Comparative Analysis of Library Self-Service Circulation Systems (Postprint)

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Abstract

[Purpose/Significance] With the continuous growth in demand for self-service borrowing and returning systems in domestic libraries, issues concerning their functionality and cost have attracted increasing attention. Through comparative analysis of the functionalities of Barcode mode, RFID mode, and Barcode+RFID mode, this study provides a reference for domestic libraries in their selection. [Method/Process] Based on comprehensive investigation and research, this study summarizes and organizes the functions and characteristics of various modes, and conducts comparative analysis from the perspectives of cost and price, borrowing and returning efficiency, and security of the three modes. [Results/Conclusion] The Type D self-service borrowing and returning system in Barcode mode offers low price and superior functionality compared with similar products. It is recommended that small and medium-sized domestic libraries prioritize this product when selecting Barcode-mode self-service borrowing and returning systems.

Full Text

Comparative Analysis of Library Self-Service Checkout Systems

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Abstract

[Purpose/Significance] With the growing demand for self-service checkout systems in domestic libraries, concerns regarding their functionality and cost have become increasingly prominent. This study compares and analyzes the functionalities of Barcode mode, RFID mode, and Barcode+RFID mode systems to provide a reference for library procurement decisions in China.

[**Method/Process**] Based on comprehensive investigation, this paper summarizes the functions and characteristics of various system types and conducts a comparative analysis across three dimensions: cost, borrowing/returning efficiency, and security.

[**Result/Conclusion**] The D-type self-service checkout system in Barcode mode offers superior functionality at a lower price compared to similar products. It is recommended that small and medium-sized libraries in China prioritize this Barcode mode system when selecting self-service checkout solutions.

Keywords: Barcode mode; RFID mode; library; self-service checkout system
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2 Overview of Three Types of Library Self-Service Checkout Systems

2.1 Barcode Mode Self-Service Checkout System

The Barcode mode self-service checkout system utilizes barcode recognition technology, library management software, and electromagnetic strips embedded in book spines for automatic charging/demagnetization operations. After decades of application and continuous improvement, this technology has matured and stabilized. Its most significant advantage is low cost, as it does not require adding electronic tags to existing book collections, saving both time and labor. This system has made substantial contributions to libraries by reducing human and material resources, increasing book circulation rates, and simplifying borrowing/returning procedures.

2.2 RFID Mode Self-Service Checkout System

RFID mode self-service checkout systems employ non-contact automatic identification technology, using radio frequency signals to automatically identify electronic tags attached to books for information management and self-service operations. Due to RFID's strong recognition capability, multiple tags can be identified simultaneously, enabling batch processing of dozens of books in a single transaction. However, RFID tags have poor anti-theft performance and are susceptible to interference from human bodies and metal objects, leading to missed or incomplete readings and potential book loss. Additionally, converting to RFID requires removing existing magnetic strips and replacing them with RFID tags, creating substantial workload and high investment costs.

The first RFID self-service checkout system was implemented at the Singapore National Library in November 2002, with domestic adoption beginning at Dongguan Library in November 2005. Currently, over 100 libraries in China have deployed this technology.

2.3 Barcode+RFID Dual-Mode Self-Service Checkout System

The Barcode+RFID dual-mode system is a recent development that integrates both Barcode and RFID technologies, combining the advantages of both while eliminating their respective disadvantages. This hybrid system offers the following key functions:

2.3.1 RFID Smart Tag Conversion System

This conversion system serves as a bridge between RFID technology and library management systems. By binding the RFID unique identifier with the library's barcode number, it enables seamless transition from barcode to RFID technology while maintaining access to detailed book and patron information.

2.3.2 Intelligent Book Checkout and Demagnetization

The dual-mode system can intelligently detect whether a book contains an RFID tag. In the absence of RFID tags, it automatically activates barcode scanning equipment and employs traditional demagnetization methods for security management.

