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Review Paper

Revolutionizing Oil and Gas Industries with Artificial Intelligence Technology

Abdulhamid Musa[1]

[1]Electrical and Electronic Engineering Department, Petroleum Training Institute, Effurun, Nigeria

Author's Mail Id: musa_a@pti.edu.ng

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Abstract: The oil and gas industries must adapt and modernize their processes to stay competitive, reduce environmental impact, and promote sustainability. This involves investing in artificial intelligence, automation, and data analytics to streamline operations, improve efficiency, and reduce costs. The focus of this paper is the revolutionary impact of Artificial Intelligence technology on the oil and gas industries. However, the technology of Artificial Intelligence has revolutionized the oil and gas industries by automating processes like drilling and production, improving equipment reliability and safety, and providing valuable insights into reservoir management and supply chain management. Besides, there are risks and constraints, such as limited model generalizability and the need for new resources to train new datasets. Thus, using artificial intelligence in engineering can reduce costs and improve quality, but ethical considerations must be taken into account such as job displacement and ensuring the decisions by the artificial intelligence technology align with societal values. Integration of artificial intelligence requires careful examination of technical and ethical factors too. Accordingly, this study also highlights the immense potential of artificial intelligence in the oil and gas industry, while also acknowledging the need for careful consideration and implementation. By leveraging the power of artificial intelligence, we can unlock new discoveries and streamline processes in this vital industry.

Keywords: Artificial Intelligence, Oil and gas industry, Machine Learning, Intelligent Automation, Algorithm, Maintenance.

1. Introduction

The utilization of artificial intelligence (AI) has gained significant prominence in the field of engineering, and its interpretation can be perceived through multiple lenses. Artificial intelligence, technically speaking, pertains to the capacity of computer systems to imitate human intelligence by means of employing algorithms and machine learning (ML) methodologies. Artificial intelligence (AI) is a fast-developing technology that has been in use for more than two decades in various industries, including the medical, retail, media, and financial sectors. The ethos of AI is one of open sharing and publication. [1-3]. Virtual sensing, production control, optimization, forecasting, and simulation are just some of the many ways AI is put to use in exploration and production (E&P). However, AI applications have not yet become industry standards; the most prevalent AI applications in the E&P industry are still limited to case studies and pilot initiatives [1]. Nevertheless, AI has demonstrated significant innovation and growth potential across all disciplines, and it has become the most essential general-purpose technology [3] available today. Artificial intelligence (AI) solutions entail intricate algorithms that have undergone training on extensive and valuable datasets. These datasets are consistently supplied with new data to facilitate the process of generating value Fields [3]. The potential of AI-based work has been demonstrated as a promising avenue for various fields, including but not limited to optimization of development plans; detection of residual oil; detection of fractures; better oil recovery; and dynamic prediction of oilfield production [4]. It is important to note that AI solutions are not universally applicable and cannot be readily procured. Rather, they necessitate customization to align with the specific business context and data of the organization [2, 3]. Consequently, it is imperative for enterprises to develop internal groups of professionals specialized in data and artificial intelligence in order to effectively integrate AI into their operations and offerings. Over the course of the upcoming decade, professionals with expertise in artificial intelligence will likely become an essential component of virtually all innovation initiatives within the oil and gas sector (OGS). The oil and gas industry (OGI) is expected to adopt a partially data-driven approach due to this emerging trend, with the integration of AI technology across various stages of the industry [2]. AI was born without any significant business influences and has been a product of academic research that has been ongoing for decades [1-3].

AI is a swiftly developing field of technology with significant applications in to do with the oil and gas business. Intelligent drilling is just one of the many applications it has in OGI,

development, pipeline construction, and processing. Furthermore, the OGS has the potential to leverage AI to appraise the potential ramifications of novel undertakings or to scrutinize the ecological hazards linked to a new initiative prior to formulating blueprints. Figure 1 illustrates the various branches of the artificial intelligence [5]. Various AI techniques have been effectively implemented within the OGS.

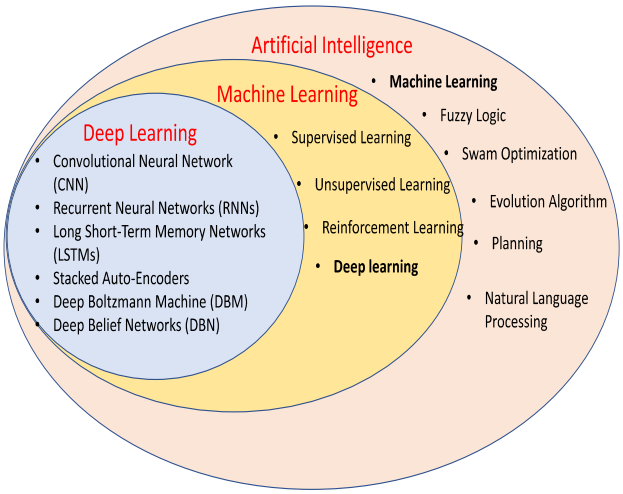

Figure 1. Branches of Artificial Intelligence.

Accordingly, the OGS comprises a range of intricate industrial activities, with the upstream, middle, and downstream domains representing the majority of these operations. The OGS is depicted in Figure 2. The term "upstream sector" pertains to the initial stage of the oil and gas life cycle. As per prior scholarly investigations, this stage encompasses a diverse range of activities, including but not limited to reservoir engineering, to do with the oil and gas business. Intelligent drilling is just one of the many applications it has in the OGI [5].

