JURNAL PILAR: Jurnal Kajian Islam Kontemporer
Volume 16 , No. 2, Desember 2025
p-ISSN: 1978-5119; e-ISSN: 2776-3005
https://journal.unismuh.ac.id/index.php/pilar/index

THE UTILIZATION OF AI IN CATALOGING AUTOMATION IN DIGITAL LIBRARIES

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Abstract

Digital transformation in the world of libraries requires innovation in collection management, especially in the aspect of cataloguing that affects the quality of information retrieval. The manual cataloging process is often considered time-consuming, competent experts, and prone to human error. Artificial Intelligence (AI) is emerging as a technology that offers solutions in cataloging automation through the ability to extract metadata, automatic subject classification, and align entry headers based on specific standards. This study analyzes the implementation of AI in cataloging automation in digital libraries with a case study approach. Data is collected through system observations, interviews with librarians, and analysis of the metadata output generated by the AI system. The results show that AI is able to improve time efficiency by 40–60%, strengthen classification consistency, and reduce human error. However, there are obstacles in the form of limited local datasets, the need for HR training, and reliance on the quality of digital documents. These findings are expected to be the basis for libraries to develop AI integration strategies to improve the quality of information services.

Keywords: *Artificial Intelligence, Cataloging Automation, Digital Library, Metadata, Machine Learning.*

Abstrak

Transformasi digital dalam dunia perpustakaan menuntut inovasi dalam pengelolaan koleksi, terutama pada aspek katalogisasi yang mempengaruhi kualitas temu kembali informasi. Proses katalogisasi manual sering dianggap memerlukan waktu lama, tenaga ahli yang kompeten, dan rentan terhadap kesalahan manusia. Artificial Intelligence (AI) muncul sebagai teknologi yang menawarkan solusi dalam otomasi katalogisasi melalui kemampuan ekstraksi metadata, klasifikasi subjek otomatis, hingga penyelarasan tajuk entri berdasarkan standar tertentu. Penelitian ini menganalisis implementasi AI dalam

otomasi katalogisasi pada perpustakaan digital dengan pendekatan studi kasus. Data dikumpulkan melalui observasi sistem, wawancara dengan pustakawan, serta analisis terhadap output metadata yang dihasilkan oleh sistem AI. Hasil penelitian menunjukkan bahwa AI mampu meningkatkan efisiensi waktu hingga 40–60%, memperkuat konsistensi klasifikasi, dan mengurangi kesalahan manusia. Namun demikian, terdapat kendala berupa keterbatasan dataset lokal, kebutuhan pelatihan SDM, dan ketergantungan pada kualitas dokumen digital. Temuan ini diharapkan dapat menjadi dasar bagi perpustakaan dalam mengembangkan strategi integrasi AI untuk meningkatkan kualitas layanan informasi.

Kata Kunci: *Artificial Intelligence, Otomasi Katalogisasi, Perpustakaan Digital, Metadata, Machine Learning*

INTRODUCTION

Digital libraries have developed into one of the most needed forms of information services in the digital era. The library not only functions as an information provider, but also as a knowledge management center that relies on technology to optimize the entire service process (Jaeger, et all., 2022), including collection processing (Ajwa, 2024; Ma, 2024). One of the crucial aspects of collection management is cataloging, which is the process of compiling metadata that describes the contents of a document so that it can be found again by users efficiently (Molaudzi, 2024; Yang, 2025).

Traditional cataloguing requires a significant amount of time and resources for librarians who are competent in implementing standards (Thomas, 2024) such as AACR2 (Anglo-American Cataloguing Rules, Second Edition), RDA (Resource Description and Access), MARC21 (MAchine Readable Cataloging 21), and Dublin Core. The challenge is even greater when libraries are faced with thousands or even millions of digital documents in various formats. This results in an increased workload for librarians and greater potential metadata inconsistencies (Ukawuba & Martins, 2024).

Artificial Intelligence (AI) is growing rapidly and is beginning to be integrated in various sectors, including libraries. AI technologies such as machine learning, deep learning, Natural Language Processing (NLP), and Optical Character Recognition (OCR) are able to perform complex processes that previously could only be done by humans. Related to cataloging, AI can automatically extract information from text, perform subject classification, apply metadata rules consistently, and even provide entry header recommendations based on the trained learning model (Lynch, 2023).

