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Research on Community Fire Risk Monitoring Technology Based on GIS

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Abstract: *In recent years, with the preliminary construction of a well-off society, a series of fire safety problems in urban communities have gradually attracted wide attention. Community fire accidents have the characteristics of noticeable series effects, numerous combustibles, and too complex electrical lines. Therefore, fire safety departments have also highly valued this problem with the continuous occurrence of accidents. However, the current measures can only start from the prevention, and there are not many countermeasures for emergency rescue and monitoring and early warning. Therefore, based on the above background, this paper summarizes a Community Fire Risk Assessment System after an in-depth study by analyzing the classic community fire accidents in China and abroad in recent years. On this basis, the Community Fire Risk Assessment Model is transformed into a computer programming language, and the risk assessment management of fixed-point positioning and orientation of community fire in cities is realized based on GIS global geographic information technology. On this basis, the Community Fire Emergency Rescue Decision System based on GIS is developed and designed, and the calculation of the alarm path is optimized.*

Keywords: *GIS; Fire-safety; Risk monitoring technology*

1. Introduction

With the rapid progress of urbanization in our country, communities continue to carry out the process of centralized promotion. Many fire-safety issues in urban communities have gradually received widespread attention in this process. [1] Community fire accidents have the characteristics of apparent series effects, numerous combustibles, and over-complex electrical circuits. Therefore, with the continuous occurrence of accidents, this issue has also received significant attention from the fire safety department. However, the current measures can be obtained from the prevention, and there are not many response measures for emergency rescue and monitoring and early warning.

This paper analyzes the classic community fire accidents at home and abroad in recent years, and after in-depth research, summarizes a set of Community Fire Risk Assessment Systems. On this basis, the Community Fire Risk Assessment Model is transformed into a computer programming language based on GIS global geographic information technology. Realize the risk assessment and management of the fixed-point orientation of the city fire risk. [2] On this basis, develop and design a GIS-based Community Fire Emergency Rescue Decision-making System, and optimize the calculation of the alarm route.

2. Summary of the Research Status of Fire Emergency Rescue Decision-making.

2.1 The Status Quo of Domestic Fire Assessment System.

The following researches have been conducted on fire risk assessment in communities in China:

(1)The establishment of a Community Fire Risk Assessment Index System is achieved by systematically measuring the fire risk of urban communities.

(2)Through systematic and quantitative evaluation and calculation of fire risk in urban communities, we can study fire's specific causes and frequency.

(3)Study on Systematic Risk Coefficient Evaluation of Urban Community Fire Risk

(4)Analysis of Emergency Measures and Rescue for Community Fire Risk in Urban Areas

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(5)The overall evaluation system of fire risk is formulated.

2.2 Present Situation of Foreign Fire Assessment System

The establishment of a foreign fire assessment system has been carried out since the industrial revolution. At that time, the relevant assessment was mainly carried out for the occurrence of fire accidents on electrical lines, and the appropriate supervision and maintenance were primarily carried out for the equipment of factories and enterprises. [3] On this basis, Dow Chemical Company of the United States sorted out and improved the primary fire risk assessment and response measures of the factories and introduced the first fire risk assessment methods in the world. On this basis, through continuous improvement, later generations formed today's fire assessment system.

3. Establishment of Community Fire Risk Assessment Index

3.1 Principles and Theoretical Basis of Establishing Evaluation Index

The establishment of a Community Fire Risk Assessment Index needs to be based on the division of urban communities. The division is based on the area of the community, uniform city size, and the risk areas of various abnormal types ， it should be covered as far as possible to carry out practical urban fire management guidance and arrange relevant personnel to carry out work through the local fire department. [4]

The theoretical basis of community fire risk assessment indicators originated from the ' Fire Safety Concept Tree Guide ' published by the American Fire Safety Association for local intensive industrial areas. The theory puts forward a complete set of measures for community fire risk prevention, including the isolation measures for fire combustibles, the control of fire sources, a series of measures for controlling the spread of fire, and so on. As the core object of fire prevention, community residential buildings should be combined with the dense population and the characteristics of the group to establish a targeted risk index evaluation system.

