Original Paper

The Application of Big Data Technology in Petroleum Engineering Information System

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Abstract

With the rapid development of information technology, big data technology has been widely applied in various industries, and petroleum engineering information systems are no exception. This article aims to explore the application of big data technology in the information system of petroleum engineering, and analyze its role in improving the efficiency and decision-making level of petroleum engineering management. This article provides an overview of the basic concepts and core components of big data technology, including data collection, storage, processing, analysis, and visualization techniques. It introduces the main components of petroleum engineering information systems and the current challenges they face. Through specific cases, this article elaborates on the practical application of big data technology in oilfield development, drilling engineering, and production management, demonstrating the significant advantages of big data in real-time monitoring, parameter optimization, fault prediction, and production analysis. This article discusses the challenges faced by the application of big data technology in petroleum engineering information systems, such as data quality, security and privacy, and technical talent, and proposes corresponding countermeasures. This article looks forward to the future application prospects of big data technology in petroleum engineering, emphasizing the importance of the combination and innovation of emerging technologies in promoting the development of informationization and intelligence in petroleum engineering. Through this study, we hope to provide valuable references for the optimization and innovation of petroleum engineering information systems.

Keywords

Big data technology, Petroleum engineering, Information system, Data collection, Data analysis

1. Introduction

With the rapid rise of the Internet of Things and cloud computing, as well as the rapid popularity of

intelligent terminals, data has penetrated into various industries and fields, gradually becoming an important production factor. The characteristics of data are gradually evolving and developing towards larger, faster, and more complex directions, giving rise to a new concept - big data. In 2011, J. McKinsey et al., published "Big Data: The Next New Frontier for Innovation, Competition, and Productivity", which marked a historic high in attention to big data.

Petroleum engineering is acquiring larger amounts of data and more diverse data at a faster pace than ever before. In addition to data collected from tens of thousands of sensors, this data also includes a large amount of semi-structured and unstructured data. Drilling, logging, and logging data, production data, and operation logs can all be quickly added as TB or even PB level information. The objects of oil and gas exploration and development are invisible underground rocks and fluids, so petroleum engineering has a stronger dependence on data. Compared with traditional information technology, big data technology analyzes and processes massive amounts of data more quickly and efficiently, improving the accuracy, timeliness, and comprehensiveness of decision-making. It plays an important role in promoting the increase of oil and gas reserves, production, cost reduction, and efficiency improvement. To this end, the author introduces the definition and characteristics of big data, analyzes the current application status of big data technology in the field of petroleum engineering, and proposes development suggestions for big data technology in petroleum engineering to accelerate the research and application of big data technology in petroleum engineering (Shang, Ji, Jiang et al., 2023).

2. Overview of Petroleum Engineering Information System

The petroleum engineering information system is the application of modern information technology to various aspects of petroleum exploration, development, production, etc. Through data collection, storage, processing, and analysis, it achieves digital, networked, and intelligent management of the entire petroleum engineering process. With the rapid development of information technology, especially the advancement of technologies such as big data, the Internet of Things, cloud computing, and artificial intelligence, petroleum engineering information systems are playing an increasingly important role in improving production efficiency, reducing costs, optimizing resource allocation, and enhancing decision-making levels.

The core of petroleum engineering information system lies in the efficient management and utilization of data. The data acquisition system is the foundation of information systems, responsible for real-time data collection from various sensors, instruments, and equipment. These data include geological data, drilling data, production data, equipment operation status data, etc. Modern data collection systems adopt advanced sensor technology and Internet of Things technology, which can achieve high-precision and high-frequency data collection, and transmit data to a central database through wireless or wired networks.

The data management system is responsible for storing, organizing, and managing the collected data. Petroleum engineering data has a large volume and diverse types, and data management systems

require strong storage capabilities and efficient data processing capabilities. Distributed storage systems and cloud storage technology have been widely used in petroleum engineering data management. In addition, data management systems need to provide functions such as data retrieval, data sharing, and data backup to ensure the security and availability of data.

Data analysis and decision support system is the core of information systems, responsible for in-depth analysis and processing of collected data to support decision-making and management in petroleum engineering. Data analysis techniques include data mining, machine learning, statistical analysis, and simulation. By analyzing historical and real-time data, patterns and trends in the data can be discovered, future development trends can be predicted, and optimization solutions and decision support can be provided. For example, by analyzing drilling data, drilling parameters can be optimized to reduce drilling risks and costs; By analyzing production data, production plans can be optimized to improve output and efficiency (Yang, Wan, & Qiu, 2022).

