Damage Identification in Rotary Shafts via Vibration Monitoring and Physics-Informed Neural Networks

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Abstract

Integrating machine learning (ML) with physics-based principles enables virtual models to approximate high-fidelity system behavior while supporting real-time evaluations. However, many data-driven models operate as black boxes, providing predictions that may lack physical interpretability or fail to align with underlying system dynamics. This work develops a physics-informed framework for damage identification in a helicopter transmission shaft, facilitating informed decision-making. It employs two parallel physics-informed neural networks (PINNs): one localizes damage by learning an adjustment vector, while the other estimates severity by inferring stiffness loss and increased excitation forces. Once deployed, the framework processes vibration data for online damage assessment. A numerical case study on a rotary helicopter shaft under ballistic impacts validates its accuracy, demonstrating reliable predictions using limited vibration measurements.

Keywords: Physics informed neural network, damage identification, rotating shaft

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