PROJECT TITLE

AI- Based Predictive Maintenance System for Electrical Equipment

PROJECT CATEGORY

Energy

PROJECT OUTLINE

Electrical equipment such as motors, pumps, transformers, and generators are essential components in industries, power plants, and even educational campuses. These machines are expected to operate continuously, but their maintenance, action is taken only after failure occurs, which often leads to sudden downtime, safety risks, and expensive repairs. Scheduled maintenance, while preventive, does not consider the actual condition of the equipment and can result in unnecessary servicing or missed early faults.

For example, in a manufacturing plant, an induction motor driving a conveyor belt may gradually develop excessive vibration due to bearing wear. Since the motor appears functional during routine checks, the issue goes unnoticed until the bearing fails completely, causing unexpected shut downs, production delays, and financial losses. Similar situations occur with transformers overheating or pumps operating under abnormal load conditions.

The core engineering problem lies in the lack of continuous and intelligent monitoring system capable of detecting early warning signs of failure. Manual inspections are periodic, labour- intensive, and prone to human error as system size and complexity increases. In practical deployments, collecting reliable and labeled maintenance data is also a major challenge due to inconsistent sensor availability, unreliable manual logging, and missing fault records.

TECHNOLOGY/ TOOLS/ METHOD

The proposed solution uses a combination of sensor data, data processing techniques, and machine learning to predict equipment failures. Operational data such as temperature, vibration, current, and voltage is passively collected from existing electrical infrastructure and historical records, reducing reliance on additional sensors. This data is cleaned and processed to remove noise and handle missing values. Machine learning models are then trained to learn normal operating patterns and identify abnormal behaviour that indicates potential faults. The predicted results are presented through a simple smartphone-based dashboard that displays equipment health status and alert notifications. This approach enables condition-based maintenance using accessible and widely available technologies.

SOLUTION ABSTRACT

The proposed solution is an AI-based predictive maintenance system designed to monitor the health of electrical equipment and predict potential failures before they occur. The system focuses on commonly used machines such as motors, pumps, transformers, and generators, which play a critical role in industrial operations, power systems, and institutional faculties. Instead of relying on traditional reactive or fixed-schedule

maintenance methods, this solution uses data-driven analysis to support proactive and condition-based maintenance decisions.

The system operates by collecting equipment operating data such as temperature, vibration levels, electrical current, voltage and operating hours. This data can be obtained from sensors installed on machines or from historical and simulated datasets where real-time sensors are unavailable. To address practical deployment challenges, the system is designed to leverage passively available operational data wherever possible, reducing dependence or extensive sensor installations. The collected data is processed to remove noise, handle missing values, and standardize measurements, ensuring accurate representation of equipment condition.

Machine learning models are trained to learn normal operating patterns and detect deviations that indicate early-stage faults or abnormal behaviour. By continuously analysing trends rather than relying on fixed thresholds, the system can identify potential failure before they escalate into critical breakdowns. This enables timely maintenance planning based on actual equipment condition rather than assumptions or periodic schedules.

To improve accessibility and real-world usability, the proposed system integrates a smartphone-based maintenance dashboard. The dashboard enables remote monitoring of equipment health, displaying key indicators such as health status, failure risk levels, and alter notification. Real-time warnings and simple status messages are delivered directly to mobile devices, allowing maintenance personnel to take timely action without continuous physical supervision. The interface is designed to be intuitive, ensuring that users can interpret insights without requiring advanced technical or data expertise.

This solution addresses the identified engineering problem by reducing unexpected equipment failures, minimizing downtime, and lowering maintenance costs. Early fault detection helps prevent hazardous failure such as overheating, electrical faults, or mechanical also extends equipment lifespan by preventing excessive wear and unnecessary servicing. In addition, the system supports better resource planning by enabling maintenance teams to prioritize equipment that genuinely requires attention.

Overall, the proposed AI- based predictive maintenance system provides a practical and scalable approach to improving equipment reliability and operational efficiency. It demonstrates how data- driven intelligence and be effectively applied to real-life engineering problems, making maintenance smarter, safer, and more cost-effective. The solution is suitable for gradual adoption and can be extended to support multiple equipment and larger system in the future.

TOP 3 EXPECTED BENEFITS AND PRIMARY BENEFICIARIES

The proposed AI-based predictive maintenance system delivers significant value to end user by improving equipment reliability, operational efficiency, and maintenance decision-making.

1. Reduced Equipment Downtime and Failures

The primary benefit of the solution is the early detection of potential equipment failures. By continuously analyzing operational data and identifying abnormal patterns, the system provides advance warnings before a breakdown occurs. This enables maintenance teams to take timely preventive action, significantly reducing unplanned downtime and avoiding costly emergency repairs. As a result, critical operations can continue without sudden interruptions.

2. Optimized Maintenance Costs and Resource Utilization

Traditional maintenance strategies often lead to unnecessary servicing or delayed fault detection. The proposed solution supports condition-based maintenance costs, minimizes spare-part wastage, and improves workforce efficiency. Maintenance schedules become data-driven rather than time-based, leading to better utilization of resources. Automated data collection further reduces manual effort and lowers deployment costs in resource-constrained environments.

3. Improved Safety and Equipment Lifespan

Early fault detection helps prevent hazardous failures such as overheating, electrical short circuits, or mechanical breakdowns. This improves workplace safety and reduces risk to personnel. Additionally, timely maintenance prevents excessive wear, thereby extending the operational lifespan of electrical equipment.

Primary beneficiaries of this solution include maintenance engineers, facility managers, industrial operators, and organizations that rely on continuous and reliable operation of electrical equipment.

Time Spent and Roles

The solution was developed individually over approximately 45-50 hours. This time was spent on problem research, data understanding, model development, system design, and documentation. All roles including problem analysis, machine learning implementation, system design, testing, and report preparation were handled by a single contributor.

SCALABILITY AND FUTURE SCOPE

Yes, the proposed predictive maintenance system can be improved and scaled further. In the next stage, the system can be integrated with real-time sensors to collect live equipment data instead of replying on historical or simulated datasets. The solution can be extended to support multiple types of electrical equipment across larger facilities or industries. Cloud deployment can enable remote monitoring and scalability for multiple users. Advanced analysis such as remaining useful life prediction and automated data integration with existing maintenance management system can support large-scale industrial applications

PROTOTYPE STATUS

The project is currently at the concept and initial development stage. The system architecture, data flow, and machine learning approach have been designed and validated using sample and simulated datasets. The next step involves building a functional prototype with real-time data integration.