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Artificial Intelligence (AI) applications and usage among the LIS professionals of Pakistan

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Abstract

Artificial intelligence (AI) is an important and emerging sub-discipline in information technology that is progressively being implemented in every field. It is gradually being introduced to support new forms of research, discovery, and reuse of library contents in advanced and interesting ways. University libraries have the potential to substantially improve their library services through the implementation of sophisticated AI tools. This study explored the application of AI tools in the university libraries of Pakistan, as well as draw a comparison in the usage of AI tools between public and private sector universities. This is a quantitative study and data is collected through survey methodology. We used purposive sampling to collect the data from 175 university libraries. The collected data was analyzed using a statistical package for social sciences (SPSS-version 22). Findings indicate that while AI-based services are starting to be introduced into university libraries in Pakistan, no university library has implemented the full suite of AI-based tools. Natural language processing, voice searching, and chatbots are the most familiar and popular tools currently used in libraries. However, robotics technology is rarely used with a mean value of (1.62) because of the financial investment and high level of IT skills required. We found that private university libraries are using AI tools more as compared with public sector university libraries. The study concludes with several key recommendations, including closer collaboration between the library and the respective university IT department for technical support and assistance; improved financial support and ICT infrastructure to establish AI technology-based library services; and training development plans for library staff. Insights gained from this study should contribute to the capacity of Pakistani University librarians and their staff to maximize the full potential of AI within their institutions. The research implications are helpful to library leaders and policymakers in building a policy for AI-based technology in their respective university libraries.

Keywords

Academic librarians, Artificial Intelligence, Chatbot, Natural Language Processing (NLP), Robotics, Text Data Mining

Introduction

Artificial intelligence (AI) is one of the important emerging trends in technology. Although it is regarded as a computer science discipline. Still, it has significant impact on all walks of life and professions. It has already had a well-documented impact on several fields, including libraries, medicine, learning and teaching, and higher education, etc. (Cox et al., 2019; Heck et al., 2021; Massis, 2018; Popenici and Kerr, 2017). Although historically libraries have always provided innovative services through technology, an early study indicate that AI had initially had relatively

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little impact on libraries due to the significant financial, human, and technological investment needed for AI system technology implementations in libraries (Hsieh and Hall, 1989). However, in the era of big data analytics, research data management, text data mining, and quick data retrieval tools, there is, nevertheless, a greater chance for libraries to embrace AI-cutting edge tools after academic libraries successfully underwent automation, and digitization for more than three decades (Cox et al., 2019; Schreur, 2020). Librarians may be better able to use artificial intelligence to manage their libraries in light of the evolving technological environment and the emerging data library ecosystem (Ratledge, 2017; Wood and Evans, 2018). Artificial intelligence fields such as data analytics, data visualization, and data analysis have an impact on future information trends. Machine learning processed the fastest information/data to support the researchers and librarian users like Rayyan, Covidence and etc.

Gujral et al. (2019) reported that AI is to be introduced and used effectively, a robust infrastructure for information and communication (ICT) is required. Even though ICT is already essential to the provision of library services, its significance will only grow as these services are expanded to encompass expert systems, big data, text data mining, and pattern recognition, as well as the intelligent processing, preservation, reuse, and retrieval of information (Dyas-Correia and Alexopoulos, 2014; Mckie et al., 2022; Shi et al., 2020; Shrivastava, 2018). In the last decade, there has been growing interest in—and debate about—ways in which AI may either directly or indirectly support librarians with their work (Arlitsch and Newell, 2017; Luca et al., 2022; Tait and Pierson, 2022; Vijayakumar and Sheshadri, 2019; Wheatley and Hervieux, 2020). Researchers have also documented librarians' concerns about funding, financial inequalities, bias, data privacy, possible job loss, and ethical issues (Ali et al., 2020; Barredo Arrieta et al., 2020; Bradley, 2022; Cox et al., 2019).

Artificial Intelligence

According to Guo (2015, p. 3), "The fundamental tenet of AI is that human intelligence can be studied and simulated so that computers can be programed to do things that (human) minds can do." Artificial Intelligence is a branch of computer science (Asemi and Asemi, 2018) that has been applied in different fields, for example, information and communication technology (ICT), medicine, human resources, economics, higher education, and business. Historically, the term "AI" was first used in 1955 by J. McCarthy when preparing a research proposal for the Dartmouth Summer Research Conference. The idea was to investigate how AI could be applied to what they referred to as "automatic computers," as well as programing computers to use language, and the potential for intelligent machines to "self-improve" (McCarthy et al., 2006). According to Hilker (1986, p.15), "artificial intelligence is a branch of computer science that concerns the ability of computers to perform intelligent tasks, such as those requiring recognition, reasoning, and learning." Mogali (2015) states that "AI mainly focuses on understanding and performing intelligent tasks such as reasoning, learning new skills, and adopting to new situations and problems."

Robotics technology. Abram (2019) has defined a robot as "a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer." Robotics is often described as a subfield of AI that focuses on tasks with machine learning (Mogali, 2015). Although AI and robots have been under development for many decades, Phillips (2017, p. 10) correctly notes, "there seems to be a growing consensus that we are on the edge, or indeed already tipping into, a new era of development."

