A Method of Security Emergency Plan Decision Making by Cloud Model Computing

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Abstract. This paper designed a method of security emergency plan decision making by cloud model computing. This method is made in order to accurately determine security emergency plan in time when safety accident occurred. First, built a index system which is suitable for comprehensive transportation projects. Second, ran a cycle improvement rate according to cloud thickness to get the evaluation indexes and cloud weight, and then put them into the comprehensive formula to get the reference cloud. At last, drew reference cloud and evaluation clouds on a 3D picture by Matlab and compare each evaluation cloud with the reference cloud, the plan which had the finest similarity is the best one. This method can realize visual comparison for safety emergency plans.

1. Introduction

Comprehensive traffic project is a large-scale project composed of two or more kinds of traffic projects, such as expressway, municipal road, urban rail transit and railway. Its safety performance and support capacity have great influence on the unblocked traffic arteries. However, integrated transport projects are faced with many threats, including natural disasters such as earthquake, landslip, mudslide, windstorm, ice and snow freeze, artificial destructions such as incendiary and booming attack, performance degradation and traffic accidents caused by long-term environmental effects and so on. Once the safety accident happens, it is difficult to repair and ensure the safety, which can easily lead to chain disasters or secondary disasters. Therefore, how to make a timely feasible emergency plan when suddenly danger happens with the lack of complete information is an urgent problem to be solved.

Some scholars have carried out research on safety emergency response: Jiang Xin and his group [1] applied AHP method and Order parameter method to study the safety emergency management of hydropower DAMS, Hong hang with his colleagues [2] used the information entropy theory to design an evaluation model of safety emergency plan and used in the field of public emergencies, Zhang Huaqin [3] identified the safety risk sources of the three gorges lock, evaluating the navigation safety accident model by using AHP method, La Juanjuan [4] used AHP method and Euclidean distance method to evaluate the performance of urban safety emergency information system, Ma Qifeiyang et
al. [5] used TOPSIS method to study the problem of setting up decision points for railway emergency rescue, Liu Shixing et al. [6] designed an emergency management system integrating GIS, wireless transmission, wireless communication and other technologies, centering on the public safety issue in Hefei city, Guo Yantao [7] discussed how to apply the Internet of things technology to the safety emergency management of urban rail transit.

Although some achievements have been made in the existing research, the existing scheme evaluation methods are not able to solve the most critical problem of selecting the comprehensive traffic project safety emergency plan, which is how to realize the mutual conversion between qualitative and quantitative description in the case of limited time and insufficient information, in the meantime taking into account the fuzziness and randomness of evaluation, quickly and accurately selecting the best safety emergency plan. In view of this, the author will bring in the cloud model theory, designing a safety emergency plan comparison method in order to solve the above key problems, through Matlab programming to implement the safety emergency plan visualization comparison.

2. Theoretical basis of cloud model
The theoretical basis of cloud model is probability theory and fuzzy mathematics, which was first proposed by Li deyi, academician of Chinese academy of engineering. Its essence is an uncertain reasoning technology, which is a qualitative and quantitative transformation mathematical model of uncertain knowledge composed of specific structural algorithm [8]. The cloud model incorporates randomness on the basis of fuzziness, which is the core of Traditional fuzzy set theory, achieving the compatibility and free conversion of both qualitative concept and quantitative data.

2.1. Cloud model concepts and digital features
Let a certain qualitative concept be \( A \), a certain one-dimensional or multidimensional domain that can be expressed by specific values be \( U \). \( A \) implies a certain qualitative concept on \( U \), and \( x \) is a certain element in \( U \). Then there must be \( y = \mu_A(x) \) to represent the degree to which \( x \) describes \( A \).

Therefore, the cloud model is defined as the distribution of \( x \) on \( U \).

