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Rapid Loss Assessment for Earthquake Disaster Based on AHP and Case Matching

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Abstract

Timely and rapid assessment of earthquake loss in the gold 72 hours after earthquake is important for rescue decision-making. In practice, however, earthquake related data are complex and coming from various sources, making it difficult to obtain the detailed data in the incomplete information regions. Existing popular assessment methods usually need lots of detailed data, which will delay the evaluation time and miss the gold rescue time. Based on the similar theory and the historical earthquake cases, this paper proposed a novel case matching approach for earthquake loss assessment in the area of incomplete information. The proposed approach first identified earthquake influence factors through analyzing ninety-two historical earthquake cases, and then gave the weight of each factor by using the analysis hierarchy process (AHP) method. Finally, it matched the best similar earthquake case and estimated the deaths and the disaster level according to the similar earthquake case. Three representative earthquakes are presented as case studies to evaluate the proposed approach. The results show that, the proposed method can rapid loss evaluation results without detailed data. It can provide useful information for the post-earthquake rescuing, especially in the incomplete information region.

Keywords: *earthquake, rapid loss assessment, case matching, incomplete information, analysis hierarchy process*

1. Introduction

Earthquake is one of the most serious natural disasters in the world [1]. For example, the 1994 Northridge earthquake in the USA caused 12.5 billion USD insurance losses [2]; the 2003 Bam earthquake in Iran resulted in more than 30 000 deaths [3]; the 2008 China Wenchuan earthquake (M_s8.0) had 69,142 death tolls. Unfortunately, accurate earthquake prediction is still a difficult and even impossible task. In this situation, timely and rapid post-earthquake emergency response and rescue services is an effective way to mitigate the disaster. Rapid loss assessment after earthquake is very important for making decision of the corresponding post disaster emergency rescue strategy.

In the last decades, a great number of approaches have been proposed to evaluate earthquake damage. These approaches can be generally categorized into two classes, that is, the Remote Sensing (RS) based approach and the Geographic Information System (GIS) based approach. The remote sensing based approach often retrievals and extracts potential damage information from high resolution remotely sensed images by means of image change detection [4,5]. The GIS based approach is

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usually applied by combining GIS with certain evaluation models. In the model calculation process, it often needs lots of detailed exposure data such as the population distribution data, building distribution data and so on. Overall, both the RS and GIS based methods are need lots of detailed information of the disaster area.

However, in some undeveloped areas or emergency situation, it is difficult to get detailed information. In the case of incomplete information, to quickly assess the earthquake loss also needs to rely on other methods. In China, earthquake loss assessment related factors such as the spatial distribution of earthquake, the fault zone distribution and the secondary disasters have strong regional distribution regularity and similar values [6]. Therefore, if two earthquakes have similar influence factors, they have similar disaster loss. Based on this, this paper proposed a novel case matching approach for earthquake loss assessment in the area of incomplete information.

The proposed method quickly and roughly estimates the earthquake loss by matching similar earthquake case in the historical earthquake cases. Firstly, it extracted the top ten influence factors from the ninety-two historical earthquakes in Chinese mainland. Then it determined the weights of the influence factors by analytic hierarchy process approach. Finally, it matched the best similar earthquake from the historical earthquake cases database. This paper is organized as follows. In section 2, it presents the case matching method for earthquake loss; section 3 uses three real earthquake cases to illustrate the proposed approach; and, section 4 concludes the paper.

2. Methodology

2.1 Case Matching Method for Earthquake Disaster

Earthquake is an emergency event, which is uncertain, sudden and urgent. After the emergency, the decision makers need to make scientific and rational decision-making in the shortest possible time to minimize the loss. Earthquake case matching technology tries to assist decision-making in the shortest possible time after earthquake through historical case matching and correction.

