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Potential and Challenges of AI-Enhanced IoT Systems for Smart Libraries: A Systematic Review

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Abstract

The sudden advancement of artificial intelligence (AI) and the Internet of Things (IoT) has created fresh opportunities for evolving conventional libraries into automated and smart libraries. This systematic review examines the incorporation of AI and IoT technologies within smart libraries, highlighting their potential benefits and challenges in enhancing user experiences, optimizing resource management, and refining library operations. In accordance with the PRISMA guidelines, the researcher systematically identified and analyzed 20 pertinent peer-reviewed articles published from 2014 to 2024. The analysis indicates that AI-driven IoT applications concentrate on five main areas: 1) Intelligent Space Management, 2) Personalized User Services, 3) Enhanced Security, 4) Efficiency and Infrastructure Management, and 5) Data-Driven Decision Making. The study reveals that important uses are covered by Smart Libraries, such as immediate resource tracking, automatic cataloging, intelligent energy management, and tailored user suggestions. Besides, significant improvements in optimizing resources, user experience, and operational effectiveness have been reported by the study; however, the review also highlights important drawbacks, including the need for staff upskilling, high implementation costs, data privacy concerns, and technical interoperability issues. For researchers and library administrators, this review offers a fundamental framework that outlines the state-of-the-art, gaps in the literature, and future research possibilities for the ethical and sustainable growth of next-generation smart libraries.

Keywords: *Smart Library, Artificial Intelligence, Internet of Things, Systematic Review, Potential, Challenges*

I. INTRODUCTION

Historically, libraries have served as the foundation for knowledge transmission and communal education. However, the digital age brought about an evolution of the paradigms from traditional repositories to intelligent, interactive, and flexible platforms due to the

explosion of information and shifting user expectations (Bi et al., 2022). The "Smart Library" concept has arisen in reaction to this transformation, utilizing advanced technologies to improve services, streamline operations, and foster immersive learning experiences (Xie et al., 2020). Traditional library operations are being replaced by intelligent, automated, and user-centric service delivery models in smart libraries (Shahzad et al., 2024). AI-augmented IoT solutions are transforming the administration and user experience in smart libraries (Narendra et al., 2025). The architecture of AI-IoT systems generally has three tiers: the perception layer, the network layer, and the application layer. The perception layer comprises IoT devices and sensors that gather data, whereas the network layer enables data transmission (Al-Garadi et al., 2020). The application layer utilizes AI algorithms for data processing and decision-making (Al-Garadi et al., 2020). Intelligent libraries integrate IoT sensors (RFID, WSN, occupancy, environmental) with AI technologies (ML, NLP, recommender systems, computer vision, expert systems) for automated inventory management, customized services, enhanced sustainability, and safeguard collections (Bi et al., 2022). Adoption of smart libraries demonstrates prototypes and pilots but encounters challenges related to privacy, interoperability, data quality, cost, and talent deficiencies (Shahzad et al., 2024). The integration of AI and IoT technology in library environments offers increased operational efficiency, richer user experiences, and data-informed decision-making. However, there are a number of ethical, financial, and technical obstacles to the actual deployment of these systems, which call for a thorough analysis of the body of existing research (Xie et al., 2020).

II. OBJECTIVE OF THIS STUDY

The study's main goal was to conduct a comprehensive review in order to investigate the potential, advantages, and challenges of AI-Enhanced IoT Systems for Smart Libraries.

