# Impact of Artificial Intelligence on Design and Construction of Buildings

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**ABSTRACT**

Artificial Intelligence (AI) represents a revolutionary advancement in the fields of design and construction. This study aims to examine the impact of AI on the design and execution of buildings. The study adopts a descriptive approach through a review of relevant literature.

The findings reveal several opportunities for the use of AI in the design process, including resources procuring, facilitating drawing and planning processes, generating a large number of creative alternatives, providing innovative design solutions, and enhancing environmental sustainability.

Regarding the construction phase, AI contributes to improving efficiency by enhancing safety, saving time and effort, reducing errors, predicting potential risks, and improving project and construction site management.

On the other hand, AI faces several challenges in the design and construction of buildings, including the availability and quality of data, high initial costs, lack of digital skills among workers, weak infrastructure, limited interoperability, and the absence of ethical, regulatory, and legal frameworks.

## Introduction

The construction and building industry has undergone continuous transformations in recent years as a result of advancements associated with the technologies of the Fourth Industrial Revolution. This revolution has introduced innovative approaches to the design and construction of buildings, enhancing their efficiency, productivity, accuracy, and safety (Baduge et al., 2022). Artificial Intelligence (AI) technologies are considered among the most significant outcomes of this revolution, gaining increasing and rapid importance across various fields, including building design and construction projects (Victor, 2023).

AI applications have demonstrated a remarkable presence in the building design process by offering a wide range of creative capabilities. These include generating innovative designs that achieve both functional and aesthetic objectives while considering social, cultural, and environmental aspects. This is made possible through AI's ability to analyze and process large volumes of data, thereby improving the speed and accuracy of decision-making (Li et al., 2025).

The benefits of AI are not limited to the design phase; rather, they extend to supporting all stages of the building lifecycle, including construction, supervision, operation, and maintenance (Wu et al., 2024; Chen et al., 2023).

These technologies are considered effective tools for enhancing the efficiency of construction project execution, improving workflow progress, strengthening safety measures, and reducing risks. Moreover, AI provides advanced opportunities for improving project management and minimizing resource waste (Wu, 2023; Victor, 2023).

Despite the rapid advancement of these technologies and their increasing applications in building design and construction, a gap still exists in their practical implementation. This gap is attributed to several challenges, including the ability of professionals in the field to adopt and utilize these technologies on a wide scale, as highlighted by studies such as Hai and Tien (2025), Khan et al. (2024).

This situation calls for educational and training institutions to enhance the digital competencies of their graduates, raise awareness of the importance and potential of these technologies, and encourage their adoption. Achieving this requires the development of guiding and explanatory materials, as well as simplifying the existing knowledge in this field. A review of the available scientific literature reveals that knowledge in this area is scattered across various foreign studies with differing perspectives. Therefore, this study provides a comprehensive review of the capabilities of Artificial Intelligence and its impact on the design and construction of buildings.

**Research Problem**

Based on a review of related studies on the applications of Artificial Intelligence in building design and construction, it is evident that most studies focus on specific aspects of the field. Furthermore, Arabic studies in this domain are very scares, which negatively affects awareness and understanding of these technologies and their potential. This gap has been observed by the researchers through their work at The Higher Institute of Engineering Technologies is one of the institutions of higher education affiliated with the National Technical Education Authority in Libya (Tripoli). Accordingly, this study presents a comprehensive review aimed at outlining the overall landscape of AI applications in building design and construction, as well as identifying the challenges concomitant with them. This, in turn, contributes to enhancing the knowledge of trainees and professionals in the sector regarding Artificial Intelligence and its potential applications in their work.

**Research Questions**

This study seeks to answer the following questions:

- What is the impact of using artificial intelligence technologies in the building design phase?
- What is the impact of using artificial intelligence technologies in the building construction and execution phase?
- What challenges face the use of artificial intelligence in building design and construction?

**Research Objectives**

This study aims to achieve the following objectives:

- To identify the impact of using artificial intelligence technologies in the building design phase.

- To identify the impact of using artificial intelligence technologies in the building construction and execution phase.
- To identify the challenges facing the use of artificial intelligence in building design and construction.

**Significance of the Study**

With the rapid advancement of artificial intelligence technologies and the vast capabilities they offer across various fields, research has begun to explore their applications within the architectural and civil engineering sectors.

