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RESEARCH PAPER

Intelligent Electronic Management of Library by Radio Frequency Identification Technology

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In the information era, the knowledge learned in the campus can hardly meet the needs of the society, so the library has become one of the choices for people to supplement their knowledge. With the increasing demand for libraries, the traditional library management method has been difficult to support the demand. In order to promote the intelligent transformation of the library, the basic structure and principle of Radio Frequency Identification Devices (RFID) technology were briefly introduced in this paper, and the intelligent library management system based on RFID was also introduced. Then the library of Huaqiao University was divided into two regions, and the performance of collection counting, book query and passage efficiency of traditional library management based on magnetic stripe together with bar code and intelligent library management based on RFID were compared. The results showed that the collection counting efficiency of intelligent libraries was much higher than that of traditional libraries, the high accuracy and stability of book query avoided the dislocation and chaos like traditional libraries, and there was no congestion even during rush hours because of the higher passing efficiency.

Keywords: Radio frequency identification devices; smart library; electronic tags; book management

1. Introduction

After entering the information age, information knowledge has been in a blowout state. The knowledge accumulated in the campus era has been difficult to keep up with the development needs of the times. Therefore, it has become the choice of most people to enter the library to find and learn knowledge (Timoshenko 2017). Moreover, there are more and more literature books in the library due to the simultaneous blowout development of information knowledge. The traditional library management method (Cho et al. 2015) relies on bar code together with magnetic strips. Bar codes record information about books, while magnetic strips are used for security and reader identification. Although the traditional book management method is simple in operation and low in cost, it requires more manpower for inventory collection, and there will be problems of dislocation and chaos (Garri 2015). The emergence of Radio Frequency Identification Devices (RFID) technology has promoted the development of intelligent management of libraries. Compared with traditional bar codes, RFID electronic tags can store more book information, and their information doesn't need to be read and sent with direct contact. The information interaction of multiple objects can also be carried out, which greatly improves management efficiency. For example, the traditional way of book management can only query the approximate area where books are located by computer, but it is impossible to confirm whether the book exist in that area. The real-time location of books can be queried by using the intelligent book management mode of RFID. In the aspect of book checking, the traditional book management needs a large number of people, and there may be loopholes, but in intelligent libraries, the number and location of books can be quickly confirmed through the positioning function of RFID. In the aspect of security of books, the traditional book management uses the magnetism of magnetic strips, but it needs periodic magnetization, which is troublesome to operate, but in intelligent libraries, magnetizing and demagnetization are not needed, extra energy is also not needed, and the book information can be feedback in real time as long as the book is within the detection range. There are some related researches. Cheng et al. (2016) designed a set

of visual book retrieval management system with handheld client software by combining RFID technology with WiFi communication technology. The experimental results showed that the system not only greatly improved the retrieval and management of books, but also saved human and material resources to a great extent, which had practical application value. Gao et al. (2017) proposed a non-metric multidimensional RFID non-distance algorithm, which realized indoor RFID multi-tag co-location. The simulation results show that the algorithm is superior to the existing RFID single positioning algorithm. He et al. (2017) proposed an RFID indoor positioning algorithm based on Bayesian probability and K nearest neighbor. The experimental results showed that the proposed algorithm had a smaller positioning error, about 15 cm, than the traditional RFID indoor positioning algorithm Landmarc. The basic structure and principle of RFID technology were briefly introduced in this paper, and the intelligent library management system based on RFID was also introduced. After that, the library of Huaqiao University was divided into two areas, and the performance of collection counting, book query and passage efficiency of the traditional library management based on magnetic stripe together with bar code and intelligent library management based on RFID were compared.

2. RFID technology

RFID (Toivanen et al. 2016) is an automatic identification technology that does not require physical contact with the identification object. The common bar code recognition technology is another semi-automatic identification technology without physical contact. Magnetic stripe recognition technology is a traditional contact recognition technology. According to electromagnetic theory (Xu et al. 2017), RFID technology relies on electromagnetic field to realize non-physical contact identification of information. RFID technology is also called proximity card, electronic tag, etc. in daily life.

