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Editorial: Wind turbine fault and damage diagnosis and prognosis

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Editorial on the Research Topic
Wind Turbine Fault and Damage Diagnosis and Prognosis

To remain competitive, wind turbines must be reliable machines with efficient and effective maintenance strategies. Thus, it is essential to develop robust and cost-effective prognostic and health management strategies, both in terms of their structure and their components.

On the one hand, the purpose of wind turbine structural health monitoring (SHM) is to detect, locate, and characterize structural damage, so that maintenance operations can be performed in due time. SHM has been widely applied in various engineering sectors due to its ability to respond to adverse structural changes, improving structural reliability and life cycle management. In the near future, SHM has the potential to be a wind energy harvester, in particular for offshore wind turbines. On the other hand, fault diagnosis and prognosis strategies based on condition based maintenance for the different systems (gearbox, main bearing, generator, *etc.*) of the wind turbine are crucial. Vibration-based condition monitoring is a well-established strategy, but it usually relies on high-sampled data (>10 kHz) leading to a large amount of data from a large number of sensors. Finding patterns in such multivariable datasets is a challenge under the variety of operational modes and environmental conditions that wind turbines are subject to.

This Research Topic invited contributions that addressed wind turbine fault and damage prognosis and diagnosis through novel contributions and innovative applications covering, but not limited to, any of the following topics around wind turbines: condition monitoring, structural health monitoring, fault diagnosis, damage diagnosis, machine learning, deep learning, model-based.

After rigorous review, five high-quality articles contributed by 28 authors were finally accepted for their contributions to the topic.

In the article "*Intelligent Fault Diagnosis Method of Wind Turbines Planetary Gearboxes Based on a Multi-Scale Dense Fusion Network*," Huang et al. suggests using a CNN-based model with an upgraded multi-scale dense fusion network to diagnose faults in planetary gearboxes in wind turbines under challenging operating conditions. The two-dimensional wavelet time-frequency diagrams are utilized as the network input after the continuous wavelet transform is done to preprocess the vibration signals. The extraction and classification stages of fault features are then performed using the multi-scale feature fusion module and a feature of maximum module, respectively. The multi-scale characteristics of each network layer are then combined to improve the fault characteristics. Finally, the separable fusion result of the fault features is extracted to obtain the high fault diagnosis accuracy. On a planetary gearbox dataset, the suggested technique achieves an average defect diagnostic accuracy of greater than 99%.

In the article "*Remote Health Monitoring of Wind Turbines Employing Vibroacoustic Transducers and Autoencoders*," Czyżewski describes the use of remote monitoring technology on actual wind turbine structures to look for potential reasons of failure. For this, both well-known accelerometers and a novel multi-axis contactless acoustic sensor sensing acoustic intensity were employed. Techniques for signal processing, such as feature extraction and data analysis, were suggested. Two tactics were looked at: Mel frequency cepstral coefficients that have been trimmed using principal component analysis and feature extraction from autoencoders. Data was collected and analyzed as a result of the scientific experiment to identify probable wind turbine mechanism problems.

In the article "*Wind Turbine Gearbox Failure Detection Through Cumulative Sum of Multivariate Time Series Data*," Latiffianti et al. investigate the potential for small-magnitude symptoms to accumulate as a result of the slow deterioration of wind turbine systems, as a critical element to allow early warnings of failure. The article describes the creation of a wind turbine failure detection approach with such early warning capabilities, which was inspired by the cumulative sum control chart method. In particular, the issues of what fault signals to accumulate, how long to accumulate, what offset to utilize, and how to set the alarm-triggering control limit are discussed. On 2 years' worth of Supervisory Control and Data Acquisition data collected from five wind turbines, the suggested methodology is used. The study focus on gearbox failure detection, where the suggested method exhibits its capacity to foresee failure events with a respectable advance time.

In the article "*Appraising machine learning classifiers for discriminating rotor condition in 50 W–12 V operational wind turbine for maximizing wind energy production through feature extraction and selection process*, Dhanraj et al. explore at the use of vibration signals to predict blade damage. A nonlinear relationship between specific significant damage features and the associated uniqueness measures is established by the machine learning method. Based on the excellent condition of the edge, the learning algorithm was developed and put to the test. Classifier models were used to forecast blade faults, including naive Bayes, multilayer perceptrons, linear support vector machines, one-deep convolutional neural networks, bagging, random forests, XGBoosts, and decision tree J48, and the results were compared based on their parameters to propose a more effective fault diagnostics model.

In the article "*Review of corrosion monitoring and prognostics in offshore wind turbine structures: Current status and feasible approaches*," Brijder et al. review the state-of-the-art in corrosion mechanisms and models, corrosion monitoring, and corrosion prognostics with a special focus on their applicability to Offshore Wind Turbine (OWT) structures. Moreover, research challenges, open issues, and strategic directions for future research and development of cost-effective solutions for corrosion monitoring and prognostics for OWT structures are thoroughly discussed. It is noteworthy the finding of the suitability of non-destructive autonomous corrosion monitoring systems based on ultrasound measurements, combined with hybrid prognosis methods based on Bayesian filtering and corrosion empirical models.

It is clear that the majority of the publications in this Research Topic deal with the creation of advanced algorithms by means of machine learning and deep learning techniques. These emerging and promising techniques are gaining popularity due to recent technological advancements in sensors, as well as high-speed internet and cloud-based computation. There is no doubt these techniques will play a key role in the future development of structural health monitoring and fault diagnosis and prognosis methodologies in the wind turbine industry.

Finally, the guest editors would like to extend their gratitude to all the authors for their insightful contributions, as well as to all the reviewers for their tremendous work on the reviews. We would especially want to thank the journal's editor-in-chief and the editorial board for their outstanding support of this Research Topic.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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