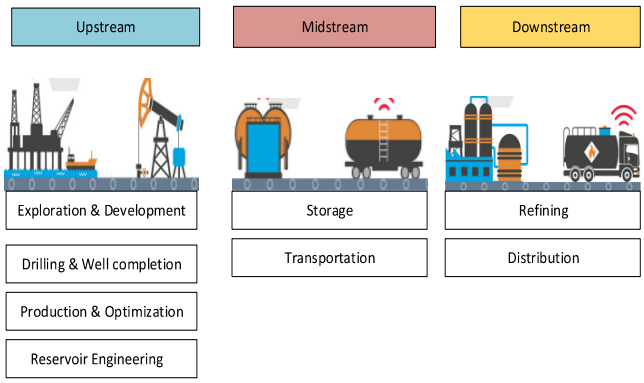

Figure 2. Oil and gas Industry Sectors.

This paper is divided into several sections that explore the role of using A.I. to Improve the Oil and Gas Sectors. The first section delves into extraction of petroleum and natural gas, while the second section focuses on Refining and Distribution. The third section examines the Role of AI in the Gas Industry, highlighting how AI is transforming the way we extract and process natural gas. The fourth section explores the Impact of AI on Control and Automation, discussing how AI is revolutionizing the way we monitor and management of oil and gas production. The fifth section delves into AI in Maintenance and Safety, discussing how AI is improving safety and reducing downtime in the OGI. Finally, the paper concludes with a discussion on the Oil and Gas Industry AI's Bright Future, highlighting the potential for AI to transform the industry in the years to come.

2. Literature Review

This section provides an overview and evaluation of the relevant papers in the field of Oil and Gas Industries With AI Technology. The purpose of the section is to identify, select, and critically review the existing literature on AI technology as applied to Oil and Gas Industries. This enables us to develop new insights into the topic under study.

The potential of intelligent wellbore systems and new sensors has been acknowledged by the petroleum industry. The management of real-time data processing necessitates the involvement of an operator to oversee the software. The implementation of intelligent systems is deemed the sole feasible approach to endow novel hardware with the capacity to perform real-time analysis and decision-making [6].

Artificial Intelligence (AI) is a cognitive system that is progressively being employed in the OGS, specifically in the areas of intelligent drilling, intelligent pipeline, and intelligent refinery. Artificial intelligence (AI) can facilitate the establishment of an ecosystem that enables the collaboration and coordination of various levels, sectors, and areas. This ecosystem can effectively prolong the life cycle of oil fields, and enhance to maximize economic gains while reducing expenses and improving decision quality[7].

The present article offers an exhaustive analysis of the current state of AI in the OGI. The focal points of this study encompass three principal domains, namely the interpretation of geological data, price prediction, and flow regime projection. The implementation of AI has been shown to enhance the efficacy of exploration and production processes, thereby enabling the attainment of superior outcomes while minimizing associated expenses. Data mining techniques have the potential to be employed throughout all phases of the oil extraction [8].

Oil and gas companies are starting to use AI and has gained significant traction. This study aims to examine the implementation of AI in crucial areas such as forecasting production dynamics, optimizing development plans, identifying residual oil, detecting fractures, and enhancing oil recovery. A comparative analysis has been conducted on the advantages and disadvantages of extant AI algorithms, and an assessment has been made of the present state of AI implementation in the domain of oilfield development. Additionally, recommendations and prospective avenues for future research have been put forth [9].

The OGS has exhibited a sluggish pace in embracing nascent technologies; however, in the current era of AI, it is at the cutting edge of new technology. The advent of artificial intelligence (AI) has brought about a significant transformation in the manner in which companies generate, retain, and furnish value. Consequently, conventional competencies and aptitudes in the oil industry are currently facing a precarious situation, with the possibility of becoming outdated and irrelevant. The present manuscript elucidates the manner in which artificial intelligence (AI), automation, and robotics have redefined the contemporary notion of labor in the oil industry. Furthermore, the manuscript expounds upon the novel challenges and responsibilities that have arisen as a result of the AI revolution. The article additionally delineates various conventional job designations in the oilfield industry that have been rendered vulnerable due to automation. It also acknowledges the apprehensions of experts occupying these vulnerable positions and presents a strategic plan for enduring and prospering in a world that has undergone a digital transformation [10].

The present study examines the impact of AI on the E&P side of the oil and gas sector. In this paper, we delineate the latest patterns in the advancement of artificial intelligence (AI)-based instruments and ascertain their impact on expediting and mitigating risks in various processes. The article also examines the primary non-technical obstacles that impede the widespread implementation of AI in industry, specifically pertaining to issues surrounding data, human resources, and collaborative efforts. This paper presents an overview of three potential scenarios regarding the evolution of AI within the oil and gas sector, and its potential implications for the industry going forward [11].

The OGI has witnessed a surge in demand for sophisticated and resilient tools, owing to the growing focus on intelligent fields, smart wells, and real-time analysis of voluminous information for process improvement. The integration of artificial intelligence (AI) into the mainstream industry has progressed significantly, as evidenced by recent advancements in AI systems. This article provides an overview of some of the latest and most sophisticated applications of AI in the industry, as well as a discussion of their potential impact on the industry's future [12].

The OGS necessitates advancements in technologies and methodologies to enhance its management, engineering, and cyber capabilities. The present study centers on qualitative investigations pertaining to the performance of blockchain, big data, and AI in the industry. It is anticipated that professions associated with this field will witness the implementation of measures aimed at enhancing transparency, safety, and operational efficiency. [13].