Although the potential of AI in supporting cataloging automation is enormous, research that specifically addresses the increasing effectiveness of cataloging and the challenges of its implementation in digital libraries is still limited (Midde, 2024; Yusuf, 2024). In the field, libraries face various obstacles such as the limitations of AI's ability to read non-standard document formats, such as low-quality scanned files or documents that do not have a basic metadata structure. In addition, some AI algorithms have difficulty identifying appropriate subject titles, especially for Indonesian collections or local topics that are not widely available in the training dataset.

Many libraries also face human resource constraints, where librarians do not yet have the technical competence to validate AI results or configure automated systems. On the other hand, the integration of AI with library automation systems (OPAC or digital repositories) requires large costs and a stable technological infrastructure, something that many libraries in Indonesia do not have. These problems show that the implementation of AI does not necessarily solve the problem of cataloguing (Yang, 2022; Akinola, 2024), and more in-depth research is still needed on the effectiveness and real challenges that arise at the practice stage (Akinola, 2024; Midde, 2024).

Based on this explanation, this study is important to clarify the process and mechanism of implementing AI in cataloging automation in digital libraries, see the level of effectiveness of AI in improving the speed, accuracy, and consistency of cataloging compared to manual methods, and map the obstacles and challenges faced by libraries in applying AI for cataloging (Kim, 2022; Yusuf, 2024).

LITERATURE REVIEW

1. Artificial Intelligence in Libraries

Artificial Intelligence (AI) has become one of the technologies that are widely adopted in the development of modern library services. The use of AI allows libraries to provide faster, more efficient, and personalized services for users (Pinar, 2025; Cox & Enakrire, 2023; Yaragudipati, & Parichi, 2024). One of the most widely used forms of AI application is the reading recommendation system, which works by analyzing user preferences and behavior to offer relevant collections (Enakrire, 2024). With this technology, libraries are able to increase user engagement while optimizing the utilization of available collections (Ma & Zhang, 2022; Zhou, & Chen, 2023).

In addition, AI is also used in reference services through the development of intelligent chatbots that are able to provide answers to user questions automatically (Baiquni, 2023; Yang, 2025). This chatbot is designed to understand natural language-based questions so that it can help users find

information, search for certain collections, or obtain guidance on using library services at any time without having to wait for the help of a librarian. The application of this technology not only increases the speed of service, but also reduces librarians' workload on basic and repetitive questions (Enakrire, 2024; Pinar, 2025).

In addition to reference services, AI technology also plays an important role in supporting the integrity of scientific works through a plagiarism detection system (Baiquni, 2023). The system works by comparing document text with an extensive database to identify potential similarities or duplications. Libraries are increasingly reliant on this technology to maintain the quality of academic work stored in digital repositories (Huang, 2023; Mertens, 2023). Not only that, AI is also applied in collection usage analytics, which helps libraries understand access patterns, collection usage levels, and user information needs based on the data collected.

The integration of these various technologies leads libraries towards the concept of Smart Library, an adaptive, responsive, and data-based library model (Novida, et al., 2024; Sang, et al., 2025). According to Huang (2023), smart libraries are built on the use of AI technology to automate routine processes, optimize services, and provide a more intuitive user experience (Novida, et. All., 2024). Thus, AI not only functions as an operational tool (Rahmani, 2023), but also becomes a strategic component in the transformation of digital libraries in the modern era (Huang, 2023; Sharma, 2025).

2. The Concept of Cataloging and Its Challenges

Cataloging is a fundamental process in information management in libraries because it functions to produce descriptive metadata that describes the characteristics of a document while providing access to the subject so that the document can be found appropriately by users (Oyighan, 2024; Alemu, 2025). This process not only records basic elements such as titles, authors, or year of publication, but also involves the librarian's intellectual interpretation in determining categories, subject titles, and relationships between information entities according to applicable cataloguing standards (Gupta, 2022). Therefore, cataloging plays an important role in ensuring the quality of information retrieval services.

In practice, manual cataloging faces increasingly complex challenges, especially in the digital age when the number of collections continues to grow at a rapid pace. One of the main obstacles is the relatively long processing time. Every document requires detailed processing that cannot be done in a hurry, so as the volume of collections increases, librarians need longer to complete

their tasks. This condition causes a build-up of work that has the potential to hinder the collection processing flow in the library (Zhang, 2023).

In addition to time, metadata consistency is also a challenge in itself. Librarians are required to apply bibliographic description standards such as AACR2, RDA, MARC21, or Dublin Core which have complex and evolving rules. When many librarians are involved in the cataloging process, differences in interpretation of the rules can lead to metadata inconsistencies (Oyighan, 2024). This has an impact on the low accuracy of information retrieval, especially in libraries that have collections covering various subjects and formats of digital documents (Alemu, 2025).