Robotics technology is one of the important AI components which has started being used in libraries (Norwin, 2016; Tella, 2020; Yao et al., 2015). Some robots are used for the retrieval of material and circulation purposes (Wang, 2019). Shelf-reading robots can locate missing or out-of-sequence books, even along curved shelves. Tella (2020, p. 15) notes that in libraries "Robots collect data automatically, they transfer data from collection and acquisition systems, and they now find solutions to clients' problems." There has also been a qualitative study conducted about the possible usage of robotics in libraries and the gaps between its potential positive impact and the corresponding view of library staff (Wang, 2019). Mckie and Narayan (2019, p. 275) have observed that "A customized and personalized chatbot can make [their] experience a lot more interactive and pleasurable, leaving the students with a good experience in their library interactions."

Chatbots. Early notable chatbots included ELIZA, invented in 1966, and Parry, designed in 1972 by Kenneth Colby, both of which had their roots in psychological science. Artificial Linguistic Internet Computer Entity (A.L.I.C.E.), developed in 1995, was used by Tsinghua University Library as the model for a reference chatbot named Xiaotu. It worked through Chinese natural language processing, which is quite different from Western languages (Yao et al., 2015). Pixel is an example of another library chatbot; it was developed by the University of Nebraska-Lincoln Libraries to provide users with general information about the library and to locate information for them on the Libraries' website (Allison, 2012). Khan et al. (2017) have observed that contemporary digital reference services (DRS) rely on tools such as instant messaging, video conferencing, email, and chatbot (what they refer to as "Chatterbot") for users to submit queries. An AI-based medical chatbot, known as "Project Plutchik," has been developed for searching and retrieving information from

the National Centre for Biotechnology Information (NCBI) databases (Bohle, 2018). A chatbot service known as ANTswers is being used at the University of California, Irvine for reference services. A study reported that 3536 (34.19%) queries were received on library services and collection items, borrowing and analysis were the most popular categories (Kane, 2019). Safadel et al. (2023) employed IBM Watson chatbot application in order to study virtual reality. The study reported that users of libraries can benefit from virtual reality based systems.

Besides the normal chatbot, AI based Chatbot Generative Pre-Trained Transformer generally known as ChatGPT 3.0 (launched in November 2022) and ChatGPT4.0 (launched in March 2023) are considered as game changer and paradigm shifted tools in education, research, libraries and information industries. ChatGPT potential area identify in the context of libraries are explained discovery and search, research, reference, information literacy and digital literacy, copyright, academic writing, and productivity (Cox and Tzoc, 2023). In library and information management industries Chat GPT is used for reference service and retrieval of information. Ali, 2024) reported that ChatGPT has demonstrated success in two key areas: references and information retrieval services.

Natural Language Processing (NLP). Natural Language Processing (NLP) is a branch of artificial intelligence that "helps computers understand, interpret, and manipulate human language" (Nguyen et al., 2021, p. 1). According to Edgcomb and Zima (2019) reported that even hough natural language processing emerged in the 1970s, certain areas subfields of computer science and linguistics are still dedicated to what the authors refer to as the "nuances of NLP" (p. 347). It is one of the most important components of AI used in speech recognition, voice assistance, and chatbots to follow the instruction of users (Singh and Thakur, 2020). In libraries, NLP is used in processes involving, for example, information retrieval, language translation, and voice assistance for circulation, reference services and information processing (Herron, 2017; Hervieux and Wheatley, 2021; Massis, 2018).

Big Data Analytics. Recent studies, such as the one conducted by Favaretto et al. (2020), have shown that there is a wide range of definitions of "Big Data," despite its common use as a term. Many are variants of Jin et al. (2015, p. 59) description of its essential characteristics as 5 Vs: "huge Volume, high Velocity, high Variety, low Veracity, and high Value." According to the European Commission : (2022) "Big data refers to large amounts of data produced very quickly by a high number of diverse sources."

AI has gained popularity because of its use of advanced algorithms as well as its contribution to swift computing power and storage in the era of Big Data (Duan et al., 2019). "There is a necessity to fully understand the synergy of AI and Big Data and its implications for AI research and practice" (p. 69). In the context of librarianship, large volumes of data generated from different sources, for example, online databases management, citation counts of individuals / institutions, downloads, and traffic hits of library websites, have to be organized and analyzed to support a library's services (Ahmad et al., 2019).

Text Data Mining/data mining. Mahender et al. (2020, p. 147) have defined text mining as "the procedure of synthesizing information, by analyzing relations, patterns, and rules among textual data [in] semi-structured or unstructured text." As a corollary, the "extraction of interesting information or patterns from data in large databases" is commonly known as data mining (Yehia et al., 2016, p. 2). Both data mining and text data mining are very relevant in the field of information management. The use of the #hashtag and @ tag in Twitter is an example of very popular mechanisms to call attention to relevant contents, posts, tweets, videos, and images, etc. Data mining has been utilized extensively to identify trends related to their usage (Belhadi et al., 2020).

