Intelligence Design and Application of Inquiry Management System for Deep-sea Nautical Data Resources

Shuang Li[1*], Xiang Gao[2], Zhenkai Fan[1], Qihan Zhou[1], Yi Sun[3]
e-mail:ls02020029@163.com, jessegao21@163.com, 2775778584@qq.com, johnny6666@live.com, 260910949@qq.com

[1]Dalian Naval Academy Dalian, China

[2]Shenyang Centralized Fund Collection and Payment Management Center Shenyang, China

[3]China Navigation Publication Press Tianjin, China

Abstract—In order to promote the sharing of teaching and training resources for deep-sea navigation and improve the level of information management, in view of the spatial and confidential characteristics of deep-sea nautical data resources, the deep-sea nautical resources intelligent query and management system was designed and applicated in this paper. The online sharing and informatization management system of deep-sea nautical data resources has been established. The system can meet the needs of users to retrieve deep-sea nautical data online based on the spatial attribute information. At the same time, the process of borrowing and approving military secret-related materials through the system is strict, meeting the needs of military information security management and control. The system improves the use efficiency and management support efficiency of deep-sea nautical data resources. It can provide a certain reference for the management of navigation data resources and the construction of a co-construction and sharing system for classified resources.

Keywords- deep-sea nautical data; information management; resource sharing; spatial properties; confidentiality; RFID

1 INTRODUCTION

The policy of military education in the new era requires improving the level of informatization, intelligence, and actual combat in the teaching of military academies, and deepening the sharing of education and training resources. Over the years, various units of the navy have accumulated rich deep-sea nautical data resources of teaching and training based on tasks such as teaching, guarantee, and drills. However, due to the confidentiality and security factors involved in military information, many resources cannot be shared in time. Under the premise of confidentiality and security, breaking the "data island", strengthening the sharing of resources, and changing the current situation of scattered deep-sea nautical data resources, low

ICICA 2022, December 02-04, Chongqing, People's Republic of China

DOI 10.4108/eai.2-12-2022.2328035

level of informatization management, and unobstructed access paths are the inevitable requirements for strengthening the modernization of the military [1,2].

The predecessors have done a lot of research on the intelligent management of resources and the sharing of high-quality resources, and achieved certain results [3-5]. As the most basic and widely used content of ocean navigation data resources, the management and sharing of navigation book resources has similarities with local libraries, but it is not exactly the same. The management and support of military navigation data resources has the following characteristics. Firstly, charts have spatial attributes that ordinary books do not have. Secondly, many military data on deep-sea navigation is confidential information, which involves the responsibility of security and confidentiality. Thirdly, the number of people guaranteed for deep-sea nautical training is large, and there are many batches of borrowing and returning. In view of the above characteristics, on the basis of previous researches, this paper initially designs and develops an intelligent query and management system for ocean navigation data resources combining with actual military application requirements. The purpose is to promote the sharing and sharing of military navigation resources and improve the level of military information management.

2 REQUIREMENTS ANALYSIS

The main function of the intelligent query management system for deep-sea nautical data resources is to realize the information management and maintenance of deep-sea nautical data resources under the premise of ensuring the confidentiality and security of military information. At the same time, it meets the needs of users to retrieve, download and share data resources online based on different attribute information such as space and category.

2.1 User Interface

Distinguish between administrators and ordinary users. After logging in through account and password, ordinary users can only access the data query interface, while the system administrator can also access the data maintenance and borrowing management interface to realize the background online management of deep-sea nautical data resources and system interface functions. When administrators and ordinary users borrow data resources, they need to approve according to the process. The use case diagram is shown in Fig.1.

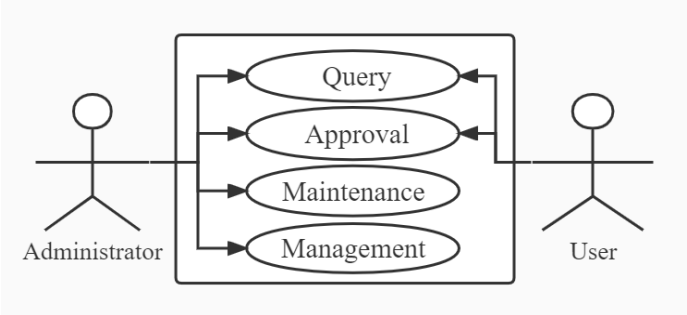

Figure 1. The use case Diagram.

