8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

COMPARISON OF SESIMIC STRUCTURAL RESPONSES IN DIFFERENT STORIES VIA FUZZY CLUSTERING

Davoud REZAZADEH
M.Sc. Earthquake Engineering, Kharazmi University, Tehran, Iran
davoudrezazadeh@gmail.com

Mohsen SHAHRUZI
Civil Engineering Department, Faculty of Engineering, Kharazmi University, Tehran, Iran
shahruzi@khu.ac.ir

Keywords: Data Mining, Earthquake Records, Structural Response, Fuzzy logic

Clustering can be considered as the main method of unsupervised learning. Clustering attempts to subdivide the data into clusters so as to obtain the highest similarity between the data within each cluster and the least similarity between the data in the different clusters (Zimmermann, 2001). Clustering methods are divided into definitive and fuzzy clusters (Davarynejad et al., 2007). In fuzzy clustering, each object falls into a specific cluster with a membership degree (Shahrouzi and Farahabadi, 2018). In this paper, clustering of earthquake records and seismic responses is performed using fuzzy logic algorithm. For obtaining data matrix was used to the PEER site. This matrix contains 56 earthquake records in different places in the world with magnitude, fault mechanism, soil type and different focal lengths. The magnitudes of the selected earthquakes are larger than 5 (5 <M). The acceleration criteria used in Standard 2800 are earthquake magnitude, distance to cause fault, fault mechanism (Standard 2800, 2014). These parameters partly reflect the characteristics of the region. Due to new database changes, the fault mechanism criterion has been added to the existing criteria list. Other criteria used in this study include maximum ground acceleration (PGA), maximum ground velocity (PGV), maximum ground displacement (PGD), arias intensity and Housner spectral intensity. The last two can be considered as parameters representing the earthquake input energy to the structures. In the algorithm used, each record is considered a vector object, including elements representing different earthquake record features to be used in clustering. To obtain seismic responses using OpenSees software a two-story with vibration mode first period 0.45 S, six-story with period 0.92 S and ten-story with period 1.28 S steel moment frame structure (4 bays at direction X and 3 bays at direction Y). Time history analysis for each record using only horizontal components and seismic responses were obtained, including maximum acceleration, maximum velocity and maximum displacement center of mass story, arias spectral and Housner spectral intensity. Clustering criterion extracted for both the main X and Y directions of the structures. Each row of data matrix represents the seismic response of an earthquake record and each of the matrix elements is a criterion, then clustering was performed using the algorithm and the degree of membership results of each seismic response were calculated. After make it the data matrix, the data matrix is normalized to equalize the weight of the criteria. Clustering analysis was performed in four clusters. After fuzzy logic clustering analysis, the membership records of the records were compared with the seismic responses. Then values, mean error, standard deviation of error, mean absolute error value between degree of membership earthquake records and seismic response were calculated as Equations 1 to 3. In these formulas (μ_R) is degree of membership earthquake record and (μ_r) is degree of membership seismic response. For example, in Figure 1, fuzzy memberships in the first cluster for earthquakes records (violet) and seismic responses of fifth floor 10-story structure (yellow) has been shown.

