

# Utilisation of artificial intelligence for the provision of information services at the University of Limpopo libraries

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Received: 13 March 2024

Accepted: 31 August 2024

*In the wake of the fourth industrial revolution, artificial intelligence has been used in every aspect of human activity, including library operations. Artificial intelligence refers to the process of collaborating with robotic machines to improve job performance, generate increased competence and drive economic progress. In the library and information services, artificial intelligence can carry out a series of operations such as information retrieval. The purpose of this study was to investigate the utilisation of artificial intelligence for the provision of information services at the University of Limpopo library in South Africa. The study used a qualitative content analysis to gather data. The findings indicate that artificial intelligence can be used to provide information services in the library such as responding to students' enquiries and helping users to locate books faster. However, the findings further indicate that the University of Limpopo library must have adequate artificial intelligence infrastructure in place to integrate with the library management system to provide effective information services. The study recommends that an intelligent robotic machine be adopted and applied to the information service at the University of Limpopo library to deal with students' enquiries regarding the availability of the books and the location of the books in the library. The study also recommends that the University of Limpopo library provide training programmes and workshops to help library professionals improve their knowledge of artificial intelligence technologies. The study proposes a framework for the utilisation of artificial intelligence for the provision of information services in the fourth industrial revolution at the University of Limpopo libraries in South Africa.*

**Keywords:** Artificial intelligence, robotic machines, fourth industrial revolution, information services, University of Limpopo Library

## 1 Introduction

In the aftermath of the fourth industrial revolution (4IR), artificial intelligence (AI) has permeated every facet of human activity, extending its influence even to library operations (Abayomi et al. 2021). The integration of AI in libraries represents the amalgamation of various cutting-edge technical breakthroughs. These advancements empower libraries with access to equipment capable of perceiving, understanding, acting, and learning. This technological evolution enables libraries to furnish pertinent information to users in the 4IR (Owolabi et al. 2022).

The 4IR, also known as Industry 4.0, signifies the contemporary and evolving landscape where disruptive technologies like the Internet of Things (IoT), robotics, AI and virtual reality are reshaping the operational dynamics of libraries (Hussain 2020; Frederick 2016). In the realm of the 4IR, AI has demonstrated remarkable utility and benefits across a diverse array of industries, including banking and finance, marketing, healthcare system administration and the development of smart applications (such as facial recognition, voice recognition, location assistance and so forth). Holmes, Bialik and Fadel (2023) define AI as the emulation of human intelligence in machines programmed to think and act like humans. Essentially, AI comprises computer programs designed to execute tasks that traditionally necessitated human intelligence (HI), encompassing robotic machines and AI chatbots.

AI has the potential to assist libraries in enhancing their relevance in the contemporary digital landscape, facilitating the update and expansion of their services. Traditionally recognised for collecting, managing, archiving, and disseminating printed resources (Oyetola et al. 2023), libraries have evolved in recent years. The modern library is transitioning from being primarily a repository of printed materials to becoming a provider of electronic resources (Tella 2020). This transformation is closely associated with the widespread adoption of computer systems, ongoing reliance on computer networks, the rapid

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evolution of the web and the internet, and a substantial increase in the quality and quantity of available information (Oyetola et al. 2023).

Within library and information services (LIS), AI plays a pivotal role in executing various operations, including the retrieval of information resources. In the 4IR, information services encompass the capability for library users to engage with the digital world affordably and accessibly, thanks to technological advancements that transcend time and location constraints. Libraries now offer both on- and off-campus access to information resources, allowing users to utilise facilities with just an internet connection, available around the clock, seven days a week (Chigwada & Nwaohiri 2021).

However, challenges persist in the realm of information services, primarily linked to insufficient infrastructure for conducting digital activities and a lack of technological skills to navigate such advancements (Barsha & Munshi 2024). Ajani et al. (2022) point out that the absence of consistent and high-speed internet connectivity, along with the absence of suitable technological infrastructure, hampers the effective adoption of AI-driven applications in libraries. This limitation, in turn, restricts their potential impact on information access and user services.

