The Journal of Academic Librarianship 49 (2023) 102803

Contents lists available at ScienceDirect

The Journal of Academic Librarianship

journal homepage: www.elsevier.com/locate/jacalib

Investigating applications of Artificial Intelligence in university libraries of Pakistan: An empirical study

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ARTICLE INFO

Keywords:
Emerging technologies
Fourth industrial revolution
Machine learning
Deep learning
Smart libraries
Robotics in libraries

ABSTRACT

This study aims to investigate the applications of Artificial Intelligence (AI) in the university libraries of Pakistan. Following the explanatory sequential mixed-methods approach, this study was completed in two phases. In the first phase, quantitative data was collected from 237 university librarians from across Pakistan. In the second phase, 10 purposefully selected university librarians were interviewed. The results reveal that Pakistani university libraries are using limited AI-based library services including text-to-speech and speech-to-text technologies, Google Assistant to search by voice command, Radio Frequency Identification (RFID) system for self-checkout, check-in, and security purposes, and intelligent data analysis for collection management. This study explored key factors that influence implementation of AI applications including highly integrated technological infrastructure, funding/cost associated with AI, collaboration between AI experts and professionals, and library users' feedback. The major identified challenges were the requirement of a highly networked and integrated environment, lack of budget, high cost of AI technologies, and lack of staff expertise. This study claims to implement the first comprehensive survey of AI applications in Pakistani university libraries at the national level. The research findings would support library and university administrators to integrate AI applications in libraries not only in Pakistan but also in other developing countries.

Introduction

The fourth industrial revolution has a great impact on fast technological transformation, and organizational activities are changing dramatically. With the emergence of AI, the entire landscape of education and industry is being disrupted and changing (Shahroom & Hussin, 2018; Tella & Ajani, 2022). AI is pervasive in contemporary society, and it has transformed commercial and intelligent automation processes (Gursoy et al., 2019). Due to its exponential potential, business and organizations around the world are embracing applications of this technology to reap the optimum benefits. AI is often seen as critical to future economic progress. According to an estimate (Jacques et al., 2018), over 70 % of organizations will embrace at least one tool of AI technology and may generate an additional US$13 trillion in economic activity by 2030, expanding global GDP by around 1.2 % each year.

Due to the evolving aspect of this domain, there is no consensus on a single definition of AI (Elsevier, 2018; NCB, 2018). In AI scenarios, the emphasis is on human behavior and how machines may mimic intelligent human behavior (Asemi et al., 2021). In an early definition, McCarthy (2007), a prominent computer scientist, characterized AI as "the science and engineering of making intelligent machines, especially intelligent computer programs. The ultimate effort is to make computer programs that can solve problems and achieve goals in the world as well as humans" (p. 2). Later on, AI is visioned as "a cluster of technology and approaches to computing focused on the ability of computers to make flexible rational decisions in response to unpredictable environmental conditions" (Tredinnick, 2017, p. 37). To be concise, AI is the emulation of human intelligence processes by computer systems and the focus has been on modelling conceptual frameworks utilized in human problem solving.

Library professionals have historically responded to new technological advancements that provide advances in the profession of librarianship (Hervieux & Wheatley, 2021). AI has revolutionized enterprises and has become a vital tool for libraries (Cox, 2023; Folorunso & Momoh, 2020). The application of AI technology in libraries may allow library resources to be virtually recreated. This reimagining can

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https://doi.org/10.1016/j.acalib.2023.102803
Received 12 July 2023; Received in revised form 16 October 2023; Accepted 17 October 2023
Available online 20 October 2023

assist the library in exploring new methods to fulfill client demands and facilitate academic pursuits for anybody from anywhere. AI can enable continuous access to an expanding domain of full-text online resources, allowing libraries to deliver services that transcend the customary (Okunlaya et al., 2022). However, with the advent of AI, the functions of libraries will grow more complicated, and future library professionals might need more complex, critical, innovative, and imaginative thinking, as well as emotional involvement (American Library Association, 2019; Huang, 2022).

Statement of the problem

Libraries in the developed world began to embrace IT in the 1970s, but Pakistani libraries began to use it in the late 1990s. Nonetheless, new technology has typically been introduced gradually in Pakistani libraries. However, librarians have welcomed emerging technologies in libraries during the previous decade (Asim et al., 2022). Moreover, AI has yet to be included in library and information science programs. Continuing education programs in Pakistan tend to be poorly organized (Rafiq et al., 2017), and librarians must independently develop their knowledge and skills in new technologies. Thus, this study investigates AI awareness, adoption, and the problems faced by Pakistani university librarians in using AI technologies. The outcomes of this study will help university library professionals and university administrators to analyze the extent of AI acceptance among university librarians, challenges associated with AI applications, and perceived benefits in the libraries. The findings may help them to come up with an appropriate plan of action to cope with identified challenges and adopt this promising technology. The findings may also help the library schools to understand the necessity of incorporating AI components in academic curriculum.