Expectation (Ex), Entropy (En) and Hyper Entropy (He) are used to represent the digital characteristics of both fuzziness and randomness of cloud model, which reflects the overall quantitative characteristics of the qualitative concept \( A \). Ex is the point in the number domain space that can represent the stereotype concept \( A \), corresponding to the center of the cloud. En is used to comprehensively measure the randomness and fuzziness of qualitative concept \( A \). He is related to fuzziness and randomness simultaneously, used to express uncertainty of En, which can be simply understood as the entropy of En. When Ex is fixed, the smaller the En value is, the smaller the cloud droplet group range is, meanwhile the smaller He is, the smaller the dispersion of cloud droplet group is. In other words, Ex reflects the stability of the cloud model, En reflects the change span of the cloud model, and He represents the instability degree of En [9].

2.2. Cloud generator
Cloud generator is the core application algorithm of cloud model, which can achieve the mutual transformation between qualitative and quantitative, and is easy to be programmed and calculated. Cloud generators include forward cloud generators and reverse cloud generators [9]. Forward cloud generator can transform the qualitative language value and its quantitative expression indeterminately, which is the most effective when expressing natural language atoms. Forward cloud generator is used to produce qualified Cloud-Drop \((x, \mu_A(x))\) by the digital features of cloud model, then \( N \) cloud droplets form the cloud model together. Its role is to restore the digital characteristics (Ex, En, He) of
the cloud model based on the given data, and then complete the conversion to $A^0$. The operation mechanism of cloud generator is shown in figure 1.

![Figure 1. Mechanism of forward and backward cloud generator.](image)

3. Comparison method of security emergency plan based on cloud model

Here we are going to study an example, which is a comprehensive transportation project causing catastrophic risks, taking place in a city. This comprehensive transportation project consists of three parts: the upper expressway viaduct, the lower railway dedicated line and the municipal road, with very complex structure and large traffic flow. It's 23:55 p.m. on a day, part of the expressway viaduct of this project suddenly collapsed, and part of the bridge deck fractured and fell to the lower layer as a whole. Many heavy trucks and cars driving on the bridge fell down with the bridge, with one of the tankers caught fire and exploded, cutting off the lower rail sidings and municipal roads. The city's traffic safety emergency headquarters was alerted to the situation and acted immediately. On the basis of identifying dangerous situations and integrating the known information, the multi-department joint meeting was held quickly, five safety emergency response plans are drawn up for comparison and selection.

- **Plan A**: At first, fire trucks drive from the viaduct into the site of the fire, other rescue vehicles' driving routes will not be decided until the fire is under control.
- **Plan B**: Railway authorities dispatch railway rescue vehicles, fire and other rescue vehicles divided into three, respectively driving from the urban railway line, viaduct and lower municipal road into the site of rescue.
- **Plan C**: Fire and rescue vehicles from the viaduct and municipal road respectively drive into the site of rescue.
- **Plan D**: Fire and rescue vehicles drive from the lower municipal road into the site at the same time to rescue.
- **Plan E**: While the fire engines were putting out the fire, allocate two 30t class engineering rescue robots from outside the city.

The scheme comparison method is as follows: firstly, construct the evaluation index system of comprehensive traffic project safety emergency plan, secondly, ask the expert group to make a preliminary evaluation index and substitute the evaluation results into the reverse and forward cloud generators to generate a preliminary evaluation cloud, observe the initial evaluation of cloud thickness and dispersion of cloud droplets to determine whether cyclic improvement scores were needed, substitute the optimized index evaluation cloud and weight cloud into the formula to obtain the comprehensive cloud of each scheme, finally, make similarity comparison with the evaluation cloud of available safety emergency rescue plans and reference cloud. The best scheme is the one with the highest similarity with the reference cloud. The specific process is shown in figure 2.
3.1. Construction of safety emergency plan evaluation index system
Due to the particularity of the comprehensive traffic project, once a major safety hazard occurs, the site situation is particularly complex, involving many influencing factors, which requires us in the decision-making process of the safety emergency plan, not to care about one thing and lose the other, but to make an overall plan and comprehensively consider the key influencing factors. On the basis of literature and case studies [10], relevant institutions are combined, such as government construction management institutions, safety supervision institutions, fire departments, project investment and financing side, design institute, construction enterprises and other units of the safety management personnel, experts from universities, interviewing research institutes, taking advice to improve itself. Finally, the evaluation index system of comprehensive traffic project safety emergency response scheme is constructed, which is listing in table 1.

