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学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（情報科学）　　氏名　劉　倬驛

学　位　論　文　題　名

Wind speed and wind power forecasting system based on data decomposition and deep learning neural network

（データ分解と深層学習ニューラルネットワークに基づく風速・風力発電出力予測システム）

The overexploitation of fossil fuels, such as coal, oil, and natural gas in recent years has made the development of renewable energy forms an inevitable trend in energy development. Wind energy, as an environment-friendly new energy source, has gradually become the most promising, fastest-growing, and relatively mature renewable energy generation method because of its easy access and low cost. However, because of the volatility of wind speed, wind power generation is always accompanied by uncertainty. Effective wind speed and wind power forecasting are essential for grid dispatch, controllability, and stability, and accuracy is crucial for the effective utilization of wind energy resources.

This study proposes an accurate and efficient wind power forecasting system based on a wind speed forecasting model. First, in the construction of the wind speed forecasting model, a novel wind speed forecasting system is developed based on data decomposition and deep learning neural networks for ultra-short-term wind speed (wind speed at the next moment of 10, 30, and 60 minutes interval) and short-term wind speed (24 h-ahead hourly average wind speed) forecasting. The system consists of three modules: an extraction module, a data pre-processing module, and a forecasting module. In the data extraction module, a considerable amount of valid historical data are extracted, filtered, classified, and used as training data. In the data preprocessing module, the complementary ensemble empirical mode decomposition (CEEMD) is used to decompose the wind speed data. In the forecasting module, an optimized long short-term memory network (LSTM) is employed to forecast the decomposed wind speed data and integrate them into the final forecast results. The results of numerical simulations for 10 locations in Hokkaido indicate that the proposed forecasting system has higher forecasting accuracy and better stability performance than other forecasting models for wind speed at different locations in different periods. Secondly, three forecasting models are proposed to forecast 1-hour ahead wind power based on the structure of wind speed forecasting model, and a hybrid forecasting model based on the three forecasting models with different forecasting accuracy under different conditions is proposed and numerically simulated with the power generation data provided by the sotavento wind farm in Spain. The numerical simulation results indicate that the forecasting system can obtain good forecasting results in different time periods and that the accuracy is less affected by the environmental conditions, thereby confirming the high generalizability of the forecasting system. The comparison with other forecasting models shows that the proposed system has relatively high accuracy.

Overall, the proposed wind speed and wind power forecasting system exhibits good generality, good stability, and high accuracy and is expected to be used in practical wind power forecasting.

This dissertation consists of Six chapters, and the contents are summarized as follows:

Chapter 1 introduces the background of the study and then briefly describes the current status of wind power generation today and the current status of research on wind speed and wind power forecasting.
Chapter 2 details the methods, models, neural networks, and optimization algorithms used in the various stages of forecasting model building, which form the basis of the forecasting model proposed in this thesis.
Chapters 3 and 4 presents the method for constructing the wind speed forecasting model. The wind speed forecasting models are classified into ultra-short-term forecasting models and short-term forecasting models according to the forecasting time scales. The problems faced by the two forecasting models in the three processes of data selection, data decomposition, and optimization of neural networks are discussed and dealt with by corresponding means to propose a adaptable wind speed forecasting model.
Chapter 5 presents the construction method of the wind power forecasting model. Three wind power forecasting models are proposed based on the proposed wind speed forecasting model and the method used to construct this model. The numerical calculation results show that the three forecasting models have their advantages and disadvantages in different situations. To effectively utilize the points of the three forecasting models, a hybrid forecasting model based on the three forecasting models is proposed, and the effectiveness of the method is verified by numerical simulation.
Chapter 6 is the conclusion of this thesis.