ISPEC
Uluslararası Sosyal ve Beşeri Bilimler Dergisi
International Journal of Social Sciences & Humanities

Review Article e-ISSN: 2717-7262 https://doi.org/10.5281/zenodo.15696893

Evolution of Libraries with Artificial Intelligence in the Digital Transformation Process

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Article Info

Received: 07.03.2025
Accepted: 28.04.2025

Keywords
Library,
Technology,
Digitalization,
Automation,
Artificial Intelligence,
Expert Systems

Abstract: Artificial intelligence has emerged as a transformative force for libraries, as it has for many other areas on a global scale, reshaping library operations, services, and user interactions. Early automation efforts in cataloging and inventory management in the 1970s paved the way for today's developments. This study questions the role and meaning of artificial intelligence for libraries in light of the data obtained from scanning domestic and foreign literature. The scope of the study consists of the concept of the library with its historical background, the relationship between library and technology, the concept of artificial intelligence and its sub-technologies, the role and meaning of artificial intelligence in libraries, and the conclusion and recommendations. Thus, the study provides a perspective on the evolution of libraries from the past to the present and their technological development combined with artificial intelligence. The study's findings show that despite the many opportunities that artificial intelligence offers libraries, education and awareness on this subject are insufficient. As well as financial investments, collaborations, and qualified education programs are essential in libraries in Türkiye and worldwide to use artificial intelligence effectively. Establishing relevant standards, guidelines, and legal frameworks for successful implementation is crucial. Considering the decisiveness of artificial intelligence for the future of libraries, it is recommended that these challenges be addressed and solution-oriented approaches be adopted.

1. Introduction

Artificial intelligence (AI) technologies have affected libraries as well as other fields. AI technologies have led to a transformative change in the operations and services of libraries, which are essential institutions for educational, cultural, intellectual, and social development. The roots of this transformation have origins in the second half of the twentieth century when technological initiatives began to reshape cataloging, automation, and inventory management practices. This study explores AI's historical development and projected future role in libraries, drawing on a comprehensive review of local and international literature. The study aims to provide a theoretical perspective on AI integration in libraries, its opportunities, and its challenges in this context by examining the relationship between libraries and technology, the evolution of AI, and its sub-technologies. Although it is clear that AI has great potential for improving library services, available studies show that many libraries still face barriers such as inadequate staff training, budget constraints, and other obstacles. Developing strategies to address these issues quickly and collaboratively is critical for libraries to improve their effectiveness and efficiency today and prepare for the future.

2. Library Concept and Its Historical Background

The library comes from the Latin “liber,” meaning “book” The corresponding term in Greek and Romance languages is “bibliotheca”. A more precise definition is a collection or group of books and/or other printed or non-printed materials organized and maintained for use (e.g., reading, consultation, study, research). Institutional libraries are organized to facilitate access for a specific user population and are staffed by librarians and other personnel trained to provide services to meet user needs (Reitz, 2014). The term “kütüphane” (library) in Turkish is derived from the Arabic Kitab, the plural form of kütüb, and the Persian hane, kütüb-hane, meaning books-house, a place where books are collected. The Arabic word “kitab” has “writing” and “name” in its origin (Keseroğlu, 1989). Depending on their type, libraries serve different audiences with different functions. Public libraries generally provide everyone free access to books and resources, while university and school libraries support students and researchers in educational institutions. Special libraries cater to specific fields, such as medicine or law, while national libraries preserve a country's historical and literary heritage (Amiri, 2014). Libraries are institutions that carry the educational, cultural, and intellectual heritage of various civilizations and play an important role in both social development and the advancement of sciences. The fact that many ancient civilizations interacted with each other and/or with later civilizations in a scientific and cultural context suggests that we can find the roots of today's science and culture in these civilizations. Library and archives are the most important carriers of the intellectual accumulation product of this interaction (Keseroğlu ve Demir, 2016).

