RESEARCH ARTICLE

Design and Implementation of 3D Library Application System-Taking The Library of Henan University of Technology as an Example

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Abstract

As more and more traditional application systems begin to integrate 3D technology, building a 3D library application system with the advantages of 3D technology is conducive to improving the user's borrowing experience, improving the efficiency of users' querying books and reserving seats, and combining monitoring equipment can effectively improve the accuracy of seat occupancy monitoring, and through the statistics and analysis of reservation data, borrowing data and other data, it can provide decision support for library managers, thereby improving the quality of library services. This paper takes the library of Henan University of Technology as an example, based on the SuperMap iClient3D 10i for WebGL platform, based on the actual scene and related textures of the library, using AutoCAD and 3D MAX for 3D modeling; then using computer WEB, Cesium and Node.js Finally, a three-dimensional library application system with functions such as scene browsing, book query, seat reservation, occupancy monitoring, reservation statistics, borrowing statistics and user management is realized.

Keywords: 3D library, 3D website, SuperMap, Cesium, Node.js.

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1 Introduction

Nowadays, as an important part of the social public cultural service system, the library has become one of the important application scenarios of the new technology [1].

The function display form of the traditional library application system is relatively simple, mainly in two-dimensional and 2.5D forms, lacking three-dimensional, intuitive and vivid, and it is difficult to attract readers' interest in reading [2]. With the development and maturity of the 3D library application system, the 3D library application system brings a brand new reading experience to users by virtue of its advantages of three-dimensional interconnection, strong immersion, strong interaction, and multi-sensory.

In recent years, with the increasing maturity of computer hardware technology, 3D technology has been widely and successfully applied in urban planning, education, military, entertainment, tourism, medical and other fields [3]. In terms of 3D systems, the United States is one of the first countries to start the research and application of 3D virtual reality technology, and it still represents the highest level of international 3D virtual reality technology. As early as the middle of the 20th century, the library system in the United States had already set up three-dimensional information service projects, and many application results have been achieved, among which the famous

application projects are the Virginia Beach Public Library "Great Scenic Story" project completed in 2011 and The Binghamton University Library Application "Wonderful AR Books" project completed in 2014 and so on [4].

Compared with foreign countries, the research and application of 3D virtual technology in my country started late but developed rapidly, and many excellent application results have been achieved today. As one of the earliest units in China that started to study 3D virtual technology, Zhejiang University has successively developed a desktop real-time roaming system for building environments; in 1996, Tianjin University developed the earliest virtual campus system in China based on VRML, which has opened up virtual reality since then. The prelude to the application of technology in the domestic education field. Tsinghua University, Peking University and other universities have also developed their own virtual campus systems. Among them, the virtual roaming system of Tsinghua University can not only meet the needs of users to understand the campus, but the model can also truly reflect the actual location of the building, and users can roam in it. , can interact with virtual objects, and realize the query and information display of objects in the virtual campus environment; the virtual library system of Hunan University is a system similar to a three-dimensional game. There is a small character representing the user in the scene, and the user clicks on the scene Characters anywhere will automatically find their way and walk over [5]. Subsequently, some domestic map software also began to use virtual reality technology.

At present, there are still the following problems in the research and application of 3D library application system in China: First, the application results of 3D technology in libraries are very limited, and the number of related articles published on major platforms is relatively small. 2. Some 3D virtual library systems are too focused on reader education and scene roaming, but neglect to expand the library's business functions (such as book query, seat reservation and seat occupancy monitoring that are frequently used by users), resulting in Its business function is too single and its presentation form is too ordinary [6]. 3. The existing 3D library application systems are rarely able to provide decision support, and lack the statistics and analysis of user data (such as borrowing data, reservation data, etc.) [7–9].

In view of the above problems, a 3D library application system based on B§architecture is designed. By using 2D pictures and 3D bookshelf model to enhance the display effect of book query, by using TensorFlow to capture the data captured by monitoring equipment (such as cameras) [10–12]. The user image is identified to determine whether the seat is occupied, and the user data received by the system is analyzed, and the generated 3D visualization results are displayed in the 3D scene, so as to enhance the business capabilities of the 3D library application system and increase business functions form of presentation.

2 Overall Design

2.1 Functional Design

The system has scene browsing function, book query function, seat reservation function, seat occupancy monitoring function, reservation statistics function, borrowing statistics function and user management function.

2.2 Module Design

According to the functions of the system, the 3D library application system includes 8 modules: library scene model, scene browsing module, book query module, seat reservation module, seat occupancy monitoring module, reservation statistics module, borrowing statistics module and user management module.

