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EMERGING TECHNOLOGIES AND LIBRARIANSHIP: REQUIRED CONNECTIONS

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Liliane Chaves de Resende[1] and Cíntia de Azevedo Lourenço[2]

ABSTRACT

The fourth phase of the industrial revolution (4IR), marked by technological advances, contributed numerous improvements to human life. At the same time, this technological revolution requires from all domains, including libraries, a change in patterns and behaviors, in order to be able to use the technologies proposed by this revolution. This article presents emerging technologies that can contribute to library practices. A theoretical contribution of the necessary relationships between the area of librarianship and the emerging technologies of the 4IR. The objective is to present challenges in the adoption of these technologies by libraries. This is an exploratory-descriptive research, with a qualitative approach. The bibliographic research method is used to deepen the theme, enabling the construction of a theoretical understanding about the contributions of the adoption of emerging technologies to library activities. An overview of the main emerging technologies used in libraries and how these technologies contribute to library practices is presented. It is considered that the librarian's work can be improved with the use of 4IR's technological resources, making the library a more accessible and significant place. It is recommended that library science courses include the development of these competencies in their curricula, so that future professionals can develop technological skills and competencies that meet the demands of 4IR.

Keywords: Librarian. Library services. Information and Communication Technologies. Emerging technologies. Fourth Industrial Revolution.

[1]Doctorate student in Knowledge Management and Organization
Federal University and Minas Gerais
Email: lilianederesende@gmail.com
Orcid: https://orcid.org/0000-0002-4650-0540
Lattes: http://lattes.cnpq.br/2649366358599878
[2]Dr. in Information Science
Federal University and Minas Gerais
E-mail: cal@eci.ufmg.br
Orcid: https://orcid.org/0000-0002-2172-7300
Latttes: http://lattes.cnpq.br/8222736336322955

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INTRODUCTION

The daily life of the professional librarian has been suffering from the digital transformation of contemporary society, and numerous changes are taking place in the offer of library services and products due to the technological advances of the fourth phase of the industrial revolution. In practice, "the whole world we inhabit is largely technological" and, for most professionals, working without using technological resources is almost impossible (kirsch, 2020, p. 1). Immersed in this technological and challenging arena is the professional librarian.

The trends of the Fourth Industrial Revolution (4IR) are that information management is largely focused on the digital environment and that information is generated in electronic format and in the form of large volumes of data. The production and access to the large volume of this information generated from digital environments drives technological development, requiring innovations in the provision of services and products offered by traditional libraries. Above all, regarding information management, whose tendency is to be focused, especially in the digital environment, in electronic format, and in large volumes of data, coming from the printed medium or already "born" in the digital environment.

The central idea of 4IR is the mass use of Information Technologies (ITs) to manage this main input that is information (Ascoli; Galindo, 2021). In this sense, it is necessary for library professionals to take advantage of the opportunity to use technologies as an important tool in the execution of their services and professional practices. And it is imperative that this professional develops appropriate technological skills and abilities to adapt to these demands of this market, also assuming as a mission the leadership in the management and use of digital information (Silva, 2020, p. 11).

The use of technological resources to perform their professional activities is no longer a choice, but a necessity. The 4IR imposes new paths to be followed for libraries and librarians, representing an opportunity for innovation in performance (Hussain, 2020).

However, the challenges of the modern world for the professional librarian are numerous and "the 4IR requires the innovation of orthodox services and products currently offered by the traditional library" (Galindo, 2023, p. 6). Like any other profession affected by digital transformations, it is necessary for these professionals to redefine and innovate their profession, seeking possible solutions to stand out in this complex and changing scenario.

To fill these gaps related to the impositions presented by the 4IR, a new profile of the professional is required for the librarian profession. One of the great challenges is to

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balance technical, cultural and humanistic training with a solid technological training, aligned with the challenges of a digitally interconnected global market (Paletta; Moreiro-González, 2020).

In a promising perspective, innovation will take place with structural changes in the curricular training of future professionals, adapting new functions related to the use of technological resources that enable better management of digital information. Hussain (2020) also states that developing new professional skills related to cutting-edge technologies and artificial intelligence will allow librarians to further reaffirm their profession before society.

In view of the above, the main objective of this article is to present the contributions of emerging 4IR technologies to library practices, presenting driving technologies for libraries and describing opportunities and challenges faced by libraries in adopting these technologies.

The study is a *quasi-systematic review*, applying a qualitative approach to the bibliographic material collected. Following this parameter, in addition to the contextualization of the theme, the methodological procedures adopted, a theoretical review developed and, finally, the final considerations are presented.

This study provides a starting point to offer the reader relevant and more detailed publications on the emerging technologies used in library practices, presenting a scenario of application of these technologies in libraries.

METHODOLOGY

This is a review article that uses a qualitative approach, based on bibliographic and exploratory research. Scientific articles are used to present a theoretical contribution on the subject, as defined in Severino (2017, p. 108).

