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Narrative Review

A Narrative Review of the Implementation Requirements for Developing Smart Libraries

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Abstract

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Introduction: Smart libraries represent a new generation of libraries whose use is growing. This study aims to provide a narrative review of the implementation requirements needed for their development.

Methods: This paper used a narrative approach to collect and review studies. In this review, published documents from 2000 to 2023 were retrieved by searching the following three electronic scientific databases: Web of Science, PubMed, and Scopus using keywords including “smart library,” “intelligent library,” “concept,” “infrastructure,” “resource,” “service delivery,” and “implement challenge.” Endnote software was used to manage search results and data collected using a form based on content analysis.

Results: A smart library integrates advanced technologies and user-centered services to provide automated resource access. Smart libraries rely on technologies like the Internet of Things (IOT), Radio Frequency Identification (RFID), and data mining to enhance services. Smart libraries prioritize user satisfaction by integrating intelligent human and material resources, leveraging artificial intelligence and metadata to automate resource procurement and decision-making based on user characteristics and open resource analysis. Smart libraries deliver physical and remote services through the Internet, allowing users to interact with the library at any time and location. Smart libraries face security, infrastructure integration, financial costs, and staff training challenges.

Conclusion: Libraries and information centers must comprehend the functions and requirements of a smart library and facilitate the transition to the new generation of smart libraries and their effective implementation. This demands increased attention from information center managers and officials.

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Introduction

Today, the capabilities of smart and intelligent systems have expanded in various sciences and services (1). The growth of intelligent systems stems from the effective application of technology, which researchers consider the most crucial element in the

field of information retrieval (2-4). In recent years, many activities have been conducted in the areas of big data and artificial intelligence (AI). Reports from the Technology and Science Committee in the United Kingdom and the Royal Society indicate a



growing trend among institutions to adopt new technologies and various branches of AI, including machine learning (5, 6).

Traditional library management systems suffer from inefficiencies that impact service quality, so implementing a smart library system is essential for improving integration, user-friendliness, and information accuracy (7). Libraries and information centers must be dynamic and keep pace with modern technologies to respond to and discover the new needs of their users. The emergence of various information sources, users' demand for quick access to resources, and budget constraints of information centers have made the adoption of advanced and intelligent technologies in libraries unavoidable (8, 9). For this reason, in libraries and information centers, various activities, including book lending, information retrieval, and specific reference services, are managed through smart technologies (5, 6), and multiple types of smart services, such as chatbots, have been used in reference sections (10, 11). In some cases, book recommendation systems have also been employed by users as part of an effort to enhance the smart capabilities of libraries (12).

Prominent examples of using intelligent library technologies include display kiosks, location-based technologies, and resource digitalization tools (13, 14). Furthermore, this technological advancement has transformed libraries from repositories of print documents to providers of virtual or digital documents accessible from anywhere. Technological tools have revolutionized libraries, creating smart libraries and expert systems with multifaceted capabilities such as natural language processing, big data analytics, cloud computing, and intelligent information service systems (15, 16).

Conceptually, the term “smart library” refers to a new generation of libraries encompassing intelligent systems, classification techniques, the ability to create personal libraries, informed searching, and statistical reports (17). Developed countries have seen various types of smart libraries emerge, with a significant portion leveraging diverse technologies to facilitate library operations such as collection management, book returns, journal subscriptions,

and late fee calculations (18). Examples include the HCL Intelligent Library project and the China Digital Library Information System Project, which emphasized user satisfaction in their development (19, 20).

Given the rapid technological changes on the one hand and the necessity to address diverse user needs in libraries on the other, it is crucial to explore the requirements and functionalities of employing new technologies in them. Therefore, this research reviews previous studies to understand the implementation requirements for developing smart libraries. The current study aims to find the concepts, infrastructures, type of resources, service delivery methods, and implementation challenges for smart libraries. The results of this study can be used by libraries, librarians, and policymakers in library and information sciences to develop and use smart library services.

