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Research on the application of artificial intelligence in oil and gas exploration and development fields

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Abstract. The development of artificial intelligence has brought profound impact and changes to the world and has been widely used in the fields of defect detection, pedestrian re-identification, and rapid development within cross-disciplinary fields. This paper reviews the beginnings of AI, introduces the main AI technologies and their connotations applied in the exploration and development field, describes the significant progress and recent advances of AI in five important subfields of the exploration and development: lithology identification, logging curve reconstruction, seismic data processing and interpretation, production prediction, and EOR screening, and finally presents the inevitability that AI will continue to develop and be tied to the oil and gas sector, summarizes the important subfields where good progress has been made at present, outlooks the possible future research domains in the the exploration and development field, and discusses the factors that may prevent AI from being more effectively and widely used that lie behind this flourishing scene.

Keywords: Artificial intelligence, Exploration and development, Machine learning, Production forecast, Lithology Application.

1. Introduction

In 1950, Alan Turing proposed the Turing test. In 1956, at the Dartmouth Conference, artificial intelligence was officially defined as the name of this research area. However, there is no unified definition of artificial intelligence, and the basic consensus is: 'Make computers have human intelligence'[1]. In recent years, as deep learning, represented by neural networks, began to emerge, driving artificial intelligence has been developing, and Google robot alphaGo defeated Go ninth dan Lee Sedol and Ke Jie in 2016 and 2017 respectively, pushing artificial intelligence to the limelight. Nowadays, with the rapid progress of AI, it is widely used in many fields such as medical, home, commercial retail, transportation, and finance, and it is gradually playing a more important role, bringing countless opportunities and challenges to various industries.

2. Concepts and connotations of key AI technologies applied in the field of reservoir engineering

2.1. Artificial intelligence

There is no unified definition of artificial intelligence at present. In general, it is an emerging field that integrates the knowledge of information theory, psychology and physiology to research and develop

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theories, methods and application systems of human-like intelligence. At present, it has been applied in the field of oil and gas all over the world, data-driven intelligent oil and gas field development that moves toward the integration of geological engineering and productions, and intelligent oil and gas exploration that can accurately find oil and reduce exploration cost[2].

2.2. Machine learning

Machine learning is a field involving that studies how computers can simulate or implement human learning behaviors to acquire new knowledge or skills and reorganize existing knowledge structures to continuously improve their performance. It is widely used in the field of oil and gas in various fields, such as exploration and reservoirs.

2.3. Deep learning

Deep learning is a general term for a class of pattern analysis methods that can learn and process various types of text, images and other multimodal information with learning and analysis capabilities, allowing machines to have the ability to recognize text, images, etc. with human capabilities, and is widely used in various subfields such as rockiness recognition and yield prediction.

2.4. Neural networks

Neural network is an algorithmic mathematical model that mimics the behavioral characteristics of animal neural networks for distributed parallel information processing. This network relies on the complexity of the system to process information by adjusting the interconnected relationships between lots of inside neurons and is widely used in various subfields such as seismic data processing and interpretation and EOR screening.

3. The current state of application of AI in the exploration and development field

Recently,artificial intelligence technology has developed rapidly and has made dazzling achievements in many fields [3,4]. Inevitably, AI has also attracted great interest from domestic and foreign scholars in the petroleum field and has been continuously attempted by scholars to be integrated with the exploration and development of petroleum. Globally, the application of AI in various aspects of the oil and gas field is still in its early stages, but in some subfields, AI has already achieved good results or made some progress, gradually bringing positive help to energy companies and countries and demonstrating great potential for application.

3.1. Lithology identification

Machine learning, deep learning, etc. have been widely used in image recognition and model building in the field of lithology recognition at present. Although there are core image analysis software based on image processing algorithms (e.g. Avizo, etc.) that can automatically identify lithology, the actual operation relies heavily on human-computer interaction and expert experience, which is inefficient; and rock thin section identification is still mainly manual identification, which has a series of problems such as low efficiency, subjective influence, and long experimental period. Although some scholars have already applied deep learning to core image processing [5-7], further research is needed in this field to improve the intelligence level. Ren Yili innovatively constructed an intelligent lithology identification scheme based on migration learning technology, integrated core images and logging curves, and achieved good results; the prediction accuracy based on core images reached more than 89% [8].

3.2. Logging curve reconstruction

For curve reconstruction, a variety of common approaches have been developed in the past, re-logging, using empirical statistical models, petrophysical theoretical models, etc. However, all of the above methods have obvious drawbacks, such as high cost, very dependent on expert experience or inefficient. With the continuous introduction of artificial intelligence, intelligent curve reconstruction

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based on machine learning is gradually becoming a major reconstruction approach.Zhang Dongxiao et al. proposed a method to reconstruct well logging curves based on long short-term memory neural network (LSTM). After verification by real logging data, it is found that the accuracy is higher than that of traditional methods[9].