Some studies focus on the architectural design process and the creative potential that artificial intelligence provides in this domain, while others investigate the integration of these technologies into construction processes, building execution, and related project management activities. Despite the growing research interest in this topic, there remains a noticeable gap in Arabic-language studies in this field. This limitation negatively affects the ability of educational and training institutions to fully understand the current state of these technologies, as well as the opportunities they create and the challenges they present.

Accordingly, the connotation of this study lies in enriching the Arabic research literature on artificial intelligence in building design and construction, and in providing a comprehensive review of the impact of these technologies on design and construction processes, as well as the opportunities and challenges associated with their adoption.

**Methodology of the Study**

The study adopts a descriptive literature review approach, relying on a range of relevant studies and research in order to address the research questions and achieve the study objectives.

**Previous Studies**

A study conducted by (Li et al. 2025) entitled ***"A Review of Artificial Intelligence in Enhancing Architectural Design Efficiency"*** aimed to explore the application of artificial intelligence (AI) in the field of architectural design and its impact on design efficiency. The study adopted a systematic review and meta-analysis methodology, where 92 studies were selected from a total of 1810 studies collected from various databases. The review indicates that AI possesses significant potential within the design process, as it contributes to creative development, data analysis, and problem-solving. Additionally, the study highlights several applications of AI in architectural design, including predictive analytics, construction supervision, and facility maintenance. Despite its advantages and wide range of applications in the sector, the study notes that AI implementation faces several challenges, such as high costs and the limited availability of compatible hardware and software, which restrict accessibility for many professionals. The study recommends the need for further guidance and regulation to ensure greater innovation and advancement in the use of AI in architectural design.

Another study by (Emad et al. 2025) entitled ***"The Role of Artificial Intelligence in Developing Future High-Rise Buildings"*** aimed to explore the role of AI in construction and analyze the integration between artificial intelligence and skyscraper development. The study employed a qualitative methodology primarily based on literature review, in addition to a hybrid analytical approach and a comparative analysis between traditional methods and AI-enhanced approaches. Its findings indicate that AI significantly influences key areas of construction development, particularly in high-rise buildings, by improving design processes, energy management, construction operations, and operational efficiency.

Furthermore, the study identifies both short-term and long-term advantages of AI in construction. Short-term benefits include enhanced architectural design through rapid generative design iterations and material optimization. Long-term benefits involve adaptive construction technologies and improved sustainability. The study also highlights the vast potential of AI in the design and management of skyscrapers, (such as structural optimization, energy efficiency, safety protocols, and operational performance), through the use of advanced technologies like machine learning, computer vision, and predictive modeling. The study recommends balancing AI-driven innovation with established architectural principles to ensure a future that integrates technological advancement with core design values.

A study by (Corticos et al. 2025), titled "***The Impact of Artificial Intelligence on Architecture: A Comprehensive Analysis of AI Software Tools and Their Global Adoption,***" aimed to conduct a comprehensive analysis of the role of AI in architecture. The study employed a qualitative analysis of relevant literature. The findings indicate that although AI tools used in building design provide comprehensive features across different design stages, their effectiveness is influenced by design capabilities, sustainability assessments, feasibility considerations, holistic architectural processes, and external stakeholder interactions. The study also emphasizes the need for specialized AI tools tailored to effectively support the architectural workflow—from conceptual design stages through execution and building permitting processes. While on the other hand, the study conducted by (Anber (2025), titled "***The Impact of AI-Supported Platforms and Tools on Architectural Education,***" aimed to investigate how AI-powered platforms and tools are reshaping the architectural education landscape. The study adopted an experimental approach involving students from the Architecture Department at the Higher Institute of Engineering in El Shorouk City, Egypt. Fifty students participated in a residential villa design experiment conducted over two weeks. During the first week, students used traditional methods such as sketching and physical model-making, and their work was evaluated based on architectural design studio criteria. In the second week, students used AI-powered platforms (Promel and Midjourney), and their work was assessed using the same evaluation criteria. The results showed a noticeable improvement in student performance after using AI tools, demonstrating their effectiveness in enhancing architectural design outcomes of the students.