The AI machine learning component is used for data mining, the processing of big data, knowledge management, and information processing. Within the specific context of librarianship, machine learning has been helpful in automating traditional library cataloging and classification processes, as well as in managing citations and creating bibliographic materials (Boughanem et al., 2020; Jones, 1991; Pong et al., 2008; Pradhan et al., 2019). As Sreenivasulu (2000) has suggested, digital librarians offering specialist services will require a limited knowledge of data mining to satisfy users' unmet information needs. Furthermore, "For this purpose, unsupervised learning techniques such as clustering, and composite term discovery techniques etc., are useful" (p. 14).

Pattern Recognition. Pattern recognition is one of the emerging fields of AI technologies. Different types of patterns are designed to perform day-to-day services and operations. Mogali (2015, p. 3) defines it as "the process of establishing a close match between some new stimulus and previously stored stimulus patterns." The primary function is to facilitate the collection and extraction of data from particular platforms. Pattern recognition is widely used in key functions on devices, such as cell phones and laptops (Ehatisham-ul-Haq et al., 2018).

In libraries, pattern recognition has been implemented in activities, such as library users / staff check in and check out. Pattern recognition is also used for barcodes, QR Codes and RFID codes (Bhoi, 2017; Shi et al., 2020; Tu and Hwang, 2020).

Image Processing. Image processing has been an important tool in medicine for several years. Caban et al. (2007), for

example, have highlighted its importance in biomedical research and the use of open-source libraries to support its development. In discussing the potential impact of AI specifically in radiology and pathology, Jha and Topol (2016, p. E2) have proposed the emergence of a new role, that is, information specialist, within those disciplines "whose responsibility will not be so much to extract information from images and histology but to manage the information extracted by artificial intelligence in the clinical context of the patient." Such information can be used with medical library data and patient management system data to support healthcare professionals (Eggerth et al., 2020).

In libraries, image processing is used in two principal ways, that is, processing of archival records and of non-digitally born materials (Conway, 2011). The latter includes library physical materials, for example, resources in print form. It plays an important role in managing current images and other AV materials that are to be preserved on a long-term basis. In multimedia libraries, the image processing technique is used for the quick retrieval of information from resources, such as videos and music (Tsai, 2007). In addition, image processing is used for the facial recognition of library staff and patrons (Ali et al., 2021).

Literature Review

Artificial Intelligence in libraries

The initial stages of AI have only been discussed about library systems as of the late 80s. The late 1980s and early 1990s saw the advent of library automation systems and system experts (Anderson, 1988), with some AI-based services prototypes, for example, cataloging, indexing, and reference (Bailey, 1991), and information retrieval to find out accurate printed books from the respective libraries (Jones, 1991; Smith, 1987).

AI is slowly making its way into libraries; within the past 10 years, relevant research has begun to gain momentum, for example, in the area of library recommender systems (Asemi and Asemi, 2018) and library job and respective opportunities (Arlitsch and Newell, 2017). AI has significant impact in library management systems indicated six important tools that is, automated classification and cataloging, recommender system, chatbot, personalization, digital preservation, and data analytics (Bisht et al., 2023). Chen and Shen (2020) evaluated the library usage behavior with intelligent library, services innovation, and service quality. A study reported that intelligent virtual agents, robots and chatbots are used 33% university libraries in China (Huang et al., 2023). The AI policies of various developed countries like USA, UK, European Union, Canada, and China were discussed (Lo, 2023). The study focused on four key areas: ethics, transparency, the balance between innovation and regulation, and data privacy. The discussion of AI bias pertains to prejudice in data representation, decision making processes, and and lack of transparency in AI algorithms within the context of libraries and the information economy. These biases have a direct impact on how fairly information is used (Saeidnia, 2023). According to an evaluation of AI literacy among LIS researchers in the Association of Southeast Asian Nations (ASEAN) region, library researchers have good skills when it comes to information retrieval via AI tools (A. S., Paladhi et al., 2023).

The level of statisfaction among Nigerian higher education library users was assessed by a quantitative survey. The results showed that there was a significant relationship between applications of artificial intelligence in the libraries and level of users' satisfaction (Okpokwasili Nonyelum, 2019). Another study revealed that librarians had a high degree of perceived knowledge and skill set for the implementation of artificial intelligence tools in libraries. (Subaveerapandiyan et al., 2023). A recent study describes how AI is applicable in the area of library automation, reference services, decision making, that is, selection of books and e-content, and the acquisition, searching, and retrieval of information from the web and databases (Chemulwo and Sirorei, 2020). Another study identified three important points: phrase-based indexing, semantic-based indexing, and word embedding representation, for information retrieval through AI based applications (Boughanem et al., 2020).

Artificial Intelligence in Pakistani libraries

Pakistani university libraries are in an evolving phase. For example, AI has slowly been incorporated into library management systems (LMS) which use RFID-based technology to prevent the theft of books (Rehman et al., 2016). In Pakistani university libraries, current status shows that approximately 26.6% university libraries use automated book security, with 18.1% using RFID technology (Yousuf Ali, 2017).

