Assessing the Application of Internet-of-Things and Artificial Intelligence in Real-time Site Progress in Lagos-Nigeria

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Abstract

Nigeria's building industry needs to go fully digital for efficiency in project management, and cost control. The crucial roles expected of professionals in Lagos State, the financiers, their clients, and all other parties directly involved in construction activities are not being fulfilled. This study established that the ability of a digital innovation or computer-controlled robot or gadget to carry out construction frequently associated with intelligent beings is known as Artificial Intelligence (AI) incorporated with the Internet of Things (IoT). The study evaluated how some selected stakeholders in site development, construction project management, coordination, and progress in the built environment are using IoT and AI. The study adopted quantitative analyses of both structured questionnaires and interviews obtained from randomly selected construction sites in Lagos metropolis and its suburbs. A sample frame consisted of 65 key stakeholders currently working on selected 113 projects with resident professionals who are the relevant key players and operators of IoT+AI. It considered seven drivers of IoT and AI which are common in the following areas; site operation, the technology deployed, model innovation, site coordination, industry collaboration, construction project management, and finally the construction methodology. The following challenges and limitations were identified as some of the barriers to the adoption and application of IoT+AI. The lack of skilled personnel, lack of internet connectivity, lack of IoT+AI libraries, lack of awareness of the technology, and lack of installation and maintenance tools. Also identified as a limitation is the lack of electricity and a conducive socio-economic environment in Nigeria. This study revealed that the inaccessibility to IoT+AI libraries and technology is very critical in the construction industry. The applications of these technologies were also examined for an enhanced understanding of their operations in the industry and services delivery to the people.

Keywords: AI, Construction Equipment, GPS, IoT, UAV, Virtual and Augmented Reality.

1. Introduction

The ability of a digital computer or computer-controlled robotics and construction equipment to carry out activities that are usually done by trained personnel is known as artificial intelligence (AI), using the Internet of Things (IoT) as a tool (Xiao, Shi, & Zhang, 2023; Dhawan & Batra, 2020; Skinner, 2019). The word is widely used to describe a project that aims to create systems that possess human-like cognitive abilities, such as the capacity to reason, find meaning, or gain knowledge via experience (Xiao, Shi, & Zhang, 2023; Skinner, 2019). Since the advent of the digital computer in the 1940s, it has been proven that computers are capable of being programmed to perform extremely difficult jobs, such as finding proofs for mathematical theorems or

mastering the game of chess (Pérez, Pérez, & Kacprzyk, 2022). Some computer programs are capable of doing some activities at levels comparable to experts and professionals. Since quite a few years ago, AI has been demonstrated to do tasks that indicate the effectiveness of AI algorithms or applications (Pérez *et al.*, 2022).

The disruptive nature of artificial intelligence has had a significant impact on a variety of industries, greatly promoting their growth. One such industry is the engineering and technology sector, where programs exist that can identify engineering errors and flaws early on. The building sector is at the front burner in the adoption and integration, as it has gained a lot from the activities and innovations brought about by AI technology. Some characteristics of AI include the capacity to reason, act, learn, and behave independently or autonomously (Dwivedi, Hughes, Ismagilova, Aarts, Coombs, Crick, & Williams, 2021). The Internet of Things (IoT) is the interconnection of network-enabled physical things with unique identifiers (UIDs) that may send data over a network without the need for human-to-human or human-to-computer interactions, yet its importance cannot be understated. IoT enables a device to interact with people and other internet-capable objects. The Internet is no longer just a network of computers; it has developed into a network of objects of all shapes and sizes, including, among other things, smartphones, home appliances, toys, cameras, and buildings (Dwivedi *et al.*, 2021).

AI is widely used to refer to the task of creating AI systems that possess human-like cognitive abilities, such as the capacity for reasoning, meaning-finding, and experience-based learning. The ability of a digital computer or computer-controlled robot to carry out actions frequently associated with intelligent beings is known as AI. This is applicable due to the dire need for specialized skills and a limited workforce in the construction sector. In addition, the emergence of 3D printing and UAV technologies for construction operations has brought robots to the forefront of AI applications in the construction industry (Dwivedi *et al*., 2021). Given the amount of efficiency that may be created when they are combined, AI and IoT are both becoming standard practices in the construction industry (Dwivedi *et al*., 2021; Pan & Zhang, 2022).