3.2. Determine the indicators to evaluate the cloud
Indicator evaluation cloud is determined by expert consulting method [11]. It is difficult to quantify the index evaluation value of safety emergency plan, so qualitative language is chosen to describe it. The advantage of it is that it can give consideration to the fuzziness and randomness of indicators, accurately reflecting the expert cognition, and the evaluation conclusion is more accurate. Indicator evaluation cloud is divided on a semantic scale of 7: super poor, very poor, poor, average, good, very good, and super good.

Comments on bilateral constraints with upper and lower limits, Number field is $[F_{\min}, F_{\max}]$, according to the following equation [11].

![Flow chart of safety plan comparison based on cloud model.](image)

**Figure 2.** Flow chart of safety plan comparison based on cloud model.

| No. | Index name                                           |
|-----|-----------------------------------------------------|
| C1  | Feasibility of safety emergency plan                |
| C2  | Effectiveness of safety emergency plan              |
| C3  | Safety emergency plan personnel requirements       |
| C4  | Ability to respond to risks with safety emergency plan |
| C5  | Contingency capacity of safety emergency plan       |
| C6  | Multi-department coordination ability of safety emergency plan |
| C7  | Social influence of safety emergency plan           |
$$E_i = \frac{F_i \max - F_i \min}{6}, \quad H_i = k$$  \hspace{1cm} (1)

$k$ is adjusted according to the degree of semantic ambiguity of qualitative language.

Let’s draw corresponding cloud maps of different levels of qualitative languages according to language habits: super poor($0, 0.045, 0.003$), very poor($0.29, 0.055, 0.003$), poor($0.39, 0.083, 0.003$), average($0.55, 0.076, 0.003$), good($0.7, 0.081, 0.003$), very good($0.86, 0.084, 0.003$), super good($1, 0.08, 0.003$), which is showing in figure 3.

Figure 3. Risk assessment standard cloud.

Inviting 7 experts from universities, government construction and management institutions, safety supervision institutions, fire departments, large engineering enterprises, medical institutions and other units to form the expert group, using $\left( B_1, B_2, ... B_7 \right)$ to represent them, who evaluated each of the seven indicators of the five proposed safety contingency plans. Indicators are showing as $\left( C_1, C_2, ... C_7 \right)$. $\left( B_i \left( C_i \right) \right)$ represents the evaluation value of the indicator $i$ by the $j$ expert, $i = 1, 2, ..., 7$; $j = 1, 2, ..., 7$. The evaluation results are shown in table 2. The evaluation value is represented by Ex value, due to space limitation, scheme 1 is taken as an example.

Table 2. Evaluation value of safety emergency disposal plan.

| Expert | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
|--------|-------|-------|-------|-------|-------|-------|-------|
| B1     | 0.78  | 0.52  | 0.16  | 0.68  | 0.65  | 0.68  | 0.52  |
| B2     | 0.85  | 0.33  | 0.19  | 0.52  | 0.21  | 1    | 0.68  |
| B3     | 0.53  | 0.52  | 0.17  | 0.52  | 0.29  | 0.85  | 0.52  |
| B4     | 0.63  | 0.68  | 0.15  | 0.68  | 0.18  | 0.68  | 0.52  |
| B5     | 0.52  | 0.52  | 0.65  | 0.33  | 0.03  | 0.85  | 0.68  |
| B6     | 0.78  | 0.33  | 0.74  | 0.68  | 0.17  | 0.85  | 0.68  |
| B7     | 0.83  | 0.52  | 0.33  | 0.68  | 0.15  | 0.68  | 0.52  |