Generally, earthquake case matching approach includes three key steps: constructing influence factor set, determining weights and matching the best similar cases. In earthquake case matching approach, influence factor set represents an earthquake. Constructing influence factor set is the premise and foundation of case matching. The weight of an influence factor represents its relative importance. The weights of all influence factors are calculated by applying the analytic hierarchy process. To matching the best similar cases, it needs to calculate the evaluation scores of the historical earthquakes and experimental earthquakes first. The evaluation scores(S) can be calculated as follows:

$$S = \begin{pmatrix} f_1 & f_2 & \cdots & f_n \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = f_1 * w_1 + f_2 * w_2 + \cdots + f_n * w_n \quad (1)$$

Where, f_i is normalization value of the factor i(i=1,2,…,n); w_i is the weight of the factor i(i=1,2,…,n); the evaluation scores of historical earthquakes were named $S(H_i)$ (i=1,2,…,n) and the evaluation scores of experimental was named $S(P)$. Calculating the absolute value of the difference between $S(H_i)$ and $S(P)$, find the minimum absolute value and the corresponding historical earthquake is the best similar earthquake. The whole process of earthquake loss assessment based on case matching is shown in Figure 1.

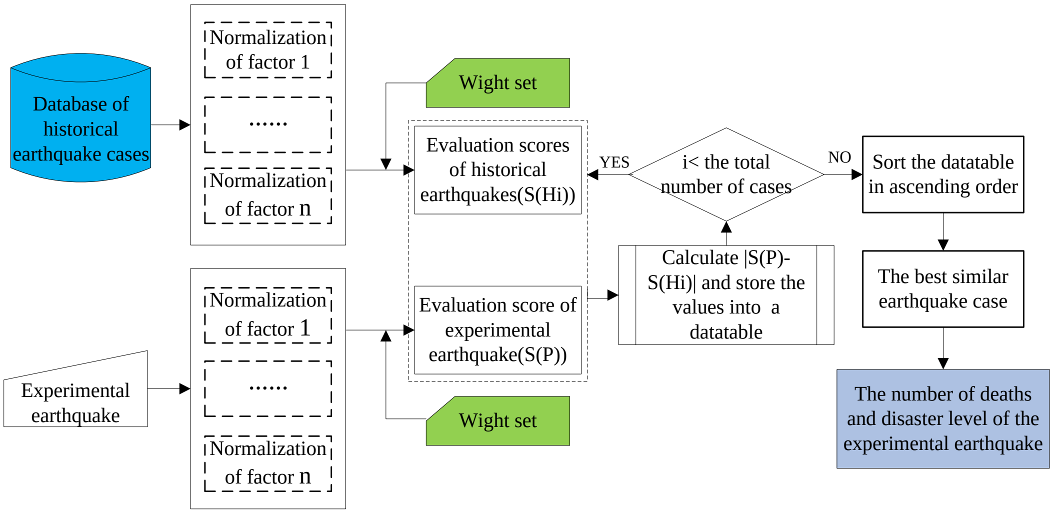

Figure 1. Flow Chart of Earthquake Loss Assessment based on Case Matching

2.2. Earthquake Influence Factor Set

The damage caused by an earthquake is determined by multiple influence factors. A number of influence factors composed the earthquake influence factor set. Earthquake influence factor set represents an earthquake case. Constructing influence factor set is the first step of earthquake case matching.

Different earthquakes have different influence factors. Ideally, considering all influence factors and constructing influence factor set for every earthquake will get more accurate evaluation result. However, evaluating in this way will greatly reduce the efficiency and universality of earthquake disaster assessment. In practice, however, it is impossible to take all influence factors into consideration for every earthquake. The top ten important influence factors are applied in the present research, in order to enhance the efficiency and universality of the case matching model.