III. LITERATURE REVIEW

Smart libraries employ AI for sophisticated analytics and IoT for real-time data collection, which helps them better serve patron demands. IoT-enabled gadgets, such sensors, smart shelves, and RFID tags, make automated inventory management and book tracking possible, cutting down on human labor and maximizing resource use (Al-Fuqaha et al., 2015). By offering tailored book suggestions, enhancing search algorithms, and forecasting user preferences based on past data, AI further improves these systems (Bayani et al., 2017). Research has also demonstrated how AI-driven chatbots and virtual assistants may provide user-focused services including handling bookings, directing users to the resources they want, and responding to questions (Cheung et al., 2023). Besides, Natural Language Processing (NLP) technologies are being used in AI-supported smart libraries to improve semantic search, comprehend queries, and provide conversational reference services (Al-Garadi, 2020). Through chatbot interfaces, NLP systems offer automated support and facilitate more natural user interactions with library catalogs (Guo et al., 2025). Moreover, to offer individualized resource recommendations, AI-powered recommender systems make advantage of user profiles, borrowing histories, and behavioral analytics (Al-Fuqaha et al., 2015). According to implementation studies, the usage of tailored suggestions increases user engagement and resource discovery rates (Dwivedi et al., 2019). Research also shows that security monitoring, book identification, and automatic shelving are all supported by

computer vision applications (Bayani et al., 2017). Although adoption of smart libraries is still mostly in the research and pilot stages, robotic systems are being investigated for inventory management and retrieval activities (Wang & Xu, 2024). Pilot IoT-AI systems have been implemented at a number of university libraries around the world with encouraging outcomes. For example, RFID, occupancy sensors, and AI analytics are successfully integrated in the University of Hong Kong's smart library system to enhance user services and space management (Cheung et al., 2023). Metrics of operational efficiency have improved by 30–40% at other universities with comparable deployments (Dwivedi et al., 2019). AI-enhanced IoT systems have a number of obstacles in spite of their potential. Since gathering and processing vast volumes of user data raises the possibility of cyber-attacks and unwanted access, data privacy and security continue to be crucial issues (Shahzad et al., 2024). The integration of diverse IoT platforms and devices frequently necessitates defined protocols and frameworks, making interoperability another major hurdle (Dwivedi et al., 2019). Another obstacle is the expensive cost of installation and maintenance, especially for universities with tight resources (Wang & Xu, 2024). Attention should also be paid to ethical issues surrounding AI decision-making and how it affects user autonomy (Xie et al., 2020). In order to show that sophisticated AI-IoT integration is feasible, academic research has built a number of prototype systems. The majority of implementations, however, are still in the pilot stage, underscoring the disconnect between theoretical research and practical application. Furthermore, thorough reviews that particularly examine the possibilities and difficulties of AI-Enhanced IoT Systems for Smart Libraries are lacking. The purpose of this study is to close the knowledge gaps and support the appropriate use of smart libraries in any setting.

IV. RESEARCH METHODOLOGY

The Systematic Literature Review (SLR) approach, a thorough and repeatable procedure for finding, assessing, and summarizing all pertinent research on a given topic, was used in this work. The technique adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to guarantee transparency and thoroughness. The review was guided by the principal research objective: "The study's main goal was to conduct a comprehensive review in order to investigate the potential, advantages, and challenges of AI-Enhanced IoT Systems for Smart Libraries". This was divided into sub-components concentrating on certain AI approaches (e.g., machine learning, computer vision), IoT elements (e.g., sensors, actuators), and assessed results (e.g., user satisfaction, operational efficiency, cost reduction, etc.).

Literature Search Strategy

A thorough search was performed in prominent academic databases, such as Scopus, Web of Science, IEEE Xplore, ACM Digital Library, and ScienceDirect, to get multidisciplinary insights from computer science, education, and information studies. The search strategy utilized a systematic query constructed from keywords and Boolean operators, including: ("Artificial Intelligence" or "Machine Learning" or "Deep Learning") and ("IoT" or "Internet of Things" or "Sensor Network") and ("Smart Library" or "Digital Library" or "Academic

Library") and ("Potential" or "Challenge" etc.). Furthermore, a snowballing method was employed by examining the reference lists of pivotal publications to uncover further pertinent research. The retrieved records were evaluated in two stages: initially by title and abstract, followed by a review of the complete text. Studies were eligible if they were peer-reviewed journal articles, conference proceedings, or book chapters published between 2014 to 2024 that directly addressed the convergence of AI and IoT in smart library environments. The exclusion criteria included research not published in English, critique articles, non-peer-reviewed literature, and works in which AI or IoT is not a primary element of the proposed system.

