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Artificial Intelligence Utilized in 3D Printing Construction Technology

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Artificial intelligence (AI) is increasingly being researched and developed for a wide range of societal applications in the USA, Europe, and even some Asian countries. This study aimed to determine the trend of artificial intelligence and 3D printing technology in construction. Results showed that a 3D digital model is necessary for all 3D printing processes, and the BIM artificial intelligence software enables automated 3D printing for construction projects. Using 3D printing technology boosts productivity and efficiency while lowering labor expenses and increasing accuracy. In addition, Artificial Intelligence (AI) application in 3D Construction Printing has ethical impacts on unemployment, humanity, security, and intellectual property. In addition, impacts on machines include AI bias, global regulations, and accelerated hacking.

Keywords: Artificial intelligence; 3D printing technology; automation in construction.

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1. INTRODUCTION

Our world is frequently conceptualized and studied through vast, intricate, and interconnected systems, many of which are global in scope. Examples include the evolution of capitalist modernity, trade and monetary exchange mechanisms, changing political structures, and ecological and environmental changes [1].

Our place in the world's system appears to be spinning out of control. More new technologies than any of its predecessors have already been introduced by the Fourth Industrial Revolution, including gene editing, driverless vehicles, artificial intelligence, and the Internet of Things [2].

Artificial intelligence has evolved to influence the world and aid its systems in the various industries of the nation and the entire planet. The majority of people's lives will likely improve over the next ten years, according to experts, but many people are worried about how these developments will alter what it means to be human, to be productive, and to have free will [3].

In the field of engineering, there are many applications of AI. In one study, a hybrid adaptive pattern recognition system was proposed to analyse real-time driving behaviour of people relative to other drivers in the road [4]. Artificial Intelligence has been used as an aid to different industry. Specifically, AI supports operation of construction as in the case of 3D printing technology in automation of construction. The environment is greatly benefited by the novel construction technique known as 3D printing, which solves problems with efficiency, precision, speed, and reduces labour costs [5].

In the construction industry, the core countries enjoyed the use of updated technology with the exploitation of peripheral countries thru their manpower supply. The introduction of these technologies may create a technological gap dilemma between the rich and poor countries. Raising awareness through this research will help the society especially the construction industry in addressing issues that may disrupt the construction operations.

It is for these reasons that the researcher would like to examine the systems of technological ecology of AI and 3D printing as used in the construction industry.

2. OBJECTIVES OF THE STUDY

This case study aimed to determine the trend of artificial intelligence utilized in 3D printing technology in construction. Specifically, it:

1. Explore Artificial Intelligence and the World.
2. Explain the Artificial Intelligence in 3D Printing Technology in Construction.
3. Examine the ethical impacts of the artificially intelligent system.

3. METHODOLOGY

This paper uses the case study method in determining the trend of artificial intelligence and 3D printing technology in construction. The data used secondary information collected from published research, related studies, journals, and available news report on the web.

4. DISCUSSION

4.1 Artificial Intelligence and the World

Artificial intelligence is the application of computer science programming to replicate human thought and behavior by analyzing data and the environment, resolving, or anticipating issues, learning or self-teaching, or adapting to a variety of activities [6]. In almost every sector, artificial intelligence is influencing how people will live in the future. It already serves as the primary force behind developing technologies like big data, robotics, and the Internet of Things, and it will continue to do so for the foreseeable future [7]. Its applicability has been evident in different areas like healthcare, engineering, finance, gaming, social media, manufacturing industry, entertainment, agriculture, and education.

Today, artificial intelligence (AI) serves as the foundation for computer systems handling activities like voice recognition and translation on smartphones, driving autonomous cars, and managing robots that automate household and industrial jobs [8].

In addition, human intelligence is responsible for some of history's biggest tragedies as well as some of humanity's greatest victories. What would happen then if we developed artificial intelligence (AI) that was much smarter than any human? Will it enable us to achieve even higher heights or, as some experts' fear, bring about the worst disaster of all: the end of humanity? [9].

AI in USA: The National AI Initiative's main objective is for the US to set the global standard for the creation and application of AI in both the public and private sectors. The research, development, demonstration, and deployment of AI in a variety of applications across society is being considerably aided by federal agencies [10].