Research aim and objectives

This study aimed to explore AI applications in the university libraries of Pakistan. To achieve the stated study's aim, the following four research objectives were developed:

1. To explore AI-based library services being offered in Pakistani university libraries.
2. To investigate the benefits of AI in Pakistani university libraries.
3. To investigate key factors that influence AI-technologies implementation in Pakistani university libraries.
4. To explore the challenges to adopting and implementing AI in Pakistani university libraries.

Literature review

This section discusses the understanding of AI, AI applications in libraries, and the challenges associated with AI adoption and usage in libraries.

What is AI?

The use of AI is quite wide, leading to the digitalization of every commercial procedure and convergence in numerous elements of production across departments and functions (Gursoy et al., 2019). AI consists of two components including machine learning and its subset of deep learning. Machine learning enables machines to learn on their own and anticipate or make decisions without being deliberately programmed. Machine learning deals with the development of computer programs capable of accessing data and learning on their own (Edgcomb & Zima, 2019; Rebala et al., 2019). Machine learning technologies within AI include robotics, chatbots, text data mining, big data, and pattern recognition (Ali et al., 2020).

Deep learning is a sub-set of machine learning that concentrates on training multiple-layer artificial neural networks to learn data structures with hierarchical representations. It is based on the anatomy and functioning of the human brain, where information is processed by linked neurons (Hou, 2022; Wang, 2022). Deep learning enables machines to address complicated issues even with a varied, unstructured, and interconnected data set (Jakhar & Kaur, 2020). Deep learning uses AI techniques such as natural language processing (NLP), image processing, and neural networking.

AI applications in libraries

The primary aim of a university is to be a scientific innovator and to create a supportive and conducive ambience for academics. University libraries are supposed to have an essential role in facilitating teaching and research activities. Thus, it is important to investigate the variables for deploying AI applications in university libraries and the associated challenges. AI is a novel and emerging technology, and libraries' readiness to accept AI applications is susceptible to change as AI technology advances. AI is an appropriate way of allowing library customers to access library resources without constraints in the event of an interruption (Folorunso & Momoh, 2020). Available literature documented various forms of AI-based services, such as automatic cataloguing and classification, expert system-based automatic indexing, smart interaction with internet sources, and immersive bibliographic teaching (Huang et al., 2020; Mogali, 2014: Omame & Alex-Nmecha, 2020; Vijayakumar & Sheshadri, 2019). Virtual reference chatbot is one of the most prominent applications of AI, providing users with responses to simple queries (Arora et al., 2020). University libraries employ virtual assistants (VAs) for responding to users' simple queries (Zimmett, 2020). The VAs applications have been offered to the general public since 2011 when Apple and Siri used voice-assistive technology to interrupt the smartphone industry. Library professionals have witnessed the potential for VA's informative query skills to increase and impact library patrons (Hoy, 2018). Asemi et al. (2021) proposed that expert systems are acceptable intelligent systems in university libraries because they mirror the behavior of expert library professionals, whereas robots are suited for detecting and placing books on the shelf. Augmented intelligence is an exciting development in the advancement of AI research that has received little attention in the discipline of librarianship (Wójcik, 2021). Harisanty et al. (2023) argued that numerous AI-based solutions could be utilized in university libraries to support conventional or repetitive operations such as classification, cataloguing, shelving, and circulation desk activities. Nonetheless, decision-making and the potential to drive innovation are limited since libraries are still skeptical about the feasibility of AI.

Few researchers conducted qualitative and quantitative studies to investigate the perspectives of librarians about the use of AI in libraries. In a qualitative study, Cox et al. (2019) reported that library directors and IT professionals in the UK believe that AI is expected to have profound ramifications for reference services, information browsing and retrieval, information literacy, and cataloguing. Ali et al. (2020) conducted interviews with 10 chief librarians from Pakistani university libraries to investigate AI adoption. They noticed that the Pakistani university libraries were employing a few AI-based services, such as patron recognition by QR, bar code, or RFID, voice search on Google and YouTube, data text mining (#hashtag) and NLP Google translation. In another qualitative study, Ali et al. (2022) interviewed five chief librarians of Pakistani universities to explore AI-based services. They reported that AI is being slowly integrated into Pakistani university libraries due to the shortage of funds and technical manpower. However, Pakistani university librarians believed that AI help libraries to provide novel services and meet the growing needs of user requirements.

In addition to qualitative research, a few studies reported questionnaire-based surveys to study the perspectives of academic librarians towards AI in different countries. Lund et al. (2020) circulated an online questionnaire via different listservs and found that the earliest users declared favorable opinions towards AI employing in academic library environment. Later, Huang (2022) investigated the adoption of AI applications in Taiwanese university libraries using a questionnaire.

He found a variety of AI-based services, such as guide robots, automatic indexing, NLP, chatbots, intelligent data analysis for circulation activities and collection management, and face recognition for book check-in and check-out. Recently, in a mixed methods study, Abayomi et al. (2021) studied the awareness and perceptions of Nigerian university librarians towards the employment of AI in library management. They discovered that while Nigerian university librarians were knowledgeable about the presence of AI utilization in libraries, but the fear of job loss was the biggest impediment to the acceptance of AI among them.