3.3. Seismic data processing and interpretation

This field is mainly based on deep learning techniques, various types of neural network applications, and good results have been achieved in some important subfields at present. For fault automatic recognition, several scholars have used different convolutional neural networks and deep learning techniques to obtain higher fault recognition accuracy or provide new ways for fault intelligent recognition in recent years [2,10,11]. This year, Feng Chao et al. proposed a fault high-resolution intelligent identification method, based on the application of deep learning, to establish a library of high-resolution and low-resolution fault labels to train a deep neural network and obtain a high-resolution detection model, and the effectiveness of this method in fine fault identification was verified by the model and actual data[12]. Seismic inversion, based on raw seismic data, solves the spatial structure and physical properties of subsurface rock formations through known geological laws, logs, and other information as constraints, and artificial intelligence has advanced considerably in this subfield in recent years. In wave impedance inversion, Wu, BY et al proposed a semi-supervised learning workflow based on generative adversarial networks (GAN) to improve the poor performance of traditional deep learning methods due to the lack of sufficient labeled data (well logs)[13]. The results show that the workflow is more advantageous than the traditional CNN approach in the Marmoussi2 model, and its predicted seismic wave impedance is more realistic.

3.4. Production forecast

In terms of production forecasting, the use of deep learning techniques based on raw production data and the construction of mapping relationships between raw data and oil and gas production according to the needs of each oilfield are now widely used. Wang, Hongliang et al.,out of the need to describe the correlation of time series data,chose to construct oilfield production prediction models based on historical oilfield production data using long short-term memory neural networks (LSTM),taking into account the linkage between production indicators and their influencing factors and the trend and backward and forward correlation of production over time at the same time, and achieved good results[14]. Wang, SH et al. chose DNN algorithm to develop a data-driven model, which has advantages over conventional numerical simulation in many aspects[15]. Model construction is easier because it does not require the construction of a real reservoir model and is more computationally efficient for production prediction. More importantly, possesses greatly generalizable potential and can be applied to other shale fields by implementing DNN algorithms using datasets from other shale reservoirs.

3.5. EOR screening

The growing global demand for petroleum resources has been accompanied by an increasing deterioration in the quality of crude oil worldwide and a decrease in natural production, which has placed more stringent demands on EOR technology innovation and more efficient and accurate EOR screening than in the past. This section only addresses about EOR screening. In recent years, a considerable number of scholars have applied ML to EOR screening with good results[16,17]. Cheraghi, Y et al. collected more than 1000 global EOR project experiences and used RF, DT, shallow and deep ANN algorithms, etc. to study the EOR screening problem from the ML perspective[18].The test results show that the performance of the DNN and RF models are the best, but the RF model is better in use and training.

In addition to this, Cheraghi, Y presented a number of issues that deserve deeper consideration and remain to be solved in the field of EOR screening for current applications of ML, such as changing EOR screening in the form of multiple-choice questions into a classification problem of finding the most suitable EOR method for candidate reservoirs , or the economic cost is not explicitly represented in the dataset, but it is also a factor that influences EOR screening, providing guidance for the future direction of the field [18].

4. Conclusion

Although the current application of artificial intelligence in the oil and gas field is in its initial stage, it has gradually produced a series of applications with good results in the upstream of oil and gas. As scholars and executives in the oil and gas field gradually realize the great potential of artificial intelligence, it will become an important force and the necessary way for oil companies to develop intelligently and respond to the needs of cost reduction, efficiency improvement, and enterprise transformation.

Important subfields in the field of petroleum exploration and development that have achieved significant results and certain progress in combination with AI applications at present include lithology identification, logging curve reconstruction, seismic data processing and interpretation, production prediction, EOR Screening, etc. This thesis also has certain shortcomings and lacks some empirical analysis in some of its arguments. Artificial intelligence will also occupy a more important position in the field of petroleum exploration and development in the future. As AI continues to make progress in the various exploration and development subfields, a solid foundation is laid for AI to be put into practice. The future trend of AI applications is more likely to develop from points to surfaces, gradually spreading to larger subfields. Therefore, the future research fields of the exploration and development include intelligent logging, intelligent geophysical exploration, etc., and thus develop into larger fields such as intelligent geology and intelligent oilfield.

References

[1] McCarthy, J., Minsky, M. L., Rochester, N., & Shannon, C. E. (2006). A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence, August 31, 1955. AI Magazine, 27(4), 12. https://doi.org/10.1609/aimag.v27i4.1904

[2] Hongen, Dou., Lei, Zhang., Lan, Mi., Yi, Peng., & Hongliang Wang. (2021). Status and Prospects of Artificial Intelligence in the Global Oil and Gas Industry. Oil Drilling & Production Technology(04),405-419+441. doi:10.13639/j.odpt.2021.04.001.

