Research and implementation of tunnel construction schedule management system based on Unity3D

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Abstract: In view of the slow progress of tunnel engineering construction in China due to the influence of terrain geology and climate, a tunnel construction progress management system based on virtual reality simulation technology is developed. The article uses Revit for high-quality model, Unity3D is a three-dimensional virtual reality engine to develop a construction progress management system for construction progress recording and early warning. The results show that the tunnel construction progress management system developed based on Unity3D can alleviate the lag of construction progress, achieve safe and controllable construction site.

1. Introduction

China is the country with the fastest development of tunnel construction technology in the world. However, the construction of the separated special mountain tunnel still faces a series of related problems. The increased construction pace has led to fierce market competition, and corporate pursuit of progress is greater than quality, often with management chaos and nest work; The traditional ledger management system has a single form, lacks organizational coordination, and lacks core technical support. Therefore, it is particularly important to develop an interactive construction progress management system for real-time progress control and construction early warning.

The characteristics of virtual reality technology with higher simulation, stronger interaction, and multi-software integration are gradually accepted by the public. However, Unity3D technology is rarely used in tunnel construction management. This article introduces Unity3D research to solve a series of major problems in the tunnel construction process. It compares actual progress with predictions, performs construction early warning, and improves construction coordination rate to reduce engineering risks and improve construction quality. In order to strengthen the identification of risk factors in tunnel construction and avoid the disadvantages of account book management with errors and delays. Based on the four-color early warning mechanism, this article attempts to use the
surrounding rock data to calculate the current construction position and surrounding rock distance, and proposes the prediction of surrounding rock and construction early warning algorithm. The article introduces the system development process, to achieve the purpose of reducing schedule lag and improving construction efficiency.

2. System design

2.1 System Requirements Analysis and Functional division

According to the survey, the traditional ledger management method is often used to manage the construction progress of tunnel projects in China. The shortcomings are relatively obvious, mainly including the inefficient update of information and irregular information records.

In view of the deficiency of the traditional progress management mode, the preliminary functions of the construction progress management system are divided as follows:

(1) The system design input and record module. The design function is: real-time input of actual and planned progress data, daily excavation length data and records.

(2) The system design comparison module, the function is: read the actual progress of the day, compare the actual and expected progress of the day, calculate the value of over-excavation.

(3) The ultra-excavation section of the early warning, the system design display function, the function is: show the daily actual and expected progress, show the system after processing the over-excavation value;

(4) The system design query module has the functions of: querying the current left and right hole excavation length, the distance between the palm face and the next surrounding rock level, historical overdue and underdue data, cumulative overdue value.

(5) The system storage function is: to store the data used for input and comparison functions.

Based on the above functional description, the plan management module diagram is generated, as shown in Figure 1.

![Figure 1. Plan management module diagram](image)

2.2 System technical route

According to the demand analysis of users and the function division of schedule management software, the development project of schedule management program is created. Based on the UNITY platform design to create a progress management system, divided into data operation scene and progress display scenarios for the results of the presentation, each scene by the model additional code
production method to achieve. This project content is divided into two parts: model making and algorithm design.

First, the modeling team used Revit and 3ds MAX to build a model according to the two-stage construction drawing, and modeled the site terrain and component materials and collected samples for model mapping. Second, the algorithm group generates a planning document based on functional analysis, and writes the algorithm one by one as required. After the program is initially completed, internal testing is performed to achieve the above functions. Finally, according to the demand analysis, the project application is carried out with the Taitian Tunnel as an example, and the result analysis is performed according to the application situation. The system development process is shown in Figure 2:

![System development flowchart](image)

**Figure 2.** System development flowchart

3. System implementation

3.1 Technical preparation

Before design, it is necessary to survey the terrain, collect rock and soil samples on site, establish material library, analyze the climate characteristics of the tunnel site area, geological conditions, form survey report, make the tunnel daily progress plan according to the requirements of the system design, analyze the detailed functional requirements of the system, generate planning documents.