Challenges associated with AI in libraries

Technology provides limitless potential, but it also creates hurdles to individuals and organizations navigating AI adoption and deployment, such as technological, standardization, security, and privacy concerns. The issues of ethical problems, decision intelligibility, and sustaining data quality were highlighted when examining the influence of AI on university libraries (Cox et al., 2019). Talley (2016) also noted several risks and concerns including the fear of joblessness, the expense of AI adoption, privacy concerns, and legal challenges associated with AI applications. According to Johnson and Verdicchio (2017), three major variables contribute to AI anxiety: "an exclusive focus on AI programs that leaves humans out of the picture, confusion about autonomy in computational entities and humans, and an inaccurate conception of technological development" (p. 2267). Addressing AI's ethical problems, Miao (2019) evaluated the literature on human rights ethics in AI and advocated that while developing AI products, researchers should include the essential ethical principles in their programming.

The Ex Libris White Paper addressed four key library professionals' worries such as they may be substituted by AI, human imagination and compassion could disappear, AI may amplify inequalities and unfairness, and the moral consequences of AI on data privacy (Huang, 2022). Omame and Alex-Nmecha (2020) identified several AI challenges, including a requirement of an abundance of technological knowledge, insufficient funds, high costs for creating and operating systems, the inherent complexities of AI systems, and a scarcity of AI experts.

In Pakistan, Ali et al. (2020) revealed that lack of finance and technological infrastructure were the major issues towards the adoption of AI in university libraries. Similarly, Hervieux and Wheatley (2021) argued that because most AI technologies are privately owned, most AI users are unfamiliar with how AI tool functions. Additionally, they highlighted that vendors' servers are located in different jurisdictions and the information can be stolen by breaking the security bridges. In a qualitative study, Harisanty et al. (2022) explored the challenges faced by Indonesian academic librarians in adoption or use of AI-base services included lack of visionary leadership, lack of support from organizations, lack of technological infrastructure, and electricity issues. More importantly, limited financial resources impede the implementation of AI in libraries.

Gap in the extant literature

The above-cited literature reveals that the studies were carried out to explore AI technologies in libraries across the globe. Most of the studies were literature reviews and qualitative in nature. However, a few studies used a quantitative research approach. More specifically, research was conducted in Pakistan, one of which was a content analysis (Hussain, 2023) and the other two were qualitative studies (Ali et al., 2020; Ali et al., 2022). The two qualitative investigations were limited in scope since only university librarians from Karachi, a biggest city of Pakistan, were interviewed. Hence, the extant literature lacks in providing a comprehensive picture of AI applications in Pakistani university libraries. Therefore, this study will address a knowledge gap in two distinct manners: (1) the present state of AI applications in Pakistani university libraries, and (2) the problems that university libraries face in implementing new technologies, notably AI.

Research methodology

This study aimed to investigate AI applications in the university libraries of Pakistan. AI is a novel phenomenon, particularly in developing nations such as Pakistan. To investigate a novel phenomenon, an extensive understanding of underlying dimensions and the factors that influence adoption and use is required. AI is an emerging technology and requires state-of-the-art technological infrastructure and expert manpower to implement in an organization. Moreover, limited literature, especially from the Pakistani context, led us to adopt a mixed-methods approach (Fig. 1) to investigate comprehensively the phenomenon under study at the national level. By combining qualitative and quantitative methods, a phenomenon can be explored from multiple lenses and gather a more holistic understanding (Creswell & Clark, 2017; Tashakkori & Teddlie, 2010). Thus, an explanatory sequential mixed-methods design (Creswell & Clark, 2011) was adopted to examine the opinions of Pakistani university librarians through a structured questionnaire followed by a semi-structured interview of the selected experts.

The study's population consisted of 237 university librarians from around Pakistan. This study focused on universities/degree-awarding institutions recognized by the Pakistan Higher Education Commission (HEC), the country's primary regulatory body for higher education. This research was carried out in two phases. In the first phase, quantitative data was collected through a structured questionnaire from one respondent to each university library. In the survey questionnaire, the respondents were asked about AI-based services, benefits of AI in libraries, factors influencing the implementation of AI applications, and challenges of AI adoption and use in libraries. A few statements of AI-based library services, factors influencing the implementation of AI applications, and challenges of AI adoption and use in libraries were taken from the study of Huang (2022). Before launching the survey, the questionnaire was validated by a panel of four experts having experience in diverse domains: (1) knowledge management, (2) information management, (3) administration and management, and (4) AI platforms development.

Additionally, the Cronbach alpha reliability test was used to guarantee the questionnaire's reliability. According to the Cronbach value, the average correlation coefficient of 45 assertions was 0.905. This structured questionnaire (Annexure-A) was developed in Google Docs, and the survey link was distributed to 237 university libraries in Pakistan's five provinces, the Federal Capital, and Azad Jammu and Kashmir (AJ & K) territory. An online survey is an efficient technique for swiftly collecting information when the sample group is geographically spread (Frippiat et al., 2010). After several follow-ups, 119 (50.21 %) university librarians submitted their response to the survey. Since this research project has not received funding from any organization, the participants responded voluntarily to this survey.

