Safety Monitoring System of Tunnel Construction Based on Webgis

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Abstract: In the process of tunnel construction, rock and soil are inevitably disturbed. The resulting soil deformation will affect the ground buildings and existing pipeline facilities. The deformation reaches a certain level, affecting the safety of ground buildings and the normal operation of underground pipelines. Therefore, the ground movement and deformation caused by tunnel engineering, especially the impact and control methods caused by urban engineering with dense ground engineering facilities and underground pipelines, has been a topic of concern for relevant researchers. In the construction process, in order to ensure the safety of the construction site in the process of tunnel construction, it is necessary to observe the safety of the buildings around the tunnel construction project. The traditional construction monitoring method has the problems of complex data redundancy and long data processing cycle. Based on the above, this paper introduces the concept of WebGIS into the management of tunnel construction monitoring information system, and realizes the visualization and network management of monitoring information. This paper first introduces the optimization function of model UV algorithm in tunnel construction, and the technology of its application in WebGIS platform, and then introduces the monitoring management and risk assessment technology of database in WebGIS platform. At the same time, the characteristics of the current mainstream commercial WebGIS platform are compared. Secondly, starting from the system design principles and design objectives, the paper deeply discusses the use requirements, risk assessment module design and design direction of the safety monitoring system.

1. Introduction

China has a variety of landforms, many of which are suiTable for and need to build tunnels. The development of railway, expressway, subway and other road network construction will inevitably bring a lot of tunnel construction [1]. In terms of railway, many geographical conditions limit its development and construction, and many tunnels have to be built. In mountainous areas, there is a large part of tunnels in the whole railway line [2]. For example, the Chongqing Huaihua railway, which has been completed in China, has a total length of 630 km and 190 tunnels, with a total length of 243 km, accounting for 36.86% of the total length of the line. At present, the total length of railway tunnels that have been constructed and put into use in China has already ranked the first in the world. In terms of highway, according to 2012 statistics, there are 6189 highway tunnels nationwide, with a total length of 4213 km, including 192 extra long tunnels, with a total length of 850.16 km. In terms of urban subway construction, the total length of daily tunnels accounts for nearly 100% of the total line length [3].

The diversity and anisotropy of geological structure and composition of rock and soil in tunnel construction area determine the complexity of mechanical properties of rock and soil. The heterogeneity and discontinuity of rock and soil itself make engineering geology unpredicTable [4]. The prediction possibility is to ensure the safe and smooth progress of tunnel construction and reduce unnecessary losses. In tunnel construction, monitoring methods reflecting the stress state of surrounding rocks and supporting measures as well as the impact on the surrounding environment should be used [5]. In order to reduce the monitoring workload, reduce labor costs and safety risks, and ensure the safety of tunnel construction, automatic monitoring methods are increasingly used in tunnel construction. The monitoring and early warning system based on automatic real-time monitoring technology can realize unmanned automatic data collection on the project site [5]. After identifying the risk of the collected monitoring data and confirming whether there are abnormal changes in the monitoring data of each monitoring field, the early warning method is used to give the corresponding level of early warning to the corresponding position of the abnormal part of the data [6].

WebGIS is divided into web + GIS. It is the GIS system of web on the web page. We can process and display GIS data on the web page (through Internet browser) [7]. WebGIS three-tier architecture is mainly display layer, map service layer and data layer. 3dwebgis is the direction of the near future, because big data visualization, the best way to cooperate with display is 3D map elements display (building, route information), spatial analysis (shortest path, fastest path), data analysis visualization (real-time traffic situation), POI interest points (nearby attractions, businesses, food, etc. [8]. Web server generally refers to the web server, which can be simply understood as the file resources on the computer, which can be deployed through the web server, so that people through the Internet can access the preview. At present, some popular map JS libraries with user base in the industry mainly include: arcgisapi for JavaScript, openlayers, leafet, mapbox maptalks.js [9]. The research direction of this paper is to organically combine WebGIS technology with relevant factors existing in tunnel construction to make it a platform for monitoring tunnel construction [10].

