Research on BIM-based drawings query and feedback system with smart hand-held devices

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Abstract

Recently, BIM technology has got a certain development in China, however, it is still lacking of abilities in application and operation, especially in drawings query and real-time data feedback and update on site. The paper is to develop a drawings query and feedback system using technologies of network, two-dimension code and database with smart hand-held devices of android platform, with which the engineers is allowed to consult 3D drawings on site, and feedback timely and achieves data linkage between computer and handheld terminal. Through the case application, it shows that the hand-held terminal drawings query and feedback system can reduce information loss and improve the efficiency of project management to a certain extent.

Keywords: BIM, Smart Handheld Device, Drawings Query, Feedback, Database.

Nowadays, BIM (Building Information Modeling) technology has become a hotspot in the research and application of information technology in construction industry around the world, and its application value has obtained the general recognition of government and the high attention of construction industry. However, the practical application of BIM in the field of engineering construction is still very difficult. Workers require a lot of construction drawings to manage construction process, especially for complex projects, but it is not convenient for the engineer getting drawing of BIM through PC on site, additionally, BIM model is difficult to achieve rapid updates due to the high frequency of project change in construction industry in China. These factors above lead to the decrease in application value of BIM technology in the construction process.

1. Introduction

Under the guidance and support of government policy, academic circles, software companies and design and construction enterprises respectively carried out the research, development and application of BIM technology. BIM has become one of the hottest topics in China's construction industry. Although in recent years research on BIM and the application of demonstration projects have achieve some results and practical experience, BIM is still an unfamiliar technology for the whole of China construction industry.

Wu, etc. writes an investigation about the application of BIM in China's construction industry in the BIM academic magazines published by the American Institute of Building science (National Institute of Building Sciences, NIBS) (Wu Wei, Raja RAIssıa,& Jiayi Pan, 2000).It shows that 31.6% of respondents don’t known BIM technology, 23.7% begin to pay attention to BIM technology after 2006. The application of BIM suffers from the short of collaborative design and the participants lack of overall management in different phases and professional areas. It is especially obvious in domestic operation project (Zhang Jianxin, 2010).Now, to solve these application obstacles of BIM technology in our country, many scholars have developed application systems based on BIM. Akcamete, etc. proposed the records of facilities inspection and maintenance to support operational managers to analysis the priority of each task and reasonably arrange operation plan (Akcamete A, Akinei B, & Garrett J H, 2000).Hu Zheng-zhong, etc. developed intelligent management system of mechanical and electrical equipment based on BIM and achieved component positioning with hand-held terminal (Lv Yuhui, Yu Qiyuan, & Zhang Shang, 2000).Lv Yuhui , etc. developed construction project multi-factors integrated management computer information systems based on BIM and this system is useful for workers to get construction information (Yin Kui,Wang Xingpo, & Liu Xianwei,Hu Zhenzhong Lupton, 2000).

Recently, the study on application of BIM technology in construction mainly focus on how to gather and manage construction information of BIM via personal computer, and there is still few literature studying on BIM-based drawings query and feedback system with hand-held devices on construction site. So for the construction site management, it does not make full use of the technological innovation advantages brought by
BIM technology to improve construction process management. So the paper is to develop a BIM-based drawings query and feedback system with smart hand-held devices to help the better management of construction process.

2. System structure

2.1. System platform

For the development of intelligent handset drawings queries and feedback system, we should first consider the choosing of system platform. Based on Linux kernel, Android uses the structure, of software stack and it is shown in figure 1. The bottom is the kernel, developing by C language, and as abstraction layer between with the hardware and software, it hides the details of hardware and provides a unified service for the upper layers. Above the Linux kernel layer, it is interlayer composed of the Libraries and Runtime layer developed by c++ language. The role of the Dalvik virtual machine is to provide a runtime environment for each Android application program to make them run in their own process. Above the middle layer is the Android application layer, it includes application software and frame design.

