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Research on Renewable Energy Generation Prediction Based on Artificial Intelligence

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ABSTRACT
The development and utilization of renewable energy is regarded as an important way to solve energy problems. In this context, accurate prediction of renewable energy generation is of great significance for energy allocation and grid management. Artificial intelligence technology has played an important role in predicting renewable energy generation due to its outstanding capabilities in data processing and predictive analysis. Therefore, this paper explores the application of artificial intelligence technology in improving the accuracy and efficiency of renewable energy generation forecasting, aiming to provide reference for optimizing the existing energy structure.

KEYWORDS
Artificial intelligence; Renewable energy; Power generation forecast; Deep learning

1 Introduction

Renewable energy, as a key alternative to traditional fossil fuels, is gradually expanding its share in the global energy supply. Among them, renewable energy sources such as wind and solar have received widespread attention and rapid development due to their clean and sustainable characteristics. However, due to the instability and unpredictability of renewable energy, accurately predicting its power generation has become an important issue in achieving energy optimization configuration and stable operation of the power grid. Artificial intelligence technology can provide high-precision predictions of future states by learning complex patterns from historical data, which is particularly suitable for predicting renewable energy generation. Based on this, this paper will explore the optimization and implementation of an artificial intelligence based renewable energy generation prediction model, aiming to improve the accuracy and real-time performance of predictions by introducing advanced algorithms and models. This will help energy producers, grid operators, and policy makers better manage and schedule resources, while enhancing the market competitiveness of renewable energy and promoting the widespread application of clean energy.

2 Overview of Artificial Intelligence Technology

Artificial intelligence is a scientific technology that studies and develops theories, methods, techniques, and application systems for simulating, extending, and expanding human intelligence. [1] Its core goal is to enable machines to perform complex tasks that require human intelligence to complete; At the application level, artificial intelligence covers multiple aspects such as language processing, image recognition, automatic planning, and robot control. With the advancement of technology, AI is gradually being applied in fields such as medical diagnosis, stock trading, robot control, legal consultation, and autonomous driving. Currently, the development of artificial intelligence technology has brought significant social and economic benefits, but it is also accompanied by dual ethical and technological challenges. With the popularization of AI technology, how to protect personal privacy, ensure data security, and prevent algorithm bias has become an urgent problem to be solved.

3 Basic Principles of Artificial Intelligence Prediction Models

3.1 Data Driven Prediction Model

In data-driven prediction models, data processing is both fundamental and crucial. The initial dataset comes from equipment such as weather stations, solar panels, and wind turbines. These data have certain processing difficulties due to their large size and frequent updates, and must undergo strict cleaning and formatting processing. During the processing, it is necessary to eliminate outliers, fill in missing values, and perform data normalization to eliminate biases caused by different data sources or ranges. Meanwhile, these data also need to undergo time series processing. This process involves time window partitioning of data, aimed at ensuring that the model can understand and utilize the impact of time factors on power generation. Feature engineering is another important aspect of improving the performance of prediction models. In renewable energy generation forecasting, the main task of feature engineering is to select the most influential variables from raw data and create new features to enhance the explanatory power and predictive ability of the model. Wind power generation needs to consider meteorological conditions such as wind speed, wind direction, and humidity, while solar power generation focuses more on parameters such as light intensity and sunshine duration.

3.2 Algorithm Basis of the Model

Machine learning algorithms are the cornerstone of building renewable energy generation prediction models. The widely used algorithms in prediction models include support vector machines, decision trees, random forests, and gradient boosting machines. These algorithms each have their own advantages and can demonstrate unique effects in different data features and prediction requirements. In order to achieve optimal prediction performance, optimizing the model structure requires adjusting the model parameters, such as setting the learning rate and selecting regularization terms; These parameters directly affect the generalization ability and prediction stability of the model. Due to the nonlinearity and high-dimensional features of its data, deep learning can capture deep data patterns through its multi-level network structure, thereby achieving more accurate predictions. [2] The commonly used deep learning models mainly include convolutional neural networks and recurrent neural networks. The application of these models enables the patterns learned from historical data to effectively predict the trend of future power generation changes.