(1) Library scene model: The 3D scene model of the 3D library application system is made by AutoCAD software and 3D MAX software.

(2) Scene browsing module: After the 3D scene is loaded, operations such as translation, rotation and zooming of the scene can be realized through the mouse.

(3) Book query module: Search the library collection data through the keywords provided by the user, and query the matching information. When the user clicks on a specific piece of data, then query the specific bookshelf where the book corresponding to the data is located. Finally, according to the text information of the bookshelf position, match and find the position of the bookshelf in the three-dimensional scene, and move the scene to the position of the bookshelf. While displaying the position of the bookshelf in the 3D scene, it also shows the floor plan of the bookshelf on this floor and the position of the bookshelf, assisting the user to locate the position of the bookshelf in the real space. Moreover, users can also choose to send the result information found in the system to their own mailbox.

(4) Seat reservation module: realize the reservation of library seats, as well as the functions of check-in, check-out, temporary departure and return after reservation. And the ability to get individual reservation status and get all seat reservation status.

(5) Seat occupancy monitoring module: Obtain images of library seats through monitoring equipment (such as cameras, etc.), and then use TensorFlow.js to identify the images, analyze the recognition results and the reservation data of library seats, and find out who is occupying the seats. condition.

(6) Reservation statistics module: Obtain all seat reservation data within the specified time period through the crawler program, analyze according to the specified reservation method (the most number of reservations for analysis and the least number of reservations for analysis), and display the analysis results in a three-dimensional scene, which is a book Library managers help with decision-making.

(7) Borrowing statistics module: By analyzing the data of books borrowed by users within a specified time range, the number of books borrowed by each unit in the campus is counted, and the geographic location information is given to the data, and the statistical results are displayed in a three-dimensional data visualization idea. In the three-dimensional scene, it can provide decision support for library managers.

(8) User management module: Provides functions such as user registration, login and logout.

2.3 Database Design

1) Database table division: According to demand analysis and preliminary analysis of the system, it is concluded that MongoDB can be used as the database of the system. Database tables can be divided into bookshelf (bookshelf table), bookshelfMap (bookshelf SmUserID table), users (user table).

2) Introduction to database tables

(1) bookshelf (bookshelf table): Stores information about bookshelves in the library, as shown in Table 1.

(2) bookshelfMap (bookshelf SmUserID table): You can check the SmID and SmUserID of the bookshelf, as shown in Table 2.

(3) users (reader table): authorized user ID and authorized user ID, as shown in Table 3.

Table 1. Datasheet details of bookshelf.

Field Name	type	MEANING
modeID	Int32	Bookshelf Model ID
floor	Int32	The floor where the bookshelf is located
direction	String	The direction of the library where the bookshelf is located (east and west)
row	Int32	Number of rows of bookshelves
face	String	A and B sides of the bookshelf (front and back)
cameraArg	Object	Camera positioning parameters for bookshelves

Table 2. Datasheet details of bookshelfMap.

Field Name	type	MEANING
SmID	String	Bookshelf Model SmID
SmUserID	String	Bookshelf Model SmUserID

3 Development Process

According to the functions and modules of the system, combined with the general process of software development, the development process of the 3D library application system is divided into 5 steps:

(1) After planning the layout of the scene, extensively collect all kinds of materials needed through online search, field shooting, recording, etc., including model stickers, text, arrow marks, artificial voice prompt audio, etc. For picture materials with low resolution and unsatisfactory size, it is necessary to first use Photoshop to process the normal map that can produce stereoscopic effect, is more realistic and can ensure the smooth running of the system; for voice and audio files, you can use video recording software such as EV Record audio files in MP4 format, and then convert them into high-quality audio files in MP3 format

Table 3. Datasheet details of users.

Field Name	type	MEANING
username	String	username
password	String	Password
targetSeatID	String	User reservation target seat ID
setName	String	The name of the target seat reserved by the user
userId	String	User's id
tag	String	Remark

through audio processing software such as GoldWave. Finally, the original material is analyzed and classified to prepare for subsequent modeling [13–15].

(2) Based on the surveying and mapping data, the CAD drawings of the library of Henan University of Technology were drawn with AutoCAD software. Combined with the field, according to the basic modeling requirements, with the help of 3D MAX software, the polygon modeling method is used to model indoor tables and chairs, bookshelves, books, windows, characters, outdoor teaching buildings, flower beds, trees, indoor and outdoor ground, etc. The corresponding white model is attached, and the texture of the model is attached to the model surface. In view of the fact that the model with large amount of data has high requirements on computer hardware, in order to make the 3D library application system run on various devices as smoothly as possible, all models in the system need to be simple models. Finally, a tile cache is generated from the completed 3D scene model for smooth display in Cesium.