In early history, there was not much distinction between the concepts of library and archive. The library concept developed alongside recorded information, with the first libraries appearing over 5000 years ago. Before the invention of the book, most information was written down on clay tablets, papyrus scrolls, parchment rolls, and other materials, most likely preserved in highly secure places. These places or repositories were transformed into libraries. In the 1970s, excavations in the library at the ancient city of Ebla in Syria uncovered more than 20,000 clay tablets written in cuneiform (Ukwueze ve Onoh, 2025). When we consider the evolution of libraries from ancient clay tablet repositories in Mesopotamia to today's digital environments, we see technological advances and changing socio-cultural priorities. The earliest libraries, such as the Library of Ashurbanipal (7th century BC), held clay tablets only available to the elite. Classical civilizations such as Greece and Rome expanded this concept with institutions such as the Library of Alexandria serving as intellectual centers. After the fall of the Roman Empire, monastic libraries preserved classical works through meticulous manuscript copying. The development of the printing press and the Renaissance democratized knowledge, paving the way for libraries and printed books that were more accessible to all. The 19th and 20th centuries witnessed the rise of public libraries, often supported by philanthropists to promote literacy and self-education (Onunka et al., 2023). The dynamics that most triggered the development of both university and other types of libraries were the scientific, intellectual, and political movements of the 18th century and the widespread understanding that reason was the most important source of reference. A growing awareness of human rights, equality, embracing diversity, democracy, and other values gave libraries their golden age. University libraries, founded in the Middle Ages, made their materials available in contrast to the protective attitude of monastic libraries, and other libraries gradually socialized and developed as social service units where books and other materials used and lent, laying the foundation for today's library structures (Demir, 2024a). In addition, after the World War II, the massification of education fed the development of the idea of the university library. It increased the emphasis on access to collections, government funding for collection development, library restructuring, collaboration, and automation. Beginning in the 1970s, the diffusion of new technologies

accelerated the development of university libraries (Demir, 2024b). Parallel or simultaneous to the development of public libraries were developments in school libraries. In the 19th century, many states in the United States passed laws authorizing taxpayer funding for school libraries. However, school libraries faced two significant problems: a lack of dedicated space and a lack of trained professionals to manage the collections. Increasingly popular public libraries filled this gap by providing materials and services to local schools. In the early 20th century, with the advancement of library education, the role of libraries began to change. The experiences of the mid-1900s, especially after the World Wars, accelerated the shift toward technology. Libraries began to incorporate multimedia materials, especially audiovisual materials, and school libraries had to adapt to these evolving educational tools (North Dakota State Library, 2023). The historical evolution of libraries from private and protected repositories restricted to the privileged classes to modern accessible information centers is important for understanding how societies laid the foundations for literacy, education, socialization and the preservation of cultural heritage.

3. The Evolution of Technology in Libraries

Technological advances throughout the 19th and 20th centuries have greatly affected libraries as they did other organizations. These developments have led librarians to face various challenges. These challenges are not new for libraries and librarians because as society experienced the changes brought about by the Industrial Revolution, libraries also experienced their share (Hicks, 2014).

Musmann's (1993; cited in Crawford, 1994) anecdotal history of libraries points out that librarians make the mistake of thinking that today's technological challenges are unprecedented, ignoring the significant changes libraries have faced throughout history. It was the same in the 1960s with LPs and automation technologies, in the 1970s with lending/circulation systems, online searching, and the introduction of videotapes, or in the 1980s with bibliographic studies, online catalogs, CD-ROMs, and similar technologies. The sense of the end of the printed book is not new; concerns in this context date back to the 1910s, when figures such as Homer Croy and Melvil Dewey predicted the rise of new forms of media. Musmann's (1993; cited in Crawford, 1994) account shows how, against all odds, librarians adapted to technological change from 1887 to 1958. In short, libraries have continually evolved and are constantly evolving. Digital libraries, a product of rapid developments in information and communication technologies, emerged in the early 1990s and rapidly gained interest among librarians. By the early 2000s, 64 definitions were identified in the literature, reflecting the lack of consensus on a digital library. Many terms, such as 'electronic library,' 'virtual library,' 'library without walls,' and 'bionic library,' were coined to refer to the digital library concept. The Digital Library Federation's 1998 definition of digital libraries as "organizations that provide resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works" offers the most comprehensive view of digital libraries as organizations that manage and preserve digital collections for specific communities (Candan, 2022).

Today's digital libraries result in a transformation enabled by artificial intelligence technology. Integrating AI into digital libraries has enabled automated and faster processes, improved search options, various user experiences, personalized ones, and the control and analysis of big data. Integrating AI in digital libraries aims to improve how users discover and use information resources. This goal is an important component of using technology to benefit humanity, i.e., the design of Society 5.0.