Methods

The current study is a narrative review research. To collect data, the Scopus, Web of Science, and PubMed databases were searched using keywords including “smart library,” “intelligent library,” concepts, infrastructures, resources, “service delivery,” and “implement challenge” by using the Boolean operator. In this review, the criteria for inclusion were as follows: 1) The examination of smart libraries, 2) Articles published in academic journals, and 3) Publications dated from 2000 to 2023. The exclusion criteria included 1) Studies that do not address any functions of smart libraries, 2) Outcomes that are not relevant to any aspect of library somatization, and 3) Duplicate entries.

All results were transferred into the EndNote reference management software. Duplicates and non-journal publications were eliminated. Subsequently, the titles and abstracts of the remaining articles were reviewed to assess their relevance to the research objectives. The chosen articles were then evaluated according to the established inclusion and exclusion criteria. A data collection form was used to gather bibliographic information and data about the most important subjects related to the concepts, infrastructures, type of resources, document delivery

methods, and implementation challenges for smart libraries. Simple content analysis was employed to examine the articles, selecting the findings related to research objectives.

Results

Initially, using various search strategies,

2,834 documents were retrieved from the selected databases. After identifying and removing 401 duplicate records and excluding unrelated studies, 52 articles were finally selected for analysis. Tables 1 show the different definitions and concepts for smart libraries.

Table 1. Concepts of smart library

Number	Definition	Resources
1	The smart library is a library without a physical lending unit, without paper books, and without shelves, consisting only of large servers and digital archives connected through digital networks to machines for copying and distribution. This library features AI-based technology and provides Internet of Things services for smart readers. The main task of the smart library is the systematic development of collections, the storage and organization of information and knowledge in digital form, and the creation of easy and cost-effective access from various locations via the Internet.	(1)
2	A smart library that does not require staff is always open for users. This technology enables remote control of the library building, including automatic doors, lighting, self-service kiosks, and public computers. As a result, the library's operating hours will significantly increase, allowing more people to use the library at times that are convenient for them.	(21, 22)
3	A smart library is a location-aware mobile library service, without spatial limitations, that helps users find books and related information. A smart library employs software quality engineering practices, aiming to minimize the likelihood of errors in using the libraries and maximize the user's ability to identify and correct mistakes if they occur.	(3, 7)
4	A smart library understands the connections between books, the connections between books and people, and the connections between people anywhere and anytime. Digitization, networking, and the intelligent management of information form the technical foundation of the smart library. Essentially, the smart library is people-centered. It embodies sustainable development and user convenience, with the goal of meeting the increasing informational needs of readers.	(8)
5	Smart library is a smarter way to transform the interaction of users and library systems using the next generation of information technology. To improve the clarity, flexibility and responsiveness of interaction, intelligent services and management	(9)
6	Smart library is a more advanced development of hybrid library and digital library. In the Internet of Things environment, smart library relies on cloud computing technology and intelligent equipment. Book-book understands people's books and people's communities and provides intelligent services for users.	(10, 23)
7	Smart libraries are those libraries which have smart readers, e-resources, smart places, Li-Fi facilities with green environments and smart services, smart librarians. It is a library where all the documents are stored in digital format, processed in digital format and accessible through computers with radio frequency identification facilities, standard Integrated Library Management System (ILMS), federated search tools, discovery tools, web OPAC, standard. Digital software (Dspace/E-Print), content management software.	(2, 14)

Based on the reviewed studies, Table 2 presents the infrastructure requirements for smart libraries.

Table 2. Infrastructures requirements for smart libraries

Number	Infrastructure and technological requirements	Resources
1	- High-speed internet, uninterruptible power supply, cloud data - Radio Frequency Identification (RFID), barcode, smart card, plagiarism detection software, information retrieval software - Wi-Fi/Li-Fi, Economic Transformation Database (ETD) - Green library building, library website, library blog - Budget, ILMS standard, electronic library - Electronic resources (databases, books, magazines, reference sources, audio-visual collections, newspapers, etc.) - Scanner, printer, digital Xerox machine, Closed-Circuit Television (CCTV), sensor, digital gate	(2, 24)
2	- Smart card for user identification and login - Using RFID system for cataloging and resource lending - Centralized databases - Intelligent statistics and reporting - Web-based modules	(7, 15, 25)
3	- Smart card and gate access - Resource fee collection tools - Self-service kiosks - Free Wi-Fi - Public computers - Printing, photocopying, scanning - Access to the library catalog via personal computers	(6, 26, 27)

Table 3 highlights the importance of intelligent types, automated procurement systems, and the role of resources in smart libraries, focusing on their diverse artificial intelligence (AI) in decision-making processes.