![Android Structure](image)

Because the hierarchical structure, developers can make further development by taking application layer as an organic whole without studying other levels. At the same time, the lower layer can provide many services for the upper ones. Such a hierarchical structure minimize dependence between each level, and it will be very conducive to standardized work. Compared to some of the main system platform, the Linux kernel in Android have strong network performance, and broader adaptation of hardware platform.

In view of the above characteristics, Android platform is very suitable for application service of BIM-based drawings query and feedback system, and this system will have a bright application prospect. Therefore, we select Android platform to develop the intelligent handset drawings query and feedback system.

2.2. Two-dimensional code technology

As an information storage and transmission technology, two-dimensional code is geometric plane shapes formed in accordance with specific encoding rules (Russ A, 2002). It can express information in horizontal and vertical directions at the same time, thus can store a lot of information within a small area. It has a large storage capacity, high reliability, strong confidentiality, and low cost. In addition, it can store multinational text, data files, images and other information efficiently.

With the coming of 3G era, the application of two-dimensional code in mobile device is becoming more and more diverse (Lycon S, & Kschischan F R, 2010). As the most popular smartphone platform currently, Android system makes the information stored, read and spread in phone by the form of two-dimensional code. Mobile device can be used as a carrier of the two-dimensional combined with read application equipment. Furthermore, the development of related applications based on implicit information in two-dimensional code can be realized by the identification of the code on commodities with the in-built or downloaded read engines.
In all kinds of QR code, the commonly used code systems are: Data Matrix, Maxi Code, Aztec, QR Code, PDF417, CODE 16, etc., among which Quick response Code (Quick Response code, QR Code) is one of the most successful two-dimensional Code. As a matrix code, it have a large capacity of information and 1817 characters, or 7089 figures, or 4200 English letters can be put into a code. Numbers, Chinese character, photo and fingerprints, audio/video information can be embedded in it. Compared to other code, QR code has the advantages of fast read speed, large data density and small occupation space. It has an important theoretical significance and practical value to applying the QR code in the mobile platform, and developing QR code identification system based on Android system.

2.3. Database Technology

BIM model Databases’ establishment must satisfy the required conditions of the Relational model, so we used the relational model database system. The calculation system is based on SQL Server 2005 for data management tools between Multithread and SQL database management system. It has a simple, friendly interface with strong scalability, high performance, consistence and can maintain the integrity of the data information. Moreover, it can be implemented with Windows NT, Internet with no difference integration, so it is a common database designing tool. According to the different using scope of the data, these data are stored in each unit interior workstations and servers, it can not only improve the efficiency of data, but also reduce many terminal access, avoid too much burden of server (Marco Bellinaso, 2008).

2.4. System structure

Intelligent handset drawings query and feedback system architecture is the typical C/S structure, as shown in figure 2.

- **Client**: As the client, an Android phone or tablet can support wireless network transmission and QR code scanning through a configuration file to realize the connection between the current terminal and server
- **Network**: network is a channel to connect server and client. Usually, the server is set up by the Internet. An IP address and a port number are specified for client to be connected to the Internet and communicate with the server via accessing the server's IP address and port number
- **Server**: the server consists of routers, firewalls, and SQL Server, which is responsible for providing services such as data storage, access and management

![Figure 2 BIM-based Drawings Query and Feedback System Structure](image)
• Database: a BIM data warehouse is to store all of the drawings in the server, according to the level of the relationship between the various devices and build physical path of files, and then build up the drawing description information database. Many things can be achieved by the relational model of database operation, namely, drawing query, attribute information query and drawings of components between logic. Thus the storage structure clear, rationality, priorities, and safety can be guaranteed.

3. The system function design

This system consists of seven main modules including user management, files, drawings query, pictures, workbench, modification and canning query. Its functional organization structure is shown in Fig. 3.

The user interface will appear after entering the system, which consists by toolbar and main window, as shown in Fig. 4.