4. Artificial Intelligence (AI) Concept and Historical Background

Oxford Learner's Dictionaries (Artificial intelligence, 2025a) defines artificial intelligence as "the study and development of computer systems that can copy intelligent human behavior". Encyclopedia Britannica (Artificial intelligence, 2025b) defines it as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.". These abilities are associated with mental processes typical of humans, such as the ability to reason, discover meaning, generalize, or learn from experience.

Artificial intelligence is the field of computer science that focuses on creating machines that can mimic and perform behaviors that are the product of human intelligence. Research areas of artificial intelligence include (1) expert systems, (2) fuzzy logic, (3) artificial neural network, (4) evolutionary algorithms, (5) case-based reasoning, (6) image processing, (7) natural language processing, (8) speech recognition, and (9) robotics. These areas are not independent, and in many intelligent systems, two or more AI techniques contribute to problem-solving simultaneously (Asemi and Asemi, 2018). Descriptions of these sub-technologies are below:

Expert systems: Expert systems are advisory computer programs designed to emulate the knowledge and skills of one or more experts to solve a specific problem (İçen and Günay, 2014). As a practical application of artificial intelligence research, expert systems, also defined as knowledge-based systems, have been developed to disseminate the knowledge and skills of experts engaged in tasks such as diagnosis, interpretation, prediction, instruction, design, and monitoring through a computer program. Through the development of such systems, organizations seek improved and consistent performance where relevant expertise is not otherwise accessible (Feather and Sturges, 2003).

Fuzzy logic: Fuzzy logic, a mathematical discipline, is a system that we use in our daily lives and reaches the structure where we interpret our behaviors. Fuzzy logic concepts we encounter in many parts of our lives include very high, high, medium, low, and very low values. Fuzzy sets, which form the basis of fuzzy logic, are the most essential elements of fuzzy systems. The first explanation of fuzzy sets was made in 1965 by Prof. Dr. Lotfi A. Zadeh, originally from Azerbaijan and a faculty member at Berkeley University, in his article “Fuzzy Sets,” published in the journal “Information and Control.” In the classical set approach, elements either belong to that set (1) or not (0). In the fuzzy logic approach, the belonging of elements to that set varies between 0 and 1 (Ödük, 2019). This system, which consists of computer-aided and artificial intelligence-oriented applications that reason in a way that mimics human behavior and the functioning of nature, enables the rating of imprecise sentences that people use in everyday language. For example, vague sentences such as 'a little cold', 'almost wrong' and 'very slow' help solve problems, but it does not seem possible to express them numerically. In such cases, the fuzzy logic algorithm imitates the human mind and produces vague solutions and numerical models (Seher, 2022).

Artificial neural networks: Artificial neural networks, or more simply, neural networks, are new systems and computational methods used for machine learning, knowledge representation, and, finally, the application of acquired knowledge to maximize the output responses of complex systems. A neural network is a data processing model that models how biological nervous systems, such as the brain, process data. It focuses on the neuronal structure of the mammalian cerebral cortex but on a much smaller scale. Many AI experts believe that neural networks are the best and perhaps the only hope for designing an intelligent machine (Dastres and Soori, 2021).

Evolutionary algorithms: Evolutionary algorithms (EA) are computer applications based on evolutionary artificial intelligence that solve problems using processes that mimic the

behavior of living things. As such, it uses mechanisms typically associated with biological evolution, such as reproduction, mutation, and recombination. Evolutionary algorithms operate in a Darwin-like process of natural selection; the weakest solutions are eliminated, while more vigorous, more viable options are retained and re-evaluated in the next evolution. The aim is to arrive at optimal actions to achieve desired outcomes (Cognizant, 2025). These algorithms are understood as population-based stochastic direct search algorithms that mimic natural evolution. Points in the search space are considered individuals (solution candidates) who comprise a population. Their fitness value is a number that indicates their quality for the problem at hand. Besides initialization and termination, which are necessary components of every algorithm, EAs can consist of three important factors: A set of search operators (often implemented as 'recombination' and 'mutation'), an applied control flow, and a representation that maps sufficient variables to viable solution candidates (called 'genotype-phenotype mapping'). Evolutionary algorithm, in its most common definition, is a collective/umbrella term for all variants of (probabilistic) optimization and approximation algorithms inspired by Darwinian evolution. Optimal states are approximated by successive improvements based on the variation-selection paradigm. Thus, variation operators generate genetic variation, and selection drives evolutionary search (Beyer et al., 2002; Bartz-Beielstein et al., 2014).

