Transforming Library Services: A Comprehensive Review of AI Applications, Challenges, and Future Directions

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المُستخلص:

يستعرض هذا البحث الأدبيات المتعلقة بتطبيق الذكاء الاصطناعي (AI) في المكتبات، مع التركيز على الفرص والتحديات والتوجهات المستقبلية. يسلط الضوء على جهود المكتبات للاستفادة من تقنيات الذكاء الاصطناعي لتحسين مختلف الخدمات والعمليات وكذلك استجابة أمناء المكتبات تجاه هذه التكنولوجيا. تستخدم الدراسة المنهج الوصفي من خلال مراجعة المحتوى للمقالات المتعلقة بعلم المكتبات والمعلومات من قاعدة بيانات Web of Science للفترة من ٢٠١٠ إلى ٢٠٢٤. تكشف الدراسة أن الذكاء الاصطناعي يساهم بشكل كبير في وظائف المكتبات، بما في ذلك الخدمات الفنية مثل الفهرسة والتصنيف، والبحث والاكتشافات، والروبوتات والدردشات الافتراضية، والحفظ الرقمي، وكذلك دعم التعلم. تضمنت التحديات خصوصية وأمان البيانات، والاعتبارات الأخلاقية، وارتفاع تكلفة التنفيذ. تضمنت التوجهات المستقبلية الذكاء الاصطناعي التوليدي والمساعد الافتراضي والفهرسة الألية وإدارة المحتوى. لقد استخدمت العديد من المكتبات

الأكاديمية والعامة تقنيات تعتمد على الذكاء الاصطناعي. يمكن تطوير برامج تدريب مهني لأمناء المكتبات للمساعدة في تقبل ودمج الذكاء الاصطناعي في المكتبات. تقدم النتائج رؤى قيمة للأكاديميين والممارسين وصناع السياسات المشاركين في تطوير وتطبيق تقنيات الذكاء الاصطناعي المتقدمة في بيئة المكتبات. يبرز هذا البحث الحاجة إلى استمرار البحث والتطوير لضمان التنفيذ المسؤول للذكاء الاصطناعي في فهرسة المكتبات والخدمات الأخرى. بما أن الذكاء الاصطناعي سيعزز بشكل كبير عمليات وخدمات المكتبات، فإنه سيزيد من أهمية المكتبات في عالم رقمي متطور باستمرار. يجب أن يستمر البحث والتطبيقات العملية في فحص وتطوير تقنيات الذكاء الاصطناعي، لضمان بقاء المكتبات مؤسسات ضرورية وحديثة تقود التقدم التكنولوجي.

Abstract:

Purpose – This paper reviews the literature on the application of Artificial Intelligence (AI) in libraries, with a focus on opportunities, challenges, and future directions. It highlights the efforts of libraries to leverage AI technologies to enhance various services and operations as well as librarians' response toward this technology.

Design/methodology/approach – The study employs a descriptive method, by content reviewing articles related to Library and Information Science from the WoS database from 2010–2024.

Findings – The review reveals that AI significantly contributes to library functions, including technical services like cataloging and classification, search and discovery, chatbots and virtual assistants, digital preservation, as well as adaptive learning support. Challenges included data Privacy and security, ethical considerations, and high implementation cost.

Future directions included generative AI and virtual assistants and automated cataloging and content management. Many academic and public libraries have utilized technologies based on AI. Professional training programs for librarians could evolve AI integration in libraries. The findings offer valuable insights for academics, practitioners, and policymakers involved in the

development and application of cutting-edge AI technologies in library environments.

This paper highlights the necessity for ongoing research and development to ensure the responsible implementation of AI in library cataloging and other services.

Outcomes - As AI will greatly enhance library operations and services, thus boosting the importance of libraries in an ever-evolving digital world. Ongoing research and practical applications should persist in examining and perfecting AI technologies, guaranteeing that libraries stay essential and up-to-date institutions leading technological advancements.

الكلمات المفتاحية: الذكاء الاصطناعي، المكتبات، شات بوتس، الروبوت، تحول خدمات المكتبات، خدمات المعلومات.

Key Words: Artificial intelligence, Libraries, Chatbots, Robots, Transforming Library Services, Information Services.

1.Introduction:

AI has emerged as a transformative force across various sectors. AI has revolutionized numerous industries, including healthcare and education, by enabling automation, enhancing data analytics, and improving decision-making processes. AI is defined as “a cluster of technologies and approaches to computing focused on the ability of computers to make flexible rational decisions in response to unpredictable environmental conditions” (Tredinnick 2017). Similarly, AI is distinguished as “systems that change behaviors without being explicitly programmed based on data collected, usage analysis, and other observations”. They identify AI as a trend that encompasses "process automation," the "Internet of Things," "data processing," "tangible robotics," "conversational interaction," and "decision support." (A. M. Cox, Pinfield, and Rutter 2019). Another definition focusing on the legal sector, identifies the "AI bucket" more specifically as including: big data; analytics; machine learning; natural language processing (NLP); data visualization; and decision logic (Smith 2016). However, there is no clear consensus among researchers on a specific definition, making AI somewhat difficult to define (Bradley 2022). AI has numerous applications and sub-fields, many of

which focus on data, text, and images (Bradley 2022). Machine learning and algorithms are now fundamental to everyday information systems like Internet search engines and social media. However, many scholars have highlighted issues in social media's machine learning datasets, such as racial, gender, and disability biases, as well as an over-reliance on algorithmic content moderation, which can amplify misinformation (Bradley 2022).

The current excitement around AI builds on the previous enthusiasm for big data, as the integration of large datasets with computing power unlocks new AI potentials. Key areas of development include machine learning, which enables computer systems to enhance their operations through data processing without explicit programming, and NLP, which allows computers to interpret and respond to inputs beyond structured text, such as voice recognition (A. M. Cox, Pinfield, and Rutter 2019).

