

A Study on AI–IoT Integrated Smart Library System for Real-Time Resource Tracking and Efficient Book Retrieval in Higher Education

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Abstract- This paper examines how AI and IoT are converting university libraries from book based systems into advanced digital ecosystems with real-time services and improved user experience. It discusses digital resources management, smart libraries, user services, and technology adoption. It discusses AI technologies like ML, NLP, predictive analytics, and conversational systems, which enable efficient cataloging, smart information retrieval, personalized recommendations, and automation, which improve decision-making and overall service quality in academic libraries. It explains how IoT supports tracking, smart systems, and automation with features like smart shelving, space management, and safety. AIoT creates a connected system that improves performance and resource utilization and discusses implementation affected by infrastructure, support, user acceptance, and staff experience. It highlights challenges such as data privacy concerns, value based issues, high costs, and opposition to change. It stresses the importance of future planning, training, and policy development for successful implementation. Overall, AI and IoT are transforming libraries into intelligent, efficient, and user centered systems. It also focuses on making smart library technologies secure, ethical, and sustainable.

Keywords: Artificial Intelligence (AI), Internet of Things (IoT), Smart Libraries.

I. INTRODUCTION

The rapid advancement of artificial intelligence (AI) and Internet of Things (IoT) technologies has significantly transformed various sectors like higher education and library management. Modern university libraries are changing from traditional book systems into intelligent information ecosystems that are capable of supporting real time services and automated resource management for digital libraries [1]. This transformation enables libraries to move beyond physical limitations and provide continuous access to information. It also supports faster data processing and improves the overall efficiency of academic resource management. In addition, the transformation into digital ecosystems allows libraries to support multiple users simultaneously without physical constraints. This significantly improves accessibility and ensures uninterrupted academic support.

It also enables better integration with online learning platforms, making libraries an essential part

of modern education systems. The integration of AI assisted IoT technologies has further enhanced the efficiency and functionality of emerging smart and digital libraries, in which AI IoT integrated have many functionalities like accessing and managing to know about any book introduction in short and how books are efficient for students and readers, and easy to handle big data of libraries [2]. These capabilities reduce the time required to search and retrieve information. As a result, users can access relevant academic resources more quickly and efficiently, improving their overall experience. Furthermore, the integration of AI and IoT helps in reducing operational costs by automating repetitive tasks. This allows library staff to focus on improving user services and managing complex information needs. It also supports scalability, enabling libraries to efficiently manage growing volumes of data over time.

The impact of AI on library and information science in higher education institutions has been substantial, particularly in improving digital resource

management and academic services [3]. This shows that AI plays a crucial role in enhancing the quality of services provided by academic libraries. It also supports better decision making by analyzing large volumes of user and resource data. In addition, AI technologies contribute to improving the accuracy of search results, which enhances user satisfaction. This ensures that users can quickly find the most relevant information for their academic work. It also supports continuous improvement in library services through data driven insights. AI powered tools also contribute to effective digital resource organization and management in academic libraries [4].

This improves the organisation of digital content and ensures that users can easily locate the required information. It also minimizes manual errors and increases system reliability. Moreover, digital resource management systems powered by AI improve consistency in data organization. This ensures standardized classification and indexing across large collections. Such improvements make library systems more reliable and user friendly. The adoption of smart technologies has further improved teaching, learning, and library science education in developing regions[5]. This is particularly beneficial in areas where access to physical resources is limited. Smart technologies help bridge the gap by providing digital and remote learning support. In addition, smart technologies encourage self learning by providing students with easy access to digital resources at any time. This supports independent study and research activities. It also helps educational institutions modernize their infrastructure and remain competitive in the digital era.

Technological advancements such as 5G infrastructure and intelligent development strategies have provided strong support for the modernization of university libraries[6]. These advancements ensure faster connectivity and support the integration of multiple smart systems within library environments. This leads to more efficient and responsive services. Furthermore, these technological advancements support the development of smart campuses where library systems are interconnected with other academic services. This creates a more integrated

and efficient learning environment. It also improves system reliability and reduces delays in information access. The adoption of IoT technologies has enhanced knowledge management and operational efficiency within university library systems[7]. IoT enabled systems allow real time monitoring of resources and improve overall operational efficiency. This helps in better management of both physical and digital assets. In addition, IoT technologies enhance transparency in library operations by providing real time data on resource usage.

