A Study of Developing the Fire Investigation System with Building Information Modeling Application

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Abstract –

The content of fire cause investigation is not only the fire prevention as reference but also the significant gist to improve firefighting. But in point of fire site investigation, mostly were using handwriting document for recording information at present, obviously lacking with carrying convenience and recording instantaneity. Meanwhile, after causing of fire, the investigation work also utilize building information captions to display the original fire scene and identify the ignition point. But traditional two dimensions floor plan is limited to provide architectural spaces information, usually can't represent the actual appearance of the building. If using three dimensions Building Information Modeling (BIM) outputting the relevant elevations, perspectives information and so on to assist the reviewer mind produced visualize and spatialize information. The smart handheld device becoming more and more popular in recent years, it has matured software and hardware communications technology. By using the hardware of smart handheld device to support the need of investigating items in fire investigation into electronic check and form filling.

This research uses two-tier system architecture, respectively for the client and server. The server side uses both WAMP as the operating system, and MySQL as the database engine. The client side is used with PHP technology. Based on the studying illustration result, this system not only provides the data storage of inspection results, but also can be used for the relevant units in the future review.

Keywords –

Fire cause investigation; Smart handheld device; Building Information Modeling (BIM).

1 Introduction

In case of any fire disaster happen, most of all is to salvage human life and disaster rescue, afterwards professional work is fire investigation. The content of fire causes investigation are vital essential work in each fire disaster due to the fire outcome is not only to be the reference as fire prevention but also the significant gist to improve firefighting. At the practice of site fire investigation, most are using notebook to recording describe information as official document, such process is obviously lacking for carrying convenience and recording instantaneity. However, traditional two dimensions floor plans are limited to provide architectural spaces information, therefore, this research is applying smart handheld device combined with BIM technique, systematizing "Fire cause investigation testimonial" among information of the investigation. This research illustrates with fire disaster simulation examples, checks through survey data and collection, develops with PHP, MySQL and etc. of information technology to build a cross-platform of fire disaster investigation. By using this system can be reduced mistake situation judgments, meanwhile can effectively increase the practical request of fire investigation.

2 Literatures review

2.1 Definition of fire investigation

Fire work mainly by the disaster before the fire, the disaster when the fire, the disaster after the investigation of the three parts of the composition, each with a joint relationship. The fire investigation is one of the most basic work in the fire system and one of the most important projects. Through the implementation of the fire investigation work, after the consolidation analysis, you can enhance the fire code to make up the missing, improve the efficiency of fire fighting. The connotation of the fire investigation includes the technical level, the scientific level, the psychological level, the legal level, etc., is an administrative and legal action [1].

2.1.1 Taiwan 's fire investigation system

The current fire investigation process in Taiwan is when the fire occurs, the county and city fire department service center to accept the public alarm. Area of the fire unit to attend attendance at the same time, will also inform the fire department under the fire investigation section staff dispatched, fire investigators in accordance with the regulations to the site investigation [2]. But in case of special fire cases, fire investigators need to immediately go to the survey, the investigation site, such as the discovery of special, major or fire causes unknown fire cases, the county fire department may hold the county fire identification committee or apply for the Ministry of Interior Fire Department support.

After the investigation is completed, the fire investigators in accordance with the provisions must be completed within 30 days of fire investigation and identification of the cause, and transferred to the local police authorities for follow-up investigation. The police unit is transferred to the local seizure office according to law, the prosecutor will be in accordance with the provisions of the Taiwan Criminal Law, the suspect will be prosecuted, if the case is mild, no prosecution or slow prosecution of the punishment. When the prosecution by the court after the trial, so that the case until the decision. In the country, the District Prosecutor's Office and the court to clarify the truth, Will summon the fire investigators to witness the identity of the case [3].