However, in the 4IR, AI technologies such as AI chatbots and mobile applications are leveraged to inform users about recent arrivals, provide reminders for book loan due dates and guide users to relevant information, enhancing research and scholarly communication (Kaushal & Yadav 2022). Robotic machines are deployed to navigate shelves, retrieve pertinent books or information sources, and deliver them to users. AI proves exceptionally beneficial in information services by alleviating the workload on information librarians, such as doing routine work of searching the catalogue for users and also checking out books. AI allows them to concentrate on other tasks while users receive prompt attention. Consequently, in the 4IR, the library becomes more efficient and effective (Adetayo 2023). Therefore, this study aimed to investigate the utilisation of AI for managing information services in the 4IR at the University of Limpopo (UL) in South Africa with a view to developing a framework. A framework may help the UL library to provide information services quicker and easier using AI. In this regard, the users may benefit by accessing the information services in the library promptly. Therefore, the purpose of the framework is to guide the UL library to adopt AI and for other institutions to benchmark when adopting AI for information services.

## 2 Context of the study

The UL is situated approximately 30 kilometres east of Polokwane in the Limpopo province. Established through the merger of the University of the North and the Medical University of Southern Africa (MEDUNSA) on 1 January 2005, it underwent a subsequent demerger in 2014 (University of Limpopo 2022). The UL library's distinctive objective is to "deliver an efficient and effective client-driven and creative information service" (UL Strategic Plan 2014: 20).

To stay relevant, the UL library subscribes to the following professional bodies:

South African National Library and Information Consortium (SANLIC), Library and Information Association of South Africa (LIASA), Committee of Higher Education Libraries of South Africa (CHELSA), South African Online User Group (SAOUG), International Federation of Library Associations and Institutions (IFLA) and International Association of University Libraries (IATUL)

The library at the UL is organised into four sections, namely Acquisition, Cataloguing and Classification, Information Services, and Subject Reference Services, with a particular focus on the information services section for this study. This section plays a vital role in assisting library users in accessing and retrieving information in a manner that is effective, efficient, and user-friendly (University of Limpopo 2022). Information librarians in this section guide users on how to search for relevant information sources for research and learning. The study was motivated by the UL library's commitment to adapting to the transformative forces impacting teaching and learning, research, and community involvement, while staying abreast of evolving technologies.

## 3 Problem statement

The UL library's information service desk could be facing delays in providing services due to extended queues, potentially resulting in prolonged waiting times for students seeking assistance in this area. As students wait for services, impatience may arise, prompting some to leave the library, while others may attempt to navigate the library independently, leading to difficulties in retrieving relevant information. If students encounter challenges in accessing the necessary information sources, it could impede their ability to complete assignments, potentially resulting in module failure and, subsequently, course failure. Nicholas et al. (2015) supports this notion, asserting that inadequate library skills, including the inability to access information sources and a lack of information access, can significantly impact academic success.

Writing and successfully completing assignments is a prerequisite for earning participation marks, enabling students to qualify for examinations (University of Limpopo 2022). If students fail to meet examination requirements due to insufficient access to information in the library for assignment completion, it could contribute to a high failure rate, negatively impacting

the university's reputation. Beyond the university's academic performance, this issue may have broader economic implications. The shortage of individuals with relevant skills and knowledge, which leads to bottleneck at universities, could affect companies and government departments.

However, AI has the potential to address this challenge by eliminating long queues and contributing to a higher pass rate through the utilisation of robotics. The integration of robots in the UL library could expedite information access for learners. Thus, this study aimed to explore AI's application in information services provision at the UL library, seeking solutions to enhance efficiency and contribute to the overall success of students and the university.

#### **4 Purpose and objectives of the study**

The purpose of this study was to investigate the utilisation of AI for the provision of information services in the 4IR at the UL library in South Africa. The following are the objectives of the study:

- To assess the role of AI in providing information services in the 4IR at the UL library in South Africa.
- To evaluate the information services activities that can be performed by AI in the 4IR at the UL library in South Africa.
- To identify the AI infrastructure required to provide the information services in the 4IR at the UL library in South Africa.
- To recommend a framework to utilise AI for the provision of information services in the 4IR at the UL library in South Africa.