Artificial intelligence:

AI has evolved significantly since its conceptual beginnings in the mid-20th century. The term "artificial intelligence" was first coined by John McCarthy in 1956 during the Dartmouth Conference, which is considered the founding event of AI as a field of study. Early research focused on symbolic AI, where researchers like Alan Turing and Marvin Minsky worked on developing algorithms and theoretical frameworks for machines to simulate human reasoning and problem-solving abilities (Andresen 2002). The 1960s and 1970s saw the development of foundational AI programs such as ELIZA, a natural language processing program, and the first expert systems designed to mimic the decision-making abilities of human experts (Treusch 2017).

In recent decades, AI has expanded from these early theoretical and symbolic roots into a multitude of practical applications across various industries, driven by advancements in machine learning, neural networks, and data availability. Machine learning, particularly through deep learning techniques, has enabled AI systems to learn from vast amounts of data, identifying patterns and making predictions with

remarkable accuracy. This has led to significant improvements in fields such as healthcare, where AI is used for diagnosing diseases, personalizing treatment plans, and managing medical records (Kalisdha 2024) .

The implications of AI's growth are profound, encompassing ethical, economic, and social dimensions. AI technologies offer the potential to automate routine tasks, enhance productivity, and foster innovation, but they also raise concerns about job displacement, privacy, and security. Ethical considerations are crucial, particularly regarding biases in AI decision-making and the need for transparent, accountable AI systems.

Libraries have historically been essential in the dissemination and preservation of knowledge. In the digital age, libraries face the challenge of managing vast amounts of information and meeting the diverse needs of their users. The digital revolution has brought significant technological advancements, including the internet, digitization of resources, and electronic databases. These technologies have transformed how libraries operate, but they also present new challenges in terms of data management, user engagement, and resource accessibility. AI has emerged as a groundbreaking technology with the potential to address many of these challenges. AI in libraries refers to machine-based systems capable of performing tasks requiring human intelligence—such as visual perception, speech recognition, and language translation—by using data, algorithms, and computing power. These systems can learn, adapt, and operate autonomously, making predictions, recommendations, and decisions to meet human-defined objectives and influence both real and virtual environments (A. M. Cox and Mazumdar 2022). AI encompasses a range of technologies, including machine learning, natural language processing (NLP), computer vision, and robotics, which can be leveraged to enhance various aspects of library operations. AI's ability to process large volumes of data, recognize patterns, and make predictions offers transformative potential for libraries (A. Cox 2022). It can automate routine tasks, provide personalized user experiences,

enhance resource discovery, and improve the preservation of digital and physical materials .

The application of AI in libraries is an emerging area of research. Despite AI's potential to transform library services, there is limited understanding of its application in libraries. Existing research is often fragmented, focusing on specific applications without a holistic view of the broader trends and challenges. This gap underscores the need for a review to map the landscape of AI research in libraries and evaluate its implications. Therefore, there is a need for a comprehensive review that synthesizes these findings, identifies overarching trends, and highlights future research directions. This review aims to explore the current applications of AI in libraries, assess the benefits and challenges associated with these technologies, and provide insights into future research and practical implementations. This study seeks to contribute to the evolving discourse on the role of AI in library science and inform practitioners and researchers about the potential and pitfalls of AI integration in libraries.

Problem Statement:

The rapid advancement of AI technologies presents both opportunities and challenges for libraries. While AI has the potential to significantly enhance the efficiency of technical and administrative processes, its integration into library systems is not without obstacles. This study seeks to address the gap in understanding how AI applications are currently employed in libraries, the challenges faced during implementation, and the future directions for AI in this sector. Additionally, it explores efforts of academic libraries in establishing AI technologies and the response of librarians to these technologies.

Study Objectives:

1. To identify the current applications of AI in academic libraries.
2. To examine the challenges associated with the implementation of AI technologies in libraries.
3. To explore future directions and potential advancements of AI in the library sector.

4. To identify case studies of academic libraries that have established AI labs and centers.
5. To assess the responses and attitudes of librarians towards AI technologies.

Study Questions:

1. What are the current applications of AI in academic libraries?
2. What challenges do libraries face in implementing AI technologies?
3. What are the potential future directions for AI in the library sector?
4. What are efforts of academic libraries in promoting AI?
5. What are the responses and attitudes of academic librarians towards AI technologies?

Study Importance:

This study is important as it provides a comprehensive review of the role of AI in libraries specifically academic libraries, highlighting both the benefits and challenges associated with its integration. By examining case studies and librarian responses, the study offers valuable insights into practical applications and potential improvements. The findings and recommendations can guide stakeholders in making informed decisions about adopting and optimizing AI technologies in libraries, ultimately enhancing library services and user experience.

Study Limits :

- **Temporal Scope:** The review is limited to literature published between 2010 and 2024.
- **Geographical Scope:** While the focus is global, the availability of literature in different regions may vary.
- **Database:** The study primarily utilizes the Web of Science (WoS) database, which may exclude relevant studies not indexed in WoS.
- **Language:** The review is limited to literature available in English, which may exclude pertinent studies in other languages.

Terminology of the Study:

- **Artificial Intelligence (AI):** The simulation of human intelligence processes by machines, especially computer systems, including learning, reasoning, and self-correction.
- **Academic Libraries:** Libraries associated with post-secondary institutions that serve the information and research needs of their students, faculty, and staff.

Methods:

This study aimed to explore the current use of artificial intelligence applications in libraries, challenges, and future directions. Moreover, this research explore efforts of libraries in promoting AI as well as librarians' responses towards AI technologies. To achieve this, the study utilized a descriptive method, reviewing relevant literature published in English .