(3) After meeting the basic requirements of coordinate axes, animation, shader, scale, etc., export the model data with 3D MAX, and open the input UDB data source in SuperMap iClient3D 10i for WebGL software to load the model data. SuperMap iClient3D 10i for WebGL software is the core technology of the system. On this basis, the entire system completes the development of modules such as scene browsing, model loading, book query, seat reservation, seat occupancy monitoring [16–18], reservation statistics, borrowing statistics and user management.

(4) The back-end technology stack of the 3D library application system adopts Node.js, express, ejs and MongoDB. Using Node.js to support back-end services, the main work includes acting as a static resource server and starting crawler programs. Use express for creating simple servers, managing routes and using various middleware. Using ejs as the rendering engine of the page to provide support for the rendering of the page. Finally, use MongoDB for system data storage and query.

(5) The front-end of the system uses the Bootstrap framework to design UI interaction, and all controls and window designs adopt the native Bootstrap style and are customized. In addition, front-end development improves system development efficiency by using jQuery framework.

4 System Implementation

4.1 3D Model Establishment

The three-dimensional models that this system needs to establish include library model, road model, table and chair model, bookshelf model, book model, character model, teaching building model, tree model, etc.

The 3D model is mainly developed in 3D MAX software, and the final output data set file.

In 3D MAX, the polygon modeling method is used for modeling. Any object is composed of points, lines and planes. The models required by the 3D library application system are based on basic shapes, and are modified by changing points, lines and planes. For some more complex models, you can adjust them by modifying the command after the basic model is established.

In order to improve the fidelity of the 3D model, some 3D model surfaces need to use textures. For this type of texture, generally use realistic network pictures, and then use Photoshop software to adjust the image, enlarge or reduce the scale of the texture, make the texture fit the size of the model, and change the color of the image to match the model.

4.2 Construction of System Function

4.2.1 Scene Browsing

After entering the system, the system automatically loads the 3D scene. Users can interact with the mouse, such as pressing the left button, right button, middle button, etc. to move, so as to realize the movement, zoom and rotation of the scene. Figure 1 is the external scene display interface of the library, and Figure 2 is the internal scene display interface of the library.

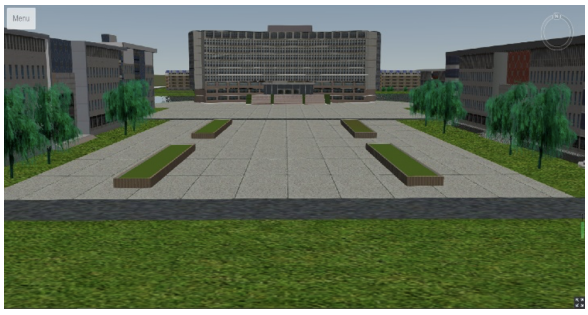

Figure 1. External scene display interface of the library.

4.2.2 Book Query

Users can inquire about book information by 2D and 3D positioning of the book and by sending the information to the mailbox. 3D positioning refers to

Figure 2. Library interior scene display interface.

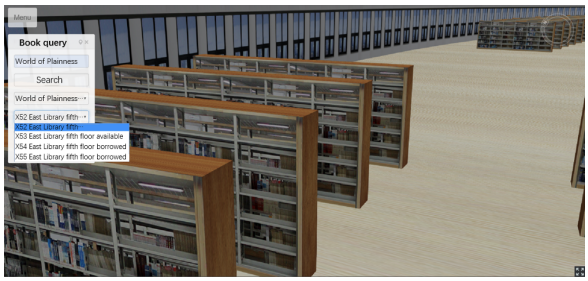

Figure 3. Search results.

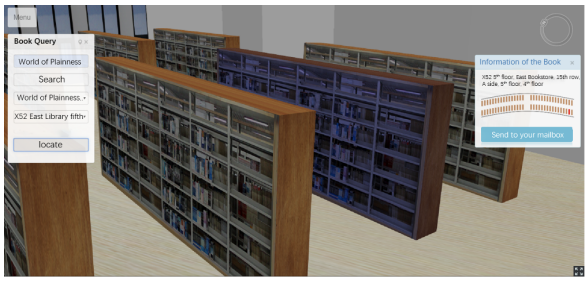

Figure 4. Book positioning.

locating the bookshelf where the book is located in the 3D scene and highlighting it. Two-dimensional positioning refers to the use of canvas technology to display the floor plan of the floor where the bookshelf is located, and to highlight the bookshelf where the books are located.