This helps in better planning and decision making. It also reduces the chances of resource loss or misplacement. Additionally, technology acceptance models highlight the importance of successful AI and IoT integration in ensuring system effectiveness and user adoption[8]. User acceptance is essential because even advanced technologies may fail without proper usage. Therefore, training and awareness programs are necessary for successful implementation. Furthermore, user friendly system design plays a crucial role in increasing acceptance of new technologies. Systems that are simple and intuitive are more likely to be adopted successfully. This highlights the importance of aligning technology with user needs and expectations.

Student perspectives indicate that IoT based systems can significantly improve service redesign and resource accessibility in university libraries[9]. These systems simplify access to resources and reduce the time required for searching and borrowing materials. They also enhance user satisfaction by providing convenient services. In addition, improved accessibility encourages more frequent use of library services among students. This contributes to better academic performance and research outcomes. It also supports collaborative learning by making resources easily available to multiple users. Smart technologies applied across various industries also demonstrate the effectiveness of AI driven systems in improving monitoring, automation, and safety management[10].

This demonstrates that AI technologies are highly effective in handling complex systems and improving operational control. Such applications can

also be extended to library environments. Furthermore, the ability of AI systems to monitor and analyze real time data makes them highly effective in dynamic environments. This can significantly improve the overall management of smart libraries. It also ensures better control over system operations and enhances service quality. Despite these advancements, limited research specifically addresses the integrated application of AI and IoT for real time resource tracking and efficient book retrieval in higher education libraries. Therefore, this study examines the integration of AI and IoT technologies to enhance operational efficiency and real time tracking and resource retrieval performance in university library systems.

II. LITERATURE REVIEW

The integration of artificial intelligence (AI) in library systems has significantly transformed traditional libraries into more intelligent and user-oriented services. Wang et al. [11] examined the development of AI-driven libraries in China and emphasized that AI technologies are improving information retrieval, cataloguing, and user services by allowing automation and increasing efficiency. Their study focused on how AI contributes to the evolution of libraries from passive repositories to active knowledge service centers and also suggested that artificial intelligence is not just a supporting tool but a major force transforming traditional libraries into smart and dynamic systems.

According to the authors, the AI improves cataloguing, searching, and user services by making them fast and more accurate. The study reveals that libraries are gradually moving towards a digitally stable and automated environment, where most tasks can be efficiently handled by machines and computers, which makes the whole work fast, easy to manage, and reduces the time of work. They also highlighted that in the future, AI can be used for developing completely digital libraries operating 24/7 with very minimal human involvement, and AI can support personalized recommendations based on user interests, which helps improve user experience. Overall, the study tells the importance of adopting modern technologies to remain relevant in

the digital world and manage large volumes of information effectively while improving user satisfaction for libraries.

Ethical concerns surrounding AI adoption in libraries have also gotten attention in recent years. Ikwuanusi et al. [12] focused on data privacy issues and noted the importance of implementing ethical AI suggestions to ensure the protection of user data. The study reveals that transparency, accountability, and proper data governance are important for AI driven systems, particularly in areas where large amounts of personal and behavioral data are collected and processed. They also suggested that libraries must adopt strict privacy policies and ethical guidelines for safeguarding sensitive user information from misuse or unauthorized access by hackers and protect all the data from cyber attacks. The study also stated that without introducing well-defined ethical frameworks, the integration of AI technologies could subject users to risks such as data breaches, surveillance, and loss of confidentiality.

Also, they said that maintaining user trust is the primary responsibility of libraries because this belief depends strongly on how securely users' personal data is managed by smart libraries. This study also tells that improving developments in AI-based library systems should introduce new advanced encryption techniques and secure data storage mechanisms, and clear regulatory standards to ensure compliance with ethical norms. Also, they highlighted that continuous monitoring and auditing of AI systems are necessary to protect against biases and ensure fairness in decision-making processes to promote responsible and sustainable use of AI in libraries.

