Fault Detection in Wind Turbine System Based on Signal Analysis and Convolutional Neural Networks

Nejad M Y Alagha
Department of Electrical Engineering, Faculty of Engineering, Universiti Malaya, Kuala Lumpur, Malaysia

Anis Salwa Mohd Khairuddin
Department of Electrical Engineering, Faculty of Engineering, Universiti Malaya, Kuala Lumpur, Malaysia

Obada Al-Khatib
School of Engineering, University of Wollongong in Dubai, Dubai Knowledge Park, 20183, Dubai, UAE

Jeevan Kanesan
Department of Electrical Engineering, Faculty of Engineering, Universiti Malaya, Kuala Lumpur, Malaysia

Abstract

Wind turbines are vital to the global transition toward renewable energy. Wind turbines consist of several components that work together to generate electricity, and a fault in any component can ultimately affect the overall operation of the turbine. The accuracy of wind turbine fault detection is hindered by the complex fault patterns within the vibration signals as they are non-linear and non-stationary due to factors such as varying load, different weather conditions and interaction of different mechanical parts. Hence, signal processing methods are important to give insights and analyze these signals to enhance the accuracy of the fault detection. Generally, it is important to combine signal processing and convolutional neural networks to detect faults in the wind turbine gearbox, ensuring robust and accurate fault diagnosis. In this work, a novel approach for wind turbine gearbox fault detection is proposed by using a Complete Ensemble Empirical Mode Decomposition with Adaptive Noise (CEEMDAN) and Multiscale Convolutional Neural Network (MSCNN). The CEEMDAN technique decomposes vibration signals into intrinsic mode functions, effectively isolating critical fault features across multiple scales. These features are then fed into the MSCNN, which leverages hierarchical feature extraction to classify faults with high accuracy, achieving an F1 Score of 98.95%. The model's robustness is evaluated using real-world datasets, demonstrating its capability to handle varying signal durations and outperforming previous techniques in both fault detection precision and computational efficiency. Overall, the proposed method strikes a balance between high classification performance and computational efficiency, making it a robust and practical approach for fault diagnosis in wind turbine systems.