In the second phase, 10 university librarians having knowledge and skills in deploying AI applications in Pakistani university libraries were purposefully selected for interviews. These semi-structured interviews (Annexure-B) were conducted via cell phone. The interviewees inquired about the benefits of AI, the impact of AI on library services, key factors to implementing AI applications, and the challenges to use AI applications in university libraries. The interviewees volunteered to take part in this study. The thematic analysis technique was adopted to analyze the collected qualitative data. Thematic analysis allows for an abundance of adaptability in data interpretation and makes it less complicated to approach large data sets by categorizing them into broad themes (Flick, 2013).

Findings of the study

This section consists of qualitative and quantitative data analysis that are discussed in the following section.

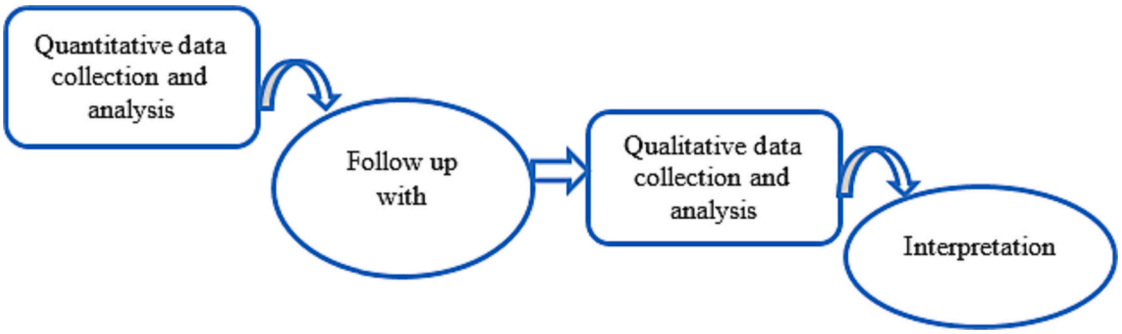

Fig. 1. The exploratory sequential design (Creswell & Clark, 2011).

Quantitative data analysis

Respondents' profile

The results of the demographics analysis (Table 1) reveal that the majority of the respondents were male (96; 81 %). The findings demonstrated that the majority of respondents (52; 44 %) were above the age of 40 years, while 39 (33 %) respondents were between 36 and 40 years. A little more than two-thirds of respondents (86; 72 %) were from public sector university libraries and held the designations of assistant librarian (40; 34 %) and librarian (39; 33 %). In terms of job experience, 39 (33 %) respondents had between 11 and 15 years of experience, while 26 (22 %) had more than 20 years.

AI-based library services

The respondents were asked about AI-based library services that have been implemented in their libraries. The findings (Table 2) shows that the majority of the respondents were using text-to-speech and speech-to-text technologies to market their library resources among disabled library users (53; 44.5 %), Google Assistant to search for information by voice command (44; 37.0 %), RFID system for self-checkout and check-in and/or security purposes (38; 31.93 %), intelligent data analysis for collection management (35; 29.4 %), patron recognition by QR Code, Bar Code (31; 26.1 %), and language translation to access multilingual resources (31; 26.1 %). However, most of the respondents who had not yet implemented these AI-based library services were enthusiastic and planning to initiate in the near future, for example, face recognition for checking books in and out (27; 22.7), intelligent data analysis for collection management (26; 21.8 %), virtual reference librarian (25; 21 %), and automating cataloguing and classification processes through machine-learning techniques (25; 21 %).

Table 1
Respondents' profile.

Variable	Level	Frequency	% (rounded off)
Gender	Male	96	81
	Female	23	19
Age	Less 25 years	1	1
	26–30 years	10	8
	31–35 years	17	14
	36–40 years	39	33
	Above 40 years	52	44
University type	Public	86	72
	Private	33	28
Designation	Chief Librarian	18	15
	Deputy Chief Librarian	17	14
	Senior Librarian	05	4
	Librarian	39	33
	Assistant Librarian	40	34
Working experience (year)	1–5	13	11
	6–10	18	15
	11–15	39	33
	16–20	23	19
	Above 20	26	22

Table 2
Current status of AI-based library services.

Sr #	Ai-based library service	Launched		Plan to launch in the near future	
		Freq.	%	Freq.	%
1.	Text-to-speech and speech-to-text technologies to market library resources among disabled library users	53	44.5	18	15.1
2.	Google Assistant to search for information by voice command	44	37.0	21	17.6
3.	RFID system for self-checkout and check-in or security purposes	38	31.93	22	18.48
4.	Intelligent data analysis for collection management	35	29.4	26	21.8
5.	Patron recognition by QR and bar code	31	26.1	18	15.1
6.	Language translation to access multilingual resources	31	26.1	18	15.1
7.	AI-powered indexing tool (automatically assign keywords based on text through)	27	22.7	24	20.2
8.	Virtual reference librarian (chatbots)	25	21.0	25	21.0
9.	Automating cataloguing and classification processes by applying machine-learning techniques	15	12.6	25	21.0
10.	Face recognition for book check-in and check-out	10	8.4	27	22.7
11.	A guide robot for library users	7	5.9	19	16.0