The 4th Industrial Revolution is inducing a transformation in the OGS, albeit at a sluggish pace, owing to inherent structural challenges ingrained in the configuration of systems from the previous century. Various solutions have been devised to assist companies operating within the industry, including applications that pertain to the subsurface in geophysics, completion design, and production. To address the challenge of data silos, it is necessary to adopt a new approach to cloud infrastructure that takes into account the considerations of user access, data privacy, and data residency requirements. The evaluation of data quality, diversity, and variation is a crucial step to avoid unnecessary expenditure of resources by companies in developing and fine-tuning machine learning algorithms. Innovative approaches have been devised to alleviate data congestion, enabling decision-makers to transition from a state of understanding to one of anticipation and facilitate transformation [14].

The utilization of the Internet of Things (IoT) alongside the advancements in sensor technology, data analytics, and AI has facilitated noteworthy enhancements in efficiency and productivity within the oil and gas sector. Although engineered to function in challenging environments, ESPs are susceptible to malfunction. The present study investigates an innovative artificial intelligence (AI) driven system that facilitates operators to proactively prevent expensive electrical submersible pump (ESP) malfunctions while simultaneously enhancing production efficiency. A proof-of-concept and subsequent pilot project were conducted in an onshore oilfield, wherein 30 Electric Submersible Pumps (ESPs) were utilized. The pumps had varying power capacities, ranging from 200 kW to 500 kW. The ESPs were monitored using a predictive maintenance model that was supported by Artificial Intelligence (AI). In a particular instance, the likelihood of an Extra Sensory Perception (ESP) malfunction was ascertained 12 days prior to the manifestation of an ESP failure [15].

The present study provides an overview of the latest advancements and operational procedures in the OGS. It presents a SWOT analysis as a tool for strategic management and technology facilitation. The study concludes that in order to fully capitalize on the advantages of machine learning in tasks that are crucial to the success of a mission, it is imperative for the industry to make use of the most recent technological advancements, maintain a consistent strategic orientation, and establish teams of data scientists and domain experts that are both agile and collaborative [16].

3. Methodology

The methodology utilized in this study involves identifying the key processes of Artificial Intelligence (AI) in relation to its technical input and role within the OGS. This approach intends to supply a thorough understanding of how AI functions and contributes to various sectors as shown in Figure 3. By analyzing the technical aspects of AI, we can gain valuable insights into its potential applications and limitations.

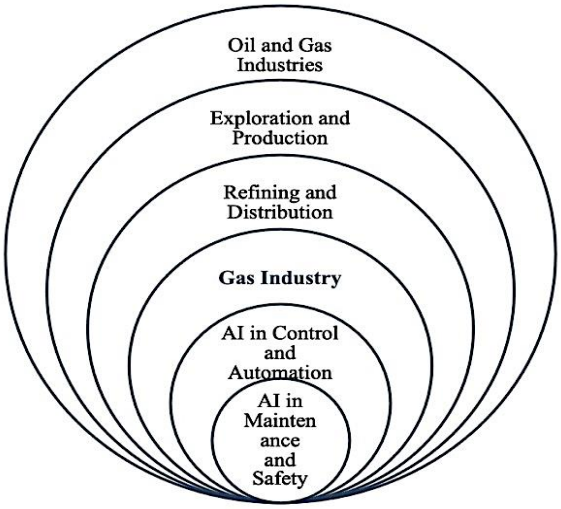

Figure 3: The categories of the industries.

4. Potentials of AI Technology

This section includes a look at how AI might be used in the energy sector, including the OGI, as they relate to the groupings depicted in Figure 4.

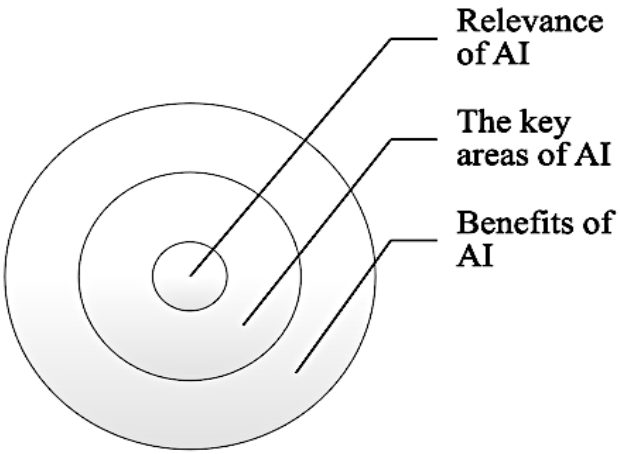

Figure 4: Arrangement for the AI analysis

4.1 Relevance of AI

4.1.1 Oil and Gas Industries

Using AI algorithms, developers can construct a variety of realistic research and production application technologies. The primary implementation of AI technology in oil field development, based on production data from previous oil fields, is to fine-tune the blueprint for development. As a result of using this method, exploratory risks have been mitigated and drilling success rates have increased [17]. New drilling devices, such as automated drilling platforms and intelligent drill pipes, have substantially enhanced drilling quality and decreased costs. In addition, investigated are AI approaches and algorithms, as well as the purpose and accessibility of the segment's data [3, 17]. Using AI can expedite and reduce the risk associated with hydrocarbon exploration, field development, and production [3]. AI can aid in the discovery of new hydrocarbon and gas reserves [17]. The increasing use of AI in the OGS is nevertheless hampered by non-technical challenges related to data, people, and new forms of collaboration. Education, organizational culture, and the availability of data can affect the rate and direction of AI industry penetration. In the next five to twenty years, there are three potential scenarios for the development of AI in the OGI. Despite this, artificial intelligence is a useful instrument that can benefit the OGI [3]. An example of how machine learning can enhance the industry's understanding of its applications is the improved processing of seismic data. This study evaluates both technical and non-technical aspects of ML adoption in OGI, including network architecture, ML development platforms, and the possibilities and difficulties [18]. Diverse participants in the oil and gas ecosystem, including regulators, major international oil companies, smaller field operating companies, start-ups, universities, and technology-oriented oil service companies developing novel AI-assisted tools for oil companies, are developing AI solutions [3].