To support the main concepts of this research, a literature review was carried out. The search, consultation and selection of literature was carried out using the *GOOGLE* Scholar database because it is a broad database and indexed by the Portal of Journals of the Coordination for the Improvement of Higher Education Personnel (CAPES).

Scientific articles, articles published in conferences and review articles, books and book chapters that addressed Library and 4IR terms were included in the study. A Boolean search strategy was applied, using a time frame between 2015 and 2025 through the following keywords presented below:

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SEARCH EXPRESSION 1)

"Library Science" AND (LIS OR "Library and Information Science" AND (library or librarian) AND (Library services OR library practices) AND "Emerging Technologies" AND ("Fourth Industrial Revolution" OR "Industry 4.0" OR I4.0 OR "Industrial revolution" OR "4th Industrial Revolution" OR "Technological Revolution")

SEARCH EXPRESSION 2)

("Library Science" AND (LIS OR "Library and Information Science")) AND ("Artificial Intelligence" OR "Robotics" OR "Internet of Things" OR "Big Data" OR "Data Analytics" OR "Cloud Computing" OR "Augmented Reality" OR "Gamification") AND "Emerging Technologies" AND (curriculum OR curricula)

SEARCH EXPRESSION 3)

"Library Science" AND "technology skill"

The findings of the study aimed to examine the emerging technologies present in library services, describing trends and challenges that these technologies have brought to the library environment.

The inclusion criteria for scientific articles included those related to the theme of the research and those that, after reading the title and abstract, did not contribute to the development of the research. *Snowballing* was used to supplement the articles retrieved from the databases based on the reference lists of the relevant articles.

INFORMATION TECHNOLOGY IN THE CONTEMPORARY CONTEXT

According to Castells (1999), Information and Communication Technologies (ICTs) are present in all spheres of human life, and that a new society has emerged and has become dependent on Information Technology (IT) to generate wealth, exercise of power, creation of an organizational culture based on information, knowledge and the provision of services. Because of this, technological momentum has emerged with the need for greater qualification on the part of professionals working in the job market.

Rocha, Jucá and Silva (2019) explain that in pre-industrial society, power was concentrated on land ownership and control of the agrarian workforce. In the industrial phase, power was concentrated in the production of industrial goods and those who owned capital. In the post-industrial society that is based on the provision of services, power has

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been transferred to those who control information and make use of it as a competitive advantage. The provision of services has risen and has become predominantly virtual, with these services being performed through the use of ICTs controlled by a set of software and "intelligent" machines. These changes clearly affected the entire contemporary society, causing changes in the social structure of work. (Rocha; Jucá; Silva, 2019)

Throughout the implementation of digital transformations in the workplace, this scenario has been expanding, bringing aspects such as location and time independence. Information has become the main capital of organizations and the IT employed contributes to a greater and faster production than occurred in the industrial era. The post-industrial phase focuses on a globalized market, emphasized by the use of information through technological artifacts and the world wide web, the internet.

IT, together with the internet, in the last 50 years, have become the essential technological resources for the generation and commercialization of products and services and for the generation of data, information and communication. Consequently, most human activities migrated to the digital environment, also changing economic, social and cultural activities. The trends are that, through ICTs, the technological environment unifies everything, directly linking the physical world to the virtual world, where people, computers, networks and objects can access and control their environment from anywhere and at any time (Cascio; Montealegre, 2016).

As a result, the digital revolution of the post-industrial era, called the fourth phase of industrial evolution, has been transmuting the human being into a hybrid being, where human and technology are part of the same living organism. Ubiquitous computing is emerging and dominating almost everything, controlling access to anyone, at any time, and from anywhere. Expanding more and more, it is minimizing the boundaries of the physical world to the digital world. (Schwab, 2016)

The technological resources that are used from the fourth phase of the industrial revolution are evolving very fast, becoming available, accessible, processed, transferred and stored in a transparent and borderless way, creating new virtual spaces. For Silva et al (2018), the contemporary post-industrialization society is immersed in a digital culture arising from a global connection, influenced by the technological revolution and the immediate interactivity provided by digital resources.

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THE FOURTH INDUSTRIAL REVOLUTION AND ITS TECHNOLOGIES

History has recorded movements driven by major technological changes that have revolutionized the human experience in several dimensions. Briefly knowing how this occurred is essential to perceive and analyze the moment in which society finds itself. These movements were characterized by phases or revolutions considered disruptive, profoundly impacting organizations and people's lives.

The first phase or industrial revolution began in the eighteenth century in Europe and America when the steam engine was invented for use in the iron and textile industries. At that moment, the race to achieve greater production began. The second industrial revolution occurred before World War II, when steel, oil, and electricity were used for mass production. The period was marked by several developments including the telephone, light bulbs, phonograph and the combustion engine. The third industrial revolution, on the other hand, occurred in the early 1980s, with the advancement of digital technology, marked by the advent of the popularity of personal computers, access to the internet and the development of communication and information technologies. (Chigwada; Chisita, 2021)

The fourth phase of the industrial revolution (4IR) occurred from 2011 onwards, continuing the three previous industrial revolutions, and situated as post-industrialization. In this phase, the rapid and uncontrollable development of a set of emerging technologies is concentrated, mainly through the development of technologies in the area of Artificial Intelligence (AI) and Internet of Things (IoT) (Holland, 2020; Hussain, 2020).

