Research on fine management of expressway construction schedule, quality and safety based on mobile terminal

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Abstract: In view of the management characteristics of highway engineering, it integrates BIM, mobile Internet, cloud computing, Internet of things and other technologies to study and establish a fine and collaborative management platform for project progress, quality and safety on the basis of mobile terminal application. This paper realize the dynamic control of project construction resources with progress as the main line and the collaborative management of projects with safety and quality as the core. It can meet the application analysis demands of all parties involved in the construction of highway for the whole service data, and give full play to the convenience of mobile terminals, and carry out task coordination and mobile operation of various management work in time through the mobile terminal anytime and anywhere. At the same time, the data of the mobile terminal is associated with the structure through BIM model, which can be statistically analyzed and visually displayed, and realize the collaborative association of various business data, thus greatly improving the refined management level of highway engineering construction.

1. Introduction

The highway project involves a large number of production factors such as personnel, materials and machinery, etc. From the receiving inspection of raw materials, the quality control and inspection in the construction process, and the organization and management of personnel, to the control of implementation progress, safety management and cooperation of multiple types of work, there are full of challenges in the management of each link. In order to ensure the demands of the progress, quality and safety, it is particularly important to explore the application of BIM technology in highway project management.

According to the characteristics of highway engineering, such as large volume, long route, scattered construction sites, etc, this paper establishes the digital mobile terminal based on BIM on the management and research of construction process by means of information technology. And it constructs the digital asset library of highway engineering to realize the visual intelligent management of engineering construction, which improves the informatization and fine management level of expressway engineering construction.

2. Collaborative Management of Mobile Terminal Framework Based on BIM

Based on the BIM model, the collaborative management platform divided the model into monomers and associates it with the coding of divisional and sub-divisional works. And the process inspection is

initiated from the mobile terminal to feedback the actual project progress in real time, and compare with the plan to realize the schedule management of the project. Besides, on-site quality inspection and process inspection are carried out simultaneously, and the project quality assurance documents are generated in the quality management system. The data of each major business module is associated with the BIM model through the divisional and itemized coding.

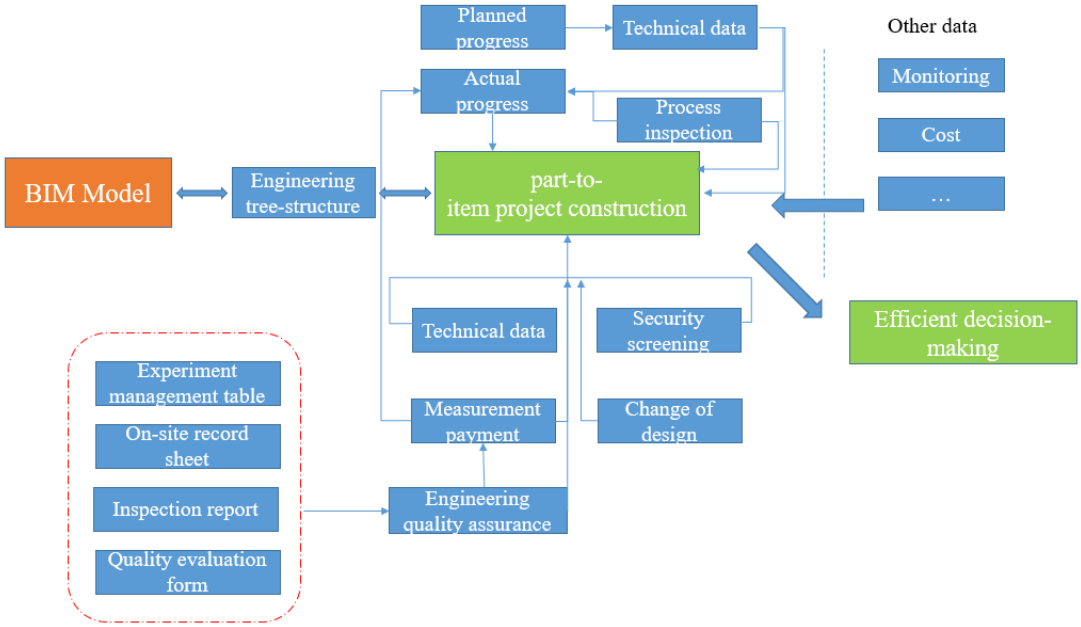

Figure 1 Overall architecture of management platform

Based on HTML5, the mobile APP is divided into three structural layers: the basic data in bottom layer, the construction data in the middle layer, and the application in the top layer, as shown in Figure 2.

