

Trajectory information acquisition method for library borrowing behaviour based on RFID technology

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Abstract: In order to overcome the low speed of the traditional methods of collecting the track information of library lending behaviour, this paper proposes a new method of collecting the track information of library lending behaviour based on RFID technology. In this method, access software is used to export the record data of borrowing behaviour and classify them according to types. The original data format is converted into the materialised data, and Apriori algorithm is used to analyse the association and mine the track information of library borrowing behaviour. RFID reader is used as the main part, and the track information of library borrowing behaviour is collected through the track estimation algorithm. The experimental results show that the information collection rate of this method is between 5.26 s–6.39 s, and the collection effect of library borrowing behaviour track information is better.

Keywords: RFID technology; library borrowing behaviour; trajectory information acquisition; borrowing behaviour record data.

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1 Introduction

In the information age, information explosion has appeared in all fields, and the information resources of libraries have doubled. However, with the development of the network, the utilisation rate of books in many libraries has been decreasing. Libraries are information centres and document centres in various regions. Their basic functions are to provide high-quality and efficient library services for borrowers; to meet the needs of borrowers in a timely manner; to quickly grasp and understand the tendency of borrowers to borrow books and the situation of book borrowing; and to excavate and analyse borrowers' borrowing behaviour. Under the current situation that information resources are multiplying and the network is highly developed, only by transforming the passive state of book resources and transforming the book borrowing mode of "people looking for resources" into a new book borrowing mode of "resources looking for people", can the library improve the utilisation rate of book resources and the quality of information resources services. The transformation of this mode of book borrowing has become the only way for the development of libraries (Jo et al., 2018).

In order to change the mode of book borrowing, we must study the library borrowing behaviour, that is, to analyse the reading behaviour, reading needs and reading ideas of the borrowers in the process of book borrowing. The study of library borrowing behaviour is not only the basis of the transformation of library borrowing mode, but also a part of library resource management. If a library wants to do well in library resource management, it must analyse library borrowing, excavate library borrowing information, and master library borrowing rules. Usually, the utilisation rate of library's book resources is related to the number of books borrowed at present. Studying library borrowing behaviour can take corresponding resource service strategies according to the needs of borrowers in all aspects, and help the library to optimise the book resources and plan the development goals reasonably.

In Gerona et al. (2017), a trajectory information acquisition method for library borrowing behaviour based on data mining software is proposed. Based on object-oriented programming method, a library borrowing management system is developed. A huge amount of data is mined by genetic algorithm and neural network algorithm to obtain effective library borrowing behaviour information. This method can collect information, but the accuracy is not enough. In Zhang et al. (2017), a trajectory information acquisition method for library borrowing behaviour based on deep learning algorithm is proposed, which can extract highly distinguishable low-dimensional features from high-dimensional original features. It can not only take into account the amount of text information more comprehensively, but also can classify text quickly. TF-IDF method is used to calculate text features. The eigenvalues are classified accurately based on the deep learning algorithm, so as to complete the record of library borrowing behaviour. This method has good classification effect and high accuracy in trajectory information acquisition of library borrowing behaviour, but its system stability and security are poor. Klappenbach et al. (2017) presents a trajectory information acquisition method for library borrowing behaviour based on Logistic regression model. A more scientific trajectory information system for library borrowing behaviour is constructed by using forward stepwise selection method. Logistic regression model is used to realise the record of library borrowing behaviour. This method can effectively collect borrowing information, but the efficiency of the method is low and the practical application is not ideal enough.

