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The application of fuzzy mathematical method in antiseismic structures

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Abstruct: In this paper,the fuzzy ISODATA algorithm is applied to forecasting liquefaction of sand in the antiseismic structures.According to the data of the earthquake taken place in Tang SHan in 1976, we construct a model of mathematics,on which we forecast 32 samples in the earthquake of Tang Shan. The correct rate of forecast is 90.7%.

1 Introduction

The liquefaction of sand is a harmful phenomenon of the earthquake.The earthquakes,which taken place in America and Japan in 1964,resulted in serious destruction of the buildings because of the liquefaction of sand of foundation.So the problem of the liquefaction of sand is attracting the people's attention. In order to give evidence for the earthquake-resistant structure,it is required to solve the problem of forecasting liquefaction of sand. In this paper we give a method of forecasting liquefaction of sand and also give a practical example.

2 The method of forecast

First we choose the samples that sand was liquefied

$$X_1, X_2, \ldots, X_n$$

where each X_i is on m factors. Therefore X_i is characterized by a m-dimensional vector,that

$$X_i = (x_{i1}, x_{i2}, \ldots, x_{im}),\ i = 1,2 \ldots,n.$$

Then we apply the fuzzy ISODATA algorithm to X_1, $X_2,\ldots,X_n$. Assume that the clusters are obtained as follows

$$A_1, A_2, \ldots, A_k.$$

Extend $A_1,A_2,\ldots,A_k$ into fuzzy subsets in the universe of discourse R^m (R^m is a m-dimensional linear space)

$$\underset{\sim}{A_1}, \underset{\sim}{A_2}, \ldots, \underset{\sim}{A_k}$$

and their membership functions are

$$\underset{\sim}{A_1}(x), \underset{\sim}{A_2}(x), \ldots, \underset{\sim}{A_k}(x)$$

respectively. Set

$$\underset{\sim}{A} = \bigcup_{i=1}^{k} \underset{\sim}{A_i}$$

Thus

$$\underset{\sim}{A}(x) = \bigvee_{i=1}^{k} \underset{\sim}{A_i}(x)$$

Now we intruoduce a method of forecast.

First we fix a level λ_0.Let x denote an arbitrary sample,compute the grade of membership of x in $\underset{\sim}{A}$:

$\underset{\sim}{A}(x) = \lambda$.

If $\lambda > \lambda_0$, then we forecast that sand will be ligu-efied; if $\lambda < \lambda_0$, then we forecast that sand will be unliquefied.

3 A practical example

We shall employ the example of earthquake appeared in TangShan in 1976. We choose samples

$$X_1, X_2, \ldots, X_{40}$$

and we choose 7 factors for each X_i:

Y_1 : seismic intensity scal .

Y_2 : epicentral dis-tance .

Y_3 : everange grain diameter .

Y_4 : nonuniform coefficient .

Y_5 : ground water level .

Y_6 : embedment depth of sand stratum .

Y_7 : sdandard penetration value .

Thus X_i may be expressed as

$$X_i = (x_{i1}, x_{i2}, \ldots, x_{i7}),$$
$$i = 1, 2, \ldots, 40.$$

Then applying the fuzzy ISODATA algorithm to

$$X_1, X_2, \ldots, X_{40},$$

we obtain Table 1 and Table 2.

Table 1 The result of cluster

A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}
1	2	3	4	5	22	7	8	6	10	11	27	17	23	29	32	37
	34		12		24	16		9		13	28	18	25	30	35	38
					26			14			33	19		31	36	39
								15				20			40	
												21				

Table 2 The centers of clusters (omitted).

Extend $A_1, A_2, \ldots, A_{17}$ into fuzzy subsets in R^7

$$\underset{\sim}{A_1}, \underset{\sim}{A_2}, \ldots, \underset{\sim}{A_{17}}.$$

The membership function of A_i is defined as

$$\underset{\sim}{A_i}(x) = \begin{cases} 1-b_i \| x-V_i \|^2, & 1-b_i \| x-V_i \|^2 > 0; \\ 0, & 1-b_i \| x-V_i \|^2 < 0. \end{cases} \qquad (1)$$

Where b_i is a parameter in the relation to the great cluster radius of center V_i. The values of b are given in Table 3 .

Table 3 The values of b

b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
10000	22.22	20000	57.14	2000	17.83	17.83	2000

Table 3 The values of b (continued)

b_9	b_{10}	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}	b_{16}	b_{17}
17.83	2000	57.14	17.83	7.69	200	22.22	7.69	7.69

We fix a level value = 0.6. For example, for sample

$$x = (0.55, 0.47, 0.15, o.86, 0.06, 0.12, 0.01)$$

(data have been standardized), then (1) yields

$\underset{\sim}{A_1}(x) = 0.96$, $\underset{\sim}{A_2}(x) = \underset{\sim}{A_3}(x) = \ldots = \underset{\sim}{A_{17}}(x) = 0$.

Thus $\underset{\sim}{A}(x) = \underset{\sim}{\vee} A_i(x) = 0.96$.

Because $0.96 > 0.6$, we forecast that sand will be liquefied. It conforms with reality.

Now forecast is done by applying this model to 32 samples in TangShan(See Table 4),then the results of forecast are shown in table 5. The correct rate of forecast is 90.7%.Table4 The standard data of 32 samples(amittied).Table5 The forecast results of 32 samples(Amitted).

References

[1] L.A.Zadeh,Fuzzy sets,Inform.and Ctrl.8(1965).