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Title: Benchmarking Machine Learning Algorithms for Bearing Fault Classification Using Vibration Data: A Deployment-Oriented Study

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Abstract: This study presents a comprehensive benchmarking of 33 machine learning (ML) algorithms for bearing fault classification using vibration data, with a focus on real-world deployment in condition monitoring systems. A total of 81,000 samples were collected from three case studies involving SKF7205, SKF7206, and SKF7207 rolling element bearings under varying fault conditions. Feature selection using Principal Component Analysis (PCA) and correlation-based filtering was employed to reduce redundancy and enhance model performance. The classifiers were evaluated across multiple metrics including validation accuracy, test accuracy, misclassification cost, training time, and area under the receiver operating characteristic (ROC) curve (AUC). Ensemble Bagged Trees consistently outperformed other models across all case studies, demonstrating superior classification accuracy, robustness, and low misclassification cost. Fine Tree models also demonstrated competitive performance while maintaining low computational demand, while Wide Neural Networks exhibited high predictive performance with longer training times. This work provides a practical reference for researchers and practitioners by systematically comparing ML algorithms and elucidating the trade-offs between predictive accuracy, computational efficiency, and deployment readiness in real-world fault diagnosis applications.

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