Fault Diagnosis of Electric Motors Using Signal Processing and Machine Learning

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Abstract

This project presents a machine learning-based approach for detecting and classifying faults in electric motors using raw vibration signals. The methodology combines data preprocessing, supervised learning, and evaluation metrics to achieve high diagnostic accuracy. Two models, Random Forest and XGBoost, were trained and tested on diverse operating conditions, including different fault types, noise levels, and rotational frequencies. The results show that both models can accurately identify motor faults, with Random Forest achieving 96.6% accuracy and XGBoost achieving 93.1% accuracy.

1. Introduction

Electric motors are critical components in industrial systems. Unexpected failures can cause costly downtime, equipment damage, and safety hazards. Early fault detection enables predictive maintenance, improving reliability and reducing operational costs.

This work explores the use of supervised machine learning for fault classification based on time-series vibration data. The dataset contains multiple classes, each representing a specific fault condition (e.g., bearing damage, rotor faults, imbalance) under varying noise and frequency conditions.

2. Methodology

2.1 Dataset

Two datasets were used:

- Motor_features_diverse.csv — Preprocessed features extracted from vibration signals.
- Motor_signals_diverse.csv — Raw time-series vibration signals (1000 samples per instance).

2.2 Workflow

1. Data Loading & Preprocessing

- Removal of label column for feature extraction

- Encoding of categorical fault labels into numeric form
- Normalization to ensure uniform feature scaling

2. Model Training

- Random Forest Classifier
- XGBoost Classifier

3. Evaluation

- Accuracy score
- Classification report (precision, recall, F1-score)
- Confusion matrix visualization for each model

3. Results

Random Forest:

- Accuracy: 96.6%
- Robust across most noise and frequency conditions

XGBoost:

- Accuracy: 93.1%
- Slightly lower performance on certain noisy conditions

Both models demonstrated strong classification performance, with Random Forest slightly outperforming XGBoost in overall accuracy.

4. Conclusion and Future Work

This study demonstrates that machine learning algorithms can accurately classify motor faults from raw vibration signals, even in the presence of noise. Random Forest showed superior performance, making it a promising candidate for real-time fault detection systems.

Future improvements could include:

- Expanding the dataset with more real-world motor conditions
- Testing deep learning models such as CNNs or LSTMs for automatic feature extraction
- Deploying the trained model to an embedded or edge device for real-time monitoring