3.2 System and Weight of Evaluation Index

Many factors cause fire accidents, and the combination of these factors is the leading cause of the fire. Therefore, it is necessary to carefully consider and evaluate these indicators, on this basis, the index set, to determine the five first-level indicators as the basis for establishing the evaluation index system. The above urban Community Fire Risk Evaluation Index System is shown in Figure 1.

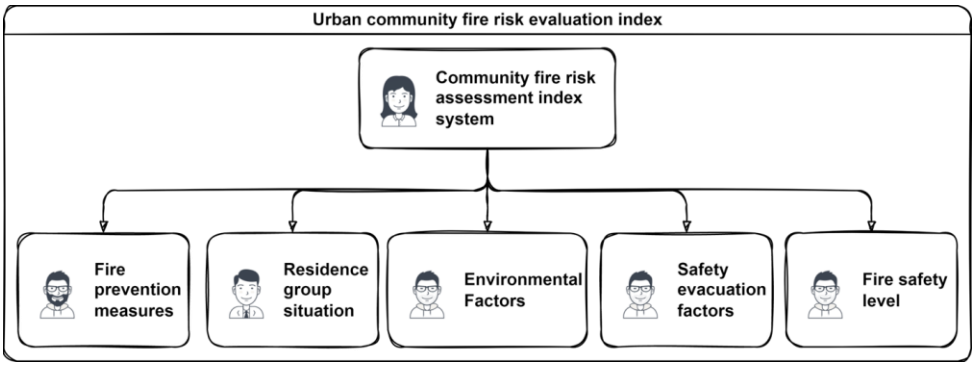

Fig. 1 Urban Community Fire Risk Evaluation Index System

The weight of the evaluation index mainly depends on the analytic hierarchy process to screen the main and secondary factors. On this basis, it is further verified by an expert investigation.[5] The main implementation methods of expert analysis are as follows:

First, we need to determine the risk factor weight coefficient c_i questionnaire of fire risk evaluation index, where c_{ij} is the importance coefficient of the j -th expert to impact factor m_i , need gratification $\sum_{i=1}^{n} c_{ij} = 1$.

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Then organize the fire factor coefficient obtained by the expert investigation method. $\sum_{j=1}^{m} j$ is the statistical value of the importance coefficient of the influence factor of the j -th expert. According to the mathematical formula, the importance coefficient is expressed as:

$$c_i = \frac{\sum_{j=1}^{m} c_{ij}}{\sum_{j=1}^{m}\sum_{i=1}^{n} c_{ij}} \quad (1)$$

Then by calculating the factor weight set, the $C = (c_1, c_2, \cdots, c_n)$. The above calculation can be summed up in the Fire Risk Factors Importance Table to represent its weight and distribution system.

4. Establishment of Community Fire Risk Assessment Model

4.1 Community Fire Risk Assessment Model Based on Grey Correlation Theory

4.1.1 The Technical Route of Grey Correlation Theory

Grey correlation theory belongs to multi-correlation factor degree methods in many analysis systems. It belongs to the classical method proposed in the eighties of the last century. It mainly uses the uncertainty related to analyzing the state of multiple objects with multi-factors and determines the correlation degree. [6] In this study, the fire risk assessment results are sorted by the correlation degree to determine the fire risk level linked to the regional level.

4.1.2 Processing Strategy of Grey Correlation Method

The processing strategy of the grey correlation method is as follows:

1) Determine the evaluation data: Assuming that there are n buildings in the community, are residential structures, the specific process of the indicators are as follows:

$$\begin{aligned} X_1 &= \{x_1(1), x_1(2), \ldots, x_1(20)\} \\ X_2 &= \{x_2(1), x_2(2), \ldots, x_2(20)\} \\ &\cdot \\ &\cdot \\ X_n &= \{x_n(1), x_n(2), \ldots, x_n(20)\} \end{aligned} \quad (2)$$

2) Initialization data: the qualitative indicators are quantified and then normalized. The specific model is as follows:

$$X_i^n(k) = \frac{x_i(k) - \operatorname{Min} x_i(k)}{\operatorname{Max} x_i(k) - \operatorname{Min} x_i(k)} \quad (3)$$

quorum $k = 1, 2, \cdots, 20; i = 1, 2, \cdots, n_0$.