2.1.2 The significance of the fire investigation

The information obtained by the fire accident is quite costly, because the fire accident is an irreversible process, because the relationship between time and man, the scene of the information will be more difficult to preserve and obtain, any scientific experiments can only be simulated close, can not really reproduce, so the fire investigation of the delicate degree is different from the other. Therefore, each of the accident investigation, the need for complete collection and aggregation, avoid the loss of property and casualties paid, and the information into a viable fire safety improvement policy, it doesn't lose the meaning of fire investigation [3].

2.1.3 Fire investigation legal value

A fire investigation is an objective proof of the fact of a fire, it's a speculation about the fire and the spread of disaster. The uncertainty of the fire liability of the parties becomes deterministic, the investigation itself does not change the facts, but the incomplete content of the investigation will change the interests of the parties. According to the laws and regulations to implement the fire investigation procedures, from another point of view, to clarify the cause of the fire and the responsibility of the accident is a legitimate rights and interests of the parties, it's also a recognition of responsibility and obligation [4].

2.2 Statistical Analysis of National Fire Types

According to the Ministry of Interior Fire Department statistics from 2008 to 2012, although the number of fires decreased year by year, but the maximum number of fire for the building [4]. 2012 Buildings fire with a maximum of 1,199 times, accounting for 76.2% of all the fire (Figure 1) Derived from the data can be used to make use of building information modeling 3-dimensional advantages of modeling to do the presentation, can assist in the identification of investigators to do post-disaster analysis, to write a fire investigation report.

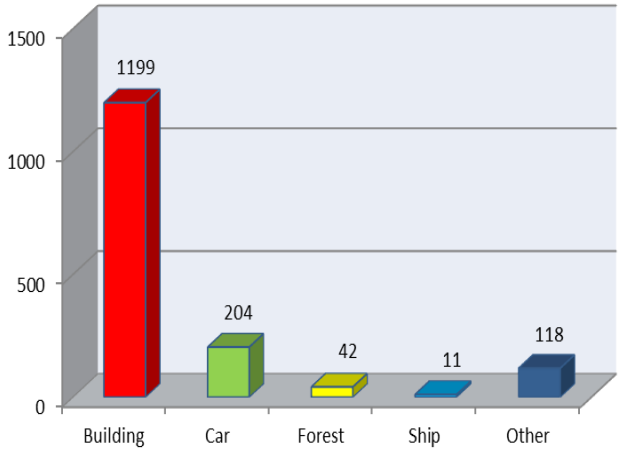


Figure1. All kinds of fire statistics in 2012 [4]

2.3 Building information modeling

Object guide theory and technology in the field of information technology in the gradual development, Europe and the United States began to use this technology to describe the product life cycle information, build product data modeling, including the creation, organization, use, maintenance and other information to master and transfer, exchange and other applications. This technology first in the aviation, machinery, and manufacturing flowering results, and gradually extended to the construction industry. Professor Charles Eastman of the Georgia Institute of Technology, who has studied the building information modeling technology for a long time, in the "Building Product Models" book, that is, details of the building elements of the information model structure principle, unveils the opening of the Building Information Modeling (BIM) terminology concept [5]. In 2002, Autodesk began to use Building Information Modeling to describe the company AEC (Architecture, Engineering, and Construction) related product design

concept, in conjunction with the construction industry analyst - Jerry Laiserin positive author recommended, so many 3D tool software manufacturers, such as Tekla, Bentley Systems and Graphisoft and other follow-up, entered the pursuit of the ideal BIM technology tools in the competition. There are increasingly mature and easy to use tools, coupled with the development of many years of product life cycle information management and application of the theoretical basis, and through the successful application of many cases, in recent years, BIM technology development and application can be said to flourish. At present, the development of BIM related technologies can be divided into three aspects: information exchange standard, modeling technology and model operation technology [6].