Similarly, a study by (Almaz et al. (2024), entitled "***The Future Role of Integrating Artificial Intelligence in Architectural and Interior Design Education to Improve Efficiency, Sustainability, and Creativity,***" aimed to explore the potential of AI in architectural design and methods for integrating it into the design process. The study adopted an experimental methodology to integrate AI applications into architectural and interior design education at Horus University in Egypt. This was implemented through three approaches: the model generation phase, the architectural drawing production phase, and an integrated approach combining AI applications with traditional design methods. These approaches were tested across three case studies. The findings revealed the vast potential of

AI in architectural education. AI tools assist architects in exploring design alternatives, improving projects in terms of energy efficiency and structural safety, and analyzing large datasets to support informed decision-making. Additionally, AI-powered design tools enhance the understanding of aesthetics, architectural styles, and project requirements, improving the early design phase. On the other hand, integrating Building Information Modeling (BIM) technologies enables real-time analysis and optimization of designs, saving time and resources while reducing waste. AI applications also have the potential to revolutionize architectural education by generating initial project models and enabling students to develop innovative designs.

Another study by (**Talebian et al. (2024)** entitled ***"The Impacts of Artificial Intelligence on Architecture and Smart Urban Environments: A Comprehensive Review"*** aimed to examine the influence of artificial intelligence on architecture and the urban environment. The study adopted a comprehensive review approach.

The findings indicate that existing research focuses on the use of artificial intelligence in data-driven decision-making, energy optimization, predictive maintenance, and assessing the efficiency and resilience of urban infrastructure. The study also highlights AI applications in designing energy-efficient buildings, selecting smart materials, and developing intelligent urban systems such as traffic management, water distribution, and waste management. Moreover, AI tools (such as generative design and predictive analytics) enable architects and urban planners to develop adaptive and resource-efficient solutions that address global urbanization challenges and climate change. Accordingly, artificial intelligence has the potential to establish new standards for human-centered architecture. However, the study also identifies several challenges, most notably data interoperability, ethical concerns, and computational resource requirements.

Another study by (Hamdy (حمدي2022) entitled ***"The Application of Artificial Intelligence in Developing Interior Design Process Management"*** ***تطبيق الدكاء الاصطناعي في تطوير أداراه عمليات التصميم الداخلي*** aimed to identify the contribution of artificial intelligence to the development of the interior design process. The study adopted a descriptive analytical approach through reviewing relevant literature and analyzing the interventions and contributions of AI applications.

The findings indicate that artificial intelligence offers several advantages in the field of design. It assists designers in collecting and processing data and executing designs with high accuracy, reduced error rates, and increased speed. In interior design specifically, AI provides multiple applications across all design stages, including problem definition, data documentation, concept development, cost estimation, design management, execution, and post-occupancy evaluation. AI algorithms also enable the monitoring and interpretation of user behavior to generate unique designs tailored to individual needs and user experience expectations.

Furthermore, AI applications support the control of heating and air conditioning systems through natural language processing and the interpretation of human gestures. The study also highlights several AI-powered interior design software applications, such as ***(Leaper*** and ***Décor Matters***), which generate unique interior design solutions using artificial intelligence tools.

Another study by (Adunadepo & Sunday (2016) entitled ***"Artificial Intelligence for Sustainable Development of Smart Buildings"*** aimed to evaluate the use of artificial intelligence alongside green architecture to achieve sustainable smart buildings in smart cities. The study explored the relationship between artificial intelligence, nanotechnology, lean construction, and green architecture. The study conducted a literature review on artificial intelligence and Building Information Modeling (BIM), in addition to collecting primary and secondary data on green architecture in Lagos, Nigeria, through field visits. The findings indicate that green building materials were the most widely used aspect of green architecture, while prefabricated construction systems represented the main component of lean construction techniques in Lagos. The study recommends the adoption of integrated project delivery systems and Building Information Modeling (BIM) to enhance sustainability and efficiency in construction processes.

The previous studies confirm that artificial intelligence has created a revolution in the field of building design and construction. It offers numerous opportunities and capabilities that enhance outcomes in this domain, particularly by improving design efficiency and fostering innovation. It also contributes to increasing the effectiveness of project execution, management, and decision-making processes.

**Theoretical Framework**

**First: Artificial Intelligence – AI)**

Artificial intelligence emerged in the 1950s as a major development in the field of data science, representing a significant scientific breakthrough. It was primarily developed to build machines capable of simulating human cognitive processes, ranging from simple expressions to complex modeling systems, thereby demonstrating the ability of AI to gradually think and adapt in a human-like manner (Matter & Gado, 2024).