Initially conceived in Germany, this movement was the result of economic policies adopted by the association of representatives of companies, government and academia aimed at strengthening the German manufacturing industry, considered the most competitive in the world and a global leader in the manufacturing equipment sector. The German government joined the initiative, agreeing to the strategies for the development of highly revolutionary technologies, proposed by the industrial sector, thus influencing most professional and scientific segments around the world since then.

Some of the most relevant technological advances associated with the Fourth Industrial Revolution (4IR) are linked to emerging technologies in the digital sphere, used by organizations to offer services. The following is a list of the main emerging technologies considered to be drivers of the fourth phase of the industrial revolution in the view of several authors and which are directly related to library practices:

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- *Artificial Intelligence (AI):* Systems that simulate human intelligence to automatically extract and analyze data. It includes features of other technologies such as machine learning, deep learning, pattern recognition, and others. A well-known example is Chatbots and virtual assistants. (Ajakaye, 2021)
- *Internet of Things (IoT):* A network of interconnected devices that collect and share data. It is associated with the concept of the virtual world or web of things, where "things" (devices, software, users) interact with each other autonomously, enabling an interaction between man and machine. An example of this technology includes inventory trackers, room controllers, etc. (Igbinovia, 2021).
- *Blockchain:* Immutable ledger technology for digital security. It ensures the transparency and authenticity of digital asset transactions. "Blockchain ensures authenticity of digital files", enabling them to "maintain their authenticity and be trustworthy" (Malgwi; Otubelu; Sadiq, 2023, p. 5).
- *Augmented/Virtual Reality (AR/VR):* It is a technology that superimposes virtual elements as if they were real. These technologies provide the user with an immersion where the physical and digital worlds converge. They make environments immersive, focused on virtual labs, experiments, and complex subjects, focusing on optimizing student learning. AR/VR transforms learning in libraries, improving the engagement and loyalty of its users. (Patel *et al.*, 2022).
- *Big Data Analytics:* It is a technology that uses an immense amount of data, with characteristics of large data capacity and various types, available online for analysis and discovery of patterns and knowledge. It makes use of other technologies such as Data Mining and Data Analysis to optimize data-driven decisions. (Duan *et al.*, 2019).
- *Robotics:* It is a branch of engineering and computer science that involves the conception, design, manufacture, and operation of robots, which are autonomous machines aimed at performing repetitive tasks. It proposes the execution of activities in a cooperative way between robots and humans, without safety restrictions. In libraries, robots are used for various functions, navigating printed materials in real time through a web interface. (Tella, 2020; Ehoniyotan; Amzat, 2023)
- *Cloud Computing:* It is a technology that uses remote internet and centralized servers to maintain data, software, and applications. Provides storage and remote access to data, applications, and infrastructure. The cloud computing services

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offered are of high cost, efficiency and elasticity for the user and include hardware, software, infrastructures, systems development environments, etc. Libraries can link all of their services to the cloud, and all of these services facilitate collaboration between libraries. (Nepali; Tamang, 2022; Ehoniyotan; Amzat, 2023)

- *3D/4D printing:* It is a technology that focuses on the creation of physical objects for prototyping, being developed from the technology of layer-by-layer manufacturing of structures in three dimensions directly from computer-aided design. 4D technology uses 3D technology to print living three-dimensional objects in various areas, such as skin treatment, biotechnology, ultrasound, prosthetics, etc. In libraries, 3D printing supports *makerspaces* (collaborative spaces to create and share knowledge). (Igwe; Suliman, 2022)
- *Social Media:* These are technologies that facilitate collaboration and networking for people. It makes human interaction accessible through platforms, forming a rich environment for the exchange of resources and knowledge. In libraries, social networks expand the dissemination of library services and promote connections and a global network for library professionals and users. (Opele, 2023).

The technological trends presented by all these researchers demonstrate that the librarian profession can innovate its performance and obtain new job opportunities. Through a range of new services, including "real-time reference services, easier-to-consult library materials, consortium procurement mode, provision of ICT training facilities, and intrapreneurship" (Opele, 2023, p. 8).

LABOR MARKET IN THE FOURTH INDUSTRIAL REVOLUTION

The 4IR involves all segments of the labor market, causing challenging impacts in all sectors, especially industrial and service provision, and in all areas that permeate society, especially in the economic, social, and cultural (Kuzior *et al.*, 2022). For Oztemel and Gurserv (2020, p. 128) "Industry 4.0 defines a methodology for social transformation" and, from this perspective, everyone will be affected, both people, organizations, and even the technologies themselves. In order for professionals to be able to stand out in this scenario, it is necessary to develop technological knowledge to be able to act in the production, storage and circulation of information concomitantly and dynamically (Rocha; Jucá; Silva, 2019 p.2).