As shown in **Figure 1**, the complete RFID technology includes readers for transmitting and receiving signals and electronic tags for storing information, where the readers (Koskinen et al. 2015) and electronic tags include receiving and transmitting antennas, receiving and transmitting parts and control parts. The control part of the electronic tag is mainly used as an information storage tool, and the stored information is actively sent out when the signal is received. The control part of the reader is connected to the computer system to exchange information, which realizes the writing of new information and the verification and correction of the received electronic tag information and prevents the forgery of the electronic tag. Information and energy is interacted between the reader and the electronic tag through the antenna.

As shown in **Figure 2**, when the RFID technology is in operation, the reader is started, and an electromagnetic field is formed in a certain range around the reader after signal transmission through the reader's antenna (Rui et al. 2015). When the identified object which carries electronic tag that contains the information of the object enters the electromagnetic field, an induced current is generated in the internal electronic tag due to electromagnetic induction, then sufficient energy is obtained to emit the information containing the identified object, i.e., the electronic tag is activated. When the electronic tag is activated, the stored

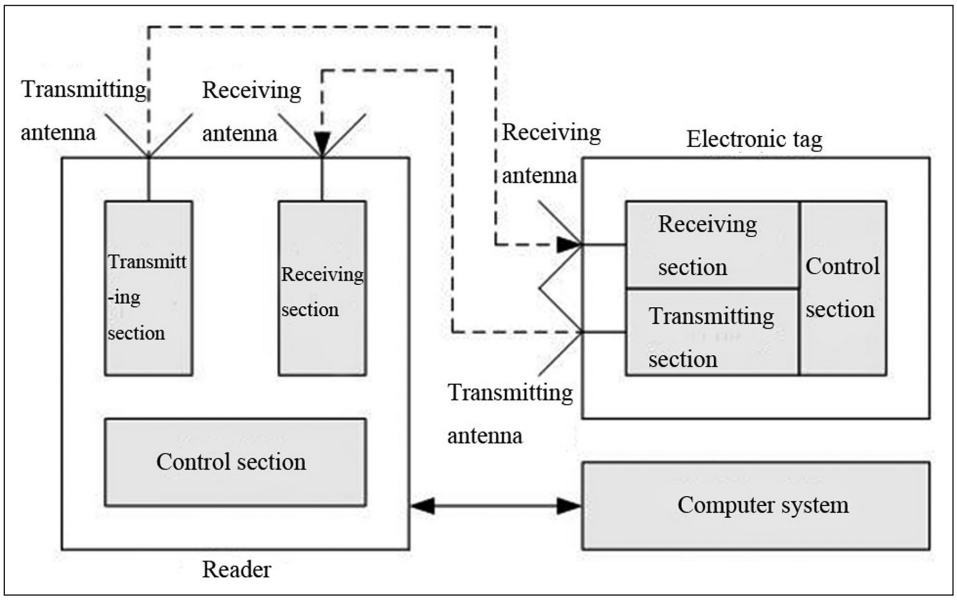

Figure 1: The composition of radio frequency identification technology.

information is transmitted through the antenna as set. After receiving the signal from the electronic tag, the reader decodes the signal and transmits the decoded signal to the computer system. A corresponding command will be made by the computer according to the information contained in the signal, and then the command is executed by the corresponding actuator, such as goods sorting in logistics.

Compared with the traditional identification technology, the RFID technology has the following characteristics (Korotkov 2016). The first characteristic is data interaction. The data in the tag can be read and written by the electromagnetic field in the RFID, while the traditional bar code can only be read. The second characteristic is small electronic tag volume and strong information penetration. Under the premise of maintaining the basic structure, the electronic tag has various shapes and sizes, which can adapt to various needs, and moreover the electronic tag can be embedded in the recognition object without affecting the performance due to the penetration of the electromagnetic field as long as the tag is not made of metals. The third characteristic is that electronic tag storage information part is the internal electronic structure, and the electronic tag can be used repeatedly because of its data interaction as long as the information is modified. But the traditional bar code cannot be repeatedly used and the data cannot be read if there is a little pollution.