Table 3. Type of resources in smart libraries

Aspect	Description	Examples	References
Intelligent resources	Include both human and material resources tailored to meet user needs.	Electronic resources, databases, books, e-journals, AI tools.	(28, 29)
Types of resources	Diverse range of materials to cater to different user preferences.	Books, e-books, audio collections, DVDs, reference tools.	0.51
Resource procurement	Utilizes AI and metadata to automate collection and integration of user-requested information.	Deep learning mechanisms for data collection and analysis.	(13, 28, 30)
Decision-making system	Requires scientific determination of influencing factors such as user demographics and preferences.	Combines user group characteristics and personal user data.	(15, 18, 31)
Open resource collection	Comprehensive analysis of open resources to inform procurement decisions.	Integration of diverse data sources for informed decision-making.	(32, 33)

Table 4 summarizes smart library service delivery previous literature. methods, their descriptions, and examples from the

Table 4. Smart library service delivery methods

Method	Description	Examples	References
Physical delivery	Uses Internet of Thing (IOT) and automation to enhance in-person services. Integrates intelligent systems to streamline repetitive tasks.	- IOT devices (RFID, smart shelves) for real-time data tracking. - Automated cataloging, classification, and document issuance. - Self-service kiosks for borrowing/returning books. - Interactive IOT devices for user tasks.	(18, 34-36)
Online delivery	Provides remote access via internet-enabled platforms. Enables 24/7 access to services without physical presence.	- Cloud-based resource access. - Mobile apps and virtual library portals. - Remote control of lighting, doors, and public computers. - Extended operating hours via automated systems.	(4, 12, 26, 37)
Hybrid integration	Combines physical infrastructure with digital platforms for seamless service.	- IOT-enabled buildings synced with online databases. - AI-driven recommendations accessible both onsite/online.	(35, 38, 39)

Table 5 illustrates the implementation challenges related to smart libraries.

Table 5. Smart library service delivery methods

Challenge/Opportunity	Description	Examples	References
Security challenges	Data leaks, malicious tagging, hacker attacks. Integration issues with digital access control systems.	Privacy concerns, unauthorized data access. System malfunctions during peak hours.	(30, 40, 41)
Infrastructure challenges	Integration difficulties and meeting infrastructure needs. Unavailability of digital infrastructure.	IOT system integration, internet connectivity requirements. Limited information and communication technology (ICT) infrastructure in some regions.	(42-45)
Financial challenges	High costs for IOT implementation, maintenance, and repair. Cost of upgrading library technology and staff skills.	Expenses for sensors, actuators, and internet connectivity. Investment in modernization and service improvement.	(43, 46, 47)
Human resource challenges	Lack of ICT skills among librarians. Requirement for skilled human resources.	Need for training courses and educational materials. Encouraging participation in external training programs.	(30, 44, 45, 48, 49)

Discussion

In today's era, utilizing smart technology to modernize libraries is imperative. Paying attention to this technology encourages more people to use the library. A system equipped with smart technology, entirely dedicated to assisting library users, can meet their needs without staff assistance and without wasting time (50, 51). Moreover, a smart system extends library hours and enables users to conveniently access library services according to their preferences and suitable timings. Neglecting any of these dimensions leads to user time wastage and dissatisfaction with current libraries. The extensive applications of AI can be seen in the dissemination of knowledge at the societal level, consultation at the collection level for resource acquisition, resource planning for acquisition, development, and translation of user needs in accepted formats, and information center management (39, 46).