Libraries are moving toward the adoption of AI-based services for their users, for example, chat reference or virtual reference services (Ali and Haider, 2016; Malik and Mahmood, 2014; Younus, 2014). For example, the seven major AI tools, that is, chatbot, robotics, Natural language processing (NLP), big data analytics, text data mining (TDM), pattern recognition, and image processing, are directly or indirectly impacting on Pakistani libraries' technical and user services (Ali et al., 2020). Ali et al. (2021) have also reported that Colleges of Physician and Surgeons (CPSP) Library, Karachi, has used facial recognition machines for the user check-in and check-out since 2018. Khan and Bhatti (2018) have examined the use of artificial intelligence tools for structuring digital content, including the accuracy of results from the Semantic Web. Furthermore, they have stated that AI technology is used for security purposes and speech recognition.

A recent qualitative study using an ethnographic approach examined the implementation of AI in Pakistani university libraries. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis presented the possible institutional strengths, weaknesses, opportunities, and threats as discussed by university library leaders (Ali et al., 2024). Researchers noted that while AI technologies are now employed at a very low levels in university libraries, Pakistani university libraries plan to provide AI-based library services shortly. Additionally, librarians, have positive perception about AI-based library technology. In response to a recent survey that asked about 10 different AI technologies, 237 university librarians reported that the majority of these tools are in use in libraries (Asim et al., 2023).

In the Pakistani context, there has been relatively little empirical research reported in the literature so far about AI adoption in Pakistan academic libraries. Only a few studies explored AI usage and applications in libraries, for example, Hussain and Ahmad (2021) have included AI in their proposed framework of smart library technologies for utilization in Pakistani university libraries. Few studies explored the usage of AI in academic libraries (Ali et al., 2020, 2024; Asim et al., 2023; Khan and Bhatti, 2018; & Khan et al., 2017). These studies were either descriptive or delimited to their scope in terms of population or study setting. Although university librarians in Pakistan have begun to discuss intelligent technological applications and how they might affect libraries, no adequate research has been done on the use of AI in Pakistani university libraries. Therefore, a large-scale study was conducted with an aim to determine the usage of AI tools in academic libraries.

Objectives of the Study

- To determine the usage of AI tools in the university libraries of Pakistan.
- To find a difference if any in the usage of AI tools among public and private sector university libraries.

Methodology

This is a quantitative study to determine the adoption of AI technology tools usage in the university libraries of Pakistan. The research population of this study, which is homogeneous but scattered throughout the country, is comprised of LIS professionals working in university libraries in Pakistan. The survey research method was used to collect the data from the respondents. The questionnaire was developed with the help of the literature and accessing the AI usage and implementation status in the university libraries. The questionnaire consists of two parts. Part I consists of questions about the respondents' knowledge regarding seven AI tools (Robotics, Chatbot, Natural Language Processing, Text Data Mining, Big Data, Pattern Recognition, and Image Processing) and their possible use in libraries and information centers. Responses to 24 statements were measured using a 5-point Likert scale (1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always). Part II of the questionnaire consists of questions about the demographical information of the respondents, that is, gender, institution name, type of institution, designation, and age. Researchers used purposive sampling to collect the data from the participants. Data were collected between the period of 21 May 2022 to 31 Oct 2022 .Researchers distributed the online questionnaire among a total of 212 participating university libraries in Pakistan. These universities were recognized by the Higher Education Commission of Pakistan as of January 2021. Of the 212 university libraries, we received responses from the 175 university libraries with a response rate of 82.54%. On the other hand, researchers distributed 350 questionnaires, of which we received 245 responses from the participants with a response rate of 70%.

The collected data was analyzed using a statistical package for social sciences (SPSS-version 22), and data was presented in frequency, percentage, mean, and standard deviation. However inferential statistical test Independent sample t-test was used to compare AI usage between private and public sector universities.

The study was started by obtaining ethical approval from the Islamia University of Bahawalpur. Informed consent was obtained from the respondents through a cover letter that was distributed along with the questionnaire to the respondents. The participation was voluntary, there were no incentives were offered to the participants. This may be recorded as one of the reasons for non-response biases.

Data Analysis

Demographical information

Respondents were asked 5 questions, that is, gender, designation, and university type. Of the 245 respondents, the majority of 169 (69%) were male and 76 (31%) were female. The junior category rank 13 (5.3%) was represented by others (such a s library assistants). In our cohort there were 63 (25.7%) assistant librarians, deputy librarians were 21 (8.6%), and associate librarians were 4 (1.6%). In the senior category rank, Library in charge 18 (7.3%), librarian 79 (32.2%), senior librarian 15 (6.1%), and chief librarian 32 (13.2%) participated in this survey (Table 1). Out of 212 HEC recognized universities as of January 2021, respondents from 175 universities participated in this survey, with 141 (57.5%) from private sector universities and 104 (42.5%) from public sector universities (Table 1).

Usage of Artificial Intelligence Tools

Seven different AI tools' usage in the library were included in the questionnaire, namely robotics, chatbot, Natural language processing (NLP), Big Data Analytics, Text data mining (TDM), pattern recognition, and image processing results are discussed as under.