Generally, the influence factors are extracted by analyzing historical earthquake cases. In this study, in order to improve the objectivity and comprehensiveness of case studies, ninety-two representative and universal historical earthquake cases are collected. The spatial distribution of all used historical earthquake cases is shown in Fig.2. It is noticed that these earthquake cases are distributed in all parts of Chinese mainland. Earthquakes with magnitude more than 7.5 are mostly distributed in western China region. By contrast, earthquakes with magnitude less than 5.5 are mostly distributed in central China region. The number and region attributes of these earthquake cases are shown in Table 1 and it is noticed that these cases contain all levels of destructive earthquakes including the top ten level earthquakes in Chinese mainland since 1966.

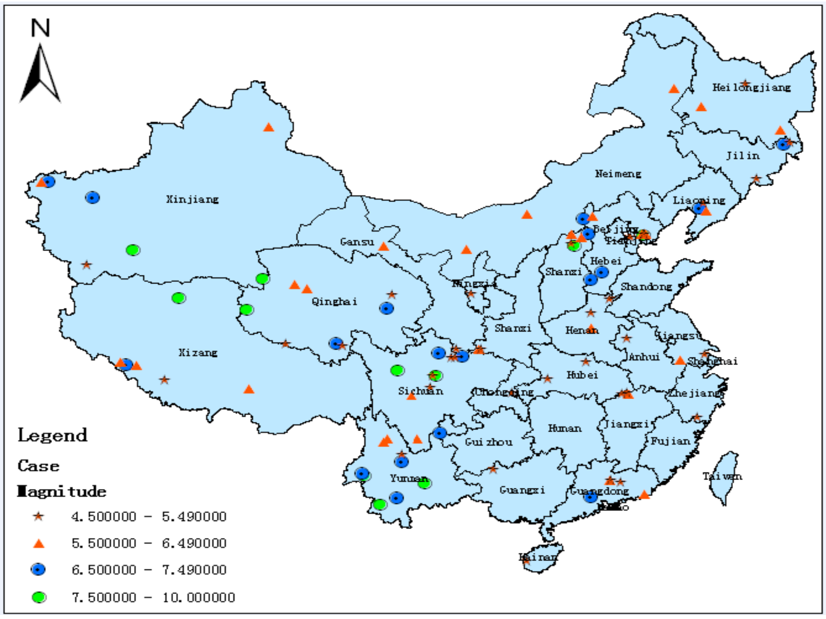

Figure 2. Spatial Distribution Map of Historical Earthquake Cases

Table 1. Number and Region Attributes of Historical Earthquake Cases

Regions	$M_S \geq 7.5$	$6.5 \leq M_S < 7.5$	$5.5 \leq M_S < 6.5$	$4.5 \leq M_S < 5.5$
North-South earthquake zone	√	√	√	√
Tianshan earthquake zone	√	√	√	√
North China region	√	√	√	√
East China region	√	√	√	√
South China region	×	√	√	√
Northeast China region	×	√	√	√
Central China region	×	×	√	√
Tibetan Plateau region	√	√	√	√
Case Number	11	19	28	34

√ means there have earthquake cases in this region.
× means there is no earthquake case in this region.

According to the process of earthquake, these influence factors can be divided into pre-disaster factors, co-disaster factors and post-disaster factors. Pre-disaster factors are mainly related to earthquake prediction. Co-disaster factors are strength parameters of earthquake and states of hazard bearing body. Post-disaster factors describe the emergency rescue condition. According to the features of earthquake influence factors and the stage in the process of earthquake, the top ten important influence factors can be summarized in five categories: (1) Earthquake forecast; (2) Time and strength parameters of earthquake; (3) Social and economic attributes; (4) Secondary disaster; (5) Emergency rescue condition. Factors of some categories like (2), (3) and (5) include subordinate factors.

Each influence factor is also divided into different levels corresponding to the different damage levels of earthquake loss. In the China Earthquake Emergency Plan, earthquake damages are divided into four levels including huge, vast, big and general. Because some earthquakes do not cause death, but cause certain degree damages and economic loss, the present research add a slight earthquake damage level describing the earthquake which has a magnitude less than five and causes a certain economic loss. Therefore, there are five earthquake disaster levels (V_1~V_5) are considered, as shown in Table 2.