Figure 1: Drivers of IoT and AI in the Construction Sector (Source: Author's study indicators).

As shown in Figure 1 topical areas can integrate the application of IoT using AI tools; technology, operations, construction methodology, model innovation, site coordination, and industry collaboration. These devices are capable of learning via practice and carrying out activities similar to those carried out by humans (Pan & Zhang, 2022). Today, it goes without saying that everyone wants to interact with AI technology in some way, whether it is as a consumer or by seeking a profession in the field.

To get ready for the industry's transition, the paper highlights current best practices for each of the relevant areas and offers illustrative case studies of creative methods (Pan & Zhang, 2022). IoT and AI seem to hold great promise for developing nations, particularly in sub-Saharan Africa. In the developing world, numerous technologies are already being developed to raise productivity and living standards (Wu, Lu, Xue, Li, Zhao, & Tang, 2022). It is important to remember that the adoption of new technology should be carefully considered because, if done correctly, it has the potential to be highly useful. AI has the potential to have a negative economic impact on developing countries. This study examines the following seven parameters as the major factors determining the necessity of IoT and AI (Figure 1).

2. Literature Review

The Architecture, Engineering & Construction (AEC) professionals, stakeholders, and financiers involved in the construction sector have been reluctant to fully take advantage of the latest technological opportunities, and associated labor productivity, efficiency, quality, and speed of work have stagnated as a result (Oguejiofor, Omotosho, Abioye, Alabi, Oguntoyinbo, Daraojimba, & Daraojimba, 2023; Fahm, 2023; Xiao *et al.*, 2023. In contrast, the majority of other industries have undergone significant change over the past few decades and have reaped the benefits of process and product innovations (Oke, Arowoiya, & Akomolafe, 2022). This unimpressive track record can be attributed to several internal and external issues, including the industry's continued fragmentation, inadequate supplier and contractor collaboration, difficulty finding talented employees, and inadequate succession plans in project delivery (Oke *et al.*, 2022). However, the industry can still improve its production and efficiency through digitization, cutting-edge technologies, and fresh building methods. Take into account the quick development of augmented reality, drones, 3D printing, and scanning (Oguejiofor *et al.,* 2023; Fahm, 2023; Wu *et al*., 2022).

Businesses would increase their productivity, streamline project management and procedures, improve quality, and increase safety by implementing and utilizing technological advances (Fahm, 2023). The industry would need to make a dedicated and concerted effort across many areas in the construction industry (Oke, et al, 2022).

An evaluation of the industry's current situation and its eventual future developments is done at the outset of this paper. It then offers a conceptual framework for industry transformation, outlining several actions that would fundamentally alter the industry system. The actions are divided into three categories: those taken alone by private businesses; those taken jointly with other businesses or by the entire industry; and those taken by the government, which serves as both a major project owner and a regulator.

The application of artificial intelligence was still in its infancy in the 1960s, and there were not many publications discussing optimization techniques (Hashim, Sallehuddin, Safie, Husairi, Abu Bakar, Yahya, & Abdel-Ghany, 2022).

By assessing growing conditions and advising on the best practices, AI and IoT are being utilized to increase agricultural output and growth. Before patients enter the operating room, an AI application in the medical field employs 3D printing to

evaluate and counsel surgeons on their anatomical features (Wu et al., 2022). Using AI has the potential to significantly improve the lives of people in underdeveloped countries, but it is not without risks—both financially and legally. The introduction of these new technologies could limit if not completely erase, the benefits of their positive effects on the economy. In today's industry, AI applications are frequently used to replace low-skilled or unskilled labor. If many low-wage workers lack the requisite technical knowledge, ethics, and work experience of the applicability and usage in the economy, could be a problem. Due to the architectural and construction innovation of AI, which demands a highly educated and technically proficient workforce to sustain economic activity, most of the state institutions and professional associations and the typically underfunded educational institutions are exposed.