[3] Qingxiang, Xue. (2022).AI middle office becomes the new infrastructure of financial digi talization. China Finance(S1),47-50.https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDAUTO&filename=ZGJR2022S1013&uniplatform=NZKPT&v=MbXxxG_x1ZtEDenQWSVHOfYgHzDwmm-PZuUSjdNg-lfg02eyq7-aE1aLMYW0eYaN

[4] Yibo, Gao., Puquan, Huang., & Dajun, Liu. (2018). AI Enables High Quality Developme nt of Compulsory Education Curriculum under the New Curriculum. Journal of Educat ional Science of Hunan Normal University.https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CAPJ&dbname=CAPJLAST&filename=FLJY20221013001&uniplatform=NZKPT&v=bzlk0n-ZuN04aEj1HOP9tAcL81BKW_cjJYwo4AZWPWfROzCJ14pzm13_FP4TiPVr

[5] Tian, X., Daigle, H., & Jiang, H. (2018). Feature Detection for Digital Images Using M achine Learning Algorithms and Image Processing.https://onepetro.org/URTECONF/proceedings/18URTC/D023S034R004/157307

[6] Guojian, Cheng., Wenhui, Guo., Lan, Mi., & Pengzhao, Zhao. (2017). Convolutional neural network based rock image classification. Journal of Xi'an Shiyou University(Natural Science Edition), 32(4), 116-122.http://www.cqvip.com/qk/92589b/20174/672687600.html

[7] Chauhan, S., Rühaak, W., Khan, F., Enzmann, F., Mielke, P., Kersten, M., & Sass, I. (2016). Processing of rock core microtomography images: Using seven different mach ine learning algorithms. Computers & Geosciences, 86, 120-128.https://www.sciencedirect.com/science/article/pii/S0098300415300789

[8] Yili, Ren., Jia, Liang., Yanzi, Yang., & Xiaoyu Zhang. (2021). Intelligent lithology identification technology that integrates core images and logging curves. China CIO

News.https://www.cnki.com.cn/Article/CJFDTotal-XXXT202103030.htm
[9] Zhang, D., Yuntian, C. H. E. N., & Jin, M. E. N. G. (2018). Synthetic well logs generation via Recurrent Neural Networks. Petroleum Exploration and Development, 45(4), 629-639.https://www.sciencedirect.com/science/article/pii/S1876380418300685
[10] Jing, Wang., Junhua, Zhang., Yong, Yang., Yushan, Du., & Gang, Wu. (2019). Research and Application of Convolutional Neural Networks in Fault Recognition. In:2019 China Earth Science Joint Academic Conference. Beijing. pp. 36-38.https://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZGDW201910024014.htm
[11] Xi, Di.,Yang, Liu., Suoliang, Chang., Haoran, Zhang., &Yuxi, Zhang. (2020). Automatic fault identification of seismic data based on deep learning.In:2019 China Earth Science Joint Academic Conference. Beijing. pp. 72-73. https://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZGDW202010016024.htm
[12] Chao, Feng.,Jianguo, Pan., Chuang, Li., Qing, Yao., &Jun, Yao. (2022).Deep neural network-based tomographic high-resolution recognition method. Earth Science.http://kns.cnki.net/kcms/detail/42.1874.P.20220808.1640.036.html
[13] Wu, B., Meng, D., & Zhao, H. (2021). Semi-supervised learning for seismic impedance inversion using generative adversarial networks. Remote Sensing, 13(5), 909.https://www.mdpi.com/2072-4292/13/5/909
[14] Hongliang, Wang.,Longxin, Mu., Fugeng, Shi., &Hongen, Dou. (2020). A recurrent neural network-based production prediction method for oil fields with very high water content period. Petroleum Exploration and Development, 47(5), 1009-1015.http://www.cpedm.com/article/2020/1000-0747-47-5-1009.html
[15] Wang, S., Chen, Z., & Chen, S. (2019). Applicability of deep neural networks on production forecasting in Bakken shale reservoirs. Journal of Petroleum Science and Engineering, 179, 112-125.https://www.sciencedirect.com/science/article/abs/pii/S0920410519303523
[16] Ali Mohammadi.(2019).Design and development of an expert system for EOR screening based on machine learning.China University of Petroleum (East China).https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202102&filename=1021665884.nh
[17] Khazali, N., Sharifi, M., & Ahmadi, M. A. (2019). Application of fuzzy decision tree in EOR screening assessment. Journal of Petroleum Science and Engineering, 177, 167-180.https://www.sciencedirect.com/science/article/abs/pii/S0920410519301287
[18] Cheraghi, Y., Kord, S., & Mashayekhizadeh, V. (2021). Application of machine learning techniques for selecting the most suitable enhanced oil recovery method; challenges and opportunities. Journal of Petroleum Science and Engineering, 205, 108761.https://www.sciencedirect.com/science/article/abs/pii/S0920410521004216