There are several advantages for mobile APP to provide better management experience of "cloud + end" portable project: (1) Good adaptability and unified experience to adapt the platform of Android and IOS; (2) An updated version of the server for users to see the latest APP information forever; (3) Fewer mobile client and storage data to save the mobile space for users.

Basic data layer: project information (overview, drawings), project personnel information (unit, contact information, emergency contact, etc.), sharing documents (safety rules and regulations, quality rules and regulations, construction organization scheme, standards and specifications, etc.), material management, equipment management.

Construction data layer: Users can realize mobile office work through APP, and carry out quality inspection, safety violation and team management in real time on the construction site, which greatly improves work efficiency and information timeliness.

Application layer: in business management, it provides various functions, including schedule management, quality management and safety management and others for business personnel of various functional departments. In real-time control, it provides real-time data query, statistical analysis, event tracking and other functions for project manager. In decision support, it provides schedule and efficiency analysis as well as support and analysis data for decision managers.

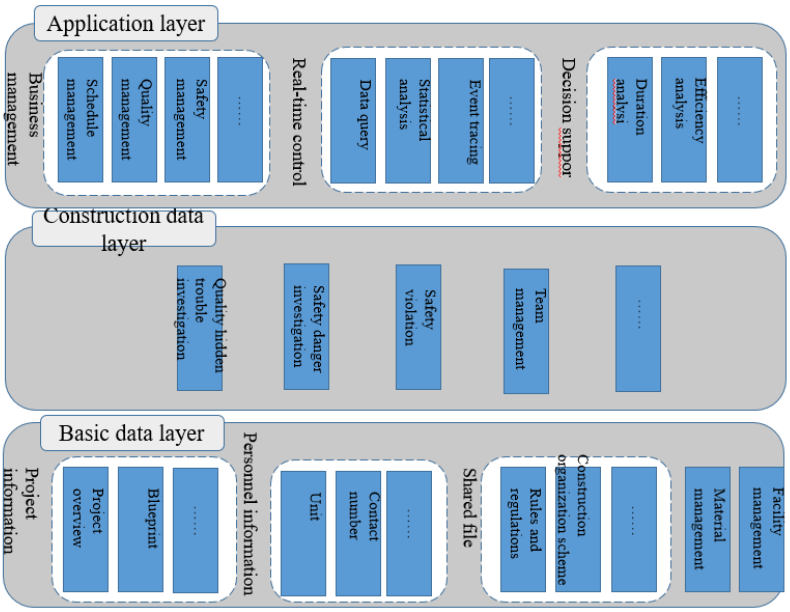

Figure 2 Architecture diagram of mobile APP

3. Application of BIM model lightweight technology

BIM model is a big platform model with big data, and its final manifestation is a visual multi-dimensional, multi-purpose and multi-functional computer graphics model, which displayed on the device in the end. This visual BIM model often features a huge size which takes up a lot of space, so it has higher requirements for computer configuration. In addition, the computer run in a low speed when users use it, which greatly reduces the user's visual experience of product. Therefore, it is necessary to lightweight the BIM model, including the elimination of redundant information in BIM model and information combination of each participant. Besides, it can be used to browse the model, view the properties and 3D section on the web, PC and mobile app, which is convenient for all participants to work together.

The lightweight treatment of large-scale BIM mainly includes two parts: internal lightweight and external lightweight.