Another opportunity for technology to aid in infrastructure advancements may present itself through IoT+AI. AI can reduce the effects of chronic underfunding, the exodus of educated and talented individuals to more developed regions, and democratize access to education in underdeveloped countries. The educational apps allow for the creation of individualized teaching materials, the administration and grading of exercises, and the detection of test fraud. Another finding from historical research trends is that, in the last ten years, machine learning has become the subfield of interest in the construction sector, surpassing knowledge-based systems (Hashim *et al.*, 2022). This is explained by the growing need to address labor and skill shortages. Additionally, the advent of 3D printing and UAV technologies for construction operations has brought robots to the forefront of AI applications in the construction industry (Hashim, et al, 2022). However, the construction industry's least-researched sector has been natural language processing (Chan, Olawumi, Saka, & Ekundayo, 2022). In the previous ten years, over 70% of AI application research in the construction industry has been conducted, and this work has sparked or accelerated the development of cutting-edge technologies like blockchain, quantum computing, and the Internet of Things (IoT). Certain computational problems can be solved more quickly and effectively by quantum computing than by classical (or regular) computers. Quantum algorithms outperform classical (or traditional) algorithms due to the unique properties of quantum information (Chan *et al.*, 2022).

IoT and AI Optimisation in the Construction Sector

Quantum computing's capabilities can be used by AI to speed up problem-solving and improve its results (Okpo, Ikediashi, & Ansa, 2022). Recent technological developments including sensors, actuators, wireless technologies, cloud computing, and quicker, less expensive devices with more processing power have made this change possible (Okpo *et al.,* 2022). The Internet of Things (IoT) and artificial intelligence (AI) have been combined in the construction industry in a variety of ways, including energy-saving on demand for intelligent building energy monitoring, an IoT-enabled building information modeling (BIM) platform to achieve real-time visibility and traceability in prefabricated construction, and the generation of early warnings and alarms as dynamical safety barriers for hazard energy on underground construction sites (Chan, et al, 2022). AI has a self-improvement mechanism that enables it to gain knowledge from the repetition of human behavior. The methods for self-improvement aid in the development of AI algorithms (Dzobo,

Adotey, Thomford, & Dzobo, 2020). IoT, as was previously described, deals with the computation of a sizable amount of data that needs to be processed by human intelligence (Oguejiofor *et al.,* 2023; Fahm, 2023).

Dzobo *et al*. (2020) opined that to create an efficient user interface and analyze computed data in IoT devices, several AI algorithms are deployed. The tracking (gathering), monitoring (analyzing), controlling, optimizing (training), and automation (modeling and predicting) of data are the stages in this process of IoT and AI interoperability. Positive revolutions have been ushered in by these phases of integration in a variety of industries, including renewable energy, the banking sector, the health sector, and the agricultural industry (Dzobo *et al*., 2020). The tools are intelligent things that people have made that could act and perform without prior instructions or activation. These devices can reason, act morally, and think clearly (Young, 2019). A layperson with a passing familiarity with technology would associate it with robots (Mahmudnia, Arashpour, & Yang, 2022). Artificial intelligence, which can act and reason for itself, resembles the Terminator. According to some studies, it is a collection of algorithms that can produce outcomes without needing specific instructions from people. The term AI is applied to relate to the competence that machines demonstrate. In the modern world, interest in AI has greatly increased (Oguejiofor *et al.,* 2023; Fahm, 2023; Pan & Zhang, 2022).

Okpo *et al.* (2022), stated that the difficulty of constantly evolving cyber-attacks threatens the wealth of benefits brought about by greater access to the internet and globally networked systems (Okpo *et al.,* 2022). Malware, social engineering, and phishing are a few types of cyber threats that frequently affect the construction sector (Mohammed, Sallehuddin, Yadegaridehkordi, Safie Mohd Satar, Hussain, & Abdel-Ghany, 2022). The implementation of level 3 BIM and a growing reliance on virtuality would raise exposure to cybercrime, it has been established, even if the construction industry does not frequently appear in research regarding cybersecurity (Mohammed *et al*, 2022).