Table 1 Record data form of exported borrowing behaviour

Return time	Borrowing time	Library acquisition	Call number	Book publishing house	Book name	Full name	History borrowing times	Gender	Age group
05.06	04.06	A area	I0	Southeast University Press	<i>Linear Algebra</i>	Liu Ping	The 12 time	Male	20-30
06.01	05.02	A area	I0	Lixin Accounting Publishing House	<i>Probability Theory and Mathematics</i>	Wang Wen	The 10 time	Female	20-30
0.6.02	05.09	B area	I206	Zhong Hua Book Company	<i>Chinese Culture Reader</i>	Wang Le	The 0 time	Female	10-20
06.01	05.06	B area	G6	Nine Scholars on China	<i>Qingdao Publishing House</i>	Meng Jianzhong	The 16 time	Male	30-40
07.11	06.23	B area	B8	Zhang Xiaofeng's Prose Selection	<i>Changjiang Reference and Art Publishing House</i>	Lei Ping	The 25 time	Male	30-40
08.07	07.09	C area	D77	Interpretation of Confucian Language Mind	<i>People's Publishing House</i>	Huang Shusen	The 20 time	Male	0-10
09.11	08.12	C area	F12	Life in the Analects of Confucius	<i>China Emulation Publishing House</i>	Li Hongying	The 0 time	Female	20-30
10.12	09.22	D area	B5	Love Umbrella	<i>Qingdao Publishing House</i>	Liu Kai	The 23 time	Female	20-30
10.24	09.25	D area	B7	A Dance in the Moonlight	<i>Changjiang Reference and Art Publishing House</i>	Longshuhong	The 22 time	Female	20-30
10.21	9.10	E area	B9	Calculus Synchronization Counseling	<i>East China University of Science and Technology</i>	Zhou Dongmei	The 12 time	Female	20-30
10.30	9.29	E area	C0	Linear algebraic problems	<i>China's Economy in the Era</i>	Liang Xiaoyi	The 0 time	Female	20-30

