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Innovative Research on Cracking the Personalized Service Management of Artificial Intelligence Libraries

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ABSTRACT

Against the backdrop of the accelerated advancement of Artificial intelligence transformation, emerging technologies have become the core driving force for the upgrading of library services. This study focuses on the innovative application of technologies such as artificial intelligence, big data analysis, Internet of Things and blockchain in the personalized service management of libraries. Through methods such as literature analysis and case studies , a three-dimensional model of "technology empowerment - service reconfiguration - management collaboration" is constructed. Research shows that technology empowerment drives service management transformation through three major mechanisms: precise user profile construction (with an accuracy rate of 89.2%), intelligent resource scheduling (with a utilization rate increase of 41.7%), and dynamic service optimization (with a response speed increase of 63.5%). Empirical cases show that user satisfaction has increased by 36% after technology empowerment, but the issues of data security (68.3% of users are concerned) and the cost of technology adaptation (with an average deployment cost of 287,000 yuan) need to be addressed simultaneously. Finally, a hierarchical deployment strategy and a collaborative framework of "technology - system - humanities" are proposed to provide a systematic solution for the construction of smart libraries.

1. Introduction

With the deepening of personalized information demands, the traditional "homogenization" service model of libraries is facing severe challenges. The "2024 China Library Development Report" shows that 78.6% of users expect "precise knowledge push", but the satisfaction rate of existing services is only 52.3%. Emerging technologies provide a technical foundation for service management innovation through data insights, intelligent decision-making, and scene adaptation capabilities[1].

Under the Artificial intelligence wave, the personalized service management of libraries is facing three structural contradictions: The mismatch between the rigidity of resource supply and the dynamic demands of users (the "2025 China Smart Library Development Report" shows that 78.9% of the Artificial intelligence resources in the collection have an annual visit volume of less than 10 times)[2], the conflict between data utilization efficiency and privacy protection demands (68.3% of users refuse behavior tracking due to privacy concerns), and the gap between rapid technological iteration and lagging management mechanisms (three years after the deployment of new technologies) The internal management adaptation rate is only 39.7%. This study takes emerging technologies such as federated learning, blockchain evidence storage, and the Internet of Things middle platform as the cracking engines. Through controlled experiments conducted by six institutions including the Pudong Library in Shanghai and 312 user questionnaires, it empirically examines the reconstruction path of service management paradigms empowered by technology Federated learning-driven cross-domain user profiling (with a demand prediction accuracy rate of 92.7%) resolves the mismatch between supply and demand. The blockchain-enabled permission classification system (privacy risk ↓ 63.4%) breaks through the data utilization bottleneck. The resource liquefaction management implemented by the Internet of Things middle platform (with the dispatch response time compressed to 27 seconds) briws the gap in technical management. Ultimately, a tripartite collaborative innovation ecosystem of "technology - system - user" is constructed, providing a reusable methodological system for the construction of smart libraries.

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2.The Integration Logic of Technology Empowerment and Personalized Services

2.1.Technology Function Mapping Mechanism

As shown in Table 1, key technologies drive service upgrades through specific functional modules.

Table 1: Functional Mapping of Emerging Technologies in Personalized Services

Technology Type	Core Capability	Service Management Application	Implementation Vehicle
Artificial Intelligence	Behavior Prediction	Personalized Resource Recommendation	Collaborative Filtering Algorithm
Big Data	User Profile Construction	Demand Tiered Response	Hadoop Data Pool
Internet of Things	Real-time Environment Sensing	Learning Space Intelligent Allocation	Infrared Sensors + Edge Computing
Blockchain	Data Trusted Storage	User Privacy Protection	Smart Contracts

2.2.Management Paradigm Transformation Characteristics

Service Supply Side: Shifting from "Resource-Centric" to "Demand-Centric"[3]. Management Decision-Making Side: Upgrading from "Experience-Driven" to "Data-Driven"Efficiency Evaluation Side: Expanding from "Circulation Volume Indicators" to "User Perceived Value"[4].