#### **6 Literature review**

This section provides a literature review focusing on the role of AI in information services, the various activities that can be accomplished through AI in the context of information services and the requisite AI infrastructure for delivering effective information services.

##### **6.1 The role of AI in information science**

The integration of AI in information services ensures the rapid availability of information through innovative means. Monokpo and Ntogo-Saghanen (2019) emphasise that the mere existence of information resources loses significance if users lack effective means to access them. Accessibility, surpassing mere availability, entails the ability to use information when needed. In alignment with this perspective, should AI be implemented at the UL library, the aims would be to expedite access to available information, eliminating prolonged waiting times for users. The utilisation of robotic machines and chatbots streamlines the information retrieval process, ensuring ease and speed.

AI facilitates user interaction on a unified platform, enabling the tracking and fulfilment of personalised information needs while ensuring access to accurate information (Yusuf et al. 2022). Leveraging the library portal on the UL website, users can set alerts to stay informed about new information materials. This eliminates the need for manual reminders from librarians about overdue books, as AI takes on the role of notifying users promptly.

##### **6.2 Information services activities that can be performed by AI**

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##### **6.3 AI infrastructure needed to perform information services**

AI infrastructure encompasses the technology that facilitates machine learning, involving the use of AI and machine learning to develop and deploy reliable, adaptable, and targeted data solutions. It encompasses raw processing capacity for constructing and training AI algorithms, as well as network and storage capabilities for storing and sharing data, all of which are essential components in AI infrastructure services (Lins, Pandl & Teigeler 2021).

As Whitehair (2016) highlights, AI infrastructure enables libraries to shift their focus by ensuring easy and timely access to information resources. Libraries leverage AI infrastructure to enhance content access and prepare for the integration of cognitive computing, specifically AI technology, as a tool to elevate the quality of library services (Vijayakumar & Sheshadr 2019). Key components of a robust AI infrastructure for information service provision include machine learning, deep learning, neural networks, natural language processing (NLP) and automated classification. The following are examples of AI infrastructure that can be employed for providing information services.

### **6.3.1 Expert system**

Expert systems are computerised knowledge-based systems designed to function as intelligent interfaces or gateways, facilitating access to databases for obtaining pertinent information (Mogali 2014). A well-designed expert system algorithm enhances effectiveness by guiding users through the system and facilitating the retrieval of relevant information. Notable examples of expert system tools applied in library settings include the Reference Materials Searching System (RefSearch), a machine-assisted application for general reference materials; REFLESS1 (Reference Librarian Enhancement System); ORS (Online Reference System), which encompasses a vast array of reference works in the science library; and Plexus, which specialises in answering queries. Additionally, ORA (Online Reference Assistant) and Answerman (which utilises contextual categories to interpret dictionary terms) play a crucial role in assisting users to obtain answers to ready-reference questions. These tools empower librarians to deliver more efficient and effective services, allowing them to concentrate on other opportunities for professional development (Echedom & Okuonghae 2021).

### **6.3.2 Natural language processing algorithm**

AI infrastructure employing NLP algorithms facilitates communication between computers and humans using natural languages (Woodward 2018; Kalaiselvan, Sharma & Gupta 2021). The system analyses substantial amounts of natural language data, including speech and text. NLP algorithms enable users to interact with AI-embedded software and applications, supporting automated question answering where the algorithm processes questions and generates responses. Information retrieval poses a considerable challenge but stands out as one of the most frequently employed NLP applications.

In this context, the meaning of words or sentences is derived not solely from the words themselves, but also from the context and semantics. Phrases composed of entirely different words can convey the same idea. Leveraging NLP, an information retrieval (IR) system empowers users to efficiently search documents and extract meaningful information based on a search text or query (Cabanac, Frommholz & Mayr 2020).

### **6.3.3 Machine learning algorithm**

According to Tredinnick (2017), machine learning algorithms empower a computer program to autonomously learn and evolve its logic and outcomes based on occurrences, rather than relying solely on pre-programmed instructions. These algorithms generate patterns that facilitate the establishment of relationships between files containing information, enabling users to retrieve them more easily. Additionally, machine learning algorithms can analyse user search behaviour and preferences, delivering customised search results that enhance user satisfaction and the relevance of retrieved information (Barsha & Munshi 2024).