The data visualization system presents complex data and analysis results to users in a visual way through charts, maps, dashboards, and other forms, helping users better understand the data and make scientific decisions. Modern data visualization technologies include 3D visualization, virtual reality, and augmented reality, which can achieve panoramic display and real-time monitoring of oil fields, drilling platforms, and production facilities.

However, despite significant achievements in improving production efficiency and management level, petroleum engineering information systems still face some challenges and problems in practical applications. Firstly, data quality issues are a significant challenge. Petroleum engineering data has a wide range of sources, diverse data types, and uneven data quality. There may be issues such as data loss, errors, and redundancy during the data collection process, which can affect the accuracy and reliability of data analysis. Therefore, how to improve data quality and carry out effective data cleaning and preprocessing is an important challenge faced by information systems (Yang, 2022).

In addition, data security and privacy protection are also key issues. Petroleum engineering data involves the core business and trade secrets of enterprises, and data security and privacy protection are crucial. Information systems need to establish comprehensive data security mechanisms, including data encryption, access control, identity authentication, and intrusion detection, to prevent data leakage and illegal access (Wang, 2021).

4. The Application of Big Data Technology in Petroleum Engineering Information System

In recent years, the low international oil prices have become the new normal, and the profits of oil companies have significantly decreased. How to use big data technology to reduce oil and gas exploration and development costs and improve exploration and development efficiency has become a new breakthrough point for the development of oil companies and oil service companies. Compared with the Internet, aviation, e-commerce and other industries, the research and application of big data technology in the oil and gas industry started late. At present, domestic and foreign companies are

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trying to apply big data technology to petroleum engineering, and have made some progress (Wu, 2021).

Big data technology has played an important role in data collection. Traditional data collection methods often suffer from problems such as incomplete data collection and low data frequency. Through big data technology, petroleum engineering can utilize advanced sensors and IoT technology to achieve real-time high-frequency data collection for various links such as geology, drilling, and production. For example, China National Petroleum Corporation (CNPC) has deployed thousands of sensors in its oil fields to collect real-time geological and production data through IoT technology. These data are transmitted to the central database through wireless or wired networks, providing a rich data foundation for subsequent data processing and analysis.

In terms of data storage, big data technology adopts distributed storage systems and cloud storage technology to solve the problem of large amounts and diverse types of data in petroleum engineering. Distributed storage systems can store data in multiple nodes, improving the reliability and access speed of data storage. Cloud storage technology provides flexible storage space and computing resources, meeting the needs of petroleum engineering data management. For example, ExxonMobil utilizes cloud storage technology to centrally store its oil field data from around the world in the cloud, facilitating centralized management and analysis of data. In addition, big data technology also provides data compression and deduplication techniques, further optimizing data storage efficiency.

Data processing and analysis are the core applications of big data technology in petroleum engineering information systems. Through technologies such as data mining, machine learning, statistical analysis, and simulation, big data technology can conduct in-depth analysis of massive data, discover patterns and trends in the data, and provide scientific decision support. For example, BP uses machine learning algorithms to predict the distribution and reserves of oil reservoirs through the analysis of geological data, guiding exploration and development work. By analyzing drilling data, BP can optimize drilling parameters, reduce drilling risks and costs. For example, Chevron Corporation utilizes big data technology to analyze production data, optimize production plans, and improve output and efficiency. In addition, big data technology can also be used for fault prediction and equipment health management. Through real-time monitoring and analysis of equipment operation data, signs of equipment failure can be detected in advance, preventive maintenance can be carried out, and the downtime losses caused by equipment failure can be reduced (Geng, 2021; Su & Liu, 2020).

4. Challenges and Countermeasures of Big Data Technology in Petroleum Engineering Informatization

Although significant progress has been made in introducing big data technology into petroleum engineering information systems, there are still many challenges to be faced. These challenges mainly focus on data quality, data security and privacy protection, technology and talent bottlenecks, as well as the complexity of data processing and analysis. In order to fully unleash the potential of big data

technology, the petroleum industry must take effective measures to address these challenges.