3. Intelligent library management based on RFID

As shown in **Figure 3**, the intelligent library management system based on RFID can be basically divided into five modules, namely information processing function, access detection function, book statistics function, book search function and self borrowing and returning function.

The information processing function (Dan and Qi 2016) is mainly used to manage the document information in the library and the user's information such as the term of the borrowing and returning books, the name of the borrowing book and the permission of borrow books. At the same time, this function also includes the unified processing and distribution of the electronic tags. Most books in circulation don't come with an electronic tag, but every officially published book comes with bar code. Traditional libraries usually use bar codes as storage data, so the intelligent library needs to build another RFID database to match bar codes with electronic tags. The newly-entered book also needs to be issued with a new ID number for the normal use of other functions of the system.

The access detection function (Budak and Ustundag 2015) is mainly used to distinguish and authenticate the staff and the general readers who enter the library, and moreover it has the function of preventing theft of books. The former is realized by the user information stored in the information processing function of

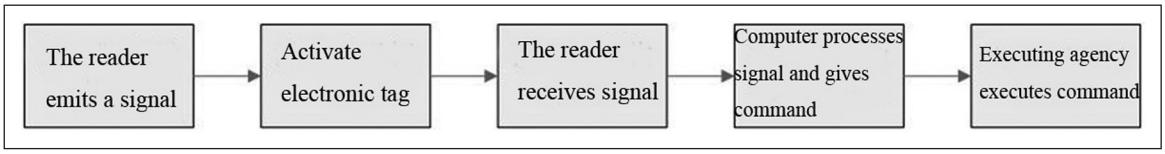

Figure 2: The working principle of RFID technology process.

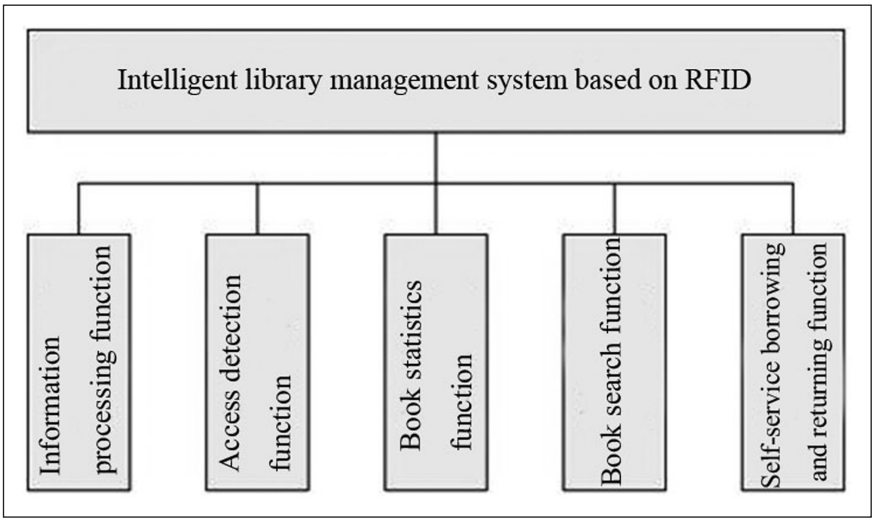

Figure 3: The framework of intelligent library management system based on RFID.

the system, and the admission personnel can check the user information in the electronic tag through the detection port, which greatly increases the traffic flow; the latter is that each recorded book has a unique electronic tag. When the books are passed through the detection port and the data recorded by the electronic tags is inconsistent with the data registered in the system database, an alarm will be issued immediately to effectively prevent the theft of books.

Self-borrowing-and-returning function (Chu 2015) is one of the important functions and features of the intelligent library. With the help of RFID technology, the intelligent library can realize the unmanned operation of books.

The book statistics function and book search function (Fortinsimard et al. 2015) is mainly used to quickly count the number of books in the library and provide readers with accurate book location services. The basic principle of the two functions is the same, as shown in **Figure 4**.