Makinde et al. [13] provided a comprehensive review of AI technologies in academic libraries and noted that tools such as machine learning and natural language processing greatly improve user experience and service delivery. This indicates that AI enables the personalization of information services by analyzing user interests, search history, and user habits for providing more relevant and timely recommendations. They show that future libraries will lean on intelligent systems to automate routine

tasks such as cataloguing, indexing, and classification, which will reduce manual workload, time, and improve functional and operational efficiency. Integration of AI technology contributes to the development of user-centered library systems that focus on improving reliability, accessibility, and satisfaction. They point out that continuous technological advancement, with proper training and skill development among library staff, is important for the effective implementation of AI tools. They say that AI driven systems can support decision making processes by providing data-driven insights hugely to improve the overall quality of library facilities and monitor that libraries remain competitive in the digital environment.

Along with AI, the Internet of Things (IoT) is becoming important in modern libraries. Opele and Adeyeye [14] point out that the application of IoT in libraries and information centers. They point out that IoT enables the automation of daily operations such as inventory management, book tracking, and environmental monitoring through interconnected devices and sensors. It also noted that taking up smart technology reduces human effort, minimizes the errors and enhances the accuracy of resource management systems.

They emphasized that IoT-based solutions help libraries to monitor real time data related to resource usage, space utilization and environmental conditions which improves overall efficiency. Also, they highlight that in the future libraries may become completely automatic where smart devices coordinate with each other to manage operations without constant human involvement. They also suggested that IoT can improve user experience by providing faster access to information and using better navigation within library spaces. Adopting IoT technologies can significantly improve operational productivity by transforming traditional libraries into smart technology-driven service centers.

Shah et al. [15] investigated the adoption status of IoT in university libraries, and in result they understand various opportunities such as smart shelving, management, and real time tracking. They state that IoT technologies enhance user interaction

by letting fast access to resources and improving the efficiency of library services. They suggested that features such as automatic book return systems and smart inventory tracking can significantly reduce time and effort for both users and staff. The study also provides challenges such as high implementation costs, technical complexity, and data security concerns, which may affect common adoption of IoT. This study highlighted that proper planning, budgeting, and policy development are necessary to overcome these barriers, and future advancements in technology may reduce costs and improve system reliability, which makes IoT more accessible for academic universities. They tell the importance of balancing technological benefits with potential risks to ensure sustainable implementation. Continuous evaluation and enhancement of IoT systems are important to maximize its effectiveness in library services.

Khan et al. [16] notice that factors influencing the success of IoT services in academic libraries, like infrastructure readiness, staff expertise, and institutional support, are key determinants of successful implementation of IoT technologies as demonstrated in Fig1. They suggested that without proper technological infrastructure and skills, the adoption of IoT systems may not get desired results. In addition, they also suggested that training and development programs are important to equip library staff with the required technical skills and knowledge, and also highlighted that collaboration between management, technical teams, and users plays an important role in ensuring effective adoption. Also, they suggested that strong organizational commitment and financial investment are required to smooth IoT initiatives.

Also, integrating human resources with technical systems is important for enhancing library performance and delivering high quality required library services. Xie et al. [17] proposed an IoT-based risk warning system for smart libraries in which they stated that the integration of IoT technologies allows real time monitoring of library surroundings, which allows rapid detection of major risks like fire hazards, equipment failure, and environmental fluctuations. They show that these systems can seriously improve

safety by providing immediate alerts and automatic responses, which minimize the damage to important resources and infrastructure. They highlighted that the implementation of advanced sensors and connected devices allows libraries to maintain required conditions for preventing books and digital equipment. Furthermore, they suggested future advancement in IoT technology may include more intelligent and predictive systems, which are capable of identifying risks before they happen. Observations show that adopting such safety oriented technologies not only protects assets but also strengthens the overall proficiency and toughness of modern libraries.



