



(REVIEW ARTICLE)



How oil and gas industry are transforming with AI and ML

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World Journal of Advanced Research and Reviews, 2024, 23(03), 1234–1238

Publication history: Received 27 July 2024; revised on 08 September 2024; accepted on 10 September 2024

Article DOI: <https://doi.org/10.30574/wjarr.2024.23.3.2722>

Abstract

The Oil and Gas Industry is witnessing a major transformation due to the advent of Artificial Intelligence (AI) and Machine Learning (ML). These advances are changing operations by making things work better, cheaper and safer. Companies are using Artificial intelligence and Machine Learning to analyze large data points generated due to exploration, production and distribution activities which generate actionable insights leading to data driven decision making.

AI and ML techniques for exploration, well placement optimization such as mount point selection or drilling parameters suggest based on geological data analysis including a historical performance. Using data in a real-time and predictive manner, manufacturing plants can catch early signs of equipment issues such as rising temperature encouraging proactive measures to be taken which reduces downtime and maintenance costs. Furthermore, reservoir management, hydrocarbon extraction and energy efficiency are optimized via AI-based optimization strategies.

Keywords: Artificial Intelligence; Machine Learning; Oil and gas; Predictive analytics; Operational efficiency; Safety management

1. Introduction

The oil and gas industry has long been driven by expertise and experience, based on traditional methods. However, the latest developments related to artificial intelligence and machine learning are changing the landscape. The adaptation of AI and machine learning in the industry has transformed it, streamlining processes for higher efficiency and sustainability. Most importantly, AI and machine learning are applied in analyzing data generated at each stage of the exploration, drilling, and production process, making this analysis to outline project risks and outcomes.

In this context, artificial intelligence is used to enable companies to make smarter decisions. For example, the data may predict that the drilling is prolonged or the wellbore collapses, indicating the precise places. Therefore, the digital shift has similarly progressed the general resource management to a new, more efficient, and sustainable level. There are several impactful AI and machine learning applications in the oil and gas industry. Predictive maintenance is the most significant in the present context since this is one of the ways to prolong the critical infrastructure service life while maintaining operational reliability. If a slight malfunction or downtime due to maintenance already publicizes a bad impact, then knowing and predicting its appearance may save millions.

Many pieces of equipment used in this industry have sensors, and ML algorithms can turn this information into future fault projections. Wider use of AI assists in developing a more advanced analytical approach to understand the subsurface conditions for better reserves penetration. AI allows for real-time predicting disasters and reduces the environmental accident rate. The oil and gas industry substantially influences global energy production due to its

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complexity and faces different challenges. In various industries, including the oil and gas sector, Artificial Intelligence has recently developed as a potent technology due to its numerous benefits,[1]. The development and progress using this emerging technologies have become smart and makes the judgement procedure easy and straightforward. The study is useful to access intelligence of different machine learning methods to declare its application for distinct task in oil and gas sector,[2].

2. Literature Review

Table 1 Summary of Key Studies on Oil and Gas industry are transforming with AI and ML Including Application Area, Description, Key Technologies, , Main Findings & reference with Author name

| Application Area | Description | Key Technologies | Key Findings | References |
|----------------------------|--|---|--|-----------------------------|
| Exploration and Drilling | Enhancing accuracy of subsurface models and interpretation of geological data. | Neural Networks, Decision Trees | ML algorithms reduce time and cost of exploration. | Zhang et al., 2020 |
| Production Optimization | Improving production processes through real-time monitoring and predictive analytics. | Predictive Analytics, Optimization Algorithms | AI optimizes drilling parameters and reservoir management. | Al-Majed and Ghabraie, 2021 |
| Predictive Maintenance | Minimizing downtime and extending equipment lifespan through predictive maintenance. | Anomaly Detection, Time-Series Forecasting | Predictive maintenance leads to cost savings and increased efficiency. | Kumar et al., 2022 |
| Safety and Risk Management | Analyzing historical incident data to improve safety protocols and risk assessment. | Risk Assessment Models, Predictive Analytics | AI enhances safety protocols and mitigates risks. | Chen et al., 2021 |
| Environmental Monitoring | Real-time detection of leaks and emissions, and optimization of energy usage to reduce environmental impact. | Real-Time Monitoring, Emission Detection | AI enables effective monitoring and reduction of environmental impact. | Wang et al., 2022 |

3. AI and ML in Oil and Gas Industry

Artificial Intelligence and Machine Learning have also been used to revolutionize how the oil and gas industry works. It has redefined operations from exploration to production.