4.1.2 Exploration and Production

Various aspects of the OGS including E&P have been quick to implement AI and ML. AI is being used to reduce exploration risks, refine development plans based on historical data, improve drilling quality while reducing costs, and improve drilling efficiency. AI also facilitates the use of precision drilling and automation in oil and gas operations. AI is able to interpret vast amounts of data generated by a variety of sources, including seismic exploration, logs, and cores, among others. Several artificial neural networks (ANN) models have been developed for real-time applications, including the estimation of the rate of penetration (ROP) and drilling performance. ANN is currently the most widely used artificial intelligence technique in the industry. However, there are challenges associated with AI integration, such as the need to integrate AI's data-handling capability with petroleum engineers' extensive industry domain expertise. In addition, there may be a lack of trust and dread of job loss associated with the use of AI in E&P; however, it is anticipated that humans will use AI to improve their decision-making abilities as opposed to replacing them. Integrating AI also allows oil and gas producers to reduce risks, increase output, and save time and money. Unresolved is the legal implications of AI recommendations and the allocation of responsibility among the AI algorithm, the user, and the developer [17]. In spite of this, AI algorithms are already being incorporated into exploration and production processes and are being utilized as a catalyst for digitalization across industries. The oil and gas industries will make extensive use of machine learning in the future years.

4.1.3 Refining and Distribution

Developing AI models involves several stages, including data acquisition, refinement, labeling, and distribution. To ensure that these stages are carried out effectively, various types of managers are needed to support and manage the process. According to the research [19], the role of general managers involves providing support by comprehending the AI professionals' scheme and effectively managing personnel to

facilitate the successful processing of research and development. Acquisition, refinement, and labeling managers are responsible for selecting and training their team members to assist in emphasizing the improvement of the model's capacity. Nonetheless, there is a need for large-scale educational initiatives and assistance to assist novice researchers in attaining advanced levels of education. The selection of a precise learning technique, data gathering, improvement, and labeling can address the issue of manpower, which is one of the major obstacles in the development of AI. To surmount this difficulty, an innovative method of allocating labor for the development of AI processes is proposed, which can aid in resolving the issue of manpower constraints in AI development projects [19]. Therefore, it is essential to have a well-managed and skilled team to ensure that the AI model is developed effectively and efficiently.

4.1.4 Gas Industry

The OGI has traditionally relied on empirical methods to identify and develop new oil and gas fields. However, with the advent of AI, the industry is moving towards a more data-driven approach to exploration and production [3]. AI is being used to de-risk the industry, optimize upstream, midstream, and downstream operations, reduce costs, and improve safety measures [3, 20, 21]. AI-based instruments are being created to speed up and de-gamble measures in the industry, and AI is being used in drilling operations to optimize drilling parameters and reduce non-productive time [3, 20]. AI-powered predictive maintenance has the potential to increase asset uptime and reduce maintenance costs, while AI can help identify and mitigate safety risks by analyzing past incidents and identifying patterns. AI-enabled reservoir modeling and simulation can provide insights for better decision-making in exploration and production, allowing for optimization of production, reduction in costs, and enhancement of safety. In addition to these applications, AI is being used for geological assessment, drilling, reservoir engineering, and production optimization [3]. The OGI has the potential for swift expansion of machine learning implementation due to its ability to process large data sets and exhibit high computational velocity, as noted in the reference. Since the 1990s, Total and other corporations have employed artificial intelligence (AI) and ML algorithms to classify oil and gas fields. This highlights the capacity of AI in the field [2]. While there are adoption-related difficulties of machine learning industry-specific technologies, such as data challenges and technical efforts to improve AI systems for practical usage, collaborations between businesses, institutions, and governmental organizations are crucial for intensifying the method for innovation in the AI sector [3, 20, 21].

4.1.5 Control and Automation

AI, or artificial intelligence, is an increasingly prevalent technology that covers a broad range of tools used to substitute for human cognitive ability. The use of AI in control and automation has experienced a new wave of popularity in the 21st century. AI has been applied to certain energy-related issues, like energy-saving building techniques and energy economics, making it advantageous for the automation of the energy system control (ESC) [22]. ML is an important subfield of AI that studies computer algorithms that improve autonomously through experience. Supervised learning requires labeled data, whereas unsupervised learning does not require any labels. Some ML algorithms, such as black-box models, cannot comprehend and control their deviations [1]. Besides [4] present a novel iteration of AI that is applicable to Smart Grid (SG) applications. Despite its capacity to recognize intricate patterns and relationships with minimal pre-processing, artificial intelligence (AI) is unable to generalize multiple tasks. The limitations of AI in terms of generalizing multiple tasks necessitate the need for specific implementation and appropriate control mechanisms for addressing specific problems. Research papers have analyzed the effects of artificial intelligence (AI) on energy storage systems (ESC) in the context of the energy transition process. Additionally, computational obstacles related to the implementation of automated ESC have been deliberated. The effective utilization of AI in ESC automation can be facilitated by contextualizing the acquired data, aiding in human decision-making, and reducing the cognitive burden on operators. The utilization of artificial intelligence (AI) in energy storage system control (ESC) automation necessitates the establishment of standards and testing protocols to safeguard person access and preserve the integrity of the energy system [22].