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The technological skills previously acquired by professionals throughout their lives are not enough to maintain jobs at 4IR. In addition, new and distinct skills and abilities are being needed in addition to the traditional ones, especially IT-related skills. The trend is that the most valuable skills to be developed for the future will be those in which human characteristics should complement rather than compete with automation, regardless of which area it is (FYA, 2017).

In this scenario, defining a methodology that can outline social transformation so that both organizations and people can connect to this environment is an imminent factor and begins, mainly, in the formation of human capital.

CHART 1 - IT areas considered Important and Concerning in 2023

IT AREAS	2023	2022
AI / Machine Learning / Expert Systems	**1 (38.8%)**	**3 (22.6%)**
Analytics / Business Intelligence / Data Mining	**2 (35.1%)**	**1 (36.3%)**
Security / Cybersecurity	**3 (29.1%)**	**2 (32/3%)**
Staff Development / Training	**4 (20.0%))**	**4 (18.7%**
Disaster recovery/continuity planning	**5 (18.3%)**	**8 (15.9%)**
Data Integration/Quality	**6 (17.9%)**	**9 (15.4%)**
Cloud computing (e.g., SaaS, PaaS, IaaS, etc.)	**7 (15.8%)**	**6 (17.4%)**
Legacy Applications - Replace/Replatform	**8 (15.6%)**	**10 (12.4%)**
Innovation/Disruptive Technologies	**9 (14.7%)**	**5 (17.8%)**
Application software developer. /Maintenance	**10 (14.4%)**	**10 (12.4%)**
Application and data integration	**10 (14.4%)**	**17 (11.3%)**

Source: Adapted from Johnson *et al.* (2023) * Values in parentheses refers to item/Year classification

A study conducted by SIM (*Society for Information Management*) in 2023 on the IT trends considered most important and worrying (Chart 1) that had a greater focus on investments for organizational management, point to a greater adherence to the main areas of IT used in organizations, with greater emphasis on Artificial Intelligence and Machine Learning technologies (Johnson *et al*., 2023).

The scenario of the labor market of the future imposes survival conditions for any professional, and it is necessary to develop skills through knowledge of several other areas beyond the base. According to FYA (2017), more than 60% of students are entering the job market in professions that are at risk of being or are already being replaced by technological advances and automation. And this replacement could occur within the next 10 to 15 years. The report recommends that a good strategy is to emphasize the development of digital competencies and skills at the beginning of students' career path. That way they can concentrate more and develop what they need to secure a position in the job market.

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Digital literacy skills are required in almost every field of work. Graduates are expected to be able to select, synthesize, and leverage information in decision-making. Along with these skills, being able to think objectively and holistically, collecting data and evaluating it to support the decision-making process is also fundamental. Therefore, having these skills is has a competitive advantage in the job market. (Khuraisah; Khalid; Husnin, 2020)

Hussain (2020), when researching the impacts of 4IR on the labor market, concluded that 4IR was reduced and almost affected many professions, and libraries are also one of them. Part of library practices are already transforming and becoming automated, and AI and IoT resources are being used for this.

In the 4IR scenario, it is also noticeable that, in this (re)evolution, despite favoring economic development, it leads to precariousness and devaluation of the human workforce, especially those who do not have or are poorly qualified for this work environment to the detriment of the highly qualified. (Cascio; Montealegre, 2016)

Highly skilled human capital began to be needed as the computer became part of business operations. Predominantly repetitive and routine jobs began to be replaced by the use of ITs. But Frey (2019) points out that, even so, with the Industrial Revolution introducing mechanization technology without the need for human capital, general-purpose technologies needed skilled operators.

The need for qualified human capital was also due to changes in the labor market due to technological progress. Frey (2019) also identified two types of technological progress adopted from an economic perspective: 1) Technologies that replace work, making labor positions and professional skills redundant; 2) Enabling technologies, increasing people's productivity in relation to existing tasks or new jobs. The first concerns the use of technologies to perform tasks that were previously performed by people with certain skills. As an example, the author cites how it occurred in the rise of the industrial phase where light bulbs were replaced by the advent of electricity and electric street lighting. And the second is the use of technologies to facilitate the execution of activities by people as a means of maximizing productivity, even generating new professions. A good example of this is the increased productivity of the work performed by qualified professionals (engineers, architects, etc.) when using computer-aided design software.

What the job market demands from entry-level professionals is that they have ICT-related skills, self-learning capacity and information skills that combine with analytical and

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critical skills. To do this, universities need to be ready to play a key role in preparing and developing these skills. (Khuraisah; Khalid; Husnin, 2020).

