



Navigating the Digital Frontier: The Impact of Emerging Technologies in Libraries Services

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Abstract

The rapid evolution of emerging technologies is revolutionizing the way libraries operate, interact with users, and provide access to information. This study aim to explores the impact of specific emerging technologies on library services, most especially focusing on Artificial Intelligence (AI). Our research reveals that this technology have the potential to enhance user experience, improve resource discovery, and increase accessibility. However, it also pose significant challenges, such as data privacy concerns, staff training needs, and infrastructure requirements. This study provides insights into the benefits and drawbacks of emerging technologies in libraries, offering recommendations for strategic implementation and adoption.

Keywords: digital frontier, emerging technologies, library services, artificial intelligence.

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Introduction

Libraries have traditionally served as a vital institutions for preserving and disseminating knowledge (Bouaamri, 2024); (Abumandour, 2021). With the rise of Artificial Intelligence (AI), libraries are embracing innovative technologies to enhance their operations, improve user experiences, and adapt to the evolving needs of patrons. Libraries are no longer the only source of information for academics and researchers, as the information boom concomitant with the

complex transformation in information and communication networks has modified researcher behavior by increasing the likelihood of their use of online digital sources over traditional library systems and resources. Furthermore, online resources offer innovative search and analytic tools that render huge available data sets more accessible and of greater functional value to the researcher, based on contemporary technologies such as machine learning and artificial intelligence (AI).

The practice of using online resources is adopted by many researchers (Haleem et al., 2022); (Abbad, 2021). Therefore, libraries and librarians are striving to return to the research and scientific investigation scenario by adapting to and embracing these leading-edge technologies and progressive tools. However, limitations in technical infrastructure, and the volume and diversity of data, make it difficult to integrate and implement such technologies and applications. Procedures to incorporate these resources will consume most of a librarian's time even before the data can be made available to researchers. Efforts towards digitalization in academic libraries are evident, especially considering the trend towards e-learning and distance learning (Papachristopoulos, 2024); (Mhlongo et al., 2023). The development of technologies such as artificial intelligence, machine learning, statistical analyses of big data and cloud computing, as emerging technologies with their large and promising future that will revolutionize the map of the industry and the economy, generates a necessity for extensive studies to investigate the possibility of applying these technologies to the library's work environment and amenities. Studies should include the field of services, procedures, and methods of management to produce a comprehensive, user-centered concept that focuses on cognitive intelligence.

In this study, we examine the most advanced digital technologies, with a focus on emerging technologies such as artificial intelligence, machine learning, and big data (Aldoseri et al., 2024); (Dwivedi et al., 2023). We explain some of its key features and applications in the context of digital transformation in academic and research libraries. Furthermore, the study provides a roadmap for how libraries can build their AI-based systems. The aim is to identify opportunities and avoid the threats that some of these technologies may pose to the libraries. Additionally, we discuss how libraries can achieve a renewed competitive advantage by redesigning their services in alignment with current innovation and technology. The possible use of game theory is investigated to reformulate the strategies of libraries and their information structures to overcome internal reservations and become more open towards collaboration and technology adaptations. More so, according to (Mitha & Omarsaib, 2024); (Ubogu, 2019) emerging technologies are used for service delivery in the library. Numerous technologies have emerged recently, and some of these technological facilities are used in the library. Artificially Intelligent Robots have penetrated almost all the fields of life including libraries which can do things even humans are incapable of with higher efficiency.

Also, the evolution of human civilizations through different industrial eras, from Industry 1.0 to Industry 4.0 represents significant milestones in technological advancement and societal transformation. Each era has been characterized by key innovations that have shaped the way humans live, work, and interact. With Industry 4.0, also known as the Fourth Industrial Revolution, the fusion of digital technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) is revolutionizing various sectors, including libraries.