Benefits of AI in libraries

The survey respondents were asked about the benefits of AI in their libraries. The findings (Table 3) exhibit that the majority responded that AI technologies enhance the accuracy and efficiency of library search systems (mean = 4.36, SD = 0.66), AI can help automate repetitive tasks, allow librarians to focus on more complex and meaningful activities (mean = 4.32, SD = 0.63), AI-powered recommendation systems help users identify relevant resources (mean = 4.31, SD = 0.66), AI-powered analytics provide valuable insights into library usage patterns and trends (mean = 4.23, SD = 0.62), and AI can assist in curating and creating digital collections, and expanding access to diverse resources (mean = 4.17, SD = 0.70). The benefits of AI in libraries indicate that university librarians are well aware of the AI applications and understand how libraries could grow instantly by integrating AI technologies.

Factors influencing the implementation of AI applications in libraries

The respondents were asked about the factors that influence the implementation of AI in libraries. It was found (Table 4) that funding/cost associated with implementation (mean = 4.20, SD = 0.80), support from university administration (mean = 4.18, SD = 0.91), library system providers' intentions to integrate AI in their products and make available

Table 3
Benefits of AI in libraries.

Sr #	Benefits of AI in libraries	Mean	SD
1.	AI technologies enhance the accuracy and efficiency of library search systems.	4.36	0.66
2.	AI can help automate repetitive tasks, allowing librarians to focus on more complex and meaningful activities.	4.32	0.63
3.	AI-powered recommendation systems help users discover relevant books, articles, and resources.	4.31	0.66
4.	AI-powered analytics provide valuable insights into library usage patterns and trends.	4.23	0.62
5.	AI can assist in curating and creating digital collections, expanding access to diverse resources.	4.17	0.70
6.	AI can assist in cataloguing and classifying library materials, improving organization and accessibility.	4.15	0.80
7.	AI can analyze user behavior and preferences to personalize the library experience.	4.14	0.79
8.	AI-based text recognition and extraction tools can digitize and preserve rare or fragile library materials.	4.10	0.70
9.	AI chatbots can provide quick and accurate responses to library user inquiries.	4.07	0.77

Scale: "Strongly Disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5".

Table 4
Factors influencing the implementation of AI applications in libraries.

Sr #	Factors influencing the implementation of AI applications in libraries	Mean	SD
1.	Funding/cost associated with implementation	4.20	0.80
2.	Support from university administration	4.18	0.91
3.	Library system providers' intentions to integrate AI in their products and make available to libraries	4.16	0.74
4.	Librarians' willingness and experience	4.14	0.89
5.	Maturity and reliability of AI applications	4.11	0.87
6.	Innovative services/alignment with technological trends.	4.09	0.77
7.	Human resources	4.05	0.93
8.	Acceptance by users (e.g., attractiveness, function, convenience).	4.00	0.88

Scale: "Strongly Disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5".

to libraries (mean = 4.16, SD = 0.74), and librarians' willingness and experience (mean = 4.14, SD = 0.89) were the major factors that influence the implementation of AI applications in the Pakistani university libraries.

Challenges to AI adoption and use in libraries

The respondents were asked about the challenges they had faced during the adoption and use of AI applications in their libraries. The results (Table 5) highlight that university librarians encountered a variety of challenges, for example, budget, needed technological infrastructure, fear of losing jobs, skilled-technical manpower, security and privacy, etc. while adopting or deploying AI systems in their libraries. These challenges include the availability of a highly networked and integrated environment (mean = 4.30, SD = 0.80), lack of budget (mean = 4.17, SD = 0.86), high cost of AI technologies (mean = 4.16, SD = 0.91), high cost of support services for AI technologies (mean = 4.15, SD = 0.84), inadequate technological resources for promoting AI in libraries (mean = 4.10, SD = 0.87), and lack of technical staff (mean = 4.10, SD = 0.84). The outcomes indicate that major challenges are related to a lack of technological infrastructure and finance.

Qualitative data analysis

Ten university librarians having adequate knowledge and engaged in implementing AI applications in university libraries were interviewed. They were questioned about the AI benefits, AI adoption, critical considerations for implementing AI in university libraries, and challenges associated with the deployment and usage of AI applications in university libraries. Based on qualitative data, five broad themes including understanding of AI, AI adoption in Pakistani university libraries, benefits of AI, key factors to implement and use of AI applications in the university libraries, and the challenges associated with AI were developed.

Table 5
Challenges to AI adoption and use in libraries.