Additionally, the construction sector is among the least digitally advanced in the world, which has made it challenging for it to address the issues it is currently facing. Artificial intelligence (AI), a cutting-edge digital technology, is currently changing sectors like manufacturing, retail, and telecommunications (Khurshid, Danish, Salim, Bayram, Ozbakkaloglu, & Mosaberpanah, 2023). Machine learning, knowledge-based systems, computer vision, robotics, and optimization are examples of AI subfields that have been effectively implemented in different industries to boost profitability, efficiency, safety, and security (Khurshid *et al.*, 2023). Evolutionary algorithms (EA) are a new class of metaheuristic algorithms that were developed alongside artificial intelligence (AI) in the 1950s (Sloss & Gustafson, 2020; Lu, Chen, & Zheng, 2012; Lagaros, & Plevris, 2022). If there is no adequate network security and response plan, any digital technology utilized in the construction sector, including AR/VR, IoT, and even AI like hard and soft robots, is susceptible to cyberattacks (Manzoor, Othman, Durdyev, Ismail, & Wahab, 2021). Evolutionary algorithms (EA) are a new class of metaheuristic algorithms that were developed alongside artificial intelligence (AI) in the 1950s (Sloss & Gustafson, 2020; Lu, Chen, & Zheng, 2012; Lagaros, & Plevris, 2022). If there is no adequate network security and

response plan, any digital technology utilized in the construction sector, including AR/VR, IoT, and even AI like hard and soft robots, is susceptible to cyberattacks (Manzoor, Othman, Durdyev, Ismail, & Wahab, 2021).

To understand AI applications, assess currently employed AI methodologies, and pinpoint potential and difficulties for AI applications in the construction sector, an evaluation of the existing research on AI's uses in the construction sector, including activity monitoring, risk management, and resource and waste minimization, was carried out. Despite recognizing the advantages of AI applications, this study found that the construction sector still faces many AI-related problems and this study also highlighted and discussed the prospects and difficulties associated with AI applications in the construction industry.

3. Research Methods

The study adopted the use of both structured questionnaires and interviews administered to selected stakeholders comprising a random sample frame of 65 sampled key players (AEC registered professionals) currently working on 113 projects with resident professionals who are the relevant key players comprising 32 AEC firms and companies within the Lagos State cutting across the following areas; Lekki, Ibeju-Lekki, Epe Area, Lagos Mainland, Ikeja GRA Districts were considered for this study due to the high rate of building development in the areas. The study also considered some parts of Ogun State which have been integrated as part of the Lagos Metropolitan Masterplan such as the Mowe-Ibafo, Akute, and Sango Ota development pressured areas. This study population was selected because they constitute the Architect, Builder, Structural Engineer, Quantity Surveyor, Landscape Architect, Mechanical and Electrical Engineers, Environmental Health and Safety experts (HSE), General Contractor + Subcontractor, Construction Project Manager, Clients-Home Owners, and other financiers that are directly involved in the execution of construction projects. Structured interviews were conducted directly with the resident professionals at the time of the visit Joint interviews were conducted among the key players and resident professionals available at the time of the pre-construction, construction, and post-construction stages. Questions included the awareness, use, and impact of IoT and AI on the design process, the impact on the post-contract stage, factors preventing the adoption and application of IoT and AI, and solutions to challenges. Answers from respondents were collected and analyzed. The results from the variables were tabulated and the mean value was determined. The mean values were used to determine the seven identified variables at every level on site. The study further assesses the application of the Internet of Things (IoT) and Artificial Intelligence (AI) in real-time site progress in Lagos. It considers the seven drivers of IoT and AI which are common in the following areas; site operation, the technology deployed, model innovation, site coordination, industry collaboration, construction project management, and finally the construction methodology.

4. Results

The result from the on-site assessment of the adoption and the total adoption implies the total deployment of any digital technology used in the construction industry, AR/VR, BIM, IoT, and even AI such as hard and soft robots, and unmanned area vehicles (UAV) for monitoring and site inspection. Partial adoption means the application of any of the AI tools in project management and

delivery which could cut across any of the following; Residential (Mass Housing), Commercial, Industrial, Administrative, School, Religious, and Mixed-use Buildings as identified in this study.

Table 2 further reveals the level of adoption and application of IoT+AI in site operation, site coordination, management, and construction methodology. This shows the reduction in the consumption of energy as time progresses as a result of AI and IoT. In site investigation, AI and IoT can help monitor site operations using smart systems that can help monitor light, temperature, humidity, and even soil moisture using connected sensors. With AI and IoT, drones can be deployed to monitor the position and volume of materials and labor on site. The internet has developed beyond merely providing human-to-human communication to enabling human-to-human communication between various items to build a smart environment. The primary area of study interest in the use of IoT+AI subfields for the construction sector has historically been optimization which is closely related to the industry's ongoing battle with low productivity levels and poor expertise.