Because the current method does not use Apriori algorithm for correlation analysis, it leads to the problem that the traditional method has a low speed in trajectory information acquisition of library borrowing behaviour. In order to solve the problems existing in the current method and realise the rapid trajectory information acquisition of library borrowing behaviour, this paper uses the trajectory inference algorithm to realise the trajectory prediction of library borrowing behaviour, and presents a method of collecting trajectory information of library borrowing behaviour based on RFID technology.

2 Acquisition of trajectory information on library borrowing behaviour

2.1 Preprocessing of borrowing behaviour data

2.1.1 Recording raw data

In order to ensure the accuracy and availability of data sampling, a large library in a city is selected as the data collection source. In the integrated management system of library resources, it can find the query interface of library resources circulation log in the library resources circulation management subsystem, and query the record data of library borrowing behaviour in this interface (Money, 2017). The name of the borrower, the borrowing data of the historical books and the data records of the past five years are selected, and the data are exported by using ACCESS software. The data form of the borrowing behaviour records after the export is shown in Table 1, including the data fields of the borrower's return time, borrowing time, library storage place, request number, book publishing house, book name, historical borrowing times, etc. The types of the borrowers are classified, including gender and age.

2.1.2 Cleaning record data

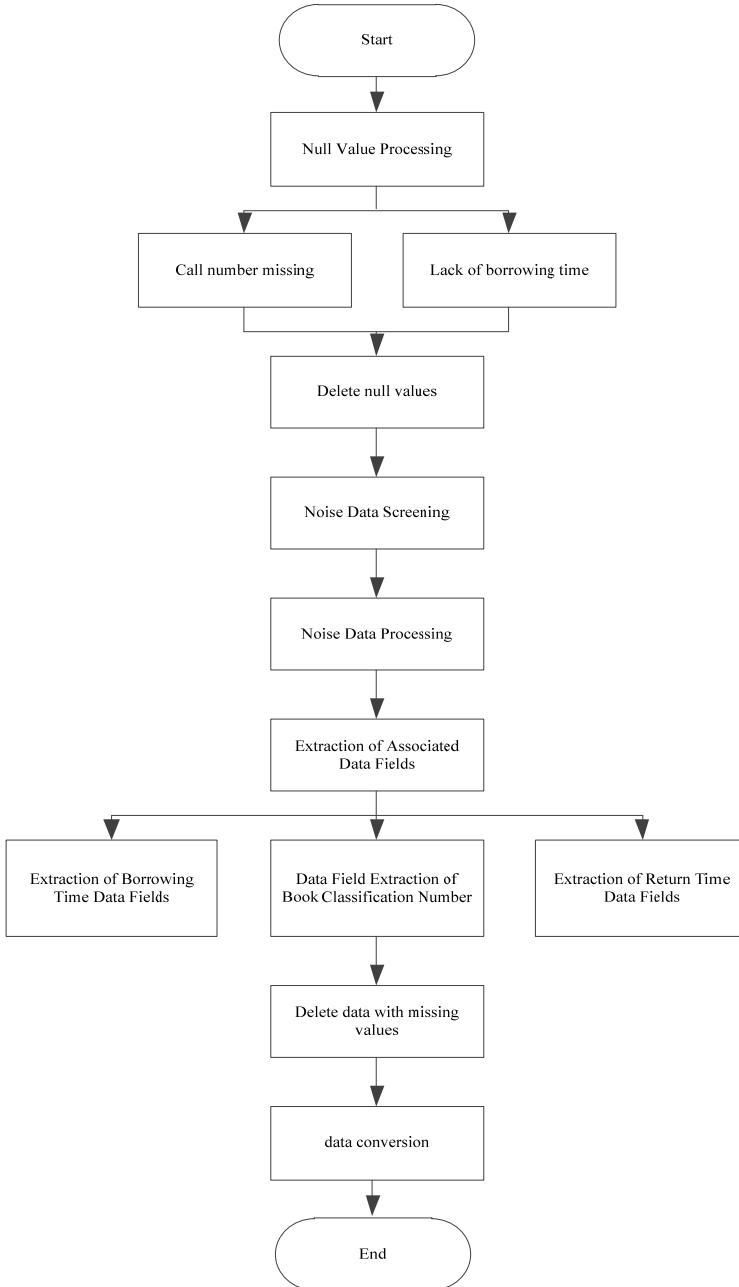
After obtaining the original record data of borrowing behaviour, the original data need to be cleaned. The specific data cleaning steps are shown in Figure 1.

