Project Title : AQM (Air Quality Monitoring) – IOT

Phase 2: Innovation

This work dissects the application of big data and artificial intelligence (AI) technology in environmental protection monitoring. The application principle of big data in environmental data collection is analysed based on atmospheric science and AI technology. In addition, a combined model of air quality forecasting based on machine learning is proposed to resolve real air quality monitoring challenges in environmental protection, namely, the improved complete ensemble empirical mode decomposition with adaptive noise-whale optimization algorithm-extreme learning machine (ICEEMDAN-WOA-ELM). On this basis, deep learning is introduced to establish a deep learning-based time-space-type-meteorology (TSTM) model to predict air quality. Finally, the model is verified by experiments. The results demonstrate that the ICEEMDAN-WOA-ELM model significantly outperforms a single AI model in air quality forecasting. The five evaluation index values of ICEEMDAN-WOA-ELM are 14.187, 17.235, 0.140, 0.067, and 0.946, which are higher than those of the other models. The single-step accuracy and average of the TSTM model in the heavily polluted weather forecast results almost reached full marks, with a maximum of 1.00. The performance also decreases with the growth of the step size but remains above 0.86. It can be seen that a single AI model can no longer meet the requirements of air quality forecasting. The ICEEMDAN-WOA-ELM model combined with big data has advantages in air quality monitoring and is effective for environmental protection.

Big data have gradually entered all walks of life. Data resources will be a critical wealth in the future. Applying big data thinking and artificial intelligence (AI) diagnosis technology in environmental governance can provide data and technical support for environmental public governance. In addition, environmental governance can provide scientific and accurate ideas for government decision-making in public environmental monitoring and early warning through data collection, real-time monitoring, and citizen participation management. In recent years, global air quality monitoring has developed rapidly. These infrastructure improvements related to air quality monitoring can be attributed to governments’ new or expanded monitoring networks and essential contributions from global citizens and nongovernment agencies. Despite progress, many countries and regions still lack air quality monitoring, leaving large sized populations without access to the information necessary to address pollution and make informed health decisions. Globally, Africa, Latin America, and West Asia have the sparsest monitoring networks. After 2020, the world has taken significant epidemic prevention measures and improved air quality. However, the air pollution caused by human activities such as climate deterioration and burning fossil fuels is still severe. Pollution levels are very high in California, South America, Siberia, and Australia due to wildfires and dust storms triggered by a warming climate.

The use of big data technology to process the environment will significantly improve the efficiency of environmental governance, which has become a new trend in the development of environmental governance in China ([Nie et al., 2020](https://www.sciencedirect.com/science/article/pii/S2444569X22001299#bib0028); [Schürholz et al., 2020](https://www.sciencedirect.com/science/article/pii/S2444569X22001299" /l "bib0034); [Ullo & Sinha, 2020](https://www.sciencedirect.com/science/article/pii/S2444569X22001299#bib0039)). With the development of AI technology, historical data related to environmental pollution can be used to construct predictive models. AI can intelligently gather all kinds of ecological environment monitoring data, such as environmental quality, pollution sources, and ecological conditions. AI can also build an intelligent ecological environment monitoring brain that serves the entire business of ecological environment monitoring, which includes all horizontal monitoring elements and covers all vertical multilevel analysis perspectives. It can be applied to the three terminals of large screens, personal computers, and mobile phones. Current big data have been integrated with people's travel, environmental monitoring, and urban resource allocation. This fused technique has provided a perfect solution for urban greening and beautifying the urban environment.

The biggest drawback of the traditional environment is that there is no way to collect comprehensive data; additionally, data transparency is generally low. Usually, environmental protection departments need to spend human and material resources to collect these environmental data in different departments of separate units and disclose it to the public through appropriate channels. It cannot fundamentally explore the authenticity and reliability of the data while consuming much. From the perspective of the operation process, the environmental protection data eventually became meaningless numbers due to the lack of coordination among various departments. The application of big data and AI algorithms makes it possible to communicate and compare environmental data. Big data technology can archive the data collected by each unit and effectively use the internet to achieve transparency and openness. It enables the public to participate in environmental protection work and enables everyone to clearly understand environmental protection departments. AI has an extensive application space in air pollution forecasting and early warning. However, a single machine learning algorithm cannot achieve an excellent monitoring effect in the case of highly fluctuating pollutant concentrations. Therefore, it is essential to construct a complete ambient air quality monitoring system and an innovative air quality decision-making method.

Given the above status survey results, a single machine learning algorithm is inadequate to monitor the environment in the case of highly fluctuating pollutant concentrations. Therefore, this paper adopts literature research and modelling methods and studies the application of big data and AI in environmental protection based on atmospheric knowledge. Innovatively, a combined model is proposed based on machine learning and the deep neural network for air quality forecasting and creative monitoring decision-making methods. The experiment proves that this model is better than the conventional air quality prediction model, offering new ideas for future research on air quality monitoring and contributing to environmental protection.

Related work

For a long time, people have tried to mine the value behind data for decision analysis and prediction, which gave birth to the predecessor of Data Mining and various Machine Learning algorithms. From the current Internet development fundamentals perspective, Big Data and AI will be a vital development direction. The Internet needs Big Data to complete its value bearing; meanwhile, AI will further expand the application boundaries of the Internet. The development of Big Data and AI is also an inevitable result of the development of the Internet, promoting the practical applications of the Internet. As one of the critical development directions in the future, Big Data has been recognized by scientific and technological circles. There are three main reasons for this. First, Big Data has opened up new value space. Second, Big Data can create new Industrial ecology and then cultivate a series of industrial chains. Third, Big Data can empower the development of traditional industries in an all-around way, and the industry application prospects are vast. AI is a popular direction in the current technology field. On the one hand, the Internet of Things, Cloud Computing, and Big Data are gradually implemented, which relies on AI technology. On the other hand, AI will dramatically improve productivity. At present, the voice of traditional industries for AI is relatively high. Therefore, the development of AI is inevitable.