Data Sources and Search Strategy:

The WoS database was used to conduct a comprehensive search for articles published between January 1, 2010, and May 31, 2024. Access to the WOS was obtained on November 1, 2022. The WoS was chosen due to its reputation for indexing journals of superior quality in comparison to other databases (Furstenau et al. 2021). It stands as one of the largest academic multidisciplinary databases, housing over 171 million records (Web of Science 2022). The database was searched using these terms Keywords "Artificial Intelligence" AND ("Libraries" OR "Library" OR "library Services" OR "Academic Libraries"). The search strategy concentrated on the topic field, aiming to query the title, abstract, author keywords, and keywords plus to enhance the retrieval of pertinent results. Inclusion criteria included peer-reviewed articles, review papers, case studies, and conference proceedings related to AI applications in libraries. Articles not focused on libraries were excluded, those published before 2010, and non-peer-reviewed sources .

Data Extraction and Analysis:

Relevant data on AI applications were extracted, challenges, future directions, case studies, and librarians'

responses from the selected literature. A thematic analysis was conducted to categorize and synthesize findings related to the study objectives and questions. The results were gathered into a cohesive narrative that addresses the study objectives, supported by evidence from the literature.

Results and Discussion :

RQ1: What are the current applications of AI in academic libraries?

AI has become an increasingly vital component in the modernization of library services (Mallikarjuna 2024). By automating routine tasks, enhancing data management, and providing personalized user experiences, AI technologies are transforming how libraries operate and serve their patrons. Libraries, as longstanding repositories of knowledge and information, have undergone significant transformations to meet the evolving needs of their patrons. In the digital age, AI offers unprecedented opportunities to enhance library services and operations. AI is already acknowledged as a significant trend in the legal information sector, but it is only beginning to gain attention in academic libraries (A. M. Cox, Pinfield, and Rutter 2019) .

Although the concept of AI was officially coined in the 1950s and perhaps imagined even earlier, the idea of applying AI in libraries has been contemplated since at least 1985, with a surge of heightened interest in the past five years (Massis 2018). Naturally, this has led to concerns that robots and intelligent agents could potentially replace the professional roles of librarians (Huang, Cox, and Cox 2023). Furthermore, the adoption of AI in libraries is hindered by librarians' limited knowledge of AI, difficulties in integrating AI with existing library systems and services, and the high cost of AI products. However, several libraries have already implemented AI-based applications or claim to be "smart" or "intelligent," there is still significant room for growth and improvement in how these technologies are utilized (Huang, Cox, and Cox 2023). One key area where AI is expected to have a substantial impact is in search and resource discovery. The literature on AI in libraries spans

several key areas, including AI applications, benefits, challenges, and the future of AI integration in library sciences.

Automated Cataloging and Classification

AI leverages Natural Language Processing (NLP) and machine learning algorithms to automate the cataloging and classification of library materials. NLP algorithms analyze the text for new materials, classify documents, and assign subject headings to generate metadata, enabling efficient categorization and indexing. These systems analyze the content of books, articles, and other resources to identify keywords and subjects, automating the traditionally manual process of cataloging. For example, projects like the Google Books Ngram Viewer utilize NLP to extract and analyze data from a vast array of texts, making it easier to identify and classify content based on linguistic patterns (Weiss 1994; Amin and Razmi 2009). Machine learning models, trained on large bibliographic datasets, recognize patterns in bibliographic data, allowing for dynamic updates and corrections to catalog records. Library of Congress: Utilizes AI to streamline the cataloging process, enhancing the accuracy and speed of metadata generation. Stanford University Libraries: Implemented a machine learning system to classify research papers automatically, improving efficiency and accuracy. This mechanization reduces the labor-intensive task of manual cataloging and ensures that classification systems remain up-to-date with evolving information. (Weiss 1994; Amin and Razmi 2009) .

A recent study investigates the potential of language models like ChatGPT to revolutionize library cataloging. Through a series of experiments, the author illustrates ChatGPT's capability to generate accurate MARC records using RDA and other standards, including the Dublin Core Metadata Element Set. The findings highlight ChatGPT's promise as a tool for streamlining record creation and enhancing efficiency in library environments (Brzustowicz 2023). Benefits can include increased efficiency by reducing manual labor. Improved accuracy and consistency

in cataloging. Faster processing of new materials, enabling quicker access for users.

The integration of AI in cataloging systems not only accelerates the process but also ensures a higher degree of uniformity in the classification and metadata generation. The implications of this are profound, as it allows librarians to allocate their time to more complex and intellectual tasks, thus enhancing the overall productivity of the library.

Enhanced Search and Discovery

AI-powered search engines utilize sophisticated algorithms to interpret and contextualize user queries, delivering more precise and relevant search results (A. M. Cox and Mazumdar 2022). These engines employ semantic search techniques, understanding the intent behind queries rather than relying solely on keyword matching. For instance, WorldCat uses AI to enhance search capabilities, making it easier for users to find relevant resources across global library collections. Google's BERT (Bidirectional Encoder Representations from Transformers) model enhances search accuracy by considering the context of words in a query (Hirvonen et al. 2023). Additionally, AI-driven recommendation systems, akin to those used by commercial platforms like Netflix and Amazon, analyze users' past interactions and preferences to suggest relevant books, articles, and other resources (Upshall 2022). These systems utilize collaborative filtering and content-based filtering techniques to provide personalized recommendations, enhancing user engagement and resource discovery Generative.

Benefit scans include more relevant and precise search results, enhanced user satisfaction and engagement, and improved discovery of resources that might have been overlooked with traditional search methods. The deployment of AI in search and discovery is particularly transformative. By understanding the context and nuances

of user queries, AI systems can deliver more accurate and relevant results, thereby significantly enhancing the user experience.

