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IMPLIMENTATION AND ADVANTAGES OF ARTIFICIAL INTELLIGENCE (AI) FOR GEOPHYSICS AND SATELLITE COMMUNICATIONS: PRESENT AND FUTURE TRENDS

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ABSTRACT

This paper introduces the position of implementation and advantages of two technical fields of artificial intelligence in geophysics and satellite communications to explore the impact of computer technology in the research of the two fields and to look forward to the future development trend of the cooperation between the three. Artificial Intelligence (AI) made a breakthrough in 2010, and the technology breakthrough in the industry red line became the common expectation of the society. Triggered by both national policies and market demand, the AI expansion swept through country like China. Since the 21st century, the information expressway has swiftly surfaced, and communication technology represented by satellite communication has become increasingly significant advantageous in the country's economic growth. Geophysics, a branch of earth sciences has made various breakthroughs in theory and practice, bringing a wide range of application value for social growth. There are many crossovers between the fields of communication engineering and machine learning. Geoscience has high demands for complex and changing inhomogeneous and multimodal data, and being able to analyze and process big data in integration with artificial intelligence is a direction that many scholars are exploring.

Keywords: Geophysics; satellite communications; artificial intelligence; machine learning; deep learning; communication engineering.

INTRODUCTION

Artificial intelligence is a subfield of computer science that fucuses on creating intelligent agents capable of performing tasks that would typically require human levels of intelligence, such as problem-solving, speech recognition, and decision-making, among others. AI is an interdisciplinary science with many approaches and can be rule-based and operate under a predefined set or conditions or can use machine learning algorithms to adapt to its environment. The latter is particularly powerful, as it allows AI system to learn from data, making them more versatile and capable of handling unforeseen scenarios.

Human society is experiencing tremendous technological change, namely the fourth industrial revolution (Liu et al., 2023). Artificial Intelligence (AI) thrives and has many applications in industry, finance, and medicine. (Electronics Society of China et al., 2020). Artificial Intelligence technology broadly comprises of deep learning, perception, natural language processing, machine learning, and mapping knowledge domain. Amid them, machine learning is one of the central technologies of artificial intelligence, using a huge amount of data to train models so that the computer can learn and judge. Secondly, as part of machine learning, deep learning simulates the brain's neural network through an artificial neural network, which can aid the machine to learn independently.

Communication Engineering was brought into existence along with the development of China's communication business and developed from the mutual complementary development of wired electricity, electronic technology, wireless communication, post and telecommunications, and other specialties. Satellite communication is a technology that applies artificial satellites for communication. It can transmit information and data, including video, image, voice, and broadcasting through satellite networks. Satellite communication can accomplish wide-area coverage and global communication and has the advantages of long transmission distance, rapid transmission speed, and high dependability.

Geoscience refers to all the sciences that study the Earth and is a specialized area of planetary science whose various disciplines usually study the Earth from the perspectives of physics, mathematics, chemistry, geology, geography, meteorology, and biology. Amid them, geophysics is a crucial branch of earth science, mainly responsible for studying the Earth's physical properties and physical processes. Explicitly, geophysics explores the Earth's surface based on quantitative variations in physical parameters, as well as searching for the subterranean, which is rich in mineral resources needed for the progress of human society. The further development of modern geophysics has broadened the perspective from the outer layers of the Earth's atmosphere to other planets in outer space.

More also, advances in acquisition and exploration equipment have led to explosive growth in the total amount of geophysical observation data, covering a wide variety of disciplines, and have also put the problems of comprehensive sources of geologic data, huge-scale, long-term time scales, and high complexity in front of us as well (Yan et al., 2015; Chun and Li, 2014). Wide temporal and spatial scales are one of the characteristics of the Earth, and computers have the qualities to process information quickly and accurately to help scientists better comprehend scientific phenomena. Using computer science to process various data generated in geophysics can therefore promote the solution of the present challenges faced by geophysicists and further promote the innovation and growth of geoscience research. Satellite communication can make use of artificial intelligence algorithms to enhance, perfect and make better the process of communication transmission.

On the other hand, AI can be utilized for signal processing, coding, and decoding in satellite communications to better communication efficiency significantly. In addition, AI can be applied to the adaptive adjustment and optimization of satellite communication systems to automatically adjust and optimize network configurations and resource allocations according to real-time environmental and demand changes to provide more reliable and efficient communication services. Therefore, satellite communication and artificial intelligence can integrate and develop to provide people with better communication experiences and services.