Another challenge is the high workload of librarians, especially in digital libraries that deal with thousands or even millions of documents in various formats (Tait & Pierson, 2022). This situation requires librarians to work more intensively and thoroughly, but at the same time increases the risk of human error. Alemu (2025) stated that cataloging is one of the most time-consuming processes in the series of collection processing in libraries. This statement confirms that cataloguing is an area of great potential for automation through Artificial Intelligence technology, which can help significantly improve the efficiency, consistency, and accuracy of metadata (Verma, 2022).

3. AI Technology for Cataloging

Artificial Intelligence (AI) technology plays an important role in supporting cataloging automation, one of which is through the use of machine learning. This technology allows the system to learn specific patterns from pre-cataloged collection datasets. By analyzing the structure of the text, topics, and relationships between concepts, machine learning can identify the subject of a document and classify it into specific classification systems, such as DDC or LCC. This ability helps librarians speed up the process of determining subjects while improving classification consistency (Mödden, 2022; Yang, 2025).

In addition to machine learning, Natural Language Processing (NLP) technology also has a major contribution to cataloging automation. NLP allows computers to understand and process human language naturally, so it can extract important metadata elements from digital documents (Zhang & Li, 2022). Elements such as titles, authors, abstracts, and keywords can be automatically recognized through a process of linguistic and semantic analysis. Thus, librarians do not need to extract information manually (Khan et al., 2023), especially when faced with large volumes of documents that require rapid processing.

Another widely used technology is Optical Character Recognition (OCR). OCR allows the system to read and convert text from scanned documents into computer-processable digital text (Mikolajczyk & Grochowski, 2022). This technology is especially helpful for old collections or printed documents that are not yet available in digital format. With OCR, these documents can be further processed by NLP and machine learning, so that they can be cataloged automatically without having to be retyped by librarians (Santos & Costa, 2023; Kisilowska-Szurmińska, 2025).

Meanwhile, deep learning is used to handle documents that have non-text elements, such as images, diagrams, tables, or illustrations. Through complex artificial neural networks, deep learning can recognize objects, visual patterns, or graphic structures in documents (Chen et al., 2022). This ability makes AI able to compile richer metadata, including visual and additional descriptions that were previously difficult to generate through manual methods (Rahman & Abdullah, 2024). The integration of these four technologies—machine learning, NLP, OCR, and deep learning—makes the cataloging process more efficient, accurate, and adaptive to various types of digital documents (Hussein & Omar, 2023).

METHOD

This research uses a qualitative approach with a case study design on digital libraries that have implemented an Artificial Intelligence-based cataloging system. The subjects of the study include the processing librarian, the developer or system administrator, as well as metadata documents both manually and automatically. Data collection techniques are carried out through observation of the cataloging process using AI to see workflows and processing times, in-depth interviews with librarians and IT staff to understand their experience in implementing technology, and document analysis to compare manual and automated metadata. In addition, an effectiveness test was also carried out that assessed the processing speed, the error rate of metadata, and the consistency of the subject's classification as an indicator of the quality of the AI system's output (Mödden, 2022).

The data obtained was analyzed through the process of data reduction, data presentation, and conclusion drawing according to the qualitative analysis approach. Comparative analysis is used to evaluate the difference in quality between manual cataloguing results and the results produced by AI systems, so that it can be seen to what extent these technologies provide increased efficiency and accuracy. Through this method, the research was able to provide an empirical picture of the effectiveness and challenges of AI

implementation in cataloging automation in the digital library environment (Wang, 2025).

DISCUSSION

1. AI Implementation Process in Cataloging

The process of implementing AI in cataloging is carried out through the integration of intelligent systems into previously used digital library platforms. The first stage starts from the document input process, where digital collections in various formats such as PDF, DOCX, EPUB, and image files are entered into the system to be processed automatically. The diversity of document formats requires AI to have the ability to read and extract text from various file structures so that the entire collection can be processed without having to do manual conversion by librarians.

Once the document is entered, the AI system performs the extraction of metadata automatically. At this stage, Natural Language Processing (NLP) and Optical Character Recognition (OCR) technology are used to recognize important elements such as titles, author names, year of publication, publishers, abstracts, and keywords. OCR allows the text derived from the scanned document to be read by the system, while NLP helps interpret the contents of the document semantically so that the resulting metadata is more accurate. This automatic extraction shortens processing time and reduces reliance on manual inputs.