### **6.3.4 Deep learning algorithm**

Deep learning algorithms, a subset of machine learning, involve artificial neural networks or algorithms inspired by the human brain, learning from extensive datasets (Vieira, Pinaya & Mechelli 2017). These algorithms empower machines to tackle intricate problems, even when the data are diverse, unstructured and interconnected (Ali, Naeem & Bhatti 2020). Deep learning can identify specific subjects, such as a thesis or dissertation, and categorise them in the institutional repository. Subsequently, a robotic machine can demonstrate the availability of the material in the institutional repository. Systems like Primo operate with algorithms to ascertain the presence or absence of information material in the library catalogue.

### **6.3.5 Robotics**

Robotics is commonly considered an AI subfield that focuses on machine and perceptual tasks. A robot, in this context, is a mechanical device employing AI techniques to perform automated tasks, either directly under human control or through a predetermined program (Abraham 2019). In libraries, robots are used for various functions, including automated storage and retrieval of items, inventory management, shelf reading, RFID scanning, shelving and identifying materials, as well as addressing repeated and directional reference inquiries (Kim, 2017; Smith, 2020; Tella, 2020). Robots such as Xiaotu, Libby

and Sifiso, named by their respective institutions, contribute to the ease of librarians' work by helping with information and reference services, as well as offering answers to general library questions.

## 7 Research methodology

Research methodologies should be presented clearly and concisely, aiming to provide researchers with a comprehensive understanding of the study's approach rather than just its outcomes (Nayak & Singh 2021). This encompasses conceptual frameworks, employed strategies, the study's design, as well as the tools and procedures used for data collection.

This qualitative study employed content analysis as its research methodology. Content analysis is a methodical approach to analysing qualitative data. It can be applied to verbal sources such as focus groups, radio programmes, open-ended surveys, visual materials such as movies, videos and TV shows, and written sources such as newspapers, magazines and theoretical or methodological trends in journal articles. It provides the chance to analyse latent and interpretative material, which produces themes, as well as manifest and descriptive content, which produces categories (Graneheim, Lindgren & Lundman 2017). The data for this study were collected through a literature review, focusing on the role of AI in information services, the information service activities that can be performed by AI and the infrastructure required to integrate AI for information services. The literature was navigated using themes and keywords. The keywords used included "fourth industrial revolution," "artificial intelligence," "information services" and "artificial intelligence infrastructure."

The researcher utilised search engines and databases, including Google Scholar, Emerald Insight, and Library and Information Science Source, because it directed the researcher to multiple websites that stored or included data relevant to the study. Within these databases, an extensive review and analysis of the literature were conducted, with a focus on selecting content aligned with the study's objectives. To systematically analyse the qualitative data extracted directly from the literature, the researcher read the titles and abstracts of the generated articles. The full-text articles that met the inclusion criteria were then further reviewed using the thematic analysis technique established by Braun and Clarke (2006).

## 8 Findings of the study

The findings suggest that AI plays a crucial role in enhancing information service efficiency during the 4IR at the UL library in South Africa. AI proves instrumental in delivering information services, such as promptly responding to students' inquiries about library materials and their locations. AI would perform routine tasks that are usually done by librarians such as directing the users to the location of the information source. AI would also work 24 hours a day with the utilisation of a chatbot where users can get reference advice even when the librarian is not available. The literature underscores the significance of AI in providing information in the 4IR at the UL library in South Africa. The 4IR has brought together computer science, communications, and mass media industries to collaborate on digital information (Kapoor et al. 2018). AI enables users to engage on a unified platform, enabling the sharing of ideas and conducting research through diverse online information services. These platforms include chatbots where users communicate with a virtual librarian and can form discussion forums to share information and ideas. Its importance is further highlighted as AI allows academic libraries, including UL, to rely on information technology for preserving and disseminating knowledge sought by remote users (Kapoor et al. 2018). Users can search for and retrieve information without the need to visit the library by using technologies brought by AI.