When it comes to the librarian profession, the use of emerging technology has substantially altered the offer of library products and services. What used to be centered on collections in the vicinity of the library's physical space, centered on documentation and literary publishing, now, with the migration to online services being developed through the use of the computer and internet connection, the librarian's work is largely centralized in this environment. Pierre-Robertson (2023) states that after the COVID-19 pandemic, the librarian's workspace "is totally virtual" (p. 3) and has been intensified in the face of several challenges brought about by emerging technologies. Almost all tasks related to information skills tend to be performed digitally. Therefore, it is essential that the professional librarian is qualified to master the use of ITs, expanding his profession and maintaining his value in the management and maintenance of digital information.

THE LIBRARIAN PROFESSION AND THE FOURTH INDUSTRIAL REVOLUTION

In the area of librarianship, the job market in Brazil is currently largely concentrated in the traditional market, composed of public, academic and school libraries, cultural and information centers. However, there are indications that librarians have been expanding their field of work to several other places besides the library, from bookstores and publishers to private companies, banks and digital companies that work with large and specific databases in a digital environment (Tabosa; Félix, 2019).

The emerging technologies of 4IR have given rise to new fields of professional activity, including for professional librarians, giving rise to new practices, knowledge and skills. In Msauki's (2021) view, the greatest impacts caused by the 4IR refer to the mass development of emerging technologies that can be disseminated in the library. And to keep up with these changes, it is crucial to understand these technological trends, incorporating them into education in Library Science (Mwaurah; Gathama; Namande, 2024).

Goel (2022), list a list of technologies considered trends for library services and practices:

> "emerging trends and technologies in library and information services include, but are not limited to, library automation, digitization, institutional repository and digital library services, consortium-based services, QR Code implementation, EM, and RFID, open access, outreach programs, reference management, open science, virtual/digital reference services, ask the librarian, content management, CAS/SDI services, profiling system, discovery services, Web 2.0 and 3.0-based services, use

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> of social media, green library concept to help with classification/accreditation, remote login, cloud computing, mobile-based library services, use of expert systems and robotics, Internet of Things, augmented reality tools, and virtual reality tools, semantics, artificial intelligence, and machine learning." (Goel, 2022, p. 493)

Because of technological advances, librarians will be called upon to play a greater role in the development of services, programs, educational offerings, systems, and applications that focus on quantitative information. Libraries will manage, store, and preserve datasets in real time. (Vijayalatha, 2023)

Mwaurah, Gathama and Namande (2024) also presented in their research new library responsibilities, functions and services that librarians can have and perform with the use of emerging technologies (BOX 2):

TABLE 2: Library responsibilities, functions and services in the 4IR

RESPONSIBILITIES	FUNCTIONS	SERVICES
- Assist in decision-making about access to content; - evaluate research produced by the institution; - innovative use of technology to support learning; - help researchers discover and access content; - assist authors in submitting articles for publication; - scientometric research to meet institutional needs; - promote the use of content in the institution; - catalog and process metadata; - function as auditor; - report the use of the content; - assist authors in applying for grants; - act as a link between the institute and research	- information manager; - information consultants/trainers; - system and network managers; - print and electronic media information brokers; - educator; - site manager; - database manager; - policy maker; - business manager; - image creator; - Knowledge Manager	- library automation; - digitisation; - digital library and institutional repository services; - consortium-based services; - implementation of QR Code; - RFID services with IoT; - open access; - dissemination programs; - reference management; - open science; - virtual/digital reference services; - content management; - CAS/SDI services; - profiling system; - discovery services; - Web 2.0 and 3.0-based services; - social media use; - Use of the concept of green library; - remote login; - cloud computing services; - mobile-based library services; - use of expert systems and robotics; - Internet of Things Services; - augmented reality tools and virtual reality tools; - Services with Artificial Intelligence and Machine Learning.

Source: Adapted from Mwaurah, Gathama and Namande (2024)

To sustain these new roles and functions it is necessary for them to also have a variety of skills, including IT, communication, management, learning and teaching skills to

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run library services effectively and efficiently. For the authors, "it is crucial to understand the various emerging ICT trends in the LIS profession in order to renew their education and incorporate it" (Mwaurah; Gathama; Namande, 2024, p. 146). However, there are several challenges imposed on librarians in relation to the management and retrieval of information and activities related to the organization, classification and indexing of large volumes of data through these technologies (Milagre; Segundo, 2015).