Methodology

In this paper, we explore the importance and impact of Artificial Intelligence (AI) specifically in library settings. Libraries, as crucial centers for knowledge dissemination and community engagement, are leveraging AI technologies to enhance their services, optimize

resource management, and adapt to changing user needs in the digital age. This exploration delves into the role of AI in improving information access, transforming user experiences, and shaping the future of libraries. Through a detailed examination of AI applications in libraries, we uncover how these technologies are reshaping traditional library functions and contributing to the evolution of modern library services. Additionally, we will address the challenges and ethical considerations associated with AI adoption in libraries with prospects for AI-driven innovations in the library landscape. By examining the intersection of AI and libraries, we aim to highlight the transformative potential of AI technologies in empowering libraries to fulfill their missions more effectively in the 21st century digital era. Opportunities of Using Emerging Technology in Libraries. The following are some of the advantages of emerging technologies for libraries:

- i. Emerging technologies boost libraries' capability to provide better and faster services.
- ii. It has an impact on librarians' and the library's creativity, problem-solving skills, and self image.
- iii. It helps to process innovations and bring value to existing products and services.
- iv. It strengthened library knowledge and opportunities for the future.
- v. Quick service is simple to deliver.
- vi. It saves time.

Results and Discussion

The evolution of human civilizations through different industrial eras, from Industry 1.0 to Industry 4.0, represents significant milestones in technological advancement and societal transformation. Each era has been characterized by key innovations that have shaped the way humans live, work, and interact. Let's explore each industrial era along with examples of major advancements:

- A. Industry 1.0 - Mechanization with Water and Steam Power: Industry 1.0, also known as the First Industrial Revolution, began in the late 18th century with the mechanization of production processes using water and steam power. Agricultural Equipment: Inventions such as the plow and irrigation systems revolutionized agriculture, leading to surplus food production and urbanization. Steam Power: for mechanized production in factories and facilitated transportation via steam locomotives and ships.
- B. Industry 2.0 - Mass Production with Electricity: Industry 2.0, or the Second Industrial Revolution, emerged in the late 19th and early 20th centuries, marked by the widespread use of electricity and assembly-line production. Printing Press: Johannes Gutenberg's invention of the printing press in the 15th century revolutionized communication and knowledge dissemination, laying the groundwork for mass literacy and the spread of ideas. Telegraphs: Inventions like the telegraph enabled rapid long-distance communication, facilitating trade, coordination of activities, and dissemination of news.
- C. Industry 3.0 - Automation with Electronics and IT: Industry 3.0, or the Third Industrial Revolution, began in the mid-20th century with the advent of electronics, computers, and automation. Computers: The development of electronic computers and digital technology revolutionized data processing, leading to the automation of various tasks in industries, offices, and households. Internet: The invention of the internet transformed communication, commerce, and social interactions, connecting people globally and enabling the exchange of information at unprecedented speed and scale.
- D. Industry 4.0 - Digitization and Integration with AI and IoT: Industry 4.0, also known as the Fourth Industrial Revolution, is characterized by the fusion of digital technologies, artificial intelligence (AI), and the Internet of Things (IoT). Artificial Intelligence: AI technologies, including machine learning and deep learning algorithms, enable computers to perform tasks

that traditionally require human intelligence, such as data analysis, decision-making, and automation of complex processes. IoT: The Internet of Things connects physical devices embedded with sensors and software to collect and exchange data, enabling smart systems for monitoring, control, and optimization across various sectors such as manufacturing, health care, transportation, and infrastructure. The era of Industry 4.0, with its focus on digitization, AI, and IoT, holds the promise of further revolutionizing how humans live, work, and interact with technology (Rashid & Kausik, 2024).

Definition of Artificial Intelligence (AI)

Artificial intelligence (AI) is the science and technology of creating machines or computer systems that can mimic human behavior, learn from data, adapt to new situations, and perform tasks that typically require human intelligence (Collins et al., 2021); (Xu et al., 2021). AI aims to develop algorithms and models that enable computers to perceive their environment, reason, make decisions, and take actions autonomously, often with the goal of achieving human-like levels of performance in specific domains. Evolution of AI has been Shaped by Contributions from Numerous Researchers and Pioneers:

