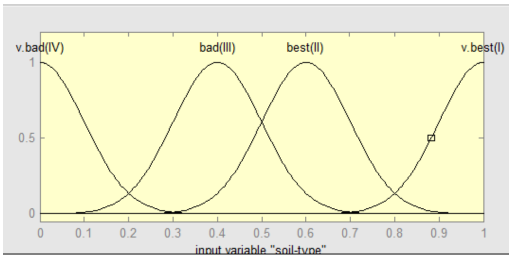

Fig. 3. Fuzzy Functions of Soil Type.

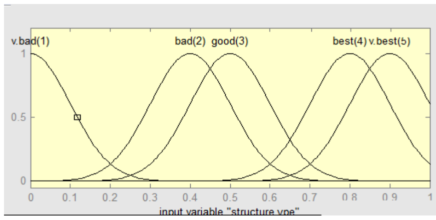

Fig. 6. Fuzzy membership functions of the structural system.

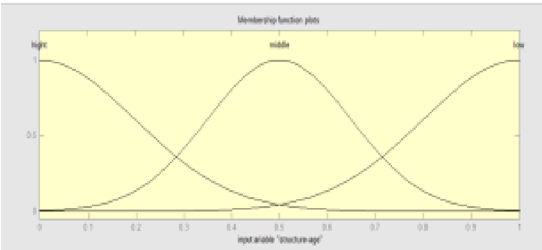

Fig. 4. Fuzzy Function of Structure's age.

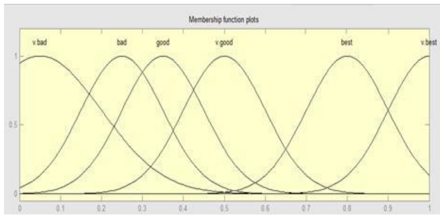

Fig. 7. Fuzzy membership functions of various foundation structures.

2. MEMBERSHIP FUNCTIONS OF EFFECTIVE PARAMETERS

For maximum horizontal acceleration (PGA), according to the 2800 standard, the four values of 0.2g, 0.25g, 0.3g, and 0.35g, respectively, with degrees of membership of 1, 0.6, 0.4, and 0.2 for the design of the membership functions of this parameter Gaussian type was used [6],[7].

In standard 2800, 4 soil types I, II, III, IV are defined and designed in the shape of the curve, and with degrees of membership of 1, 0.6, 0.4, and 0.1, respectively [6],[7],[8].

Three qualitative descriptions were used in the membership function of the structure, with a low membership degree of 1, average membership degree of 0.5, and high membership degree of 0.1 [2],[6],[9].

The amount of regularity in the structure of the plan is considered as yes or no, and according to individual judgments and from different people's points of view. Membership Functions of this parameter are of a sigmoid type [1],[9],[10].

Based on the information related to the selected structures for modeling, there are five types of structural systems (concrete flexural frame with the shear wall, concrete flexural frame, moment steel frame, simple steel frame with a brace, building with masonry with The degree of membership of 0.9, 0.8, 0.6, 0.4, 0.2), and six types of foundation (paddle foundation without tie, paddle foundation with tie and ramp, horizontal cradle under the wall, strip foundation, combined footing and raft foundation with membership functions of 0.1, 0.25, 0.35, 0.5, 0.8 and 0) [2],[6],[9]. The membership functions of these parameters were considered as Gaussian functions according to the building's function against earthquakes and different judgments of individuals and experts about each of them for uncertainty, as it is shown in Fig. 6 [9],[10][11].

The output parameter or the seismic risk aversion of the building is divided into three categories of the low, medium, and high-quality description [1],[2],[4]; the membership functions of this parameter are Gaussian curves. The system uses the Sugeno class. Some of these rules are given below [12]:

1. If (PGA is 3) and (Soil type is1) and (Age is 1) then (Hazard is 1).
2. If (PGA is 3) and (Soil type is 2) and (Age is 2) and (Order plan is 1) then (Hazard is 1)

To evaluate the accuracy of the designed model, from 400 schools across Chaharmahal and Bakhtiari province, information from 300 schools was used to train, and information from 100 schools was used for the final test of the inductive system randomly. In this case, the accuracy of the system is designed once for training data (300) and

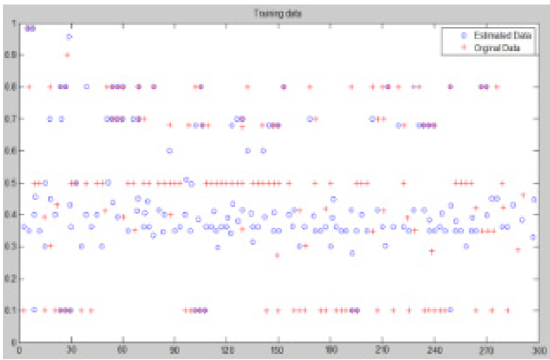

Fig. 8. Main data model after training for 5 data.