The findings also highlight that in the 4IR, AI can facilitate various information services at the UL library in South Africa, including "Ask a Librarian," which enables users to virtually communicate with librarians. Online book renewal streamlines the process, saving users the time and effort to visit the library to renew overdue books. Client service support offers virtual assistance to users and access to databases, both on and off campus, eliminating the need for physical visits to the library when seeking information resources. Instead, users can simply search the library catalogue and online resources. The UL library provides activities that are well-suited for integration with AI. Some of the information services, such as the "Ask a Librarian" service, are already conducted online. Integrating the library management system with these activities has the potential to enhance the efficiency of information services.

The findings also highlight that to deliver high-quality information services in the 4IR, the UL library needs AI infrastructure. Essential components of this AI infrastructure include expert systems used for reference services, such as RefSearch and Plexus, also Refworks that is available in the UL library. Additionally, NLP algorithms play a vital role in enabling users to communicate using natural language with AI-embedded software and applications (Kalaiselvan et al. 2021). Machine learning algorithms can analyse the search behaviour and preferences of users to deliver personalised search results and improve user satisfaction and the relevance of the information retrieved (Barsha & Munshi 2024).

## 9 Recommendations

This study recommends the adoption and application of an intelligent robotic machine in the information service at the UL library to address students' inquiries about the availability and location of information materials within the library (Adetayo 2023). A robotic machine can also help the users to locate print books on the shelves and even retrieve them. The robot may take care of shelf reading to make sure that the books are always in their right place for access. Additionally, the implementation of chatbots and virtual reality is suggested to enhance the effectiveness of information service activities and promote the library's services. Furthermore, the study recommends that the UL library acquire sufficient AI infrastructure to effectively leverage AI tools for providing information services (Ajani et al. 2022). The UL library should implement training programmes and workshops aimed at enhancing the knowledge of library professionals in AI technologies (Adetayo 2023). By offering these educational opportunities, the UL library can cultivate a skilled workforce capable of effectively utilising AI technologies and systems, equipping them with the necessary information and practical experience.

### 9.1 Proposed framework

This section introduces the framework for the integration of AI in providing information services at the UL library. Figure 1 illustrates that AI is essential for performing various activities related to information services. To ensure the effectiveness and efficiency of these activities, it is crucial to establish proper AI infrastructure. This streamlined process in information services will facilitate quick and easy assistance to users, eliminating the challenges of long queues at the UL library. The incorporation of AI supports convenient and remote access, facilitated by robust AI algorithms embedded in the library website and applications. The use of AI-powered intelligent robotic machines enhances information services, ensuring improvement and effective and efficient provision of quality services at the UL library for the benefit of users.

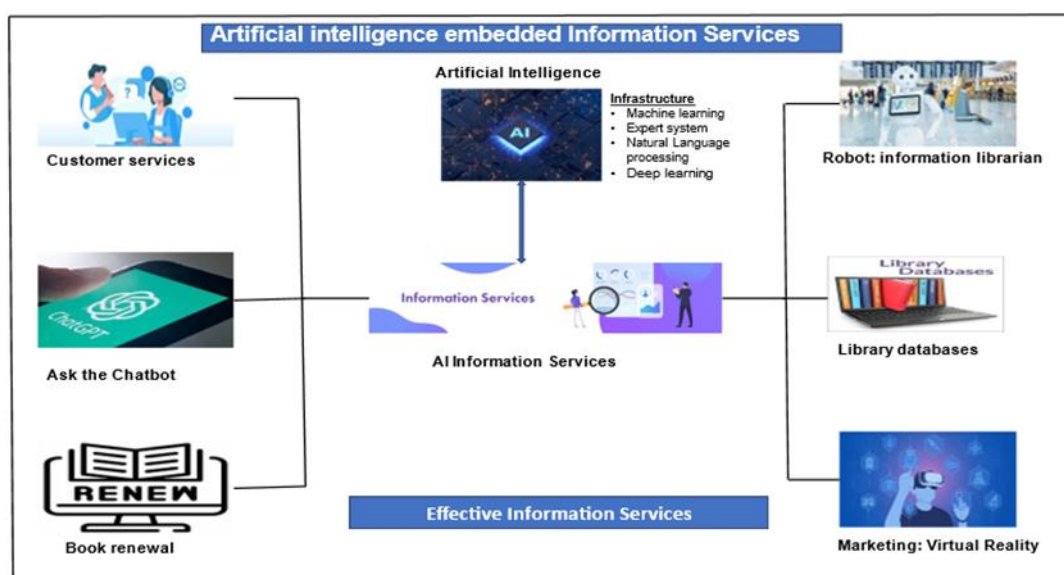


Figure 1: Framework for utilisation of AI for the provision of information services in the 4IR