$$Mean\_Error = mean(\mu_R - \mu_r) \tag{1}$$

$$Mean\_AbsError = mean(Abs(\mu_R - \mu_r)) \tag{2}$$

$$Std\_Error = std(\mu_R - \mu_r) \tag{3}$$

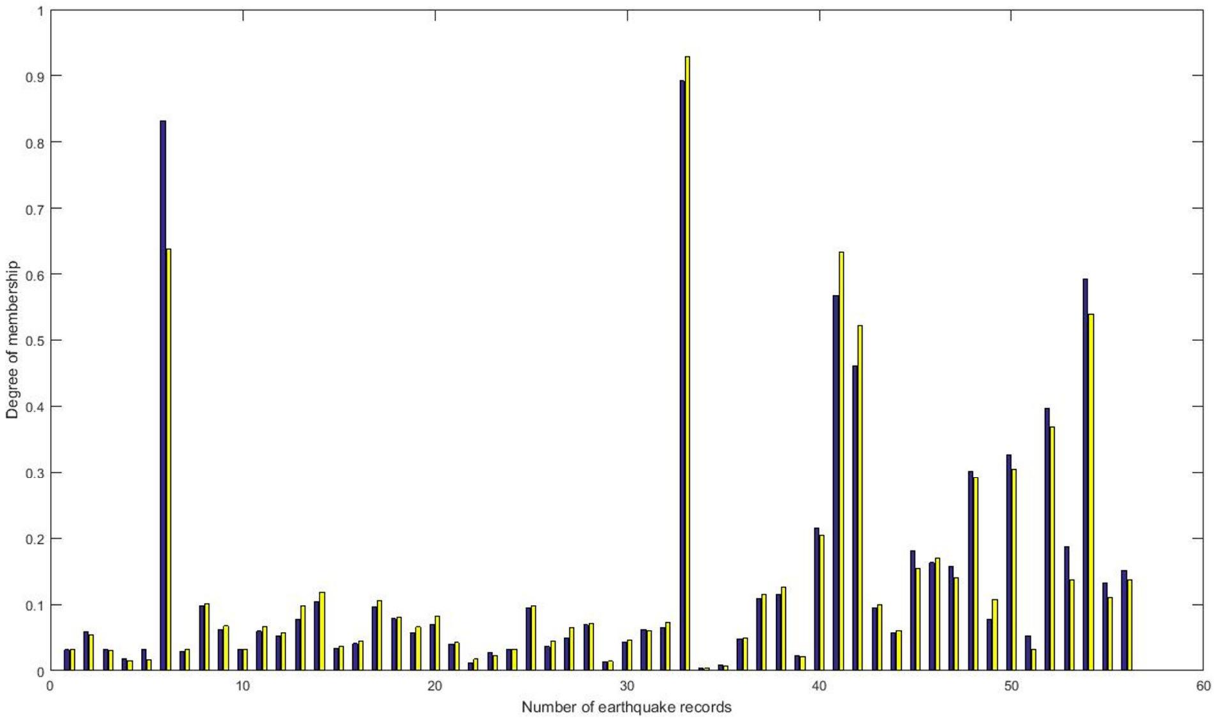

Figure 1. Fuzzy memberships in the first cluster for earthquakes (violet) and responses fifth floor 10-story structure (yellow).

Table 1. Error mean absolute, mean error and standard deviation of error values.

	Error mean absolute, mean error and standard deviation of error values											
	First cluster			Second cluster			Third cluster			Fourth cluster		
	Std (E)	Mean (E)	Mean (Abs(E))	Std(E)	Mean (E)	Mean (Abs(E))	Std (E)	Mean (E)	Mean (Abs(E))	Std (E)	Mean (E)	Mean (Abs(E))
Comparison degree of membership records with roof 2-story structure	0.0525	0.0097	0.0181	0.0354	0.0214	0.0254	0.109	0.027	0.0659	0.1263	0.2093	0.2128
Comparison degree of membership records with third floor 6-story structure	0.1575	0.0083	0.0581	0.0925	-0.038	0.0582	0.1389	-0.0973	0.1020	0.2311	-0.1584	0.2289
Comparison degree of membership records with roof 6-story structure	0.1187	0.0318	0.0431	0.0256	0.0015	0.0131	0.1801	0.0993	0.1066	0.1081	0.1258	0.1329
Comparison degree of membership records with fifth floor 10-story structure	0.1954	0.1535	0.1909	0.0871	-0.0516	0.0601	0.1602	0.0231	0.0621	0.2207	-0.1770	0.2252
Comparison degree of membership records with roof 10-story structure	0.1058	0.0155	0.0405	0.0272	-0.002٠	0.0134	0.0462	-0.0079	0.0288	0.1065	-0.0067	0.0690

REFERENCES

Davarynejad, M., Akbarzadeh, T.M.R., and Pariz, N. (2007). A novel general framework for evolutionary optimization: Adaptive fuzzy fitness granulation. 2007 IEEE Congr. Evol. Comput. CEC 2007, 951-956.

Pacific Earthquake Engineering Research Center, PEER Strong Motion Database, http://peer.berkeley.edu/smcat/.

Shahrouzi, M. and Farahabadi, H. (2018). A fast fuzzy-tuned multi-objective optimization for sizing problems. *Int. J. Optim. Civ. Eng.*, *8*, 53-75.

Standard No. 2800 (2014). Iranian Code of Practice for Seismic Resistant Design of Buildings, 4th Edition, Tehran, Iran.

Zimmermann, H.-J. (2001). Fuzzy set theory and its applications. *Fuzzy Sets Syst.*, doi: 10.1007/978-94-010-0646-0.