This system is of an open structure based on components with good reusability and maintainability to adapt to the different application requirements. So it can provide personalized service and is easy to learn and use. The following functions can be realized when engineers use smart handheld terminal as an access to BIM model information:

- Convenient browsing: BIM model is free to be enlarged, narrowed or translated by finger touch. Navigation can also be used to walk around the building. Models can be browsed arbitrarily by skipping in the small map.
- Check the model properties: any attribute of components, namely, material, size and so on can be got easily by clicking the components in BIM model.
- Filter: models can be filtered according to the dimensions of floor or the types of components.
- Viewpoints and notation: some interested part of BIM model can be recorded via view function, and workers can return to this location at any time. Red notation can also be signed to record model problems, which is convenient for engineer to handle it later.
- QR code positioning: model component can be associated with QR code, achieving rapid positioning to the required artifacts.
- Picture upload: pictures of construction site can be uploaded through the terminal and matched with BIM model, when constructors inspect the onsite construction through hand-held terminal.
4. Application and Feedback

The total construction area of intercontinental hotel project in Wuhan international exhibition center reaches about 200000 square meters, with the 101 meters in height and 21 floors. The on the ground part is used for hotel, office, commercial, catering and other related supporting function rooms, and the underground part is used for garage and equipment rooms. It is a five-star hotel, matching with international conference center, and is one of the largest and highest level of hotel in Hubei province. The quality goal of the project is to get Luban Prize which is the highest national construction engineering quality prize. And the safety requirement is to reach the national 3A standard. Compared with the traditional BIM project management via computer, the use of BIM-based drawings query and feedback system with smart hand-held devices has the following advantages.

4.1. Access to information

In the construction process, engineers use a mobile terminal equipment to scan QR code on the components, and get other ancillary information associated with the components by connecting to remote database according to attribute information provided by QR code. So the engineers can refer to the information of installation and maintenance manual, component parameters, construction personnel without carrying a lot of paper documents to the ground. Thus the electronization of operation can be realized, as shown in Fig. 4.

4.2. On site photos uploaded

In the process of construction site management, constructors can check and manage the whole constructing areas by smart handheld terminal. And they can take photos and upload to match them to BIM model on site as soon as they find any mismatching between the actual construction site and the BIM model. And then they can refer to the data and analysis it after they return to the office, as shown in Fig. 4.

4.3. Equipment emergency handling

When there is an emergent equipment failure, constructors can scan the QR code by handheld device directly. And then they can get a real-time access to parameter properties of the equipment and locate the position of the broken equipment as well as other ones related to it precisely and directly. It is a good way to help operators deal with emergencies more conveniently and accurately, as shown in Fig. 4.
5. Conclusion

Drawings query and feedback system with smart hand-held devices makes an integrated use of technologies of BIM, computer aided engineering, mobile network, database and QR code. Based on IFC international standards, the real time obtaining and updating of drawing information is realized through the smart feedback system with hand-held devices. As a construction site information management platform, the system provides an efficient information access for constructors and guarantees the quality and safety of the construction process, which is especially suitable for large and complex projects.

References

Wu Wei, Raja RAIssa and Jiayi Pan. The Status of BIM Application in China’s AEC Industry.[J] BIM. 2010 (fall): 35-37.
Zhang Jian-xin. Study on Barriers of Implementing BIM in Engineering Design Industry in China [J]. Journal of Engineering Management, 2010, 8 (4):387-392.
Akcamete A, Akinei B, Garrett J H. Potential utilization of building information models for Planning Maintenance activities. Nottingham, UK, 2010.
Lv Yu-hui, Yu Qi-yuan, Zhang Shang. Research on BIM-based construction project multi-factors integrated management.[J]. Construction Economy,2013(8):35-38
Yin Kai, Wang Xingpo, Liu Xianwei, Hu Zhenzhong. Research on BIM-based MEP Facility Management. [J] CONSTRUCTION TECHNOLOGY 2013(42):86-88
Russ A. Two dimensional bar codes. [J] Adams Communications, 2002, 27(4):15-18.
Lycon S, Kschischan F R. Two-dimensional barcodes for mobile phones. [C] 2010 25th Biennial Symposium Communications (QBSC) Washington, DC: IEEE Computer Society, 2010:344-347.
Marco Bellinaso forward, Yang Jian bite. ASP.NET2.0 website development throughout resolve [M]. Tsinghua University Press, 2008.1-10