

Possible Future Applications of Machine Learning Approaches to Water Environments

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Description

With the rapid increase in the volume of data on the aquatic environment, machine learning has become an important tool for data analysis, classification, and prediction. Unlike traditional models used in water-related research, data-driven models based on machine learning can efficiently solve more complex nonlinear problems. In water environment research, models and conclusions derived from machine learning have been applied to the construction, monitoring, simulation, evaluation, and optimization of various water treatment and management systems. Additionally, machine learning can provide solutions for water pollution control, water quality improvement, and watershed ecosystem security management. In this review, we describe the cases in which machine learning algorithms have been applied to evaluate the water quality in different water environments, such as surface water, groundwater, drinking water, sewage, and seawater. Furthermore, we propose possible future applications of machine learning approaches to water environments. With rapid economic development; wastewater containing various pollutants is generated, posing serious threats to natural water environments. Thus, various water pollution control measures have been developed. To a large extent, water quality analysis and evaluation have substantially improved the efficiency of water pollution control. To date, many methods have been developed to monitor and assess water quality worldwide, such as the multivariate statistical method, fuzzy inference, and the Water Quality Index (WQI).

Machine Learning: Tool in the Fields of Environmental Science and Engineering

For evaluating water quality, although most water quality parameters can be monitored according to the procedures defined in the relevant standards, the final water quality evaluation results may widely vary owing to the choice of parameters. Considering all water quality parameters is unrealistic because it is not only expensive and technically difficult but also fails to deal with the variability in water quality. However, in recent years, with the advances in machine learning methods, an increasing number of researchers believe that vast amounts of data can be successfully captured and analyzed to

meet the complex and large-scale water quality evaluation requirements. In machine learning, a branch of artificial intelligence, algorithms are used to analyze data and attempt to mine potential patterns in the data to predict new information. As a new data analysis and processing method, machine learning has been widely used in many fields owing to its high precision, automation, high speed, flexible customization, and convenient extensibility. Complex nonlinear relational data can be easily handled with machine learning, which facilitates the discovery of the underlying mechanisms. The excellent adaptability of machine learning has demonstrated its potential as a tool in the fields of environmental science and engineering in recent years. Therefore, more accurate evaluation results can be expected despite the complexity of using machine learning for water quality analysis and evaluation. Water types, including drinking water, wastewater, groundwater, surface water, seawater, and freshwater, are complex. These different types of water have different characteristics, leading to considerable challenges for research on their quality. Based on the findings of previous studies, machine learning can be an effective approach to addressing these challenges.

Advantages and Disadvantages of Commonly Used Machine Learning Algorithms

As such, in this review, we summarize the advantages and disadvantages of commonly used machine learning algorithms and discuss the applications and performance of machine learning in surface water, groundwater, drinking water, wastewater, and seawater. As a powerful data analysis approach, machine learning is widely used to identify patterns or make predictions based on big data generated from different scenarios. Before machine learning is applied in practice, data acquisition, appropriate algorithm selection, model training, and model validation need to be conducted. Among these processes, the choice of algorithm is crucial. Supervised and unsupervised learning are two main classes of machine learning technologies. The main difference between these two classes is the presence of labels in the datasets. Supervised learning deduces predictive functions from the labeled training datasets. Each training instance includes input values and expected output values.

Supervised learning algorithms try to identify the relationships between the input and output values and generates a predictive model to predict the result based on the corresponding input data. Supervised learning can be used for data classification and

regression, and a variety of algorithms, including linear regression, Artificial Neural Network (ANN), Decision Tree (DT), Support Vector Machine (SVM), naive Bayes, K-Nearest Neighbor (KNN), Random Forest (RF), etc. have been developed.