

Artificial Intelligence in Academic Libraries: Prospects and Challenges

الذكاء الاصطناعي في المكتبات الأكاديمية: الآفاق والتحديات

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Abstract:

This study explores several key aspects of artificial intelligence that define its potential as a tool for the development of library systems. It analyzes the obstacles hindering the implementation of intelligent libraries and proposes concrete strategies to foster progress in this vital field.

Artificial intelligence, as an extension of human intelligence, has taken hold across various sectors. Its application in libraries is considered a major advancement in the information sector, as it stimulates many human cognitive abilities. The adoption of AI in virtual reference services represents a new model of electronic services in libraries. It has also compelled information professionals to engage with the latest technologies in order to enhance and personalize services for their users. Some of these enhancements include virtual reality, which involves users within libraries and strengthens their information literacy and reading skills.

Keywords: Artificial Intelligence; Smart Libraries; Libraries of the Future; Chatbots

ملخص:

تتناول هذه الورقة بعض الجوانب الرئيسية للذكاء الاصطناعي التي تحدد فائدته المحتملة كأداة لبناء أنظمة المكتبات، ويناقش العوائق التي تحول دون تطوير أنظمة المكتبات الذكية، ويقترح الاستراتيجيات الممكنة لإحراز التقدم في هذا المجال المهم.

فالذكاء الاصطناعي باعتباره امتداد للذكاء البشري فقد استحوذ على قطاعات مختلفة، واعتبر تطبيقه في المكتبات بمثابة تقدم كبير في قطاع المعلومات باعتباره يحفز العديد من القدرات البشرية، كما يعتبر اعتماد الذكاء الاصطناعي في الخدمات المرجعية الافتراضية بمثابة نموذج جديد للخدمات الإلكترونية في المكتبات، كما فرض على أخصائي المعلومات التعامل بأحدث التقنيات لإشراك وتعزيز الخدمات لمستخدميهم، وتشمل بعض الإضافات كالمواقع الافتراضي الذي يشرك المستفيدين في المكتبات ويعزز مهارات القراءة والكتابة المعلوماتية.

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الكلمات المفتاحية: الذكاء الاصطناعي ; المكتبات الذكية ; مكتبات المستقبل ; المحادثة الآلية

1. Introduction

The twenty-first century is a field of rapid transformation and technological advancements,

organizations must adapt to evolving technologies to meet consumer demands. The use of Artificial Intelligence in libraries can be seen as a collection of technologies enabling machines to sense, comprehend, act and learn and can perform administrative functions and have provided cutting edge technologies for libraries. Librarianship is known as a profession known for integrating cutting edge technologies not just for information dissemination but in terms of technology as well. Artificial Intelligence has become the new emerging trend for libraries. Artificial intelligence has proven to be a breakthrough for information sectors such as law, which has had significant impacts (Smith, 2016; Chen and Neary, 2017). Artificial Intelligence have had positive impacts on academic libraries and has brought changes in search and retrieval methods, discovery search, chatbots, text and data mining (Fernandez, 2016, p22)

2. Artificial Intelligence: A Conceptual Overview

According to Wang (2019), the term "artificial intelligence" can be traced back to a 1955 summer proposal led by John McCarthy from Dartmouth College.

The paper includes numerous "intuitive and ambiguous" concepts, which gave rise to a field that has traditionally lacked a shared theoretical foundation, as well as consensus on evaluation criteria, milestones, and benchmark standards (Wang, 2019, p. 7).

To this day, the lack of a widely accepted definition remains an ongoing issue, both within the field and beyond. Nevertheless, I will present three key definitions that will help frame the concepts explored in this research.