Input the evaluation value of indicator $C_m$ into the inverse cloud generator to obtain $(\text{Ex}, \text{En}, \text{He})$, then substitute the data into the positive cloud generator to get the cloud map. Observe whether the cloud thickness is too large and the cloud droplets diverge, the more serious this phenomenon is, the more inconsistent expert group members’ views on $C_m$ are. Traditional evaluation methods will ignore
the cognitive differences among experts and directly calculate an evaluation value, and the few opinions cannot be reflected in the evaluation results. For an information system, any information is valuable, not to mention the condition that few opinions are likely to be correct. If the information can be fed back to the expert group for rediscussion, the opinions will be more consistent and the evaluation results will be more accurate. The author now designs a method to score according to the cycle of cloud thickness. If the evaluation cloud thickness is too large, the information will be fed back to the expert group for rediscussion and a new round of evaluation. Repeat this process until the cloud thickness meets the requirements, then the evaluation result is the optimal index to evaluate the cloud. Take indicators from the first contingency plan as an example, experts rated the safety emergency feasibility $U(C_i(B_j))$ are (0.17, 0.83, 0.32, 0.43, 0.55, 0.16, 0.36, 0.16, 0.43), the numerical characteristics obtained by substituting the former into the inverse cloud generator formula are (0.269, 0.139, 0.022), then the evaluation cloud of $C_i$ is obtained by substituting into the positive cloud generator, which is shown in figure 4a.

![Figure 4. Plan 1 feasibility of the emergency (C1) marking cloud.](image)

From the observation of figure 4a, it can be seen that the cloud thickness is too large and the dispersion of cloud droplets is very strong, indicating that the evaluation cognition of expert group members on indicators is quite different, and the evaluation cloud cannot fully reflect the information of indicators $C_i$, thus losing the evaluation significance. The scoring result and cloud map will be fed back to the expert group for re-scoring after discussion. After discussion, the expert group scored again and got the evaluation cloud map 4b. It was observed that cloud thickness was significantly improved, indicating that the expert group had reached a consensus. Repeat this process, gradually improving the differences between experts, until finally a satisfactory cloud map is obtained. After five rounds of scoring, the indicator $C_i$ and Evaluation of cloud $S_j$ given by the expert group are shown in figure 4c. As we can see the cloud thickness is already ideal, the remaining indicators are evaluated by the above method.

3.3. Determine the index weight cloud
Index weight is an important part of solution evaluation cloud, which is determined by combining subjective method with objective method. Objective methods are used to determine the indicators that meet the conditions of quantitative analysis, while other indicators are determined by subjective methods. In the subjective method, the importance of weights is usually described in terms of level 4–6 semantics. Considering the complexity of the evaluation index of comprehensive traffic project safety...
emergency plan, the author chooses the 6-level semantic to measure the weight set of the index \( W = \{ w_{c1}, w_{c2}, \ldots, w_{cm} \} \). Since the information is not complete, it is difficult to give the exact weight value, so the experts are allowed to make fuzzy evaluation to reduce the decision-making pressure. The 6 levels of qualitative language are: not important, less important, slightly important, important, more important and very important, and the number range is \([0,1]\). The numerical intervals of all levels of semantics are shown in table 3.

| Grade          | Not important | Less important | Slightly important | Important | More important | Very important |
|----------------|---------------|----------------|--------------------|-----------|----------------|----------------|
| Value range    | 0-0.09        | 0.083-0.302    | 0.272-0.506        | 0.469-0.702 | 0.674-0.916 | 0.88-1         |

    | Ex | En  | He  |
|----|-----|-----|
| 0  | 0.045 | 0.004 |
| 0.198 | 0.045 | 0.004 |
| 0.392 | 0.045 | 0.004 |
| 0.593 | 0.045 | 0.004 |
| 0.798 | 0.045 | 0.004 |
| 1  | 0.045 | 0.004 |

The data corresponding to expert rating are substituted into the reverse cloud generator to obtain the digital features of the cloud \((Ex, En, He)\), then input them into the forward cloud generator formula to obtain the cloud graph of risk index weight, as shown in figure 5.