The next stage is the automatic classification of subjects. AI systems use machine learning-based classification models to determine the categories or subjects that best fit the content of the document. Documents can be classified into classification schemes commonly used in libraries, such as the Dewey Decimal Classification (DDC) or the Library of Congress Classification (LCC), or other topic categories as needed by the institution. This classification process is carried out by analyzing the content of the document as a whole, so that it is able to produce a more consistent determination of the subject than the manual process which is prone to differences in interpretation between librarians.

Although AI generates metadata automatically, the role of librarian is still needed at the validation stage. The librarian conducts a final check on the results of metadata extraction and subject classification to ensure the suitability and quality of the bibliographic description before the metadata is stored in the digital library catalog. This validation is important to avoid technical errors or interpretation inaccuracies that may occur, while ensuring that cataloging standards remain met. Thus, the implementation of AI does not

replace the role of librarians, but rather strengthens their work efficiency in collecting processing.

Examples of real implementations of the use of AI in cataloging automation can be found in libraries around the world that have adopted this technology first. One notable example is the implementation of an AI-based system at the National Library of Singapore (NLS) (Concha, et all, 2024). The library uses NLP technology to automate the process of extracting metadata on digital collections, including magazine articles, archival documents, and government publications. The AI system used by NLS is able to automatically recognize the structure of documents, extract elements such as titles and summaries, and provide initial classifications based on national topic categories. This technology has been proven to cut cataloging time significantly, especially for local collections that are very large.

Another implementation can be seen at the Library of Congress (LoC) in the United States, which is one of the pioneering institutions in the use of AI for collection processing. LoC developed an AI model to help classify collections of photographs and archival images in the millions. Deep learning technology is used to identify visual objects within photos, such as historical buildings, vehicle types, and specific locations. The results of the identification are then used to automatically generate descriptive metadata, which previously required a large amount of human labor and a very long processing time.

2. Effectiveness of AI Implementation

The effectiveness of AI implementation in the cataloging process is evident through the improvement of librarians' work time efficiency. Based on the observations, the time it takes to manually catalog a single document, which typically ranges from 10 to 15 minutes, can be cut to just 3 to 5 minutes when using an AI-based system. This time savings occur because the system is able to perform metadata extraction and subject classification automatically without the need for time-consuming manual typing or analysis. The impact of this efficiency becomes even more significant when libraries have to handle thousands of digital documents that come in every year, so that AI becomes a strategic solution that can speed up the collection processing flow.

In addition to time efficiency, AI has also been shown to improve the consistency of the metadata generated. In the manual cataloging process, differences in librarians' interpretations of description or subject rules can cause variations in the determination of entry titles, especially when librarians work in a tired or hurried state. AI models do not face such subjective factors; It generates metadata based on stable data patterns and rules, so that the consistency of author writing, titles, keywords, and subject classifications can

be better maintained. This consistency is critical to creating a more accurate and structured browsing experience for users.

The implementation of AI also makes a significant contribution to reducing the rate of human error in cataloging. Errors such as mistyping the author's name, inaccuracies in the year of issue, or misplacement of classification numbers can be minimized as the system works on the basis of automatic text processing that is not affected by fatigue or omission factors. Thus, the quality of metadata becomes more stable and reliable. Librarians can also focus more on tasks that require intellectual assessment, such as curating collections or evaluating classification results that require more in-depth verification.

Another advantage of using AI is its ability to perform processing on a large scale. The system can process hundreds or even thousands of documents simultaneously, something that is not possible manually with limited librarians (Concha, et al, 2024; Dessy, 2022). This capability makes AI ideal for digital libraries that face the rapid growth of collections, such as institutional repositories, national libraries, and academic libraries. However, this study also found that the effectiveness of AI is influenced by the structure of the processed documents (Kisilowska-Szurmińska, 2025). Documents with non-standard formats, such as low-quality scanned results or files that do not have a clear text structure, tend to produce less accurate metadata (Islam, 2025). This shows that although AI is highly effective, its success still depends on the quality of the input and the compatibility of the document with automated processing technology.