In summary, one of the questions this study has been thinking about is what discoveries the rapidly developing artificial intelligence can bring to geophysics and satellite communications. We have already seen examples of cooperation between the three in real life, such as the Google Earth software that can provide information such as 3D models, satellite images, and maps of the Earth on a global scale. For future research needs and career directions, the author aims to start from the status of the latest applications of AI in geophysics and satellite communications, analyze their strengths and weaknesses, and

develop predictions of future trends in turn. This study is paving the way for more geophysics researchers, satellite communication, students, and teachers to comprehend and use AI computer technology.

METHODOLOGY

Application Status of Artificial Intelligence Technology in the Field of Geophysics

The integration of geophysics and artificial intelligence has been applied to some extent, such as in seismic exploration and electromagnetic data interpretation. These applications have made better the accuracy and dependability of geophysical research and helped to solve some new insights and discoveries that traditional methods could not realize.

Applications of Machine Learning in Geophysics

Growing hardware computing power, intelligently enhanced and perfected algorithms, and broadening database capacity have integrated to make machine learning (ML) a new type of competitiveness in our country. Machine Learning is the process of allowing computers to perform and optimize human learning behaviors. Machine learning integrates multiple disciplines and shows the latest research results of present computer technology in China. Through thorough reading of literature and visiting surveys, one is aware that machine learning has been widely used in geophysics. Specific cases include:

(1) Geophysical data analysis:

Machine learning algorithms can be applied for geophysical data analysis, such as those used in geological exploration, to automatically extract and analyze the features of these data and predict the properties of geological layers, such as rock type, ore content, thus aiding geologists to comprehend better and assess the geology and mineral resources of an area.

(2) Climate change prediction:

Machine learning algorithms can be used for climate change prediction. By studying past climate data, machine learning algorithms can learn different patterns and trends in climate change and predict future climate change. Such predictions can aid decisionmakers better comprehend the effects of climate change and develop appropriate response strategies.

(3) Groundwater model prediction:

Machine learning algorithms can be used for groundwater model prediction. By studying groundwater level and quality monitoring data, machine learning algorithms can learn the laws and patterns of its changes and predict future groundwater conditions. Such predictions can aid water managers to better strategies and manage groundwater resources.

(4) Geological disaster monitoring and prediction:

Beidou GNSS "sensing, transmission, intelligence, and use" entire business chain geological prediction system, utilizing multi-loop double backup communication mechanism and intelligent disaster monitoring and warning assessment model based on

multidisciplinary intersection, realizing the whole process of monitoring and warning of disasters and emergency rescue (Fan et al., 2020). Machine learning algorithms can use seismic wave data to detect seismic events and classify and localize them automatically. By analyzing the characteristics of seismic signals, machine learning algorithms can learn how to differentiate seismic pieces from other signals and automatically detect and record seismic events, thus improving the accuracy and efficiency of earthquake monitoring.
In conclusion, machine learning is an efficient data-driven approach different from the traditional model-driven approach. Based on data-driven, deep learning can be widely used in data exploration, disaster prediction and environmental monitoring. It has a wide range of applications and can help improve research efficiency, reduce labor costs, and improve the accuracy and precision of predictions.

Application of Deep Learning in the Field of Geophysics
Deep learning originated from generations of scientists' research on artificial neural networks. Deep learning helps humans extract and summarize multiple features of the explored objects, thus saving labor costs and reducing errors. In addition, it is worth mentioning that artificial intelligence can recognize deeper features, which are unmatched and consistent with the higher-order functions of the human brain. However, the human brain cannot guarantee a long period of "deep work." In the opposite, artificial intelligence can guarantee this "difficult work, but the human brain cannot guarantee "deep work" for long periods, while AI can guarantee the continuity of such "difficult work." At present, put the perspective back to the geophysical field, deep learning, mainly in seismic exploration and source localization, geomagnetic bathymetry data special processing, and other fields play a prominent role.

(1) Seismic exploration:
Deep learning technology can be used for processing and analyzing seismic exploration data. By training deep neural networks, the features of seismic signals can be automatically recognized and extracted, and the properties and distribution of geological layers can be predicted. Such predictions can enhance the accuracy and efficiency of exploration for mineral resources such as oil and gas. Additionally, deep learning can be combined with traditional geophysical methods, such as seismic waveform analysis and source mechanism solution, to enhance seismic exploration's accuracy and dependability.