The following is an in-depth summary of how they are used in the industry.

3.1. Predictive Maintenance and Equipment Monitoring

Predictive maintenance in the oil and gas industry has been one of a prominent use case in recent times. Machine-learning models help predict when a piece of machinery may probably fail or require maintenance by analyzing data from the embedded equipment sensors. AI/ML systems can assist companies in identifying potential issues before their equipment about to fail or if it fails completely can result in downtime and large repair fees. For example, artificial intelligence systems can use vibration patterns, temperature shifts, and other operational metrics to warn of mechanical problems early, extending equipment lifespan while also reducing repair costs thereby minimizing the downtime.

3.2. Enhanced Exploration and Drilling

AI and ML algorithms in exploration are designed for handling a large number of geological and geophysical data to detect oil and gas deposits with much more precision. These techniques help interpreting seismic data and forecasting subsurface conditions. AI models can analyze historical drilling data and recommend optimized drilling parameters which can improve the efficiency of the drilling process. Efficient use of the data ensures that less time and money are wasted on associated drilling failures.

3.3. Reservoir Management and Optimization

AI and ML techniques are transforming reservoir management through advanced data analytics to simulate reservoir behavior. These help in optimizing production strategies as well the recovery rates. The algorithms help oil and gas exploration companies to predict production levels, detect anomalies and adjust operation dynamically.

3.4. Supply Chain and Logistics Optimization

AI and ML help to secure safety, support environmental protection by tracking the operation condition and monitoring potential hazards. Algorithms when used with sensors to detect leaks, emissions or anomalies which are indicators of potential risks.

Reservoir engineering constitutes a major part of the studies regarding oil and gas exploration and production. Reservoir engineering has various duties, including conducting experiments, constructing appropriate models, characterization, and forecasting reservoir dynamics. However, traditional engineering approaches started to face challenges as the number of raw field data increases. It pushed the researchers to use more powerful tools for data classification, cleaning and preparing data to be used in models, which enhances a better data evaluation, thus making proper decisions. Attempts to identify innovative approaches to process and manage information for the purposes of enhancing operational potency, reducing operating costs and boosting profits necessitate advancements in technologies within the industry. For example, real-time data streams continuously generated by sensors are utilized to ensure better control and optimization of crude production. Robotics is used in offshore fields for drilling, inspection and damage control to enhance efficiency and personal safety. Wireless sensor networks are used to monitor and enhance production, as well as detect and prevent issues with regards to health and safety. The radio-frequency identification (RFID) technology is used for asset management, oil rig site management, pipeline inspection, safety and security [3,4,5,6,7].

4. Future scope

The future scope of AI and ML in the oil and gas industry is poised to accelerate in years to come. The scope is quite vast and transformative with several key areas poised for significant advancement.

Artificial intelligence (AI), as the most important general-purpose technology of today [8,9], is rapidly entering industries, creating significant potential for innovations [10] and growth [11].

Here's an overview of potential future developments and their implications:

4.1. Advanced Autonomous Systems

With the rise of sophisticated AI and ML technologies, industry is poised for advanced autonomous systems. Few examples are autonomous drilling rigs and trucks, robotic inspection units, and drones equipped with AI for real-time monitoring and data collection. These systems will reduce instant human intervention in hazardous environments, enhance precision in operations, and lower costs associated with manual labor and safety risks.