The table 1 shows that Architects have the highest number of ongoing projects with the utilization of IoT + AI. Meanwhile, 2 of their projects have a partial application of IoT+AI. However, clients (home/project owners) seem not to know the application of IoT+AI in the day-to-day control of their projects.

Table 1: Table showing the Key Players in IoT and AI Adoption in Lagos Nigeria

Key Players	Number of Professionals	Number of Ongoing Projects	Project with IoT and AI	Percentage of Ongoing Projects (%)
Architects	9	17	2	15
Builders	7	10	0	9
Civil + Structural Engineers	4	15	1	13
Quantity Surveyors	5	9	2	8
Landscape Architects	5	6	0	5.5
Land Surveyor/GIS Experts	3	7	3	6
Mechanical and Electrical Engineers	4	11	0	10
Environmental Health & Safety Experts	2	5	0	4.5
General Contractor + Subcontractor	11	15	3	13
Construction Project Manager	7	8	1	7
Clients / Home Owners	10	10	0	5
Total	65	113	12	100

Table 2: Table showing the Ongoing Projects and the level of IoT and AI Adoption in Lagos Nigeria in the year 2022

Key Players	Residential + Mass Housing	Commercial +Industrial	Administrative + School	Religious	Mixed-use Buildings	Total adoption	Partial Adoption
Architects	2	–	–	–	–	–	^^
Builders	–	–	–	–	–	–	–
Civil+Structural Engineers	1	–	–	–	–	–	^
Quantity Surveyors	1	1	–	–	–	–	^^
Landscape Architects	–	–	–	–	–	–	–
Land Surveyor/GIS Experts	–	3	–	–	–	–	^^^
Mechanical Engineer Electrical Engineer	–	–	–	–	–	–	–
Environmental Health & Safety Experts	–	–	–	–	–	–	–
General Contractor + Subcontractor	1	–	–	–	2	*	^^
Construction Project Manager	1	–	–	–	–	*	–
Clients/ Home Owners	–	–	–	–	–	–	–
Total						2	10