4.1.6 Maintenance and Safety

Currently, AI is used in a variety of industries and areas to improve maintenance and safety standards. The implementation of AI technology in these fields requires attention to safety considerations, including ethical and fairness concerns [23]. Despite these challenges, AI is being employed to prevent accidents and ensure the proper function of machinery. In manufacturing industries, AI-powered predictive maintenance systems can monitor equipment for any signs of wear and tear, enabling technicians to address issues before they become major problems. This helps reduce the chances of unexpected equipment failure, unplanned downtime, and costly repairs. In addition, AI is used to predict and prevent accidents in various sectors such as transportation, construction, and mining. For example, AI algorithms can detect and flag potential hazards like mechanical failures and human error in real-time, allowing for timely interventions to be put in place [23]. Furthermore, AI-powered safety systems can also be utilized to monitor employee behavior and ensure that they are following proper safety protocols. These systems can alert management when an employee engages in unsafe behavior, such as not wearing protective gear or violating safety protocols. By integrating AI technology into maintenance and safety practices, industries can improve their overall safety standards and reduce the likelihood of accidents and injuries.

4.2 The Key Areas of Artificial Intelligence

4.2.1 Oil and Gas Industries

The deployment of Oil and gas companies using AI has proven highly effective in optimizing a variety of industrial objective functions [24]. The Upstream Petroleum and

Natural Gas Sector has become a major application area for artificial intelligence, with applications in geological assessment, drilling, reservoir engineering, and production optimization [3]. Oil and gas deposits have been characterized using AI and ML techniques [17]. Subsurface images from seismic surveys have been interpreted using computer vision technologies. Several hundred million dollars have been saved as a result of the implementation of Predictive maintenance for pumps, compressors, and turbines. Utilizing natural language processing to analyze technical documents automatically, artificial intelligence algorithms can detect the type of extracted rock and the probability of failure, resulting in time and cost savings [3, 17, 25]. Moreover, AI has been implemented in oil and gas operations to improve safety and reduce environmental impact [25]. While AI is predominantly used in the OGI to increase efficiency [3] there are legal concerns regarding AI's recommendations in the industry. Also of concern is the classification of accountability between the AI algorithm, the user, and the creator of the AI [17]. Petroleum engineers may be required to learn how to work with industrial-application-specific versions of Alexa and Siri-like artificial intelligence assistants. It has been posited that the role of AI is to enhance human decision-making capabilities rather than supplant them. Consequently, it is incumbent upon companies to devise strategic blueprints and legal frameworks that can meaningfully enhance decision-making proficiency [17].

4.2.2 Exploration and Production

Researchers in the petroleum industry have acknowledged that employing AI in exploration and production has a number of advantages. The significant advantage of artificial intelligence is that it can solve optimization problems with exceptional performance, ensuring better results for industrial decision-making purposes. For instance, AI has been utilized extensively to optimize various objectives in the petroleum sector, such as reducing drilling costs and increasing production efficiency [24]. In addition to optimization, another benefit of AI in exploration and production is its potential to automate drilling systems, making drilling processes more efficient and less risky. The mining industry has a lot to gain from AI-enabled digital transformation services, which can be offered to customers. These services can enhance productivity and lower costs by providing better decision-making capabilities. Moreover, the use of AI can lead to new business opportunities for mining industry customers [26]. Mining companies can leverage AI to gain insights into their operations, enabling them to make informed decisions that can increase profitability. Hence, the use of AI in exploration and production can provide numerous benefits to the petroleum and mining industries, including optimization of objectives, automation of drilling systems, and new business opportunities.

4.2.3 Refining and Distribution

Artificial Intelligence (AI) offers numerous benefits in refining and distribution processes in energy, petrochemical, oil and gas, and power generation, and similar businesses. AI is the use of computer algorithms to automate processes, such as refining and distribution, resulting in increased efficiency and cost savings. One of the key benefits of AI in refining is the life extension of oil and gas facilities [27]. AI algorithms can refine and incorporate features to optimize refining processes, such as intuitive text features [28]. Besides, AI can be used to coordinate decentralized problem-solving efforts, ensuring that the benefits of decentralization are not lost [29]. Distributed processing with AI is applicable to this situation to manage a vast scope of applications, including refining and distribution. Knowledge-based AI can be used in hypothesis testing, iterative refinement, and more, enabling strengths and weaknesses to be identified and addressed [30]. AI is divided into two approaches: heuristic search employing list processing and low-level agents doing local plan refining. However, the efficacy of AI methodologies depends on the specific applications and domain features [31]. State-of-the-art AI research is being incorporated into mobile edge computing (MEC) platforms, with several new features being developed for refining processes [32]. Thus, AI can be used to refine content through successive versions, with micro theories offering a means of organizing and refining content [33]. Therefore, AI has numerous applications in refining and distribution processes, with new applications continuing to be researched and developed [34].

4.2.4 Gas Industry

Artificial intelligence, or AI, is transforming various industries from finance to healthcare and even energy. The midstream sector of the OGI is not left out in this transformation. AI technology can be used to improve pipeline and infrastructure maintenance. By utilizing sensors and machine learning algorithms, potential leaks and corrosion can be detected early on, preventing catastrophic events like explosions or spills that harm the environment. Furthermore, midstream companies can leverage AI technologies to optimize transportation routes, resulting in reduced costs by lowering fuel consumption and improving delivery times. With reliable predictive analytics provided by AI technology, midstream operators are equipped to make informed decisions that lead to cost savings while reducing unplanned downtime with real-time monitoring of assets in their networks. As such, Artificial Intelligence has great potential in bringing efficiency and innovation into midstream operations for faster decision-making processes while ensuring safety standards are met.