In their research on the concept of 4IR and its main technological advances, Isiaka (2024) and other researchers listed several services that are facilitated by emerging technologies, enhancing the user experience, improving efficiency, and becoming even more relevant in the digital age. Among the services presented by the authors, the following stand out: the use of *AI Chatbots* : libraries are using *AI-powered chatbots* to provide instant assistance to users, answering common questions and helping with basic queries; Personalized recommendations: AI algorithms analyze user preferences and loan history to offer personalized reading recommendations, enhancing the user experience; Automated cataloging: AI can automate the cataloging and classification of materials, streamlining the process of adding new items to the library's collection; It has improved services for automated indexing of collections and content, automatic generation of abstracts, semantic mapping of themes, automated indexing of collections, intelligent correlation of documents (via machine learning algorithms), semantic mapping of themes for non-linear organization of information, automatic generation of abstracts to optimize academic research, in addition to features such as plagiarism detection, personalized recommendation of materials (based on history of users) and instant translation of international works. These innovations not only elevate technical accuracy, but also extend the accessibility and operational efficiency of modern libraries; utilizing IoT technologies to improve workflow and services, organize or integrate resources and systems to achieve service innovation, and also connect library resources and services with even more people; libraries implement IoT devices to create smart spaces that adjust lighting, temperature, and other factors based on user preferences and occupancy; use IoT sensors to track the occupancy of study rooms and living areas, helping to optimize the use of space and social distancing if necessary; Using IoT resources, it is possible to integrate different types of existing technologies, such as AI, database, data collection, and cloud systems to implement an online library supply chain.

In close relationship with the user, the librarian plays a decisive role in promoting literacy, supporting education and facilitating access to information. 4IR's digital

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transformations brought this professional's main focus on using cutting-edge technologies and advanced data analysis skills to provide innovative services tailored to user needs. However, the role of the librarian has also evolved, with a greater focus on the needs of library users. Increasingly occupying itself with issues related to diversity, equity, digital inclusion, social justice, sustainability and community engagement. It aims to ensure that library resources and services are accessible to all members of the community. (Acharjya, 2024)

Therefore, to meet the demands of this scenario, it is extremely important that the librarian profession undergoes a remodeling process. Remodeling the librarian function to adapt to the offer of new services and informational products in the contemporary labor market is not optional. With technological advances, there is a demand for new skills and competencies for these professionals and a critical reexamination of the curriculum becomes inevitable. (Nkamnebe; Ogwo, 2021)

The librarian profession has been the target of constant reflections and the class has sought new roles to keep up with this reality, including questioning what profile is required of these professionals today (Amaro, 2018). To achieve better technical recognition and obtain good academic training, librarians need to get out of their comfort zone (Souza, 2018). Ascoli and Galindo (2021) agree with this statement when they state that the librarian profession does not appear in the ranking of professions on the rise in 2020.

In a joint reflection with several librarian professionals, Amaro (2018) concludes that the biggest problem of the profession is the absence of real training during graduation in aspects related to technologies and their resources, especially emerging ones. Therefore, "it is necessary that the training of librarians be under constant review". (Amaro, 2018 p.36)

For Prudêncio and Rodrigues (2023), the provision of services in the library is going through a paradigm transition. And to accompany this journey towards the future of library services, it is necessary to redesign the profession and adapt to the new. However, one of the most critical bottlenecks still focuses on the deficiency of technical skills of its professionals, also generating a challenge for librarian training schools (Msauki, 2021; Rahmah, 2020).

Ascoli and Galindo (2021) believe that in order to achieve a new format for the librarian profession, it is necessary to overcome the limits that prevent its evolution and follow the trends that emerge in the field of information. "The lack of appropriation of emerging trends in the area and the lack of skills to use new technological tools is

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notorious, which, in turn, prevents the job market from viewing librarians outside their traditional activities of keeping and preserving books in libraries." (Ascoli; Galindo, 2021, p.11)

Prudêncio and Rodrigues (2023) clarify that the 4IR work environment substantially changes social organization and that librarians should be more deeply involved in the improvement of new skills and competencies related to new practices and knowledge resulting from the use of emerging technologies.

Librarianship, as a scientific discipline, needs to evolve and expand its field of action beyond the physical space of the library or information units, advancing into the 4IR environment. To do this, it is necessary to be able to respond to its dynamic and rapidly changing rhythms. Otherwise, because of the tendency to resist evolving professionally, this professional may be considered irrelevant to the market and, consequently, to society (Ascoli; Galindo, 2021; David-Wes, 2021; Baby; Wedge; Café, 2018).

For Cherinet (2018), librarian skills for the twenty-first century are considered enabling skills and involve a mixture of several skills. The ability with information technology, for example, was integrated into his skills so that he has the technical competence to manage the information and knowledge from an infinity of data generated on the network, thus achieving better results in the information literacy of users.

CHALLENGES FOR THE LIBRARIAN PROFESSION IN 4IR

Despite the need for libraries to reinvent themselves by immersing emerging technologies in their practices and services, their relevance has not diminished and remains essential; however, his performance continues to be questioned as a way to reassess his role in the 4IR. (Marwala, 2022)

The most recurrent challenges in the literature on libraries' adoption of emerging technologies of the Fourth Industrial Revolution (4IR) include digital equity. Libraries in marginalized communities often lack basic infrastructure, such as stable internet access and adequate devices, widening the informational and digital divide (Ubogu, 2021). In addition, cybersecurity emerges as another critical obstacle, as the protection of user data and intellectual property from attacks requires continuous high investments in robust systems, resources that are scarce in libraries that have limited funding (Amoah; Minishi-Majanja, 2023; Fourie *et al.*, 2024).