*Please note: *(Total Adoption) ^ (Partial Adoption), - (No Adoption)*

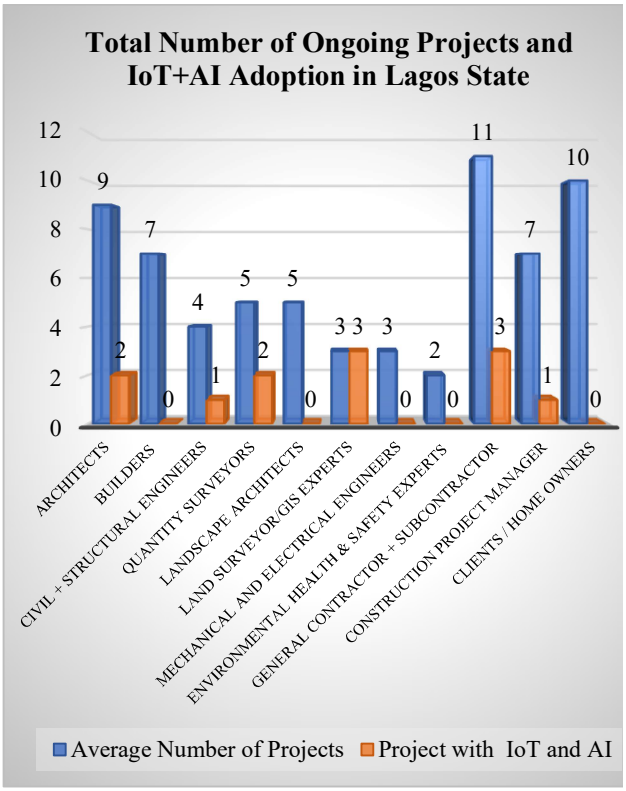

Figure 1: The key players in IoT and AI adoption in Lagos State, Nigeria

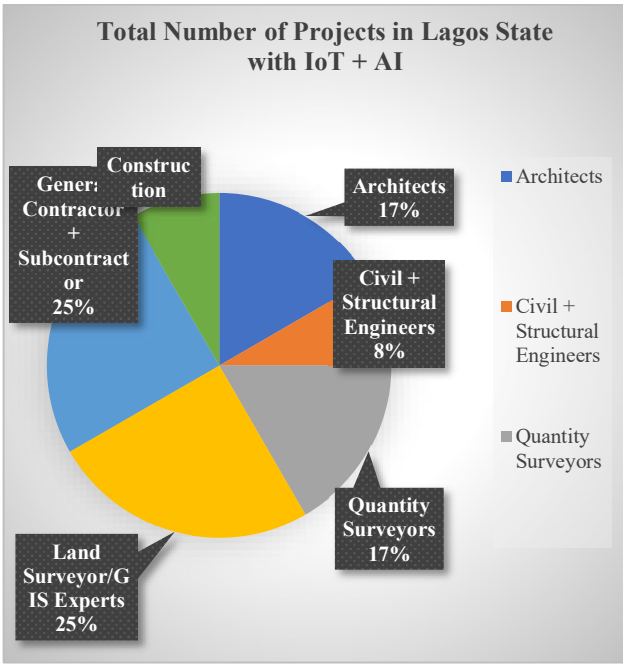

Figure 2: The key players in IoT and AI adoption and their level of involvement

The Land Surveyor/GIS Experts and the Main Contractor appear to have three projects each ongoing whereby the partial adoption of IoT+AI had been introduced (see Figure 2). The knowledge of the construction project manager is not sufficient for him/her to adopt the use of IoT+AI due to the challenges and bewildering professional practices in Nigeria (see Figure 3). The result shows the key players interviewed on-site and their various firms stating the average number of projects and personnel on site and staff members in the office with or without the knowledge of BIM. There were various stages of work at the selected sites during the visit and the Main Contractor (25%), Architect (17%), Civil Engineers (8%), Construction Project Manager (8%), Land Surveyor (25%) and Quantity Surveyor (17%) seem to have the highest number of projects; respectively. While their IoT + AI proficiencies, awareness, and knowledge vary accordingly with the contractors showing a high level of appreciation followed by the Land Surveyor and of course the Landscape Architects and Environmental Health & Safety Experts have limited or no knowledge of the innovation having very few projects and personnel to either train or use (see Figure 2). The creation of innovations in a variety of industries has increased steadily as a result of the quick technological advancements in fields like AI and IoT. This growth and advancement in technology have reached most facets of human endeavor and key among these new developments include the IoT and AI.

In line with the study, the Internet of Things (IoTs) is made up of enormous systems of interconnected devices. The characteristics of the Internet of Things (IoT) focus on connectedness and modifications involving these gadgets, including the beginning and closing down of this equipment, the transfer of information and generation of reports,

the measurement of an equipment's heating rate, and a variety of all other development and infrastructure to the IoT's particular function.

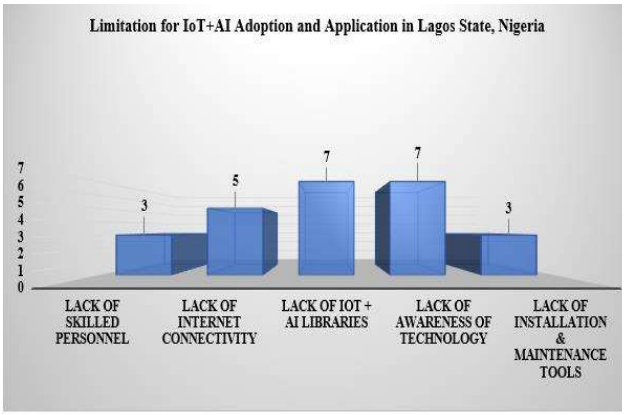

Figure 3: Major challenges against the application of IoT+AI

IoT requires additional cognition to successfully interpret and provide output, which itself is inherent to AI. On the other hand, this invention steadily decreases the demand for human labor because it uses human intelligence to complete daily chores without the assistance of people. Compared to nations with emerging economies, these technologies are more commonly used in industrialized economies. It is important to strike a balance in light of these problems because IoT and AI work best together. The following challenges and limitations were identified as some of the barriers to the adoption and application of IoT+AI. The lack of skilled personnel, Lack of internet connectivity, lack of IoT+AI libraries, lack of awareness of the technology, and lack of installation and maintenance tools. Also identified as a limitation is the lack of electricity and a conducive socio-economic environment in Nigeria. Figure 4, reveals that the inaccessibility to IoT+AI libraries and technology is very critical in the construction industry in this part of the world.