This capability is crucial for academic libraries where precise information retrieval is essential for research and scholarship.

Chatbots and Virtual Assistants

AI-driven chatbots and virtual assistants have been created to handle directional and other predictable inquiries, but their potential extends to answering reference queries in the future (A. M. Cox, Pinfield, and Rutter 2019) . These tools serve as digital intermediaries, providing users with real-time assistance and support. These systems employ conversational AI, which combines NLP and machine learning to understand and respond to user inquiries accurately (Aboelmaged et al. 2024). Chatbots can handle a wide range of tasks, from answering frequently asked questions to guiding users through complex search processes. For example, the University of Oklahoma Libraries implemented an AI chatbot named "Libby" to assist users with inquiries and improve service efficiency (Smith, 2020). "Ask NYPL" at the New York Public Library: Provides real-time assistance and information to users through a virtual assistant. Virtual assistants further personalize the user experience by learning from past interactions and offering tailored recommendations and support, thereby augmenting the traditional librarian's role (Vincze 2017).

Benefits provide 24/7 assistance, improving accessibility and convenience, reducing the workload on library staff, allowing them to focus on more complex tasks, enhancing user interaction and engagement with library services (Aboelmaged et al. 2024). AI-driven chatbots and virtual assistants represent a significant leap forward in user support. These systems provide continuous assistance, which is particularly beneficial for remote users or those requiring help outside of regular library hours. By handling routine inquiries, chatbots free up librarians to engage in more specialized support activities.

Digital Preservation:

The preservation of physical and digital materials is a critical function of libraries, and AI plays a pivotal role in this domain. Automated digitization processes, powered by AI, streamline the conversion of physical documents into digital formats through Optical Character Recognition (OCR). AI algorithms enhance the quality of scanned images and ensure accurate text recognition, making digitized materials accessible and searchable (Teel 2024). Additionally, predictive analytics models analyze environmental data and material conditions to forecast deterioration, allowing libraries to implement preventive preservation measures proactively. Projects like the British Library's "Save our Sounds" utilize AI to identify and preserve audio recordings at risk of degradation, ensuring their longevity (Teel 2024). Harvard Library implements AI tools to enhance the quality and accessibility of digitized manuscripts, making them more available to researchers and the public.

The benefits of using AI in digital preservation include preserving valuable cultural and historical materials for future generations and enhancing the accessibility of digitized content through improved quality and metadata. Additionally, AI automates the preservation process to make it more efficient. AI's role in digital preservation is critical for safeguarding cultural and historical artifacts. By improving the quality of digitized copies and automating preservation tasks, AI ensures that valuable resources are maintained and accessible for future generations. This is particularly important for libraries holding rare or fragile items that require meticulous handling.

Data Analysis and Management

AI enables libraries to harness the power of data analytics for informed decision-making and resource optimization. Usage analytics, powered by AI, provide insights into how patrons interact with library resources, identifying trends and patterns that inform collection development and resource allocation (Tenopir, King, Edwards, & Wu, 2009). Machine learning models can predict future demand for materials,

enabling libraries to manage their collections more effectively. Furthermore, AI-driven data management systems automate routine tasks such as inventory control, acquisition processing, and resource distribution, enhancing operational efficiency (Sharma et al. 2022).

Usage Analytics at the University of California Libraries involves AI analyzing data to improve collection development and user services, ensuring resources meet user needs. Similarly, Predictive Analytics at MIT Libraries uses AI to predict trends in resource usage and manage inventory accordingly, ensuring popular resources are available when needed. The benefits of using AI in data analysis and management include data-driven insights for better decision-making and the optimization of resources and services based on usage patterns (Sharma et al. 2022). Additionally, AI provides an improved understanding of user needs and behavior. Through sophisticated data analysis, AI enables libraries to make informed decisions about resource allocation and service improvements. By understanding usage patterns and predicting future trends, libraries can better align their offerings with user needs, ultimately enhancing service delivery and resource management.

Adaptive Learning Support

In educational contexts, AI supports adaptive learning by tailoring resources and experiences to individual learners' needs (Popenici and Kerr 2017). Personalized learning paths are created using AI algorithms that analyze students' academic performance, learning styles, and preferences. Automated tutoring systems provide real-time feedback and assistance, adapting their instructional strategies based on students' progress and comprehension. For example, platforms like Coursera and Khan Academy use AI to personalize learning experiences, ensuring that students receive content that matches their skill levels and learning pace (Piech et al., 2015).

Examples of AI in education include Coursera and Khan Academy, which use AI to provide tailored learning paths and real-time feedback, enhancing the learning experience for

users. University libraries implement adaptive learning platforms to support student education, offering resources and guidance based on individual learning styles and progress. The benefits of these technologies include personalized learning experiences that cater to individual needs, enhanced educational outcomes through tailored content and feedback, and increased engagement and retention of learners (Lo 2023).

AI's application in adaptive learning support is transformative for educational outcomes. By personalizing learning experiences, AI ensures that educational resources are tailored to the unique needs of each learner, thereby improving engagement and retention. This personalized approach is especially beneficial in academic libraries, where diverse student needs must be met effectively (Lo 2023).

Accessibility Improvements:

AI significantly enhances accessibility in libraries, making resources available to a broader audience (A. Cox 2022). Text-to-speech and speech-to-text technologies convert written text into spoken language and vice versa, aiding visually and hearing-impaired users. AI-driven language translation services break down linguistic barriers by translating materials into multiple languages, ensuring that non-native speakers can access and benefit from library resources. These technologies democratize access to information, fostering inclusivity within the library environment. For instance, AI tools like Google's Cloud Speech-to-Text and Cloud Text-to-Speech APIs enable seamless accessibility enhancements for diverse user groups (Google Cloud, n.d.).