2. Algorithm Establishment

2.1 Model UV Algorithm

Given the coordinates a (Xa, Ya, Za), B (Xb, Yb, Zb), C (Xc, Yc, Zc), $\overrightarrow{AB}$ vector calculation formula is as follows:

$$\overrightarrow{\mathrm{AB}} = \vec{\mathrm{b}}(\mathrm{Xb}, \mathrm{Yb}, \mathrm{Zb}) - \vec{\mathrm{a}}(\mathrm{Xa}, \mathrm{Ya}, \mathrm{Za}) \tag{1}$$

The calculation formula of $\overrightarrow{AC}$ vector is as follows:

$$\overrightarrow{\mathrm{AC}} = \vec{\mathrm{c}}(\mathrm{Xc}, \mathrm{Yc}, \mathrm{Zc}) - \vec{\mathrm{a}}(\mathrm{Xa}, \mathrm{Ya}, \mathrm{Za}) \tag{2}$$

The calculation formula of OP vector is as follows:

$$\vec{\mathrm{p}} = \overrightarrow{\mathrm{AB}} \times \overrightarrow{\mathrm{AC}} \tag{3}$$

The vector of the U-axis of the plane coordinate system is calculated as follows:

$$\vec{m} = \vec{p} \times \vec{e} \tag{4}$$

The vector of the v-axis of the plane coordinate system is calculated as follows:

$$\vec{n} = \vec{m} \times \vec{p} \tag{5}$$

With$\vec{n}$ and $\vec{m}$ vectors, the coordinates of the plane UV coordinates (UK, VK) of any triangle vertex K(XK,YK,ZK) in the space rectangular coordinate system can be defined as the projection distances of the corresponding vectors$\vec{k}$(Xk,Yk,Zk) on $\vec{m}$ and $\vec{n}$ vectors. The calculation formula of (UK, VK) is as follows:

$$U_k = \frac{\vec{k} \cdot \vec{m}}{|\vec{m}|} \tag{6}$$

$$V_k = \frac{\vec{k} \cdot \vec{m}}{|\vec{n}|} \tag{7}$$

The calculation formula of the redefined UV coordinates of vertex K in the corresponding triangular surface is as follows:

$$\mathrm{K}\left(\frac{\vec{\mathrm{k}} \cdot \vec{\mathrm{m}}}{|\vec{\mathrm{m}}|}, \frac{\vec{\mathrm{k}} \cdot \vec{\mathrm{m}}}{|\vec{\mathrm{n}}|}\right) \tag{8}$$

2.2 Database Monitoring Algorithm

In the design of WebGIS database, we should pay attention to the analysis of users and the construction of database. We should use the general gateway interface development technology of WebGIS technology to guide the user information into the data monitoring system, and match the corresponding internal operation test data. Under the premise of ensuring the complete collection of tunnel construction data, the system monitoring and control operation are carried out. At the same time, combined with the central allocation system with strong network connectivity, the displacement and direction of tunnel soil can be tracked. By using WebGIS mode, the geological conditions of different regions are reflected in the map module to realize the same user operation in different regions and build the geological conditions collection system.

According to the network operation platform structure, the geological information supervision space is constructed, and the construction formula is as follows:

$$Z=\frac{n!}{r!(n-r)!}+\frac{1}{2} \tag{9}$$

Where, Z is the space parameter of information supervision, R is the unknown geological information data, and R is the query accuracy coefficient of internal query function. After the above operation, the landslide information state is transformed, and the landslide information is input into the software monitoring and processing system, waiting for the software database adjustment operation.

While improving the operation of the image display database, we should strengthen the management of the attribute database, test the data information in the attribute database, and construct the test equation as follows:

$$N=\sqrt{c^2+k^2}\cdot\frac{1}{p} \tag{10}$$

In the formula, n is the inspection parameter data, C is the internal database operation parameter, is the management strength index, and sound is the central space monitoring information data.

At the same time, we should strengthen the management of temporal database, adjust the information storage location of the database in time, and transfer the stored data to the internal database space according to the central storage structure

$$J=\sum_{i=1}^{i}(sj+l)\cdot a \tag{11}$$

The stored data s is transferred to the information storage location coefficient L, and the information content of the spatial factor J of the database is adjusted at any time. According to the transfer rule a, the collected data is transferred to the internal spatial database to obtain the transfer data J.