Internet access may not be a major challenge as most key players would have sufficient access to internet data, sustaining it with electricity and other factors like installation and maintenance is the greater issue militating against the wide application of this 21st-century technology. The main stakeholders' perspectives on how the barriers should be removed were revealed via the responses to the questions and interviews. Such are the demands for more study, different degrees of training, and the development of fundamental infrastructure to facilitate the usage of IoT+AI.

5. Results and Discussion

The above research demonstrates that the decision about the BIM software to be used is important to all major stakeholders and specialists in the building sector. The most popular in this region of the world is Revit, nevertheless. Users can develop, edit, and view building models in a three-dimensional environment with this well-known BIM design program. It is one of the most widely used BIM software products on the market and is used by construction practitioners, BIM architects, and BIM engineers all around the world.

This study shows that all the key players and professionals in the construction industries have a stake in deciding on the applicability of IoT and AI, especially in the AI and IoT advancements are blazing the trail in most industries and it is expedient to emphasize that technological advancements and Information and communication technologies (ICTs) have accelerated and progressed lives significantly. As a result of new information technology and high-speed internet connectivity, new avenues for resolving global concerns in academia, healthcare, agribusiness, economics, science, and government have recently opened. With this in mind,

it is critical to emphasize that the adoption of new technology will benefit the development of the construction industry in Nigeria. The study identified some of the benefits that come with the integration of IoT+AI into real-time site management and coordination. Usually, the solution identified in the study uses IoT hardware that contained a battery-powered vibration sensor and a GPS sensor integrated into the tool with screws and the sensors sent data to the IoT platform using a cellular network.

It helps the key players in the construction sector used in problem identification and solving while reducing cost and saving enormous time on the task. This however adds value to the project. The study identified the following list as considered benefits of IoT+AI; Supply chain transparency, Industrial equipment monitoring, machine controllers, equipment, wifi network, motion detection, geolocation, and air quality. Sometimes this application could be mobile applications with unique user IoT interfaces used for both data storage and data analysis. However, choosing the correct hardware can often be the most complicated part of developing an IoT solution. Things like availability, cost, intended environment, battery life, and connectivity options all have to be factored together when making hardware choices by the key players. An IoT+AI solution provides data about varying machine component conditions on site and can help the project manager monitor conditions and reduce maintenance costs with condition-based maintenance. It is designed for asset tracking and data integration and can benefit customers in a range of industries. An IoT solution that grants access to machine data can help architects, builders, and site engineers remotely measure, monitor, and manage production from anywhere. For site equipment monitoring solutions, the hardware choice is often limited to choosing a gateway that can bridge the gap between your equipment's local environment and your IoT cloud platform.

AI and IoT in Greenhouse Gas Reduction and Site Assessment

Numerous businesses, organizations, NGOs, and governments are committed to improving energy efficiency and reducing greenhouse gas emissions following the UN's sustainable objectives for access to cheap, clean energy as well as climate action. The current craze is for renewable energy. The use of drones in the energy sector is one way that AI and IoT have affected renewable energy. Drones are flexible and widely applicable across many economic sectors. Drones are employed in the energy industry for both the production and distribution of energy. The use of "Electric Vehicles" (EVs) to reduce greenhouse gas emissions is another technological development in the energy sector that is in line with renewable energy. The Integration of reinforcement learning Algorithm (product of AI) is used in electric vehicles to reduce energy consumption.

Construction work Tracking & Site Equipment Monitoring

With regard to the opportunity of applying IoT+AI, an equipment manufacturer has recently learned that business owners who buy their products would like to integrate location and usage tracking information into their equipment to help them better manage resources. Construction equipment often gets lost, left behind, or mismanaged. Not knowing the location and condition of equipment leads to a lack of insight into day-to-day site operations. If a project is delayed, bad reviews are reported and activities slow down. Access to location data can

give insight into what's going on to resolve problems for the contractor.