Fig.1. Flowchart showing the layer architecture to implement IoT in academic libraries [16]

Khan et al. [18] discussed the restructuring of libraries into smart spaces by IoT-based innovative services. According to them, IoT technologies enable the creation of intelligent environments where systems such as automatic lighting, temperature controllers, and residency detection enhance user comfort. Study reveals that these smart features allow libraries to optimize resource utilization and reduce energy consumption. Additionally, they recommended that IoT-based systems can adapt to user behavior, creating a more responsive and personalized environment. The study highlighted that such advancements raise the user experience by

making library spaces more interactive and accessible. Further, they suggested that future libraries will increasingly depend on intelligent systems that automatically adjust to changing user needs and preferences. They showed that the development of smart libraries represents a transformation towards user centered design where technology plays an important role in increasing both functionality and satisfaction.

Shahzad et al. [19] conducted a systematic literature review on factors shaping IoT adoption in university libraries. They say that successful adoption depends on various factors including technological readiness, organizational support, money feasibility and user acceptance. The study gives ideas that libraries must develop clear strategies and make sure of proper infrastructure before implementing IoT systems in the libraries. Also, the study focuses on awareness and training programs which are very essential for increasing acceptance among both staff and users. They highlighted that resistance to change and lack of technical knowledge can act as barriers on adoption. It was also suggested that long-term success depends on how well technology matches institutional goals and user needs. They add that IoT use needs not just technology investment but also changes in how the organization works and thinks.

Choubey et al. [20] investigates the integration of AI, ML, and IoT in smart education systems. They stated that combining these technologies can create a data driven ecosystem that upgrades learning, decision-making and academic performance. They suggested libraries can play a main role in this ecosystem by providing smart and adaptive information services. By continuing, they emphasize that data analytics helps institutes to make informed decisions and improve efficiency. They also highlighted that future educational systems will depend heavily on automation and personalized learning environments which are supported by advanced technologies. The study show that integrating AIML and IoT allow libraries for better resource management and improved user engagement. Technological integration is important for developing innovative and sustainable academic environments.

Ramanujam and Chakraborty [21] studied the part of AI and IoT in online education systems. They stated that these technologies support watching, checking and reviewing steps by giving real-time data and computer-controlled analysis. They suggested that libraries can combine with digital learning platforms to offer easy and improved services to users. Additionally, they emphasized that AI enhances easy access by allowing remote access to information and resources. They highlighted that IoT helps to system efficiency by ensuring smooth operation of digital framework. The study also suggested that future libraries will become a combined part of online education environments, supporting continuous learning and digital engagement. They say that taking up these technologies is important for increasing ease, accessibility, and total educational outcomes.

Su and Chen [22] created an advanced information system using virtual reality and eye-tracking technology as illustrated in Fig2. They stated that these advanced technologies improve user usage by providing immersive and interactive experiences. They say that virtual environments allow users to explore information in a more engaging and intuitive manner and they emphasized that technology that follows eyes can improve custom by understanding user behavior and likes. This study highlighted that these innovations improve accessibility and make information retrieval a lot efficient. Also, they show that future libraries may use virtual platforms to provide remote and interactive services. They emphasized that putting together modern technologies represents a significant step towards updating library services and improving user involvement.

Nova et al. [23] looked into information based insights for academic resource management. They stated that artificial intelligence allows libraries to review large volumes of user data to improve decision making processes. They suggested that understanding user behavior helps in upgrading resource allocation and service delivery. Moreover, they emphasized that data analytics allows libraries to identify trends and patterns, leading to more efficient management. They highlighted that data-

driven approaches improve both good working and user satisfaction. They also pointed out that future libraries will increasingly rely on analytics tools to make strategic planning. The study reveals that effective use of data is essential for increasing performance and maintaining competitiveness in the digital world.