Data quality issues are a major obstacle in the application of big data technology. Petroleum engineering involves a wide range of data sources and diverse data types, including geological data, drilling data, production data, and equipment operation data. These data may experience issues such as data loss, errors, and redundancy during the collection and transmission process, which can affect the accuracy and reliability of data analysis. To address this issue, oil companies need to establish a comprehensive data cleaning and preprocessing mechanism. By using advanced data cleaning tools and algorithms, noisy and erroneous data can be effectively removed, ensuring the accuracy and completeness of the data. In addition, standardized data collection processes and strict data verification mechanisms are also important means to ensure data quality. For example, automated data validation and cleaning tools can be introduced into its data management system, greatly improving data quality (Liu, 2017).

The issues of data security and privacy protection are also major challenges faced by big data technology in the informatization of petroleum engineering. Petroleum engineering data involves the core business and trade secrets of enterprises, and once leaked, it may cause huge economic losses and reputation damage to the enterprise. In order to protect data security, oil companies need to establish comprehensive data security mechanisms, including data encryption, access control, identity authentication, and intrusion detection. Advanced data encryption technology can be used for this purpose, encrypting sensitive data for storage and transmission to prevent data theft during transmission. Meanwhile, strict access control and identity authentication mechanisms can ensure that only authorized personnel can access sensitive data, preventing data from being illegally accessed. In addition, real-time intrusion detection systems can promptly detect and prevent potential network attacks, ensuring data security.

The bottleneck of technology and talent is also an important challenge faced by big data technology in the informatization of petroleum engineering. Big data technology involves the application and integration of various advanced technologies, including data mining, machine learning, statistical analysis, and simulation. These technologies require high levels of technical expertise and talent quality, and the current petroleum industry is facing a shortage of technical talents and a fast pace of technological updates. In order to address this challenge, oil companies need to strengthen technical training and talent development, improve the overall quality and innovation ability of their technical teams.

In addition, the application of big data technology in petroleum engineering informatization also faces issues of system integration and interoperability. Petroleum engineering involves multiple business systems and data sources, and the data formats and interface standards between each system are not unified, resulting in difficulties in data sharing and integration. To address this issue, oil companies need to establish unified data standards and interface specifications to promote data interoperability and integration among various business systems.

In the process of addressing these challenges, oil companies also need to pay attention to the continuous innovation and application optimization of big data technology. Big data technology is developing rapidly, with new technologies and methods constantly emerging. Oil companies need to maintain their attention and research on cutting-edge technologies, timely introduce and apply new technologies and methods, and improve the efficiency and effectiveness of data processing and analysis. For example, by utilizing Internet of Things (IoT) technology, real-time data collection and monitoring of devices and sensors can be achieved, further enriching and improving data sources, and enhancing the real-time and accuracy of data.

5. Conclusion

The application of big data technology in petroleum engineering information systems has significantly improved the efficiency and benefits of the entire industry. By collecting, storing, processing, and analyzing a large amount of data, the information system of petroleum engineering can have a more comprehensive understanding of underground resource conditions, optimize mining plans, reduce risks and costs, and improve production efficiency. Specifically, the application of big data technology in petroleum engineering information systems is mainly reflected in the following aspects: big data technology greatly enhances the data processing capabilities in petroleum exploration and development. It can process massive geological, geophysical, and production data, provide more accurate and comprehensive underground resource models, improve exploration success rates, optimize drilling and extraction plans, and reduce costs; Big data technology has played an important role in equipment monitoring and maintenance. By monitoring real-time equipment operation data, potential faults can be detected in a timely manner, maintenance can be carried out in advance, production shutdowns and safety accidents can be avoided, equipment utilization and lifespan can be improved, and production safety and stability can be guaranteed; Big data technology also plays an important role in optimizing production management and decision support; Real time collection and analysis of production data, comprehensive understanding of various parameters and indicators in the production process, optimization of production processes and techniques, and improvement of production efficiency. By analyzing historical data, predict future production trends and market demand, assist in formulating scientific production and sales strategies, and enhance the competitiveness of enterprises; Big data technology also has important applications in environmental protection and sustainable development. Through real-time monitoring and analysis of environmental data, environmental pollution problems can be detected and dealt with in a timely manner, waste disposal and resource utilization plans can be optimized, environmental impacts can be reduced, and green and sustainable development of petroleum engineering can be promoted.

The application of big data technology in petroleum engineering information systems has greatly improved the efficiency and benefits of exploration, development, production, and management, reduced costs and risks, ensured safety and stability, and promoted green and sustainable development.

In the future, with the deep integration of big data technology with emerging technologies such as artificial intelligence and the Internet of Things, the information system of petroleum engineering will usher in broader development prospects, injecting new impetus into the high-quality development of the petroleum industry.

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