

ABSTRACT

INDUSTRIAL ROTARY EQUIPMENT CONDITION MONITORING AND FAILURE DETECTION USING CLASSIFICATION MACHINE LEARNING MODELS

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Condition monitoring of industrial rotary equipment is essential to ensure reliability, safety, and operational efficiency. This research presents a machine learning-based framework to detect failure conditions in a water injection pump using sensor data and diagnostic labels. Six datasets from different pump components were used to train and evaluate three classification models: Random Forest, XGBoost, and CatBoost.

The data preparation process included label mapping, residual feature generation, and feature scaling. Model performance was evaluated under baseline conditions and after hyperparameter tuning. Bayesian optimization was used during tuning to improve classification performance, especially for minority classes associated with early failure detection. Evaluation metrics included test accuracy, cross-validation, confusion matrices, and per-class classification reports. A Streamlit-based dashboard was also developed to provide an interactive interface for visualizing model predictions and sensor anomalies.

The results show that Random Forest consistently achieved the best performance, with test accuracy ranging from 94.81% to 99.89% and cross-validation accuracy from 94.54% to 99.90%, outperforming the other models across both temperature and vibration datasets. Random Forest was particularly effective in detecting the minority classes. The interactive dashboard further supported condition monitoring by displaying sensor behavior and highlighting residual spikes associated with anomalies. Overall, this study demonstrates that machine learning classification models, especially Random Forest, can effectively model the behavior of an industrial rotary pump and offer a reliable framework for intelligent condition monitoring and failure detection in industrial systems.

Keywords: Condition Monitoring, Machine Learning, Classification, Industrial Pumps, Streamlit

INTISARI

PEMANTAUAN KONDISI DAN DETEKSI KEGAGALAN PERALATAN BEROTASI INDUSTRI MENGGUNAKAN MODEL PEMBELAJARAN MESIN KLASIFIKASI

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Pemantauan kondisi pada peralatan industri berputar sangat penting untuk memastikan keandalan, keselamatan, dan efisiensi operasional. Penelitian ini menyajikan kerangka kerja berbasis machine learning untuk mendeteksi kondisi kegagalan pada pompa injeksi air menggunakan data sensor dan label diagnostik. enam dataset dari berbagai komponen pompa digunakan untuk melatih dan mengevaluasi tiga model klasifikasi: Random Forest, XGBoost, dan CatBoost.

Proses pra-pemrosesan data mencakup encoding label, pembuatan fitur residual, dan penskalaan fitur. Performa model dievaluasi pada kondisi baseline dan setelah hyperparameter tuning. Optimisasi dilakukan menggunakan pendekatan Bayesian untuk meningkatkan performa klasifikasi, terutama dalam mendeteksi kelas minoritas yang mengindikasikan kegagalan dini. Evaluasi dilakukan menggunakan akurasi pengujian, validasi silang, matriks kebingungan, dan laporan klasifikasi per kelas. Selain itu, dashboard berbasis Streamlit dikembangkan untuk menyediakan antarmuka interaktif dalam memvisualisasikan prediksi model dan anomali sensor.

Hasil penelitian menunjukkan bahwa model Random Forest secara konsisten memberikan performa terbaik, dengan akurasi pengujian berkisar antara 94,81% hingga 99,89% dan akurasi cross-validation antara 94,54% hingga 99,90%, serta mampu mengungguli model lainnya pada dataset suhu maupun getaran. Random Forest juga paling efektif dalam mendeteksi kelas minoritas. Dashboard interaktif mendukung fungsi pemantauan kondisi dengan menampilkan perilaku sensor dan menyoroti anomali residual yang relevan. Secara keseluruhan, penelitian ini menunjukkan bahwa model klasifikasi machine learning, terutama Random Forest, dapat secara efektif memodelkan perilaku pompa industri berputar serta menyediakan dasar yang andal dan skalabel untuk condition monitoring dan deteksi kegagalan yang cerdas.

Kata Kunci: *Pemantauan Kondisi, Machine Learning, Klasifikasi, Pompa Industri, Streamlit*