4.2.5 Control and Automation

The use of AI in control and automation has numerous benefits. One of the most significant breakthroughs in the study of computer-generated intelligence (AI) is its ability to automate tasks that were once exclusively carried out by human beings. The development of Intelligent Automation, which can learn, adapt, and progress over time, has made this possible. In the past, automation was predominantly limited to manual tasks, but with AI, automation can also be applied to knowledge work and service work. For instance, algorithms are being developed that would enable the automation of cognitive tasks. This has substantial implications for office and administrative labour, consulting, and other knowledge-intensive professions [35]. By using automated processes, one may manage their environment,

their resources, and their data more effectively, resulting in greater control and automation productivity and efficiency [36, 37]. Moreover, AI can be advantageous for public sector control and automation [3]. For example, artificial intelligence and customer service robots can enhance the quality of the consumer experience. Moreover, AI can enhance support for travelers and enhance organizational decision-making. Moreover, AI can improve employee safety, security, and job satisfaction [37]. Intelligent Automation can also improve the efficacy of business processes. Finally, the utilization of robots within scientific laboratories has the potential to decrease labor requirements, enhance precision, mitigate hazards to human operators, eliminate sample contamination, and expedite task completion when compared to manual human processes [35].

Sequel to the above, AI has the potential to revolutionize control and automation in numerous industries, providing benefits in terms of efficiency, safety, and productivity.

4.2.6 Maintenance and Safety

AI can bring significant benefits to maintenance and safety in the OGI. One of the most prominent benefits is predictive maintenance. Predictive AI techniques can help with condition-based maintenance by providing accurate estimates of future failure times. This allows companies to schedule maintenance activities efficiently and avoid unplanned downtime. Additionally, AI can generate recommendations for operational actions through prescriptive AI, which can improve safety and optimize production processes. The use of AI in industrial applications can also lead to improvements in process design and control, which can help reduce the likelihood of accidents and improve overall safety performance [38]. However, the use of AI can also result in a drop in accuracy, as some algorithms may not always perform as expected [39]. Due to restricted computing resources and storage at ENs, lightweight AI algorithms are needed to ensure efficient processing of data and effective implementation of AI in maintenance and safety. Overall, the use of AI in maintenance and safety has great potential to improve operational efficiency and safety performance in the OGI [39].

4.3 The Benefits and Challenges of AI

4.3.1 Oil and Gas Industries

In the energy and petroleum industries, AI provides numerous benefits. AI techniques enable access to information utilized in the oil and gas industry that is both complex and intricate, facilitating real-time analysis and decision-making in the industry [40, 41]. Using AI-based models simplifies the number of tests needed to identify reservoir characteristics in a laboratory, saving time and money. Moreover, AI techniques such as Artificial Neural Networks (ANN), Fuzzy Logic, Swarm vector optimization, and genetically improved accuracy and speed in porosity prediction are possible with enhanced neural network algorithms [40]. The oil and gas business may greatly benefit from the application of AI approaches in the areas of risk and cost optimization, as well as the resolution of difficult problems. The accurate knowledge of permeability and porosity provided by AI-based models can aid in the creation of a sound reservoir development plan and the administration of hydrocarbon recovery. AI can also be used to optimize and design production systems. Critical safety systems can be monitored by AI-powered predictive algorithms to prevent failure and protect employees. In addition, AI can be used to analyze and modelling well information for forecasting well output, as well as with software for reservoir simulation to enhance reservoir management. Besides, AI-based models can aid in the design and accurate analysis of drilling fluid, in the selection of drill instruments and challenges linked to drilling, and the optimization of existing oil and gas infrastructure [40]. The literature provides an overview of the application of various AI techniques in petroleum engineering and the potential benefits these techniques can bring to the industry [40, 41].

4.3.2 Exploration and Production

Despite the extensive use of AI to solve optimization problems in the OGI, its implementation encounters significant obstacles. One of the most significant obstacles relates to data, as the industry requires large quantities of data for effective AI implementation but struggles with data storage and IT infrastructure issues, especially for smaller companies. An additional difficulty is the absence of standardization and consolidation of AI applications as standard E&P industry solutions [1]. The allocation of responsibilities among the AI algorithm, its user, and its developer remains ambiguous, potentially giving rise to concerns regarding trust and employment displacement. However, petroleum engineers must learn to work with AI assistants, which requires a certain level of technical expertise [3]. Combining AI's data-handling capabilities with engineers' extensive industry domain expertise is also a challenge. The legal ramifications of AI's recommendations remain unresolved. In addition, enterprises and organizations within the oil and gas AI ecosystem have diverse AI development stages, strategies, and priorities [3]. Despite these challenges, AI techniques can be used to overcome them in exploration and production, particularly in areas of high risk and uncertainty such as drilling activities [42]. Thus, the challenges associated with using AI in exploration and production are not specific to the industry but common at this stage of the AI development [17]. Ultimately, combining human and machine intelligence will be necessary to efficiently arrive at solutions in exploration and production, as a comparison of human and artificial intelligence strengths and shortcomings must be considered [43].

