User Experience Measurement and Improvement Strategies for Library and Information Services in the Smart Library Era

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Abstract

Abstract: The application of artificial intelligence technology continues to deepen, driving smart library services to transition from traditional models to intelligent paradigms, with heightened emphasis on personalized services that deliver high-quality user experiences. Currently, following digital transformation, smart libraries have established novel frameworks for library and information service models. Through AI-enabled intelligent information retrieval and resource recommendation mechanisms, service quality is ensured and operational efficiency is enhanced. In response to increasingly diverse user demands, scientific measurement and continuous optimization of user experience are imperative to guarantee service relevance. This paper investigates user experience measurement and enhancement strategies for library and information services in the smart library era.

Full Text

User Experience Measurement and Improvement Strategies for Library and Information Services in the Era of Smart Libraries

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Abstract

The application of artificial intelligence technology continues to deepen, enabling smart library services to transform from traditional models to intelligent ones with greater emphasis on personalized services, thereby delivering high-quality user experiences. Currently, smart libraries have established new frameworks for library and information service models following digital transformation. The

application of AI technology, intelligent information retrieval, and resource recommendation mechanisms ensures service quality and improves efficiency.

To address increasingly diverse user demands and ensure service relevance, scientific measurement and continuous optimization of user experience are essential. This paper investigates user experience measurement and improvement strategies for library and information services in the smart library era.

Keywords: smart library era; library and information services; human-computer interaction design; user experience measurement; improvement

Smart libraries have undergone transformation through artificial intelligence technology, big data technology, and other innovations, achieving automated borrowing functions and intelligent navigation capabilities. However, significant shortcomings remain, including low user engagement and homogenized services. To effectively address these issues and meet escalating user demands, libraries must provide convenient services that satisfy personalized needs while enabling sufficient interaction. Traditional approaches inadequately reflect experiential deficiencies [1]. Constructing a user experience measurement model enables accurate identification of service shortcomings in libraries, facilitates the proposal of improvement strategies, and provides a foundation for optimizing library resources and innovating services, thereby promoting the advancement of smart libraries toward "user-centered" ecological services.

1. Service Innovation and User Experience Analysis

1.1 Personalized Recommendation

Libraries that continue to operate under traditional management models require users to physically visit the library to obtain relevant information. Within the library, users must employ classification-based retrieval systems and, when necessary, rely on staff recommendations. This operational approach presents numerous inconveniences, fails to deliver personalized services, and forces users to spend considerable time searching—an inefficiency incompatible with today' s fast-paced lifestyle. To create an intelligent environment, libraries must fully leverage smart technologies to provide personalized recommendations based on actual user needs, thereby delivering superior experiences [3]. Particularly through the application of advanced data analytics technology, systems can deeply analyze users' reading records during operation, identify materials of interest, and make recommendations based on user preferences.

For instance, when a user who enjoys historical books operates the library query system to search for historical materials, the library prioritizes recommendations for related books. Simultaneously, the system automatically collects information, recording user operations and behaviors when they log into electronic resource platforms for browsing, thereby identifying topics of particular interest. As such data accumulates, the system employs sophisticated algorithms during operation to obtain precise results, successfully identifying books and articles

that users need from vast resource collections.

As another example, smart libraries operate RFID intelligent document retrieval subsystems that ensure seamless integration with OPAC systems, enabling intelligent positioning and navigation functions that plan optimal paths. The RFID intelligent document retrieval subsystem primarily adopts a Browse/Server architecture, allowing users to query materials more efficiently. Readers can employ fuzzy search methods by entering approximate information in dialog boxes for title, author, subject terms, and other fields to perform multi-level queries, obtaining detailed book information with graphical displays that accurately locate books on shelves [4]. Operating a Web publishing system, a sub-link on the library website provides readers with suitable book retrieval methods, making library services more humanized. The system also functions as an IE plugin, achieving seamless integration with the library OPAC system. (Figure 1 [Figure 1: see original paper]: 3D Book Location)

Analysis of Figure 1 reveals that book locations can be determined based on query results by selecting the location view column to obtain relevant information. All book location information derives from actual conditions, with library floor plans rapidly generated in the backend, enabling automatic modification of library structures and facilitating convenient maintenance by librarians. Based on query results and combined with actual floor plans, clicking the location view pops up a 3D floor plan of the library, with red dots marking current book positions [5].