2.2 Main function

The main function of the system is the query, maintenance and management of ocean navigation data resources.

- Firstly, the system provides diversified display and retrieval methods according to their attribute information for different types of navigation data. Data resources with spatial attribute information can be retrieved according to spatial location information.

- Secondly, the system optimizes the design of the human-computer interaction interface to improve management efficiency. The system optimally designs the interface according to the common requirements of the administrator. Different types of data in the system are maintained and managed separately. The administrator can modify data attributes based on management requirements self-defined.

- Thirdly, it is necessary to realize the full life cycle control and intelligent management of resources online [6].

2.3 Information security

The management of military secret-related materials should strictly implement the hierarchical responsibility mechanism to ensure the security of military information.

- The system connects to the personal card account, and the data borrowing is checked and approved level by level according to the prescribed process. The accurate approval history record is kept, which is finally reviewed and confirmed by the administrator, and watermarked files can be exported for future reference.

- The system administrator can manage the user's download permission as a whole, and adjust the user's access and download permission to different levels of classified data according to different users.

- The system must be equipped with data backup and recovery functions to reduce the risk of data loss during system running.

- In the process of system operation, the integrity of data needs to be strictly controlled. Data that does not meet the standards cannot be saved, and users should be prompted at the same time.

3 THEORY AND METHODOLOGY

In this paper, the RFID technology is improved and applied to the management of paper charts/books of deep-sea navigation. Customized and developed software systems according to management requirements. RFID technology is integrated with the software system, and users can use the system to complete the intelligent query and management of deep-sea nautical data resources.

3.1 The technology principle of RFID

The system adopts RFID (radio frequency identification devices) technology to design intelligent dense chart cabinet and bookshelf. That is, readers, antennas, identification lights and other devices are installed on the traditional cabinet. A chart or book is tagged with a custom-made RFID tag that contains a chip with data information. The administrator controls the reader to signal through the intelligent information system. When the tag is in a magnetic field, it receives a radio frequency signal from the reader and uses the energy obtained from the induced current to send product information stored in the chip. After that, the reader reads and decodes the information and sends it to the central information system for data processing. The design drawing of intelligent chart cabinet is shown in Fig.2.

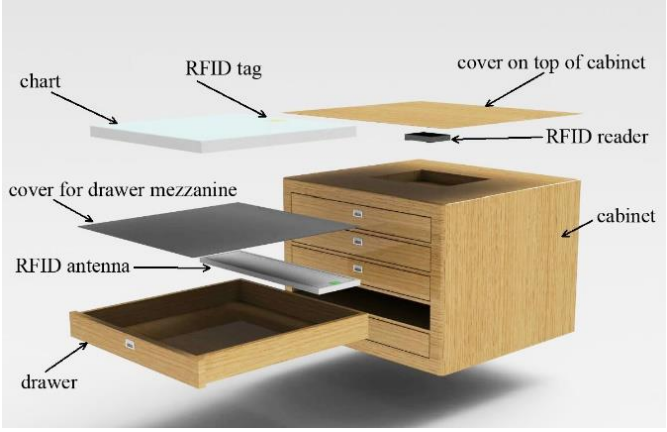

Figure 2. The design drawing of intelligent chart cabinet.

Nautical chart tags feature high density and 100% overlap. The key to the application of RFID technology on nautical charts is to use a multi-tag anticollision algorithm, develop a decoder that can adapt to intensive reading, and achieve an accurate reading of intensive chart tags. The principle of the anticollision algorithm is to continuously send an inquiry command to the tag containing a serial number. After the tag receives the command, it checks whether the serial number in the command is the same as its own serial number, and if it is different, it will not answer. If the reader does not receive an answer within the specified time, it will send an inquiry command containing another serial number until a tag whose serial number meets the requirements and completes data communication with the reader.