Data Extraction and Analysis

A consistent data extraction form was created to systematically categorize information from each study included. Essential data points encompassed: bibliographic details, research aims, utilized. AI methodologies, outlined IoT infrastructure, particular applications (e.g., smart inventory, personalized education, energy management), reported advantages, and identified challenges (e.g., privacy, expense, interoperability). The studies' quality was evaluated using checklists specific to their methodologies (e.g., empirical studies were examined for research design clarity and outcome validity). The retrieved data were thematically examined to discover, compare, and contrast recurrent patterns, predominant designs, successful application fields, and consensus on future research paths and unresolved difficulties. The findings were organized to deliver a thorough and contemporary summary while addressing the established research purpose. A narrative synthesis accompanied by graphic representations (e.g., charts, tables) was presented to encapsulate the principal results.

Validation & Ethical Considerations

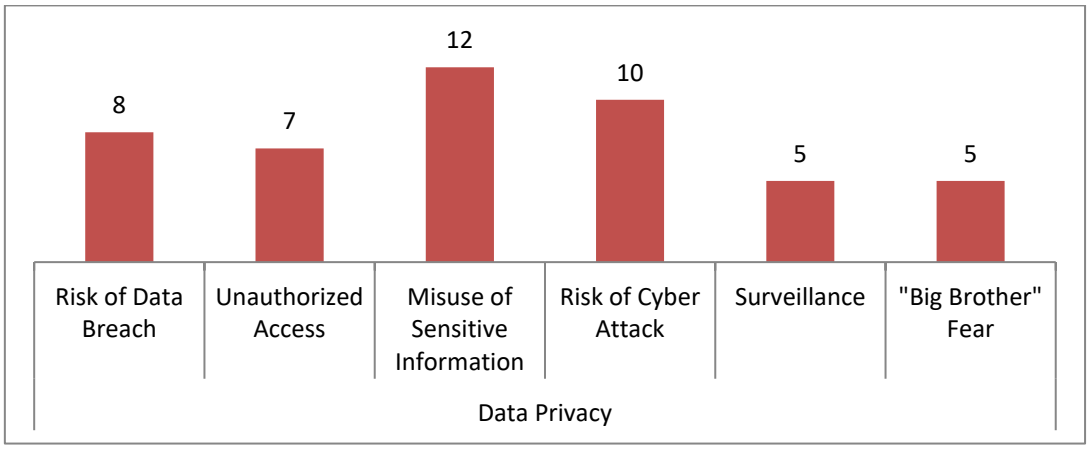
To ensure the quality and reliability of the results, the researcher employed two more reviewers to complete the data extraction and book selection processes. Any disagreements were settled by dialogue or by bringing in a third reviewer. Since this is a systematic review, ethical problems were minimized because neither primary data collection nor human participants are used. Citations have been used to properly acknowledge each author of the material.

V. FINDINGS OF THIS STUDY

As was previously said, the researcher carried out a systematic review to investigate the potential, advantages, and difficulties of AI-Enhanced IoT Systems for Smart Libraries. The method section provided a description of the systematic data collection and analysis process. The following is a description of the data analysis findings:

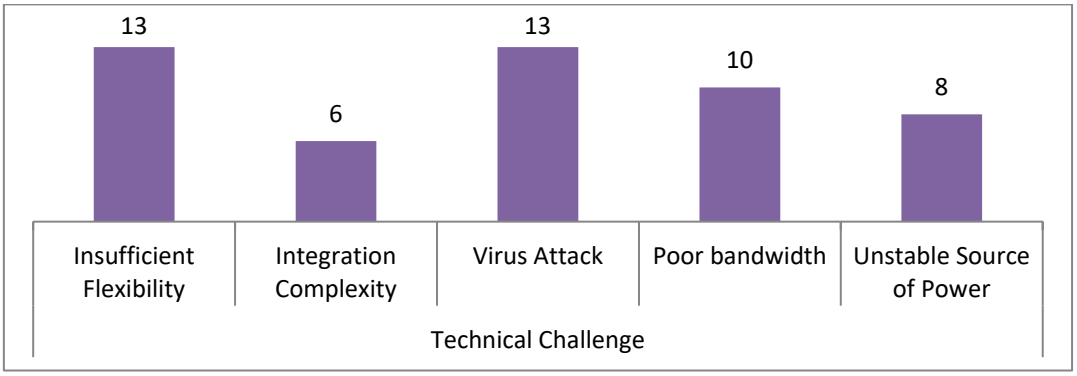
A. Reported Challenges

Data Privacy



Perhaps the most important category of issues is this one. Ensuring data privacy is essential to retaining patron and library trust. A major ethical conundrum for libraries is the possibility of sensitive information being misused (N=12) or accessed without authorization (N=7). According to the studies, the IT infrastructure of a smart library might not be built to resist complex cyber-attacks (N=10) that aim to steal this priceless repository of individual behavioural data. Highly detailed profiles of patrons' personal and intellectual interests could be made public by a breach (N=8). The dread of Big Brother (N=5), on the other hand, is a result of extensive, ongoing surveillance that takes away people of their freedom and privacy, instills fear of retribution for any perceived dissent, and fosters a culture of conformity and obedience. In direct opposition to the library's mission as a bulwark of intellectual freedom, the ongoing surveillance may have the chilling effect of making users feel watched and reluctant to investigate contentious subjects.

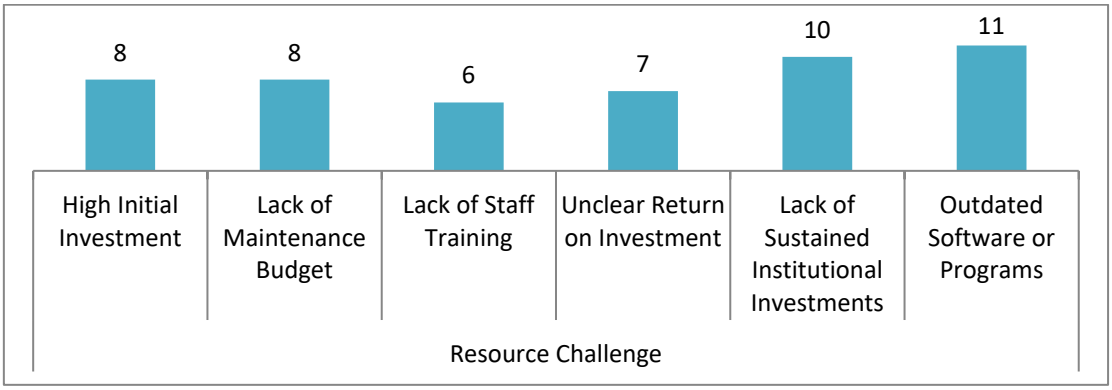
Technical Challenges



The lack of flexibility (N=13) in AI-Enhanced IoT Systems for Smart Libraries has been identified as a challenge in numerous studies, highlighting the system's incapacity to readily adjust, grow, modify, or develop in response to shifting requirements, technologies, or unforeseen circumstances. An AI model is trained on historical user data to suggest books. When a novel educational trend arises or a worldwide event unexpectedly elevates a niche