The concept of AI refers to the simulation of human intelligence by machines and includes all systems that enable machines to perform intelligent tasks such as data classification, judgment-making, and self-improvement (Koyamparambath et al., 2022; Talebian et al., 2024). Furthermore, AI represents the ability of automated systems to correctly interpret external data, learn from it, and use it to achieve specific goals through flexible adaptation (Haenlein et al., 2019). AI aims to reduce the need for human intervention by mimicking human cognitive processes such as problem-solving and decision-making. It enables computers to adapt to new conditions, learn from experience, and make independent judgments (Hassani et al., 2020). Accordingly, the ultimate goal of AI is to develop systems and software that closely replicate human intelligence to perform complex tasks with high accuracy and efficiency (Babu & Vasumathi, 2023).

Artificial intelligence includes several subfields such as machine learning, deep learning, natural language processing, generative AI, robotics, computer vision, expert systems, cognitive computing, and fuzzy logic (الجبرAl-Jabir, 2024; مخلصMukhlis et al., 2024). On the other hand,) Hamdy (حمدي2022), مخلصMukhlis et al. (2024), and ادريسIdris (2023) identify three main types of artificial intelligence as follows:

- **Artificial Narrow Intelligence (ANI):** This is a form of AI that simulates human intelligence but is limited to a specific task or domain. It focuses on performing specialized tasks such as autonomous vehicles, image recognition, and speech recognition.
- **Artificial General Intelligence (AGI):** This represents a stronger form of AI that aims to replicate human-like general intelligence in machines and robots, enabling them to solve problems, make decisions, and perform a wide range of tasks similar to humans.
- **Artificial Superintelligence (ASI):** This type of AI surpasses human intelligence, allowing it to perform complex tasks more effectively than human experts. It is characterized by advanced capabilities in learning, planning, communication, and decision-making.

**Second: Applications of Artificial Intelligence in Building Design (Design Phase)**

Artificial intelligence (AI) applications are gaining increasing importance today, as they are widely used across many fields. AI can be applied in various stages of the construction process and the building life cycle (Elwy & Hagishima, 2024). In architectural design, AI offers several advantages, particularly in saving time, effort, and cost associated with project analysis and the production of design drawings (Almaz et al., 2024). It also contributes to generating a vast range of ideas and design alternatives, including models with different colors and styles, through algorithms and inputs provided by the designer (حمديHamdi, 2022).

AI is used in a variety of architectural design domains, most notably in producing a large number of proposals and design models that offer different design solutions. It also assists in selecting optimal building materials based on data specified by the designer regarding the surrounding environment, climate conditions, and the functional requirements of the building. Accordingly, these applications help address design challenges and problems. However, this does not mean that design is fully carried out by these technologies, as the architect still retains the ability to define contextual, social, cultural, and historical relationships within the design (Bolek et al., 2023).

Nowadays, AI, machine learning, and algorithmic approaches are used to generate accurate information that supports designers in making effective design decisions by providing multiple options and simulating them virtually during early design stages. This creates greater opportunities for creativity and for managing spatial relationships and other design aspects (Borglund, 2022). These technologies have also enhanced the ability to create non-physical spaces through virtual simulation, allowing designers to develop and modify virtual architectural environments according to functional requirements. One of the most notable examples is the virtual Guggenheim Museum, which presents exhibits within uniquely designed virtual spaces, offering users an innovative and memorable experience (خليلKhalil, 2014).

Additionally, AI helps manage the vast amount of interrelated details found in drawings and construction documents (Amer, 2023).

Additionally, AI provides spatial programming capabilities by proposing site planning designs and functional distribution models. It also supports building restoration processes by generating designs for missing or damaged parts (Bölek et al., 2023). Moreover, through machine learning and natural language processing, AI assists designers in making faster and more accurate decisions in areas such as creative exploration, data analysis, and problem-solving. In addition, parametric design enhances innovation and improves the quality of design solutions (Li, Chen Yu, & Yang, 2025).