The concept of a smart library

With a look at the background of libraries and information centers, it is evident that the evolution of libraries has occurred through three stages: modernization, automation, and digitization (5). In some studies, the term "smart library" has appeared interchangeably with concepts like "digital library" or "virtual library" in various contexts (6, 21, 26). The term "smart" implies flexibility, adaptability, scalability, verification, and human-like characteristics. The concept of the "smart library" was coined by Aittola, Ryhanen, and Ojala in 2003 specifically for university libraries, and librarians have since endeavored to implement smart libraries through various methods (8). The smart library is designed so that any authorized user with a computer and connection to library networks can access not only the resources of that library but also various types of information available through national and international networks such as the Internet and intranet (9, 13). Any library can become smart if users can access the building, resources, and library services without needing library staff or other personnel to be physically present (14). Using different concepts to describe a smart library indicates that such a library must be user-centered

and responsive to user needs. Intelligence means that the library should automatically record information and provide resources and services to meet these needs (34, 52). Practical definitions of smart libraries describe it as a new library model aimed at providing better services to users. Some studies overly focus on technology and fail to provide a comprehensive definition for constructing a smart library. Recent research categorizes types of smart libraries into technical (17, 18), service-oriented (2, 4), and pattern-oriented dimensions (53). For instance, Chongqing University and Beijing University of Posts and Telecommunications have established a smart library from a systems perspective (4). In contrast, Taipei's smart library focuses on service provision (7), and Nanjing University's smart library is based on service and technical perspectives, albeit neglecting the human aspect (54).

Technological infrastructure for smart library

One key infrastructure for establishing smart libraries includes technologies such as mobile phones, wireless systems, RFID technology, IOT, data mining, standards, and protocols. These technologies enable online library systems to provide services. Generally, these technologies alone do not make a library smart. Still, without them, libraries cannot design the services that library users expect (5).

The IOT has been the primary technology discussed in studies for smartifying libraries. In summary, the benefits of employing IOT in libraries include better access to collections and resources, the ability to track and locate physical items and inventory control, recommendation and information services, and the use of floor pressure pads and guide lights on shelves for tracking user movements and providing information via mobile alerts, fire detection, and safety management in libraries, lighting control, ventilation, smart air control, and relative humidity control, better preservation of paper books and documents, occupancy information systems using floor pressure pads and pressure sensors, crowd management in study halls by users, physical access to special collections such as rare manuscripts, and tailored recommendations based

on loan history data, and the like (42). However, every technology may present challenges, and the challenges of IOT in libraries and information centers include security and privacy concerns. To make better use of IOT, users may need to keep mobile data active at all times, potentially exposing their location. Moreover, unauthorized access to devices may jeopardize contents such as photos and documents, posing risks to individual privacy (42).

The IOT represents a significant development that can substantially change libraries, specifically how they interact with their users. IOT is a pattern of change within society and has the potential to reshape library configurations. The importance of leveraging IOT and moving towards smart environments in libraries lies in eliminating many unnecessary tasks, streamlining workflows, and even parallel activities across different departments, thereby saving costs and enhancing decision-making speed and service delivery. IOT can present a positive image of libraries as modern institutions, which can be utilized in marketing and elevating the position of libraries. The prevalent nature of IOT technologies today promises a more interconnected world and anticipated benefits from these deeper connections. It can establish global links among numerous universities, libraries, and research centers (36, 55-57). The compelling reason for the prevalence of IOT technologies today lies in their promise of a more globally interconnected world and the anticipated benefits of these deeper connections (58). These technologies can potentially create global links among many universities, libraries, and research centers (59).

Type of resources in smart library

Intelligent resources encompass both human and material resources. Smart libraries are essentially established to meet the intelligent needs of smart users. Therefore, all efforts made in the smart library project are aimed at user satisfaction, and users are the most crucial part of the smart library system (29). Various information resources that have been carefully selected to meet the needs of library visitors constitute a smart library. These resources may include electronic resources, databases,

books, electronic journals, electronic reference tools, CDs, DVDs, audio collections, electronic newspapers, reference books, monographs, and so on (14, 60). With the development of metadata and AI technology, the intelligent resource procurement system can automatically collect and integrate all the information requested by users and various document resource information through a deep learning mechanism. Thus, building an intelligent resource and document procurement decision-making system is possible. Constructing an intelligent procurement system requires attention to two key points. First, it is necessary to scientifically and reasonably determine the influencing factors. The library can create a scientific and objective decision-making model by combining comprehensive factors such as user group characteristics (such as gender, age, educational background, occupation, etc.) and personal user information. Second, in an intelligent procurement system, open resources should be comprehensively collected and analyzed (8, 28, 31, 32, 61).