Respondents' usage of robotics. The respondents were asked a set of three statements regarding their usage of robotics. All these statements received a mean value around 2, indicating that the majority of respondents rarely used robotics for self-check-in and out in the library (Mean = 1.74, SD = 1.19), stocktaking in the library (Mean = 1.62, SD = 1.04), or searching library material/information (Mean = 1.72, SD = 1.20). Using Independent Sample t-test, we found a statistically significant difference in the usage of robotics between private and public university libraries. That is, robotics used for self-check-in and out (Mean = 1.98, SD = 1.32; vs Mean = 1.57, SD = 1.06), t value (2.718), $p = 0.007$; stocktaking in the library (Mean = 1.79, SD = 1.20; vs Mean = 1.50, SD = 0.89), t value (2.173), $p = 0.034$; and searching library material (Mean = 1.90, SD = 1.31; vs Mean = 1.58, SD = 1.10), t value (2.091), $p = 0.038$ (Table 2).

Respondent's usage of chatbot. The respondents were asked a set of three statements regarding their usage of chatbots. All these statements received a mean value between 2.36 and 3.06, indicating that the majority of respondents used chatbots "sometimes" for reference services/reference query in the library (Mean = 2.36, SD = 1.22), voice assistant for searching online information (Mean = 2.67, SD = 1.12), and voice search on Google Chrome or YouTube for information or videos (Mean = 3.06, SD = 1.24). Using an Independent Sample t-test, we found a statistically significant difference in the usage of chatbots between private and public university libraries that is, chatbots for reference services/reference query, with private university score (Mean = 2.58, SD = 1.22, vs Mean = 2.20, SD = 1.20, t value (2.419), $p = 0.016$); voice assistant for searching online information, with private university score (Mean = 2.88, SD = 1.19; vs Mean = 2.52, SD = 1.17, t value (2.302), $p = 0.022$), and voice search on Google Chrome or YouTube for information or videos,(Mean = 3.38, SD = 1.11, vs Mean = 2.83, SD = 1.29, t value (3.464), $p = 0.001$). The mean values of the private university respondents were higher as compared to public sector universities, showing more use of chatbots among private universities (Table 3).

Respondent's usage of Natural Language Processing (NLP). The respondents were asked a set of three statements regarding their usage of NLP (as shown in Table 4). All these statements received a mean value between 2.56 and 3.06, indicating that the majority of respondents used NLP "sometimes," or "frequently" for Google translation for text translation from English to Urdu or any other Language (Mean = 3.78, SD = 1.02), information retrieval searching strategy or advanced search via voice on Google Scholar, PubMed (Mean = 3.11, SD = 1.15), and automatic text detection in online reading materials (e.g. optical character recognition (OCR) for text recognition in different languages (Mean = 2.56, SD = 1.26). The mean values of the private university respondents were higher as compared to public sector universities, showing a significantly more usage of NLP in private universities as compared with public sector universities that is, Google translation for text translation from English to Urdu or any other language (Mean = 4.02, SD = 0.86, vs Mean = 3.60, SD = 1.22, t value (3.031), $p = 0.003$), and information retrieval searching strategy or advanced search via voice on Google Scholar, PubMed (Mean = 3.26, SD = 1.03, vs Mean = 2.99, SD = 1.23, t value (1.795), $p = 0.007$. However, a statistically no significant difference between private and public sector universities found in the usage of the automatic text detection in online reading materials (e.g. optical character recognition (OCR) for text recognition in different languages (Mean = 2.70, SD = 1.24; vs Mean = 2.45, SD = 1.27, t value (1.795), $p = 0.117$)) (Table 4).

Respondent's usage of Big Data Analytics. The respondents were asked a set of four statements regarding the usage of big data analytics (as shown in Table 5). All these statements received a mean value between 2.92 and 3.78, indicating that the majority of respondents used big

Table 1. Summary of demographical information of respondents.

Demographic	Frequency	Percent
Gender		
Male	169	69
Female	76	31
	245	100
Designation		
Assistant librarian	63	25.7
Deputy librarian	21	8.6
Associate librarian	4	1.6
Librarian	79	32.2
Chief librarian	32	13.1
Library in-charge	18	7.3
Senior librarian	15	6.1
Other	13	5.3
	245	100
University type		
Public	104	42.5
Private	141	57.5
	245	100

Table 2. Robotics usage respondents.

Robotics attributes	Mean	SD	Private		Public		t	p
			Mean	SD	Mean	SD		
Robotics used for self-check-in & out in your library.	1.74	1.19	1.98	1.32	1.57	1.06	2.718	0.007
Robotics used for stocktaking in your library.	1.62	1.04	1.79	1.20	1.50	0.89	2.137	0.034
Robotics used for searching library material/ information.	1.72	1.20	1.90	1.31	1.58	1.10	2.091	0.038

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always.
(p value < 0.05).

Table 3. Chatbot usage respondents.