The project manager has to research the IoT stack to understand how this solution could be built into the project. The IoT+AI platform provider introduced the company to the hardware partners who could provide the necessary sensors. Smart Spaces are highly connected buildings and environments that use a range of devices and sensors to enable simple, intuitive control and management of areas such as energy usage, security, and maintenance. Through IoT, the project gets remote and proactive monitoring through digital interfaces, automated workflows such as timed lighting schedules, HVAC controlling, enhanced services related to tracking human resources, and fixed and movable assets. One of the ways AI and IoT have impacted housing and infrastructural development is the deployment of drones in the construction sector. Drones and robots have wide practicability and flexibility in any sector of the economy. In the construction sector, drones are used in both the process of monitoring and coordination of project progress.

Cost Benefits of Using an IoT+AI

First, IoT+AI helps to drive cost savings & efficiency gains by detecting wear and tear on critical pieces of equipment and capital assets and predicting when and where repairs or maintenance activities are needed. Next, pinpoint risky situations and implement advised countermeasures to stop them in their tracks. Current and probable asset failures as well as climatic occurrences can be detected using machine learning. Finally, a successful company that has a long-term perspective and actively monitors ecological, societal, and political issues using our trimming technologies seems to be what drives sustainability. IoT+AI is supporting leaders, top management, and companies of industrial machinery with strong edge computing technology that allows them to make informed decisions about construction projects based on precise data, including the understanding of utility usage, building occupancy, environmental conditions, and social factors. IoT+AI is a cutting-edge technology that guarantees smooth connectivity into the current infrastructure, enabling speedier deployments and quick returns on investment for each user and all relevant parties.

6. Conclusion and Recommendations

Through smart wearables and site monitoring, the Internet of Things and Artificial Intelligence (IoT+AI) has lately achieved major improvements in the construction sector, making it ideal for all important actors as indicated in this study. For developers or clients who demand continuous and real-time on-site monitoring and preventative actions, the integration of IoT and site equipment enables project service quality and the tracking of construction progress. IoT and AI make it possible to spot problems as they arise, as well as to spot construction mistakes quickly and assist in fixing them before the project continues. Utilizing new technologies can facilitate construction project management and prevention.

Devices that record the status of the job in real-time are among them. Some of these gadgets automatically give remedies, while others, like wearable gadgets, continuously monitor earth equipment indicators. This study sheds light on some of the most important ways AI may be used to address problems unique to the construction sector as well as the way forward for achieving the benefits that AI can bring to the sector.

Making choices or judgments that, given a set of limitations, produce the best results is what optimization is all about. Making the optimal decision out of a variety of options is a construct of an optimization issue. It is a persistent phenomenon that was first recognized as a branch of mathematics that sought the best answer to each given problem.

This study has also shown the advantages of using data from IoT-enabled devices to offer cost-effective building project management that enables AI to produce precise predictions. With the proliferation of smartphones and high-speed Internet, many people increasingly use mobile applications to organize their various site meetings. IoT is useful for supply chain monitoring and installation of some components, in addition to its usage in e-design, e-planning, e-supervision, and e-coordination/Management.

The lack of trained employees, poor internet connectivity, a lack of IoT+AI libraries, a lack of knowledge of the technology, and a lack of installation and maintenance tools are some of the obstacles and limits that the study highlighted as hurdles to the adoption and use of IoT+AI. The absence of energy and a favorable socioeconomic environment in Nigeria were further acknowledged as limitations. The use of IoT+AI technologies continues to boost on-site productivity; therefore, it is only fair that we put the proper mechanisms in place to capitalize on the advantages of housing and infrastructure development.

IoT is not being used and adopted more frequently in sub-Saharan Africa, not even in Nigeria which has the biggest construction industry in Africa. The Internet of Things (IoT) application has many advantages, but it also raises the possibility of fresh security risks for healthcare systems. There are growing worries regarding confidentiality, integrity, and accessibility. A robust approach should be used to implement newer, stricter security regulations. Future research on this subject is also optimistic because IoT-based solutions will enable the application of AI algorithms from the design stage through construction and, ultimately, facility management. Both current and upcoming construction IoT and AI solutions should pave the way by incorporating usability, interoperability, and security to have a significant impact and success in the construction business. Soon, these solutions will be widely acknowledged by Nigeria's numerous professional institutions and regulatory agencies.

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