Table 2. Classification and Description of Earthquake Damage

Disaster level	Classification	Descriptions
V_1	Slight	No death, a certain degree damage and economic loss
V_2	General	Less than 20 people death and certain economic loss
V_3	Big	20~50 death or larger economic losses
V_4	Vast	50~300 death or major economic losses
V_5	Huge	More than 300 people death, or caused direct economic loss accounted for more than 1% of GDP in the first half of the province

Detailed information of the top ten important influence factors are as follows.

(1) Earthquake forecast F. It is well known that earthquake forecast is important to mitigate earthquake damage. In general, the long term forecast has important directive significance for building and strengthening, and the accurate impending earthquake forecast can greatly reduce death and economic loss [7, 8]. For example, Haicheng earthquake in 1975 and Songpan earthquake in 1976 are successful forecasting examples in China. Although the magnitudes of both Haicheng earthquake and Songpan earthquake are larger than7, their losses were much less than those of other earthquake cases with similar levels.

According to the time of earthquake forecast, F is divided into five levels[9,10]: 1) No forecast, 2) Long term forecast, which gives the potential earthquake risk in a few years before earthquake, 3) Medium-term forecast, which is an earthquake forecast one or two years before earthquake, 4) Short term forecast, which is an earthquake fore cast months before earthquake, 5) Impending earthquake forecast, which is an earthquake forecast hours or days before earthquake.

(2) Time and strength parameters of earthquake Q. Time and strength parameters are basic and significant influence factors of earthquake. It includes three second-stage factors: time (T), magnitude (M_s) and intensity (I_0).

Different occurrence time always causes different loss. Generally, casualties caused by an earthquake occurred in the 00:00-06:00 period are more serious than that occurred in other periods. According to people's sleep/waking and outdoor/indoor activities states, T is divided into five levels: 1) 07:00-09:00 and 17:00-19:00 periods, when people are often on the way to work or home, and in the open outdoors venue; 2) 09:00-12:00 and 14:00-17:00 periods, when people are often working indoors; 3) 12:00-14:00 periods, when people often take a nap indoors in day time; 4) 19:00-22:00 periods, when most people are indoors and some of them have been asleep; 5) 00:00-07:00 and 22:00-24:00 periods, when people always have been in deep sleep, leading to a poor escape consciousness.

Magnitude and intensity are two most important parameters used to measure the strength of an earthquake. Magnitude represents the severity of earthquake, and it’s a description of earthquake energy. Intensity indicates the damage degree of earthquake at various regions in a large area. According to previous research results[11,12] and the classification of China Earthquake Administration (CEA), M_s is divided into five levels in this paper: 1) $M_s< 5$,2) $5\le M_s< 6$, 3) $6\le M_s< 6.5$,4) $6.5\le M_s<7$,5) $M_S\ge 7$.Using the same way can get the five levels classification of I_0:1) $I_0<6$, 2) $I_0=6$, 3) $I_0=7$, 4) $I_0=8$, 5) $I_0\ge 9$.

(3) Social and economic attributes J. Bearing body is the human social subject that is directly affected by earthquake. The density of bearing body determines the

earthquake damage level, which represents how serious the affect caused by an earthquake should be. In the paper, population, buildings and economy, the most three important bearing bodies are considered. Therefore, J includes three second-stage factors: the population density (P), economic density (G) and building type (B_d).

Population density (P) reflects the sparsity of regional population, and the unit of P is person per square kilometer. According to the China statistical yearbook for regional economy in 2014[13], P is divided into five levels: 1) P<50 *person/km*^{2}; 2) 50 *person/km*^{2}≤P<200 *person/km*^{2}; 3) 200 *person/km*^{2}≤P<500 *person/km*^{2}; 4) 500 *person/km*^{2}≤P<1000 *person/km*^{2}; 5) P≥1000 *person/km*^{2}.