3) Standard data sequence arrangement: By arranging the maximum values of each common data as follows:

$$x = \{x(1), x(2), \ldots, x(20)\} \quad (4)$$

4) Grey correlation coefficient calculation: Grey correlation coefficient is to associate two sorts. The grey correlation coefficient of the corresponding evaluation index data $\gamma_{0,i}(k)$ in the data sequence of the fire risk assessment results and the index data $x(k)$ in the standard data sequence is shown as:

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$$\gamma_{0,i}(k)=\frac{\mathrm{Min}_i\,\mathrm{Min}_k\left|x(k)-X_i(k)\right|+\xi\times\mathrm{Max}_i\,\mathrm{Max}_k\left|x(k)-X_i(k)\right|}{\left|x(k)-X_i^{(k)}\right|+\xi\times\mathrm{Max}_i\,\mathrm{Max}_k\left|x(k)-X_i'(k)\right|} \tag{5}$$

In the upper style, $\left|x(k)-X_i^*(k)\right|=X_i(k),\mathrm{Min}_k\left|x(k)-X_i^*(k)\right|$ is the difference value of the first level Min, $\mathrm{Min}_i\,\mathrm{Min}_k\left|x(k)-X_i^*(k)\right|$ is the difference value of the second level Min, and $\mathrm{Max}_i\,\mathrm{Max}_k\,|\,x(k)-X_i^*(k)$ is the difference value of the second level Max, ξ is resolution coefficient, empirical value 0.5

5) Calculation of grey correlation degree: evaluation index corresponds to the grey correlation coefficient. [7] The correlation coefficient of the risk assessment data needs to be weighed and calculated as γ_i:

$$\gamma_i=\frac{1}{20}\sum_{k=1}^{20}w_i\gamma_{0,i}(k) \tag{6}$$

6) Classification of evaluation indexes: according to different types of risk, events are arranged according to zero risk, slight risk, medium risk, and high risk.

The flow chart of the above process is shown in Fig. 2.

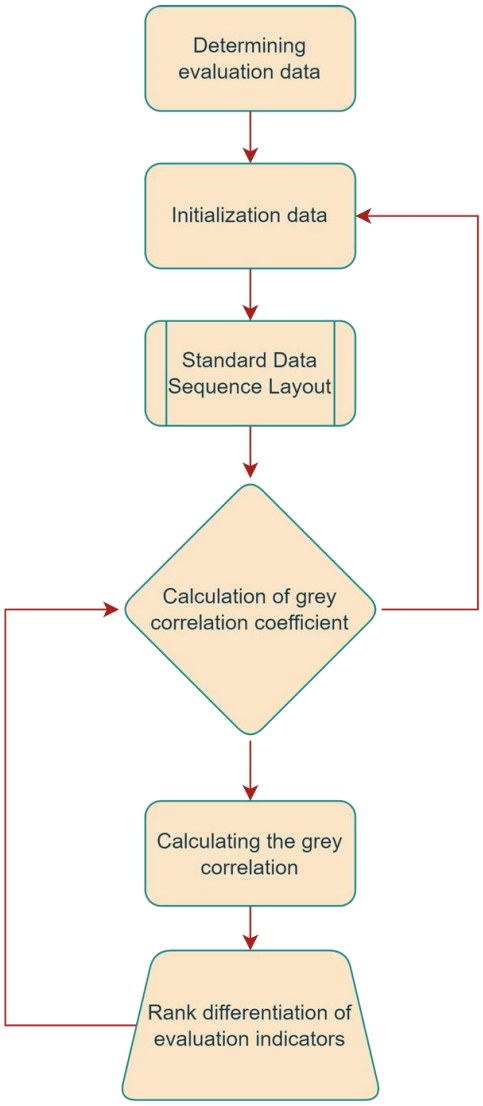

Fig 2 The Flow Chart of Grey Relation Processing Strategy

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4.2 Rescue Path Planning Based on Dijkstra Algorithm