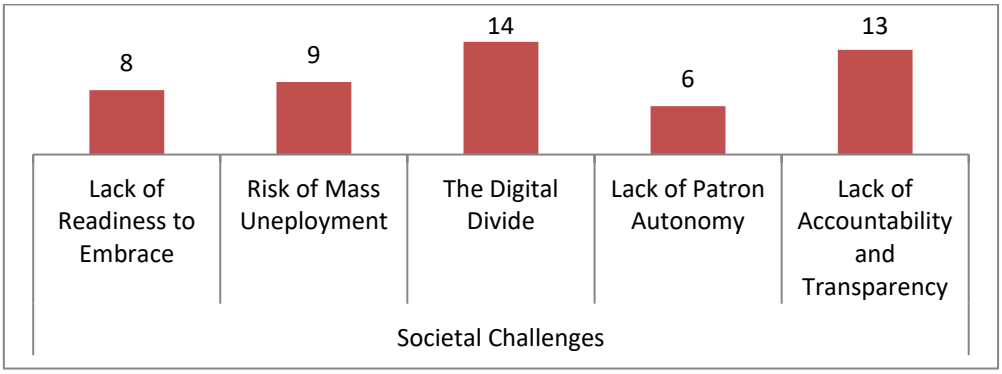
subject's popularity (e.g., a pandemic increasing the demand for virology literature), the inflexible system struggles to promptly adjust its recommendations. The library implements a designated brand of IoT sensors for monitoring book inventory. If a new sensor technology that is more accurate and less expensive appears two years later, a stiff system is so intricately linked with the legacy hardware and software that the integration of new sensors is prohibitively costly or physically unfeasible. Furthermore, smart libraries may encounter integration challenges (N=6) due to the prevalence of legacy systems (Integrated Library Systems - ILS) in most libraries. Integrating novel AI-IoT solutions with legacy, frequently proprietary systems presents a considerable technological challenge. Furthermore, numerous IoT sensors necessitate a resilient, high-bandwidth wireless (N=10) network, such as Wi-Fi 6 or 5G. Network outages or congestion (N=8) might incapacitate the entire smart system.

Resource Challenge



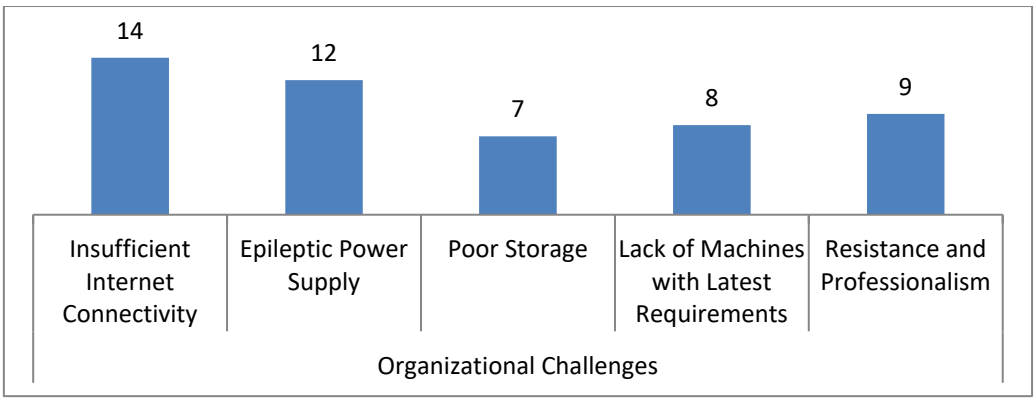
A significant obstacle is the high initial expenses (N=8) associated with purchasing a large network of IoT devices, such as RFID tags and sensors, smart shelves, environmental sensors, beacons, robots, and smart cameras. Moreover, the expenses associated with IoT sensors, AI software licenses, network enhancements, and cloud computing resources are exorbitant for numerous libraries, particularly public ones with limited resources. Expenditures persist beyond the implementation of smart libraries. The ongoing expenses encompass maintenance (N=8), software subscriptions, energy use, and staff training, among others. Furthermore, ambiguous Return on Investment (ROI) (N=7) presents an additional hurdle for AI-Enhanced IoT Systems in Smart Libraries. Quantitatively demonstrating that the efficiency enhancements (e.g., expedited shelving) and superior services (e.g., enhanced suggestions) warrant the substantial investment can be challenging (N=10). Enhancing network infrastructure to accommodate the substantial data traffic generated by IoT devices, together with the expenses associated with AI software platforms, cloud computing services (AWS, Azure, Google Cloud), and data analytics tools, presents significant resource-related problems.