Chatbot Attributes	Mean	SD	Private		Public		t	p
			Mean	SD	Mean	SD		
Chatbot used for reference services/reference query.	2.36	1.22	2.58	1.22	2.20	1.20	2.419	0.016
Voice assistant used for searching online information.	2.67	1.12	2.88	1.19	2.52	1.17	2.302	0.022
Voice search used on Google Chrome or YouTube for information or videos	3.06	1.24	3.38	1.11	2.83	1.29	3.464	0.001

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always, (p value < 0.05).

Table 4. Natural language processing usage respondents.

NLP attributes	Mean	SD	Private		Public		t	p
			Mean	SD	Mean	SD		
Google translation used for text translation from English to Urdu or any other Language.	3.78	1.02	4.02	0.86	3.60	1.22	3.031	0.003
Information retrieval used to search strategy or advanced search via voice on Google Scholar, PubMed.	3.11	1.15	3.26	1.03	2.99	1.23	1.795	0.074
Automatic text detection in online reading materials (e.g. Optical character recognition (OCR) for text recognition in different languages.	2.56	1.26	2.70	1.24	2.45	1.27	1.579	0.117

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always.
(p value < 0.05).

data analytics "frequently" for library data storage/personal data image, video, documents on clouds, that is, Google Drives, etc. (Mean = 3.19, SD = 1.22), repository management systems in libraries to preserve organizational research records (Mean = 3.04, SD = 1.24), library resources/database usage analytics via different visualization tools (Mean = 2.92, SD = 1.20), and metadata record for library OPAC (Mean = 3.78, SD = 1.22).

Using an independent sample t-test, we found a statistically significant difference in the usage of big data analytics between private and public university libraries that is, library resources/database usage analytics via different visualization tools (Mean = 3.18, SD = 1.18; vs Mean = 2.72, SD = 1.18, t value (3.005), $p = 0.003$), showing significantly more usage of library resources/ database analytics among private university respondents. On the other hand, no significant difference was found in the library data storage/personal data image, video, documents on clouds that is, Google drives, etc., (t value (1.107), $p = 0.269$; repository management system in your libraries to preserve your organizational research records t value (1.288), $p = 0.199$; and metadata record for library OPAC, t value (1.477), $p = 0.141$ (Table 5).

Respondent's usage of text data mining. The respondents were asked a set of three statements regarding their usage of TDM (as shown in Table 6). All these statements received a mean value between 2.64 and 3.06, indicating that the majority of respondents used TDM "sometimes" or "frequently" for altmetrics that

Table 5. Big Data Analytics usage respondents.

Big Data Analytics Attributes	Mean	SD	Private		Public		t	p
			Mean	SD	Mean	SD		
Library data storage/personal data image, video, documents on Clouds i.e. Google drives, etc.	3.19	1.22	3.29	1.20	3.11	1.24	1.107	0.269
Repository management system in libraries to preserve organizational research records.	3.04	1.24	3.16	1.23	2.96	1.24	1.288	0.199
Library resources/database usage analytics via different visualization tools.	2.92	1.20	3.18	1.18	2.72	1.18	3.005	0.003
Metadata record for library OPAC.	3.78	1.22	3.91	1.17	3.68	1.25	1.477	0.141

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always.
(p value < 0.05).

Table 6. Text data mining usage respondents.

TDM Attributes	Mean	SD	Private		Public		t	p
			Mean	SD	Mean	SD		
Altmetrics that is, (citation counts, views, read, etc.) from Academic Scholarly Networking sites.	2.64	1.16	2.86	1.12	2.48	1.17	2.558	0.011
Social Media # Hashtag for searching for information.	2.77	1.02	2.88	1.10	2.70	1.089	1.272	0.205
OPAC for searching the collections of other libraries.	3.82	1.10	3.98	1.00	3.71	1.16	1.920	0.056

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always.
(p value < 0.05).

is, (citation counts, views, read, etc.) from academic scholarly networking sites (Mean = 2.64, SD = 1.16), social media # HashTag for searching for information (Mean = 2.77, SD = 1.02), and OPAC for searching the collections of other libraries (Mean = 3.82, SD = 1.10). The mean values of the private university respondents were higher as compared to public sector universities, showing more usage of text data mining in private sector university libraries.

We found a statistically significant more usage of altmetrics in private sector university libraries as compared with private sector university libraries t value (2.558), $p = 0.011$. and However, we found a statistically no difference between public and private sector university libraries in the usage of OPAC for searching the collections of other libraries, (t value (1.920), $p = 0.056$), and social media # HashTag for searching for information t value (1.272), $p = 0.205$, etc (Table 6).