Automation: This term refers to a broad category of technologies—including robotics, software systems, and artificial intelligence—that replace human labor in both physical and cognitive tasks. Automation is particularly effective in areas where tasks are predictable and governed by pre-established rules and procedures (Gynor, 2020)

Artificial Intelligence (AI): AI is a branch of computer science that involves the simulation of human intelligence processes by computer systems, particularly machines. By applying data science analysis techniques, AI can extract insights related to patterns and trends. The process of analyzing this data and transforming it into actionable insights is known as predictive analytics. Data scientists use past patterns to anticipate what is likely to happen in the future. AI relies on predictive analytics in specific applications such as expert systems that simulate human judgment or behavior, natural language

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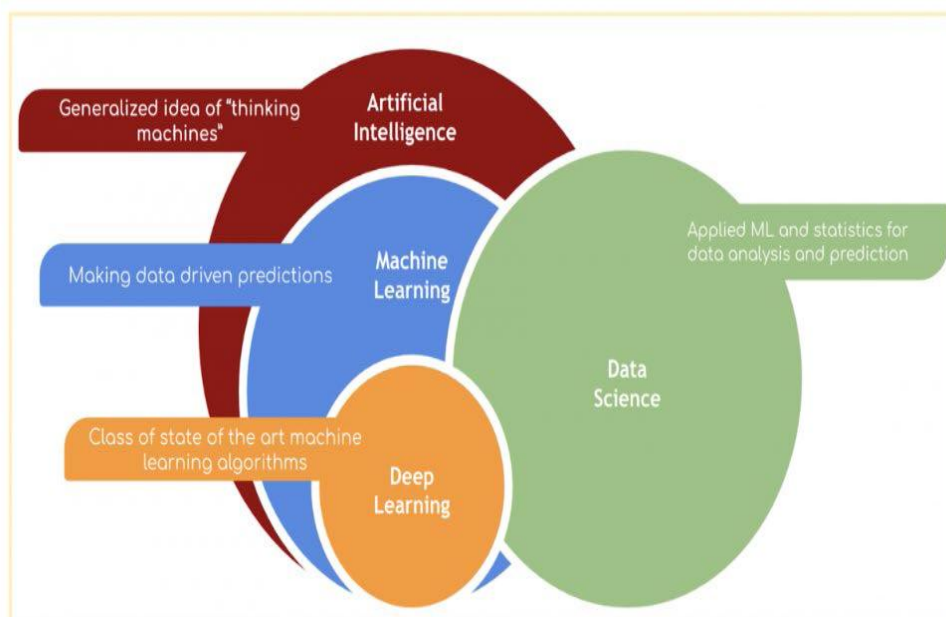
processing, image recognition, computer vision, and intelligent robotics. These applications have become increasingly advanced with the maturation of theoretical and technological research in the field of artificial intelligence.

Library Example: Humanoid or social robots functioning as greeters or concierges in a library can perceive their surroundings, recognize faces, interpret emotions, and interact with humans. (Tella & Ajani, 2022, p. 12)

Machine Learning (ML): The term "machine learning" is often used interchangeably with artificial intelligence; however, machine learning is a subset of AI. It begins without prior knowledge and becomes increasingly intelligent by mimicking the way humans learn. This is achieved through advanced data analytics and deep learning techniques, which process data in multiple layers to learn representations at various levels of abstraction. Machine learning can uncover patterns and insights from large volumes of both structured and unstructured data without being explicitly programmed. As its name suggests, machine learning is primarily concerned with acquiring intelligence, rather than simply performing tasks.

Library Example: A library chatbot is provided with examples of text-based conversations and gradually learns to adapt and improvise its responses. Over time, it becomes capable of generating and refining realistic online interactions with users, even in unfamiliar situations.

Schematic diagram showing how AI, ML, deep learning, and data science intersect.



3.Literature Review :

Verma(2022): Artificial Intelligence and the future libraries The article first defines the scope of AI, followed by a review of contemporary policies and initiatives related to AI at the international and national levels. The potential for applicability of the AI in the library operations has been analysed through a SWOT analysis for understanding strengths, weaknesses, opportunities, and threats associated with AI applications in the libraries.