(2) Deep learning can aid geomagnetic data processing, mainly in the following aspects:
i. Data prediction:
Geodetic electromagnetic data has a specific predictive value. Deep learning can utilize its ability to automatically predict the trend and distribution of future data by learning historical data, providing a scientific basis for geological exploration and development of mineral resources.
ii. Data classification:
Geodetic electromagnetic data contains various types of data, and deep learning can use its classification ability to automatically classify the data and identify the characteristics and distribution of different types of data.

iii. Model construction:

Geomagnetic data processing demands establishing complex models for data analysis and interpretation. Deep learning can use its powerful computing and automatic learning ability to rapidly build efficient models and enhance data processing and analysis efficiency and accuracy.

iv. Data pre-processing:
Geomagnetic data contains a huge amount of noise and interference, and deep learning can be used to reduce noise and de-interference processing of the data through automatic learning, to enhance the quality and credibility of the data.

v. Feature extraction:
Geomagnetic data features are relatively complex, making it difficult for traditional methods to feature extraction effectively. Deep learning can use its automatic learning ability to automatically learn and draw out the features of the data through the multi-level neural network structure, enhancing the accuracy and efficiency of feature extraction.
Deep learning (DL), a new data-driven technology, has attracted extensively more attention in geophysics, with diversified application scenarios. We can apply this deep learning-based geophysics practice to find its future application trend in geophysics.

Analysis of Advantages and Disadvantages of the Integration of Artificial Intelligence Technology and Geophysics

In addition to the application practices in specific fields discussed above, it is believed that on the one hand, integrating geophysics and artificial intelligence can enhance the accuracy and dependability of geophysical research and support solve some new insights and discoveries that traditional methods cannot achieve. Using AI technology can enhance efficiency and accuracy, reduce labor costs and risks, and bring convenience and breakthroughs to scientific research and practice in related fields.
Although integrating geophysics and AI has numerous benefits, there are also some problems. The domestic scientific and technological modification capacity in geology must be increased. There needs to be more independent modification and application of new technologies, methods, and equipment, and the degree of informatization is low (Zhang, 2014). The implementation of artificial intelligence requires a huge amount of data and computational resources, and the selection and implementation of algorithms are subject to certain constrains. The implementation of artificial intelligence needs professional technicians to develop and maintain, and there is also a certain degree of uncertainty and the rate of misjudgment of manual judgment has been high, which cannot better guide the implementation of equipment.
Generally, integrating geophysics and artificial intelligence can enhance research efficiency, reduce labor costs, and promote the innovation and development of geoscience research. Nevertheless, some existing problems need to be solved, and their advantages and disadvantages must be clarified to apply better and enhance this new research method.

Potential Prediction of the Integration of Artificial Intelligence Technology and Geophysics

Artificial intelligence technology has attracted much attention in geoscience, and the high degree of integration with geophysics is also a must choice in line with the trends of the times. What aspects of geophysics and artificial intelligence should therefore be further developed to take advantage of the benefits and avoid harm?

The researcher believes that we need to expand the application fields under the integration of the two and explore new possibilities. The use of artificial intelligence in geophysics is still relatively limited, but it may be expanded to more fields in the future. Combined with the actual needs of the business in the field of geology, Li et al. (2022) believe that the future focus of the development of AI applications can also be in the direction of intelligent mapping, intelligent geophysics, intelligent geochemistry, intelligent deep-searching, intelligent hydrology, intelligent cities, intelligent geologic equipment, and intelligent my rehabilitation. Many nonlinear optimization techniques developed in artificial intelligence, such as Markov Chain Monte Carlo, simulated degradation algorithms, genetic algorithms, and particle swarm algorithms, should also be incorporated into the research field of geophysical inversion technology more widely.

Second, the theoretical and technological research required for AI techniques in panning to geophysics must break through the bottleneck. With the U.S. Industrial Internet (Liu et al., 2023), German Industry 4. 0 (Chun and Li, 2014), Made in China 2025 and other strategic planning implementation, coupled with the increasing maturity of artificial intelligence, Internet of Things and other technologies, intelligent equipment gradually mature. In addition, it is a pleasant surprise that China Geological Survey (China Geological Survey) in the field of geoscience and technology to carry out the top ten disaster early warning projects has delivered new results - intelligent landslide online monitoring and early warning system, the use of entirely independent technology, can be operated 24 hours a day, for high-precision, high-reliability, ultra-low-power monitoring, and the accuracy has reached 95%. Monitoring and accuracy have reached more than 95%. Maoshenz et al. (2019) proposed a program for constructing a geologic disaster prevention and control system based on artificial intelligence, which provides a theoretical basis for "geologic disaster prevention + artificial intelligence" and more clues and ideas for future scientific research. This paper therefore hopes to see more rapid, more accurate, and more innovative data processing and analysis methods in the future, realizing more real-time and more accurate monitoring, exploration, and early warning, which is of decisive importance for the deeper integration of the two and the wider field of cooperation.