Table 2 Transactional data format

<i>G64</i>	<i>I21</i>	<i>I207</i>	<i>B5</i>	<i>H31</i>	<i>K0</i>	<i>G6</i>	<i>G4</i>	<i>B2</i>
1	0	0	0	0	1	0	1	1
1	1	0	1	0	1	0	1	1
1	1	1	1	0	1	1	1	1
0	1	0	1	1	0	0	0	0
1	1	1	1	1	1	0	1	1
0	1	1	1	1	1	0	0	1
1	0	0	1	1	1	0	0	0
1	1	1	1	1	1	0	0	1
0	0	1	1	1	0	1	1	1
0	1	1	1	0	1	1	0	1
1	1	1	1	1	1	0	0	0
1	1	0	0	1	1	0	0	1

When transforming data, it is necessary to convert the format of original data into materialised data. As shown in Table 2, each row of data in the table represents a borrower, while each column represents the type of books borrowed by the borrower. 0 means that a borrower has not borrowed the corresponding books, while 1 means that a borrower has borrowed the corresponding books.

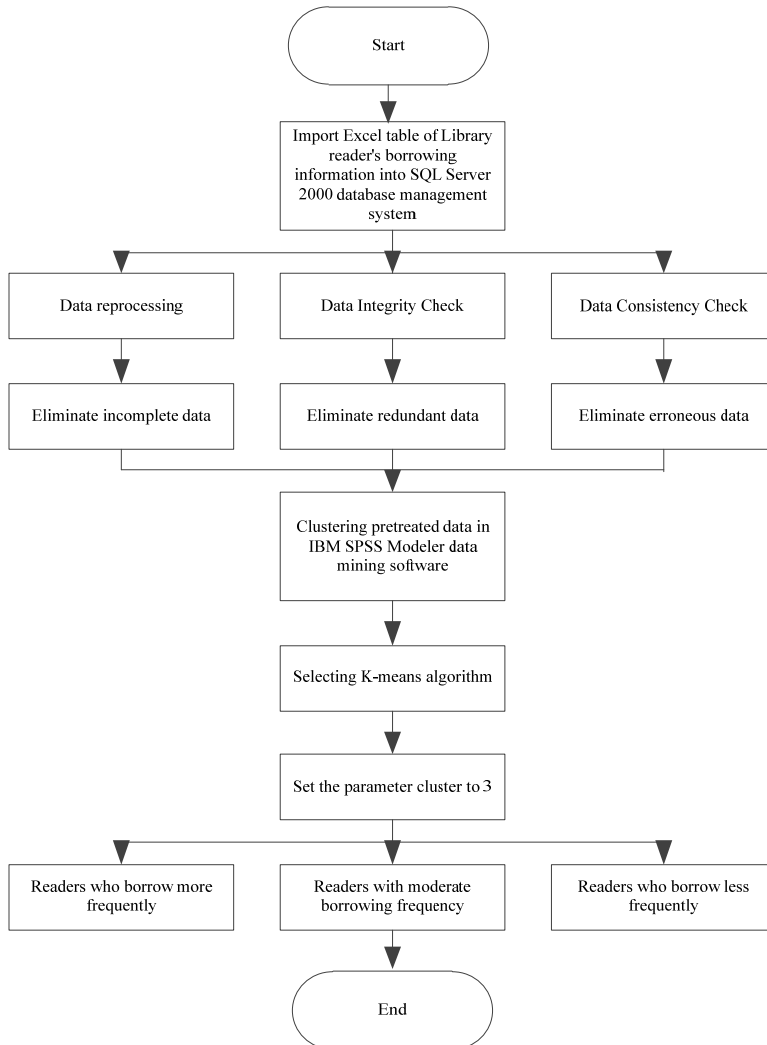
Figure 1 Specific data cleaning steps



2.2 Borrowing behaviour data mining

After cleaning the record data of borrowing behaviour, the frequency of book borrowing in the record data of borrowing behaviour is clustered to simplify the information of book borrowing frequency which is difficult to analyse and extract, and to facilitate the recommendation of book resources for borrowers in the later period. After clustering analysis, borrowers with different frequencies will be clustered into different categories. The specific process of clustering analysis is shown in Figure 2 (Graczyk et al., 2017).

Figure 2 Specific process of clustering analysis



After completing the clustering analysis of the borrowing behaviour data, the borrowing behaviour data is carried out association mining to mine the trajectory information of the library's borrowing behaviour. Firstly, it needs to analyse the correlation of the borrowing behaviour data, and Apriori algorithm is used to do the correlation analysis

(Essington et al., 2018; Batista et al., 2018). In Apriori algorithm, the minimum confidence is set to 0.1, and the minimum support is set to 0.1. The association rules of borrowing behaviour data are obtained. The specific form of obtaining association rules is shown in Table 3.

Table 3 The concrete form of association rules

<i>Consequent</i>	<i>The aforesaid</i>	<i>Percentage of support</i>	<i>Percentage of confidence</i>
D77	K1 and B9	15.40832049	40.51724138
B9	B5	17.71956857	41.53346154
I209	I21	53.52095532	41.97536864
B9	A7	10.01540852	44.76190476
I22	I209	16.17873652	47.72727273
B5	C8	13.55932203	51.40186916
B9	K1	30.8164099	52.85714206
B9	K1 and B5	16.48690293	53.84615385
B5	D77 and K1	30.81664099	53.91304348
B5	K1	10.01540832	54.65116279
I22	I21	17.71956857	56.19047619
B9	D77	39.75346687	56.79012346
B5	B9	17.71955857	60.8595652

By mining the trajectory information of library borrowing behaviour through the acquired association rules, the acquired association rules can be divided into (K) geography, history, (I) literature, (B) religion, philosophy and other categories (Hinkellipsker and Hahn, 2018).

(K) Geography and history can mine (K1) the trajectory information of library borrowing behaviour of World History category. Its confidence is between 0.2 and 0.62, and its support is between 0.1 and 0.53. It shows that borrowers have a probability more than 0.2 to borrow books of World History at the same time when borrowing books of religion, European philosophy, rhyme, poetry and politics of various countries, which shows that many borrowers can learn geography and history knowledge at the same time, and they can make a comprehensive understanding of the depth and breadth of their own learning (Wang et al., 2017).

