Machine Learning-Based Predictive Maintenance Framework for Industrial Automation Systems Using Random Forest and Real-Time Monitoring Dashboard

Swatantra Kulkarni
Independent Researcher

Abstract

Manufacturing efficiency is increasing because of deployment of Industrial automation systems such as conveyors, Automated Storage and Retrieval Systems (ASRS), shuttle systems, robotic handling equipment, and automated production lines. However, unexpected machine breakdowns continue to cause significant production losses, maintenance costs, and operational disruptions. Traditional breakdown maintenance approaches often result in unplanned downtime and reduced equipment availability. This study proposes a Machine Learning-Based Predictive Maintenance Framework for industrial automation systems using a Random Forest classification model and a real-time monitoring dashboard. A predictive maintenance dataset was generated using key machine health parameters including temperature, vibration, motor current, runtime hours, alarm count, and lubrication status. Exploratory Data Analysis (EDA), feature engineering, and model evaluation techniques were applied to identify critical factors influencing machine downtime. The Random Forest model was selected due to its robustness, interpretability, and ability to handle nonlinear relationships within industrial datasets. Experimental results showed effective failure prediction performance, enabling early identification of abnormal operating conditions before actual equipment failure occurs. To support practical implementation, a Streamlit-based dashboard integrated was designed for real-time monitoring. The proposed framework allows maintenance engineers to visualize machine health indicators, receive failure risk predictions, and take proactive maintenance actions. The framework demonstrates the potential of integrating Machine Learning with industrial automation parameters to reduce unplanned downtime, improve equipment reliability, optimize maintenance scheduling, and support Industry 4.0 initiatives. Future work will focus on real-time PLC integration, cloud deployment, and advanced deep learning techniques for enhanced predictive capabilities.

Keywords

Predictive Maintenance, Machine Learning, Random Forest, Industrial Automation, Streamlit.