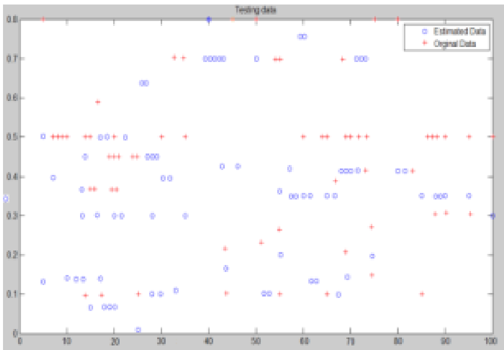

Fig. 9. Test data model after training for 5 data.

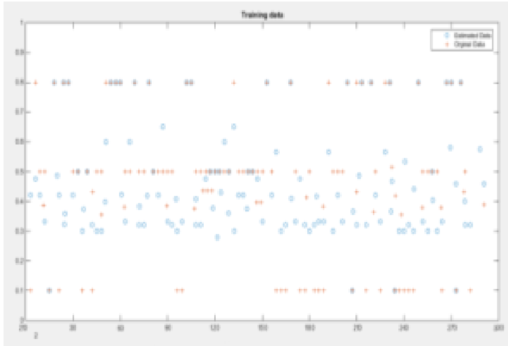

Fig. 10. Main data model after training for 6 data.

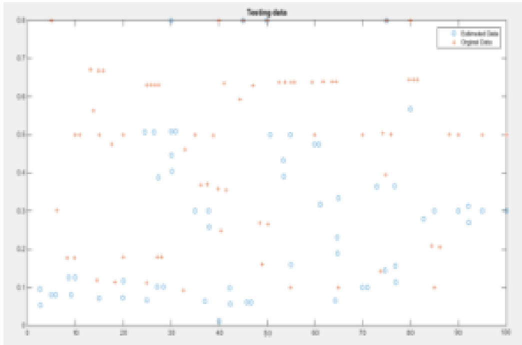

Fig. 11. Model of test data after training for 6 data.

Table 2. Results of the accuracy of the designed model.

Type of data	Number of inputs	Results from classified data	Sum of the root mean square of the error
300 data	5	0.50	0.0386
	6	0.69	0.0281
100 data	5	0.45	0.0596
	6	0.74	0.1165

once for testing data (100) in two input types of 5 inputs with continuous membership functions and 5 inputs with continuous membership functions along with the type of foundation parameter is evaluated. Also, to examine the system designed for the results, on the one hand, the number of correctly classified results was surveyed by comparing the predicted level of risk with the neuro-fuzzy system and the real hazard level and, on the other hand, calculating the amount of output dispersion of the model with the results in the data was obtained through the sum of the root mean squared error using Eq. (1) [4],[13]:

$$\sqrt{\frac{\sum_{i=1}^{n}\left(data\ hazard\ level - hazard\ level\ estimated\right)^{2}}{n-1}} \qquad (1)$$

The results obtained from performing the two above-mentioned controls on two models with a variety of parameters are According to Table 2.

Finally, the proposed model yielded 69% of accuracy in the data classification and the total root mean square error of 0.0281 in the 300-item survey. Also, in the 100-sample data, 74% of the data is classified as correct and the root mean square error is about 0.1165.

The result of the comparison of the hazard outputs based on the proposed model and the main risk category in the data is provided for the information of 300 schools. In Figs. 8 to 11, the horizontal axis represents the school number and the vertical axis represents the level of risk identified with the proposed process and the main identified risk level in the data. Therefore, to eliminate the output error of the proposed

Table 3.