The anticollision of the tags uses the dynamic disperse shrink binary tree anticollision algorithm (DDS-BT), as shown in Fig.3. In this algorithm, the initial value of the time slot counter of the tag is set to 0, and the time slot counter is gradually adjusted according to subsequent commands. When the time slot counter is 0, the tag jumps from the arbitrate state to the reply state and starts to respond to the reader:

3.1.1 When there is no reply from the tag:

a) When the reader cannot receive a reply from the tag, it first determines whether to end the checking. If the criterion is true, the checking is over.

b) If the checking is not completed, it is necessary to judge whether the number of consecutive idle time slots reaches CIN (continuous idle threshold, the typical value is 4). If the number of consecutive idle time slots is not less than CIN, then the shrink command is sent, and the value of the tag time slot counters in all arbitrate, and reply states are divided by two and rounded.

c) If the number of consecutive idle time slots is less than CIN and the command sent by the previous time slot reader is a divide command, the reader sends a divide command with the divide position of 1, and all tags with a slot counter value of 1 are divided.

d) If the number of consecutive idle time slots is less than CIN and the command sent by the previous time slot reader is not a divide command, the reader will send a repeat query command, and all tags of time slot counters in arbitrate state and reply states are reduced by 1.

3.1.2 When the tag replies correctly:

The reader receives the RN11+CRC5 that the tag replies correctly, the reader sends the code acquisition command, the tag sends the security mode, code length, and code, and jumps to the confirm state.

3.1.3 When tags collide:

a) When the reader receives multiple tag collision signals, it needs to determine whether the number of consecutive collision time slots reaches the CCN.

b) If the number of consecutive collision time slots is less than CCN (continuous collision threshold, the typical value is 3), a divide command with the divide position of 0 is sent, the tag in the reply state is divided, and the tag time slot counter in the arbitrate state is incremented by 1.

c) If the number of consecutive collision time slots is not less than CCN, a disperse command is sent, and the value of all the tag time slot counters in reply and arbitrate states is multiplied by two and then added with a random number.

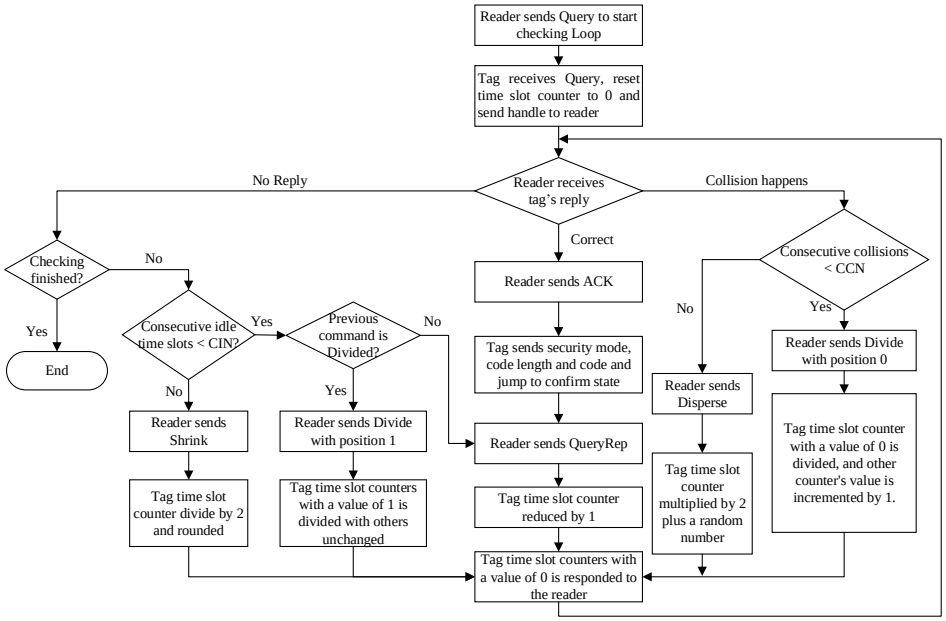

Figure 3. Multi-tag anticollision process flow chart.

3.2 System design method

The development of software system follows the principles of standardization, reliability, security, and scalability. On the premise of ensuring data security and system reliability, the portability and function expansion of the system are guaranteed to the greatest extent.

- The Browser/Server software architecture is used in the system. Users access the service through a browser without installing application software. All upgrade and maintenance work only needs to be performed on the server side, which can effectively reduce system maintenance and upgrade costs [7,8].