4.3.3 Refining and Distribution

Massive amounts of information are produced by the OGS that need to be refined and organized to reveal patterns and trends for operational improvements and strategic decision-making processes. However, challenges arise when utilizing AI in refining and distribution processes. For example, coordinating diverse data sources, proprietors, and formats can be hard and tedious at times. The task of ensuring the accuracy, authenticity, and protection of data streams as they traverse a convoluted business process pipeline can present a significant obstacle, as noted in reference. Moreover, the OGI

is comprised of numerous processes and stakeholders, each of which generates an enormous quantity of data, making the processing and management of this information a difficult task [25]. For refining large-scale data, therefore, sophisticated software for modeling, data mining applications, and trained personnel are required [34]. It is crucial to have personnel with technical and analytic skills who can comprehend the results of data processing algorithms. In addition, it is necessary to combine massive amounts of data with artificial intelligence (AI) algorithms, powerful technology, and programs to produce a variety of results [34]. Although multi-agent systems (MAS) have demonstrated successful implementation in various domains, their anticipated widespread adoption by the OGI has not yet been realized. Further investigation is imperative in the fields of ML and multi-agent systems to fully actualize their potential and enhance their adoption within the OGS [25]. The challenge is to hone and arrange data, spot and evaluate trends and patterns in the perceptions and actions of stakeholders [34]. Thus, AI has tremendous potential to enhance OGI decision-making, but these obstacles must be overcome to realize its full potential.

4.3.4 Gas Industry

The gas industry can benefit significantly from using AI and ML techniques. One of the major applications of these techniques is in the upstream activities of the gas industry to improve efficiency and accuracy. According to [2] the implementation of machine learning techniques can alleviate the workload of engineers in the field of oil and gas production engineering. In addition, the use of ML methods can facilitate the precise examination of well-logging data, ensure the quality control of fluid properties, and enable the differentiation of base production from effective interventions. According to the literature, the utilization of artificial neural network (ANN) models has been observed to be effective in predicting pipeline closure pressure, while support vector regression models have been found to be useful in predicting pipeline deformation. It is feasible to employ machine learning algorithms for the recognition of production pattern data. According to sources [2], there is hope that artificial intelligence can improve the capacity for data processing. AI technology can be a source of innovation in the gas industry, and collaboration with universities can provide oil and gas companies with access to novel AI technology. Previous research has demonstrated the benefits of implementing machine learning techniques for the evaluation and modelling of the shale gas production performance [44]. The utilization of machine learning techniques has been successfully applied in shale gas reservoirs for a range of objectives, including but not limited to fracture design optimization, production forecasting, uncertainty quantification, history matching, identification of favourable drilling locations, shale gas characterization, analysis of total organic carbon impacts, and well examination. This has been documented in reference. The incorporation of machine learning algorithms based on physics has the capability to improve the precision of predictive results while making use of restricted data samples in the domain of research on shale gas exploration and production [44]. Machine learning-based models can be used to forecast the behavior of shale gas production, which is useful for decision-making in the industry. Therefore, AI and ML techniques have various merits in the upstream sector of the OGI, which can be utilized for effective computation and decision-making in the industry [2].

4.3.5 Control and Automation

While AI has the potential to revolutionize control and automation systems, there are numerous obstacles that must be overcome for it to be fully integrated. One of the biggest challenges is the lack of adoption of AI for automation purposes. This is because many organizations are not yet convinced of the benefits of AI in automation systems. Additionally, implementing AI in control and automation systems requires significant investment in terms of time, resources, and infrastructure. This can be a major barrier, particularly for smaller organizations that may not have the necessary resources to make such investments. Furthermore, there is a significant shortage of skilled personnel with AI and automation technologies expertise. This makes it difficult for organizations to find and hire the talent they need to design and implement effective AI-based automation systems. Lastly, one of the biggest challenges is ensuring that AI systems are reliable and secure. There is a risk that AI systems could malfunction or be hacked, which could potentially cause significant damage or harm to people or equipment. Therefore, it is essential to ensure that AI systems are designed with robust security features and regularly tested for reliability [45].

4.3.6 Maintenance and Safety

The application of AI, particularly in the area of maintenance and safety, presents several challenges. One major concern is privacy issues, specifically the hacking of stored data in Industrial AI (IAR). Another challenge is the need for training to introduce IAR in an industrial setting. The implementation of IAR in food logistics also poses several challenges that hinder its use. It is essential that workers understand how to use IAR appropriately to derive maximum benefits while minimizing the risks involved. Another frequent issue is getting potential users to accept IAR.. Secure systems are critical in Industry 4.0 to address this issue. Providing adequate training is also a disadvantage of IAR, as it requires time and money for delivery. However, highlighting the system's advantages and providing adequate training can address the problem of user acceptance [38]. Unauthorized access, improper configuration, broken devices, and data loss are all potential threats associated with digitizing advanced management software. Moreover, the high cost of mistakes in the energy industry discourages many companies from undertaking novel strategies with limited expertise. Subsequently, it is exceedingly challenging to assemble a team of capable programmers to create AI-driven software with tangible advantages [46].

5. Future of AI in Oil and Gas Industries

5.1 Future Developments in AI

The use of AI in the OGS has been swiftly advancing and penetrating various sectors. There is the potential for AI-based tools to expedite and reduce the risk of industry processes [3, 17]. Using AI algorithms, developers have created numerous realistic research and production application technologies. The implementation of artificial neural networks (ANN) in exploration has led to a drop-off in exploration risks and an expansion of the success rate of exploration wells. The utilization of historical oil production data to enhance the development plan is a significant paradigm of artificial intelligence in the context of oilfield development [17]. The implementation of novel drilling technologies, including an Intelligent drill pipe and automated rig, has resulted in significant enhancements in drilling precision and cost reduction [17]. However, non-technical obstacles related to data, people, and collaboration impede the industry's pervasive adoption of AI. The study outlines three potential AI development scenarios for the OGI over the next 5, 10, and 20 years [3]. The function and availability of data are crucial factors in the evolution of AI in the business sector [3, 18]. Enhanced processing of seismic data via machine learning improves the industry's comprehension of applications [18]. Incorporating AI into the OGS is intended to provide a competitive advantage and mitigate global project difficulties [47]. The introduction of AI into the OGI will alter the required functions and skill sets of petroleum engineers. To innovate in the AI era, petroleum engineers will need a solid grasp of data science and the capacity to identify and design AI-solvable tasks [17]. Effective adaptation of previously trained models to new datasets can substantially expand the applicability of AI-assisted tools. limited data learning could allow AI algorithms to be trained using a limited number of examples [3].