- a.) Alan Turing: Turing is considered one of the founding fathers of computer science and AI. His work laid the theoretical groundwork for AI with his concept of the Turing Test, which assesses a machine's ability to exhibit intelligent behavior indistinguishable from that of a human.
- b.) John McCarthy: McCarthy coined the term "artificial intelligence" in 1956 and organized the Dartmouth Conference, which is often regarded as the birth of AI as a field of study. He made significant contributions to AI research, including the development of the LISP programming language and early AI systems.
- c.) Herbert Simon and Allen Newell: Simon and Newell pioneered research in AI problem solving and symbolic reasoning. They developed the Logic Theorist program, which demonstrated automated theorem proving, and the General Problem Solver (GPS), a framework for problem-solving and goal-directed behavior in AI.
- d.) Marvin Minsky: Minsky was a cognitive scientist and AI researcher who made significant contributions to the study of artificial neural networks, robotics, and human cognition. He co-founded the MIT AI Laboratory and wrote influential works on AI, including the book "Perceptrons" with Seymour Papert.

Artificial Intelligence, Machine Learning and Deep Learning

Artificial intelligence (AI), machine learning (ML), and deep learning (DL) are closely related fields within the broader realm of computer science and artificial intelligence. While they share common goals and techniques, they differ in scope, methods, and application. Artificial Intelligence (AI): Artificial intelligence refers to the broader field of computer science focused on creating systems that can perform tasks that typically require human intelligence. These tasks may include reasoning, problem-solving, perception, learning, language understanding, and decision-making. Examples: AI-powered virtual assistants like Apple's Siri, Amazon's Alexa, and Google Assistant that understand and respond to natural language queries. AI algorithms are used in recommendation systems by platforms like Netflix and Spotify to suggest personalized content based on user preferences. AI systems in health care for diagnosing diseases, analyzing medical images, and assisting in treatment planning. Machine Learning (ML): Machine learning is a subset of AI that focuses on developing algorithms and models that enable computers to learn from data and improve performance on a specific task without being explicitly programmed. ML algorithms identify patterns, make predictions, and learn from experience. Examples: Spam email filters that

learn to distinguish between spam and legitimate emails based on past user behavior and email content. Predictive models in finance that analyze historical stock prices and market data to forecast future trends and make investment decisions. Image recognition systems that automatically tag and classify images on social media platforms like Facebook and Instagram. Deep Learning (DL): Deep learning is a sub-field of machine learning that focuses on developing artificial neural networks with multiple layers (deep architectures) to learn complex patterns and representations from raw data. DL algorithms excel at tasks like image and speech recognition, natural language processing, and generative modeling. Examples: Convolutional Neural Networks (CNNs) are used in image classification tasks such as identifying objects, faces, and scenes in photographs. Recurrent Neural Networks (RNNs) are employed in natural language processing tasks like machine translation, sentiment analysis, and speech recognition. Generative Adversarial Networks (GANs) are used to generate realistic images, videos, and audio samples, as seen in applications like deepfake technology and image synthesis.

Generative Artificial Intelligence

Generative artificial intelligence (AI) refers to AI systems that can generate new and original content based on existing knowledge or data. These systems leverage large language models (LLMs) implemented through neural networks and trained on vast amounts of text data to produce coherent and contextually relevant outputs across various domains. Generative AI involves training neural networks, such as recurrent neural networks (RNNs) or transformer models like GPT (Generative Pre-trained Transformer), to generate new content, such as text, images, or even music, that is indistinguishable from human-created content. Examples are: Text Generation: OpenAI's GPT Series: Models like GPT-3 (Generative Pre-trained Transformer 3). Text Summarization (SummarizeBot), Creative Writing, Image Generation (DeepDream). StyleGAN: NVIDIA's StyleGAN (Generative Adversarial Network) is a framework for generating high-quality synthetic images with customizable styles and attributes. Art Transfer: (Prisma), Music Generation (Magenta Project, Jukebox).