Economic density (G) reflects the regional economic level, and the unit of G is ten thousand yuan per square kilometer. G is also divided into five levels:1) G<1000*ten thousand yuan/km*^{2}; 2) 1000 *ten thousand yuan/km*^{2}≤G<3000 *ten thousand yuan/km*^{2}; 3) 3000 *ten thousand yuan/km*^{2}≤G<6000 *ten thousand* yuan/*km*^{2}; 4) 6000 *ten thousand yuan/km*^{2}≤G<9000 *ten thousand yuan/km*^{2}; 5) G≥9000 *ten thousand yuan/km*^{2}.

Given it is hard to get detailed building theme maps, building type (B_d) is regarded as discrete variable in this paper. Type a buildings are reinforced concrete buildings which have excellent seismic performance, and mainly concentrated in developed metropolis. Types B buildings are brick structure buildings which have good seismic performance, and mainly concentrated in general city. Type C and D buildings are those buildings which have poor seismic performance, and mainly concentrated in rural areas.

(4) Secondary disaster D_s. The damage caused by during an earthquake not only has direct influence factors, but also has indirect influence factors. Secondary disaster is the most important indirect influence factors of earthquake. Moreover, the secondary disaster may cause more serious damage than earthquake itself. The mainly secondary disasters [14] are landslides, tsunamis and so on. The distribution and main types of secondary disasters is obtained from China physical geography, China physical geography atlas and regional difference of earthquake emergency in China [15]:Northeast and central regions have slight secondary disasters, and the mainly types are frostbite and floods; Southeast coastal regions have general secondary disasters, and the mainly type is floods; Xinjiang and north regions have moderate secondary disasters, and the mainly type is sand liquefaction; Ganqingning region has strong secondary disasters, and the mainly types are landslides and collapse; Yunchuanzang region has severe secondary disasters, and the mainly types are landslides, mudslides and collapse. Therefore, D_s is divided into five levels corresponding to the five damage levels: slight, general, moderate, strong, severe.

(5) Emergency rescue condition Y. Timely and sufficient emergency rescue preparation is an effective method to reduce the earthquake disaster loss. Y includes two second-stage factors including the traffic condition (T_r) and the medical condition (M).

According to the China statistical yearbook for regional economy in 2014, T_r, whose unit is kilometer per square kilometer, is divided into five levels by analyzing the land area and level highway length:1) T_r≥1.5*km/km*^{2}; 2) 1.0 *km/km*^{2}≤T_r<1.5 *km/km*^{2}; 3) 0.5 *km/km*^{2}≤T_r<1.0 *km/km*^{2};4) 0.1 *km/km*^{2}≤T_r<0.5 *km/km*^{2};5) T_r<0.1 *km/km*^{2}.

M, whose unit is person per ten thousand persons, is divided into five levels by analyzing health workers and the resident population:1) M≥80*person/ten thousand persons*; 2) 70 *person/ten thousand persons*≤M<80 person*/ten thousand persons*; 3) 60 *person/ten thousand persons*≤M<70 *person/ten thousand persons*;4) 50 *person/ten thousand persons*≤M<60 *person/ten thousand persons*; 5) M<50 *person/ten thousand persons*.

In sum, the influence factors of earthquake are divided into five categories including F, Q, J, D_s and Y. These five factors are called main rule layer factors in this paper. In the main rule layer, some factors have subordinate factors. For example, T, M_s and I_0 are subordinate factors of Q; P, G and B_d are subordinate factors of J; D_s and T_r are subordinate factors of Y. The subordinate factors and the main rule layer factors without subordinate factors then constitute the whole sub rule layer. Therefore, F, T, M_s, I_0, P, G, B_d, D_s, T_r and M are the sub rule layer factors. These ten factors are further divided into five levels corresponding to the five damage levels in the analysis. Classification of all influence factors are shown in Table 3.