2.4 Hypertext Preprocessor

PHP (Hypertext Preprocessor) is an open universal computer code language, especially for web development and embedding in HTML (HyperText Markup Language). PHP grammar learn from the absorption of C language, Java and Perl and other popular computer language features, easy for general program designers to learn. The main goal of PHP is to allow web developers to quickly write dynamic pages, but PHP is also used in many other areas. Originally developed by Ledoff in 1995. Now the PHP standard is maintained by PHP Group and open source community, the scope of application is quite extensive, especially in the development of web programs. In general, PHP is mostly implemented on the web server, by executing the PHP code to generate pages that users can browse, they can be executed on most servers and operating systems, for example, to collect data from a form, or to generate dynamic web content, or to send and receive small text files (cookies), PHP can do it [8].

PHP can be used in most operating systems, such as Linux, HP-UX, Solaris, Open BSD, Microsoft Windows, Mac OS X, RISC OS. Can be implemented on most web servers, such as Apache and Microsoft Internet Information Server (IIS). It's function is not just output HTML files, Its function also includes output graphics, PDF files, and Flash files. You can also let it output some text, such as XHTML and any other XML file, PHP can produce these files, and store them on the server, there are a lot of other expansion modules that can be used, It also supports a wide variety of databases, so it is quite easy to use the database when writing a web page.

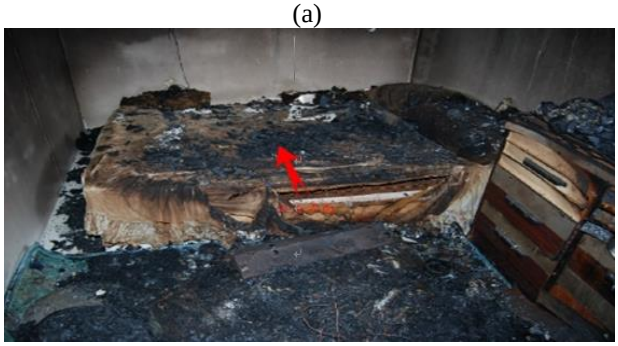
The webpage filling system written by this study is based on WordPress developed by Automattic Web Design, to PHP and MySQL as a platform for open source software and content management system, a webtemplate system with a template processor, diversified presentation can assist in the identification of investigators not only to fill in the interface concise and more free and open source-assisted media.

3 Research methods

3.1 Make the essentials of the identification book on fire cause

This research is according to the fire cause investigation process to develop a prototype system with BIM technique. Based on the studying result fire investigators can recording fire overview immediately, make more precise restore scene identification book. It's contain:(1)front and back covers, (2)contents, (3)summary, (4)scene investigation personnel records, (5)scene records and judement, (6)mobilized observation records, (7)conversation transcripts, (8)evidence identification report, (9)goods configuration diagram and site plan, (10)actual location, the scene of photographic information is shown in figure 2 [8].

(a)



(b)

(c).

Figure 2. Actual locationthe scene of photographic [9]

3.2 The shortcomings of the current fire investigation and identification book

The shortcomings of this study based on the current fire investigation and identification book are as follows:

(1) Mostly in the text to describe the situation of the fire scene:

The current fire cause investigation and identification of the book are written in the form of narrative, so the content of the more narrative-based, Use the text to describe the scene of the fire scene and the number of casualties, advantages for the detailed description of the scene conditions, but for the information reading and understanding of the poor efficiency of the staff, it's necessary to consider the use of words to avoid misleading readers of the cognitive, resulting in wrong judgments.

(2) Text description is prone to errors:

Investigators were surveyed at the fire scene, must be carried out at the same time exploration, sampling and photography operations, in addition to the scene of the environment chaos, it is difficult to carry out detailed records, so most of the simple diagram or simple words to record, return to the identification unit, and then use the scene photos and floor plan with the auxiliary, organize the relevant identification information and write the identification book, on the way back and forth may cause memory loss, so there may be errors, in addition to the use of text description of the scene conditions and spatial orientation has its difficulties, if the use of text in the cognitive error is likely to cause text errors.