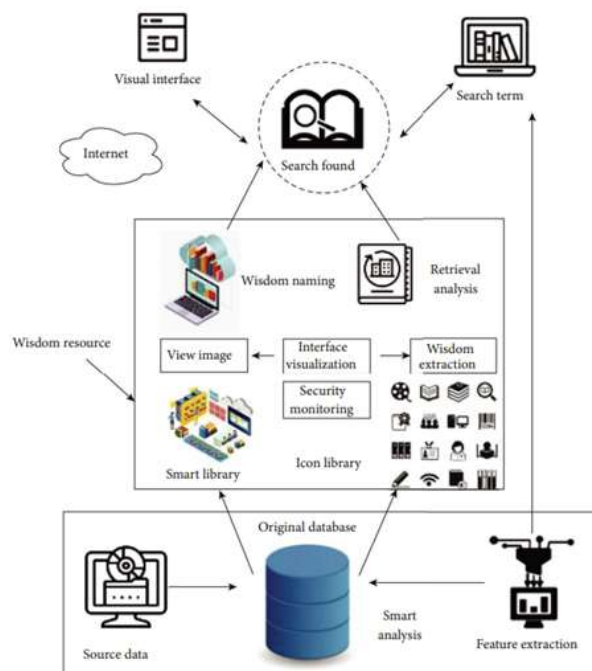


Fig.2. Representation of Virtual Reality Model of the digital library with information [22]

Jha [24] studied the hopes and issues of AI in libraries. They stated that AI offers major things such as automation, improved effectiveness and improved user services. The study suggested that despite these benefits, challenges such as high costs, lack of technical skills and opposition to change must be addressed. Also notes the importance of proper planning and spending in implementing AI technologies. They highlighted that training and skill development are necessary to overcome these hurdles and also suggested that institutes should implement a step by step approach to AI implementation. Also focused on addressing these issues which is essential for maximizing the benefits of AI in library systems.

Tizhe [25] discussed guessing analytics for user behavior in smart libraries. The study pointed out

that reading user data helps libraries guess user needs and provide individual services and predictive systems which improve efficiency by lowering the response time and improving service quality. Also, the study emphasized that knowing user behavior is important for developing effective strategies. They highlighted that such technologies enable libraries to move from responsive to active service models. Furthermore, they suggested that future developments in predictive analytics will enhance accuracy and working ability. They stressed that data driven custom is a key component of modern smart library systems.

Shahzad et al. [26] underlined libraries' readiness to adopt AI technologies. They say that the successful implementation of AI depends majorly on the skills, knowledge and attitudes of library professionals. They give ideas that continuous training and improvement are essential for preparing staff for technological changes. Additionally, they emphasized that positive opinion and willingness to adopt new technologies are critical factors. They highlighted that lack of information and resistance can delay implementation. Furthermore, they suggested that institutions should invest in skill enhancement programs. They emphasized that human resources play a very important role in ensuring the success of AI joining libraries.

Churi et al. [27] talked about real uses of artificial intelligence in higher education and mentioned its effect on upgrading teaching, learning and management work. They said that AI systems such as intelligent tutoring, automated grading and content recommendation tools really improve the performance of educational institutions. They recommended that the connection of AI in academic environments allows for more user based and flexible learning experiences where students can receive customized support based on their individual needs and performance. Also they made clear AI helps in self working repeated administrative tasks thereby allowing educators and librarians to focus on more important and thinking based activities. They showed that the use of AI contributes to improved decision making by providing data based ideas. Apart from this they suggested that libraries

can integrate AI tools to improve searching data, user assistance and digital resource management. The study suggested that the adoption of AI in higher education not only improves smooth working but also supports creativity in teaching and learning practices. The study indicated that in the future AI will play a more central role in improving academic ecosystems, making education easier to reach, easy, and user centered. All in all, the study says integrating AI into educational and library systems is essential for keeping pace with fast innovation and meeting the innovation needs of users.

Das and Islam [28] conducted a study in which they focused on the application of artificial intelligence and machine learning in advanced library systems. They shared that AI and ML technologies are widely used in various library functions including sorting, listing, data finding and suggestion tools. Study advised that these technologies help in minimizing manual workload while increasing the sharpness and speed of library operations. Also, it tells that machine learning methods can overview large datasets for identifying trends in user behavior which can further improve service delivery and also AI driven systems involve better organization and ease of use of information resources. Besides that libraries adopting these technologies can provide more efficient and user friendly services. They say that AI and ML not only improve operational efficiency but also allow libraries to shift towards more intelligent and automatic systems. They also indicated that future developments in these technologies will lead to even more advanced applications such as next step ideas and intelligent recommendation systems. They conclude that integrating these technologies is important for changing traditional libraries into modern and smart information centers.

