PREDICTIVE MAINTENANCE FOR INDUSTRIAL MOTORS USING VIBRATION AND TEMPERATURE SENSOR DATA

📌 PROBLEM STATEMENT

Industrial motors are critical components across various sectors, including manufacturing, transportation, and energy. Unexpected motor failures lead to significant operational disruptions, incurring high maintenance costs and substantial production losses. Traditional maintenance strategies, such as time-based or reactive approaches, are often inefficient and cost-prohibitive.

This project aims to develop an advanced predictive maintenance system that leverages vibration and temperature sensor data to accurately assess motor health and proactively detect potential failures before they occur.

🎯 PROJECT OBJECTIVES

- **Data Collection and Preprocessing:** Gather and meticulously preprocess motor vibration and temperature sensor data.
- **Feature Extraction:** Perform comprehensive feature extraction, including RMS, kurtosis, skewness, and frequency domain analysis for vibration data, as well as moving average, rate of rise, and abnormal spike detection for temperature data.
- **Model Development and Comparison:** Build and rigorously compare various machine learning models, including Logistic Regression, Random Forest, and LSTM (Long Short-Term Memory) networks.
- **Motor Health Prediction:** Accurately predict the motor's health status, categorizing it as Normal, Warning, or Faulty.
- **Data Visualization:** Create intuitive dashboards (using tools like Matplotlib or Power BI) to visualize motor health trends over time.
- **Model Validation:** Validate the performance of the developed models using real-world or benchmark datasets.

🛠️ PROPOSED METHODOLOGY

Data Collection

- Utilize publicly available datasets, such as the NASA Bearing Dataset or the Case Western Reserve University Bearing Dataset.
- Alternatively, simulate data collection using vibration and temperature sensors connected to microcontrollers like Arduino or ESP32, incorporating accelerometers and thermocouples.

Data Preprocessing

- Implement techniques to remove noise and normalize sensor readings.
- Segment the processed data into distinct training and testing sets for model evaluation.

Feature Engineering

- **Vibration Data:** Extract features such as Root Mean Square (RMS), peak-to-peak amplitude, and Fast Fourier Transform (FFT) for frequency domain analysis.
- **Temperature Data:** Calculate moving averages, analyze the rate of temperature rise, and identify abnormal temperature spikes.

Model Development

- Train and evaluate classification models like Random Forest, Support Vector Machines (SVM), and XGBoost.
- Employ deep learning architectures, specifically LSTMs or Recurrent Neural Networks (RNNs), for advanced time-series prediction.

Prediction & Alerts

- Develop a system to classify the motor's state into 'Healthy,' 'Warning,' or 'Faulty' categories.
- Implement a mechanism to generate timely maintenance alerts prior to potential breakdowns.

Deployment (Optional but Valuable)

- Develop a user-friendly dashboard using frameworks like Streamlit or Flask.
- Display live motor status, including key sensor readings and health trend graphs.
- Integrate a notification system (e.g., email or SMS) to alert stakeholders about detected faults.

📊 EXPECTED OUTCOMES

- An advanced AI model capable of predicting motor failures with an accuracy exceeding 90%.
- An interactive dashboard providing clear visualization of vibration and temperature trends.
- A significantly more cost-effective and efficient maintenance strategy for industrial operations.
- A functional prototype of the predictive maintenance system, ready for potential deployment.

This project offers a robust solution for enhancing industrial motor reliability and operational efficiency. Would you like to delve deeper into any specific aspect of this methodology, such as the feature extraction techniques or the comparison of machine learning models?