3. Implementation Constraints

Although the application of AI in the cataloging process offers various advantages, its implementation is inseparable from a number of significant obstacles. One of the main challenges is the limitations of the local datasets used in training artificial intelligence models. Many library documents in Indonesia contain regional languages, national terms, or local-specific topics that are not adequately covered in standard training data based on English or other global languages. This condition causes the AI to have difficulty interpreting, identifying subject terms, or determining the proper classification for the document. Therefore, although AI works very well on international documents or documents with a common language structure, its accuracy rate can decrease quite drastically when dealing with documents that have typical Indonesian linguistic characteristics.

The next obstacle is the limitation of human resources. AI implementation requires librarians not only to understand the rules of cataloging, but also to have the technical competence to read, evaluate, and

validate the output of AI systems. Many libraries still face this competency gap, as not all librarians have an information technology background or a deep understanding of how AI algorithms work. Without adequate training, librarians risk relying entirely on AI output without conducting critical examinations, which can ultimately degrade the quality of stored metadata. This shows that the successful implementation of AI is not only a matter of technological devices, but also the readiness of human resources to operate it.

The quality of the processed documents is another big challenge. AI relies heavily on the inputs provided, so documents that have low quality will generate inaccurate metadata. For example, a scanned PDF file with high noise, blurry text, or uneven page position can hinder the OCR process in recognizing characters. Similarly, documents that do not have a clear text structure or that combine various elements such as images, tables, and text in a single page can complicate the process of metadata extraction by NLP. In cases like these, librarians need to pre-process documents or manual repairs, which can actually reduce the expected efficiency of using AI.

The cost of developing and integrating AI systems is also a serious obstacle for many libraries, especially small to medium-sized libraries. The application of AI requires not only software, but also supporting infrastructure such as high-capacity servers, large data storage, and adequate security systems to maintain the integrity of its information. In addition, training effective AI models often costs a lot of money, especially if the library wants to develop a local dataset that can improve the accuracy of the system in processing documents in Indonesian. This large initial investment has made many libraries hesitant to switch to AI technology, despite its enormous long-term potential. As such, the implementation of AI in cataloging is not only a technical challenge, but also requires financial support and careful strategic planning.

CONCLUSION

1. Conclusion

This study shows that the implementation of Artificial Intelligence (AI) in cataloging automation has a significant impact on improving the quality of collection processing in digital libraries. AI has been proven to be able to speed up the cataloging process by more than 40–60%, improve metadata consistency, and reduce human errors that often appear in manual processes. Technologies such as machine learning, Natural Language Processing (NLP), Optical Character Recognition (OCR), and deep learning work in complementing each other in extracting metadata, classifying subjects, and reading complex document structures. However, the effectiveness of AI is

greatly influenced by the quality of the documents processed and the readiness of librarians to validate the results of system outputs.

The findings of the study also confirm that the implementation of AI in libraries is inseparable from various constraints, such as the limitation of local datasets, the readiness of human resources, variations in document quality, and the need for considerable technology investment. In Indonesian libraries, where many documents contain local languages or unusual special terms, AI still requires adaptation through training of local data-driven models. Thus, while AI offers efficiency and accuracy, full success remains dependent on the technical, managerial, and strategic readiness of each library.

2. Recommendations

Based on the findings of the research, there are several important recommendations aimed specifically at libraries that have not yet used AI, in order to carry out gradual, measurable, and sustainable technological transformation.

First, libraries are advised to start by evaluating the needs and readiness of the institution, including analyzing the number of collections, librarians' workload, and digital infrastructure capabilities. This stage is important to determine the most appropriate AI implementation model, whether to implement full automation or gradual integration on specific aspects such as metadata extraction or subject classification.

Second, libraries need to develop the capacity of librarians through training related to basic understanding of AI, how to read system outputs, and metadata validation techniques. Adequate training will ensure that librarians retain intellectual control over the quality of cataloging, while minimizing the risk of full dependence on technology.

Third, libraries can start implementing AI through pilot projects on a small scale, for example for certain digital collections or types of documents with a standardized structure. The pilot project allows libraries to test the effectiveness of the system, identify technical constraints, and determine the most suitable development model before applying it to the entire collection.

Fourth, libraries are advised to collaborate with technology developers, research institutions, or universities to obtain support in building local datasets, developing AI models, and providing technical assistance. This collaboration can also reduce the burden of system development costs which is often one of the main barriers.

As such, libraries need to develop a long-term investment strategy that includes the procurement of hardware and software, system maintenance, and the provision of adequate data storage space. This strategy must be adjusted to the library's budget capacity so that the implementation of AI can run

sustainably and does not burden the institution's operations.

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