Case-based reasoning: Case-based reasoning means using old experiences to understand and solve new problems. In case-based reasoning, a reasoner recalls a situation similar to the current one and uses it to solve the new problem. Situation-based reasoning means adapting old solutions to meet new demands, using old situations to explain new situations, using old situations to criticize new solutions, or reasoning from examples to interpret a new situation (as lawyers do) or to construct a fair solution to a new problem (as business mediators do) (Kolodner, 1992). This reasoning experience is an AI problem-solving technique that classifies a collection of 'cases' and relates the existing problem to an experience. This technique is used in many areas, including pattern recognition, diagnosis, troubleshooting, and planning (Gartner, 2025).

Image processing: Image processing deals with the processing and analysis of images for many purposes using various techniques and methods. Applications of image processing range from enhancing the visibility of specific organs in medical images to object recognition for handling by industrial robots face recognition for identification at airports, and image searching in image databases. The applied methods range from low-level approaches, such as boundary and color-based segmentation, to advanced object detection using statistical geometric models. It is generally necessary to combine several techniques to achieve the desired target. Examples are low-level feature extraction, clustering into regions, extraction of shape parameters, and object recognition (Van der Heijden and Spreeuwers, 2007). A real-world image is typically described as a function of two variables, represented as a (x, y), where 'a' represents the brightness at location (x, y). Images often contain regions of interest (ROIs) that represent different objects within the image. Different operations can be applied to these selected regions in advanced image processing. For example, one part of the image can be adjusted to reduce motion blur, while another can be adjusted to enhance color (Young, Gerbrands and Van Vliet, 2010).

Natural language processing: Natural language processing is a computational approach to text analysis that draws on both a set of theories and a set of technologies. Because it is a very active area of research and development, no single agreed-upon definition will satisfy everyone. However, focusing on the standard features of the concept, the following definition may apply: “Natural Language Processing is a theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of

tasks or applications." (Liddy, 2001). In other words, it is a set of methods for making human language accessible/understandable to computers. Today, natural language processing has become part of our daily lives: automatic machine translation is ubiquitous on the web and social media; text classification prevents our email inboxes from collapsing under a deluge of spam; search engines have moved beyond string matching and network analysis to a high degree of linguistic sophistication; dialogue systems provide an increasingly pervasive and effective way to obtain and share information. These diverse applications are based on common ideas that draw on algorithms, linguistics, logic, statistics, and more (Eisenstein, 2018).

Speech recognition: Speech recognition, also known as automatic speech recognition or computer speech recognition, converts a speech signal into a sequence of words using an algorithm implemented as a computer program. Research in speech processing and communication has been primarily driven by the desire to create mechanical models to mimic human verbal communication capabilities. Speech recognition technology has allowed computers to follow voice commands and understand human languages. The main goal of speech recognition is to develop techniques and systems for machine speech input (Anusuya and Katti, 2009). The speech recognition system generally consists of the following modules: acoustic-related model, language-related model, decoder, and acoustic extraction processing module. The working principle of the speech recognition system is to collect the characteristic information in the speech information model, form the acoustic model with the help of training or other methods, make it match the speech model, and then use scientific algorithms to decode such information to obtain the same data information as the original information (Leini and Xiaolei, 2020).

Robotic systems: Robotic systems are among the most important technologies that take technology to extreme dimensions and significantly affect human life. The word robot is derived from the Czech word for slave [rabu]. Today, technological devices that consist of electronic and mechanical parts can control themselves and are programmable; they are called robots. For a machine to be defined as a robot, it must have the ability to perceive sound, color, light, and position and be able to transform what it perceives with these sensors. Robots are products scientists produce and have three essential contents: emotion, thought, and movement paradigms. Robots can be sensors that perceive changes by observing their environment, artificial intelligence that decides how to react to these situations, and practitioners who try to create innovations by making changes in today's world. Robots with all these features can be defined as artificial organisms (Çaka, 2022). The image of the robot as a mechanical object began in the 1940s when the famous Russian science fiction writer Isaac Asimov conceived of the robot as an automaton with a human appearance but devoid of emotions. Its behavior is dictated by a 'positronic' brain programmed by a human to fulfill specific ethical rules of conduct. Asimov would later introduce the term robotics as a science dedicated to the study of robots based on three fundamental laws (Siciliano et al., 2010):