Societal Challenge



The Digital Divide (N=14) is a prevalent issue referenced in the majority of studies. AI-enhanced services may predominantly favour technologically adept persons, thereby exacerbating the disparity for those less proficient with technology, such as the elderly, low-income populations, or individuals with little education. This poses the risk of establishing a dual-tier library system. Moreover, numerous studies have highlighted the absence of accountability and transparency (N=13). Who has the responsibility when an AI system does something incorrectly, such giving incorrect information or incorrectly claiming a customer missed a return based on sensor data? Some AI models have a "black box" quality that makes it difficult to comprehend or question their judgments. Furthermore, excessive dependence on automation and AI interactions may undermine the essential human engagement offered by librarians, hence posing a risk of widespread unemployment (N=9). Hyper-personalized AI suggestions can generate "filter bubbles," confining users to content akin to their previous consumption, so restricting intellectual exploration and discovery, thereby undermining user autonomy (N=6).

Organizational Challenge



A dedicated, competent team and dependable, contemporary infrastructure (N=8) form the cornerstone of the smart library idea. Advanced AI and IoT systems are frequently rendered ineffective or even counterproductive by issues including inadequate internet connectivity (N=14), epileptic power supplies (N=12), inadequate storage (N=7), a lack of current machinery (N=8), resistance, and professionalism (N=9). IoT systems with AI enhancements

are naturally data-hungry. To send sensor data to cloud-based AI models for processing, receive commands and insights from the AI (like a suggestion to put a book back on the shelf), update software and AI models without interruption, and enable digital services for distant users, they depend on steady, high-bandwidth, low-latency internet connections. The system becomes disjointed and unresponsive when there is inadequate connectivity. Furthermore, "epileptic" or erratic power is a death knell for reliable digital services and delicate electrical devices. Computers, networking equipment, servers, and Internet of Things sensors all need steady, uninterrupted power. Databases can be harmed and AI training data rendered unreliable by unexpected power interruptions that damage data during read/write operations. Additionally, library employees could worry that automation and AI would render their positions obsolete. They might be apprehensive about complicated new systems they don't comprehend and at ease with conventional approaches.

B. Reported potentials or Benefits

Benefits	Count	Column N %
Easy and Swift	10	20.0%
Remote Monitoring	12	24.0%
Motion Detection	12	24.0%
Adaptive Learning Partners	9	18.0%
Interconnectivity	7	14.0%
Predictive Analytics for Collection Development	12	35.3%
Progressive Collection Preservation	10	29.4%
Event and Workshop Optimization	12	35.3%
Real Time Surveillance	8	26.7%
Theft and Loss Prevention	4	13.3%
AI-Powered Virtual Assistants	8	26.7%
Ambient Intelligence for Neurodiverse Patrons	5	16.7%
Breaking Language Barriers	5	16.7%
Automated Inventory	8	25.0%
Dynamic Space Utilization	10	31.2%
Smart Notifications	14	43.8%
Intelligent Recommendation Engines	5	18.5%
Customized Physical Pathways	10	37.0%
Asset Tracking	12	44.4%

