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Artificial Intelligence in Earth Sciences

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Abstract

Earth science and artificial intelligence: best practices and fundamental issues give a thorough, step-by-step explanation of AI procedures for resolving Earth Science issues. The book focuses on the most difficult issues in applying AI to Earth system sciences, including training data preparation, model selection, hyper parameter tuning, model structure optimization, spatiotemporal generalization, converting model output into products, and describing trained models. Regardless of prior AI knowledge, it also offers full-stack workflow lessons to guide readers through the whole process. The book addresses the complexity of Earth system issues in AI engineering and provides complete guidance for geoscientists who intend to use AI in their everyday work.

Keywords: Artificial intelligence; Atmospheric; Earthquake; Electromagnetism; Petro physics

Introduction

In several fields of earth science research, including geophysics, artificial intelligence (AI) has emerged as a highly helpful tool. For instance, it is employed in petrophysics to classify lithofacies and characterize reservoirs using well-log data. The AI is utilized in seismology for earthquake characterisation as well as in gravity and magnetism for contacts identification and causative source characterization. Artificial intelligence is utilized in seismic data processing for waveform inversion, automatically selecting seismic first-arrivals, and automatically interpreting seismic horizons and faults. ANNs are used in electromagnetism to interpret data from the air. The segmentation and categorization of topographic profiles of ridge-flank seabed are done in oceanography using artificial intelligence (AI). With the advancement of computer sciences, artificial intelligence and machine learning have emerged as a popular research topic in geophysics [1-5]. The aim of the research topic is to compile the most recent developments in the field of artificial intelligence and machine learning in geophysics. We accept articles on this research topic that concentrate on machine learning and artificial neural networks in the following areas, as well as additional pertinent research, such as:

1-Petrophysics/Formation Evaluation

2-Seismic method

3-Gravity/Magnetic Potential field methods

4-Electromagnetism/Magneto-telluric

5-Geology/Geophysics

6-Geography, Geodesy/Topography

7-Oceanography Hydrology/Hydrogeology

8-Application of the fractal Analysis combined with Artificial Intelligence in earth sciences

9-Wavelet Transform/Edges detection techniques combined with Artificial Intelligence

10-New learning techniques/Deep learning in Earth Sciences

The number of sensors being used throughout the world has allowed for a rapid expansion in human understanding of earth processes. These sensors collect enormous volumes of geolocated data every day that aid in our knowledge of the natural world, human civilization, and space. The data is necessary to: (1) learn about and comprehend natural systems; (2) anticipate trends and effects of human activity; and (3) evaluate risks to human society and the environment. We are still unable to effectively and fully use this vast data mining despite the availability of multiple tools, techniques, and theories. Due to the manual design and management of data, current hypotheses about how the planet will react to climate change are replete with irrational and subjective assumptions. In numerous situations, such as identifying street views, extracting roadways, and understanding medical pictures, artificial intelligence (AI) algorithms have surpassed traditional data management. Many well-known ideas and techniques emerged from the first wave of AI research in the 1980s, but due to computer constraints, the initial models were too laborious to train. AI has advanced scientific developments and discoveries in health, biology, and economics thanks to the recent fast growth of hardware and software [6].

Nowadays, AI is employed in numerous real-world applications, including banking, camera object detection, telecommunications, robotic cleaners for the home, recommendation systems, autonomous driving, self-checkout, etc. All of these applications rely on computer algorithms that imitate the nerve systems of the brain to process information and find solutions to issues. However, unlike human brains, which can distinguish between a variety of items after just learning one of them deductively, AI systems must first learn thousands of patterns in order to arrive at reliable conclusions. Big data manipulation is essential to creating trustworthy AI-based workflows because of the crucial role that big data plays in the development of AI. As more people are exposed to natural (such as tectonic earthquakes, volcanoes, and landslides) and manmade (such as artificial earthquakes, dam collapses), geohazards, there are more difficult difficulties that must be overcome. In order to maintain infrastructure in the face of these difficulties, earth scientists must give a greater knowledge of these occurrences and the physical principles underlying them. Even though it has a long way to go before

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it is completely realized, AI is increasingly pervasive in all facets of geology, including the look for minerals [7].

There is still a lot to learn about earthquake production processes and effects, despite their frequent occurrence and severe repercussions. Numerous applications of AI approaches have been made to earthquake predicting, the Holy Grail of Seismology. Recurrent and feed forward neural networks are two of the most popular ML techniques for this job. In these methods, neural networks provide predictions about the size and position of upcoming earthquakes within a certain window of time or place, frequently based on historical data about the frequency, size, and focus of prior quakes. There are still issues with how sophisticated DL will be successfully used for AI-based seismic forecasts, despite recent advances in this area. This is due to the fact that few characteristics are available for training more complicated models and the majority of earthquake catalogs are simply tabular in nature. However, DL techniques have sped up the creation of more accurate and effective seismic monitoring systems. AI-based earthquake monitoring techniques can improve seismic hazard safety in two ways: by giving Earthquake Early Warning (EEW) systems access to quicker and more accurate earthquake parameter estimations; and by delivering more accurate and detailed earthquake catalogs that can be used to enhance long-term seismic hazard assessments [8-10].

With an unforeseen tremendous capability of predicting the Earth's future and navigating natural risks and resources in advance to save lives and safeguard the environment, Earth AI is built to defend humankind. The power has a limit, though, and it can't save everyone in an event like a geohazard or disruptive one. What if Earth AI makes a mistake overlooks a region or population, underestimates the harm, and causes more deaths or more extensive damage? Earth AI is a sophisticated but still non-existent system that lacks legal status. However, it acts with a certain amount of self-will and its choices have an influence on society. The ethical issues raised by AI when it is in use are the subject of a vast body of study. Critics have looked at the connection between the oppression of racial minorities by AI systems and how it reinforces pre-existing prejudice, as well as the role that cultural bias plays in algorithmic inequity. Soon, there will likely be several rules and laws governing AI ethics on Earth. In this article, we briefly discuss a few of the various routes toward more moral AI in the earth and environmental sciences, including more accessible datasets and impartial algorithms. By collaborating with social scientists, ethicists, and philosophers who have been researching the societal consequences of AI in the fields of policing, law, and finance, engineers should build Earth AI ethics-related logic. This involves creating guidelines for ML researchers to engage with ethics as both a philosophical and practical endeavour, as the gathering of data and the selection of one model over another has an immediate influence on ecosystems and people. Last but not least, we think that for there to be a fair and ethical movement in AI in geosciences, one must communicate their application of any ML or AI to the larger community it impacts (for instance, if an automated method for developing land cover maps will directly impact on representations of Indigenous land).

Conclusion

Overviews the state-of-the-art technology and the advancement of AI research, with a focus on applications to geosciences. Innovations in Earth AI infrastructure and theory will advance geoscience into its next stage, Earth AI. The geoscience community needs to keep up with the explosion in observational datasets and construct usable AI models fast, accurately, and affordably. Earth AI research and development are still in their infancy, and all the major challenges—from data to models to operations—can lead to a wide range of opportunities across all fields, including academia, government, and industry. Earth AI has a promising future that will be enormously helpful to the entire human society and the Earth system. It will help usher in our civilization's next grand phase and change the planet into one that is more sustainable and healthier.

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