3.1 Internal lightweight

The internal lightweight processing of bridge BIM model is to eliminate the redundant information in the model database. This project is based on BIM highway bridge construction and maintenance integration research, which includes three stages: design, construction, operation and maintenance. When conduct BIM lightweight treatment, the idea is to optimize and improve the BIM model in the design stage according to the construction requirements, so as to achieve the overall goal of quality improvement, efficiency increase and cost reduction of BIM application in the construction period. In the phase of operation and maintenance, the model is applied on the basis of the BIM model in the construction period and combined with the BIM model in the design phase to optimize and filter the data, so as to reduce the database and realize the internal lightweight of the model. In the implementation of internal lightweight, secondary development is carried out by means of external commands with the help of Revit software. The idea is: call DLL file to load a Revit command, and click the Add-In Manager button of external tools of additional modules to execute it.

3.2 External lightweight.

After deleting redundant components of Revit model to form an internal lightweight model, it is also necessary to conduct further external lightweight operation on the model, that is simplified the model by mathematical method to ensure the similarity of the model appearance with fewer triangular patches.

In the external lightweight processing, the importance of points is measured based on the edge folding algorithm, and the model boundary is emphasized by delaying the folding order. Firstly, calculate and sort the cost of each edge, and then fold the edge from the least cost edge until all edges can not be folded. As shown in Figure 6-1, the line L between V1 and V2 is degenerated into a new point v, while moving the point V1 to the position of the new point V, and connect all the edges related to V2 to the new point V. Finally, delete the degenerated triangle and edge.

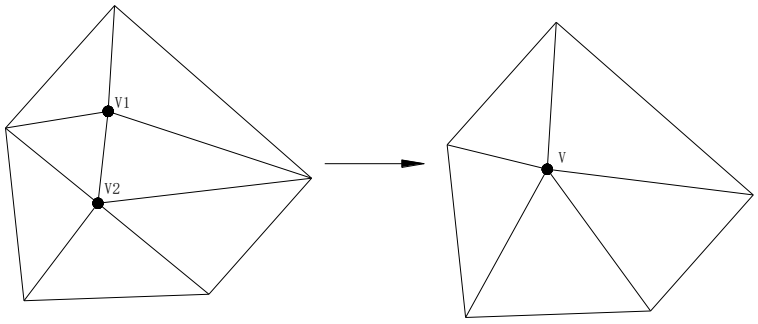

Figure. 3 Sketch of edge folding operation

3.3 Rendering technology of large-scale BIM model

BIM model is a big platform model which integrates big data with its final manifestation as a visual multi-dimensional, multi-purpose, multi-functional computer graphics model. As a result, a large space is occupied by BIM model, ranging from hundreds of megabytes to even several G, which requires high computer configuration but no ideal effect. Therefore, it is necessary to lighten the BIM model in rendering.

4. The application of platform function in project resource dynamic management

4.1 Information management of construction behaviors of contract workers

Due to the long route, multi-working site and scattered labor of the highway project, it is difficult to manage the construction behavior of contract workers. By integrating various technologies, such as machine vision, positioning label, Beidou Positioning and so on, we have developed the information management technique for construction behavior of contract workers by the promotion of information technology, which provides technical support for the accurate and refined management of workers in the process of highway engineering construction management.

(1) Recognition of helmet wearing behavior based on machine vision

By using the image information collected by various surveillance cameras distributed in the construction area, the behaviors who do not wear safety helmet by rules in the construction area are identified in the way of the image recognition algorithm of machine vision. And through the comparison between the technology of face recognition and personnel information in related management platform, we position the security violations. It is mainly divided into two parts, namely, the identification of violations and violators.

Machine vision technology is used to identify violations without wearing helmets. Firstly, the machine make a preprocessing and classification to the image, and then extract the feature of classified image, including human body recognition and helmet tracking. The basis of feature extraction is the neural network construction and training of the above two feature indicators. Based on the establishment of feature information base, the illegal behavior without wearing safety helmet can be recognized through the above process.