4 Architecture Design of Three Artificial Intelligence Prediction Models

4.1 Model Input and Data Processing

In renewable energy generation forecasting, raw data contains various irregular factors such as missing values, outliers, and noise. If these factors are not addressed, they will seriously interfere with the learning effectiveness of the prediction model. Therefore, thorough cleaning and standardization of data is the foundation for building effective predictive models. Data cleaning mainly involves removing or filling in missing values, identifying and processing abnormal data; And data standardization processing is mainly aimed at eliminating the dimensional influence between different data sources, adjusting the input variables to the same scale through data transformation, so that the model can more fairly evaluate the importance of each feature. Feature selection is an advanced stage in data processing, aimed at selecting the most predictive features from a large number of latent variables. In the prediction of renewable energy generation, there are many factors that affect power generation, including climate conditions, device performance, historical power generation data, etc. Some of these factors are key factors that directly affect power generation, while others are indirect factors that only show their influence under specific conditions. Therefore, using statistical based feature selection techniques, or model-based feature selection techniques can effectively identify the most effective predictive factors from complex datasets.

4.2 Model Output and Performance Evaluation

In the renewable energy generation prediction model, the output results include the predicted generation values and confidence intervals or prediction error evaluations; These are essential elements in decision-making. Output design should consider user interface friendliness and data accessibility, ensuring that end-users can easily access and utilize this data for daily energy management and scheduling. At the same time, the model should also be able to output analysis results about data features and prediction accuracy, so that users can understand the logic and potential uncertainties behind the model's predictions, and make reasonable decisions under complex environmental conditions. Performance evaluation is a core part of the model development process, often using metrics such as mean square error, mean absolute error, coefficient of determination, and cross validation. Among them, mean square error and mean absolute error can directly measure the deviation between predicted values and actual values; The coefficient of determination provides the model with the ability to explain variation; The method of cross validation can be used to train and test models on different subsets of data, effectively evaluating the stability and reliability of the model under various conditions. [3]

5 Optimization and Implementation of Artificial Intelligence Prediction Models

5.1 Model Parameter Optimization and Model Adjustment

The purpose of parameter optimization is to find the optimal model parameter configuration to achieve the highest prediction accuracy for unknown data. In the prediction of renewable energy generation, model parameters include learning rate, regularization coefficient, network layers, number of neurons, etc. Grid search, random search, and Bayesian optimization methods can be used to optimize these parameters; These methods can systematically explore the parameter space and identify the optimal parameter combination under specific performance indicators. Model adjustment involves not only parameter adjustments, but also modifications to the model structure itself, such as adjusting network layers, changing activation functions, or adjusting input feature processing methods. In the prediction of renewable energy generation, due to various complex situations such as seasonal changes in data and performance changes caused by equipment aging, the model needs to have a certain degree of flexibility to cope with these changes. [4] Cross validation, regularization techniques, and timely model updates can be used to ensure that the model maintains good predictive performance on new data.

5.2 Implementation Details

Hardware infrastructure is the physical foundation that supports artificial intelligence models. When dealing with renewable energy generation prediction models, powerful computing resources are particularly needed to handle large amounts of data input, perform complex data analysis and model training tasks. High performance graphics processing units are an ideal choice for executing deep learning models, as their ability to perform large-scale parallel processing and accelerate mathematical operations far exceeds traditional central processing units; In summary, sufficient memory and fast data storage solutions are also necessary to ensure fast reading and processing of data, reducing time delays in data transmission and processing. For real-time prediction systems, hardware reliability is equally important, as it ensures that the system can operate stably and safely for a long time. In addition to hardware facilities, software environment is also an indispensable element for implementing model design, training, and deployment. [5] Efficient programming languages and professional machine learning libraries are the foundation for developing high-quality predictive models. Among them, Python provides a series of preprocessing, model building, training, and validation tools with its rich library support (such as TensorFlow, PyTorch, etc.) and excellent community resources, enabling developers to implement complex algorithm logic with relatively simple code. In addition, in multi-user and high concurrency environments, a stable and efficient database management and access control system is essential to ensure data integrity and security. And with the updates of algorithms and libraries, new features and optimizations can help improve model performance and system security.

6 Conclusion

In summary, this paper explores a renewable energy generation prediction model based on artificial intelligence, with a focus on the design and implementation of the model. With the continuous advancement of technology and the continuous improvement of data quality, these predictive models are expected to become more accurate and reliable, providing powerful decision support tools for energy companies. Therefore, future research needs to continue optimizing model design and expanding the scope of practical applications.

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