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Artificial intelligence's roots date back to the 1940s, specifically to Isaac Asimov's 1942 short story 'Runaround', which laid out the Three Laws of Robotics, as mentioned above. Asimov's work has inspired many, including cognitive scientist Marvin Minsky, one of the founders of the MIT AI laboratory (Haenlein and Kaplan, 2019). On the other hand, it is also

stated that the concept of artificial intelligence dates back to ancient times, when cultures foresaw future technologies through their epics and sculptures. In Hindu mythology, stories such as Ashoka's wars with robots and the information that gods created human-like robots are included in works such as the Ramayana and Mahabharata. In Greek mythology, Hephaestus and Daedalus created Talos, a giant warrior. Philosophers such as Aristotle, Aquinas, and Descartes explored the nature of thought and the possibility of mechanization/mechanization of intelligence, which has influenced the development of artificial intelligence throughout history (Alalaq, 2024).

Charles Babbage and Ada Lovelace developed the Analytical Engine, an early general-purpose computer in the mid-19th century. Lovelace proposed a machine that could manipulate symbols, which was key to the concepts of artificial intelligence. In 1943, Warren McCulloch and Walter Pitts published a paper that combined logic and biology to offer the first mathematical model of a neural network. Norbert Wiener's 1948 book 'Cybernetics' examined control and communication in machines and animals, which influenced the development of robotics and complex systems. In 1950, Alan Turing's paper 'Computing Machinery and Intelligence' introduced the Turing Test, which is fundamental to assessing machine intelligence and artificial intelligence concepts (Ivezic and Ivezic, 2023).

Turing proposed the Test to distinguish between human and machine responses through a series of questions. If a human interrogator cannot distinguish the computer’s responses from a human’s, the computer will pass the Test. The capabilities required to pass the Turing Test include natural language processing to manage natural and effective communication with humans, knowledge representation to store the information it receives, automated reasoning to answer questions and update the results, and machine learning to adapt to new situations and recognize new patterns. Some researchers have proposed a full Turing test that involves interacting with real-world objects and people. Therefore, for the 'Extended' version of the Turing test, the machine must be equipped with two additional (and vital) capabilities: Computer vision and speech recognition are used to see and hear the environment, and robotics is used to move and interact with the environment (Toosi et al., 2021). The development of the first electronic computers in the late 1940s and early 1950s provided the hardware foundation for artificial intelligence research. The creation of the first computer programs that could perform tasks such as playing checkers or solving logic problems were important steps that paved the way for artificial intelligence (Ivezic and Ivezic, 2023).

The conference at Dartmouth College 1956 was a turning point for artificial intelligence. The Dartmouth Summer Research Project, organized by John McCarthy, Marvin Minsky, Claude Shannon, and Nathaniel Rochester, is generally considered the beginning of artificial intelligence as a research discipline. McCarthy aimed to advance discussions on computers and intelligence by coining the term 'artificial intelligence'. Although the collaboration during the project was insufficient, McCarthy cited important studies such as Information Processing Language (IPL) and Logic Theory Machine by Allen Newell, Cliff Shaw, and Herbert Simon. Despite its shortcomings, the project created a shared vision. This vision was that the concepts of learning and intelligence could be fully defined for machine simulation, simulated machines, and artificial intelligence research could be initiated (Moor, 2006). Funded by the Rockefeller Foundation, this project marked the beginning of AI as a field by bringing together prominent figures such as Nathaniel Rochester and Claude Shannon to explore machines that simulate human intelligence. After early successes such as the ELIZA program and the General Problem Solver, optimism about AI led to increased funding. However, by 1973, skepticism grew due to criticism from researchers such as James Lighthill, leading to a decrease in funding and the beginning of the AI Winter. Progress stalled despite renewed interest and funding from Japan and DARPA (The Defense Advanced Research Projects Agency) in the 1980s. Early AI

systems, such as ELIZA and expert systems, relied on rule-based approaches that limited their effectiveness. Notable successes, such as IBM's Deep Blue defeating chess champion Garry Kasparov, demonstrated the potential and highlighted the field's challenges (Haenlein and Kaplan, 2019).

