Detection of Lossy Bolts in a Jacket-Type Wind Turbine Support Using a Vibration-Only Response Mechanism Based on Accelerometer Data

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ABSTRACT

The early detection of damage in wind turbine structures is of crucial importance to ensure the safety and efficiency of wind farms. This study specifically addresses the problem of detecting a common damage: loose bolts, which can have a significant impact on the performance and lifespan of a jacket-type structure. This work focuses on the structural health monitoring of jacket-type foundations used by offshore wind turbines. A vibration-only response mechanism based on accelerometer data is specifically proposed. In this study, a methodology has been developed to detect loose bolt in the wind turbine jacket using an anomaly detection model. The methodology consists of two training phases using only healthy data: training a generative adversarial network (GAN) and training an encoder based on the learned GAN model. Through the GAN network training process, a generator, and a critic are obtained. The encoder is then trained to map healthy samples to a latent vector, placing the data at points in the latent space that correspond to the healthy state of the input data. Once the encoder training is complete, the encoder maps the input sample space to the latent space, and the generator maps the latent space back to the initial space. In the case of a healthy input, this mapping process should closely resemble the original input sample. However, when damaged-state input samples are used, the model output does not resemble the input. To identify anomalies, the reconstruction error and a comparison of the residual error of the critic properties are employed as the final two loss functions. The proposed strategy has been validated through laboratory experiments on a downscaled model. The deep learning models have proven to be an effective technique for the early detection of loose bolts in jacket-type structures of wind turbines. This approach can significantly contribute to improving the safety and performance of wind farms by enabling timely and efficient intervention in the event of possible structural failures.