Table 3. Classification of the Influence Factors

	V_1	V_2	V_3	V_4	V_5
F	impending earthquake forecast	short term forecast	medium-term forecast	long term forecast	no forecast
T	07:00-09:00 17:00-19:00	09:00-12:00 14:00-17:00	12:00-14:00	19:00-22:00	00:00-07:00 22:00-24:00
M_s	M_s< 5	5≤M_s< 6	6≤M_s< 6.5	6.5≤M_s<7	M_S≥7
I_0	I_0<6	I_0=6	I_0=7	I_0=8	I_0≥9
P	P<50	50≤P<200	200≤P<500	500≤P<1000	P≥1000
G	G<1000	1000≤G<3000	3000≤G<6000	6000≤G<9000	G≥9000
B_d	A	AB	B	BC	CD
D_s	slight	general	moderate	strong	Severe
T_r	T_r≥1.5	1.0≤T_r<1.5	0.5≤T_r<1.0	0.1≤T_r<0.5	T_r<0.1
M	M≥80	70≤M<80	60≤M<70	50≤M<60	M<50

As the ten influence factors are not the detailed distribution information, the values of these factors are easy to be obtained even in the undeveloped areas. Factors of F, T, M_s and I_0 can be acquired within several minutes after an earthquake from CEA. Publishing these four earthquake elements is the official job of CEA. Factors of P, G, B_d, T_r and M are the statistical data and can be easily obtained from the China Statistical Yearbook for Regional Economy. The distribution and main types of secondary disasters (D_s) is obtained from China physical geography, China physical geography atlas and regional difference of earthquake emergency in China.

2.3. Determining Weights by AHP

Analytic hierarchy process is a systematized and hierarchical technique of qualitative and quantitative analysis used to deal with complex decisions. It was first developed by Satty in 1970s and has been extensively studied and refined since then [16,17,18]. Generally, AHP method includes three key steps: (1) Constructing the factor set; (2) Building the judgment matrix and calculating the weight set; (3) Checking the consistency. Detailed steps of the proposed AHP procedure of earthquake loss assessment are introduced as follows.

(1) Constructing the factor set

In AHP, dividing factors into multi-layers are more advantageous than using only a signal level, when the weight set is calculated and evaluated. As mentioned above, influence factors of earthquake can be divided into ten influence factors of two levels. The two levels are the main rule layer and the sub rule layer. The influence factors in the main rule layer can be summarized as:

$$U = \{U_1, U_2, U_3, U_4, U_5\} = \{F, Q, J, D_s, Y\} \tag{2}$$

Where U is the factor set of main rule layer. U_i(i=1, 2, 3, 4, 5) means the factor set of sub rule layer and is defined as:

$$\begin{aligned} U_1 &= \{F\} \\ U_2 &= \{T, M_s, I_0\} \\ U_3 &= \{P, G, B_d\} \\ U_4 &= \{D_s\} \\ U_5 &= \{T_r, M\} \end{aligned} \tag{3}$$

(2) Building judgment matrix and calculating the weight set

Judgment matrix is the basis and foundation of calculating the weight set. It can be built through comparing the relative importance of two factors. The judgment matrix can be described as follows:

$$A_{m\times m} = \begin{matrix} & A_1 & A_2 & \cdots & A_m \\ A_1 & 1 & a_{12} & \cdots & a_{1m} \\ A_2 & a_{21} & 1 & \cdots & a_{2m} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_m & a_{m1} & a_{m2} & \cdots & 1 \end{matrix} \tag{4}$$

where a_{ij}(i=1,2,…,m, j=1,2, …,m) is the pair wise relationship between factor $a_i$at the i row and factor a_j at the j column in the same layer, and is used to indicate the relative importance of a_i and a_j.The 1-9 Satty scale[19], as shown in Table 4, is adopted to describe the importance between two influence factors in this research. Additionally, values of 2, 4, 6, 8, 1/2, 1/4, 1/6 and 1/8 are usually used as intermediate values between the two adjacent judgments.