When users want to search for a book, they can enter the keyword in the search box. After clicking the search button, the system will submit the keyword to the back-end crawler module. The crawler module starts to work on the official website of the school library to crawl the keyword search information and format the information. Return to the front end after melting. The user selects the book to be borrowed in the search results, and then performs a similar process again to crawl the detailed information of the book provided by the library's official website, including location information and collection information. At this time, the user can click the positioning button to perform two-dimensional positioning and three-dimensional positioning of the book. When performing three-dimensional positioning, it is necessary to request the camera positioning parameters corresponding to the bookshelf from the database. In addition, the user can also enter the email address to send the searched results to the mailbox. The system will submit the text information, 2D pictures and 3D pictures to the back-end server, and then the information will be sent to the user's mailbox after being processed by the back-end server.

Take the book "Ordinary World" as an example to query, locate the book, check the three-dimensional position and two-dimensional position of the bookshelf where the book is located, and test sending the information to the mailbox. Figure 3 is an interface of search results, Figure 4 is an interface of book location, and Figure 5 is an interface of receiving book information by user mailbox.

4.2.3 Seat Reservation

In a 3D scene, users can make seat reservations by clicking on unreserved seats. After booking a seat, you can also perform operations such as check-in, check-out, temporary departure, and departure and return. Users can also obtain individual seat reservation information and the reservation status of all seats by clicking a button.

When the user enters the seat reservation function, the system will detect whether the user is logged in to the account, and this function is prohibited if not logged in. After logging in, when the user opens the reservation function panel, the system will automatically retrieve and query the user's seat reservation status, update the reserved status of all seats, and start the crawler program to crawl the latest book data in real time. After that, users who have not made a reservation can click on the vacant seat (there will be a character model on the reserved seat) to make a reservation, and the reservation that conforms to the library reservation rules can be allowed. After

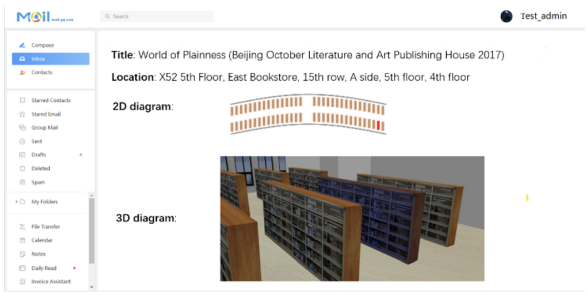

Figure 5. Book information sent to email.

the reservation is successful, the vacant seat will be loaded with a character model, which means that the seat has been reserved. Users who have made reservations can perform operations such as check-in, check-out, temporary departure, and return from departure. These operations are submitted by the system to the library server for processing, and the processing results are presented to the user. Figure 6 is the interface of successful reservation, and Figure 7 is the interface after the seat status is updated.

Figure 6. Seat reservation.

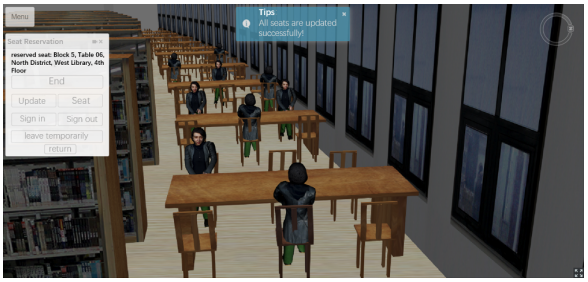

Figure 7. Update all seat status.

4.2.4 *Seat Occupancy Monitoring*

The system can capture library images through monitoring equipment (such as cameras), identify the images with TensorFlow, and determine whether there are people in each seat. Then, the obtained results are compared with the seat reservation data of the library server, and it can be obtained whether there is occupancy on each seat.

After the user turns on the seat occupancy monitoring function, the monitoring equipment such as the camera starts to work and transmits the captured image back to the front end. After the front end receives the image, it uses TensorFlow to recognize the image. According to the recognition result, it can be obtained which seats are occupied. Then, the library server is requested to obtain all seat reservation data, and the seat occupancy status can be obtained through comparative analysis with the image recognition results. Figure 8 is an interface of seat occupancy identification, and Figure 9 is an interface of seat occupancy monitoring.