The period from the birth of 'artificial intelligence' to the 1980s witnessed intense research on this subject. From the programming languages used today to books and movies about robots, this concept has become a mainstream idea. The period between 1979 and 1987 was a period of rapid growth in artificial intelligence, with governments providing funding for research. This period, when deep learning techniques and expert systems became popular, has been called the "Artificial Intelligence Explosion" in history. As mentioned before, the years 1987-1993 were called the Artificial Intelligence Winter, and in this context, funding cuts and stagnation in research were prominent due to high costs and low returns. Both governments and private investors have lost interest in the subject. The period 1993-2011 marks the years when artificial intelligence was revived. Despite the difficulties of the AI winter, there were remarkable advances, including an AI system that defeated a chess champion. The renewed interest triggered an increase in research funding and research. Since 2010, artificial intelligence has become a topic of intense interest in many sectors and fields (Coderspace, 2024).

One of the areas of influence of artificial intelligence research and evolution is libraries. Libraries are institutions that can use technology effectively within their internal processes and services and their relationships with users, society, and the institutions and organizations they coordinate. The relationship between libraries and artificial intelligence should also be considered in terms of education and awareness raising on this issue because the unchanging mission of libraries is to inform and enlighten their service audiences and societies. Libraries, which use artificial intelligence as one of the innovative solutions to improve user experiences and facilitate their processes and services, are among the areas most ready for transformation. The next section of the study will discuss artificial intelligence's role, meaning, and importance for libraries.

5. The Role and Meaning of Artificial Intelligence in Libraries

Today, as part of a system where almost every medium and channel is undergoing digital transformation, libraries are trying to fulfill their mission of providing essential and traditional information using these media and channels. They are also struggling to reduce the digital divide. Libraries mediate developing technologies and promote literacy. Like digital technology, artificial intelligence technologies are also taking over the information field and changing its boundaries (Garnier et al., 2024).

The automation efforts reflected technological advances in libraries worldwide in the mid-20th century. Cataloging was a labor-intensive process that required librarians to index and create extensive card catalogs by hand before the advent of automation. Manual indexing required librarians to meticulously create entries for every item and object in the collection. This method was time-consuming and prone to human error, making it challenging to keep catalog data accurate and up-to-date. Digitization of cataloging strategies with automation aimed to increase performance, speed up operations, and eliminate problems such as the time-consuming maintenance of physical card catalogs. This transition from physical card catalogs to digital databases has facilitated faster and more accurate processing of records, their modification, and auditing when necessary. The digital transformation of cataloging processes has provided rapid updates, improved accuracy, and greater accessibility to records for both library staff and users (Jayavadivel et al., 2024).

The application of artificial intelligence techniques to information and library studies reached its peak in the late 1980s and early 1990s, mainly in the area of expert systems. Most

of the work was either theoretical or resulted in producing a prototype; very few commercial systems were developed. Research covered various topics, including online information retrieval, reference work, cataloging, classification, indexing, summarization, and document selection (Feather and Sturges, 2003). These innovative library systems provide information-based services to library staff and users (Asemi and Asemi, 2018).

The artificial intelligence-based cataloging emergence in the 1980s and 1990s is a notable development. These systems were very advantageous to librarians because they made collection management easier and faster. These systems acted as digital assistants to support users, streamlining processes and improving the user experience. However, it was not until the 21st century that AI truly began to revolutionize libraries with the emergence of sophisticated recommendation engines and virtual reference assistance. Artificial intelligence has transformed modern libraries into dynamic centers of knowledge and innovation. It performs many functions, such as directing users to relevant resources, predicting their interests, and answering real-time questions. Artificial intelligence also fulfills obligations such as providing new opportunities for digitization projects, preservation efforts, and library data-based decision-making processes (Sangapur and Kumbar, 2021).