Examples of AI applications in libraries include Text-to-Speech at the Library of Congress, which provides audio versions of texts for visually impaired users, improving access to information, and Language Translation at the European Union Libraries, which uses AI to translate documents into multiple languages, broadening access for non-native speakers. The benefits of these technologies include improved accessibility for users with disabilities, broader access to

resources for non-native speakers, and enhanced inclusivity and user experience.

AI technologies significantly enhance accessibility, ensuring that library resources are available to all users, regardless of their abilities. By offering text-to-speech, speech-to-text, and translation services, libraries can cater to a wider audience, promoting inclusivity and equal access to information.

Security Enhancements:

AI enhances security within libraries through advanced surveillance and monitoring systems. Facial recognition technology identifies authorized users and detects unauthorized access, ensuring secure entry and use of library facilities. AI algorithms analyze behavior patterns to identify suspicious activities, such as theft or vandalism, allowing for timely intervention. These security measures protect both library patrons and resources, creating a safe and secure environment. Libraries like the New York Public Library have implemented AI-based security systems to enhance the safety of their collections and patrons.

Examples and case studies include the New York Public Library, which uses facial recognition to ensure security and prevent unauthorized access, maintaining a safe environment for users, and university libraries that implement AI-based behavior analysis to detect and respond to security threats, ensuring the safety of patrons and staff. The benefits of these technologies include enhanced security and safety for users and staff, real-time threat detection and response, and improved protection of library assets and resources.

AI-driven security systems provide a robust solution for maintaining safety in library environments. By leveraging technologies such as facial recognition and behavior analysis, libraries can proactively address security concerns, thereby ensuring a safe and secure space for all patrons.

The integration of AI in libraries signifies a paradigm shift in how these institutions operate and deliver services (A. Cox 2023). Automated cataloging and classification exemplify the

efficiency gains achievable through AI, reducing the manual workload of librarians and enhancing metadata accuracy. AI applications in libraries offer numerous benefits, including increased efficiency, enhanced user experiences, optimized resource management, and improved accessibility and security. However, the success of AI adoption remains a topic of debate due to numerous requirements that must be fulfilled to ensure inclusive integration in libraries. There is a noticeable lack of research on the practical application of AI in libraries, particularly regarding its real-world implementation (Harisanty et al. 2023). Moreover, implementing AI presents challenges, such as ensuring data privacy, addressing ethical concerns, investing in technological infrastructure, and training staff. Despite these challenges, the transformative potential of AI in libraries is immense, promising to revolutionize how libraries operate and serve their communities. Future research and practical implementations should continue to explore and refine these applications, ensuring that libraries remain at the forefront of technological innovation while preserving their core mission of knowledge dissemination and preservation.

AI can be readily adopted in libraries, particularly for technical services such as classification and cataloging, library management tasks like staffing and decision-making, and library services including referencing, information services, and information literacy. However, the success of AI adoption remains a topic of debate due to numerous requirements that must be fulfilled to ensure inclusive integration in libraries. There is a noticeable lack of research on the practical application of AI in libraries, particularly regarding its real-world implementation. This study provides valuable insights into the implementation of AI in library support services.

RQ2: What challenges do libraries face in implementing AI technologies?

The incorporation of artificial intelligence (AI) into library services and operations promises numerous benefits, including enhanced efficiency, improved user experience, and advanced data management. However, the deployment of AI

also presents significant challenges and considerations that libraries must address to ensure successful implementation and ethical use. This paper examines these challenges and provides a comprehensive discussion of the considerations involved in integrating AI into library environments (Bradley 2022).

Data Privacy and Security

One of the foremost challenges in using AI in libraries is ensuring data privacy and security, as libraries handle vast amounts of personal and usage data critical for training AI systems and improving services (Miao 2019). Privacy concerns arise because the collection and analysis of user data by AI systems can lead to potential breaches, and users may be unaware of how extensively their data is being collected and used, raising ethical issues. Additionally, AI systems are vulnerable to cyber-attacks and data breaches, making robust security measures essential to protect sensitive information. Libraries must also navigate a complex landscape of data protection regulations, such as the General Data Protection Regulation (GDPR) in Europe and the California Consumer Privacy Act (CCPA) in the United States, to ensure compliance. To mitigate privacy and security risks, libraries should implement stringent data protection policies and advanced encryption techniques. Transparency with users about data collection and usage practices is essential to maintain trust, and regular security audits and compliance checks are necessary to safeguard against potential breaches.

Ethical Considerations

The ethical implications of AI use in libraries are multifaceted, involving issues related to bias, transparency, and accountability (Bradley 2022). AI algorithms can perpetuate existing biases present in the training data, leading to unfair treatment of certain user groups, affecting recommendations, search results, and services provided by the library. Additionally, AI systems

often operate as "black boxes," with decision-making processes that are not easily interpretable, undermining user trust and making it difficult to explain or justify AI-driven decisions. Determining accountability for decisions made by AI systems also poses a challenge, requiring libraries to establish clear guidelines on responsibilities and oversight of AI operations. Addressing these ethical considerations necessitates actively working on de-biasing algorithms and ensuring that AI systems are trained on diverse and representative datasets (Miao 2019). Efforts should be made to enhance transparency through explainable AI techniques, and libraries should establish robust governance frameworks to oversee AI deployment and ensure accountability.