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Another challenge is the lack of technical skills and competencies for professional librarians. The rapid technological evolution demands constant updating of these professionals. According to Olorunfermi and Adekoya (2023) "librarians need, by necessity, albeit in an uninteresting way, to adapt to new technologies. Many have difficulty dealing with technological changes."

Financial sustainability is another barrier to the adoption of emerging technologies, as technologies such as IoT, AI, and RFID require high deployment and maintenance costs, also challenging libraries with restricted budgets (Babu, 2022).

Finally, ethical and cultural issues are also other challenges that complicate the adoption of these technologies. The use of AI and algorithms can reinforce existing biases, while the integration of global technologies does not always respect local contexts, requiring sensitive adaptations. In carrying out their duties, librarians must be prepared to deal with ethical considerations surrounding AI by using it as a source of inspiration and guidance, ensuring that human context and needs remain central to their decision-making processes (Fourie *et al.*, 2024; Hanson, 2023).

Babu (2023), presented in his research a list of challenges that libraries are facing in the implementation of emerging 4IR technologies:

- *The inadequacy of investments* to implement new technology-based library services;
- *Little awareness* of the importance of the library and its services;
- *Lack of motivation among librarian professionals* for the development of library and information services.
- *Lack of overall infrastructure* required to implement the system.
- *Lack of qualification of library staff* in the knowledge of modern tools and technologies;
- *Lack of training facilities* for professionals.
- *Privacy Concerns* - Privacy Policy.
- *Free Wi-Fi facilities are required*.
- *Website/mobile library apps are required*.
- *Signature models with simplified authentication/access*.
- *Lack of standardization in library automation*.
- *Access, usage, and usability management issues*.
- *Challenges in digital conservation and preservation practices*:
  - Rigidity in publishers' policies and data formats.

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- Lack of ICT strategies and policies.
- Lack of management support.
- Copyright/IPR issues.
- Language and literacy.
- Storage media.

Many challenges were also pointed out by Valjašková (2019), Garoufallou and Gaitanou (2021), Mwaurah, Gathama and Namande (2024), include issues of integrating these services with legacy systems, updating features, problems with data quality, ensuring data security, data privacy and security, ability to adapt other new technologies, insufficient infrastructure for storage, lack of standardization and quality of data, need for training in data analysis, need for new skill sets among library professionals.

In this sense, since the 4IR has become a moment of disruption for libraries, librarians can take advantage of this moment to create opportunities to expand the functions of the library, disseminating knowledge regardless of geographic space and making it more meaningful and accessible to all users. At 4IR, no sector was immune to its impacts, so librarians can and need to stretch their professional development to make technology their best work tool. (Marwala, 2022)

OPPORTUNITIES AND TRENDS OF EMERGING TECHNOLOGIES BY LIBRARIES

As previously demonstrated, the emerging technologies of 4IR offer transformative trends and opportunities for libraries. These opportunities include the personalization of services via AI and Machine Learning algorithms, allowing for accurate resource recommendations, improving the user experience (Ajakaye, 2021; Ubogu, 2021); use of mobile platforms and applications, such as OPAC, facilitating remote access to collections, expanding them in geographic reach (Malgwi *et al.*, 2023); process automation optimizes operational efficiency by freeing up librarians for strategic activities, electronic resource management software, radio frequency identification (RFID) software, and cloud computing technology used to track access usage and authorization, track library inventory and theft, and provide virtual storage space for library electronic resources, respectively; the adoption of these technologies in library service delivery results in 24/7 access to necessary information, efficient tracking and management of library materials, increased collaboration and sharing of resources between libraries, and increased research productivity at the

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institution (Mwaurah, Gathama, Namande, 2024; Malgwi *et al.*, 2023). In addition, augmented and virtual reality tools renew educational programs, creating immersive environments for learning. (Horsfall; Opurum, 2023)

Network collaboration through digital consortia and cloud computing allows resources to be shared between institutions, reducing costs and expanding collections (Mohammed *et al.*, 2022; Fourie *et al.*, 2024). Finally, technologies such as blockchain guarantee the authenticity of digital collections, preserving cultural heritage (Babu, 2022).

Regarding the trends in the adoption of emerging technologies, the central trend is the integration of technologies such as AI, robotics, and IoT, including the use of chatbots for instant user service; IoT also stands out for the connection of devices to monitor the use of spaces and prevent theft (IGBINOVIA, 2021); and the use of Machine Learning algorithms for data analysis and curation purposes (Ajakaye, 2021; Malgwi *et al.*, 2023).

Mobility is also another trend, with libraries developing apps and services via WhatsApp for remote communities (Sethy, 2018; Ubogu, 2021). Augmented reality (AR) and gamification gain space in information literacy programs, engaging young users (Horsfall; Opurum, 2023; Patel *et al.*, 2022).