The article also discusses the significance of making library professionals aware of issues and challenges related to AI. The data for the article has been sourced through systematic review of the published literature. The results revealed that emerging AI technology has considerable potential for integration with a library's operations and can improve its services and functions. However, there are several unexplored areas. The article gives insights that can be utilized to educate the library professionals about leveraging and integrating AI technology in the library landscape to provide adequate services to its patrons.

Massis(2018): examined artificial intelligence and its potential relationship to libraries the findings suggest "The very disruptive nature of any new technology could be viewed as a threat to many institutions, including the library. But with the eventual acceptance and incorporation of AI into its services, it is certainly possible to speculate that this latest technology "intrusion" could also offer many potential positive enhancements into a multitude of library services, many of which are only being examined, considered and piloted in their early stages of development.

Fernandez(2016): identified potential impacts of AI in libraries analyzing big corpora of data, creating metadata, translation of search and integrating search across content. Completely new ways of interacting with information, e.g. location-based search will also be part of the picture, he suggests.

4. Libraries and Artificial Intelligence:

The IFLA report refers to the "impatient user," suggesting that younger generations expect libraries to offer the latest technologies and services. If these expectations are not met, there is a risk that they will disengage from libraries altogether.

According to the International Federation of Library Associations and Institutions (IFLA), remote and virtual library services are here to stay, and data analysis lies at the core of the shift toward personalized services. These insights highlight the urgent need for libraries to continue building digital advancements. However, historically, libraries have tended to wait until technologies reach market saturation before responding to trends (Wheatley & Hervieux, 2019, p. 347). The slow and steady growth of artificial intelligence in society has dominated technological discourse for several years. This leads

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to a critical question: Are libraries able to adopt AI technologies in ways that will enable them to succeed?

Literature presents numerous examples of the use of advanced AI-driven automation in libraries. These include users checking out and returning materials with the assistance of AI robots; automated systems that reshelve physical items to improve efficiency and reduce manual tasks; and shelf-reading robots that identify missing or misfiled items using embedded Radio Frequency Identification (RFID) tags in the physical materials (Tella & Ajani, 2022, p. 16). Additionally, there are smart book drops equipped with RFID scanners installed near the return slot. These scanners read the information on returned items and automatically transmit it to the online catalog to update the records (Patric Duncan, 2022, p. 12)

Smart bookshelves are also being promoted for their ability to reshelve materials with a "worryingly high rate and level of accuracy." These systems use shelves equipped with pre-programmed call numbers and rotating mechanical arms, significantly reducing staff workload—by up to 75% (Patric Duncan, 2022, p. 12)

An internet search for library robots reveals various AI-powered machines produced by Sensorbot in Singapore, which can be used for book location and shelf-reading tasks. YouTube hosts numerous videos showcasing library robots, including a captivating promotional video of Aurora the Sensorbot and its capabilities, as well as a video from Finland demonstrating automation and AI technologies in the Helsinki Central Library. TikTok also features a small collection of videos highlighting the use of AI in libraries. These include footage of social robots in Dubai being used to interact with visitors and serve as greeters in libraries, and a mobile snack robot at the University of Technology Sydney, which roams the campus delivering fruit, nuts, chocolate, and other treats to students. Other videos feature library robots deployed at various universities around the world, including the University of Pretoria in South Africa and Nanjing University in China.

Chatbots are commonly referred to as exciting AI technology. A chatbot is a user interface—typically a website or a messaging platform such as Facebook Messenger—that receives text input and processes it through a Natural Language Processing (NLP) layer, which breaks down phrases into entities and intents. Once the intent is identified, responses are generated using a knowledge base of sample messages, and possibly through external web services for more complex requests (Ali, 2019, p. 3). AI-powered chat interactions are widely used in customer service settings by consumer retail brands such as Lululemon, Staples, and Sephora, as well as service-oriented brands like Spotify, Mastercard, and Lyft. In higher education, chatbots can be used for admissions, student affairs, career services, and other student success and support units—including library reference services. Over the years, many

libraries have accumulated large datasets of chat transcripts. Analyzing this text can help libraries better understand users' informational needs by applying NLP and machine learning techniques. NLP is an interdisciplinary field that combines linguistics, computer science, and machine learning to build algorithms that can be applied to large amounts of:

The data needed to predict outcomes or support decision-making (Wang, 2019, p. 3) .In 2016, Brigham Young University Library implemented a machine learning tool to classify patron questions into reference and non-reference categories.