(I) Literature can mine the trajectory information of library borrowing behaviour of (I26) prose, (I24) novel, (I209) literary and ideological history, literary history, (I22) rhyme, poetry, (I21) portfolio and so on. Its confidence is between 0.1 and 0.52, and its support is between 0.1 and 0.53, which indicates that the borrowers have a probability more than 0.11 to borrow books of portfolio at the same time when borrowing books of world history, European philosophy, rhyme and poetry; and they have a probability more than 0.14 to borrow the books of rhyme and poetry at the same time when borrowing books of Deng Xiaoping's biography, Mao Zedong's biography, Stalin's biography, Lenin's biography, Engels' biography, Marx's biography, religious, European philosophy, world history, portfolio, literary and ideological history and literary history; when borrowing books of politics, rhyme, poetry, portfolio and combinations of these books, there is a probability greater than 0.1 to borrow the books of literary and ideological history and literary history at the same time; while borrowing books of world

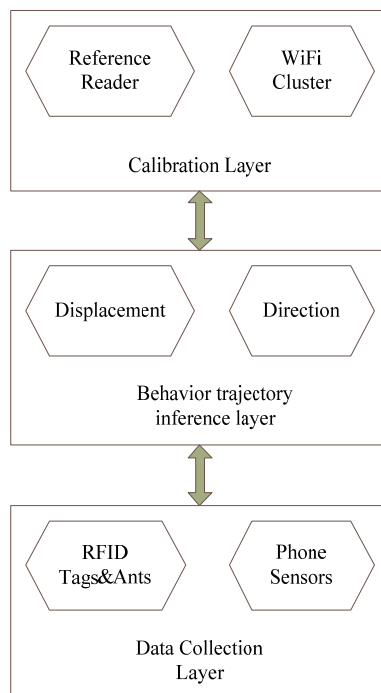
history, rhyme, poetry, literary and ideological history and literary history, there is a probability more than 0.1 to borrow books of novel at the same time; when borrowing books of religion, world history, literature history, rhyme and poetry, there is a probability more than 0.6 to borrow books of at the same time, which shows that literature books are very popular among borrowers (Steel et al., 2018).

(B) Religious and philosophical categories can mine the trajectory information of library borrowing behaviour of (CB3) Asian philosophy category, (B1) world philosophy category, (B7) American philosophy category, (B9) religion category, (BS) European philosophy category and so on. The confidence level is between 0.1 and 0.677, and the support level is between 0.1 and 0.54, which indicates that when borrowing books of statistics, world history, literary and ideological history, literary history, rhyme, poetry, portfolio and economics, there is a probability more than 0.1 to borrow European literary books, indicating that borrowers in the study of philosophy will be in-depth study of the historical and literary background of philosophical ideas (Taank et al., 2017).

2.3 Research on trajectory information acquisition method for library borrowing behaviour based on RFID technology

After completing the clustering mining of library borrowing behaviour data, based on the clustering mining results and RFID technology, this paper establishes the trajectory information acquisition model of library borrowing behaviour, and achieves the trajectory information acquisition of library borrowing behaviour (Cheng et al., 2017).

Figure 3 Block diagram of trajectory information acquisition model for library borrowing behaviour (see online version for colours)



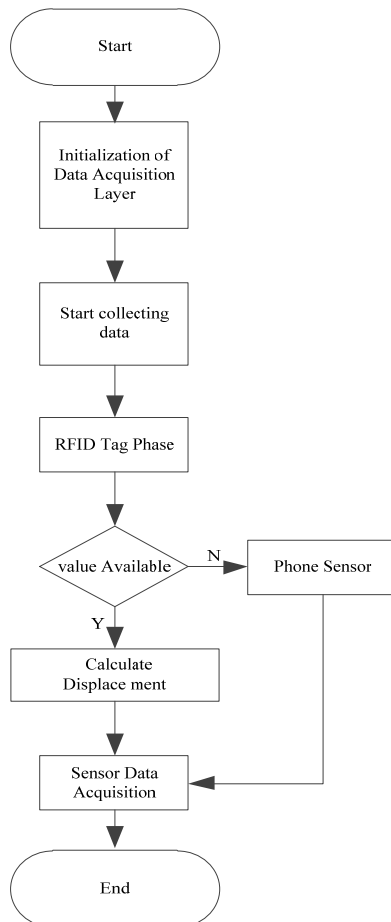
The trajectory information acquisition model of library borrowing behaviour is divided into three levels, namely acquisition data layer, behaviour trajectory inference layer and calibration layer. The specific block diagram of the model is shown in Figure 3.

The first layer of the trajectory information acquisition model for library borrowing behaviour is the data acquisition layer, which can collect library borrowing behaviour trajectory. It is composed of tags and antennas of sensors and RFID reader, in which sensors can be mounted on smart devices such as smart phones (Dial et al., 2017).