2.3 Optimization of Model UV Algorithm

In the process of scientific research, we can not follow the rules and analyze specific problems. According to the requirements of our own design, the algorithm is changed appropriately, which is more flexible and convenient than the research process, and the performance is optimized. Many values can be found at one time, so it is very useful to calculate the follow-up results. However, if the data is too large (the model data to be calculated is too large), too much ROM will be used to build the model. In this case, the existing model UV algorithm must be modified according to the design requirements.

3. Modeling Method

The prediction model of tunnel construction safety risk rating is a typical two classification model in the process of risk rating. Logist model is the most widely used model. When x is 0, it means the risk level is 0, when x is 1, it means the risk level is 1, and so on. The probability can be used to determine the risk level of the tunnel construction data storage according to the set threshold.

$$\rho(X=1|Y)=\frac{1}{1+e^{-(\beta_0+\beta_1 x_1+\cdots\beta_n x_n)}} \tag{12}$$

The fitting effect of the rating model is expressed by the pseudo-t-square statistics, which means the proportion model explained by the self-made quantity of the total variation multiple model of the dependent variable

$$\text{Cox\&Snell} - T^2 = 1 - \left[\frac{\text{Ln}(L_0)}{\text{Ln}(L)}\right]^{\frac{2}{n}} = 1 - e^{\left\{\frac{2}{n} - \text{Ln}(L_0)\text{Ln}(L)\right\}} \tag{13}$$

$$T^2 = \frac{\text{Cox\&Snell} - T^2}{1 - (\text{Ln}(L_0))^{\frac{2}{n}}} \tag{14}$$

The coverage rate of the results is in the actual rating samples, and the correct rating proportion model is as follows:

$$\text{RESF} = \frac{TA}{TA + FN} \tag{15}$$

The model describes the regression results between cloud data storage rating and related indicators. First, we use D_m with probability distribution The basic security model is obtained by learning from the training data set

$$T_m(x) \to \{-1, +1\} \tag{16}$$

Secondly, the classification error rate on the processor is calculated

$$e_m = P(T_m(xi) \neq yi) = \sum_{i=1}^{N} \text{euolxp}(-a_m yi T_m(xi)) \tag{17}$$

The final data risk treatment is as follows:

$$T(x) = \text{sign}\big(f(x)\big) = \text{sing}[\textstyle\sum_{m=1}^{M} a_m T_m(x)] \tag{18}$$

4. Evaluation Results and Research

According to the image processed by the model UV processing algorithm, the distribution of the triangle's w mapping coordinate ratio in the spatial coordinate system is consistent with that of the triangle's vertex coordinates. If the model is mapped, it will not deform. The accuracy of the UV algorithm in this paper can be obtained by comparing the rendering before and after the UV algorithm. Data and 3D model bring the effect of 3D WebGIS platform. In order to choose the best WebGIS platform, the following Table 1 analyzes and compares the current popular commercial 3D WebGIS platform.

Table 1 Comparison of 3D WebGIS development platforms

Development platform	ArcGIS	SkyLine	SuperMap	MapGIS
Plug-in unit	NO	YES	NO	YES
Charge	YES	YES	YES	YES
Cross platform	Support	Don’t support	Support	Support
Expansibility	Hard	Hard	Hard	Hard
Open Source	NO	NO	NO	YES

It is not difficult to see from Table 1 that MAPGIS is cross platform in many WebGIS commercial 3D platforms, which provides a good guarantee for the establishment and transplantation of 3D models. Its open source allows developers to develop or modify programs according to their own needs, providing more possibilities and diversity. The multi support of its plug-ins will also provide more convenience for the establishment of the model. To sum up, in the research of tunnel construction safety monitoring system based on WebGIS, MAPGIS is more conducive to its development and research.