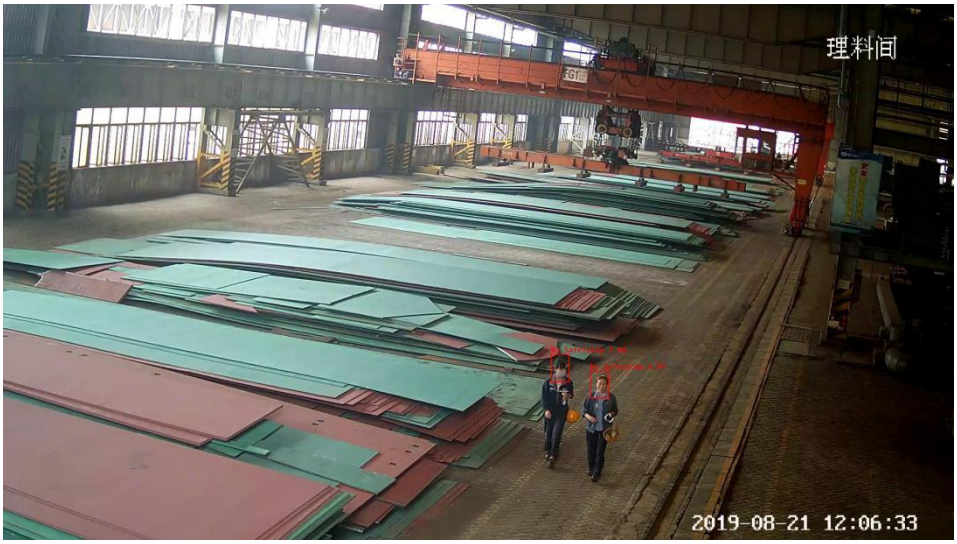

Figure 4 Recognition of helmet wearing behavior based on machine vision

(2) Positioning of workers in UWB and Beidou

In view of the features of long route and scattered construction sites of highway engineering, the demands of personnel positioning are divided into two categories: one is the centralized construction area that needs relatively accurate positioning or the construction area in the tunnel that can not receive satellite positioning signal, which need to employ UWB technology to achieve accurate positioning; the other is the construction area where the personnel are relatively scattered and no high positioning accuracy requirement, which adopt the Beidou chip built in the work card to realize personnel positioning.

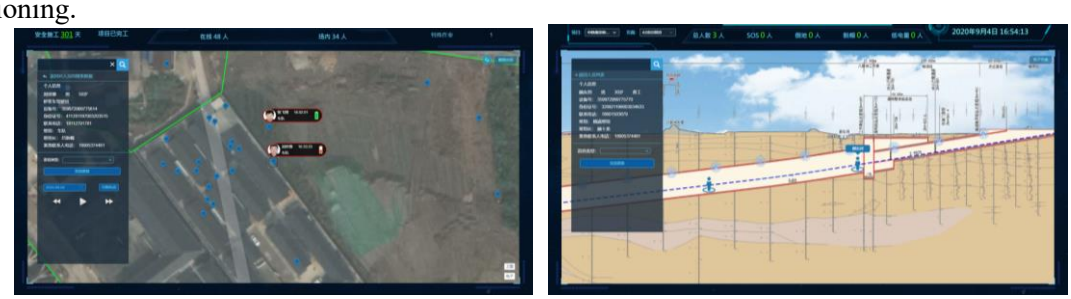

Figure 5 Positioning of laborers in UWB+Beidou

4.2 Material management

the electronic management of incoming materials can realize the registration of basic information such as material specification, origin, batch and manufacturer, and realize the process management of materials entering the site. Incoming material management is initiated by material-man, self-inspection is conducted by the person in charge of construction materials, and sampling inspection is conducted by the supervision person. Once sampling is qualified, the incoming materials will be approved by director.

5. Application of Platform Function in Project Collaborative Management

5.1 Quality management

The quality management module is mainly aimed at quality supervision stations, supervisors, owners and constructors. Its main functions include investigation of on-site quality hidden trouble, quality approval process, quality report, first project and process flow card, etc. By integrating on-site quality hidden trouble problems, laboratory test records, quality inspection forms, process flow cards and other

data, it can cooperate with schedule management and BIM data update, as well as realize collaborative work such as construction organization design, technical disclosure and analysis of quality data traceability on the basis of BIM 3-D model.