Types of Generative Artificial Intelligence Model

1. Text-to-Text Models: Example: ChatGPT, developed by OpenAI, is a text-to-text model that generates human-like responses in conversational contexts based on input prompts.
2. Text-to-Image Models: Example: Midjourney is a text-to-image model that generates images from textual descriptions, allowing users to describe scenes or objects in natural language and obtain corresponding visual representations.
3. Image-to-Image Models: Example: CycleGAN is an image-to-image translation model that learns mappings between two different visual domains without paired training data. It can be used for tasks like converting images between different artistic styles or changing the appearance of objects in photographs.
4. Image-to-Text Models: Example: Google's Cloud Vision API includes image-to-text functionality, allowing users to extract text from images, recognize objects, and generate descriptive captions for visual content.
5. Speech-to-Text Models: Example: Google's Speech-to-Text API provides accurate transcription of spoken language into text, supporting various languages and dialects with real-time processing capabilities.
6. Text-to-Audio Models: Example: Amazon Polly is a text-to-speech service that uses advanced deep learning techniques to generate lifelike speech from text input, offering customizable voices and expressive capabilities.

7. Text-to-Video Models: While specific examples of text-to-video models are less common, research in this area focuses on generating video content from textual descriptions, such as storytelling or scene creation.
8. Multimodal Models: Multimodal models integrate multiple modalities, such as text, images, and audio, to generate outputs that combine different types of information. They enable tasks requiring understanding and synthesis across different sensory modalities. Example: OpenAI's DALL-E is a multimodal model that generates images from textual descriptions, demonstrating the ability to understand and synthesize visual content based on complex textual prompts.

Examples of Best Artificial Intelligence Tools

1. Solve anything: chat GPT, Gemini, Copilot, AnonChatGPT, iAsk.AI,
2. Write anything: write sonic, Chatsonic, flawlessly ai,
3. Generate Arts: Midjourney, Character.AI,
4. Generate code: replit, phind,
5. Generate video : synthesia
6. Generate Music soundrow
7. Generate Tiktoks: fliki
8. Generate avatars- starrytars
9. Generate PPT- slideAI
10. Edit pictures: remini, Upscayl,
11. Edit video: pictory
12. Summarise note: wordtune, Copy.ai, ChatPDF

Definition and Significance of Prompt Engineering in AI Interactions

Prompt engineering in AI interactions refers to the process of formulating clear, contextually relevant, and effective prompts or queries to elicit desired responses from artificial intelligence (AI) models. It involves crafting precise instructions or questions that convey the user's intent and requirements accurately, guiding the AI system to generate appropriate outputs. Prompt engineering encompasses considerations such as task objectives, context, language nuances, and the capabilities of the AI model being used.

Significance of Prompt Engineering in AI Interactions

1. Improves AI Performance: Well-designed prompts can enhance the performance and accuracy of AI models by providing clear guidance on the desired task or outcome. Effective prompt engineering ensures that the AI system understands the user's intent and generates relevant responses accordingly.
2. Facilitates Communication: Prompt engineering enables seamless communication between users and AI systems, allowing individuals to convey their needs, preferences, and inquiries effectively. Clear prompts minimize ambiguity and misunderstandings, leading to more productive interactions.
3. Enhances User Experience: By formulating prompts that align with user expectations and preferences, prompt engineering contributes to a positive user experience with AI technologies. Users are more likely to engage with and trust AI systems that can understand and respond to their queries accurately and efficiently.
4. Increases Task Efficiency: Well-designed prompts streamline AI interactions and expedite task completion by providing the necessary information and guidance upfront. This reduces

the need for iterative interactions or corrections, saving time and effort for both users and AI systems.

5. **Enables Customization and Adaptation:** Prompt engineering allows for customization and adaptation of AI systems to different tasks, contexts, and user preferences. By tailoring prompts to specific requirements and objectives, users can leverage AI models effectively across various domains and applications.
6. **Reduces Errors and Biases:** Clear and precise prompts help mitigate errors and biases in AI-generated outputs by guiding the system toward relevant and accurate responses. Thoughtfully designed prompts minimize the risk of misinterpretation or misalignment between user intent and AI model behavior.