The publishing platform called Kommunikation, where two library interns with limited technical or programming knowledge managed to build at San Jose State University an AI-powered chatbot named Kingbot, which uses neuro-linguistic programming for basic answering.

There are chatbot solutions available for purchase, often used in private sector companies, such as IBM, Watson Assistant, as well as open-source options like ChatterBot.

Chatbot usage has become regular, and in July 2019, the University of Oklahoma launched a chatbot called Bizzy, capable of answering basic level 1 and level 2 reference questions and connecting users to humans for further information.

While the potential of chatbots has been demonstrated in many sectors including libraries, the revolutionary impact of chatbots in libraries still appears to be in its early stages, due to budget constraints and the diversity and complexity of reference questions. (Rodriguez & Mune, library chatbots: Easier than you think, 2020)

5. Artificial Intelligence as a Library Service

Can AI be integrated into libraries as a service?

The literature suggests that AI and its initiatives are being explored through AI centers or AI labs, which are often renewable or adaptable in structure.

Canadian research universities have established AI centers, including the Universities of Alberta, Calgary, Waterloo, Toronto, Ottawa, and Saskatchewan, as well as Dalhousie University and Queen's University (Wheatley & Hervieux, 2019, p. 351) .The relationship between libraries and these centers is not always easy to define, although there may be examples of libraries that support or even collaborate with them. In September 2018, the University of Rhode Island Library (URI) became the first university library to launch an Artificial Intelligence Lab within its physical space

Through its Artificial Intelligence Center, URL's goal was to facilitate discussion around AI and to encourage collaboration and integration with both undergraduate and graduate courses across disciplines. Their lab also hosts campus-wide events related to artificial intelligence and includes technological

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resources that can be used off-site or on-site—like earlier space of creativity initiatives. Could AI centers become the next big trend in libraries?

Chris Bourg, Director of MIT Libraries, expressed hope that the AI lab at the University of Rhode Island would inspire other libraries to provide spaces and resources that support the exploration of artificial intelligence.

She believes that the library is a perfect place to foster interdisciplinary conversations and partnerships around AI, noting that MIT Libraries have a long history of supporting interdisciplinary research through various AI labs. (Mchnize, 2018)

6. Justifications for Implementing Artificial Intelligence in Libraries

Libraries have evolved structurally and in content across different eras:

The ancient, medieval, and modern eras each represent distinct phases in the transmission of information. In ancient times, clay tablets and stones served as means for recording information. This was followed by the use of papyrus during the Middle Ages, then parchment, manuscripts (both traditional and modern), paper, and microfilm. And now, we are in the digital age and the era of electronic media (Gustavsson & Hedlund, 2011). Libraries have served as depositories for various forms of information sources throughout these eras to meet the information needs of user communities. A library was formally defined as the function of a physical building where books are kept for reading and other purposes. However, today's definition of the library has gone beyond the physical building to focus on collections and services provided. As part of efforts to meet the dynamic needs of users, libraries have become without physical walls, keeping pace with technological revolutions such as the rise of the internet, virtual libraries, Library 2.0, cloud computing, and so on.

Interestingly, artificial intelligence is the current technology that has evolved with vast potential and promising applications in libraries. Hence, there is a need to explore this technology—its pros and cons—in order to properly maximize its benefits and offer innovative and optimal services in libraries. As noted by Croke, AI systems (robots) will be an important technology in this century. In short, the essence of applying AI systems in libraries lies in the fact that they are less prone to fatigue compared to humans, and can operate 24 hours a day, 7 days a week without getting tired, thus freeing librarians to perform other tasks. Ultimately, since computers can work efficiently on a large scale and at speeds beyond human capability, they will increase speed, efficiency, and effectiveness in processing library materials and enhance the delivery of library services at all levels.