Sr #	Challenges to AI adoption and use in libraries	Mean	SD
1.	Requirement for a highly networked and integrated environment	4.30	0.80
2.	Lack of budget	4.17	0.86
3.	High cost of AI technologies	4.16	0.91
4.	High cost of support services for AI technologies	4.15	0.84
5.	Inadequate technological resources for promoting AI in libraries	4.10	0.87
6.	Lack of technical staff	4.10	0.84
7.	High cost of maintenance of AI technologies	4.08	0.84
8.	Integration with existing systems	4.06	0.78
9.	Lack of support from the university administration.	4.05	0.92
10.	Ethical and legal risks while adopting AI	4.05	0.84
11.	Lack of knowledge about AI-based library services	3.95	0.96
12.	Interoperability issues	3.91	0.84
13.	Lack of policy and strategic plan	3.84	0.79
14.	Required certification for AI technologies to measure quality	3.80	0.86
15.	Lack of willingness and acceptance among library professionals	3.78	1.00
16.	Fear of hacking and virus issues	3.73	1.02
17.	Fear of losing jobs among librarians if AI technologies are implemented	3.57	1.08

Scale: "Strongly Disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5".

Understanding of AI

Four participants explained AI as a machine programmed to mimic human thought processes and behavior. One participant defined the concept of AI as a machine that mimics human intellect and performs tasks automatically. Another participant described that AI is a technology-based system that assists individuals in performing daily tasks in the library. Overall, it is found that all participants have a basic understanding of AI technology; however, the knowledge about AI-based applications for university libraries was varied (Table 6).

AI adoption in Pakistani university libraries

The participants were asked about the adoption of AI applications in Pakistani university libraries. Four out of ten participants opined that AI-based applications in Pakistani university libraries are limited. One participant explained that most the AI applications deployed in Pakistani libraries are offered by third parties, such as Google Assistant to search through voice calls or chatbots service offered by OpenAI. Another participant described that few AI applications have been implemented in Pakistani university libraries including patrons' recognition through bar and QR codes, face scanning, and intelligent data analysis for collection development (Table 6).

Benefits of AI for university libraries

Participants described different types of benefits of AI in university libraries. Three out of the ten participants opined that automated metadata generation through AI saves the time of library staff. However, this service is not yet integrated into library management systems that are used in Pakistani university libraries. One participant explained that libraries could integrate an AI powered recommended system alongside a library management system to enhance the user experience by providing personalized recommendations based on individual interests and reading preferences. Another participant highlighted that AI also

Table 6
Themes overview.

Theme	Quotes
Understanding of AI	1. "A machine programmed to mimic human thought processes and behavior". 2. "A machine that mimics human intellect and performs tasks automatically". 3. "A technology-based system that assists individuals in performing daily duties in library".
AI adoption in Pakistani university libraries	1. "AI applications in Pakistani university libraries are limited" 2. "Most of AI applications are using in Pakistani university libraries that are offering by third party such as Google Assistant to search with voice command or ChatGPT chatbots service offer by openAI" 3. "Pakistani university libraries applied few AI applications including patrons recognition through scanning cards or face to in and out the library or for the circulation of reading contents, library management systems have the ability to provide data about most issued or searched titles".
Benefits of AI for university libraries	1. "Automated metadata generation through AI simplifies the cataloguing process, saving time for library staff and improving resource discoverability". 2. "By leveraging AI, libraries can enhance the user experience by providing personalized recommendations based on individual interests and reading preferences". 3. "AI also contributes to efficient resource management by automating cataloguing, organization, and classification processes". 4. "AI can improve accessibility by converting printed materials into digital formats for visually impaired users and facilitating language translation for diverse user groups".
Key factors to adopt/implement AI in university libraries	1. "A robust technological infrastructure is crucial". 2. "Collaboration with AI experts and professionals". 3. "Involving library users and seeking their feedback is essential to understand their needs and preferences".
Challenges for AI adoption/ implementation in university libraries	1. "AI tools are very expensive, and Pakistani university libraries face a huge funding constraint". 2. "Privacy and security concerns surrounding user data must be addressed to ensure compliance and maintain user trust". 3. "Limited expertise and resources in AI can pose obstacles, as libraries may struggle to access professionals with the necessary skills". 4. "User acceptance and adoption may be hindered by unfamiliarity or skepticism, necessitating efforts to educate and engage users". 5. "Integrating AI with existing systems and workflows can present technical challenges".

contributes to efficient resource management by automating cataloguing, organization, and classification processes. Another participant explained that AI could improve accessibility by converting printed materials into digital formats for visually impaired users and facilitating language translation for diverse user groups (Table 6).

Key factors to adopt/implement AI applications

The participants were asked about factors that support the implementation of AI technologies in Pakistani university libraries. One participant expressed that technological infrastructure is required to implement AI applications and reap the optimum benefits. Another participant described that collaboration between AI experts and library professionals is required to implement AI technologies in libraries. However, it is challenging for university libraries to hire the services of AI experts due to a shortage of library budgets. So, as far as possible, university librarians should gain the expertise to implement AI applications in the libraries. Another participant indicated that users' feedback is critical while implementing AI-based applications in university libraries because the entire system is designed to serve them (Table 6).