The much-anticipated process of AI + geoscience development needs country to train more future generation physical data scientists with scientific strengths in both fields. Swiftly adapting training and education to capitalize on rising technologies has not traditionally been a strength of academia. Any intelligent software and innovative theories are the result and outcome of expert wisdom, and talent has always been a center competency of the geology industry. As artificial intelligence grows its application in various fields of the geological industry to serve geological work, intelligent software that is supposed to work closely with people cannot keep up with the requirements of the times. To achieve the synergistic development of man and machine, brainstorm from think tanks and address the obstacles to cooperation between the two fields at the source of technology and to build a nationally unified incubation base for the training of geodata scientists to break down problems such as information barriers and silos so that data can

flow more efficiently in all fields, inclusion and sharing will better prepare talents for future cross-field cooperation.
Clearly, these are only possible future trends, and the specific realization still needs to depend on the progress of technology and the actual needs of applications. Integrating geophysics and AI has a broad development potential and can bring more progress and innovation to geoscience research and application. Indeed, "artificial intelligence + geophysics" seems to be promising.

Present Situation of the Application of Artificial Intelligence Technology in the Field of Satellite Communications

In a considerable data communication technology network, the application of artificial intelligence technology is of great practical importance for enhancing communication management and achieving the efficient circulation and transmission of information (Zhao et al., 2022). Artificial intelligence technology's application in satellite communication is relatively restricted, but there are some related applications. By applying neural networks and deep learning algorithms, AI can enhance the signal decoding ability of satellite communication systems. Machine learning and intelligent algorithms can also support satellite communication systems in automatically adjusting and optimizing network configuration and resource allocation according to real-time environmental and demand changes. More so, AI can be applied to fault diagnosis and intelligent maintenance of satellite communication systems to enhance system dependability and maintenance efficiency.
For instance, Crosslink Network is an essential issue in satellite communications, which involves establishing dependable communication links between multiple satellites. Traditionally, the configuration of Crosslink Networks has depended on manual intervention and static planning, but this approach is challenged by complexity and inefficiency. By applying AI's autonomous learning and adaptive capabilities, satellites can instead adjust their cross-communication network configurations at different moments to suit various communication requirements and environmental conditions.

Analysis of Advantages and Disadvantages of the Combination of Artificial Intelligence Technology and Satellite Communications

It is believed that AI can continuously utilize maximally the satellite communication system through autonomous learning and adaptive ability to dynamically adapt the configuration of the cross-communication network according to various communication requirements and environmental conditions to enhance communication dependability and minimize energy consumption. AI's signal processing capability can improve the data transmission rate and dependability of satellite communication. Also, AI can make quick decisions in a real-time environment to adjust to various satellite communication requirements and unexpected events.
Though AI has the characteristic of "intelligence" in nature, it is not an individual because it is only a system or software (Liu, 2021). There are therefore some disadvantages of integrating AI technology with satellite communication. The most outstanding one is its complexity. Although AI technology is growing rapidly, it is itself one of the most complex

sciences presently facing humanity, and the development of AI technology requires a huge amount of computational resources and processing power, which may lead to an increase in the hardware and software needs of the satellite communication system, increasing the cost and complexity of the system. That notwithstanding, in the field of satellite communications, accessing and processing large-scale data may be challenging, especially for distant satellite systems. The implementation of AI techniques may also face data privacy and security risks, which is unacceptable for satellite communication systems.

In summary, the integration of AI technology and satellite communications brings many advantages and some challenges. These factors must therefore be considered comprehensively, fully practiced, and verified when using AI technology in satellite communication.

Potential Prediction of the Integration of Artificial Intelligence Technology and Satellite Communications

With the continuous growth of artificial intelligence technology and the continuous enhancement of satellite communication technology, the two collaborations will bring significant changes to society.