7. Application of Artificial Intelligence in Academic Libraries

Artificial Intelligence plays several roles in academic libraries and has the potential to transform the way they function. Some of the interrelated roles performed by academic libraries are enlisted in the table below-

Table-1: Application of AI in Academic Libraries

S.N	Role of AI	Application
1	Data Curation	Collection Management Digital Preservation
2	Navigatine new iInformation environment	Understanding Scholarly Communication landscape
3	Data analysis	Statical analysis
4	Content Procurement	Licensing for e-content
5	Data Quality control	Collection Management
6	Data Literacy	Information Literacy
7	Human-Computer Interaction	Reference services

The above Table describes the role of artificial intelligence in libraries along with their applications in a specific domain of libraries. Some changes with interventions of artificial intelligence have been implemented in libraries and yet some need to be done. The role of librarians as data curators would have to take up data related skills such as data management, licensing, quality control these skills along with the integration of artificial intelligence would transform libraries into an intelligent library. (Hardoon & Chumat, 2013)

By bringing together, the skills of LIS professionals and smart computational techniques, AI can help the libraries to develop themselves as an intelligent information system. Some significant AI technologies, which can be a part of library environment, are as follows:

Alert Service: Traditional recommender system notifies the limited users about the arrival of new content on the basis of their request. Whereas, in the world of algorithm, suggestions are expected on the basis of previous search pattern or interests. This is somewhat similar to the recommendations of YouTube on the basis of search trends and patterns on Chrome, Google, and YouTube. Thus, data alert system integrated with AI learns from past search criteria and informs the user when something pertaining to the area of interest appears. Few benefits that can be obtained in libraries with the smart alert services are as follows:

- ✓ **Save Time:** Sending automatic information alerts to the respective users on the basis of their past search pattern will help the libraries to save the time of staff as well as of the users.
- ✓ **Wide Reach:** In comparison to conventional alerting systems, machine learning algorithms connect the user to the relevant information on the basis of

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previous search pattern. The technique in addition to the proficient inquirer will also serve the inexperienced users who are not aware about the marking of interest areas in the system.

- ✓ Improve Quality: Quality in services can be achieved with reduction in response time.

- ✓ Image Building: Wide audience reach with quality services helps the libraries in building their image.

Chatbot: It is a combination of two concepts – „chat“ and „bot“, where chat is informal conversation between two or more people and bot is a computer program that works automatically or a robot (Bot, 2019). Thus, chatbot may be described as a computer program developed to work over internet to support software conversation with humans. The term is also referred as digital assistants, intelligent agents, interactive agent, virtual agents, talkbot. Initially, chatbot was launched with limited capabilities, which worked with predetermined rules and respond to very specific commands. Whereas, by using machine-learning algorithms i.e. by using AI and natural language processing, machines become smarter and capable to learn with experience i.e. with each conversation.

Chatbot in libraries may be a self-service option for online information services. Implementation of chatbot in libraries can be helpful in following manner: (Abram, 2019)

- ✓ Queries pertaining to the basic library information can be handled without involving library staff.

- ✓ Multiple users queries can be answered simultaneously thus save the time and efforts of library staff.

- ✓ Help the library to deal with rude and impatient customers.

- ✓ Offer more satisfaction to users by allowing them to ask any number of questions, which may be inappropriate also.

- ✓ Can act as a marketing tool and thus improves the visibility of library.

- ✓ Can be hosted simultaneously on multiple platforms like desktop machine, website, etc.

- ✓ Support to customers can be provided in 24x7 framework.

- ✓ Conversation log for resources requested through chatbot can help the library to track and allocate resources to library users.

Data Mining: The role of data mining is to turn data into information, and information into insight (Hardoon & Chumat, 2013) Data mining is about identifying hidden facts embedded in large dataset and using those facts in decision making. Libraries can use these identified patterns to understand the expectations of users and can accordingly refine the policies to improve their services.