Given the number of inquiries libraries receive, chatbots have become one of the most in-demand AI tools in libraries for some time now. As the technical barriers to developing these bots have decreased, they are becoming increasingly available. Chatbots can fulfill roles that include, but are not limited to, the following (Cox, 2023):

- Answering routine questions
- Gathering information from users
- Supporting users in routine processes
- Becoming friends with new students

Apart from this, the functions of AI in libraries are very diverse. These include converting collections into machine-readable data and describing them at scale, creating and/or enhancing metadata, knowledge discovery, information retrieval, literature reviews, creating/developing AI-supported text and images, using robots to provide information to users, designing/organizing bright spaces, using robots to manage inventory and organize shelves, supporting students to use AI tools, responding to users' need for AI literacy (including data and algorithmic literacy), and analyzing and predicting user behavior, among many others (Cox, 2023).

The worldwide research and studies on the application of AI and robotics in libraries also show the challenges and obstacles encountered along with various advancements. Jayavadivel et al. (2024) emphasize using expert systems in the 1980s and 1990s to improve library reference services. The author also draws attention to issues such as ethical problems, financial constraints, technological obstacles, and the need for continuous staff training in the application dimension of AI. Vysakh and Rajendra Babu (2019) and Liu (2011) state that AI has been found attractive for various library applications; for example, there has been interest in intelligent agents, but it has not matured to a large extent at the application level. In the late 1990s, advances in natural language processing (NLP) began to enable enhanced user interactions through chatbots and digital assistants (Jayavadivel et al., 2024). Several studies address barriers to technology adoption, such as resistance from library staff, economic constraints, and the need for special education (Suthakorn et al., 2002; Hsiung and Wei, 2013).

However, many researchers and authors emphasize that expert systems and robotics increase productivity and facilitate library operations since they automate routine tasks like inventory management, shelving, and cataloging (Guliciuc et al., 2017; Kaur, 2020). Robots

can improve user experience by assisting in book retrieval and providing access to library resources, especially for users with disabilities (Sastry, 2023; Rakshith et al., 2024). Uzwyshyn (2025) states that with AI, libraries will cease to be passive repositories of information and will become more dynamically connected as interactive, conversational entities. Libraries will evolve to maximize the use of new AI technological possibilities and adapt to the changing information and AI technological landscape. These technologies promise libraries an enriched range of libraries, archive experiences, research, and learning opportunities. New AI services will provide the multimedia and multimodal needs of postmodern or fourth-industrial revolution user expectations.

Despite the potential benefits, researchers highlight the need to overcome socio-structural barriers, including fear of job loss and concerns about data privacy (Sambo and Oyovwe-Tinuoye, 2023; Indraji et al., 2024). While the literature demonstrates optimism regarding integrating AI and robotics into library systems, significant challenges must be addressed to realize their full potential (Vlachos et al., 2020; Cheung et al., 2024). Kim (2025) notes that investing in AI and machine learning may not always be appropriate or realistic for all libraries and archives. However, for many, these technologies offer opportunities to improve services. Library and archive staff must have the knowledge and skills to use these technologies and to be able to identify which technologies will provide the most benefit. Kim (2025) highlights the challenges faced in integrating AI and that library managers and decision-makers have important responsibilities. The author stresses that managers and decision-makers must develop the long-term capacity and acquire the necessary knowledge and skills to achieve the desired results with limited resources. Creating a compelling vision, securing resources, and gaining support from all levels is also important. This process requires the involvement and expertise of staff.

Integration of computer technology in libraries in Türkiye began in the 1970s for basic tasks and developed with the introduction of automation processes in the 1980s (Tonta, 1990; Yılmaz, 1991; Özdem, 2013). However, difficulties such as a lack of standards, trained personnel, and legal frameworks have hampered the development of libraries (Yılmaz, 1991). Initiatives such as the Anatolian University Libraries Consortium and the Scientific and Technological Research Council of Türkiye in the early 2000s facilitated cooperation and digitization efforts (YÖK, 2014). Despite ongoing developments, research reveals a significant lack of awareness and training in AI among librarians, and even some people perceive AI as limited to humanoid robots (Selçuk, 2019; Sarıçoban, 2024). Recent studies show that AI can improve library functions such as cataloging and user interaction, but there is an urgent need for education and training programs to build competence in these technologies (Çuhadar et al., 2024; Kavak, 2024; Polat, 2024). Despite the generally positive attitudes towards AI, library communities in Türkiye face significant challenges such as cost, lack of training, and awareness to fully integrate AI into library services (Çakmak and Eroğlu, 2023; Ergün, 2023). Bayter (2018) points to a different problem in the relationship between libraries and technology. According to Bayter (2018), the number of library users has declined despite technology facilitating library services. The use of libraries by the younger generation, who are particularly interested in the technological age and devices and who use technological devices more actively, has begun to decline. The reason for Bayter's observation can be related to the increase in the possibilities of remote use of libraries to the point of pushing the physical use of the library into the background. Libraries do not only provide access to information. They also have important opportunities such as social interaction, creating learning communities, and access to physical resources. AI and robotics can help libraries deal with this problem in various ways. Personalized services are one of these ways. AI can offer personalized recommendations based on users' interests and reading habits to encourage young people to use libraries more. AI-based