- The system is developed with JAVA and the Spring Boot framework. JAVA has the characteristics of simplicity, object-oriented, stable, high portability, cross-platform, multi-threading, dynamic, etc, which is conducive to the cross-platform deployment and secondary development. Developers can use the Spring Boot framework to simplify the system development and deployment process, and quickly debug the system[9].

- MySQL is one of the most popular relational database management systems. It has the advantages of open access, small size, fast speed and convenient maintenance[10,11]. Since the data type and structure of nautical book information are not complicated, the MySQL database is used in the system. According to the integrity requirements of the system and data resources, a total of 12 data tables have been created to support the processing of various functional data, including the system user table, classification information table, chart information table, chart new purchase and scrap information table, and book Information table such as classification, edition, new purchase and scrap, loan and return, etc.

- In terms of system security design, the confidential data and non-confidential data are stored on different servers, and the data security in the system is ensured by backing up the database and recording user operation logs.

4 FUNCTIONS

The paper navigation books, electronic charts, navigation cases and other data resources are queried and managed by the deep-sea nautical data resources inquiry management system. The system can achieve the following functions.

4.1 Data Query

The data resource query function of the system is mainly divided into two parts: chart query and book query. Google Maps is used as a base map to accurately display geographic locations around the world in the interface of chart query. Intranet use is achieved through offline integration, and static resources are introduced to optimize the loading method of map resources to ensure fast response and extremely fast loading when multiple people query at the same time.

The chart query functions include: classification query, attribute query, longitude and latitude query and route query.

- Classification query. According to the parent class and subclass set by the administrator, users can check the classification check box to realize the chart classification query.

- Attribute query. Users can input the name or number of the chart and select the exact or fuzzy search method to query the chart with the corresponding attribute.

- Longitude and latitude query. By entering a latitude and longitude range, and selecting east/west longitude and south/north latitude, query all charts intersecting the latitude and longitude range.

- Route query. Users can draw routes by themselves and query all the charts within the range of the route. When drawing a route, click the mouse on the base map to determine the stops one by one for the route to pass through, and double-click the mouse to complete the route drawing. The latitude and longitude coordinates of the stops determined during the drawing process will be directly displayed in the right panel, which can be scrolled to view. Schematic diagram of route query is shown in Fig.4.

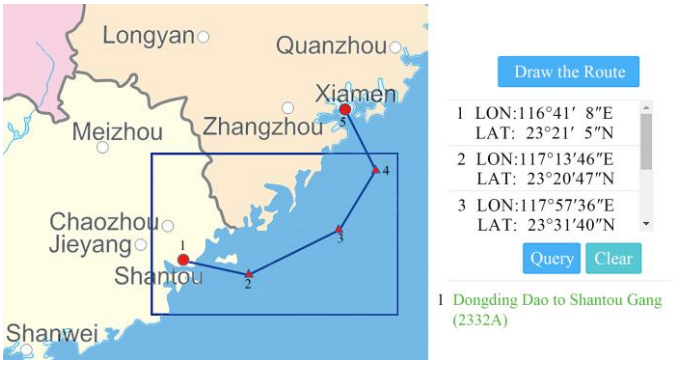

Figure 4. Schematic diagram of route query.

In addition, different chart selection methods can freely switch the chart query results under different categories by checking the chart category checkbox. Click the name of a chart in the selected query result, the latitude and longitude range of the selected chart will be displayed in the center on the base map interface, and the relevant information of the chart will be displayed at the bottom left of the interface. Users can download the selected chart online.

The book query function includes classification query and attribute query, which is similar to the chart query function. The user selects different parent categories and ticks the corresponding sub-categories to realize classification query. At the same time, the user can input the property information of the book for query. E.g. Title, isBN, author, publisher, etc. When the mouse pointer moves to the picture of the book list, click the "Details" button to view the details page of the book list, and download the book list to the local computer.

4.2 Process of Approval

Users log in to the system using identity authentication of one-card. The acquisition of resources must be approved in accordance with the prescribed procedures. The user sets up the initial process and submits it for approval. Each approver reviews the borrowing content and approval process. If it is found that the borrowing content does not conform to the borrowing procedures, confidentiality regulations and other relevant rules and regulations, then choose to refuse the borrowing and note the reasons for refusal. If errors are found in the process, the approver can adjust the process at any time. The approval history records are all kept in the system, and are finally reviewed and confirmed by the administrator. The administrator can export the watermarked loan file for inspection at any time.