AI-enhanced IoT devices have the ability to build a library that is a networked, sentient being rather than merely a collection of items. This evolution turns the library into a dynamic environment that proactively meets needs, optimizes every resource—from books to physical space—and ensures fair, tailored access to information for every community member. Our mission is to empower patrons and staff alike by leveraging technology to take care of routine tasks, allowing human creativity, expertise, and connection to thrive. Intelligent recommendation engines (N=5) are a crucial advantageous aspect of smart libraries. By employing AI to examine a customer's real behavior (time spent in particular parts, books picked up but not borrowed) along with their borrowing history, you can go beyond "users who borrowed this also borrowed..." and provide highly customized book, article, and event recommendations. Additionally, a customer may choose to receive a customized asset tracking (N=12) upon arrival that directs them to books that align with their interests, new arrivals, or pertinent project resources—all of which are optimized for the most efficient path. The system could monitor how students use resources, recommend additional readings, make reading lists tailored to their classes, or even pair them with study groups based on common academic interests as Adaptive Learning Partners (N=9). Another benefit of AI-Enhanced IoT Systems for Smart Libraries has been identified as predictive analytics for collection development (N=12). AI can forecast demand for particular subjects, genres, or books by analyzing academic curricula, borrowing patterns, and data from local events. This makes data-driven filtering and purchasing possible, guaranteeing that the collection stays economical and pertinent. Additionally, some studies have noted two additional benefits: automated inventory (N=8) and AI-Powered Virtual Assistants (N=8). RFID tags on goods and Internet of Things sensors on shelves allow for precise, real-time inventory management. Robots or vision systems driven by AI can search shelves all night long for misplaced goods, saving employees hundreds of hours of human effort. Moreover, AI-enhanced security gates can detect unwanted removals and identify patterns that may suggest future theft. Therefore, theft and loss prevention (N=4) can be identified as two additional advantages of AI-enhanced IoT systems for smart libraries. However, numerous studies have highlighted the advantages of AI-Enhanced IoT Systems for Smart Libraries, including progressive collection preservation (N=10). Special collections or archives can have their temperature, humidity, and light levels regularly monitored by environmental IoT sensors. Preventative action is made possible by the AI's ability to anticipate and notify personnel of situations that could harm fragile goods. Additionally, finding particular things (N-10) in the library becomes instantaneous. If a book is lost or in great demand, a staff member can locate it promptly. Further advantages have been highlighted in numerous studies, including smart notifications, AI-powered virtual assistants, optimization of events and workshops, assistance for visually impaired patrons, ambient intelligence for neurodiverse patrons, assistance in breaking language barriers, and other similar features.

VI. DISCUSSION ON THE FINDINGS

The convergence of AI and IoT technologies is revolutionizing conventional libraries into advanced, intelligent systems that improve user experiences and effectiveness in operation. Innovative libraries utilize these technologies in three essential areas: intelligent service,

sustainable practices, and enhanced security (Bi et al., 2022). AI-enhanced IoT systems possess the capability to establish a "Living Library"—an ecosystem that is self-optimizing, predictive, and effortlessly woven into the user's daily experience (Dwivedi et al., 2019). The library's function evolves from merely storing resources to delivering proactive and insightful services (Guo et al., 2025). The enormous potential of AI-enhanced IoT systems lies in their ability to transform a library from a mere collection of items into a cohesive, autonomous entity (Hashim et al., 2021). The library evolves into a space that proactively addresses needs, optimizes the use of every resource (from books to physical space), and ensures fair, tailored information access for every community member (Hashim et al., 2021). The objective is to enable both patrons and staff by leveraging technology to manage routine tasks, allowing for the growth of human creativity, expertise, and connection (Dwivedi et al., 2019). Applications of AI in libraries encompass automated cataloging, improved search capabilities, and tailored recommendations that foster user-focused environments (Guo et al., 2025). The integration of IoT and AI facilitates a cost-efficient digital transformation of traditional libraries, overcoming the constraints of paper-based systems and enhancing the management capabilities of libraries (Zhou, 2024). The present investigation demonstrates that the integration of AI and IoT enhances efficiency, user relevance, asset preservation, and data-driven decision-making (Islam et al., 2025). Libraries experience increased efficiency, improved resource management, and enhanced patron satisfaction when these systems are implemented and embraced by users (Kumar & Singh, 2022)). The implementation of automated check in/out and inventory tracking significantly minimizes the time staff spend on routine tasks while also decreasing error rates. The findings indicate that the system enhances accessibility. Tailored suggestions and location-sensitive searches enhance exploration and boost relevance for users. Additional research supports the notion that intelligent libraries enhance environmental monitoring and that predictive notifications contribute to the preservation of unique collections while lowering conservation expenses. Surveys and qualitative studies indicate that students and librarians anticipate improvements in service quality and convenience through IoT, provided that privacy and training concerns are adequately addressed (Kshetri, 2017). The introduction of artificial intelligence (AI) technology has undeniably led to fundamental changes in library automation.