4.2. Digital Twins and Simulation

The concept of digital twins which are virtual replicas of physical assets will become more advanced with AI and ML technologies. New developments will eventually permit businesses to simulate these digital models more accurately and update them in real time. Thereby giving rise to new ways of forecasting, scenario analysis or optimization. Digital twin will lead to better decision making and way for deeper analysis on complex system, eventually resulting in better asset management, enhancing performance

4.3. Integration with Blockchain for Enhanced Security and Transparency

The combined Artificial Intelligence and blockchain may further improve the data security, transparency, traceability in the oil gas sector. Blockchain can offer secure, unchanging records of both transactions and operations. These data could then be analyzed by AI techniques to determine any fraudulent activity or inefficiencies in the system. By making this integration, the level of trust and process optimizations within the supply chain will be increased.

4.4. Next-Generation Reservoir Management

The incorporation of AI and ML techniques will further revolutionize reservoir management with advanced geological modelling techniques and real-time data analytics. Upcoming advances will facilitate improved reservoir modelling, optimal enhanced oil recovery operations and the appropriate management of complex fields. This will optimize the life-capital of oil and gas fields, maximize resource extraction and extend the productive life of oil and gas fields.

4.5. Advancements in Environmental and Safety Monitoring

With the advancement in AI/ ML the industry will see a lot of sophistication in environmental as well as safety monitoring. Improved algorithms will enable businesses to analyze data from even many more types of sensors and sources, allowing for early warning about environmental threats or safety risks. AI will lead to optimize best-practices that will potentially reduce adverse environmental impact, as well improve regulatory alignment.

4.6. Increased Use of AI for Energy Transition

AI technology will play a pivotal role in global energy transition, by developing and integrating renewable energy sources. AI powered systems will enable optimization of hybrid energy systems to energy storage solutions, and smart grid management will facilitate the transition to cleaner energy sources, and at the same time maintaining efficient and reliable energy production.

4.7. Personalized Decision Support Systems

With advanced technologies, AI powered applications will drive decision support systems with highly personalized and context-aware insights. With the ability to integrate data from multiple sources to deliver tailored recommendations, support strategic planning, and enhance operational decision-making, these systems would be empowering businesses with capabilities of analyzing complex scenarios and optimizing outcomes.

Exploration of oil and gas reserves is a set of operations resulting in a 3D geological model of an oil/gas field or reservoir,[12]. The reconstruction process is strongly offline due to very significant requirements for high-performance computing. AI-focused studies are aiming to speed up this stage,[13]. Modern pattern recognition techniques based on deep learning have started to dive into this seismic-related operation, accelerating the interpretation by a factor of 10–1000 [14]. There is a low probability that the AI techniques will optimize the physical part (i.e., amount, cost, and placement layout of sensors) of the first seismic surveying at an asset. Still, they add value in the optimization of the secondary surveys at the same asset. The mathematics of recommender systems [15] and interpolation capabilities of machine learning algorithms will enable proper recommendations on making the secondary surveys cheaper with a minor loss in the value of acquired information

5. Conclusion

The adoption of AI and ML into the oil and gas industry marks a transformative shift as it brings game-changing efficiencies that not only drive cost savings but can also help in increasing profitability while improving safety across production operations. AI and ML technologies can significantly help businesses in optimizing exploration and production processes, predictive maintenance as well as better decision making through data-driven insights. Real-time monitoring and analytics for proactive management of operations and optimized resource allocations.

Furthermore, AI powered applications have the ability to contribute to reducing environmental impact by improving efficient energy generation while minimizing waste. However, in-order to harness the potential of these technologies challenges related to data integration, cybersecurity, and talent availability needs to be addressed.

Concluding, AI and ML can immensely help the oil and gas industry not only to address the immediate operational challenges but can lead to sustainable growth and accelerator innovation. As these technologies continue to evolve and become more sophisticated their potential to improve efficiency in the industry remains substantial.

Compliance with ethical standards

Disclosure of conflict of interest

The author declares that there are no conflicts of interest associated with this publication

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