2.3.3 Intelligent Book Inventory

Leveraging RFID's non-contact identification, rapid reading, and multi-book processing capabilities, the system enables intelligent shelf-reading and inventory management.

2.3.4 Rapid Book Location

Library staff can download book location information to mobile inventory devices, facilitating rapid search and positioning operations.

Although the Barcode+RFID system offers powerful functionality, its high cost remains a limiting factor. For a library with a collection of 1 million volumes, the initial investment exceeds 2.3 million RMB. Consequently, only a few dozen well-funded libraries, such as those at Tsinghua University, Peking University, Zhejiang University, and Shenzhen University, have adopted this system.

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3 Comparison of Three Library Self-Service Checkout System Types

3.1 System Function Comparison

Due to structural differences among the three systems, their functional capabilities—including data capacity, read/write ability, reading speed, shelf inventory, and security—vary significantly. Libraries should select system types based on their functional requirements, as summarized in .

TABLE:1 Functional Comparison of Three Library Self-Service Checkout System Types

Function	Barcode (Magnetic Strip) Mode	RFID (Electronic Tag) Mode	Barcode+RFID (Dual-Tag) Mode
Reading Speed	Slow (1 book/transaction)	Fast (multiple books/transaction)	Fast (multiple books/transaction)
Reading Distance	Small (0-50 cm)	Large (0-1000 cm)	Large (0-1000 cm)
Shelf Inventory	Not supported	Supported	Supported
Security	Dual checkout/theft detection	Prone to misreading; dual-tag (EM+RFID) security gates may have tag-magnetic strip conflicts causing false alarms	Combines advantages of both modes

3.2 Comparison of Commonly Used Barcode Mode Systems

Domestically produced Barcode mode self-service checkout systems include models such as ABC2000, ABC-2010, ZT2000-W, and ZT2000. Among the most widely used brands, four models (A, B, C, D) were selected for comparison, as shown in .

TABLE:2 Comparison of Commonly Used Barcode Mode Self-Service Checkout Systems

Feature	Model A	Model B	Model C	Model D
Implementation	Magnetic flux affected by strip length/type/position; accuracy degrades over time	Magnetic flux affected by strip length/type/position; limited technical improvement	Visible light compensation, susceptible to ambient light interference	Infrared compensation, unaffected by ambient light, high accuracy

Feature	Model A	Model B	Model C	Model D
Demagnetization & Verification	Planar coil, incomplete charging	L-shaped coil with multiple detection points, sometimes incomplete	L-shaped coil, magnetic detection far from book, poor verification	L-shaped coil, magnetic detection close to book, excellent verification
Anti-Theft Detection	Single fiber sensor Single-point detection, vulnerable to swapping	Standard phototube Susceptible to ambient light, especially with black covers	Side phototube Susceptible to ambient light and user operation	Dual fiber sensor Dual-point detection, effective even with black books
Barcode Reading	Oscillating mirror High barcode require-ments, weak decoding, slow	Fixed scanning Requires manual alignment, slow	Swing scanning Slow, low accuracy, exposed camera vulnerable	Oscillating mirror Adjustable mirror frequency, strong decoding, fast reading
Operation Conve-nience	Web query design	Button-click for each step	Requires screen button clicks	Intelligent operation detection, no button clicks needed
Traceability	Records book info only	Records book info only	Records book and patron facial images	Records book and patron facial images
Product Variety	Checkout machine, 24-hour return	Checkout machine, magnetic anti-theft	Checkout machine, 24-hour return, integrated charg-ing/demagnetization	Checkout machine, 24-hour return, integrated charg-ing/demagnetization

3.3 Comparative Analysis of System Advantages and Disadvantages

The three systems exhibit distinct advantages and disadvantages in terms of management software compatibility, checkout efficiency, and cost, as detailed in .

