Design of integrated management and control system for geological disasters of transmission lines based on GIS

Liu Dan-dan*, Hu Wei¹, Zhao Jian¹, You Po Yu¹, and Zhao Ping¹

¹Guizhou Electric Power Design Research Institute Co., Ltd., Power Construction Corporation of China, Guiyang 550002, China
* Corresponding author: liu_dan-dan@foxmail.com

Abstract. The geological environment of Guizhou Province is fragile, which is one of the most serious geological disaster areas in China. Frequent geological disasters have seriously affected the safe and stable operation of domestic transmission lines. At the same time, it has the system of detection, decision-making and security protection, which is still blank. Therefore, this paper uses database technology and GIS technology, first of all, clean up and integrate the data of transmission line, major geological disasters and hydrometeorology to establish a comprehensive database of transmission line geological disasters. Then, the risk assessment model of major geological disasters of transmission lines is established to extract the risk level information of major geological disasters of transmission lines and formulate differentiated operation and maintenance strategies. Finally, the integrated management and control system of transmission line geological disasters is designed to realize intelligent detection and decision-making of geological disasters, so as to prevent and reduce the losses caused by geological disasters and ensure the safe operation of power energy.

1. Introduction

Guizhou belongs to the mountainous area of Yunnan Guizhou Plateau, where the topography fluctuates greatly, rivers are cut strongly, rainstorms are concentrated, the geological and geographical conditions are special, and the geological environment is fragile. In addition, the serious destruction of natural vegetation by human activities and the extensive transformation of surface slopes and the movement of rock and soil lead to the development of collapses, landslides and debris flows, with large distribution density and frequent activities. Therefore, Guizhou is one of the most serious geological disasters in China [1-3]. According to the analysis and research results of geological disaster survey data of 88 counties (cities) in Guizhou Province, by the end of 2019, 10833 potential geological disaster spots have been identified in Guizhou Province, 469 lines affected by geological disaster images have been shut down, 30 substations of 110kV and below have been shut down, more than 5000 times of emergency repair have been dispatched, and the potential economic loss is about 4 billion yuan [4-5]. In this context, geological disasters have been paid more and more attention by the government, power grid and other relevant departments and enterprises, and the distribution, risk assessment and protection measures of major transmission line disasters are not perfect. At the same time, the system with the integration of physical examination, treatment and security is still blank. It can not quickly and timely understand the spatial distribution and impact of geological disasters, which has caused a serious threat to the safe operation of transmission lines and brought great pressure to the normal inspection management. Therefore, by using GIS with strong spatial analysis ability, comprehensively combing and evaluating the risk level of major geological disasters of transmission lines in Guizhou Province, and establishing
a database and management and control system, we can discover the geological hazards of transmission lines in advance, make automatic differential operation and maintenance strategies, and quickly analyze and evaluate the risk level. It provides scientific basis and technical reserves for the effective prevention of transmission lines geological disaster risk and the control of geological disasters in Guizhou Province.

2. Methods
This paper intends to design an integrated management and control system of transmission line disaster based on GIS by combining theoretical research with practical application. First of all, combined with the comprehensive data of transmission lines and major geological disasters in Guizhou Province, the risk assessment model of major geological disasters of transmission lines is established to extract the risk level information of major geological disasters of transmission lines and formulate differentiated operation and maintenance strategies. Then, an integrated management and control system of transmission line geological disasters is developed, which includes data management, aggregation, analysis and service, the overall technical route is shown in Figure 1.

3. Research on comprehensive data cleaning and fusion of transmission lines and major geological disasters
Based on GIS software, it realizes the vectorization of multi-source heterogeneous data such as landslide, collapse, collapse, ground fissure, unstable slope, debris flow and other major geological disaster grade data, meteorological data, hydrological data, geological data, and transmission line hidden danger statistical data in Guizhou Province. By using distributed processing technology and database technology, multi-source heterogeneous data are cleaned and integrated into the same geospatial framework through format conversion, coordinate conversion, spatial registration, fusion cleaning, topology modification and other processes, forming a comprehensive database of major geological disasters (Fig. 2).
4. Study on risk assessment model of transmission line

Based on the grade information of various major geological disasters, considering the existing risk factors of geological disasters, such as hidden trouble, geological conditions, hydrological and meteorological conditions, the risk factors [9-10] are selected by using the methods of correlation analysis and statistical analysis. At the same time, according to the influence of risk factors on transmission lines, the parameters and weights of risk factors are determined. Using a certain mathematical model, the risk assessment model of major disasters on transmission lines is established [11].

4.1 Risk factors of geological disasters induced by database establishment

On the basis of historical data analysis and field observation, the relationship between transmission line risk and existing fault hidden danger, geological conditions, various major geological disaster levels, hydrological and meteorological conditions in Guizhou Province is analyzed. Comprehensive application of correlation analysis, statistical analysis and other methods, the key risk factors of geological disasters under different geological environment conditions are obtained. According to the previous research results, the main risk factors of transmission line major geological disasters are the number of transmission line fault hidden danger, the transmission line affected level, the basic properties of rock strata, the basic properties of strata, the distance from the water system area, rainfall time, rainfall intensity, the distance from the rainfall center and the prediction level of geological disasters.

