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Enhancing Fault Detection in Rotating Machinery Using Wiener-CNN Method

Authors : Mohamad R. Moshtagh, Ahmad Bagheri

Abstract : Accurate fault detection in rotating machinery is of utmost importance to ensure optimal performance and prevent costly downtime in industrial applications. This study presents a robust fault detection system based on vibration data collected from rotating gears under various operating conditions. The considered scenarios include: (1) both gears being healthy, (2) one healthy gear and one faulty gear, and (3) introducing an imbalanced condition to a healthy gear. Vibration data was acquired using a Hentek 1008 device and stored in a CSV file. Python code implemented in the Spider environment was used for data preprocessing and analysis. Winner features were extracted using the Wiener feature selection method. These features were then employed in multiple machine learning algorithms, including Convolutional Neural Networks (CNN), Multilayer Perceptron (MLP), K-Nearest Neighbors (KNN), and Random Forest, to evaluate their performance in detecting and classifying faults in both the training and validation datasets. The comparative analysis of the methods revealed the superior performance of the Wiener-CNN approach. The Wiener-CNN method achieved a remarkable accuracy of 100% for both the two-class (healthy gear and faulty gear) and three-class (healthy gear, faulty gear, and imbalanced) scenarios in the training and validation datasets. In contrast, the other methods exhibited varying levels of accuracy. The Wiener-MLP method attained 100% accuracy for the two-class training dataset and 100% for the validation dataset. For the three-class scenario, the Wiener-MLP method demonstrated 100% accuracy in the training dataset and 95.3% accuracy in the validation dataset. The Wiener-KNN method yielded 96.3% accuracy for the two-class training dataset and 94.5% for the validation dataset. In the three-class scenario, it achieved 85.3% accuracy in the training dataset and 77.2% in the validation dataset. The Wiener-Random Forest method achieved 100% accuracy for the two-class training dataset and 85% for the validation dataset, while in the three-class training dataset, it attained 100% accuracy and 90.8% accuracy for the validation dataset. The exceptional accuracy demonstrated by the Wiener-CNN method underscores its effectiveness in accurately identifying and classifying fault conditions in rotating machinery. The proposed fault detection system utilizes vibration data analysis and advanced machine learning techniques to improve operational reliability and productivity. By adopting the Wiener-CNN method, industrial systems can benefit from enhanced fault detection capabilities, facilitating proactive maintenance and reducing equipment downtime.

Keywords : fault detection, gearbox, machine learning, wiener method
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