This model is grounded in the integration of AI within information services, aiming to enhance the quality and accessibility of such services. It emphasises the interconnected nature of information service activities and the underlying AI infrastructure. A notable feature of this model is the implementation of a streamlined book renewal system, offering library users the convenience of renewing their books without the need to physically visit the library. Instead, users can effortlessly renew books by logging into the library's website, utilising their credentials to access the dedicated portal, and witnessing the system generate a new return/due date for the specific book in question.

Integral to this model is the incorporation of advanced technologies, such as a robotic information librarian, customer service support and a chatbot, all employing NLP for effective communication between the application and the user. The symbiotic relationship between customer services and the "Ask the Chatbot" feature is particularly noteworthy. When a user submits a query via the chatbot, and the response is not satisfactory, the chatbot seamlessly directs the user to an information librarian, facilitating a more detailed and precise resolution to their inquiry.

The AI-powered information librarian robot plays a crucial role in answering user queries and aiding in the location of information resources. Users can input their information requirements on the robot's screen, and the robot, equipped with software enabling mobility, displays the relevant retrieved information. For instance, if a user seeks a specific book, they

can either note the shelf/call number and retrieve it independently or request the robot's assistance in fetching the book. Efficient organisation of the library database is imperative for seamless information retrieval. Leveraging deep learning algorithms, the model classifies complex and unstructured information. This classification extends to sorting information resources, such as theses and dissertations, into the institutional repository and other resources into respective databases subscribed to by the library. The integration of AI software ensures that users can access these databases remotely, enhancing accessibility and convenience.

The model also embraces virtual reality (VR) applications, such as Layar, to elevate library marketing strategies. Designers can incorporate multimedia elements into various promotional materials, including flyers, postcards, and packaging, using Layar Creator. These elements may encompass video messages, social media and website links, picture slideshows and audio recordings, resulting in more engaging and interactive promotional content. The implementation of this model is anticipated to significantly enhance the efficiency of information services at the UL library within the context of the 4IR. Through the strategic integration of AI and cutting-edge technologies, the library aims to stay at the forefront of innovation, providing users with a seamless, interactive, and highly accessible information environment.

## 10 Conclusion

In conclusion, the traditional roles and responsibilities of libraries and librarians are undergoing a profound transformation due to the influence of AI, reshaping the global information landscape. The versatile applications of AI have ushered in positive changes across various facets of library services, illustrating its efficacy in saving both time and resources. By integrating AI, libraries can significantly enhance their ability to meet user needs promptly and efficiently. The time and cost savings realised through AI applications contribute to a more streamlined and effective provision of library services. This transformative impact underscores the necessity for libraries to embrace and align with innovative technologies to stay relevant in the dynamic landscape of today's information age. The implementation of AI not only positions libraries as technologically adept, but also augments librarian productivity and overall operational efficiency.

By leveraging AI, libraries can tailor their services to meet the evolving needs of the next generation of users, ensuring a high standard of service delivery. This adaptation to technological advancements becomes imperative to maintain the library's relevance and effectiveness in catering for the diverse information requirements of its user base. Recognising the potential of AI in enhancing librarian capabilities, it becomes crucial to organise training programmes and conferences dedicated to AI. These initiatives would empower librarians with the skills and knowledge necessary to navigate and harness the capabilities of AI effectively. Ongoing education and professional development in the realm of AI will equip librarians with the tools needed to embrace and integrate innovative technologies seamlessly into their daily operations. In essence, the integration of AI into library services is not just a technological evolution, but also a strategic imperative for libraries to thrive in the contemporary information landscape. Embracing AI's transformative potential positions libraries at the forefront of innovation, enabling them to deliver high-quality services tailored to the demands of the digital age.

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