Services delivery in smart libraries

Smart library services are provided physically and remotely via the Internet and Internet-enabled access. Therefore, the two predominant methods for delivering smart library services are physical and online methods. In the physical method of delivering smart library services, technologies such as IOT can be used for real-time data recording. Several processes can be revised using business process reengineering. Implementing an intelligent library management system that integrates IOT and automates core processes of the traditional library moves the library toward the next-generation library. Users can intelligently interact with IOT devices to perform relevant tasks (62). Thus, eligible users can visit buildings to benefit from smart library services and information centers. A smart library automates time-consuming and repetitive activities in traditional libraries, such as cataloging, classification of library resources, searching catalog cards, and document issuance and return. On the other hand, in the online method, library services are accessible to library users without library staff or users in the library building (18, 35, 48, 62).



This technology enables remote control of library buildings, including automatic doors, lighting, self-service kiosks, and public computers (4). This capability extends library operating hours significantly, allowing more individuals to use the library at times convenient for them (21, 38). Smart libraries can be accessed virtually and remotely. Therefore, users can access the library from their homes through their smart devices or public library computers (23, 38).

Implementation challenges for smart libraries

Various studies have shown that controlling and reducing security issues such as data leaks, malicious tagging, and hacker attacks in smart libraries should be taken seriously (48). Infrastructure challenges (integration difficulty of systems and meeting infrastructure requirements and needs can be significant) and financial challenges (the IOT includes tagging library inventory items) may cause additional costs in the library budget. Other cost requirements include sensors, actuators, device communication, internet connectivity, and the like. Additionally, equipment maintenance and repair will also incur costs (42, 55). Although the costs of upgrading library technology and librarian skills come with expenses, libraries are inevitably influenced by new technologies and sooner or later will tend toward them. Therefore, today's costs are investments in improvement and modernization, leading to better service delivery. Addressing these issues as a significant challenge is essential (56). Not all librarians possess the skills and literacy to use new technologies, and skilled human resources are another requirement for smart libraries. In this regard, defining relevant training courses within the organization, encouraging employees to participate in external training courses, and providing educational materials, such as notes and brochures, can be beneficial (30, 55, 57, 63).

Conclusion

Smart libraries are a new generation of libraries with a smart super engine, personalized library, conscious search, and big data analysis. They are known by different names: digital, smart, or hybrid.

The shift from traditional to smart libraries marks a transformative evolution in library services, driven by advanced technologies, user-centered design, and strong infrastructure. Technologies like IOT, RFID, and AI enhance efficiency, accessibility, and personalization, revolutionizing library operations. To meet the new needs of their audience, libraries and information centers need to pay more attention to this field, understand the requirements and functions, and move towards making services more intelligent.

However, challenges such as data security, financial constraints, and the need for skilled staff must be addressed. Libraries should prioritize staff training, cost-effective solutions, and a balanced technology and user needs approach.

Developing smart libraries requires thoughtful planning, collaboration, and adaptability. By addressing these challenges and leveraging emerging technologies, libraries can modernize while maintaining their mission of fostering knowledge. Smart libraries will play a key role in shaping connected and informed societies as digital advancements continue.

Future research should focus on comprehensively defining smart libraries, addressing security and privacy issues, improving cost-effectiveness and scalability, and bridging the skills gap through scalable training models.

Declaration

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Statement

This research was approved by the Committee for Ethics in Biomedical Research of the Abadan University of Medical Sciences, code: IR.ABADANUMS.REC.1402.098.

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Authors' Contribution

Both the authors contributed to designing, developing, and writing all parts of this study.

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