1.2 Intelligent Search

When users search for materials in libraries, locating needed information among massive data presents significant difficulty. Intelligent search functions enable users to access information more conveniently, efficiently, and accurately. Through intelligent search capabilities, users can employ natural language queries, allowing the system to automatically understand user intent and extract valuable information needed from vast databases.

On the library website homepage, users select search criteria—such as title, author, subject term, ISBN, or publisher—from a dropdown menu within the search box. For example, entering the book title "Dream of the Red Chamber" and clicking "Search" on the right produces relevant results. To obtain bibliographic details, users click the book title to access detailed information and holdings data, including call number, location, and item status [6]. The system also adjusts search results based on users' search history and behavioral patterns. If a user frequently searches for certain types of information, the system prioritizes displaying relevant results, delivering a personalized experience.

1.3 Artificial Intelligence Analysis

Smart libraries digitalize various operations. During AI application, user needs require in-depth interpretation, and intelligent tools' advantageous functions

enable rapid processing of these requirements. AI technology can automatically collect user operation behavior data to construct comprehensive and precise user profiles [7].

To obtain behavioral data, implementation uses Python language combined with crawler frameworks, selecting appropriate toolkits and employing correct expression methods. Application downloaders acquire crawled data, which after parsing is stored in MySQL databases. The obtained user data is itemized on library websites and stored in databases, enabling users to access it anytime and even review borrowing history, further verifying user behavior.

During user data processing and analysis, Python collects data and performs cleaning as needed, removing missing data and eliminating meaningless information, including redundant data, defective data, and other non-essential information. Data with format issues must also be eliminated to ensure high-quality, usable data.

During data analysis, various advanced technologies should be fully utilized. Data mining technology extracts valuable data, while machine learning technology enables deep analysis of processed data. By analyzing diverse user-related data—such as basic user information, library visit patterns, reading behaviors to understand preferences, and technology usage situations—more accurate user profiles can be established.

Based on data analysis results, user profiles are constructed and displayed across multiple dimensions [8]. Through user profiles, libraries can understand user needs, identify reading habits and preferences, determine correlations with age and occupation, and compare differences in book type preferences among different users.

Key procedures are as follows:

Constructing user profiles, counting each user' s borrowing frequency, average borrowing duration, and extracting user search keywords:

```
# Count borrowing frequency per user
borrow_{count} = data.groupby('user_{id}') ['book_{id}'].count().reset_{index}(name='borrow_

# Calculate average borrowing duration per user
average_{{{borrow}}_{{duration}}} = data.groupby('user_{id}') ['borrow_{duration}'].mean().r

# Extract user search keywords
search_{keywords} = data.groupby('user_{id}') ['search_{keywords}'].apply(lambda x: ' '.joir

# Merge user profile information
user_{profile} pd.merge(borrow_{count}, average_{{{borrow}}_{{duration}}}, on='user_{id}')
user_{profile} pd.merge(user_{profile}, search_{keywords}, on='user_{id}')
```

Analyzing user behavior, classifying users based on borrowing frequency and average duration, and identifying popular search keywords:

```
# Classify users by borrowing frequency and average duration
user_{profile}['borrow_{frequency}'] = np.where(user_{profile}['borrow_{count}'] > user_{pro
user_{profile}['borrow_{{{duration}}_{{category}}}'] = np.where(user_{profile}['average_{{{
```

```
# Analyze user search keywords to identify popular terms
from collections import Counter
all_{keywords} = ''.join(user_{profile}['search_{keywords}']).split()
keyword_{counts} = Counter(all_{keywords})
top_{keywords} = keyword_{counts}.most_{common}(10)
```

2. Improvement Strategies

2.1 Enhanced Human-Computer Interaction Design

Human-computer interaction design enables all library equipment and users to interact on specific platforms where users receive friendly assistance, facilitating convenient borrowing and delivering quality experiences. An effective human-computer interaction interface should present clear content, simple operations, and intuitive functions [10].

Implementing smart navigation and self-service: Using indoor positioning technologies such as Bluetooth beacons to construct three-dimensional navigation systems allows readers to locate books in real-time through mobile apps without visiting the library, reducing book-finding time. Deploying self-service borrowing/return robots and 24-hour smart book cabinets supports face recognition/scanning code borrowing, shortening wait times for manual services.