4.3 Data Maintenance

The administrator manages and maintains data online through the intelligent system. In the aspect of data search and maintenance, it not only saves a lot of time, but also greatly reduces the error caused by human factors.

- The system automatically reads the "name", "number", "storage location", "inventory" and other attribute information of the inventory charts/books.

- Administrators can customize the parent and child classes of charts/books according to management needs. When the administrator changes the classification in the background, the classification displayed by the front-end user will change in real time.

- The operation bar of the interface displays common buttons such as "Borrow", "New Purchase", "Scrap", "Edit", and "Delete" to facilitate the administrator to perform related operations. Click the shortcut button on the upper right of the data list on the main interface to quickly add, enable, remove and delete data.

- In view of the situation of multiple editions of books, a one-to-many design method is adopted. That is, information such as the name and author is the same, and only the edition is distinguished to reduce redundant data.

- The system can generate various data statistical charts on demand, and all data can be exported as excel tables and downloaded directly to the local.

4.4 Borrowing Management

The borrowing management module is mainly used to manage the in-and-out-of-storage of the charts/books. Taking returning to storage as an example, the administrator uses a barcode scanner to read the information in the radio frequency tags of the charts/books, and the system automatically pops up the corresponding charts/books lists. When the administrator clicks the "Return" button in the operation bar, the system will automatically add the returned quantity to the corresponding quantity in stock, and automatically create a return record. Because a borrowing slip may involve multiple returns, the status of the borrowing slip will change to "returned" only when the total amount returned is equal to the amount borrowed. In addition, the function of the bank's handwritten signature version is transplanted into the borrowing registration module. Users use the signature version to sign to achieve paperless registration and borrowing.

5 CASE

The 12 columns of nautical chart cabinets in the warehouse, a total of 880 drawers, were renovated with RFID equipment installed and an intelligent query and management system for ocean navigation data deployed in the internal local area network to query and manage ocean navigation data (90GB) such as paper charts (1200 types and 130,000 sheets), paper navigation books (189 types, 12,000 copies/volume), electronic charts and navigation case materials.

5.1 RFID Identification Test

The number of nautical charts stored in each chart drawer is different, and the intelligent recognition effect of the system is different. The statistics of the intelligent recognition results of charts are shown in Table 1.

Table1 Nautical charts Intelligent Recognition Results.

Number of overlapping charts (sheet)	Chart checking time (s)	Checking success rate (%)	Cross reading rate (%)
1-50	0.5	99.9	0.1
50-100	1.2	99.6	0.1
100-150	2.5	95.2	0.1
>150	10.0	72.8	0.1

5.2 System Operation Test

In the 1000M intranet environment, the software stress test method is used to comprehensively test the performance of the software system. By simulating a large number of users operating on different pages of the software, we obtained the execution time of each page and predicted the system's average response time and server resource utilization under the scenario of a large number of data and concurrent users.

In the resource retrieval test, we simulated 200 users with 20 concurrent requests with a total of 4000 requests and conducted a 2-hour uninterrupted test. The throughput of the system can serve 63.92 click requests/s with no crashes and an average system response time per user of less than 1s.

In the resource download test, we simulated 400 users to access the client and download the same file simultaneously with a total number of successful downloads of 398 and an average system response time for each user of less than 10s.

6 DISCUSSION

6.1 Nautical charts Recognition Analysis

From the results in Table I, we can observe that with the increase in the number of overlapping charts, the checking time shows an obvious upward trend. There are two reasons for this: First, there is an exponential relationship between the number of tag collisions and the number of tags. The more tags there are, the more frequent the collisions between tags will be, making the identification device spend more time in tag sorting. This results in a significant increase in the checking time. Secondly, the increase in the number of tags increases the degree of mutual coverage and occlusion between the tags, forming a denser metal shielding layer, blocking the radio wave signal of the identification device, resulting in a weakening of communication quality and an increase in the rate of data transmission failures, indirectly increasing in the checking time.

In addition, blocking the radio signal will also lead to a certain degree of missed reading of the label. Within the number of 100 tags, missed reads are not significant. When the number of tags reaches more than 150, the success rate of chart detection decreases to 72.8%, and the number of missed readings increases significantly. At this time, the overlapping of the tags has formed a dense shielding layer. To improve the identification effect, we need a larger identification device antenna and spread the tags over a larger area, thereby reducing the thickness of the

shielding layer. The test results show that the number of charts stored in the chart drawer should be controlled within 100.