Figure 1. statistical chart of responsibilities of all parties involved in tunnel construction accident

It can be seen from Figure 2 that the parties responsible for the accident include the construction unit, the construction unit, the survey and design unit and the supervision unit. In the statistical accidents, 7% are mainly caused by the construction unit, 44% by the survey and design unit, 6% by the supervision unit and 43% by the construction unit. It can be seen that the main causes of the accident are the survey and design and construction quality and management. From the construction safety monitoring, we should pay attention to many aspects, such as construction safety monitoring.

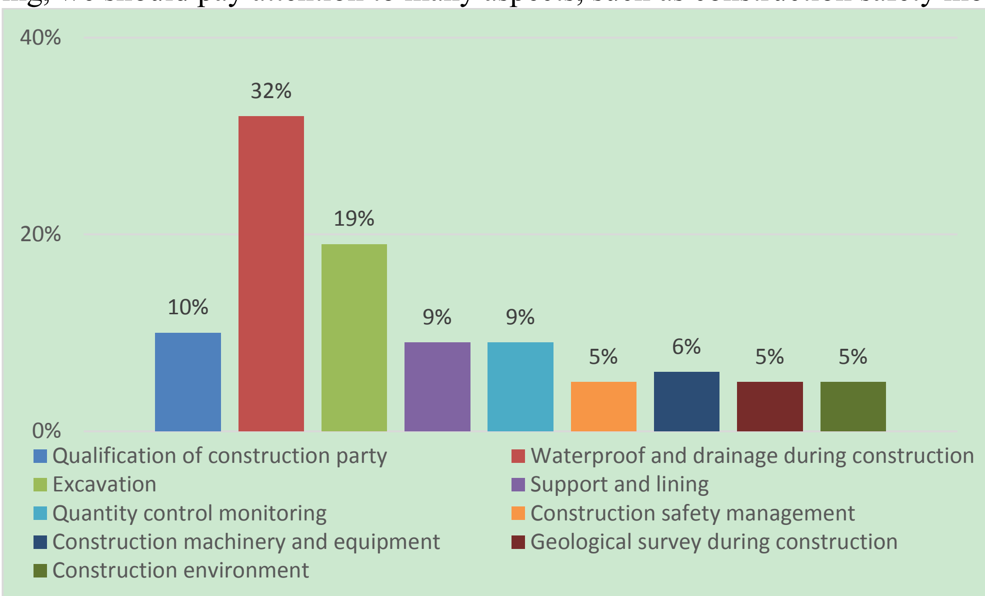

Figure 2. Statistics of main risk factors of default of construction party

Tunnel construction accidents are mainly caused by landslides. The causes of the accidents include poor coordination and management of the construction unit, lack of scientific decision-making and forced acceleration of construction progress; insufficient geological and hydrological investigation of the survey and design unit, unreasonable specific construction scheme, especially unscientific support and waterproof and drainage scheme; failure of the supervision unit to manage the project quality and progress, etc; The construction technology level of the construction unit is insufficient, construction is not carried out according to the construction scheme, cutting corners and site management is chaotic, etc. Statistics show that the construction party is the main responsible party for the collapse and seepage accidents. Statistics show that the distribution of the main risk factors of the construction party's default is shown in Figure 2.

5. Conclusion

The goal of the project is that the tunnel construction safety monitoring system based on WebGIS can provide timely information feedback during tunnel construction, provide timely and effective guarantee for the safe tunnel construction environment and the safety of construction personnel. In the process of tunnel construction, through the monitoring of WebGIS platform, the change of environmental safety coefficient in the construction process is strictly controlled within the standard limit value to ensure the personal safety of construction personnel. And real-time monitoring of the changes of the surrounding buildings or natural structures in the process of tunnel construction, to ensure the minimum damage to the original geographical landscape. At the same time, the measurement data are continuously recorded in the system. Through the big data intelligent algorithm of neural network, comprehensive and systematic reference data are provided for the future construction design, and timely information is provided for the construction party, so as to optimize the management of the whole construction project scientifically. This paper provides a suiTable mathematical model algorithm, and provides a scientific research direction for the monitoring platform. At the same time, the advantages and disadvantages of different 3D WebGIS platforms are statistically analyzed and compared, and the optimal platform selection is obtained. Scientific statistical analysis of various factors of some tunnel construction accidents provides a detailed scientific research direction for platform risk monitoring.

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