AI in Europe: The AI Act is a proposed law for Europe on artificial intelligence (AI), the first AI law ever submitted by a significant regulator. Applications of AI are divided into three danger categories by the law. First, it is forbidden to employ programs and systems that pose an intolerable danger, like China's government-run social score. Second, there are special regulatory criteria that apply to high-risk applications, such as a tool that scans CVs and ranks job applicants. Finally, applications that are not expressly forbidden or marked as high-risk are mainly unregulated [11].

AI in ASIA: Asia is becoming more and more involved in artificial intelligence (AI) research and commercialization. For many years, tech pioneers have called Asia home. According to the World Intellectual Property Organization, top tech businesses in Japan and South Korea, for instance, have some of the greatest numbers of AI patent applications. With nearly $275 billion in yearly R&D investment (slightly over 2 percent of GDP), China currently leads the globe, but other Asian countries such as Japan, South Korea, and Singapore are all above the 2 percent threshold [12].

AI in AFRICA: Africa will likely be affected by AI in several ways. Many have praised it as a force that will alter African nations, suggesting that it will lessen poverty, reduce inequality, and increase access to public services like health and education. However, the adoption of these formidable technologies is still in its infancy on the continent, and there are substantial obstacles to be addressed to develop the capacity to fully realize their promise. One of the most important of these is a lack of diversity in the industry at large, which affects every aspect of AI, from creating datasets to creating and deploying systems. The diversity here refers to the practice of including individuals from various socioeconomic, racial, ethnic, and cultural origins, as well as individuals of various genders and sexual orientations [13].

4.2 Artificial Intelligence in 3D Printing Technology in Construction

3D digital model is a requirement for any 3D printing procedure and the BIM artificial intelligence software enables automated 3D printing for construction projects. A&C processes such as architectural planning, geometrical data, scheduling, material, equipment, resource, and manufacturing data, as well as post-construction facility management, are all covered by the building information modelling (BIM) approach to management. BIM is essential to 3D printing in construction's success because it keeps large-scale digital operations safe and productive [14].

An overview of some examples of 3D printing in the construction sector is given (Stupino town, Moscow, Russia - Apis Cor first company to develop a mobile construction 3D printer). In many modeling programs, it is feasible to create a 3D model of a building that is suitable for 3D printers. The STL format is one of the most widely used for exchanging these models, and many proprietary software programs have adopted it. Additionally, combining the BIM process with 3D modeling for printing will improve design quality, lower costs, and structural isolation [15].

BIM is a process for creating and managing information for a constructed asset throughout its lifecycle, from planning and design to construction and operations [16]. It uses virtual reality building as a model and focuses on all the knowledge learned as the project advanced. A variety of processes are involved in the structural design process, such as the creation of a model, load analysis and determination, the fabrication of all drawings, and the creation of technical specifications. It is said to have high-level assistance for the BIM systems' or software's interoperability with additional programs necessary for data transfer and storage at all stages [17]. A BIM tool that addresses societal and environmental challenges is called REVIT. It is one of the BIM tools that Autodesk created. Software from Autodesk, including Fusion and AutoCAD, is well-known. BIM facilitates team communication and results in significant project savings. It facilitates a paperless, digital representation of a project for a sustainable approach to building.

Tan [18] stressed that Construction 3D printing is increasingly playing an important role in the evolution of the civil engineering sector, although

it still has a long way to go due to its infancy. The issues with building 3D printing can undoubtedly be solved with the help of artificial intelligence and BIM. Future trends indicate that 3D printing in buildings will be popular, along with BIM and artificial intelligence.

4.3 Ethical Impacts of the Artificially Intelligent System

a) **Unemployment:** The effect on employment in the construction industry is very high specially for countries like the Philippines where the human labor force is significant to construction workers' income. Government has to come up with legislations that would protect the employment in the construction industry.

   It has been discovered that 3D printing can significantly cut down on labor costs, which can help countries where the reliance on foreign labor in the building industry is high. For nations where the building industry employs a large portion of the working force and where labor is more affordable, 3D printing may not be advantageous [19].

b) **Humanity:** Owners, contractors, manufacturers, and software developers will be impacted legally by the use of 3D printers in the construction sector. It affects the income generation of construction workers on site.