Finally, technological sustainability emerges, with initiatives such as "green libraries" and the use of renewable energy for digital infrastructures (Horsfall; Opurum, 2023; Babu, 2022).

RECOMMENDATIONS

For Ascoli and Galindo (2021), the biggest challenges focus on a disconnect between the training offered in Library Science courses and the demands of the contemporary labor market. Training needs to be more flexible, interdisciplinary and integrated with the demands of society, with a focus on the development of skills in information and technology.

Moving in this direction, researchers such as Ckuwusa (2024), Isiaka *et al.* (2024), Hahzad, Khan and Iqbal (2024), Semeler *et al.* (2024), Garoufallou and Gaitanou (2021), Ridley and Pawlick-Potts (2021) suggest that the following emerging technologies and their applications should be included in library and information science curricula:

- *Artificial Intelligence (AI) and Machine Learning:* Include concepts such as natural language processing, recommendation systems, data analytics, and task automation.

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- *Virtual Reality (VR) and Augmented Reality (AR):* Explore how to integrate VR and AR to create immersive experiences, virtual tours, and interactive learning environments.
- Internet of Things (IoT): Teach students how to deploy IoT devices, analyze data generated by IoT systems, and manage IoT environments.
- *Blockchain:* Introduce blockchain concepts and their applications, such as digital asset management, decentralized publishing, and digital content authentication.
- *Social Media and Online Engagement:* Teach students how to create engaging content, utilize social media platforms effectively, and analyze social media metrics.
- *Privacy and Cybersecurity:* Include training on privacy laws, incident response procedures, and data protection best practices.
- *Digital Humanities:* Introduce digital humanities concepts such as digital storytelling, data visualization, and text mining.
- *Algorithmic and AI Literacy:* Enable students to understand programming logic to validate and adjust generated codes. Understand and critically interact with AI systems and algorithms, highlighting the unique role of libraries in this process. Libraries should promote literacies and democratic access to information, they should lead educational initiatives and critiques about algorithms, mitigating risks such as bias, opacity, and social inequalities. Highlight the importance of algorithmic literacy (understanding programming logic) as a critical skill for professionals in the field.
- *Maker Spaces and Robotics:* Teach students how to create and manage *maker* spaces, lead robotics workshops, and integrate *maker* activities into library programming. This can foster innovation and a culture of learning.
- *Cloud Computing and Collaboration Tools:* Emphasize the use of cloud-based platforms, collaboration tools, and project management software. This can facilitate teamwork and remote access to resources, can offer scalable storage and distributed processing for large *datasets* , unlimited storage of e-books, journals, and user data, automated backup, and disaster recovery.
- *Large Data Sets and Data-Driven Decision Making:* Include training in data collection, analysis, and interpretation. This can help librarians optimize resource allocation and improve the user experience.

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- *Big Data and Data Analytics:* involves large volumes of data with high velocity and variety. *Data Analytics* is the process of analyzing this data to gain insights, using techniques such as descriptive, diagnostic, predictive, and prescriptive analysis. Librarians can use *Big Data* technologies to analyze user behavior and optimize resources. With *Data Analytics*, it is possible to identify patterns of resource use, allowing optimization of collections and services.

It is important to emphasize that it is urgent to insert this knowledge in the curricula of undergraduate courses in Library Science to facilitate the entry of young professionals into this job market. Through the use of technologies, library services tend to be automated, thus providing more time for library staff to train and make more strategic decisions.

FINAL CONSIDERATIONS

This article presented emerging technologies that contribute to library practices. From a qualitative, exploratory and descriptive approach, it made use of a literature review to outline a theoretical contribution and describe concepts, technologies, opportunities and challenges faced by libraries in the adoption of these technologies in the contemporary labor market of the 4IR.

The conclusion is that technology is included in the execution of almost all activities of human life. There is no longer any way not to use this resource as the main work tool for any professional, whether at work, in education, in research, in social life, almost anywhere. Especially in the professional environment, it is almost impossible to perform tasks without making use of technology.

In the context of library services, technology serves as an indispensable channel for numerous improvements for professionals in the field. The application of this tool has the potential to optimize and refine the execution of these services. Proficiency in technology will not increase the workload of these professionals. On the contrary, the trained librarian will be much more valued by society and will be able to perform his duties with greater safety and efficiency, thus reinforcing the profession's commitment to society. Libraries need to become hybrid spaces, integrating technological innovations and maintaining social functions, especially in contexts of inequality. (Marwala, 2022)

It is important to remember that, in this contemporary momentum in which the information society is, AI, robotics and IoT are advancing day by day in the technological market, so large that researchers say it is not possible to measure exactly what will be the

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changes and consequences of the relationship of these disruptive technologies in the professional activities of the librarian. What can be said is that these technologies are already making a lot of difference in libraries, making them more organic and dynamic. Because of this, it is imperative that the area of Librarianship, in addition to information, "embraces" these emerging technologies as the main instrument for the execution of its professional activities.

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