By further adding the layer of AI to data mining will help in achieving substantial benefits. To highlight the symbiotic association between data

mining and AI, the European medical research consortium mentioned the application of AI in discovering gene signature to classify meaningfully the severe asthmatics from non-asthmatics and mild-to-moderate asthmatics. This grouping of asthma population helped to develop targeted treatment for patients for their effective recovery. (Ramanan, 2017) As the technique resulted in knowledge discover, therefore, the benefits associated with the implementation of this technique in library are:

- ✓ Better decision making.
- ✓ Improved planning and forecasting.
- ✓ Introduction of new services as per the changing behavior of users.
- ✓ Building and retaining healthy relationship with users.

Expert System for Library Technical Operations: Work in libraries is usually related to collection development, database development and access of resources. Traditionally, effectiveness of technical operations was determined in terms of quantity i.e. according to the number of titles classified and catalogued. This traditional behaviour is now shifted to an automated approach like knowledge based system. The two essential components of a knowledge based system are knowledge base (comprises of information and strategies required to provide solution to a problem) and inference engine (includes logic or reasoning portion that helps the knowledge base for interpretation). Thus, to make the system smart, it must be nourished first with relevant data set by using some standardised framework. One such powerful knowledge representation language is Resource Description Framework (RDF), a web standard of the World Wide Web Consortium (W3C). It is a standardised format to describe data by describing association between data objects and to interchange data over web. Improvements that can be achieved in libraries with an expert system are: (Mogali, 2015)

Autonomy: Reduce dependency on one expert and can be designed with multiple expertise within one system.

✓ **Consistency:** Computations in AI systems are based on rules and logics i.e. there is no space for emotions and biasness. Therefore, there would be same decisions every-time under same situations. Thus, improves the quality.

✓ **Cost Reduction:** As multiple expertise can be incorporated within one system, therefore resulted in cost reduction, which is comparatively higher in case of hiring people with different specialisation.

✓ **Interoperability:** Offer ease in information sharing.

Besides the above listed benefits, expert systems are more flexible, reliable and effective in handling the tasks which are beyond the capacity of human beings.

Indexing of Aural Data: Documents are indexed to make them accessible to people. For example, text documents in libraries are catalogued on the basis of content described explicitly in the document. Similarly, digital content in form of web pages are indexed by Google for their effective retrieval. However,

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multimedia documents like videos, audios etc. are usually indexed on the basis of text nodes extracted either from HTML pages or headers of multimedia documents. But, the useful content, which is available in form of audio data not tied to an index, is inaccessible. This limitation is due to the absence of facility that can transform aural data into textual format. Application of AI by means of smart algorithms and natural language processing (NLP) can help us by recognising and attaching relevant metadata to audio content. The technology „Audioburst“ powered by AI, indexes audio segments and makes it searchable with keywords entered by the user.

Online Search: Capabilities of search engines are unbelievable. Based on keywords search terms, search engine explores the entire internet and returns relevant results. However, AI with its distinct incredible approaches like voice search, ranking algorithms etc. has revolutionised the internet searches. By applying ranking algorithms, machines are instructed to generate an optimal list from possible outcomes. Thus, application of AI enhance the quality of search results with the aid of semantic tools like ontology.

Web Designing: Website of a library may be considered as its virtual face. Generally, libraries are creating their websites to inform the users about the available resources and services delivered by the library. Library website confirms its online presence and thus helps in improving its visibility. However, designing or creating a website requires coding skills. In this scenario, combination of AI, machine learning and Content Management Systems like WordPress, Joomla, Drupal etc. can assists library professional to create the website without much coding skills.

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8. Artificial Intelligence and Global Trends in Academic Libraries :

Artificial Intelligence has the potential to meet Educational, Informational, Assistive and Socially Interactive needs making them suitable for libraries.