Khan et al. [29] looked at the effect of talking and generative artificial intelligence systems on library services with a focus on the use of large language models. The study said that conversational AI technologies like chatbots and virtual assistants greatly improve user interaction by providing instant and exact responses to queries. They encouraged that these systems enhance easy access by allowing users to obtain information without requiring

physical help from library staff. Also they clearly said generative AI can assist in content creation, summarization, and knowledge generation by supporting both users and library professionals. They showed that such technologies involve improved efficiency by reducing response time and handling multiple queries together. Further they said that AI based conversational systems can be easily combined into library websites and digital platforms to provide all time support services. They stressed the adoption of these technologies enhances user interest and happiness. Plus also indicated that future improvements in generative AI will also improve the quality and accuracy of responses which make library systems more intelligent and interactive. Finally they said that conversational AI shows a great advancement in modern library services, allowing more dynamic and responsive communication between users and information systems.

Yu et al. [30] studied the usage of artificial intelligence in smart library systems by focusing on early implementations and foundational technologies. They wrote that AI technologies such as expert systems, intelligent retrieval systems, and automatic processing tools have played a very important role in improving library services. The study tells that these technologies allow efficient organization, storage, and access of information, making it easier for users to access relevant resources. In addition they also said AI contributes to improving the accuracy and speed of library operations by limiting human error.

They notice that early adoption of AI laid the groundwork for the development of modern smart libraries and continuous advancements in AI have led to more advanced systems capable of handling complex information tasks. This shows that AI has evolved from simple automatic tools for advanced intelligent systems that can support both decision making and user interaction. Integrating AI into library systems is essential for meeting the increasing demands of users in the digital world. All in all, they emphasized that AI is a major driver in the changing of traditional libraries into smart and technical driven environments.

Khan et al. [31] shared industrial Internet of Things (IoT) and its ease to modern systems including library environments. The study suggested that IoT is supported by a range of technologies such as sensors, connecting protocols, and cloud computing, which allow devices to communicate with each other and exchange data easily. They said the adoption of IoT in libraries can enhance operational efficiency by providing instant monitoring and automation of various processes and IoT systems improve data collection and analysis allowing libraries to make informed decisions based on accurate and timely information. IoT can help in optimizing resource utilization, helping inventory management, and elevating user experience.

Also study say that the integration of IoT with other technologies such as AI can lead towards the development of highly intelligent and automated library systems. Although it has advantages, IoT faces challenges like security risks, scalability issues, and the need for strong infrastructure. They also mentioned that addressing these challenges is main for successful adoption of AI. Also suggested that future advancements in IoT will focus on increasing connectivity, reliability, and security by allowing the development of smarter and more efficient systems. The study concluded that the IoT plays a major role in improving the future of smart libraries by empowering automation, connectivity and intelligent decision-making.

III. CONCLUSION

The integration of AI and IoT technologies has significantly transformed traditional library systems into smart, adaptive and user centric environments. This review highlights that smart libraries are no longer conceptual innovations but are actively being implemented across academic and research institutions worldwide. It reveals that AI driven tools such as machine learning algorithms, predictive analytics, and conversational systems enhance information retrieval, automate routine tasks, and provide personalised user experiences. Similarly, IoT technologies contribute to efficient resource management, real time monitoring and improved accessibility through interconnected devices and

smart infrastructure. Together, these technologies create a connected system often referred to as AIoT which strengthens the operational efficiency and service quality of modern libraries. However the transition towards smart libraries is not without challenges. Issues related to data privacy, ethical considerations, high implementation costs, lack of technical expertise and resistance to change remain significant barriers. Additionally, differences in technological infrastructure, particularly in developing areas, limit the widespread adoption of these advanced systems.

The reviewed studies emphasize the need for strategic planning, policy development and continuous training of library professionals to overcome these obstacles. This review highlights the importance of user acceptance and readiness as the result of smart library systems largely depends on how effectively users and librarians adapt to emerging technologies. Models such as UTAUT and other adoption frameworks provide valuable insights into understanding these behavioral aspects. In conclusion the future of libraries lies in the successful integration of AI and IoT technologies transforming them to active learning centers that support learning, research and innovation. Future studies should look at exploring advanced AI models and ethical frameworks to ensure that smart libraries evolve in a responsible and user focused manner.

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