Table 4. Definition of 1-9 Satty Scale

values	Definition
9	A is an extremely more important than B
7	A is a strongly more important than B
5	A is a more important than B
3	A is a little more important than B
1	A is an important as B
1/3	B is a little more important than A
1/5	B is a more important than A
1/7	B is a strongly more important than A
1/9	B is an extremely more important than A

Based on the Satty scale, the judgment matrices of the main rule layer (U) and sub rule layer (U_2, U_3, U_5) was built [Tables 5-8]. As U_1 and U_4 have only one subordinate factor, there are no needs to build judgment matrix.

Table 5. Judgment Matrix of the Main Rule Layer (U)

Influence Factors	F	Q	J	D_s	Y
F	1	1/7	1/6	1/3	2
Q	7	1	2	5	8
J	6	1/2	1	3	5
D_s	3	1/5	1/3	1	3
Y	1/2	1/8	1/5	1/3	1

Table 6. Judgment Matrix of the Time and Strength Layer (U2)

Influence Factors	T	M_S	I_0
T	1	1/5	1/5
M_S	5	1	1
I_0	5	1	1

Table 7. Judgment Matrix of the Social and Economic Layer (U3)

Influence Factors	P	G	B_d
P	1	5	4
G	1/5	1	1/2
B_d	1/4	2	1

Table 8. Judgment Matrix of the Emergency Rescue Condition Layer (U5)

Influence Factors	T_r	M
T_r	1	2
M	1/2	1

Based on AHP theory, influence factors' weight set can be expressed by the feature vector of judgment matrix corresponding to the maximum eigenvalue. For each judgment matrix, the feature vector is calculated, and is assigned as weight se. For example, Table 5 shows the judgment matrix of the main rule layer. According to AHP, the maximum eigenvalue of this judgment matrix is 5.1383, and the corresponding maximum eigenvalue is (0.06 0.48 0.29 0.12 0.05). Therefore, the weight set of U can be set as w= (0.06 0.48 0.29 0.12 0.05). The weight sets of U_2, U_3 and U_5can then be calculated from their judgment matrixes shown in Tables 6-8, and the resulting weight sets are w_2=(0.10 0.45 0.45),w_3=(0.68 0.12 0.20) and w_5= (0.67 0.33).

(3) Checking the consistency

When the dimension of judgment matrix is more than two, the judgment matrix is prone to be inconsistent [20]. Therefore, checking the consistency of the judgment matrix is necessary when calculating the weight set. In AHP, consistency checking index (CI), which means the deviation from consistency, is used to check the consistency of the judgment matrix.

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (5)$$

Where λ_{max} is the maximum eigenvalue of the judgment matrix and n means the dimension of judgment matrix. In general, the closer CI tends to zero, the greater the consistency is. In practice, absolute consistency is often impossible and a relatively satisfactory consistency ratio is used. CR is used to judge the consistency of the judgment matrix.

$$CR = \frac{CI}{RI} \tag{6}$$

Where, RI is the mean random consistency index. It has different values in different dimension of the matrix [19].

Table 9. Values of RI in Different Dimension of the Matrix

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Generally, when CR is less than 0.1, the matrix has satisfactory consistency [21]. Otherwise, a new judgment matrix needed to be rebuilt until CR is less than 0.1. In this research, judgment matrices of U, U_2, U_3, and $U_5$are all have satisfactory consistency ratio, showing the reasonable of the calculated weight sets.

3. Case Study

Three representative earthquake cases were chosen to verify the accuracy of the proposed case matching evaluation model. Factor values of the three representative earthquake cases are shown in table 10. In table 10, values of T, M_s, and I_0 were obtained from official website of China Earthquake Administration. Values of F and D_s were obtained from internet, and values of P, G, B_d, T_r and M were obtained from China statistical yearbook for regional economy and the 1% national population sample survey data.