TABLE:3 Advantages and Disadvantages of Three Library Self-Service Checkout Systems

Aspect	Barcode Mode	RFID Mode	Barcode+RFID Mode
Advantages	Compatible with existing library platforms; no need to tag large existing collections, saving money and labor; low cost, easy operation	Enables batch processing, saving patron time and increasing circulation; reduces staff workload; supports smart sorting, shelving, and location	Combines Barcode and RFID advantages while eliminating disadvantages; supports dual-mode checkout and security; seamless future technology transition
Disadvantages	Cannot process multiple books simultaneously, slower speed; lacks intelligent shelving, location, and inventory capabilities	Incompatible with original management systems; high cost with poor ROI; security issues remain unresolved	Despite eliminating individual mode disadvantages, still has high costs

4 Comparison Results and Recommendations

4.1 Comparison Results

Based on the functional and comparative analysis, the following conclusions can be drawn:

4.1.1 Cost

According to domestic vendor bidding reports, installing one D-type Barcode mode self-service checkout machine costs approximately $10,000. This system offers excellent compatibility with existing library management platforms without requiring replacement of barcodes or magnetic strips in large existing collections, saving both software upgrade costs and RFID tagging expenses. Overall, Barcode mode systems represent a low-cost investment.

In contrast, RFID and EPC reading devices cost at least $100,000 per unit, plus expenses for manually tagging existing collections (tags cost $0.30-0.60 each plus labor) and software upgrades. A library with 1 million volumes faces an initial investment exceeding 2 million RMB. This high cost has inhibited widespread adoption, with only a few dozen libraries currently using RFID mode systems.

4.1.2 Shelf Inventory Management

RFID and Barcode+RFID systems can simultaneously identify multiple electronic tags (book tags and shelf tags), enabling efficient and reliable shelf inventory management. Barcode mode systems lack this capability.

4.1.3 Checkout Efficiency

RFID and Barcode+RFID systems can identify multiple tags simultaneously, allowing patrons to checkout/return dozens of books in a single, rapid transaction. Barcode mode systems process only one book at a time, resulting in slower operations, though this can be mitigated by adding more machines.

4.1.4 Security

RFID tags are relatively large and easily detected; readers can simply damage the antenna to disable them. Additionally, RFID's high sensitivity often causes information errors, particularly in batch processing, leading to higher loss rates. Barcode mode magnetic strips are small, covertly placed, and difficult for readers to locate, while the magnetic anti-theft system provides strong detection capability, resulting in lower loss rates.

4.2 Recommendations

Based on this comparative analysis, the following recommendations are proposed:

1. **For ordinary university libraries and other institutions with limited budgets**, the Barcode mode D-type system should be the primary consideration. As demonstrated at Yantai Nanshan University Library, which purchased three D-type machines for under $30,000 in 2016, this solution offers excellent compatibility with existing systems without requiring additional equipment.
2. **For well-funded "211" and "985" university libraries**, the Barcode+RFID dual-mode system is recommended. This system combines the advantages of both modes while eliminating their disadvantages, providing substantial development potential for future smart library initiatives.

The implementation of self-service checkout systems has extended the reach of fundamental library services. Practice has proven that self-service checkout fully meets the needs of modern library development and aligns with future demands for intelligent, automated library services. Libraries should continuously improve these systems, strengthen equipment management and technological updates, enhance their competitiveness, and strive for greater user satisfaction.

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English Abstract

[**Purpose/significance**] With the increasing demand for self-checkout systems in domestic libraries, its function and cost are becoming more and more concerned. By comparing and analyzing the functions of Barcode mode, RFID mode, and Barcode+RFID mode, this paper provides reference for the purchase of domestic libraries. [**Method/process**] Based on full investigation, this paper summarizes the functions and characteristics of various modes, and compares and analyzes the cost price, borrowing and returning efficiency, and security of the three modes. [**Result/conclusion**] The D-type self-checkout system in Barcode mode is cheap and has stronger functions than similar products. It is recommended that small and medium-sized libraries in China should give priority to purchasing Barcode mode self-checkout systems.

Keywords: Barcode mode; RFID mode; library; self-checkout system

Note: Figure translations are in progress. See original paper for figures.