Technological Infrastructure and Investment

The successful implementation of AI in libraries demands substantial technological infrastructure and investment (Al-Aamri and Osman 2022). AI systems require significant computational resources, including high-performance servers and cloud-based platforms, which can be cost-prohibitive for many libraries. Developing, deploying, and maintaining AI technologies necessitates considerable financial investment, covering software acquisition, hardware upgrades, and ongoing maintenance costs (Subaveerapandiyan, Sunanthini, and Amees 2023). Furthermore, integrating AI systems with existing library management systems can be complex and may require custom solutions for seamless operation. Libraries must carefully evaluate the cost-benefit ratio of AI implementation and seek funding opportunities, such as grants and partnerships, to support technological investments. Collaborative efforts among libraries to share resources and infrastructure can help alleviate financial burdens, and prioritizing scalable solutions that integrate smoothly with current systems is essential.

Staff Training and Skills Development

The adoption of AI technologies in libraries necessitates significant staff training and skills development (Al-Aamri and Osman 2022). Many library professionals may lack the technical expertise required to manage and operate AI systems, making it crucial to bridge this skills gap for successful deployment (Shahzad, Khan, and Iqbal 2024). AI technologies are continually evolving, requiring ongoing training and professional development for library staff to keep pace with advancements (A. M. Cox and Mazumdar 2022). Additionally, introducing AI systems can lead to resistance among staff due to fears of job displacement or changes in job roles, necessitating effective change management strategies. Libraries should invest in comprehensive training programs to equip staff with the necessary skills to manage AI systems, including offering workshops, courses, and certifications in AI and related technologies. Engaging staff in the AI implementation process and highlighting the potential benefits for enhancing their work can help mitigate resistance and foster a culture of innovation.

Legal and Policy Implications

The use of AI in libraries involves navigating various legal and policy challenges (Bradley 2022). The deployment of AI technologies can raise questions about intellectual property rights, particularly concerning the digitization and use of copyrighted materials. Libraries need to develop policies that govern the ethical use of AI, data management, and user privacy, ensuring these policies are regularly updated to reflect changes in technology and regulatory requirements. Additionally, determining liability for errors or adverse outcomes resulting from AI systems can be complex, necessitating clear legal frameworks. Libraries must work closely with legal experts to address intellectual property issues and develop robust policies for AI use. Establishing clear

guidelines on liability and accountability is essential to manage legal risks, and regular review and updates of these policies are necessary to keep pace with technological and regulatory changes.

The integration of AI in libraries presents significant challenges and considerations, ranging from data privacy and security to ethical implications, technological infrastructure, staff training, and legal issues. Addressing these challenges requires a multifaceted approach that includes robust data protection measures, ethical oversight, substantial investment in technology and training, and comprehensive policy development. By proactively addressing these challenges, libraries can harness the transformative potential of AI to enhance their services and operations while maintaining their core mission of knowledge dissemination and preservation. Future research and collaborative efforts will be crucial in overcoming these challenges and ensuring the successful integration of AI in library environments.

RQ3: What are the potential future directions for AI in the library sector?

AI has already begun transforming libraries by enhancing efficiency, user experience, and data management. However, the future promises even greater advancements as AI technologies evolve. This paper explores the potential future directions of AI use in libraries, focusing on emerging technologies, anticipated benefits, and the strategic considerations necessary to harness these advancements effectively.

Emerging AI technologies are poised to significantly impact libraries, enhancing both operational efficiency and user experience. Key advancements include the integration of generative AI, machine learning, and natural language processing into various library services.

Generative AI and Virtual Assistants

Generative AI tools, such as Chat Generative Pre-trained Transformer (ChatGPT), are increasingly being utilized in libraries to provide patrons with quick, accurate responses to their queries (Hirvonen et al. 2023). ChatGPT is a chatbot developed by OpenAI that generates human-like text responses. ChatGPT was publicly launched in November 2022, and within a week, it had attracted one million users (Johnson et al. 2024). This technology can assist in tasks such as answering reference questions, suggesting reading materials, and even conducting virtual tours of library resources. These tools help reduce the workload of library staff and improve the user experience by offering immediate assistance (Lund, Khan, and Yuvaraj 2024). Incorporating ChatGPT into medical library services has the potential to improve information retrieval and user experience, offering advantages to both library users and the wider medical community (Lund, Khan, and Yuvaraj 2024). Despite the above-mentioned benefits, a valid concern is that ChatGPT might promote laziness or be misused for unethical academic practices like plagiarism. Consequently, faculty have started to modify curricula to discourage its use and prevent academic dishonesty (Johnson et al. 2024).

Automated Cataloging and Content Management

AI-driven systems are enhancing cataloging processes by automating the organization and indexing of library materials. Machine learning algorithms can analyze and categorize new acquisitions more efficiently than traditional methods, allowing for quicker integration of new materials into the library system. This technology also aids in maintaining and updating existing catalog records, ensuring that they remain accurate and current. ChatGPT is highlighted as a potential a tool for streamlining record creation and enhancing efficiency in library environments. However, the use of AI-generated

records also raises significant issues concerning intellectual property rights and bias (Brzustowicz 2023).

Enhanced User Engagement and Personalization

AI technologies are being employed to create personalized user experiences. For example, recommendation systems powered by AI can suggest books, articles, and other resources based on a patron's borrowing history and interests. Additionally, libraries are using AI to develop interactive and immersive digital resources, such as virtual reality experiences and augmented reality applications, which can make learning and exploration more engaging (Kaushal and Yadav 2022).

AI in Library Operations

AI is streamlining various back-end operations, including inventory management and administrative tasks. Automated systems can monitor stock levels, track the usage of resources, and manage reservations and renewals. This automation helps libraries operate more smoothly and frees up staff to focus on more complex and user-focused tasks (Luca, Narayan, and Cox 2022). The literature reveals several key findings on the impact of AI on library services as below.