The Importance and Impact of Artificial Intelligence in Libraries

AI Technologies play a transformation role in modern libraries:

- a) **Information Discovery:** AI powered search algorithms enhance the efficiency and accuracy of information retrieval, facilitating quicker access to relevant resources
- b) **Resource Management:** AI automates cataloguing, classification, and metadata tagging processes, optimizing resources organization and management.
- c) **User Engagement:** AI driven chatbots and virtual assistants provide instant support to users, answering inquiries and offering personalized recommendations.
- d) **Data Analysis:** AI tools analyze usage patterns and user preferences, enabling libraries to make informed decisions about collection development and services.

Enhanced User Experience

AI contribute to a more personalized and accessible library experience:

- a) **Personalized Recommendations:** AI algorithms suggest tailored resources based on user preferences and borrowing history, promoting individualized discovery.
- b) **24/7 Accessibility:** AI powered chatbots offer round-the-clock assistance, extending library services beyond traditional operating hours.
- c) **Accessibility Services:** AI technologies facilitate accessibility for users with disabilities, enabling text-to-speech conversations and alternative format requests.

Artificial Intelligence Applications in Library Services (Jha, 2023) :

- a) **Digital Archives:** AI aids in digitization efforts, image recognition, and preservation of archival materials
- b) **Text Mining and Analysis:** AI tools extract insights from large text collections, supporting research and knowledge discovery.
- c) **Automation of Tasks:** AI automates routine tasks like inventory management, circulation processes, and overdue notifications, streamlining operations.

AI applications in library services are transforming the way libraries operate and provide services to users. Some examples include (Vasishta et al., 2024) : (Cox & Mazumdar, 2024):

1. **Chatbots and Virtual Assistants:** AI powered chatbots help patron with basic inquiries, such as catalog searches, hours of operation, and research assistance.
2. **Book Recommendations:** AI driven recommendation system suggest books based on users' reading preferences and borrowing history.
3. **Cataloguing and Classification:** AI assist in cataloguing and classifying new materials, making it easier to maintain and update library collections.

4. Digitization and Preservation: AI helps digitize and preserve rare and fragile materials, making them accessible to a wider audience.
5. Research Assistance: AI powered tools aid patrons in finding relevant resources and information, and even assist with citation management and plagiarism detection.
6. Accessibility Services: AI powered tools help libraries provide accessible services for users with disabilities, such as text-to-speech software and language translation.
7. Collection Development: AI analyzes circulation data and user behaviour to inform collection development decision and identify gaps in the library's holdings.
8. User Analytics: AI helps libraries analyze user behaviour, track circulation patterns, and identify areas for improvement in library services.
9. Digital Libraries: AI powers digital libraries, providing access to e-books, articles, and other digital resources.
10. Information Literacy: AI powered tools help teach information literacy skills, such as critical thinking and source evaluation.

Challenges and Considerations

Implementing AI in libraries presents challenges and considerations (Alhitmi et al., 2024); (Murdoch, 2021):

- a) Privacy and Data Security: AI relies on user data, raising concerns about privacy protection and data security.
- b) Equity and Bias: AI algorithms may perpetuate biases present in training data, necessitating efforts to mitigate bias and ensure fairness.
- c) Staff Training: Libraries must invest in staff training to effectively utilize AI technologies and address concerns related to job roles and responsibilities.

Future Prospects and Ethical Implications (Trotta et al., 2023); (Kalbande et al., 2024) :

The future of AI in libraries holds promise and ethical considerations:

- a) Advances AI Applications: Anticipated advancement include predictive analytics, automated content curation, and AI driven recommendation systems.
- b) Ethical AI Development: Libraries must prioritize ethical AI practices, emphasizing transparency, accountability, and fairness in algorithm decision making.

Conclusion

Artificial Intelligence is reshaping libraries by optimizing operations, enhancing accessibility, and enriching user experiences. Embracing AI technologies with thoughtful consideration of ethical implications is essential for libraries to thrive in the digital era while upholding their core mission of knowledge dissemination and community engagement.

Conflicts of Interest

The authors declare no conflict of interest.”

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