4.2.1 Algorithm Logic of Digerstra Algorithm

First, assume that there are no edges with negative weights in a graph

$$G = (V, E) \tag{7}$$

The above formula takes a set of vertices in a weighted directed graph V , Divided into two groups. The first set of vertices S is the calculated shortest path set. Calculating the first set of vertices S from the source V , from another vertex set, added U to the first set of vertex set S , the repeated calculation to set U all vertices added to the first set of vertex set S ; The set vertex U of the second group is sequentially added to the set S of the first group of vertices by the shortest path length, and the order is an increasing sequence. The condition for the second set of vertices U to be added to the first set S is that the shortest path length from the source point S to the set S is not greater than that from the source point V to each vertex in the set U . Distance S is the path of the distance set of each vertex. The vertex's distance in the first set of vertex sets S is the shortest path length from V this vertex. The vertex's distance in the second group of vertex set U is the shortest path length S_{uur} from the source point v to this vertex includes the vertex S as the intermediate vertex. Then, the paths corresponding to the vertices and new source points V in the second set U are continuously calculated, and the above calculation is repeated until the vertex deviates.

The logic of the Dijsterla algorithm is shown in Figure 3.

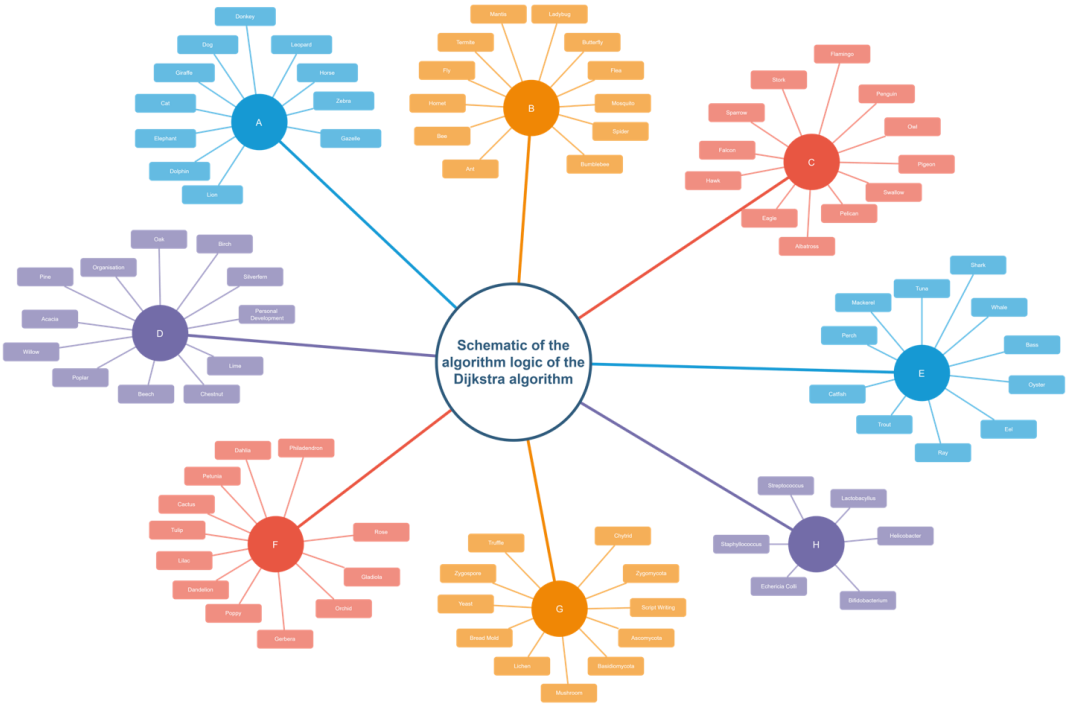

Figure 3 The Agorithm Lgic of Digesstra Agorithm

4.2.2 Rescue Path Planning Strategy

Rescue path planning optimizes the process by continually comparing sets. [8] By synthesizing more than ten indicators, the expert survey method evaluates the implementation, reaches the weight size, and determines the optimal route.

5. Conclusion

After an in-depth study, this paper summarizes a Community Fire Risk Assessment System Set by analyzing recent years of classic community fire accidents in China and abroad. On this basis, the

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Community Fire Risk Assessment Model is transformed into a computer programming language. Based on GIS global geographic information technology, the risk assessment management of fixed-point orientation of community fire in cities is realized. On this basis, the Community Fire Emergency Rescue Decision-making System based on GIS is developed and designed, and the alarm path is optimized.

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