While artificial intelligence (AI) holds significant promise for enhancing user experiences and optimizing operations, the incorporation of AI into library systems presents specific challenges. The implementation encounters considerable obstacles such as data privacy issues, elevated costs, ethical dilemmas, necessary resource investments, and the risk of job displacement (Kumar & Singh, 2022). A significant challenge in the realm of library automation through AI is the assurance of data privacy. Because AI algorithms use user data extensively for training and optimization, libraries have to strike a careful balance between protecting patron privacy and using patron data to improve services (Islam et al., 2025). The risk of unauthorized access or misuse of sensitive information presents a considerable ethical challenge for libraries. Data privacy is essential for fostering trust between libraries and their users (Manoharan et al., 2024). Libraries have historically managed sensitive patron information, encompassing borrowing history, research interests, and personal preferences.

The emergence of AI has enabled libraries to process extensive datasets, allowing for tailored services and personalized recommendations. Nonetheless, this increased data processing also elevates the risks linked to privacy violations and unauthorized access (Wang & Xu, 2024). Besides, the rise of AI-powered systems in library automation brings forth new vulnerabilities that may be targeted by malicious individuals. It is essential for libraries to implement measures that protect against data breaches, ensuring the confidentiality and trust of their patrons remains intact. The implications of a data breach go further than just harming reputation; they can also lead to legal responsibilities and financial repercussions (Jing, 2024). Even with the possible advantages, users might be reluctant to adopt AI-driven services because of worries regarding privacy, accuracy, and the perceived reduction of human interaction (Kshetri, 2017). Establishing confidence via clear communication and showcasing the benefits of AI-driven improvements is crucial for encouraging acceptance. Algorithmic biases have the potential to erode user confidence in AI-driven library services, as they may lead to the continuation of discrimination, misinformation, and unequal treatment. Individuals might experience a decline in trust towards search outcomes or suggestions if they detect bias within the foundational algorithms, resulting in doubt regarding the neutrality and equity of AI systems. It is crucial to tackle algorithmic biases and enhance transparency in decision-making processes to maintain user trust and reduce the effects of biases on user experiences (Wang & Xu, 2024). Embracing a design approach that prioritizes the user is crucial for improving user acceptance and fostering trust in AI-driven library services (Jing, 2024). It is essential for libraries to engage users in the design and development process, gather feedback, and integrate user preferences and needs into the design of AI systems. Focusing on usability, accessibility, and user satisfaction allows libraries to improve the user experience and build trust in AI-driven technologies. Future trends suggest a more profound integration with big data analytics, augmented reality, and IoT technologies, highlighting the necessity for responsible implementation that harmonizes technological progress with ethical considerations (Li, 2025).

VII. CONCLUSION

The obstacles of AI-enhanced IoT for smart libraries are too enormous to ignore, but the potential is too enormous to be overlooked. A comprehensive, all-encompassing change rather than a straightforward technology update will be necessary for the shift to be effective. Instead of implementing a drastic, all-or-nothing change, it could begin with a single, high-impact pilot project (like smart inventory) to show value and gain knowledge. Prior to investing in cutting-edge AI and IoT technologies, investors should focus on reliable power and strong internet connectivity. A smart library cannot exist on a shaky base. The budget for changing procedures and employee training ought to be equal to that for hardware. The intelligence of the system depends on its users and managers. Transparency and privacy must be incorporated into the system's fundamental design, not as an afterthought. The library's most precious asset is the trust of the public. Fundamentally, the smart library's future is not about deciding between its potential and its difficulties, but rather about effectively overcoming the latter to reach the former. In addition to being technologically sophisticated, the aim should be to build a library that is more intelligent, accessible, and compassionate. To

fully utilize the potential of these technologies, future research should concentrate on creating reliable, scalable, and moral solutions. AI-enhanced IoT systems can open the door to more intelligent, effective, and user-focused libraries for users by tackling these problems.

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