The cross-reading rate of overlapping sheets of different charts is 1%. This is because in an iron cabinet with an all-metal partition, since the partition completely shields the electric waves, the cross-reading effect is not significant. By further filtering the tag response signal, the cross-reading rate can be controlled to a lower level.

6.2 System Operation Analysis

It can be seen from the system test results that the user requests completed by the system in unit time can meet the data query and management requirements, and the system resources can be fully utilized. The average system response time of each user is within 1s, indicating that the system response time is short, and the user experience is excellent.

The success rate of simulating 400 simultaneous downloads is 99.5%, which shows that the system has good stability in distributing and downloading data packages and can meet the application requirements of the current system with maximum concurrent access of 300 users. If the concurrent access volume of the system increases to more than 400, it needs to be tuned again to ensure a good user experience for users downloading the same data resource simultaneously.

7 CONCLUSION

Based on the spatial and confidential characteristics of deep-sea nautical data resources, the intelligent query and management system of deep-sea nautical navigation data resources is designed and developed in this paper. The information management and sharing of deep-sea nautical navigation resources have been preliminarily realized. However, only the navigation chart and book resources are integrated in system, and the spatial query attribute only covers the chart data, which cannot be used for spatial retrieval of other deep-sea nautical data resources. Therefore, the system can be optimized as follows in the future. Firstly, other deep-sea nautical data resource sharing modules should be added, such as courseware, teaching methods, practical cases, training software, scientific research achievements and so on. Secondly, the spatial retrieval function should be applied to other resources to achieve the effect of one-click retrieval by using spatial attributes. Thirdly, the function of classified retrieval according to military mission scenarios should be added to improve the retrieval efficiency of military data. Fourthly, the big data analysis and decision module should be added to provide support for managers to make decisions. Analysis reports can be generated based on visits, queries, downloads and other data.

Acknowledgment. The research work was supported by the project of military training conditions. Thanks to the experts in the navigation department of Dalian Naval Academy for their contributions in the paper revision.

REFERENCES

[1] Xuehong Li. Design and Realization of an Information Management System for Maritime Practice. Hydrographic Surveying and Charting, vol. 34(2), pp. 43–45, March 2014.

[2] Jing Mu, Shujun Li, Dahai Zhang. Research on Incorporate Guarantee of Military and Civilian Navigational Material Information. Hydrographic Surveying and Charting, vol. 33(2), pp. 79-82, March 2013.

[3] Jing Zhou, Chuhan Zhang. Research on Book Information Management Based on Internet of Things. China Management Informationization, vol. 21(10), pp. 176-177, May 2018.

[4] Ming Hui. Design and Implementation of College and University Library Management System. Tianjin University, Tianjin, pp. 8–11, May 2017.

[5] Yujing Liu. Design and implementation of library management system based on Apriori Algorithm. Qingdao University, Qingdao, pp. 28–44, May 2018.

[6] Haifeng Chen. Design and Implementation of Warehouse Management System for Troops. Dalian University of Technology, Dalian, pp. 5–13, May 2018.

[7] Juanjuan Ding. Design and Implementation of Community Library Management System Based on B/S Model. Dalian University of Technology, Dalian, pp. 9–10, March 2014.

[8] Baolong Tan. Design and Implementation of Integrated Platform for Physical and Technological Prevention Systems of Multi-Heterogeneous. Southeast University, Nanjing, pp. 12–19, April 2017.

[9] Dengke Xie, Yi Ding. The management System of Enterprise Purchase, Sale and Stock Based on Java. Computer and Information Technology, vol. 28(3), pp. 54-56, June 2020.

[10] Juan Ju, Rui Huang. Design and Realization of Integrated Management Information System for Mapping Production Based on MySQL. Geomatic & Spatial Information Technology, vol. 43(3), pp. 54-56, March 2020.

[11] Lixiong Huang, Yin Chen, Songpengcheng Xia. Visual Management and Navigation System of Surveying Markers Based on MySQL. Journal of Geomatics, vol. 45(2), pp. 60-63, April 2020.