Improved Efficiency and Accuracy

Studies have shown that AI applications in libraries lead to improved efficiency in various operations, from cataloging to user services. AI tools help in reducing the time required for repetitive tasks, allowing librarians to focus more on direct patron interaction and community engagement (A. M. Cox, Pinfield, and Rutter 2019).

Enhanced Access to Information

Longitudinal research indicates that AI enhances access to information by improving search capabilities and making library resources more discoverable. AI-

driven search engines and digital assistants can understand and process complex queries, providing more accurate and relevant results than traditional search methods (A. M. Cox, Pinfield, and Rutter 2019).

User Satisfaction and Engagement

Surveys and longitudinal studies have reported increased user satisfaction and engagement when AI technologies are integrated into library services. Personalized recommendations and interactive tools create a more engaging experience for patrons, encouraging more frequent use of library resources (Kaushal and Yadav 2022).

Challenges and Ethical Considerations

Despite the benefits, studies also highlight challenges such as data privacy concerns, the need for continuous training of library staff, and the potential for bias in AI algorithms. Addressing these challenges is crucial for the successful and ethical implementation of AI in libraries (Bradley 2022; Shal, Ghamrawi, and Naccache 2024).

RQ4: What are efforts of academic libraries in promoting AI?

The integration of Artificial Intelligence (AI) within Higher Education (HE) academic libraries necessitates addressing several critical ethical considerations to ensure responsible implementation. Primarily, data privacy and security are paramount, requiring transparent data collection, informed consent, and secure storage to protect sensitive information and uphold user confidentiality (Lund and Wang 2023). Additionally, bias and fairness in AI algorithms are crucial concerns, as these systems can inherit biases from their training data, potentially resulting in discriminatory outcomes. Ensuring fairness involves ongoing efforts to minimize biases and conduct regular audits of AI models (Hussain 2023). Transparency is also essential to address

the opaque nature of some AI models, necessitating clear communication about how AI-driven recommendations are generated to foster user trust (Fernandez 2023). Accountability and oversight are integral, involving the establishment of clear roles, regular audits, and possibly the formation of ethical review boards to align AI applications with institutional values and ethical standards (Gutu, Agheorghiesei, and Tugui 2022).

Furthermore, promoting accessibility and inclusivity in AI implementations is an ethical imperative. AI systems must be designed to cater to diverse user needs, addressing potential disparities in access to AI-driven resources and services, and actively working to bridge digital divides to ensure equitable benefits for all users (Hussain 2023). Continuous ethical reflection is vital, as it allows academic libraries to regularly reassess and adapt their policies and practices in response to emerging challenges, technological advancements, and evolving societal expectations, thereby ensuring that their AI implementations remain ethically sound over time (Gutu, Agheorghiesei, and Tugui 2022). By addressing these ethical considerations, HE academic libraries can foster responsible AI use that aligns with their mission of supporting diverse and inclusive learning environments while upholding high ethical standards in technological integration.

Overall, the integration of AI in libraries is transforming how these institutions operate and interact with their communities. By embracing these technologies, libraries can enhance their services, improve operational efficiency, and offer more personalized and engaging experiences to their patrons.

The future of AI in libraries holds immense potential for transforming services and operations. Advanced personalization, improved information retrieval, predictive analytics, enhanced digital preservation, and the integration of AR and VR are just a few areas where AI can make a significant impact.

However, realizing these benefits will require strategic investments, ethical considerations, and a commitment to ongoing innovation. By proactively addressing these challenges and opportunities, libraries can harness the full potential of AI to better serve their communities and fulfill their mission of knowledge dissemination and preservation. Future research and collaboration will be essential to navigate the complexities of AI implementation and to ensure that libraries remain at the forefront of technological advancement.

Several universities have integrated artificial intelligence labs within their libraries to enhance research and innovation in the field. **Here are a few notable examples:**

- Library Innovation Lab (LIL) at Harvard University

Harvard University's Library Innovation Lab focuses on exploring how digital technologies, including AI, can transform libraries. The lab has developed projects such as the "StackLife" virtual bookshelf and the "LibraryCloud" API, leveraging AI for improved library services and user experience (Harvard University 2024).

- MIT Libraries' Center for Research on Equitable and Open Scholarship (CREOS)

While not solely focused on AI, CREOS at the Massachusetts Institute of Technology includes research into AI's role in making scholarships more accessible and equitable. Projects often involve AI-driven data analysis and digital scholarship (Massachusetts Institute of Technology 2024).

- University of California, Berkeley – The Data and AI Research (DAIR) Lab

At UC Berkeley, the DAIR Lab, part of the library, collaborates on projects that utilize AI and machine learning to enhance data management, digital archives, and research accessibility (University of California 2024).

University of Illinois at Urbana-Champaign – Grainger Engineering Library Information Center.

This library hosts an AI Lab that focuses on integrating AI into library services, including the development of AI-powered tools for research and data management (University of Illinois at Urbana-Champaign 2024).

- Carnegie Mellon University Libraries

Known for its strength in AI research, Carnegie Mellon has incorporated AI into its library systems to enhance information retrieval, digital preservation, and user services. Projects often involve collaboration between the library and various AI research departments (Carnegie Mellon University 2024).

Stanford Libraries' Center for Interdisciplinary Digital Research (CIDR)

CIDR at Stanford University works on projects that use AI to support digital humanities research, data visualization, and the development of new digital tools and methodologies for academic research (Stanford University 2024).

The Westport Library

The Westport Library is a public library in the town of Westport, Connecticut, United States. The library acquired two robots, Vincent and Nancy, that were used to help teach coding and computer programming skills, Figure 1 (Waldman 2014). The primary purpose of these robots was to teach ta kind of coding and computer-programming skills required to animate such machines. Librarian robots are primarily designed for detecting and replacing books on shelves. Recent research in librarian robot technology focuses on enhancing gripping capabilities, localization accuracy, and human-robot interaction. We conclude that advancing research in the area of smart resources is essential (Asemi, Ko, and Nowkarizi 2021).