First, librarians will classify the unit area according to the requirements of the bookshelf and divide them according to requirements. They set up a bookshelf reader in each unit area and set a unique id to correspond to the unit area. Then, the ID is corresponded to the electronic tag of books placed on the corresponding shelf by the amplifying antenna and the corresponding results are transmitted to the database through the line. The corresponding table of book-shelf is formed on the intelligent library management system platform according to the database. The self-borrowing-and-returning function described above is realized by connecting the self-borrowing-and-returning device with the database to read the bookshelf position of the books that can be borrowed and returned.

4. Case analysis

4.1. Purpose of experiment

The purpose of the experiment is to study the performance of the intelligent library management system through comparing the actual application of the traditional library and intelligent library management systems.

4.2. Experimental environment

The experiment was carried out in the university library. The library was first divided into two areas. The traditional magnetic stripe + bar code library management system was adopted in one area, and the RFID-based intelligent library management system was adopted in the other area.

The regional layout of the intelligent library management system is shown in **Figure 5**, where ① is a manual service desk, ② is an entrance and exit detection station, ③ is a separation wall, and ④ is a bookshelf. Moreover, the self-borrowing-and-returning machine is set near the bookshelf. The model of the reader set in this study is KD500 with 13.66 MHz electromagnetic field frequency during working, and its electronic tag model is icode slix. The information interaction protocol between them is ISO15693. There is basic information about the book, the shelf location and the borrowing information in the electronic tag.

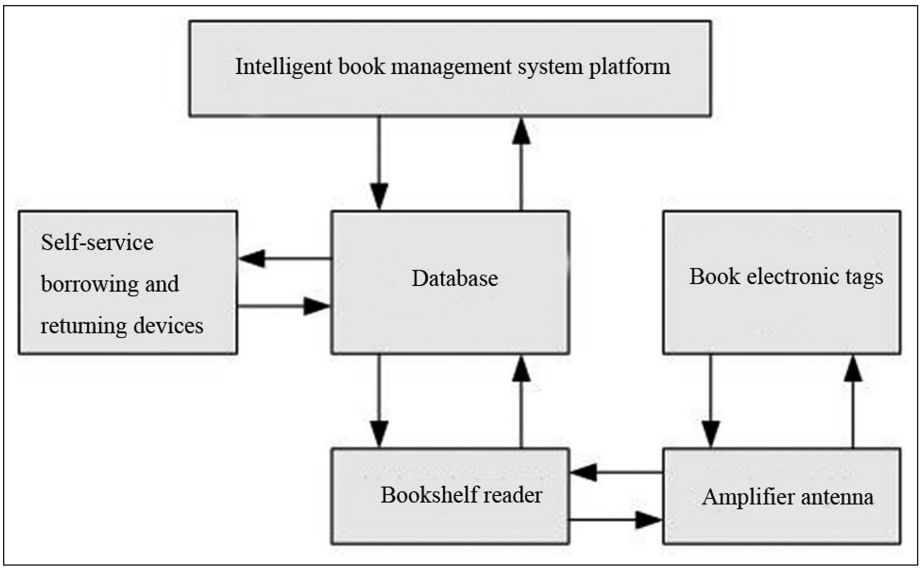

Figure 4: The operation principle of book statistics and locating function.