Respondent's usage of pattern recognition. The respondents were asked a set of three statements regarding their usage of pattern recognition (as shown in Table 7). All these statements received a mean value between 2.29 and 2.93, indicating that the majority of respondents used pattern recognition "rarely" or "sometimes" for QR codes for reading material or adding QR codes/Bar codes in their library material (Mean = 2.93, SD = 1.24), RFID technology for book security (Mean = 2.29, SD = 1.38), and images or videos processing software and image and video related material (Mean = 2.60, SD = 1.23). We found a significantly more usage of private sector university libraries as compared with public sector university libraries in QR Codes for reading of material or adding QR codes/Bar codes in their library material, (t value (2.014), $p = 0.045$), and images or videos processing software and image and video related material (t value (2.234), $p = 0.026$). However, no significant difference between public and private university libraries was found in the usage of RFID technology for book security (t value (1.351), $p = 0.178$) (Table 7)

Respondent's usage of image processing. The respondents were asked a set of five statements regarding their usage of image processing (as shown in Table 8). All these statements received a mean value between 1.82 and 2.78, indicating that most respondents used image processing for facial recognition/voice detection passwords on cell phones, laptops, tablets, or a desktop, etc. (Mean = 2.78, SD = 1.24), image processing facial/thumb recognition machine (Mean = 2.42, SD = 1.22), image processing 3-D printing

Table 7. Pattern recognition usage respondents.

Pattern recognition attributes	Mean	SD	Private		Public		*t*	*p*
			Mean	SD	Mean	SD		
QR codes for reading of material or add QR codes/ Bar codes in your library material.	2.93	1.24	3.12	1.27	2.79	1.20	2.014	0.045
RFID technology for book security.	2.29	1.38	2.43	1.46	2.19	1.32	1.351	0.178
Images or videos processing software and Image and video related material.	2.60	1.23	2.80	1.25	2.45	1.19	2.234	0.026

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always.
(p value < 0.05).

Table 8. Image processing usage respondents.

Image processing attributes	Mean	SD	Private		Public		*t*	*p*
			Mean	SD	Mean	SD		
Facial recognition/voice detection password on Cell Phone, Laptop, tablets, desktop, etc.	2.78	1.24	2.95	1.20	2.65	1.26	1.919	0.056
Image processing facial/thumb recognition machine.	2.42	1.22	2.61	1.20	2.28	1.23	2.049	0.049
Image processing 3-D printing machine for image processing / printing	1.82	1.19	1.92	1.24	1.74	1.15	1.208	0.228
Image processing manage image and video library databases.	2.33	1.05	2.52	1.06	2.20	1.03	2.378	0.018
Image processing preservation of archival records in your library in digital format.	2.78	1.22	2.96	1.21	2.65	1.22	1.965	0.051

Scale: 1 = Never, 2 = Rarely, 3 = Sometime, 4 = Frequently, 5 = Always.
(p value < 0.05).

machine for image processing/printing (Mean = 1.82, SD = 1.19), image processing, manage image and video library databases (Mean = 2.33, SD = 1.05), and image processing preservation of archival records in your library in digital format (Mean = 2.78, SD = 1.22). The mean values of the private university respondents were higher as compared to public sector universities, showing greater usage of image processing in private university libraries as compared with public university libraries. A statistically significant difference found in two statements that is, image processing facial/thumb recognition machine (t value (2.049), $p = 0.049$), image processing, manage image and video library databases (t value (2.378), $p = 0.018$). On the other hand, no significant difference found in other three statements that is, facial recognition/voice detection passwords on cell phones, laptops, tablets, or a desktop (t value (1.919), $p = 0.056$), and image processing facial/thumb recognition machine (t value (1.208), $p = 0.228$), etc (Table 8).

Discussion

Demographic information

Descriptive statistics showed that Punjab region participants comprised of 94 (38.37%) and most of the responses (n = 134, 54.69%) were from the middle career age between 31 and 40 years. In their study of Pakistani academic digital reference services (DRS), Khan et al. (2017) reported that the highest age group category was 31–40 years (40.8%), which reflects a similar result to that of the current study.

In the study by Ali and Haider (2016), private-sector Pakistani universities accounted for 66.67% of responses and private sector 33.33%, which is similar to the responses for the current study, that is, 57.5% (private) and 42.5% (public). On the other hand, in the study by Younus (2014), 49 (57.6%) responses from Pakistani university libraries belonged to the public sector, while 36 (42.4%) libraries came from the private sector. In their big data analytics study responses from Pakistan university libraries, Ahmad et al. (2019) reported public sector university respondents as 59.3% and private sector university respondents as 40.7%. Khan et al. (2017) studied the adoption of digital reference services (DRS) in Pakistani universities, reporting that 65.7% of responses came from public sector university librarians and 34.3% of responses were received from private sector universities. Results show that public-sector university librarians take more part in research activities compared with private-sector university librarians.

In terms of experience, most responses were received from mid-career library professionals. Designation-wise,

the categories of librarian (n = 79, 32.24%) and assistant librarian (n = 63, 25.71%) most actively participated in the survey, or 57.95% of total responses. In the current study, the response is like that of Ali and Haider (2016), in which Pakistani academic librarians represented 52.78% and assistant librarians 16.66%, or 69.44% of total responses, and mid-career librarians comprised the largest category of respondents.

Research Questions

The responses to the research questions are summarized below based on data analysis results.