Challenges associated with AI adoption/implementation

The participants were asked about the challenges associated with AI applications while implementing or using them in university libraries (Table 6). Seven out of ten participants opined that Pakistani university librarians aspire to integrate innovative technologies such as AI; however, AI tools are extremely expensive, and university libraries are unable to embrace them owing to financial restrictions. One participant explained that data security and privacy is a major challenge to implement AI applications. Another participant highlighted that university librarians are not equipped with AI knowledge or expertise to implement such technologies in the libraries, and the university libraries may struggle to access professionals with the necessary skills. The lack of AI expertise may cause library staff to be hesitant to implement AI applications. One of the participants expressed that integrating AI with existing systems and workflows is a major challenge for university libraries.

Discussion and recommendations

The fourth industrial revolution's growing technology gained the interest of the library community. One of the famous and innovative technologies of the fourth industrial revolution is AI which is being embraced across a variety of sectors (Ransbotham et al., 2017). There is an explosive discussion among library professionals about how AI may be integrated with existing systems to improve the efficiency and efficacy of information organizations, as well as the quantity and quality of information services (Lund et al., 2020). Over the last few years, the popularity of AI-based applications has surged in libraries across the world. However, the review of the existing literature reveals a gap on AI applications from the Pakistani university libraries perspective. Thus, this study investigated AI applications in Pakistani university libraries and highlighted AI advantages, essential components to implementing AI applications in libraries, and the main challenges in the implementation and usage of AI in libraries.

AI is an emerging technology and has been connected with a variety of industries such as commerce, defense, health, and education, but its function in library services will encourage intelligent decisions (Chen et al., 2020; Hussain, 2023; Secinaro et al., 2021). This study found that university libraries can benefit from AI because AI technologies enhance the accuracy and efficiency of library search systems, AI can help automate repetitive tasks, allowing librarians to focus on more complex and meaningful activities, AI-powered recommendation systems help users discover relevant books, articles, and resources, AI-powered analytics provide valuable insights into library usage patterns and trends, and AI can assist in curating and creating digital collections, expanding access to diverse resources. AI algorithms can help to automate the cataloguing process by extracting essential metadata from digital and physical resources, optical character recognition and NLP methods may be used to identify and obtain information from book covers, title pages, and other sources, decreasing the manual labor necessary for cataloguing (Omame & Alex-Nmecha, 2020). AI-powered recommendation systems play a critical role in assisting users in discovering relevant books in libraries. Recommendation systems generate user profiles by analyzing data such as borrowing history, search queries, ratings, and reading interests. AI systems study trends to discover comparable individuals who share the same interests and reading habits (Cox et al.,

2019). This system should be integrated with the library management system.

Because of the integration of developing technology in university libraries, library professionals now refer to the library as smart libraries, which has swiftly become a household name (Ajani et al., 2022). This study also found that few AI-based library services have been implemented in university libraries of Pakistan such as text-to-speech and speech-to-text technologies to market the library resources among disabled library users, Google assistant to search for information by voice command, RFID system for self-checkout and check-in or security purposes, intelligent data analysis for collection management, patron recognition by QR code, barcode, and language translation to access multilingual resources. Due to a lack of funds and interest of the university administration, Pakistani university libraries have adopted limited AI-based services. Most of the adopted AI applications are those that are freely available such as Google Assistant and online tools for language translation to access multilingual resources. However, library automation software such as Koha and Virtua could provide most issued or searched items intelligently for data collection management (Asim et al., 2022; Asim & Mairaj, 2019). Various university libraries have implemented RFID systems for circulation activities and inventory control systems. RFID tags are connected to library materials including books, DVDs, and CDs. AI-powered self-checkout machines with RFID readers can swiftly scan numerous items at once, allowing consumers to check out or return products without having to manually scan them. AI algorithms can help with item identification, user account verification, and loan record management. Moreover, RFID technology is also being used to improve library security. AI algorithms can monitor RFID tag signals and detect unauthorized item removal from library surroundings (Chen & Shen, 2020).

Historically, libraries have been resistant to change, permitting for a certain technology to reach market saturation before responding to a new trend (Wheatley & Hervieux, 2019). However, key considerations to apply AI applications in university libraries may vary from country to country. The results of quantitative and qualitative data analysis disclosed that Pakistani librarians should keep different key aspects in mind while implementing AI applications, such as highly integrated technological infrastructure is crucial, funding or cost associated with AI, collaboration with AI experts and professionals, and seeking library users' feedback is essential to understand their needs and preferences. This study highlighted the major challenges encountered by Pakistani university librarians, which include the requirement of a highly networked and integrated environment, lack of budget, high cost of AI technologies, and lack of staff expertise to implement AI applications. The lack of funds to incorporate emerging technologies such as AI is a serious concern for Pakistani university libraries. As a result of this dilemma, university libraries are unable to engage AI specialists who can collaborate with library professionals to integrate AI system with the existing library system. University administration with the support of Pakistan HEC should provide the required budget and needed technological infrastructure to Pakistani university libraries to deploy and use AI-based applications.