(3) Lack visualization and spatialization of data:

To describe the location and space position is still lack of visual and spatial, so the reading staff must cooperate with the floor plan and photos of the auxiliary can produce a sense of space and direction, and only for the location of the state of burning only overview, failed to clearly define the extent of its burning, so for those who did not reach the site survey of the identification of personnel, It's difficult to interpret the fire flow and the burning path.

(4) Written information is not convenient to save:

The number of buildings of all types is growing rapidly, And according to the Ministry of Interior Fire Department statistics building fire for all cases the largest case, and according to the Ministry of Interior Fire Department statistics building fire for all cases the most, It's clear that the number of relevant documents identified in the fire must be very large.

3.3 Fire cause investigation site fill form

In the modern developed science and technology society not only the computer hardware and software and the rapid development of functions, but also with the growing environmental issues, the traditional paperwork is transferred to the digital way, this digital approach has the advantages of shortening time and reducing errors, with the popularity of today's mobile networks, wireless networks and portable handheld devices, easy to send and instant record is one of the characteristics, for the number of documents, can save the query and access, follow-up archive time, also use the "keyword" to retrieve the text, can improve work efficiency, but before the text file is converted to a digital file, must first define the field items and input procedures to provide computer interpretation, the system can help to classify and summarize the information, therefore, this study to extract the cause of fire investigation and identification of the production of the part, including fire, fire and fire causes as a reference, designed to meet the identification of personnel records the scene of the subject into a "fire cause investigation site fill in the form", and then the subject is divided into belong to the material category of the "site survey table" including the basic information, the opening of the information, structural information, item information, on-site trace data, and the direction of burning and carbonation and person to prove the "staff interview table" for the record, use the table as a subsequent digitization conversion step.

3.4 Building information modeling for fire cause investigation identification book

The current fire cause investigation and appraisal of the fire scene for the building map mostly in 2 Dimensions (2D) way to show the location and floor plan, and use Computer Aided Drafting (CAD), but the software is only a general computer graphics platform, not specifically designed for building collar, so the ease of use is obviously insufficient, and the drawing of the plan can't provide a complete visualization and spatial, so the staff must be with the floor plan and photo assistance to produce space and sense of direction, for the location of the burning status of the record and the reasons for the investigation of the report in the text narrative and photographs were as different in the book chapters and pages, resulting in the inconvenience of the reference.

In this study, the use of Trimble Navigation launched by the Sketchup 3 Dimensions (3D) Building Information Modeling (BIM) software, to 3 Dimensional view of the main, the tools used to generate, view, and modify the idea of 3D also have simple and powerful features, can be through the computer software for building simulation, and from the building in the process of obtaining a variety of different information on the new concept of CAD can be established by the floor plan, elevation, profile, perspective and other surface combination.

4 Building fire cause investigation system

This research develops the system of the fire disaster cause investigation with the actual needs. First step is required prior planning system to develop process and them is in turn to set up overall system. The system contains the user requirement analysis, development tools and system show and etc.

System development tools of prototype are divided into the following four parts [10] (as shown in figure 3).

1. Worldwide web: integrate FTP, News, Gopher, WWW and other systems.
2. Wamp: Window+apache+mysql+php.
3. Dynamic web languages: the most commonly used ASP, JSP, PHP.
4. Interactive webpage.

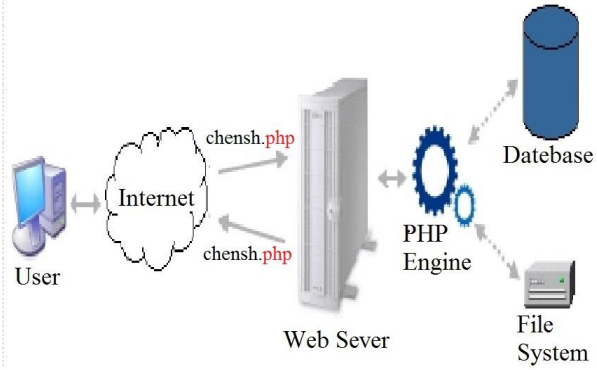


Figure 3. Dynamic web mode of operation [10]

This system provides fire investigators using any tablet PCs or smart handheld device which can support internet services and data transmission. The main structure is shown in figure 4.

