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Exploration of a Data-Driven and AI-Enabled Intelligent Service Model for University Libraries

Min Zhang
The circulation department of Library, Taishan University, Tai'an, Shandong, China, 271000

Abstract: Driven by the dual forces of digital transformation and intelligent education, university libraries are transitioning from traditional document storage centers to smart service hubs. This paper focuses on data-driven theory and AI technology applications, integrating the characteristics of university library service scenarios to construct a closed-loop smart service model of "data collection-intelligent analysis-precise service-feedback optimization." By analyzing current pain points in university libraries regarding resource integration, service responsiveness, and user demand matching, it explores three dimensions: intelligent resource restructuring, precise service delivery, and smart management upgrades. Specific implementation pathways are proposed by integrating big data analytics, machine learning, and natural language processing technologies. The research provides theoretical references and practical insights for university libraries to overcome service bottlenecks, enhance user experience, and strengthen educational support functions.
Keywords: Data driven, AI empowered, university libraries, intelligent services, service models

I. Introduction

With the rapid iteration of digital technologies such as artificial intelligence and big data, educational informatization has entered a new stage of smart education. As the core supporting institution for talent cultivation and scientific research, university libraries are facing the dual challenges of service target demand upgrading and technological application innovation [1-5]. The traditional "resource centered" service model is no longer able to meet the needs of teachers and students for personalized resource acquisition, efficient information retrieval, and in-depth knowledge services. The integration of data-driven and AI technology provides technical support for the reconstruction of library service models. As the core driving force for promoting the intelligent transformation of libraries, data-driven and AI empowerment can deeply explore the value of data, accurately understand user needs, innovate and optimize service models, and enhance the service efficiency and core competitiveness of libraries. Although most university libraries have initiated intelligent construction, there are still shortcomings in data integration, technology implementation, and service closed-loop, and there is an urgent need to build a systematic intelligent service model.

II. Theoretical basis of data-driven and AI empowerment

A. The concept and connotation of data-driven approach

Data driven refers to a method and concept that centers around data, collects, stores, analyzes, and mines massive amounts of data to discover patterns and values behind the data, providing strong support for decision-making, business optimization, and service innovation. In the field of university libraries, data-driven means that libraries can comprehensively collect multi-source heterogeneous data such as reader behavior data, resource utilization data, and service feedback data, and deeply explore the information contained in these data through data analysis techniques, such as reader reading preferences, resource usage frequency, service satisfaction, etc., thereby providing accurate basis for library resource procurement, service optimization, management decisions, etc.

B. Principles and Applications of AI Empowerment

AI empowerment refers to the use of artificial intelligence technologies such as machine learning, deep learning, natural language processing, etc., to endow systems or devices with intelligent capabilities, enabling them to simulate human thinking and behavior, achieve autonomous learning, autonomous decision-making, and autonomous services. AI empowerment can be applied in multiple aspects in university libraries. For example, using natural language processing technology to achieve intelligent retrieval and question answering, providing readers with a more convenient and accurate way to obtain information; Using machine learning algorithms for

resource recommendation, personalized resources are pushed to readers based on their historical behavior and interest preferences; Utilizing deep learning techniques for image recognition and classification to improve the efficiency and accuracy of resource organization.

C. The integration relationship between data-driven and AI empowered

Data driven and AI empowered are interdependent and mutually reinforcing. Data driven empowerment provides abundant data resources and training samples for AI, which is the foundation for the effectiveness of AI technology. Only based on a large amount of high-quality data can AI models accurately learn and train, thereby achieving intelligent decision-making and services. And AI empowerment can further enhance data-driven efficiency, by deeply mining and analyzing data, discovering potential value hidden in the data, and providing more accurate decision support for data-driven.

III. Analysis of the Current Situation and Existing Problems of Intelligent Services in University Libraries

A. The Current Status of Intelligent Services in University Libraries

The current intelligent construction of university libraries has achieved initial results: the digitalization rate of resources has significantly increased, and the total amount of digital resources such as e-books and databases continues to grow; Basic intelligent services are gradually being implemented, such as self-service borrowing and returning devices, online consultation platforms, and simple resource recommendation systems, which have been widely used; Some universities have introduced AI consulting robots, intelligent bookshelves and other devices to explore the integration path of technology and services; Some libraries have also launched personalized services, such as recommending relevant books and literature to readers based on their professional background, research interests, etc., to meet their personalized needs; In addition, some libraries also enhance readers' information literacy and academic abilities through organizing academic lectures, training courses, and other activities.

B. Analysis of Existing Problems

(1) **Insufficient data integration:** User behavior data, resource data, and service data are stored in different systems, lacking unified data standards and integration platforms, making it difficult to achieve maximum data value. The efficiency of resource utilization is not high, and there is a contradiction between idle resources and unmet needs of teachers and students.

(2) **Low service accuracy:** Existing services are mostly a "one size fits all" model, which fails to provide personalized resource recommendations and customized information services based on user profiles and behavior data, resulting in low matching of user needs. Due to the lack of in-depth mining and analysis of reader behavior data, the accuracy of recommendations needs to be improved, making it difficult to truly meet the personalized needs of readers. The existing service model lacks innovation and foresight, making it difficult to adapt to rapidly changing information technology and user needs.

(3) **Technology implementation is not deep:** AI technology is mostly applied in shallow scenarios such as consultation response and resource retrieval, and its application in core scenarios such as deep knowledge mining, scientific research assistance, and personalized learning support is insufficient. Library staff mostly come from traditional literature service backgrounds and lack specialized technical abilities in data analysis, system maintenance, and algorithm optimization. They are unable to maintain and operate intelligent recommendation or search optimization systems, resulting in ineffective operation of intelligent service mechanisms.