RQ1: What is the level of the existing AI tools usage and applications in university library services in Pakistan?. According to Ali et al. (2020), there are seven primary AI tools that are utilized in academic libraries: robotics, chatbots, natural language processing (NLP), big data analytics, text data mining (TDM), pattern recognition, and image processing. The findings of our study showed that the most common tools employed by librarians are chatbots and NLP. Several studies also indicated the growing use of chatbots in libraries (Ali et al., 2021; Liu et al., 2023). On the other hand, the findings showed that robotics and image processing have a less use in academic libraries. However, there is a moderate level of use for big data analytics, TDM, and pattern recognition. Previously, Yoon et al. (2022), also indicated the low level of robotics adoption in academic libraries. Moreover, Asim et al. (2023) found that voice searches were the most frequently used AI tool.

RQ2: what comparisons can be made in Pakistan between private and public sector university usage and applications of AI tools?. In a comparative analysis between the public and private sector universities, 104 (42.5%) responses were received from public sector/government universities while 141 (57.5%) responses were received from the private sector universities. The private-sector university mean score for AI tools was generally higher than public-sector universities. Results showed that p-value was highly significant during the comparative mean score for usage of robotics, chatbots, NLP, text data mining, pattern recognition, and image processing. However, big data analytics p-value was not statistically significant. The results showed that private-sector university librarians have good information and knowledge about AI. In a similar approach, Yoon et al. (2022) studied differences in perceptions with reference to six AI-based tools among academic libraries compared to public libraries. They reported that academic librarians have more technical awareness compared to public librarians.

In summary, university libraries are monitored by the Higher Education Commission of Pakistan, so university librarians and library staff have a good awareness of technologies. Public and private comparison creates a competitive technological environment among university libraries. Private and public universities have good awareness; librarian and library staff are keenly interested in the adoption of AI-based technologies in their respective libraries. However, in some cases private university librarians are more positive than public colleagues about certain AI tools; in other cases, the opposite is true.

RQ3: What are the existing facilities available to support adoption of AI tools and applications in Pakistani university libraries?. University libraries of Pakistan are ready to adopt AI technology tools; currently, libraries are partially using machine-based technologies. For example, libraries use RFID technologies for the security of library books, self-check-in and check-out machines, automated cataloging, and pattern recognition for the check-in/check-out of library users. Different barcodes and QR codes are used for identification of library material. Chatbots are used in libraries for reference services, Google translations are also used for the translation of articles and other related material, and text data mining is used for the tagging of library material and e-content. Ali et al. (2024), highlighted existing support and facilitating conditions in three dimensions: infrastructure, funding, and technical services. Infrastructure means hi-tech computers, Internet connection, and other related facilities and systems. Funding means financial resources to acquire AI-based technology and tools. Technical services mean the technical support for AI products and or tools. Recent research has confirmed the gradual introduction of increasingly complex technologies in Pakistani university libraries, for example, digital reference services (Ali and Haider, 2016; Khan et al., 2017; Malik and Mahmood, 2014; Younus, 2014) digital libraries (Khan and Qutab, 2016), and big data analytics (Ahmed et al., 2019). In addition, AI technologies are slowly and gradually being adopted in Pakistani university libraries (Ali et al., 2021).

The findings of our study showed that hardware and software are sufficient for the implementation of AI. Respondents were also asked about funding of AI implementation of tools with results of (Mean = 3.22, SD = 1.22). Therefore, current responses reflect that the universities of Pakistan have the potential to implement AI technologies in their respective libraries. However, developing countries struggle with a lack of funding and infrastructure for setting up cutting edge modern services and updating technologies. The current study support the findings of previous studies that adopting innovation technologies requires a high level of ICT skills (Davis et al., 1992; Hong et al., 2002; Khan and Qutab, 2016).

Conclusion

Artificial intelligence is one of the important emerging trends in technology. AI is used at different levels within different organizations and institutions. This study has described the application of AI in Pakistani university libraries. As per the research questions relating to the use of AI tools, currently, chatbots are used in libraries for library services, pattern recognition is used for the library users to check in and check out for borrowing library materials, Google (voice) Assistant is used to search the library contents, and YouTube voice search is used to discover video-based contents.

Libraries need attention and improvement regarding investment and funding for the adoption of technology which is considered as a major challenge. Librarian technical skills and computer literacy are also required for the successful implementation of technology. University librarians and IT teams need close collaboration of AI-based technological adoption in the library.

This study contributes to the body of knowledge regarding the adoption of AI in university libraries in Pakistan. It should assist library policymakers, leaders, managers, and chief librarians to understand the factors affecting the implementation of AI technology in libraries.

Robust AI technology is already changing human lives. As libraries are agents of change, they can play a very vital role in supporting the paradigm shift that AI will continue to bring about in the way how library services are delivered. The future of libraries is dependent on technology and cutting-edge services since AI will soon play a bigger role in libraries and their services. However, user education, library curriculum development, and trainings are also needed for the effective implementation of AI technology into libraries. Artificial intelligence has an influence on LIS academic learning, education, and teaching. Therefore, it is recommended that library schools need to develop and design their curriculum accordingly. Library teams also interact with the library IT team for effective implementation of AI tools and carry out training programs for library staff, if required. AI literacy will become the part of academic learning of library and information professional.

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Author Contributions

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