The expert group members conducted weight evaluation according to the above methods, obtaining the weight cloud \( W_i \) of seven evaluation indexes of comprehensive transportation project safety. The score sheet and cloud chart are omitted for space reasons.

### 3.4. Determine emergency safety plan

Substitute the index evaluation cloud \( S_i \) and weight cloud \( W_i \) of each scheme into equation (2), then can obtain the evaluation cloud of each scheme for comparison with reference cloud \([9, 10]\).

\[
A_i = \frac{\sum_{j=1}^{m} S_j W_j}{\sum_{j=1}^{m} W_j}
\]
The index evaluation cloud and weight cloud of the five safety emergency disposal plans to be selected have been calculated in III. B and III. C respectively. Directly substitute them into equation (2) can obtain the evaluation cloud $A_i$ of each scheme. The reference cloud is evaluated from the ideal optimal safety emergency plan. The seven evaluation indexes of the ideal optimal scheme are all pretty good, which often do not exist in reality, and are only used as comparison reference. The similarity between the evaluation cloud map of each scheme and the reference cloud is compared one by one, and the visual 3D comparison chart can be obtained by Matlab programming, as shown in figure 6.

![Figure 6. Clouds of safety evaluation plan compared with the reference cloud.](image)

From the observation of figure 6, it can be seen that scheme 5 analyzed above has the longest distance between the evaluation cloud and the reference cloud and is the worst scheme, which is consistent with the evaluation data given by the expert group in table 2. The evaluation cloud of scheme 1 is the closest to the reference cloud. After program calculation, it is confirmed that it has the highest similarity with the reference cloud and is selected as the best safety emergency plan.

Combined with the detailed analysis of the comprehensive traffic project safety emergency plan evaluation index system, plan 1 has the following characteristics:

1. Compared with the other four schemes, this safety emergency plan has the strongest timeliness and feasibility. These two points are the most critical factors to be considered in the comprehensive traffic project safety emergency disposal.
2. Plan 1 also gives consideration to the ability to cope with risks and the to adapt to changes. These two indexes can ensure the smooth progress of safety emergency response and calmly face complex and changeable field conditions. To change the default, adjust the template as follows.
3. Plan 1 has a good social impact, and good timeliness and feasibility can establish a positive image in the public’s mind.
4. The disadvantages of plan 1 are large demand for personnel and weak coordination ability of multiple departments, which need to be improved by strengthening personnel and collaborative security emergency drill among multiple departments and improving inter-department information system construction, etc. However, the influence of this shortcoming on the plan is controllable and can be overcome by strengthening command and other measures.

To sum up, plan 1 has the best feasibility among the five alternatives.

If the traditional method is adopted for comparison of safety emergency plans, the first round of scoring of the expert group will be regarded as the final conclusion, different opinions will be ignored by the evaluation result, affecting the accuracy of comparison. Once the safety accident happens in the
comprehensive transportation project, the decision-making time is very urgent, key information is hard to complete. However, the traditional method cannot realize the conversion between qualitative and quantitative description, furthermore greatly influence the comparison results. These problems exactly illustrate the advantages of the cloud model approach.

4. Conclusion
Through the innovation of cloud model theory and its application in the comparison and selection of comprehensive traffic project safety emergency plan, the following conclusions are obtained:

(1) The cloud model theory is applied to solve the problem of conversion between qualitative and quantitative languages in the process of scheme comparison under the circumstances of limited time and insufficient information.

(2) A set of cycle improved scoring method based on cloud thickness is designed to solve the defect of traditional safety emergency plan comparison method, that is, a few experts with correct views are ignored by the evaluation results.

(3) Matlab programming was used to realize the operation of relevant models and algorithms, giving full play to the advantages of computer intelligent decision-making, and realizing the 3D visualization comparison of comprehensive traffic project safety emergency plan.

(4) In the follow-up research, the indexes suitable for determining weights by objective methods will be further discussed.

Acknowledgments
This work was financially supported by 19CZZX02 SCTUJ1710 SCTUJ1810 and 17CZZX01 fund.

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