4.2 Research on parameter value determination and weight selection of risk factors

4.2.1 Study on the determination of risk factor parameters

The method of determining the parameter value of risk factors: for the determined parameter factors, such as rainfall intensity, landslide, collapse, ground fissure, unstable slope, debris flow and other disaster levels, as well as the number of transmission line hidden dangers, the parameter value is determined by normalization processing according to the statistical data. For quantifiable factors, such as the distance between large-scale water system and rainfall center and transmission line, the parameter value can be determined by normalization according to the analysis of the relationship between transmission line and disaster safety. For the factors that cannot be quantified, the parameter values are determined based on experts and existing research results.
4.2.2 Research on risk factor weight selection
Due to the different contribution of each risk factor to the geological stability of transmission lines, different risk factors have different weights $\Pi$. The weight calculation method is as follows: firstly, the risk factors are ranked from small to large according to their different importance to the geological stability of transmission lines. Secondly, determine the importance degree $V_{i+1,i}$ of each influencing factor, expressed by multiple, where $V_{1,0}=1$. Finally, calculate the weight of each influencing factor according to the formula:

$$\Pi_i = U_1 \prod_{i=2}^{n} u_i$$  \hspace{1cm} (1)

Where $U_1=V_{1,0}$, $U_2=V_{2,1}V_{1,0}$, $U_i=V_{i,i-1}V_{i-1,i-2}...V_{1,0}$, $n=3$, according to which the corresponding weight of each risk factor is calculated.

4.2.3 Research on the evaluation model
Combined with the previous research results, this study constructs a model by establishing a linear equation. The model takes the transmission line evaluation and calculation as the core, and can realize the comprehensive evaluation of the line and even the region through expansion. In order to simplify the process, only the transmission line unit is evaluated and calculated. The final evaluation results are mainly obtained through the synthesis of different factors. The scoring results of the target transmission line are as follows:

$$S = \sum_{i=1}^{2} \Pi_i A_i$$  \hspace{1cm} (2)

Where $A_i$ is parameter value of risk factors, $\Pi_i$ is the weight value of risk factor.

5. Research on information extraction and differentiated operation and maintenance strategy of major geo disaster risk level of transmission lines
Based on the grade information of all kinds of major geological disasters, referring to the geological and power grid industry standards and relevant research results, the influence scope of different grades of landslide, collapse, collapse, ground fissure, unstable slope and debris flow is determined. The buffer zone is made according to the affected area, and the data of each grade of transmission line is superimposed to obtain the data of transmission line location and affected grade in major disaster area [12]. Based on the risk assessment model, the transmission line risk value is calculated, and then the calculation results are divided into emergency, serious and general levels according to the relevant standards of power grid, and the three levels of transmission line risk database is established. Develop differentiated operation and maintenance strategies based on safety assessment standards[13-14]. Finally, a set of operation and maintenance standards for transmission transmission lines based on geological disasters is formed.

6. Design of integrated management and control system for transmission line disaster
Combined with geographic database technology, Oracle database technology, middleware technology, GIS spatial analysis technology, visualization technology and XML data transmission format, the integrated management and control system of transmission line geological disaster is developed and designed. The system architecture is shown in the following figure. The system includes data management subsystem, data aggregation and fusion subsystem, data analysis subsystem and data service subsystem[15].
Data management system, based on technology, is a database technology that supports extensible object-oriented data model. This technology connects common spatial databases (SQL server, Oracle spatial, etc.) and unstructured databases of big data (NoSQL, file system, etc.), so as to realize the functions of administrative division data, hydrology, meteorology, geological disasters, etc. Management of structured data and unstructured data for disaster prevention and mitigation, such as line transmission line and risk level, prevention scheme.

Data aggregation and fusion subsystem is the basis of geo disaster risk assessment by accessing, cataloging, cleaning and transforming the relevant data from distributed and heterogeneous data sources.

Data analysis system, based on statistical analysis method, spatial classification method, spatial clustering method, spatial association rule method, realizes real-time data processing. Spatial analysis functions such as distance analysis, buffer analysis, weight analysis, overlay analysis and topology analysis can be realized. In addition, it can also realize the statistical analysis function according to the hidden danger time, administrative division, line level, geological disaster type, line name and risk level.

The data service subsystem can complete the browsing of graphics and images, realize the data zooming in / out, translation, rotation, positioning and other functions, which is convenient for the monitoring personnel to view. It can realize integrated query, element editing, chart display, and intuitively understand the spatial distribution of geological disasters. It can measure the distance between the landslide area, area and disaster area and the transmission line line. By superimposing years of image data, spatial distribution data of geological disasters and line transmission line data, the mountain moving distance and speed are calculated to achieve the early warning and protection of suspected disasters.

7. Conclusions

The system is designed to realize the rapid processing of multi-source heterogeneous data such as transmission line, major geological disaster information, geological and hydrological survey data, meteorological data and operation and maintenance information data in Guizhou Province, and realize the functions of storage, query, association fusion, modification, browsing, display, statistical analysis, risk assessment and prevention plan of major geological disaster information of transmission transmission line. According to the results of evaluation and analysis, the statistics of administrative regions, regional area and disaster points can be carried out at all levels. At the same time, preventive measures can be put forward for the transmission line with geological hazards, and treatment suggestions can be put forward for the affected transmission line. Reduce human participation. Through the research of differential operation and maintenance strategy, the operation and maintenance efficiency of transmission transmission line is improved and the manual operation and maintenance cost is reduced. In order to accurately grasp the current situation, distribution characteristics, types, occurrence frequency, formation mechanism and damage degree of major geological disasters in the province. In order to solve the problem of hidden and sudden geological disasters, it is necessary to deeply study the evaluation model and comprehensive prevention measures of major geological disasters on transmission lines.
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