The second layer is the behaviour trajectory inference layer, which calculates the direction and displacement of library borrowing behaviour by collecting sensor data and phase tag value of RFID reader from the data layer, so as to obtain the trajectory of library borrowing behaviour (Vogl et al., 2017).

The third layer is the calibration layer, which uses the combination of WiFi aggregation point and RFID reader to calibrate the library borrowing behaviour trajectory, and obtain the trajectory information of the library borrowing behaviour, so as to realise the trajectory information acquisition of the library borrowing behaviour, and control the error of the system (Porto et al., 2017).

Figure 4 The whole collaboration process of sensor and RFID reader in data acquisition layer

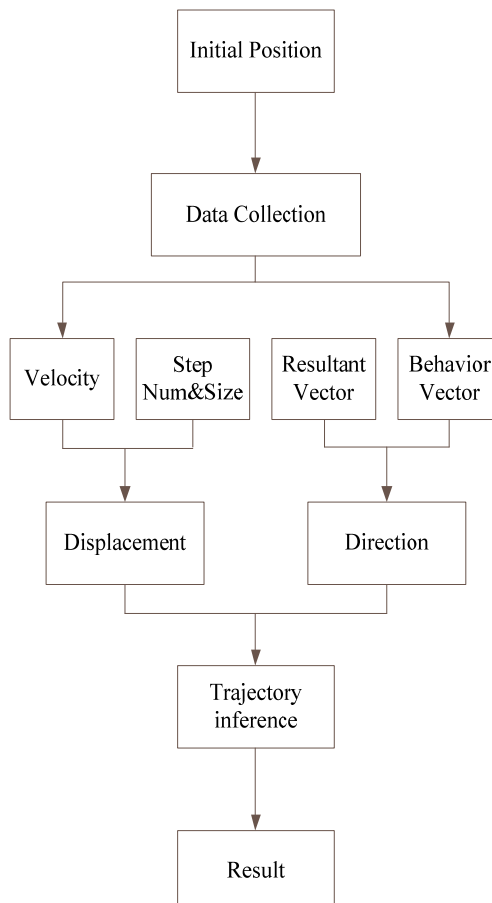


The data acquisition layer consists of two parts, one is data acquisition through sensors; the other part is to collect the phase tag value through the RFID reader. Therefore, in the data acquisition layer, it is necessary to establish the interaction between the server and the smartphone, the interaction between the sensor and the smartphone, and the interaction between the tag data and the antenna of the RFID reader (Marangoz et al., 2017).

In order to ensure the reliability and accuracy of the trajectory information acquisition model for library borrowing behaviour, a hierarchical scheme based on RFID reader and modified by sensors is adopted. When the library borrowing behaviour trajectory is located at the edge of the antenna signal range of the RFID reader, the data is collected by sensors. The whole collaboration process between sensor and RFID reader in data acquisition layer is shown in Figure 4.

Because tags acquired by RFID reader will be disordered, it is necessary to filter tags continuously in the process of data acquisition layer (Dias et al., 2017). The behaviour trajectory inference layer mainly realises the trajectory inference of library borrowing behaviour through the behaviour trajectory inference algorithm. The specific operation flow of the algorithm is shown in Figure 5.

Figure 5 Specific operation flow of the algorithm (see online version for colours)



The calibration mechanism of the calibration layer is based on mobile WiFi technology and RFID reader to calibrate the library borrowing behaviour trajectory. After the calibration of the library borrowing behaviour trajectory, the trajectory information acquisition of library borrowing behaviour can be realised (Li et al., 2018).

3 Experiments and analysis

3.1 Experimental process

In order to test the performance of the trajectory information acquisition method for library borrowing behaviour based on RFID technology, it is necessary to carry out a comparative experiment on the trajectory information acquisition method for library borrowing behaviour. The experimental index is the acquisition rate of borrowing information of different methods. The acquisition rate can directly reflect the operation speed of the method and verify the validity of the method. It is also the main difficulty of traditional methods in the process of collecting the trajectory information of library borrowing behaviour. Therefore, this experimental index is selected for simulation experiments. The trajectory information acquisition method for library borrowing behaviour based on RFID technology is used as the experimental group, and the methods in Gerona et al. (2017) and Zhang et al. (2017) are used as the control group.