On the other hand, artificial intelligence plays an active role in enhancing the environmental performance of buildings. These applications improve building efficiency by optimizing energy consumption and maximizing the use of solar radiation and daylight, as well as other passive design solutions (Caetano et al., 2020) (Passive Design). Moreover, these technologies can further enhance energy efficiency. For instance, intelligent neural networks assist in controlling heating and cooling systems in buildings and predicting natural lighting levels as well as the need for artificial lighting (Lee et al., 2020). In the context of sustainable architecture, AI contributes to the development of environmentally friendly solutions by predicting energy consumption patterns and the potential use of renewable energy sources. Additionally, architects are able to estimate the environmental footprint of their designs (Tarabishy et al., 2022).

AI can also analyze large datasets related to building performance and identify patterns that support design decision-making, such as orientation strategies and material selection for improved energy efficiency. Furthermore, these systems can predict a building's energy demand by analyzing variables such as occupancy and weather conditions, enabling more accurate energy management planning (Awuzie et al., 2024).

On another level, AI facilitates the integration of smart systems within buildings, where intelligent lighting, heating, and cooling systems automatically adapt to changing conditions. This leads to reduced energy consumption while enhancing occupant comfort (Talebian et al., 2024).

Additionally, some AI applications are used in interior design processes, where computer vision technologies can analyze and process images to determine suitable color schemes, classify furniture, organize data, monitor interactions between users and design elements, and even detect human emotions. Moreover, natural language processing (NLP) can help reduce energy consumption by enabling voice-based control systems that understand commands such as "turn on" or "turn off." NLP can also process bills, documents, and drawings related to building environmental performance through text recognition capabilities (حمديHamdi, 2022).

It can therefore be said that artificial intelligence can provide many advantages during the early stages of the design process, as it is capable of generating multiple design alternatives based on the input data, such as building function, climatic conditions, project budget, and other parameters. This leads to the creation of innovative design solutions and alternatives. On the other hand, artificial intelligence is used to improve the environmental performance of buildings by reducing energy consumption, enhancing the use of renewable energy, and improving overall sustainability. Natural language processing technologies also help in interpreting project summaries and documents more efficiently, thereby facilitating a better understanding of project requirements and supporting the creation of designs that align with clients' visions and expectations. Additionally, artificial intelligence can enhance the adaptability of interior spaces to functional changes and contribute to the development of smart buildings equipped with systems capable of controlling temperature and ventilation, as a means of improving thermal comfort and energy efficiency.

**Third: Applications of Artificial Intelligence in Building Construction (Post-Design Phase)**

The construction sector has witnessed significant development in the use of artificial intelligence systems, which has contributed to the emergence of intelligent and sustainable architectural models that rely on accurate data and information. These systems enable the proactive prediction of potential problems and the identification of appropriate solutions. It is worth noting that these technologies are not limited to the design phase but are also utilized in construction and building execution. In this phase, artificial intelligence provides important solutions to overcome challenges associated with execution, such as skill shortages, data accuracy issues, and timely project delivery (Hassen, 2024).

Furthermore, artificial intelligence reduces construction and operational costs and increases construction speed and execution accuracy (Baduge et al., 2022). In addition, the use of artificial intelligence improves workflow efficiency, enhances safety, and optimizes supply chain performance (Wu, 2023). On the other hand, the use of artificial intelligence contributes to enhancing efficiency and safety in the construction execution process through several applications. Autonomous driving technologies are used to operate bulldozers, excavators, cranes, and other heavy machinery, which improves both safety and project productivity (Na et al., 2023; Pillai & Matus, 2020). Furthermore, computer vision systems enable real-time and continuous monitoring of construction sites to detect potential hazards and ensure compliance with general safety protocols, such as the use of protective helmets and other safety requirements (Na et al., 2023). In addition, natural language processing systems and interactive chatbots help bridge the language gap between workers on construction projects and reduce the likelihood of misunderstandings among them. Machine learning and the Internet of Things also contribute to improving efficiency, reducing errors, optimizing resource management, and enhancing decision-making quality (Silitonga & In, 2023).

Alternatively, machine learning techniques can be integrated into Building Information Modeling (BIM) systems to simplify planning tasks and improve analytical processes, such as energy and cost analysis. On the other hand, robots trained using artificial intelligence algorithms enhance off-site manufacturing, which accelerates construction processes and reduces delays (Baduge et al., 2022). Additionally, augmented reality, virtual reality, laser scanning technologies, and even drones can be used in site planning and material testing (Roslon, 2022).