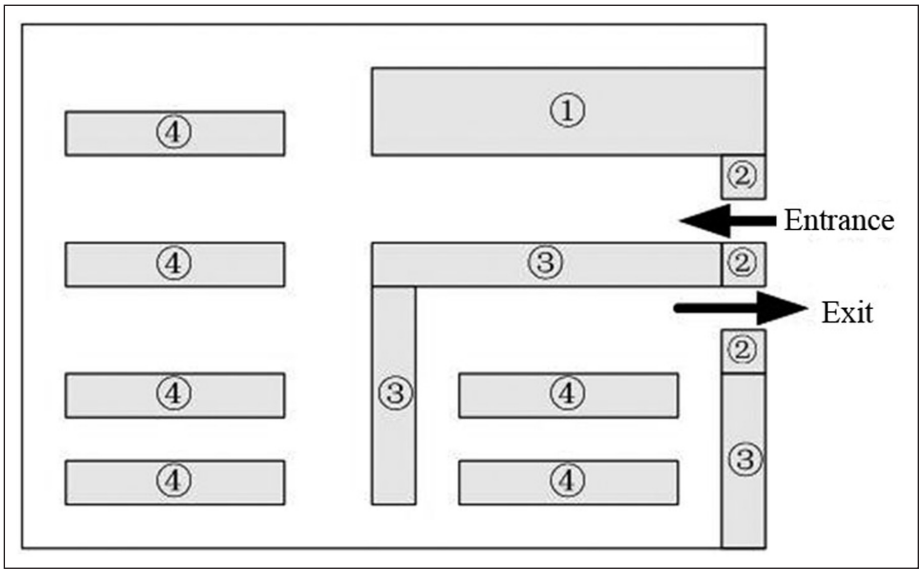

Figure 5: Schematic diagram of the intelligent library structure based on RFID.

4.3. Experimental methods

The library was divided into two areas. One of the areas applied the traditional library management system, and the other applied the RFID based intelligent library management system. Then the experiment of book counting, positioning and passing efficiency were carried out in the two areas:

(1) Book counting: Before the official opening of the library experiment, the books in the two areas were counted under the premise of ensuring sufficient staff. In the traditional library area, the method of scanning bar code was used to input the database, and in the intelligent library area, the method of scanning electronic labels was adopted. After the inventory was completed, the time and manpower used were compared.

(2) Book positioning: Before the official opening of the library experiment, after counting the books, 10 books were selected for location query, and the location of the books were checked according to the query results provided by the traditional management system and intelligent management system in the two regions; the accuracy was recorded. One week after the official opening of the experiment, the same 10 books were selected for location query, and the correctness rate was calculated based on the location confirmation books provided by the traditional management system and the intelligent management system query results in the two regions.

(3) Passing efficiency: One week after the official opening of the library, the number of people in the hall and the number of people passing through the entrance and exit in the two areas between 7 and 17 o'clock every day were counted, and the average value of each day was taken.

4.4. Experimental results

As shown in **Table 1**, it took 5 people 8 hours to check all the books in the traditional library management system. It took only one person 2 minutes to count the books in the intelligent library management area, which was far more efficient than the traditional library management system of magnetic strip and bar code. The reason was that in the traditional bar code library management system, the data of books could only be stored in the computer after books were taken out and scanned by the bar code scanner, and the position information of book in the bookshelf should be manually input; in the intelligent library management system based on RFID, it could receive the book-related information in the electronic tags of the books and the location information of bookshelf where the book was by starting the readers installed on the bookshelf. The above operations did not require staffs to directly contact the books and the inventory of each book is almost at the same time, which greatly improved the efficiency.

As shown in **Table 2**, before the library was opened, according to the traditional library and intelligent library location query, the bookshelf information was obtained, and all the ten books could be accurately found. The reason why the book can be accurately located in the traditional library was that all books were

Table 1: Collection counting efficiency of traditional library and intelligent library management system.

Region	Checking time	Number of checking people
Traditional library area	8 hours	5
Intelligent library area	2 minutes	1

Table 2: Test results of book positioning function in traditional library and intelligent library.

Testing time	Testing subject	Number of the correctly positioned books	Number of the wrongly positioned books
Before the opening of the library	Traditional library	10	0
	Intelligent library	10	0
One week after the library opened	Traditional library	4	6
	Intelligent library	10	0

placed in the correct bookshelf position after the book was counted, which was consistent with the book-bookshelf correspondence table when the books were counted and registered. One of the reasons for the accurate positioning of books in the intelligent library was the same as that in traditional libraries. The other reason was that book positioning function of RFID could accurately locate book-bookshelf information. One week after the opening of library, only four target books could be found according to the traditional library location query. After searching through the entire area, only four target books could be found on the wrong shelf, and the remaining two books were completely unrecognizable. The reason was that the correspondence between the traditional library books and the bookshelves was fixed and the accuracy of the positioning query depended on the manual sorting of readers and administrators, which might cause some flaws in a week. But in the intelligent library, accurate bookshelf location information for 10 books was still able to be provided, of which 3 books failed to match the book classification, but the book location information provided by the system was accurate. It was because that the book positioning function based on RFID relied not on the fixed book-shelf corresponding table, but the connection between the book and the existing bookshelf by electromagnetic field.

