Hybrid LSTM Autoencoder and BiLSTM-Based Predictive Maintenance for Bearing Failure in Electrical Motors

Al Winmon Benedict T. Montebon
University of San Carlos, Cebu City, Philippines

Kyn R. Honoridez
University of San Carlos, Cebu City, Philippines

Archival J. Sebial
University of San Carlos, Cebu City, Philippines

Abstract:

Unexpected failures of electric motors can lead to significant operational downtime and maintenance costs in industrial systems. This paper proposes a hybrid predictive maintenance framework combining a Long Short-Term Memory Autoencoder (LSTM-AE) and a Bidirectional Long Short-Term Memory (BiLSTM) network to detect anomalies and predict degradation stages in electric motor bearings. Vibration and temperature signals are processed using feature extraction and sliding window segmentation to capture temporal patterns. The LSTM-AE learns normal operational behavior through sequence reconstruction and identifies anomalies using reconstruction error. The encoded latent features are then used by a BiLSTM classifier to predict degradation stages categorized as Safe, Warning, and Danger. Experimental results demonstrate the effectiveness of the proposed approach in detecting abnormal behavior and forecasting failure progression, enabling proactive maintenance and improved equipment reliability.

Keywords:

Predictive maintenance, LSTM autoencoder, BiLSTM, anomaly detection, bearing monitoring, machine learning.