Row	Type of Usage	Number of floors	Area (m^2)	age of Structure	type of Structure	type of foundation	Regularity of plan	Fuzzy hazard Level	Level of the Main hazard of data
1	Kar o danesh Conservatory	1	6213	9	braced	pad	regular	0.9	Resistant (low risk)
2	high school	2	1662.6	23	flexural frame	Concrete tie	regular	0.41	Semi-resistant (medium risk)
3	Elementary school	1	106.42	35	masonry	Concrete tie	regular	0.3	Destruction (high risk)

model, the smaller difference is considered equal to 0.1 and with the main data hazard level [1],[14],[15]. Therefore, it is clear from the table and figures that the proposed method has high accuracy in the rapid determination of the risk level of structures with the help of 6 initial inputs. The effectiveness of the proposed method is examined by determining the level of risk of these schools and comparing them with existing results [4],[16],[17]. Table 3 represents the other inputs to the software as well as the results obtained. The results of Table 3 show a very consistent adaptation of the results of the suggested method with the available results. The reason for this type of difference can be explained with the help of the uncertainty debate in the proposed process [18],[19]. The results of this table represent the proper performance of the proposed method for determining the level of risk of the structure and its rapid assessment.

3. CONCLUSIONS

Using the results of the neuro-fuzzy system, qualitative assessment of seismicity of the region is possible. Based on the earthquake standard of 2800, Shahrekord is located in a high seismic area and according to the seismic zoning studies carried out in the north, central and southern parts, it has a PGA of 0.29 g, 0.24 g, and 0.30 g, respectively. However, according to the results of the neuro-fuzzy system, the values presented in Table 3, PGA of the region and the probability of destruction in resistant structures due to uncertainties, the northern, central, and southern regions have too much high, high and high risk, respectively.

REFERENCES

[1] Koohi Kamali, Mehran, "*Shahrekord Probabilistic risk analysis*", Thesis, 2009.

[2] Quick Seismic Evaluation of Existing Buildings, Journal No. 364, International Institute of Earthquake Engineering, Seismology and Earthquake Engineering, .1387

[3] Soltani, Saeed, Sardari, Soroush, Sheikhpour, Mozhgan (2010), Artificial Neural Networks, First Edition, Scientific Publishing, Nasr Cultural.

[4] Asmari Saadabad, Soheil, "*Earthquake risk analysis with fuzzy inference system and case study of Tehran*", Thesis, 2013.

[5] Goodarzi, Mohammad Reza, Kangavari, Mohammad Reza (2004), Fuzzy Decision Tree Learning, Fifth Iranian Conference on Fuzzy Systems, p. 125.

[6] Standard 2800 earthquake editing 4.

[7] Sekran, Raja, Alakami Pei, Vijay (1391), Neural Networks, Fuzzy Logic, Genetic Algorithm and Application, First Edition, Noorpardazan Publishing.

[8] www.iiees.ac.ir

[9] Zainoli Rastabi, Safdar, Ghodrati Amiri, Gholamreza, "*Shahrekord Risk Assessment*", Journal of Structural Engineering and Construction, 2014

[10] Kia, Mostafa (2010), Neural Networks in MATLAB, First Edition, Kian Publication Green

[11] Kia, Mostafa (2011), Fuzzy Logic in MATLAB, Second Edition, Publication Center, Academic Publishing Center

[12] Gherami Moghadam, Rahim, Comparison of Artificial Neural Networks and neuro-fuzzy Methods of ANFIS in the Forecast of the Bashar River Annual Year, 1393, Islamic Azad University, Shiraz Branch, 2014

[13] Wang, Lee, Fuzzy Systems and Fuzzy Controls, Translated by Mohammad Teshnehlab, Nima Safapour, Dariush Aphiunei. Khajeh Nasir Al-Din Toosi University of Technology, October 2001

[14] Wang, Lee, translation by Mohammad Teshnehlab, Nima Safarpour, Daryoush Aphiunei, "*Fuzzy and Fuzzy Control Systems*"

[15] Azar, Adel and Hojat Faraji (2007), Fuzzy Management Science, First Edition, Center for Management and Productivity Studies of Iran, affiliated to Tarbiat Modares University.

[16] N.Bartoletti, F.Casagli,S.Marsili, Libelli, "*Data-driven rainfall/ runoff modeling based on a neuro-fuzzy inference system*", Elsevier, 2017.

[17] Manhaj, Mohammad Baqir, "Fuzzy Computing (Vol. 3): Computational Intelligence", Tehran, Iran. 2009.

[18] Zs.J.Viharos "*Survey on Neuro-Fuzzy systems and their applications in technical diagnostics and measurement*", Elsevier, 2015.

[19] K. Briggs, C. Beck, "*Modeling train delays with q-exponential functions*", Statistical Mechanics and its Applications, May 2007, pp. 498-504.

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