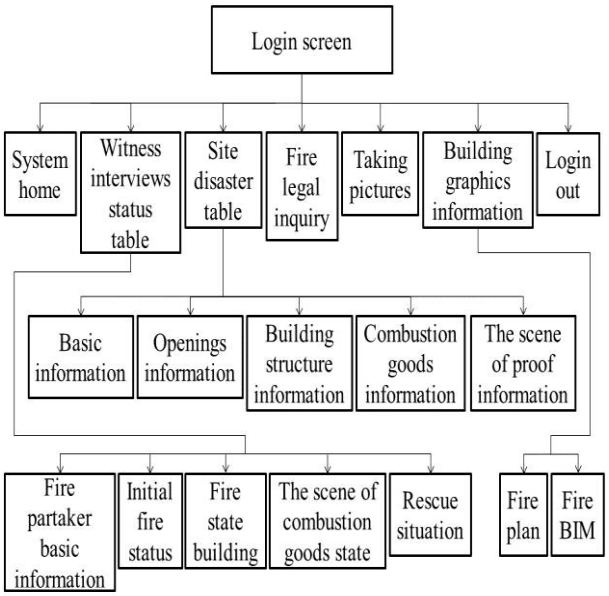


Figure 4. The main structure of system

The system development environment of build work is divided into three steps:

1. Install WAMP erection website server.
2. Setting backend server.
3. Install text editor.

After completed above-mentioned parts, this study uses wed design and development environment, then utilizes for default browser by doing webpage test.

5 System demonstrate and case simulation

To illustrate the research result; a simulation case was applied as the demonstration.

A. Fire Case Mode Description

In this case, it will be a fire happened on the second floor of a building in Taipei city. The official document of the fire cause investigation will contain the following record:

1. Summary of fire scene: Date, time, add and cause.
2. Fire disaster survey: Detailed report situation, scene of the accident and the fire creep trend.
3. Situation after burning: return for scene of the accident report, items burning case, casualty circumstances.
4. Information of pictures: The scene of photo, 2D-pics and using by Sketchup software build 3D model is shown in figure 5 and figure 6.

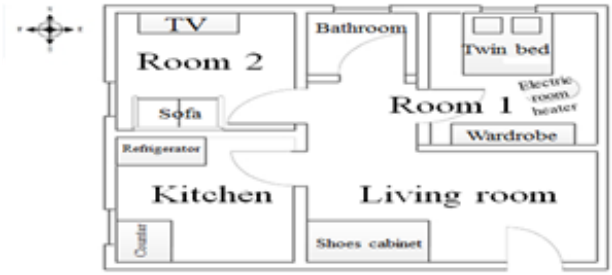


Figure 5. Fire plan of case simulated

Figure 6. Plan view of model case simulated

B. Fire Case Simulation Applied To The System Screen

According to the case explanation and fill in overview set into system page to show from previous section:

1. Login screen: Confirm the identity of the fire appraisers, user import correct account number and password (as shown in figure 7).