As shown in **Figure 6**, overall, the number of people passing through the intelligent library between 7 and 17 o'clock per hour was always higher than that of the traditional library, and the efficiency of the intelligent library rose and then decreased with time. Although the library's passing efficiency increased first and then decreased, it was not obvious and was stable compared to the change of the passing efficiency of the intelligent library. The reason was that 10 to 15 o'clock was the peak period of the library and there were many people entering and leaving the library in that period. The magnetic stripe and bar code technology used by the traditional library made the readers need to swipe the card when getting into and out of the library. Moreover, when borrowing and returning books, books needed to be magnetized and demagnetized manually, which consumed a certain amount of time, and the operators were limited. Thus the entrance and exit were congested during the peak period, and the passing efficiency was difficult to rise. The intelligent library was based on RFID technology, and the readers only needed to carry the electronic label certificate, without card swiping. Moreover they could directly get out of the library from the detection port as long as the books were registered in the library. During this period, there was no need for manual service, which greatly reduced congestion. It can be seen from **Figure 6** that the upper limit of the efficiency of the intelligent library was even higher.

5. Conclusion

In this paper, the basic structure and basic principles of RFID technology were briefly introduced, and the intelligent library management system based on RFID was introduced. After that, the library of Huaqiao University was divided into two areas, and the collection counting, book query and traffic efficiency performance of the traditional library management based on magnetic stripe and bar code and of intelligent library management based on RFID were compared. The results were as follows. It took 5 people 8 hours to count the books in the traditional library management, while intelligent library management inventory collection only cost one person two minutes, which was more efficient. Before the library was opened, the

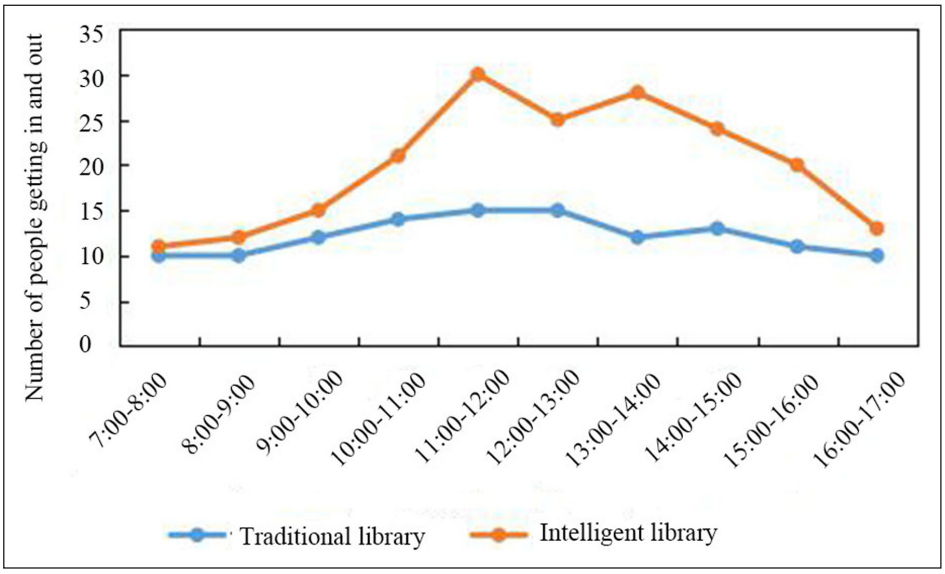

Figure 6: The passing efficiency of the two libraries.

book positioning of the two library management systems could accurately provide the location information of the book. After one week of opening, book location information in the intelligent library could still be provided accurately by the book location function, while the location information provided by the location function in the traditional library had some problems, such as wrong shelf, disorderly shelf and even providing the information of books which have been checked out. The passing efficiency of the intelligent library was higher than that of the traditional library. In the peak period, the passing efficiency of the intelligent library increased, without congestion, while the passing efficiency of the traditional library was unchanged, resulting in congestion.

Competing Interests

The authors have no competing interests to declare.

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