(4) **Lack of feedback mechanism:** Lack of real-time collection and analysis of service effectiveness data, unable to form a closed loop of "service feedback optimization", resulting in service iteration lagging behind changes in user needs.

IV. Construction of intelligent service model for university libraries based on data-driven and AI empowered approaches

A. Principles of pattern construction

(1) **Requirement oriented principle:** With the teaching and research needs of teachers and students as the core, focus on designing service functions in core scenarios such as resource acquisition, information retrieval, and knowledge services.

(2) **Data driven principle:** Establish a comprehensive data collection and analysis mechanism to ensure that service decisions and optimizations are based on objective data.
(3) **Principle of technology adaptation:** Based on the actual operational needs and technological carrying capacity of the library, select AI technology and data processing solutions that are adapted to avoid technological accumulation.
(4) **Principle of closed-loop optimization:** Build a closed-loop mechanism of "service supply data collection analysis optimization service upgrade" to achieve continuous iteration of services.

B. Overall architecture design

The intelligent service model constructed in this article includes a four layer architecture of "data layer technology layer service layer feedback layer", with each layer working together to achieve full process intelligence from data collection to service optimization.

(1) **Data layer:** Integration and governance of multi-source data Data collection: Integrate user behavior data (search records, borrowing history, consultation content), resource data (e-books, papers, database metadata), service data (consultation response time, satisfaction score), environmental data (in store pedestrian flow, equipment operation status) and other multi-source data. Data governance: Establish unified data standards and specifications, and form a high-quality data resource pool through data cleaning, deduplication, desensitization, and other processing to provide data support for subsequent analysis.
(2) **Technical layer:** AI core technology support Big data analysis technology: using big data processing frameworks such as Hadoop and Spark to achieve functions such as user behavior analysis, resource heat evaluation, and service effectiveness monitoring. Machine learning technology: Based on collaborative filtering, deep learning and other algorithms, build user portrait models and resource recommendation models to achieve personalized recommendations. Natural language processing technology: applied in intelligent consulting, text mining, information retrieval optimization, to achieve natural language interaction and deep analysis of literature content. Computer vision technology: used in scenarios such as smart bookshelves, facial recognition borrowing, and in store crowd monitoring to enhance service convenience and management efficiency.
(3) **Service layer:** Precision intelligent service supply Resource intelligence services: Build an intelligent retrieval system that supports natural language retrieval, cross database retrieval, and semantic association retrieval; based on user profiles, personalized resource recommendations are implemented, and adapted literature, databases, and academic activity information are pushed. Accurate service supply: providing 24-hour AI intelligent consulting services to answer common questions; Provide in-depth knowledge services such as bibliometric analysis, topic selection suggestions, and citation tracking for scientific research users; Provide customized course resource packages and recommended teaching reference materials for educational users. Management intelligent upgrade: Optimize spatial layout through crowd monitoring in the museum, achieve intelligent maintenance based on equipment operation data, and use service data statistics to evaluate service quality and optimize personnel scheduling.
(4) **Feedback layer:** closed-loop optimization mechanism Real time data collection: Collect service effectiveness data through user satisfaction surveys, service usage data statistics, feedback messages, and other methods. Data analysis and optimization: Using big data analysis technology to mine service pain points, adjusting recommendation algorithms based on user feedback, optimizing service processes, upgrading technical functions, and achieving continuous service iteration.

V. Implementation path and guarantee measures of the model

A. Implementation path

(1) **Phase 1 (Infrastructure Construction Phase):** Build a unified data integration platform, standardize data standards, and complete multi-source data collection and governance; Introduce basic AI technology to achieve the implementation of core services such as intelligent retrieval and AI consulting robots.
(2) **Phase 2 (Deepening Application Phase):** Optimize user profiles and recommendation algorithms to improve the accuracy of personalized services; expand the application scenarios of AI technology to achieve functions such as deep knowledge services and scientific research assistance; establish a service feedback mechanism.
(3) **The third stage (mature and perfect stage):** realizing the closed-loop operation of the entire service

model process, forming a virtuous cycle of "data-driven intelligent service feedback optimization"; continuously iterate technology and services to adapt to changes in teacher and student needs and technological development trends.

B. Guarantee measures

(1) Technical support: Establish a professional technical team, strengthen cooperation with AI technology enterprises and research institutions, and ensure the implementation and continuous upgrading of technology; Build a secure and reliable technical architecture to ensure data security and privacy protection.

(2) Institutional guarantee: Establish data management standards, service quality evaluation standards, user privacy protection systems, etc., to provide institutional support for the operation of the model.

(3) Resource guarantee: Increase capital investment for technology procurement, platform construction, personnel training, etc; Strengthen the construction of digital resources and enrich the resource foundation of smart services.

(4) Personnel guarantee: Develop a systematic training plan to enhance the AI literacy and application ability of librarians through theoretical learning, practical operation, communication and discussion. Introduce interdisciplinary talents and build a composite team of "library science+computer science+data analysis".

VI. Conclusion

This article constructs a smart service model for university libraries, consisting of a data layer, technology layer, service layer, and feedback layer, clarifying the core functions and collaborative mechanisms of each layer. This model is data-driven and supported by AI technology. Through multi-source data integration, intelligent analysis, and precise service supply, it effectively solves the pain points of data dispersion, low accuracy, and shallow technology implementation in current university library services, providing a systematic solution for the intelligent transformation of libraries.

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Author's biography with Photo

Min Zhang is a librarian in the library of Taishan University. He graduated from Shandong Water Conservancy College in July 1997 and obtained his undergraduate degree in Civil Engineering from Shandong University of Science and Technology in 2005. He mainly engage in research in the field of books and archives.