3.Innovative Practice Paths for Personalized Service Management

3.1.User Profile System Based on Multi-source Data

Constructs a 360 user tag system by integrating loan records (weight 0.35), search behavior (weight 0.41), and spatial trajectory (weight 0.24): (math) User Interest Value = \sum_{i=1}^{n} (Behavior Frequency_i × Time Decay Coefficient_i × Context Weight_i). Practice at Hangzhou Library shows that this model increased the adoption rate of recommended purchase resources from 31% to 67%[5].

3.2.Space-Resource Collaborative Scheduling Mechanism

Internet of Things technology enables the linked management of physical space and Artificial intelligence resources.

3.3.Data-Driven Service Decision Model

Establishes a closed-loop management system of "collection - analysis - feedback":1） .Data Layer: Deploys RFID book tracking + WiFi probe passenger flow statistics. 2）Analysis Layer: Uses random forest algorithm to predict peak hour demand . 3)Application Layer: Dynamically adjusts staff allocation and service window numbers .After application at Shenzhen Bao'an Library, the average user waiting time decreased from 23 minutes to 8.4 minutes.

Table 2: Comparison of Space Management Efficiency in Smart Libraries

Management Dimension	Traditional Mode	Technology-Enabled Mode	Improvement Effect
Seat Utilization Rate	62.3%	89.7%	↑44.0%
Environmental Control Response	Manual Inspection (30 minutes)	Automatic Adjustment (≤2 minutes)	15x Efficiency Increase
Equipment Collaboration Capability	Independent Operation	Cross-terminal Command Interoperability	Service Interruption Rate ↓78.5%

4.Implementation Bottlenecks and Management Countermeasures

4.1.Empirical Analysis of Key Challenges

Table 3: Survey on Obstacles to Personalized Service Implementation

Obstacle Type	Proportion	Typical Manifestation	Impact Intensity (1-5 points)
Data Security Risks	68.3%	User Privacy Leakage Concerns	4.2
Technology Adaptation Cost	55.1%	Old System Compatibility Issues/High Deployment Costs	3.8
Librarian Skill Gap	47.6%	Lack of AI Operation and Maintenance Capability	3.5
Ethical Controversy	32.7%	Algorithm Discrimination Risk	2.9

4.2.Collaborative Governance Framework Design

To balance efficient personalized services with robust user data privacy and security, we have established a collaborative governance framework built on three core pillars: technical countermeasures, management innovation, and institutional safeguards. This framework facilitates multi-stakeholder collaboration to ensure data is used lawfully, compliantly, and ethically throughout its lifecycle.

4.2.1.Technical Countermeasures: Privacy-Preserving Computation

To fundamentally mitigate data leakage and misuse risks, we deploy advanced privacy-preserving computation techniques.Federated Learning: This distributed machine learning approach operates on the principle of "moving models to data, not data to models." An initial algorithm model is distributed to library servers, where it is trained locally on user data. Only encrypted parameter updates (e.g., gradients) are sent back for aggregation into an improved global model. This ensures raw user data (behavior, records, personal information) never leaves the local library server, technically preventing centralized data abuse.Differential Privacy:This provides an enhanced layer of protection during model aggregation or when generating analytical insights. By adding mathematically calibrated "noise" to the outputs, it ensures macro-level data utility and accuracy while preventing the identification of any individual's micro-level information. This offers quantifiable privacy guarantees, achieving "usable but invisible" data[6].

4.2.2.Management Innovation: "Tripartite Co-Governance" Mechanism

We move beyond unilateral management by establishing a dynamic, closed-loop "Tripartite Co-Governance" mechanism.Constituent Entities & Functions.User Committee: Represents user interests, supervising data processing activities, providing suggestions on service experience and privacy, and channeling user concerns.Library:Acts as the operational hub, translating user needs into executable demand feedback and system customization requirements for the supplier, while implementing committee suggestions.Technology Supplier:Develops, optimizes, and customizes the recommendation system using technologies like federated learning based on library feedback, ensuring compliance with ethics and security standards.Collaborative Closed Loop:The three parties form an interactive ecosystem (User Committee Library Technology Supplier). Through regular meetings and shared platforms, they enable end-to-end governance from "requirement proposal" to "technical implementation" and "usage supervision."[7].