The integration of AI technology and satellite communications will accelerate the development of intelligent transportation. With the assistance of satellite communication technology, intelligent transportation systems can connect vehicles, transportation facilities, and traffic management centers in real time to achieve timely transmission of traffic information and mutual coordination. Moreover, artificial intelligence technology can analyze and predict traffic data, optimize traffic flow and vehicle routes, and improve road safety and efficiency.

AI technology can provide powerful capabilities for data processing and analysis, thus enabling data to be transmitted and shared more rapid and more accurately on a global scale, which will help promote the development of business activities, medical services, scientific research, and other fields on a global scale. The integration of artificial intelligence technology and satellite communications will accelerate the realization of intelligent global interconnection. Satellite communication systems can provide wide-area coverage and high-capacity transmission capabilities.

Furthermore, the integration of AI technology and satellite communications will also promote the growth of environmental protection and resource management. Through the monitoring and transmitting satellite sensors and communication systems, environmental data from all corners of the Earth can be obtained in real-time, including information on climate, soil, and water quality, to provide a more accurate and effective decision-making basis for environmental protection and resource management.

Summarily, the integration of artificial intelligence technology and satellite communications has outstanding potential and prospects and will bring numerous innovations and developments in the future. Artificial intelligence technology will be more broadly used in the 5G era, a long-term development stage needing gradual advancement (Zhu, 2019).

CONCLUSION

Appreciations to the technical services and the fast rate of publicity provided by Internet giants such as Google, Microsoft, Baidu, and Alibaba, the fashionable terms of artificial intelligence, machine learning, deep learning, and big data have become closely related to

the lives of modern human beings. Accurate face recognition, machine translation, driverless cars, and other artificial intelligence technologies are no longer scenes peculiar to science fiction movies but have become a tangible part of our real lives. The new technological model and economic activities formed by the deep integration and implementation of internet technologies and industrial sectors will significantly improve the modern economy's intelligent decision-making ability, agility, and exactness (Peter et al., 2012).

Geophysical prospecting, a critical technological area in the traditional energy industry, has been affected by this recent wave of technological revolution, and there has been a shift in the mindset and technological approach of exploration developers. Satellite communications are in a new era of development, moving toward greater efficiency, dependability, and breadth. The present generation of communication satellites has high demands for more extensive, communication quality, faster data transmission capacity, and anti-interference capability prompting an urgent need for integration with other surfacing technologies. In the period of mobile networks, AI technologies are prepared for a full-fledged increase with explosive data growth and geometric increases in computing power. AI technologies are also penetrating all aspects of satellite communications and geophysical fields at an unprecedented speed, quietly changing people's traditional ideas and concepts of geophysical and satellite communications work.

It is believed that present application of "AI + geophysics" and "AI + satellite communications" is comprehensive and in-depth. In recent years, with the continuous maturation of artificial intelligence technology (represented by deep learning and machine learning), geophysics and satellite communications are more isolated with the traditional positioning, transmission, and measurement instruments, but rather the use of artificial intelligence technology to minimize human intervention, enhance the interpretation of data accuracy and precision, minimize errors, and significantly increase the effectiveness of communication work and exploration tasks. It is certain that "AI + geophysics" and "AI + satellite communications" applied research has been rapidly developing, the field of application is expanding, and some of the results have already had a certain degree of practical ability. Simultaneously, awareness of the existence of advantages and disadvantages of everything; artificial intelligence technology is not omnipotent, and the integration of traditional fields and modern technology will not be smooth sailing; there must be times of non-adaptation and conflict, and it takes time to integrate, and the two application research is still faced with a series of challenges, for instance, how to flexibly adapt to the complexity and variability of the application scenarios, and how to build a platform for information interoperability, mutual comprehension of technology, and close cooperation between scientists.

Conclusively, geophysics and satellite communication will experience a brand-new renaissance under the coming of the artificial intelligence era. In the absence of theoretical innovation in satellite communication and geophysics and the obstruction of application practice, artificial intelligence may become a new source of innovation and power. To meet the development requirements and talent cultivation of communication engineering and geoscience, relevant scholars and experts need to take the initiative to adapt to the change, seize the crucial historical opportunity of "AI + geophysics" and "AI + satellite communication," and champion the development of AI technology in the communication and geological fields, providing a rare opportunity for these two areas.

China in soonest will catch up with this trend and promote the rise of the "star chain," injecting new vitality into the sustainable development of resources and the environment for human society.

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