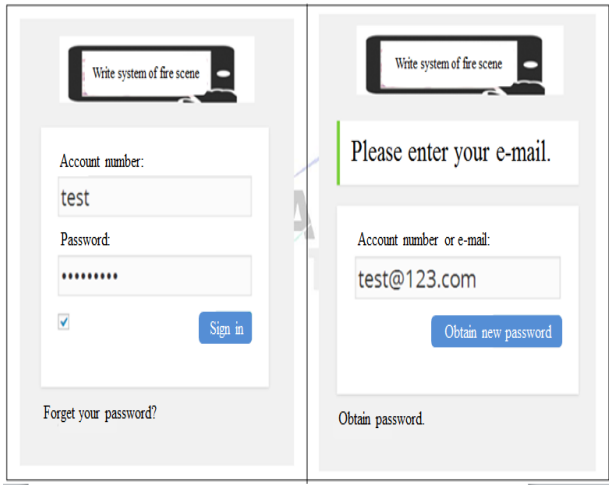


Figure 7. Login screen

2. Homepage: Show the system name and explanation, write basic data, can select their own addresses. It also can let smart handheld device in response to GPS positioning function.
3. The scene of prospecting form: First of all must be cut space and give number before exploration. Include basic information and information of openings, building structure, burning goods, the scene of site (as shown in figure 8).

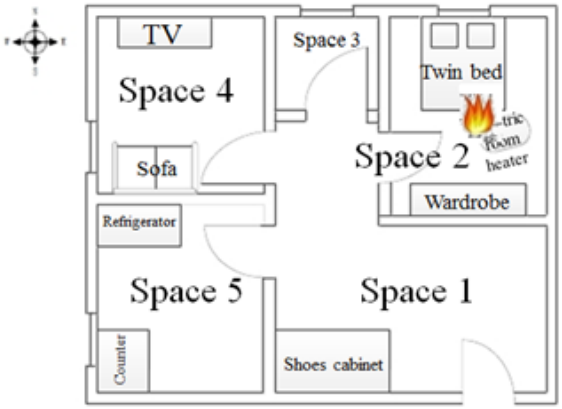


Figure 8. Simulated space case

4. Witness status interviews form: Including basic information of personal relationship, beginning fire disaster status, outbreak of fire status, the scene burning goods status and the rescue situation (as shown in figure 9).

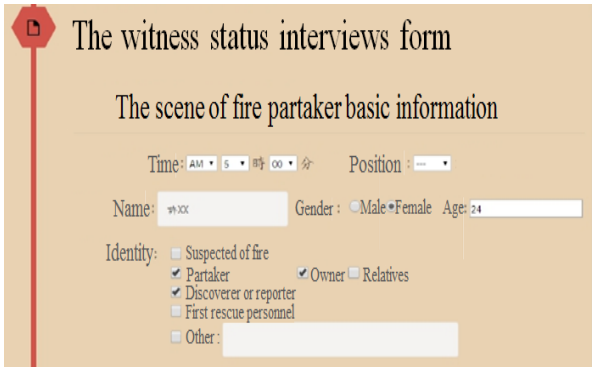


Figure 9. The witness status interviews form

5. Firefighting laws inquire: Embed the rules of fire services of National Fire Agency, provide the fire investigators to inquire these laws comfortably.
6. Take photo: This system can offered uploading photos in smart equipment, films or audio files, subjoined some words to remark.
7. Building graph information: According to WebGL and HTML5 appear interactive BIM, rotate model directly on this page, eliminates inconvenience (as shown in figure 10 and figure 11).