The information age promotes the further maturity of data technology. Data storage, mining, and application technologies have also achieved remarkable results. The relationship between environmental protection interests and measures is very complex, and many valuable resources still need to be deeply excavated. In addition, the functions of tiny sensors have become abundant, and the standard of data collection has become increasingly high. Massive amounts of data are accumulated in the digital age. The information-based Big Data technology can dramatically improve the ability to analyse environmental monitoring data and effectively realize the centralized management of scattered data to meet data sharing requirements. Therefore, AI algorithms and Big Data integration technology in environmental monitoring are an inevitable development trend. It is significant to environmental governance and environmental protection work and points out the development direction for further environmental protection work.

Many technologies are involved in the mapping from virtuality to reality via AI. In the final analysis, the technological points supporting the development of AI are Cloud Computing, Big Data, and Deep Learning. The Internet has brought a considerable amount of data, and utilizing these resources is the top priority. Although Big Data prepares resources for AI, this resource is worthless without the tool of Cloud Computing. The emergence of the internal combustion engine makes the oil an essential strategic resource. Similarly, the emergence of Cloud Computing makes the information mining behind Big Data a reality. Under this premise, AI can genuinely use Big Data resources to serve enterprises. AI research in medical and environmental protection has made people see a bright future for integrating intelligence and medical care

An intelligent industrial environment developed with the support of a new generation of Cyber-Physical Systems can achieve a high concentration of information resources The “Internet +” smart environmental protection method comprehensively uses new information techniques, including the Internet of Things (IoT), the Internet, Big Data, and Cloud Computing, to implement the open sharing of environmental management data, ambient quality inspection data, source control data, and industrial environmental data. It can construct a multi-source environmental monitoring network to support closed-loop environmental management, involving source prevention and control, process supervision, comprehensive treatment, and universal governance.

Combining AI algorithms with Big Data for environmental monitoring can provide society with high-quality ecological and environmental products based on quality improvement and environmental risk prevention.  synthesized the state-of-the-art knowledge and confirmed common gaps and clews that will set new infusive, demanding, and significant research directions. They found that Artificial Neural Networks (ANNs) and Adaptive Neuro-Fuzzy Inference Systems are the most commonly used AI models for water quality surveillance and evaluation. Most studies utilizing neural networks for surface water quality surveillance and evaluation came from Southeast Asia and Iran. Currently, most practical work uses AI techniques, including Group Data Processing methods, Radial Basis Function Neural Networks, and Multilayer Perceptron Neural Networks, to estimate the indoor temperature of buildings in tropical climates

 optimized an ANN-based AI model using a Genetic Algorithm to verify the feasibility of using the electro-catalytic oxidation process to predict bromophenol blue dye for the treatment of sulphate wastewater. The combination of IoT and Big Data technologies creates opportunities for intelligent applications to monitor, protect, and improve natural wealth. Big Data covers smart metering, intelligent environmental monitoring, smart disaster alerting, and smart farming /agriculture proposed an adaptive switching method of ecological Big Data based on a one-dimensional Convolutional Neural Network (CNN). This scheme can match the requirements for Big Data transmission and ameliorate the high transmission power consumption of microenvironment monitoring systems commonly used in forest health and safety applications compression methods.  reviewed assessment approaches based on the primary analytical technique of Big Data (such as statistical methods, data mining, simulation and optimization, and Deep Learning). The authors presented suitable evaluation methods around the characteristics of Big Data (correlation characteristics, data noise, data loss, and visualization).

To sum up, it is undoubtedly an excellent attempt to apply intelligent results to the environmental monitoring system to implement on-site management. Using AI technology to carry out environmental monitoring projects, such as water quality monitoring, meteorological monitoring, air quality decision-making, and analysis and prediction, is the general trend of future development. However, most of the current research focuses on a single AI model for environmental monitoring, and the forecasting accuracy of the combined model needs to be strengthened. The combination of AI models based on Big Data reported here can provide a new research direction for environmental monitoring.

Innovative decision-making method for environmental protection air quality monitoring based on Big Data and AI technology

Application of Big Data in environmental data monitoring

Big Data primarily uses the Machine Learning method and Natural Language Processing to process and mine data content from the Internet. A large amount of real-time, multi-source data is conducive to depicting reality from different perspectives to obtain the most realistic description, laying a data source foundation for the application of AI. With sufficient data sources, AI can achieve continuous learning, optimization, and practical applications. As one of the most important branches of environmental monitoring data, air quality is closely related to people's work, life, and physical health. The application of Big Data to monitor air quality in the living environment can comprehensively analyse meteorological data and combine the relationship between environmental protection and ecological civilization construction. The Big Data technology can conduct an in-depth analysis of the root causes of environmental problems and integrate environmental indicators and emission information of environmental pollution sources. After scientific analysis, the emission intensity, pollution source distribution, and impact on the surrounding environment of each enterprise can be analysed to formulate a scientific and environmentally friendly governance plan.

In addition, applying Big Data to air quality monitoring can effectively improve the ability of early ecological warning. Environmental monitoring and governance refer to the use of professional equipment to detect the content and emissions of different harmful substances in the environment to track the changing trend in air quality. Environmental monitoring platforms and algorithms can be used to comprehensively collect, quickly process, and analyse environmental data to improve the efficiency of environmental governance.It reveals the process of using Big Data to process environmental information.