3.2 Model building and optimization

This study combines the professional model through REVIT, and then complements the optimization of the model through 3ds Max. At the same time, the model as 3D animation material, in the tunnel roaming has been better used.

Firstly, REVIT initially established a component model of the tunnel. Concrete components include primary support, secondary lining, power communication trenches, surface layers, base layers, etc., and steel structures including steel supports, small lead pipes, grouting anchors and other components; in order to ensure the realistic environment, the terrain is modeled in three dimensions.

Secondly, 3ds Max imitates the environment and terrain of the tunnel site to establish the geological model. According to the site layout and construction conditions, add manipulator, trolley, excavator and other related equipment model loading scene. Tunnel components and models are shown in Figure 3.
Finally, take physical pictures of rocks and earth and stones at the scene to optimize the material. After the work was completed, the materials and models were organized and imported into Unity 3D. The hole scene for the 3ds Max tunnel model is shown in Figure 3.

3.3 Algorithm Implementation

It is the key point of tunnel construction to locate the palm surface accurately and quickly and clearly. For this situation, this study calculates the value of over-excavation on the basis of daily progress comparison, suggests the construction status, predicts the situation of the front surrounding rock, realizes the construction early warning, and achieves the purpose of automatic accumulation of construction progress and prediction of the surrounding rock grade. The algorithm flow is shown in Figure 4.

The specific process of the algorithm is as follows:

1. Determine whether to enter the current date: When the current date is entered, record the currently entered date, project time estimate, actual construction length, current surrounding rock level, distance from the next surrounding rock level, daily expected and actual construction comparison, the two tunnels are currently over-excavated or under-excavated, or they end directly.

2. Determine whether to input the project progress forecast for the day: When the project progress forecast for the day has been entered, record the project progress forecast for the day, and judge whether there is data on the project progress for the day, otherwise it will end directly.

① If there is data on the project progress for the day, compare the project progress estimate for the day, record the project progress for the day, display the current project, and record the data; superimpose the current project situation, Recording the superimposed data shows that the two tunnels are currently over- or under-excavated. At the same time, read the current engineering progress surrounding rock grade and record the data, display the current engineering progress surrounding rock grade.
grade, then calculate and record the next surrounding rock grade distance, and end after displaying the next surrounding rock grade distance.

② If there is no data on the progress of the project that day, it will end directly

3.4 System implementation

The prediction of surrounding rock spacing, progress display and over-excavation forecast are one of the important contents of platform display. As shown in Figure 5, the data operation interface displays the actual construction progress, the surrounding rock level, and the current construction status in real time. The data creation interface prompts the user to adjust the excavation speed according to the danger level to realize construction early warning. Since the tunnel is a left and right separated long tunnel, the data operation and progress display interface is divided into four modules such as the entrance and exit of the left and right holes.

4. Engineering Applications

A tunnel project in Fujian Province is located in the heavy hilly area of Wuyi Mountain Range. The tunnel is affected by the rainy season and construction progress is slow. Before the start of construction by the weather impact, the material preparation is insufficient.

The project introduces a progress management system in 2019. The system collects data, calculates the construction progress, and performs construction early warning. The problem of lagging progress is solved, the system application effect is good.

5. Conclusion

This study Through Unity3D, the tunnel progress management system is designed and developed to record and optimize the construction progress. In order to avoid the unexpected situation of tunnel safety accidents, the algorithm of surrounding rock prediction and construction early warning is studied and researched to improve the site construction safety.

The system made the following breakthroughs:

(1) In the aspect of construction application, the construction progress management system realizes the functions of comparing progress, predicting surrounding rocks, and prompting over-excavation and under-excavation to achieve the purpose of construction early warning and optimization of progress. In addition, the system estimates the distance between the palm surface and the surrounding rock in accordance with the actual progress, and prompts the surrounding rock in the case of tunnels with complex geology and weak surrounding rock to provide safety warning.

(2) In terms of information management, the system runs smoothly at the construction site, and the information is transmitted quickly and easily in mountain tunnels with poor communication, which is of great significance to the construction progress management at the site.
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