Robots are increasingly utilized in libraries (Tait and Pierson 2022). One practical application is a robot

that performs shelf reading and reports the findings to human staff. Others are used to retrieve large items like boxes, though identifying and picking up small, varied objects such as books remains challenging. AI-powered devices can serve as guides or personal assistants for library users, answering questions and learning over time (Calvert 2017).

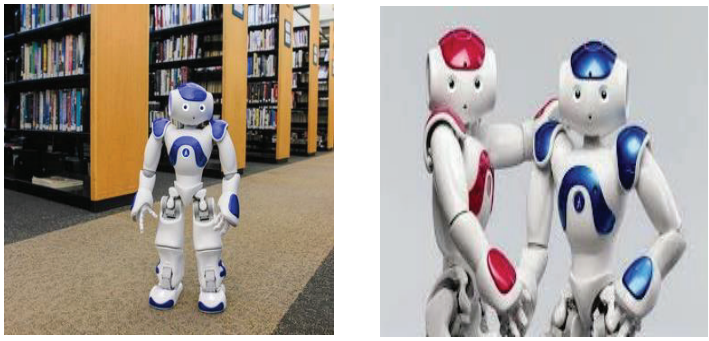

Figure 1: The robots Vincent and Nancy in the Westport Library

Omonogawa Library in Japan

Omonogawa Library, a public library in Japan examined using a robot to inventory control of books and the trial succeeded, Figure 2. The library approved a fully automated process of book stocktaking (Yamatani 2022).

Figure 2: Automated inventory control of books using a robot in Omonogawa Library in Japan

These examples illustrate how university libraries are leveraging AI to innovate and improve their services, making research more efficient and accessible for students and scholars.

The University of Pretoria's Hatfield Campus Library

Libby Robot support users in the library of the University of Pretoria's main campus in Hatfield, Figure 3. The robot helps with directions and can help students and staff find their way at the campus' main library (Mahlansu 2019).

Figure 3: Libby Robot support users in the University of Pretoria's Hatfield campus Library

RQ5: What are the responses and attitudes of academic librarians towards AI technologies?

The integration of AI in library operations, considered since at least 1985, has seen a significant resurgence of interest in the past five years (Huang, Cox, and Cox 2023). Despite concerns about AI potentially displacing traditional librarian roles (A. M. Cox, Pinfield, and Rutter 2019), the implementation of AI in

libraries has been deliberate and cautious. This cautious approach is due to the challenges of balancing competing priorities, resource constraints, and a careful strategy toward adopting new technologies (Huang, Cox, and Cox 2023). Libraries often wait until new technologies have become well-established and accessible to patrons before integrating them.

The barriers to AI adoption in libraries are varied, including limited AI understanding among librarians, challenges in integrating AI with existing systems, and the high costs associated with AI products. A study on Chinese and British academic libraries, particularly at high-ranking universities, found AI used in virtual assistants, resource navigation, events, and robots (Huang, Cox, and Cox 2023). However, AI adoption levels varied, with libraries proceeding cautiously and aligning implementation with their strategic goals. Factors such as funding, value, institutional support, and librarian expertise significantly influenced AI adoption decisions.

A bibliometric analysis on academic librarianship in the Arab States from 1951 to 2021 revealed a notable increase in publications, especially in the last four years, peaking in 2020 (Siddique et al. 2023). The research highlighted growing interest in internet and open access, and identified areas needing further exploration, such as digital libraries, research data management, green librarianship, and AI. Notably, there is a lack of studies on how leadership styles among academic librarians affect AI implementation. Understanding effective leadership, which involves calculated risk-taking, is crucial for comprehensively grasping AI adoption dynamics in academic libraries.

It is important for developing professional training programs for librarians. They provide valuable guidance on cultivating adaptive leadership strategies that align with the evolving landscape of AI integration

in academic library environments (Shal, Ghamrawi, and Naccache 2024).

Conclusions:

AI applications in libraries offer significant benefits, including increased efficiency, enhanced user experiences, optimized resource management, and improved accessibility and security. Despite the substantial challenges posed by AI implementation—such as ensuring data privacy, addressing ethical concerns, investing in technological infrastructure, and training staff—the transformative potential of AI in libraries is immense. These technologies promise to revolutionize library operations and services, enabling libraries to evolve and meet the changing needs of their patrons in the digital age. By proactively addressing these challenges with robust data protection measures, ethical oversight, substantial investment in technology and training, and comprehensive policy development, libraries can harness AI to enhance their services and operations while maintaining their core mission of knowledge dissemination and preservation. Although the integration of AI in libraries might seem like it could distance librarians from their users, it is more likely to enhance the capabilities of libraries rather than replace librarian roles. AI will significantly improve library operations and services, thereby increasing the relevance of libraries in a continuously evolving digital society. Future research and practical implementations should continue to explore and refine AI applications, ensuring that libraries remain vital and relevant institutions at the forefront of technological innovation.

Study Recommendations:

Academic libraries should invest in adopting AI technologies to remain at the forefront of artificial intelligence advancements.

There is a need for more field studies to understand the requirements for implementing artificial intelligence technologies.

It is important to diversify the AI services offered by libraries and ensure their effective activation.

Proper training programs should be delivered to academic librarians to enhance their knowledge about this new technology and hence their acceptability.

Policymakers, researchers, and practitioners need to collaborate on establishing guidelines and standards that ensure AI's benefits are maximized while mitigating its risks.

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