digital assistants can be used in libraries to facilitate users' search for information, provide access to resources, and provide information about library services. Gamification and interaction are other important opportunities. Libraries can offer users interactive and entertaining learning experiences using AI and robotics. For example, they can attract young people's attention with virtual reality applications or gamified learning platforms. In addition, libraries can analyze user behaviors to determine which services are more popular and improve their services accordingly. Robots and AI can also help build communities by organizing seminars, workshops, and events.

6. Conclusion

Technology integration into libraries began in the 1970s with early automation efforts. However, both local studies specific to Türkiye and broader international research show that libraries still face resource constraints and are not fully benefiting from the opportunities offered by AI that staff and user training is needed in this regard, and that libraries face challenges such as these. The historical background indicates that libraries have always been close to technology and have established solid foundations with automation and digitalization projects. However, there may be obstacles from personnel resistance (such as cultural structure, anxiety against innovation and disruption of order, and fear of unemployment), inadequate education, economic constraints, and ethical context.

In addition, there is a significant lack of awareness and understanding of AI technologies among librarians. There are librarians whose perception of AI is limited to humanoid robots, as mentioned before. Despite the strong potential of AI to improve library functions and user experiences, integrating these technologies does not seem mature enough at the application level.

Data obtained from the literature on applying artificial intelligence and robotic technologies in libraries, both domestically and internationally, expresses consensus and common concerns on many issues. The most agreed-upon issue is that artificial intelligence technologies, especially expert systems and natural language processing, have the power to improve library services significantly. Chatbots and digital assistants can improve user interactions, and these technologies will automate routine tasks such as inventory management, shelving, and cataloging, thus achieving efficiency.

Despite the opportunities offered by AI, there is also a great deal of consensus on the barriers to implementing these technologies. Concerns highlighted in multiple studies include resistance from library staff to new applications, financial constraints, and lack of standardization and legal frameworks. Another common theme in the literature is the urgent need for education and training programs for librarians. Many professionals lack knowledge, skills, and awareness in this regard. This issue becomes even more important because the knowledge and skills of librarians are important in user education.

Most libraries' general approaches to AI and robotics are positive because of their opportunities. However, those mentioned challenging issues hinder them from realizing their full potential. So, it is essential to overcome resistance, improve training, and better understand AI's capabilities among library staff. While these challenges are unlikely to be resolved in the short term, several basic steps will likely yield positive results. The following recommendations are summarized below:

- Libraries need to focus on training initiatives to enhance librarians’ knowledge and skills in AI.
- Libraries can organize meetings and campaigns to provide training on various artificial intelligence applications, especially in user interaction.

- Libraries can conduct joint studies and collaborations with technology providers, educational institutions, and other libraries and share information and resources.
- Exploring sustainable budget sources and funds to overcome economic barriers to the integration of AI may be beneficial.
- It will be instructive to prepare standards and guidelines that will guide the application of AI in libraries for compliance and effectiveness.
- Updating the university curriculum in the LIS field of education to consider artificial intelligence technologies will accelerate the development of students who will be future librarians.
- Each library has its unique conditions and opportunities. Since resources cannot be unlimited, priorities in technology selection must be determined strategically, and analysis, including cost, must be done rationally.

Considering these suggestions will significantly increase the efficiency and service delivery of libraries. Ongoing studies on artificial intelligence will solve many problems hindering today, perhaps tomorrow. It is among the predictions that artificial intelligence will provide the basis for much more advanced applications for future libraries. Libraries can develop by taking into account long-term plans and strategies. Therefore, libraries should consider artificial intelligence as a priority among the issues.

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