For multimodal interaction experiences, introducing voice assistants—such as DeepSeek technology—to answer consultation questions and support natural language queries of collection resources. Combined with VR/AR technology, immersive reading scenarios can be provided, such as ancient book restoration demonstrations and historical scene reconstructions.

2.2 Personalized Information Services

Modern information technology should be fully utilized to customize reading services for users, recommending needed books or materials, delivering more accurate and reliable search results, and displaying required content. Big data analytics helps libraries locate materials of interest to users, clarify their needs, and understand user behavior patterns, thereby providing personalized information services with stronger targeting and higher quality [12].

Regarding user profiles and intelligent recommendations: Based on borrowing records, search keywords, and other data, machine learning algorithms generate user interest tags to proactively push relevant books and academic developments. Implementing contextual intelligent search optimizes search engine semantic understanding capabilities, supporting fuzzy queries (such as “rural revitalization case collections”) and associatively recommending derived resources like policy

documents and local practices. Cross-database resource integration enables one-click access to full-media content including e-books, audio-visual materials, and journal articles.

2.3 Smart Library Culture Construction

During smart library culture construction, the focus extends beyond technology application to management model innovation. Libraries use information technology to shape open environments and create shared cultural atmospheres. Various activities can accomplish this work, such as hosting cultural events that disseminate smart library culture while users acquire relevant knowledge to better accept services [14]. For example, libraries can collaborate with universities to invite experts for technology lectures, inviting scholars to guide library work and introduce the latest information technology, enabling staff to expand their knowledge and apply it to practical library operations. Libraries can also hold innovation competitions to increase user attention to various library services, encouraging full interaction between staff and users, focusing on user ideas about library service innovation, and developing innovative service plans based on these ideas. These activities create a more vibrant cultural atmosphere, stimulate librarians' innovation enthusiasm, foster user innovation awareness regarding library services, and encourage active participation in smart library construction.

Cultural inheritance and community connection: Using digital technology to activate rural intangible cultural heritage resources, such as establishing dialect voice databases and folk custom digital exhibition halls, enhances cultural identity. Library learning ecosystem cultivation: Creating "reading growth archives" that record user learning trajectories and generate competency analysis reports (such as foreign language reading advancement suggestions). Thematic reading challenge competitions can also be established to enhance user stickiness through point reward mechanisms [15].

2.4 Smart Governance System Construction

Regarding organizational structure, libraries should adjust from a command perspective by analyzing current departmental settings and personnel division, clarifying each department' s responsibilities, work content, and methods, and understanding all staff members' authority. For example, libraries can establish dedicated information technology departments for information management, staffed with personnel for smart system maintenance who possess data management capabilities and can drive technological innovation based on actual library operations. Additionally, user service departments should be established to provide needed services to users, handling consultations, organizing feedback, and resolving complaints.

For example, libraries applying the Qingdao Hengrui patent system can monitor real-time visitor flow and book circulation status across branch libraries,

automatically recommending the nearest available branch and alternative titles during main library maintenance. Cloud computing platforms enable regional interlibrary resource allocation, avoiding long-term shortages of popular books. Data-driven decision optimization analyzes user behavior big data (such as shelf idle rates, high-frequency search terms) to guide procurement strategies and service adjustments. A service quality KPI system (such as borrowing efficiency improvement rate, user satisfaction) should be established and integrated into a smart management dashboard.

Conclusion

Research clearly indicates that smart libraries must prioritize user experience to achieve sustainable development, serving as both the starting point and ultimate goal of library service intelligent transformation. By enhancing user experience in library and information services, smart libraries can better meet user needs and drive library services toward greater intelligence, personalization, and efficiency. In the future, as technology continues advancing and user demands evolve, smart libraries will continue innovating and developing, bringing greater convenience to users. Libraries will no longer be mere book repositories but will become vibrant, innovative knowledge service centers and cultural exchange platforms. This study proposes that smart libraries apply artificial intelligence technology to provide quality user experience environments, utilize generative AI to enhance interaction naturalness, and promote the improvement of intelligent knowledge service platforms.

Smart libraries are not only knowledge storage spaces but also core hubs for stimulating creativity and promoting lifelong learning. Only by continuously focusing on user experience, providing personalized services, and balancing technology with humanism can smart libraries maximize their social value.

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