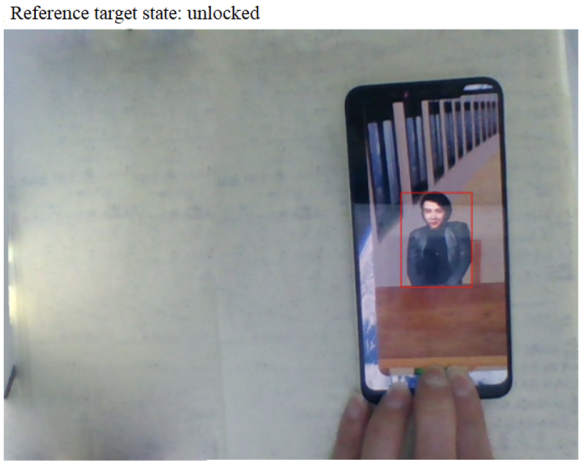

Figure 8. Seat occupancy recognition.

Figure 9. Seat occupancy monitoring.

4.2.5 *Reservation Statistics*

The user can realize the reservation statistics of the seat data by selecting the data time and method on the function panel.

After the user selects the data time period to be analyzed and the analysis method (analyzes the seat with the most reservations or the seat with the least reservation), clicks the Statistics button, the system submits the time data and other parameters to the library server, and the library server accepts the request. The data is returned, and the system analyzes the data after receiving it. After the analysis is completed, the data is displayed in a 3D visualization in a 3D scene. Fugure 10 is an interface for statistics of the method with the largest number of reservations, and Figure 11 is an interface for statistics of the method with the least number of reservations.

4.2.6 *Borrowing Statistics*

The user can select the time period on the function panel to realize the statistics of the borrowing data of the readers.

After the user selects the data time and clicks the data statistics button, the system submits the time data and other parameters to the library server, the library server returns the data after accepting the request, and

Figure 10. Most appointments.

Figure 11. Minimum number of appointments.

the system analyzes the data after receiving the data. The geographic data required for visualization will be displayed in 3D visualization in the 3D scene after completion. Figure 12 is the interface of borrowing statistics.

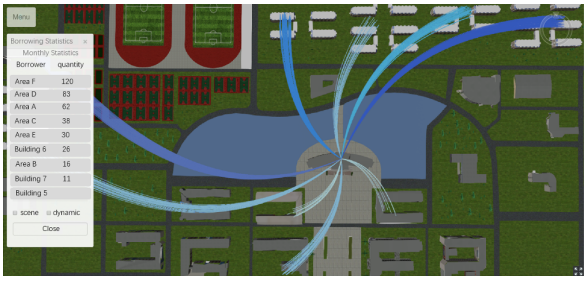

Figure 12. Borrowing statistics.

4.3 Interface Design

The interface of the 3D library application system adopts the Bootstrap style to design UI interaction to realize the functions of user login, registration and logout. When the user uses some functions in the system, if he does not log in, the user will be forced to log in, otherwise the function cannot be used.

The user clicks the register account button on the login page to perform the registration operation, and then enters the account number, password, confirmation password, verification code, etc. in turn, and then clicks the register button to submit the registration request. The back-end server verifies that the request submitted by the user is legal and approves the registration request. After completing the registration, the user uses the registered account to log in. After entering the account number, password, verification code and other information on the login interface, he can click the login button to log in. After the background server verification is passed, the login operation can be completed. The logged-in user can click the logout button to logout the login information, and the operation will destroy the cookie information set during login. The login interface of the 3D library application system is shown in Figure 13.

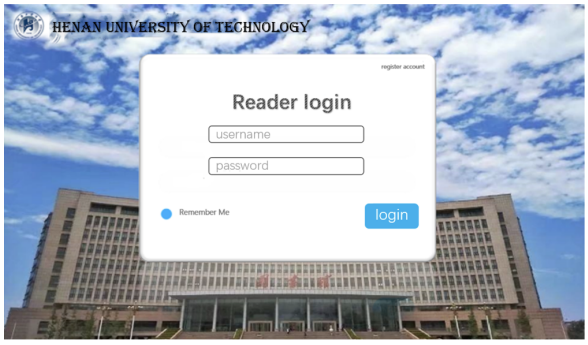

Figure 13. Login interface.

5 Conclusion

Based on AutoCAD and 3D MAX software, a realistic library scene model is obtained. Based on SuperMap iClient3D 10i for WebGL platform, Node.js, express, ejs, MongoDB, Cesium and Bootstrap, the scene browsing function, book query function, seat reservation function, Occupancy monitoring function, reservation statistics function, borrowing statistics function and user management function. In addition, the system has data analysis capabilities to provide decision support. The design and implementation of this system is a beneficial exploration and attempt to the application system of the three-dimensional library. The system truly reproduces the style and appearance of the library of Henan University of Technology, which not only realizes the basic functions of the traditional library application system, but also effectively improves the readers' experience User experience and use efficiency also provide a certain reference for the subsequent application of new technologies to libraries.

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