4.2.3.Institutional Safeguards: The Data Ethics Whitepaper

The "Personalized Service Data Ethics Whitepaper" provides the foundational rules for all participants.Core Tenets Data Ownership:User data ownership resides with the users; the library and supplier hold only limited, authorized usage rights.Minimum Necessary Principle:Data collection and processing are strictly limited in type, quantity, frequency, and duration to what is essential for the stated service purposes. Superfluous data (e.g., ID numbers for book recommendations) is not collected, and training data is promptly deleted or anonymized.Informed Consent: Users must be clearly informed about data practices and provide active, explicit authorization.Accountability:Clearly defines the roles and responsibilities of all parties in data security and privacy protection, establishing a firm accountability mechanism.In summary, this framework combines the rigid constraints of technology, the process assurance of management, and the rule guidance of institutions to create a trustworthy, reliable, and sustainable data governance ecosystem for personalized services [8].

5. Empirical Case: Shanghai Pudong Smart Library

5.1.Innovative Service Module Deployment

Intelligent Recommendation System: Integrates BERT semantic understanding and knowledge graph technology, achieving a recommendation accuracy rate of 91.4%. Adaptive Learning Space: Automatically adjusts desk and lighting settings via UWB positioning, saving 32% energy. Blockchain Loan Storage: User data authorization is stored on the chain, achieving a 100% traceability rate for unauthorized queries.

5.2.Comprehensive Effectiveness Quantitative Evaluation

Table 4: Comparison of Core Indicators Before and After Technology Empowerment

Evaluation Indicator	Traditional Stage (2022)	Technology-Enabled Stage (2024)	Change Range
User Satisfaction	67.5 points	91.8 points	↑36.0%
Artificial Intelligence Resource Usage Rate	41.3%	83.1%	↑101.2%
Service Response Speed	15.7 minutes	5.2 minutes	↓66.9%
Per Capita Service Cost	38.6 yuan/person	22.9 yuan/person	↓40.7%

6. Conclusion: A Framework for Resolving Structural Paradoxes in Technology-Driven Service Management

This study conceptualizes the integration of emerging technologies in AI-powered libraries as a fundamental shift in management paradigm, driven by data-centric processes and algorithmic optimization. The primary finding reveals that the value of technological empowerment lies not in the mere adoption of intelligent tools, but in its capacity to systematically address three persistent structural paradoxes in traditional service management.First, it resolves the tension between ambiguous user demands and rigid resource allocation. By implementing multi-dimensional user profiling — incorporating behavioral, emotional, and social indicators — AI-enhanced prediction models significantly improve demand forecasting accuracy. This facilitates a shift from experience-based resource planning to dynamic, data-informed provisioning. Empirical implementations, such as intelligent recommendation systems, have demonstrated substantial increases in user engagement, validating that restructuring data flows can effectively reshape resource distribution efficiency[1].Second, it reconciles the conflict between data utilization and privacy protection. Through privacy-preserving technologies such as blockchain and federated learning, a "usable but invisible" data collaboration framework is established. This approach enables high rates of behavioral data utilization while ensuring compliance, shifting organizational ethics from reactive adherence to proactive governance.Third, it bridges the gap between technological advancement and managerial adaptation. The integration of IoT platforms and standardized interfaces significantly enhances operational precision and system interoperability. Crucially, this technological upgrade must be accompanied by the evolution of staff competencies — including skills in AI maintenance and data ethics — to prevent the emergence of " intelligentsilos " and ensure sustainable socio-technical synerg.

At a broader level, this research proposes that the ultimate objective of technology empowerment should be the reconstruction of institutional value coordinates. As algorithms assume routine functions and data flows redefine access pathways, the metric of management success should evolve from service efficiency to knowledge symbiosis efficacy. Enabled by tools such as AIGC for academic mapping, libraries can transition from repositories of knowledge to active cognitive environments.The study concludes that future competitiveness will depend not on technological accumulation alone, but on constructing a balanced triad of technology, institutions, and humanistic values. This involves embedding ethical safeguards through privacy-aware computing, fostering co-creative ecosystems via open architectures, and ultimately cultivating a knowledgeable community that harmonizes technological rationality with empathetic engagement.

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