   The construction sector has been impacted by the surge in additive manufacturing, and project management will undoubtedly change as a result. Because 3D printers will be automated and largely autonomous, there will be fewer personnel needed on building sites. Due to the fact that 3D printers can operate 24/7 and do not require overtime, projects will be finished sooner [20].

c) **Security and intellectual property:** The safety of users in terms is structural capacity would always be a concern for 3D printing technology. In addition, the intellectual property of designers may be at risk.

   The possibility of widespread home manufacturing in the future presents two ethical concerns. First, there are concerns about safety. Our current safety laws are based on centralized manufacturing presumptions, making it challenging to apply them to this new manufacturing paradigm. Then there are problems with intellectual property. It is now possible to scan objects using a 3D scanner and print replicas of them; many objects are not covered by this by present intellectual property rules [21].

5. IMPACTS ON MACHINE

a) **AI bias:** In recent years, 3D concrete printing (3DCP) has gained popularity as a technological means of lowering the significant carbon footprint of cement manufacture. Findings reveal that 3DCP's ability to boost automation and address the existing shortage of qualified personnel in the construction industry is what gives businesses the biggest motivation to invest in the technology—not the environmental advantages. Current government procurement regulations do not sufficiently reward sustainability benefits to promote the adoption of 3DCP [22].

b) **Global regulations:** Regulatory agencies need to address the design and construction procedures along with health and safety requirements in 3D printing construction technology.

   The need for creating a regulatory framework to establish the bar for the performance of 3D printed objects is driven by the inability to tolerate structural failures and compromises on the health and safety of both workers and the general public. Based on the research, a subsidiary piece of legislation for 3D printing in buildings was recommended to balance the inherent dangers of this new technology without sacrificing public safety on the grounds of quality, health, and safety [23].

c) **Accelerated hacking:** The results also demonstrate that 3D printing has been negatively and positively impacted by the hacking culture. It has actively aided in the democratization of 3D printing by making participation and benefits equally available to everybody. However, by permitting the use of 3D printers in places outside of institutional authority where ethical approval is not necessary, it has also unintentionally fostered societal issues [24].

6. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are obtained from the analysis of this case study's findings.

Artificial intelligence (AI) is increasingly being researched and developed for a wide range of societal applications in the USA, Europe, and even some Asian countries. However, the adoption of these AI technologies in Africa is still in its early stages, and significant challenges must be overcome to build the capacity to properly utilize AI. It is recommended that the government agencies should upgrade systems to avoid the rise of technological gap between rich and poor countries. Allocate budgets on training needs of staffs regarding AI and recent technologies.

A 3D digital model is necessary for all 3D printing processes, and the BIM artificial intelligence software enables automated 3D printing for construction projects. Building information modeling (BIM) is a management strategy that covers A&C activities including architectural design, geometrical data, scheduling, material, equipment, resource, and manufacturing data, as well as post-construction facility management. BIM and other AI tools must be integrated in course offerings and therefore recommended for HEIs to consider this matter [25-26].

Using 3D printing technology boosts productivity and efficiency while lowering labor expenses and increasing accuracy. It is becoming more and more popular since it outperforms traditional construction techniques in terms of labor, cost, speed, and error margin. The clients will profit from amazing designs and a short turnaround time need that have a big positive impact on construction project end users. In addition, 3DCP offers the greatest cost savings, performs similarly to cold-formed steel in terms of CO2 emissions, and reduces construction time by around 95% when prefabricated modular concrete is eliminated. It is recommended for future researchers to consider in depth analysis on cost and benefit ratio in using AI in 3D printing technology and further studies on structural safety of building construction. In addition, technology must be adjusted in order to better meet the needs of increasingly developed smart cities. The Artificial Intelligence application in 3DCP has ethical impacts on unemployment, humanity, security, and intellectual property. In addition, impacts on machines include AI bias, global regulations, and accelerated hacking. Regulatory agencies are recommended to come up with sets of policies that will avoid the negative impact of artificial intelligence.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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