Compared to the findings of the previously published study (Ali et al., 2020), the findings of this study bring some new knowledge about AI applications and challenges faced by the university librarians during the implementation and/or use of AI applications in the university libraries of Pakistan. This study found that some new AI applications in the Pakistani university libraries that have not been identified in previous studies such as text-to-speech and speech-to-text technologies to market library resources among disabled library users, and intelligent data analysis for collection management. Prior investigations (Ali et al., 2020; Ali et al., 2022) reported that the university librarians faced funding issues and lack of technical expertise for the implementation of AI applications. These challenges are faced by library professionals to implement any new technology in the libraries of developing countries such as Pakistan (Asim et al., 2022). However, this study found some other challenges that are not reported in the previous published qualitative studies in Pakistan such as the requirement of a highly networked and integrated environment, inadequate technological resources for promoting AI in libraries, and lack of the support from university administration.

Respondents agreed with all the AI technologies' benefits to libraries, presented in the questionnaire and confirmed during the interviews. It shows that the respondents are well aware of the benefits of AI technologies and their positive perceptions about the benefits will be instrumental in the adoption of AI applications in libraries. As Librarians' willingness emerged as an influencing factor to implement AI applications in libraries (Tables 4 and 6), the positive intentions about the AI benefits paint a favorable and optimistic picture for the adoption of AI technologies in Pakistani libraries. However, it will largely depend on addressing the associated challenges (Tables 5 and 6).

Support from university administration (Table 4) is another influencing factor for the adoption of AI-based technologies in libraries. This factor is also identified as an associated challenge (Table 5). Of course, Pakistani university libraries are dependent on the university's higher administration for funding, policy interventions, etc. AI technologies are costly and require certain funding. Administrators knowledgeable of AI technologies and their benefits may support such costly endeavors in libraries. For this purpose, libraries need to work to improve perceptions of AI through seminars, lobbying, etc. Libraries need to identify the supporting persons among the university administration, coordinate with them, and work strategically to get the required support and funds for AI technologies. Most importantly, libraries need to correspond the benefits of these AI applications to the organizational mission. Such a strategy may benefit to receive support for the acquisition and adoption of costly AI technologies.

Preparing human resources for the use of AI technologies is another influencing factor. Libraries need to improve the knowledge and skills of their staff. The support of the university administration will be instrumental in this regard. University administration may fund the training of the staff. Furthermore, Pakistani library associations should support continuing education initiatives which develop library personnel competencies so that they may adopt new technology-based services in their libraries.

University librarians are eager to adopt cutting-edge technologies in libraries across the world. Despite several benefits of AI-based platforms, there are still several challenges to implementing AI-based platforms, especially in the developing world. By addressing the identified challenges, the situation may be improved significantly and enable the libraries to implement and use AI applications for library processes, operations, and services. In Pakistan, the Ministry of Information Technology and Telecommunication, the National Information Technology Board, the Punjab Information Technology Board, and the Pakistan Telecommunication Authority, are responsible for deploying IT applications in all sectors of the economy. There is an urgent need for collaboration among all the relevant stakeholders at the national level. For this purpose, Pakistan HEC, a national principal higher education regulatory organization, should collaborate with IT-related entities to implement AI technologies in the universities that would support to the development of smart campuses and smart libraries.

Implications of the study

The application of AI in libraries is a relatively new phenomenon in Pakistani university libraries. This has a few practical ramifications. Firstly, it provides valuable insights to university librarians and management, as well as policymakers institutions at the federal and provincial levels, on the present state of AI usage, its advantages, and difficulties to Pakistani university libraries. Secondly, the findings are useful for system librarians planning to adopt and use AI applications in university libraries. Finally, the issues/challenges raised in this study may help policymakers and funding agencies in developing countries to

improve regulations and protocols in order to develop strategic plans for integrating AI in libraries.

Conclusions and future research directions

This study emphasizes both the potential benefits and challenges of AI implementation in the Pakistani university libraries. This study explored limited AI applications in the university libraries. While there has been progress in applying AI to increase accessibility and efficiency, there is always potential for improvement. To fully realize the revolutionary potential of AI in the library sector, it will be necessary to overcome resource restrictions and talent shortfalls. However, the findings of this study were restricted to the questionnaire which used in the setting of Pakistani university libraries. The rapidly evolving nature of AI technologies may pose a challenge to the study because AI applications in university libraries may change or improve over time, rendering some findings obsolete. Additionally, ten library professionals were interviewed for this study, while 119 (50.21 %) of 237 university libraries responded to the quantitative survey. In the future, researchers should conduct a comprehensive survey by involving other academic libraries for a holistic assessment of AI possibilities in Pakistani academic libraries. Future researchers could also investigate the readiness of AI-associated technologies, robotics in libraries, green information technologies, intelligent virtual assistants/chatbots, intelligent data analytics for library operations, and a critical systematic literature review on AI applications in academic libraries.

CRediT authorship contribution statement

Muhammad Asim: Quantitative and qualitative data collection and analysis, writing - original draft preparation
Muhammad Arif: Conceptualization and supervising
Muhammad Rafiq: Reviewing and editing
Rafiq Ahmad: Supported in survey administration.

Declaration of competing interest

No conflicts of interest are associated with this publication. Moreover, we have not secured any financial support for this research work.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.acalib.2023.102803.

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