AI has several perspectives such as information literacy, critical thinking skills, enhancing the productivity of libraries. Technical Infrastructure to access collections is being built up in MIT so its collections are accessible by the Application programming interface and can be used by machine learning algorithms. Scholarly information needs to be in open access to collaborate with AI. LIS professionals need to get familiarized with the latest researchers and working of AI and create possibilities of AI for metadata creation and harvesting, collection development, reference services, human-machine collaboration. The future of artificial intelligence holds wide scope in the information sector as the needs of users as well as LIS professionals have been evolving at a fast pace in order to meet those needs in an effective and efficient manner the LIS professionals need to implement artificially intelligent as well as expert systems would widen and diversify the functions of library.

9. Issues and Challenges in Deploying Artificial Intelligence in Academic Libraries

In general, artificial intelligence systems are not yet in operational use in most libraries today. The constraints on implementing AI systems in libraries include the following: (Coleman, 2017)

✓ Lack of technical knowledge among library staff to use and operate AI systems

✓ Insufficient funding to develop or purchase AI systems in libraries, as hardware and software budgets are often limited, and there are always constraints on the type of system a library can afford to buy or develop

✓ High costs of developing and maintaining AI systems within information systems

✓ Insufficient power supply to run AI systems in libraries, especially in developing countries

✓ Inherent complexities in developing AI systems /expert

✓ Limited natural language processing capabilities

✓ Intelligent systems critically lack the shared base of human knowledge

✓ Restricted range of functions these systems can perform.

✓ The level of effort and technical expertise required to build AI systems in libraries is significant. The amount and nature of the investment needed to develop an intelligent library system are directly proportional to the system's

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sophistication and complexity. In other words, the smarter the system, the more effort and resources are required. Currently, the development of such systems demands highly skilled personnel and costly tools or technologies. As a result, the creation of advanced AI systems in libraries is either not yet realized or prohibitively expensive — which explains the absence of such systems in libraries.

✓ There is a limited number of AI experts among library automation vendors. The field of artificial intelligence is complex and therefore requires specialized knowledge that goes far beyond the development of traditional library automation systems. As a result, it would be necessary to hire new staff in this area before any significant or large-scale work involving AI systems in libraries can be undertaken.

10. Conclusion:

Through the application of artificial intelligence technologies, various prototype intelligent library systems have been developed—for purposes such as cataloging, information retrieval, reference services, and more. However, relatively few of these systems have evolved into fully operational models used in libraries' daily workflows. As FOX reminds us, "while AI research has been ongoing for more than three decades, it is only in the past six years that its impact has become somewhat measurable."

The lack of AI integration in libraries can be attributed to the fact that appropriate tools and technologies have only recently become widely available. However, other significant barriers—such as theoretical, technological, financial, and human challenges—have also hindered progress, and many of these issues remain unresolved.

This paper has identified key limitations of selected AI technologies that are especially relevant to libraries and has proposed possible strategies for advancing the development of intelligent library systems.

It is essential to find a balanced perspective between the belief that AI will revolutionize libraries and the opposing view that its impact will be minimal or negligible.

The application of AI in academic libraries presents several challenges and considerations. Ethical concerns, privacy issues, and the need to ensure equitable access to information are among the critical factors that must be carefully addressed.

Libraries must strike a balance between the benefits of artificial intelligence technologies and the preservation of human-centered values, ensuring that AI complements and enhances the work of librarians rather than replacing them. Looking ahead, further research is needed to explore the long-term impact of AI on library operations, user behavior, and information services. Moreover, collaboration between libraries, researchers, and technology developers is essential for creating AI solutions tailored to the unique needs of libraries and their diverse user base. Efforts should also be made to promote the exchange of knowledge and best practices to accelerate

the adoption of AI technologies in libraries. AI holds the potential to transform libraries into dynamic, user-centered spaces where information is easily accessible and services are personalized according to individual needs. It is through the strategic use of AI that libraries can truly strengthen their role and relevance in the digital age

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