International Journal of Computational Intelligence Systems (2024) 17:5
https://doi.org/10.1007/s44196-023-00391-7

RESEARCH ARTICLE

A GMEE-WFED System: Optimizing Wind Turbine Distribution for Enhanced Renewable Energy Generation in the Future

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Received: 25 September 2023 / Accepted: 5 December 2023

Abstract

This paper presents the Generation Max Electrical Energy from Wind Friendly Environment Database (GMEE-WFED) system, a groundbreaking innovation aimed at enhancement the performance and energy output of wind power generation stations. The GMEE-WFED system has been meticulously designed to provide precise wind power forecasting within distributed turbine systems, facilitating the seamless integration of renewable energy into the grid. This forecasting is enabled by the utilization of the Spatial Dynamic Wind Power Forecasting (SDWPF) dataset, which takes into account the spatial distribution and dynamic characteristics of wind turbines. The GMEE-WFED system comprises five layers, each offering unique advantages. The first layer, referred to as the "Best Distribution of Turbines Based on DOA (BDT-DOA)," is designed to achieve the following objectives: (a) increase power generation, (b) determine the optimal coordinates (x, y) for each turbine, and (c) distribute turbines based on the best locations. The second layer, named the "Effect Features Layer (EF)," focuses on: (a) identifying the impact of features on wind power generation, (b) streamlining implementation time, and (c) reducing computational demands. The third layer, denoted as the "Average and Shifting up Target Layer (AEH-SUV)," serves the purposes of: (a) enhancing accuracy by calculating feature averages, and (b) predicting future active power through target shifting at different intervals (ranging from 1 to 6 h). Meanwhile, the fourth layer is associated with the development of a prediction model based on a deep learning technique known as "Deep Learning-Long Short-Term Memory (DL-LSTM) Layer," which is utilized for: (a) forecasting future energy production, (b) evaluating model accuracy at varying intervals, and (c) assessing overall model effectiveness. The final layer is also dedicated to constructing a prediction model, but it leverages a different deep learning technique called "Deep Learning Gate Recurrent Unit (DL-GRU)." These models contribute to accurate wind power predictions at various intervals and ensure the overall effectiveness of the system. Experimental results have shown that DL-GRU outperforms DL-LSTM in all shifting cases, underscoring the system's effectiveness in predicting future wind power generation and forecasting accuracy. As a result, the GMEE-WFED system is a pioneering approach that enhances wind DC-power generation forecasting. The GMEE-WFED system, with its intricate layers and advanced modeling techniques, represents a significant leap forward in harnessing the potential of wind energy for a more sustainable future.

Keywords Distributed turbines · Distribution system · BDT-DOA · EF · AEH-SUV · DL-GRU · DL-LSTM · Wind power

1 Introduction

A distribution system [1, 2] refers to the infrastructure and network that facilitates the efficient and reliable delivery of goods, services, or resources from a central source to multiple end-users or consumers. It encompasses various interconnected elements, such as transportation, storage, and allocation mechanisms, ensuring the availability and accessibility of products or services in the desired quantities and locations.

The important of a distribution system, and related it with spatial distribution of wind turbines [3, 4]: optimized resource allocation: in the context of wind power generation, a distribution system plays a crucial role in optimizing the spatial distribution of wind turbines. By strategically placing turbines in areas with favorable wind conditions, the system maximizes the utilization of wind resources. This leads to

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Published online: 08 January 2024