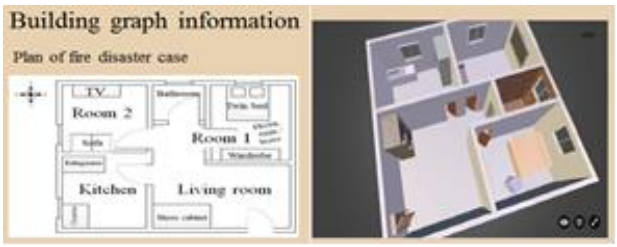


Figure 10. The fire disaster simulation case by plan and modeling

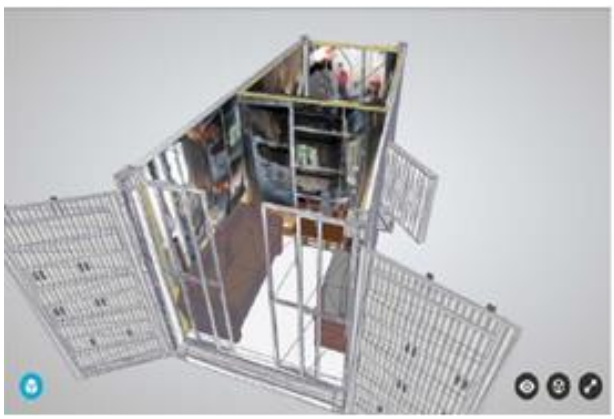


Figure 11. The scene photo planted simulation model

8. Log out: After using system, can log out in order to protect personal information.

C. The Result for Bedpan's VOF Analysis Experts Test

This research interview process with experts using the computer, the smart handheld device actual operate and comment, doing opinion exchange to feedback and revise (as shown in figure 12).

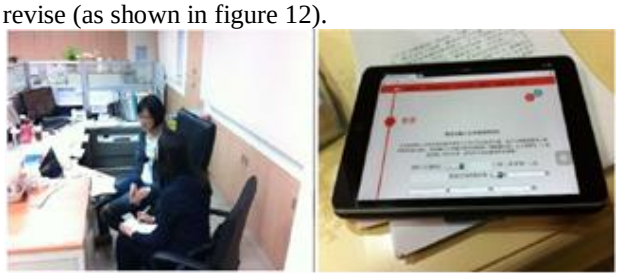


Figure 12. Interviews and test schematic diagram in smart handheld device

6 Conclusions and Suggestions

The cause of fire investigation is a very important business in fire management, the result of the fire investigation is not only a reference for the prevention of fire prevention, but also an important basis for the improvement of fire rescue, so the results of the investigation is correct or not, the relationship between the public interest is very important, therefore, the fire causes of the investigation report produced by the distribution, logical and rigorous quality of the project, for the entire investigation work, can be regarded as a key indicator of work, and this study for the convenience of fire investigators can fill out more immediately, to improve the accuracy of the situation on the fire, After research and construction of the fire cause investigation system and the building information modeling, draw the following conclusions and recommendations:

6.1 Conclusion

1. This study constructs two-tier system architecture, respectively for the client and server side. Server-side use WAMP for the server operating system, the database uses MySQL as the database engine. PHP technology to do front-end construction, and the system not only provides the results of the inspection data storage, in the future can be related to the relevant units.
2. Combined with building information modeling technology can improve the traditional plan space and visual deficiencies of the place, to enhance the convenience of the relevant personnel to read the fire investigation and identification book.
3. Systematic fire causes investigation and identification of the information in the book, do the form of information conversion, facilitate the fire scene investigation and identification of personnel records of the immediacy and correctness, echo the demands of automation; In addition, the system and after the expert test, in accordance with the recommendations to do the appropriate feedback and amendments, can be more in line with the relevant personnel to fill the scene.
4. This research constructs the system In addition to the use of desktop computer operating system, can also be used with the smart phone online login, immediately check the results stored in the back-end database, and the introduction of computerized system operations can not only effectively improve the previous handwriting records, to achieve the demands of less paper, echo the trend of environmental conservation and energy conservation.

6.2 Suggestions

The construction of the fire investigation system combined with the construction information model is a preliminary prototype system, the future can be based on practical application of continuous feedback correction, to make the system more perfect; Based on the experience of this study, subsequent research recommendations are as follows:

1. The system of this study is connected to the system page for the input URL, the characteristics of the smart handheld device has not been fully used, the future can be developed specifically designed for smart handheld devices, make operation and performance more optimized
2. After the expert interview proposal can use the form to write the information, combined with fire dynamic simulation software for the import of parameters, by the results of the simulation analysis can help the fire identification staff more clearly determine the cause of the fire.

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