5.2 Addressing the Ongoing Challenges

The OGI confronts a number of obstacles, including complex and dynamic problems and decisions with high-stakes Fields [41]. Nevertheless, AI, particularly machine learning, has the capacity to process and manage vast quantities of data generated by multiple processes and stakeholders [48]. In the OGI, new sensors permanently installed in the wellbore provide vast quantities of vital data that can be analyzed using modern data mining techniques to predict the condition of technological equipment [41, 48]. Moreover, AI can assist in the processing of massive quantities of data generated in the OGI, which is essential for timely decision-making and process optimization. Moreover, AI can be used to efficiently identify impacts and prevent destructive blowouts during oil and gas drilling [49]. Multi-agent systems (MAS) have been effectively utilized across diverse industries, such as the OGS, to enhance operational efficiencies, oversee supply chain management, and tackle various production and maintenance-related duties [48]. According to executives, the optimization of oil and gas E&P is contingent upon the utilization of big data. Artificial Intelligence (AI) is capable of resolving various challenges in the OGI, including the coordination of diverse data sources, owners, and formats. Additionally, AI can facilitate data stream validation, security, and verification as they traverse the intricate business process pipeline. This assertion is supported by reference [48]. Artificial intelligence-based intelligent systems possess the capability to address persistent challenges in the OGS [41]. Additional research is required [48] to actualize the potential of machine learning and MAS and promote their wider adoption in the OGI.

5.3 The Utilization in Engineering Applications

Engineering uses of artificial intelligence have resulted in enhanced efficiency in simulating and predicting outcomes. Moreover, the utilization of AI in the field of engineering has the potential to result in noteworthy reductions in expenses and enhanced quality management. Nevertheless, it is imperative to contemplate the ethical ramifications of incorporating AI into engineering design and decision-making procedures. One of the concerns arising from implementing automation is the possibility of job displacement. Additionally, it is crucial to incorporate ethical principles into the development of technology to ensure that the decisions made by AI systems are transparent, explainable, and consistent with societal values. The integration of artificial intelligence into the field of engineering presents a multitude of advantages; however, it necessitates a meticulous examination of both technical and ethical factors.

5.4 The Associated Potential Risks and Limitations

The oil and gas industries can gain a lot from AI, but there are also hazards and constraints to think about. Deep learning-based IT systems can help safety officials spot infractions of protocol, and deep learning-based pattern recognition can sound an alarm if an individual isn't wearing the right clothes for the job. To avoid a disaster that could have dire consequences for people's health, safety, and the environment, predictive analytics can also notify operators of the current state of their equipment. Nonetheless, oilfield operations are inherently dangerous due to a number of risk considerations, including the use of heavy equipment, exposed rotary equipment, high pressure, high-temperature processes, and aggressive compounds. [3]. Hence, it is imperative to acknowledge that the application of AI algorithms has the potential to alleviate hazards in the OGS. However, the text fails to address the potential risks associated with the utilization of AI in this industry [42]. Furthermore, conventional approaches to analyzing the vast quantities of data produced on a daily basis within the oil and gas sector entail potential hazards and constraints. Numerical approaches are impractical and time-consuming since the presence of discrepancies in rocks, oil, and brine cannot be easily explained by any closed-form solution. An additional constraint pertains to the incapacity of AI models to exhibit generalization. The generalizability of models trained on a specific geological field is limited when applied to other geological fields. As a result, it is strongly advised to restrict the implementation of the model to input parameters falling inside the bounds of the model's input parameters were trained. In addition, the reusability of Machine Learning models is quite challenging, as additional resources are required to train new datasets each time, even if they are identical to previous cases [42]. Incorporating AI into the OGI necessitates thorough consideration of the aforementioned risks and constraints.

6. Conclusion

This study discusses the use of AI in the OGI, including its potential to speed up processes and reduce risk. One exciting application is its use in discovering new hydrocarbon and gas reserves. However, there are limitations to the implementation of AI models, as they may not be generalizable to other geological fields. AI can also benefit the engineering industry by reducing costs and improving quality management, but ethical considerations must be taken into account to ensure decisions made by AI systems align with societal values. Such considerations include the possibility of job displacement and the need for transparency and intelligible decision-making. A thorough examination of both technical and ethical factors is necessary when integrating AI into engineering.

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AUTHOR'S PROFILE

Abdulhamid Musa earned his B. Eng. From Bayero University, Kano - Nigeria, and M. Eng., in Electrical Engineering in 1998 and 2019, respectively. He is currently working in the Department of Electrical and Electronic Engineering at Petroleum Training Institute, Nigeria since 1998. He is a member of IEEE since 2016. He has published more than 15 research papers in reputed international journals including SCOPUS. His main research work focuses on Artificial Intelligence and the Optimization of Electrical Power System. He has over 20 years of teaching and 10 years of research experiences.