In the implementation quality management, it is mainly based on the disassembly process of WBS project to form a standardized procedure card, which can be easily queried by mobile phone. According to the standard procedure under each sub project, stop point inspection is set for the irreversible intermediate procedure to provide the portable process and signature acceptance of mobile phone, which can upload photo records to form electronic information of on-site process acceptance of supervisors. In the process of quality inspection, the sub-project is the minimum basic unit of quality inspection management, and the system background provides the functions of file uploading, querying and editing, and associates the quality inspection data of sub-project with the BIM model to consult it at any time.

The investigation of quality hidden danger is realized by the combination of BIM and mobile APP, and its refined management includes closed-loop management of hidden danger release, problem rectification and rectification acceptance. Besides, it also can achieve the dynamic management by adding a component list on the mobile APP and connecting the quality hidden danger with BIM components of 3-D graphics platform, so as to realize the positioning and real-time query of quality hidden trouble in 3-D graphics platform. To make a statistic analysis, it need to consider the time, location, type and reason of quality hidden danger. At the same time, in the process of investigation, it is necessary to record the hidden dangers related to the quality of the construction site in real time, and recognize the urgency of the problems. Furthermore, it is convenient and efficient for inspectors to track hidden dangers by building a template pool in various quality problems.

5.2 Safety Management

The safety management module is mainly aimed at the construction party, the supervisor and the owner of the project. Its main functions include investigation of safety hidden danger, safety technical disclosure and education, special safety scheme as well as special equipment monitoring. By cooperating with the schedule management and quality management module, it can also be used for safety hidden danger treatment, safety production reward, risk management and safety accident tracing.

By carrying out security investigation in light of mobile terminal, it is more convenient to find security violations and team management. When dealing with safety violations, it is necessary to classify and identify the safety violations of workers to lock their violations, and record the situation of on-site violations and deal with them. In team management, it should establish the collection system of standardized information for team operation and a system for before, during and after work. Through the collection, statistics and analysis for the normal operation situation of the team, safety education, technical disclosure and on-site “6S” management to build the database of team work, which achieve the traceability of project quality and responsibility, and establish the evaluation system of team quantitative assessment.

Hidden danger problems related to the safety of the construction site should be recorded to clarify the emergency degree of the problems, and build the template pool for various quality problems. It is convenient and efficient for inspectors to track the hidden danger and understand the release of safety hidden danger, problem rectification and rectification acceptance, which form a closed-loop management, and shorten the closure time of problem. Meanwhile, it also can achieved by mobile APP. Besides, the investigation of potential safety hazards can also realize the dynamic management of mobile phones, associating the problems and handling situations with BIM components automatically, which realize query, summary and analysis of components.

5.3 Schedule management

The analysis includes affection in advance, lag influence and correlation influence, which provides the basis for decision-making, which mainly aims at the project supervisor, the construction party, the owner's engineering department and the relevant personnel of the planning and contract department, such as planning progress, image progress statistics, as well as analysis and control. In the planning

progress, the designated target sub-projects are realized through automation of planning, or a preliminary plan is produced semi-automatically in terms of some constraints such as output value and critical path. Then integrate the scheme with resource and BIM respectively, and further implement the scheme and control it vertically and comprehensively. In the process of image schedule statistics, real-time and accurate statistics of project image progress can be realized in the system, demonstrating the progress statistics of 3D image and bid section, unit, division and sub project.

By connecting BIM with construction progress, a model based on spatial and time information can be established, which can directly and accurately reflect the whole construction process of the building, so as to shorten the construction period, reduce the cost and improve the quality.

6. conclusion

Based on the highway construction progress of mobile terminal and the fine management of quality and safety, the study aims at establishing a unified collaborative management platform. By conducting a data association, query and analysis between the whole process of business data and the corresponding 3-D BIM model to meet the query and analysis demands of all parties involved in the construction for full service data. Therefore, all parties involved in the construction of highway engineering can achieve efficient collaborative work and realize the normalization of business collaborative management mode on the basis of BIM platform. As a new technical means of highway engineering construction management, BIM-based mobile terminal construction, on the one hand, helps to realize the overall control of project schedule, quality, safety, measurement, documents, etc. At the same time, it also provides the best technical solution to optimize the allocation of resources and the organization of production factors such as personnel, materials, facilities and equipment, as well as monitors.

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