In addition to the foregoing, robotics and drones equipped with cameras and sensors can also be used to survey construction sites and monitor operations, reducing risks associated with inaccurate drawings, dimensional errors, and omitted or uninstalled components. These devices capture visual data at the end of each day based on design and planning parameters, which are then analyzed using machine learning algorithms to measure the amount of completed work, evaluate progress, and detect errors if present. This is achieved by comparing extracted parameters with those of the original building model to identify discrepancies and construction errors (Wu, 2023; Vickranth et al., 2019).

Moreover, artificial intelligence applications can be used in construction management processes by automating tasks related to this process, including project scheduling, delay analysis, work breakdown structure, project budget planning, updating project progress and timelines, identifying deviations, generating risk maps, and allocating material and human resources (Taboada et al., 2023; Park & Yun, 2023; Akinsemoyin et al., 2023).

In addition, artificial intelligence algorithms such as Support Vector Machines (SVM) contribute to improving resource and cost management and predicting the time required to complete tasks. Meanwhile, the BuildAI application is used for monitoring workflow progress (Baduge et al., 2022). Furthermore, neural networks and sensor systems can be used to automatically recognize work data, which supports supervision processes (Pillai & Matus, 2020). Moreover, machine vision is used to enhance measurement accuracy by replacing the human eye through capturing images and sending them to a specialized processing system to extract data with high precision (Schuegraf et al., 2023; Zhang, 2021).

**Fourth: Challenges of Using Artificial Intelligence in the Design and Construction of Buildings**

The use of artificial intelligence in building design and construction faces several challenges that limit the potential benefits of its application in this sector. Most artificial intelligence techniques and branches rely heavily on data. For example, machine learning requires large amounts of data to train its algorithms; however, due to the limited availability of data in construction projects and the difficulty of accessing it, the available data may not adequately support these technologies.

The effectiveness of artificial intelligence in building design and construction is not only dependent on the quantity of data but also on its quality. High-quality and suitable datasets are often difficult to obtain, and data usually requires extensive preprocessing (Baduge et al., 2022; Bang & Olsson, 2022). In addition, the high cost of implementing artificial intelligence technologies in construction projects represents a major challenge, especially for small companies with limited resources (Victor, 2023).

On the other hand, the use of these technologies requires a certain level of digital competency among workers in the field, which reduces the willingness to adopt them. It also requires time, effort, and financial investment for training, thereby increasing initial implementation costs.

In addition, the integration of these technologies faces resistance from some parties, as certain engineering offices still operate using traditional methods and refuse to update them (Hai & Tien, 2025). Furthermore, some systems face challenges related to the interoperability of artificial intelligence technologies, where proper integration between these technologies cannot be achieved, which negatively affects workflow efficiency, integration, and the existence of a coherent and well-structured system (Li et al., 2024).

Moreover, current artificial intelligence systems lack consideration of ethical aspects that ensure worker safety, data privacy, and algorithmic bias, in addition to concerns regarding labor replacement issues (Silitonga & Jin, 2023).

A study by) Khan et al. (2024) confirms the aforementioned challenges and adds several others, including increased workload burdens, accessibility issues, intellectual property rights and data ownership concerns, data loss risks, fears of theft and cyberattacks, weak digital infrastructure in some companies, low client interest in solutions provided by artificial intelligence systems, as well as unclear financial gains and uncertainty regarding return on investment.

**Conclusion**

The study presented a review of the relevant literature on the use of artificial intelligence in the design and construction of buildings. It identified a set of capabilities and opportunities generated by artificial intelligence technologies in the design field. The most important of these include saving time and effort associated with producing design drawings, providing a large number of data-driven design alternatives, enhancing the architect's ability to solve design problems, and strengthening creativity and innovation. Furthermore, artificial intelligence can improve the environmental performance of buildings and enhance their sustainability.

On the other hand, artificial intelligence can be effectively utilized in the design process and interior design operations. Regarding the construction phase, artificial intelligence improves construction efficiency, reduces potential errors, enhances overall safety, improves the accuracy and timeliness of decision-making, and supports project management and workflow optimization.

Despite the importance of these technologies and the opportunities they offer in the field of building design and construction, they are associated with several challenges. The most significant include the need for large volumes of high-quality data to support algorithm training, high initial costs, limited digital competencies among workers in the sector, weak digital infrastructure, as well as the need for legal and ethical frameworks that ensure data privacy and security protection.

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