Table 10. Factor Values of the Sample Earthquakes in the Case Study

Earthquake	F	T	M_s	I_0	P	G	B_d	D_s	T_r	M
Wenchuan2008	long term forecast	14:28	8.0	Ⅺ	10.8	216	CD	severe	0.23	47.1
Yushu2010	long term forecast	7:49	7.1	Ⅸ	1.9	2.1	CD	severe	0.07	69.6
Puer2014	long term forecast	21:49	6.6	Ⅷ	5.5	66.4	CD	severe	0.27	46.4

To match the best similar earthquake case, the evaluation score of experimental earthquake should be obtained first. The evaluation score is calculated by the normalization value of the factors and the weights. For the normalization value of the influence factors, the influence factors should be classified to V_1-V_5 according to table 3. Then use the numerical value 1-5 to normalize the influence factors. For the weights of the influence factors, they have been obtained based on AHP in chapter 2.3. The weight set W can be summarized as:

$$\begin{aligned} W &= (w_f, w_t, w_{m_s}, w_{I_0}, w_p, w_g, w_{b_d}, w_{d_s}, w_{t_r}, w_{m}) \\ &= \begin{pmatrix} 0.06 & 0.05 & 0.22 & 0.22 & 0.20 & 0.03 & 0.06 & 0.12 & 0.03 & 0.01 \end{pmatrix} \end{aligned} \tag{7}$$

Based on the case matching evaluation algorithm, compare the evaluation scores of historical earthquakes and the experimental earthquake, and get the best similar earthquake case and the second similar earthquake case. The evaluation results of the experimental earthquakes based on case matching are shown as follows.

Table 11. Evaluation Results of the Experimental Earthquakes based on Case Matching

Earthquake	The best similar case	The second similar case	Estimated deaths	Disaster level
Wenchuan2008	Tangshan1978	Tonghai1970	Tens of thousands of people death	V_5
Yushu2010	Zhaotong1974	Longling1976	Thousands of people death	V_5
Puer2014	Puer2007	Yaoan2009	Less than 20 death	V_2

The estimated deaths and the disaster level can be generated according to the similar cases. It noted that, Wenchuan2008 earthquake had caused tens of thousands of people death, which was consistent with the actual deaths (69,227 deaths). The evaluation results of Yushu2010 earthquake and the Puer2014 earthquake were all consistent with the actual deaths (2,698 deaths and 5 deaths).

Generally, the strength of an earthquake, such as magnitude and intensity, are used to estimate the disaster level and deaths. However, it is inaccurate in some cases. For example, as the magnitude of Puer2014 earthquake is 6.6, it would be regarded as a disaster of level V3, and would cause 20~50 death or larger economic losses. In fact, the actual death of Puer2014 earthquake is only 5. That is because the population density is small and the seismic performance of Puer city is strong. Overall, the multi-factor based case matching approach is more accurate than single strength assessment after earthquake. It provides useful guidance for the rescue decision-making in the area of incomplete information.

4. Summary and Conclusions

Timely and accurate evaluation of people loss is an effective method for emergency rescue actions in the gold 72 hours after earthquake. A novel rapid loss evaluation method for earthquake based on AHP and case matching was proposed in this paper. The proposed approach can give rapid loss assessment for earthquake based on the similarity theory and historical earthquake cases. As the proposed approach does not need detailed exposure data, it is very suitable for the earthquake loss assessment in the incomplete information region.

Three representative earthquakes were chosen to illustrate and verify the proposed approach. The results show that the experimental evaluation results are in agreement with the actual earthquake damages. By comparing to single strength assessment method, the proposed approach in this paper could get a more accuracy people loss result and can provide emergency disaster information for rescue decision-making timely.

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