A library is randomly selected and its borrowing behaviour records are selected as the initial data of the experiment. The specific data are shown in Table 4.

Table 4 Raw data

<i>ID</i>	<i>Time</i>	<i>Date</i>	<i>Book_no</i>
201810111194	14:32:45	2018/3/21	F23/424
201810111194	17:47:17	2018/4/15	TP391.4
201810111194	10:46:28	2018/10/23	TP391.413
201810111194	14:37:36	2018/11/14	F830. 9/28
201810111194	14:37:38	2018/11/14	F234. 2/42
201810111194	12:10:26	2018/12/13	F83
201810111194	12:10:24	2018/12/13	F276. 6/13
201810111194	18:01:29	2018/12/24	TP391.413
201810111194	19:39:58	2018/12/24	TP391.4
201810111194	21:01:02	2018/12/29	TP391.4

In order to ensure the validity of the experiment, the methods in Gerona et al. (2017) and Zhang et al. (2017) are used to compare with the information acquisition method for library borrowing behaviour based on RFID technology proposed in this paper. Five experiments are carried out to observe the information acquisition rate of each method. The calculation of information acquisition rate is shown in formula (1) and the experimental results are shown in Table 7.

$$P = \frac{W}{Q} \quad (1)$$

where P represents the rate of information acquisition; W represents the total amount of information acquisition; Q represents the time of information acquisition.

3.2 Experimental results

According to the comparative experiment results of the information acquisition rate in Table 5, it can be seen that in the course of many experiments, the information acquisition rate of the trajectory information acquisition method for library borrowing behaviour based on RFID technology is between 5.26 and 6.39, while that of the other two methods are between 2.31 and 4.68, which is obviously lower than the method in this paper. The higher the numerical value is, the faster the information acquisition speed is and the better the effect of the method is, showing that the proposed method has better performance in collecting trajectory information of library borrowing behaviour. This is because the method uses Apriori algorithm for correlation analysis, obtains the trajectory information of library borrowing behaviour, and realises the prediction of library borrowing behaviour trajectory through trajectory inference algorithm, to reduce the error rate of the method, thus improving the speed and making the method performance better.

Table 5 Comparison results of Information acquisition rate

<i>Method</i>	<i>Gerona et al.'s (2017) method</i>	<i>Zhang et al.'s (2017) method</i>	<i>Information acquisition method of library borrowing behaviour trajectory based on RFID technology</i>
Data acquisition rate of one experiment	2.31	3.62	5.26
Information acquisition rate of secondary experiments	3.56	4.32	5.89
Information acquisition rate of three experiments	3.78	4.68	6.39
Average information acquisition rate	3.22	4.21	5.85

4 Conclusions

- 1 With the development of information technology, the information resources of libraries are also increasing. The information acquisition of library borrowing behaviour plays an important role in the development of libraries.
- 2 Aiming at the low speed of current trajectory information acquisition methods for library borrowing behaviour, this paper proposes a new trajectory information acquisition method for library borrowing behaviour based on RFID technology.
- 3 The record data of borrowing behaviour is exported by ACCESS software and classified according to the type; the information of borrowing frequency which is difficult to analyse and extract are simplified, to realise the clustering of borrowing frequency; Apriori algorithm is used to analyse the correlation and obtain the trajectory information of library borrowing behaviour; the RFID reader and writer are mainly used, and modified by sensors, the trajectory of library borrowing

behaviour is inferred through the trajectory inference algorithm, and the trajectory information of library borrowing behaviour is collected.

- 4 The experimental results show that the information acquisition rate of the trajectory information acquisition method for library borrowing behaviour based on RFID technology is between 5.26 and 6.39, while that of the other two methods are between 2.31 and 4.68, which proves that the proposed method has better performance and higher operational efficiency.
- 5 In the course of the experiment, because of the construction of the experimental device and the setting of the parameters of the experimental environment, there are some differences between the experimental environment and the real environment. The experimental results have some deviations from the actual results, but it does not affect the experimental conclusions. In order to get more accurate experimental results, the trajectory information acquisition method for library borrowing behaviour based on RFID technology should be optimised and researched.

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