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Driven Predictive Maintenance in Green Manufacturing

Team members

Dhanush kodi.K
Jovita Jasmine.D
Kanishka.K
kamalnath.R

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Abstract

- Overview of predictive maintenance and its role in green manufacturing.
- Emphasis on reducing machine downtime, energy waste, and operational inefficiencies.
- Introduction to data-driven approaches using sensor data and machine learning.
- Focuses on predictive maintenance in green manufacturing environments.
- Uses real-time sensor data and machine learning for early fault detection.
- Aims to reduce unplanned downtime and optimize resource usage.
- Supports sustainability by minimizing energy waste and emissions.
- Enhances equipment lifespan and overall operational efficiency.
- Aligns smart maintenance strategies with green manufacturing goals.

Problem Statement

- Traditional maintenance approaches are reactive, leading to unexpected equipment failures.
- Machine downtime causes production delays, energy inefficiencies, and increased costs.
- Lack of predictive insights results in over-maintenance or missed critical issues.
- Existing systems often neglect environmental impacts such as energy waste and emissions.
- There is a need for intelligent, data-driven solutions that support sustainability in manufacturing

Objective

- Develop a predictive maintenance system using machine learning and sensor data.
- Anticipate equipment failures before they occur to reduce unplanned downtime.
- Improve operational efficiency while minimizing maintenance costs.
- Integrate sustainability goals by reducing energy consumption and emissions.
- Enhance decision-making through real-time monitoring and intelligent analytics.
- Promote long-term equipment health and resource optimization in green manufacturing.
- Would you like to proceed with the Data Collection and Preparation section next?

Data Collection and Preparation

- Collected data from industrial IoT sensors (vibration, temperature, pressure, usage time).
- Gathered historical maintenance records, failure logs, and operational parameters.
- Preprocessed raw data by handling missing values, outliers, and noise.
- Performed data normalization and transformation for consistency.
- Engineered features such as time-to-failure, degradation patterns, and anomaly indicators.
- Split data into training, validation, and test sets for model development.

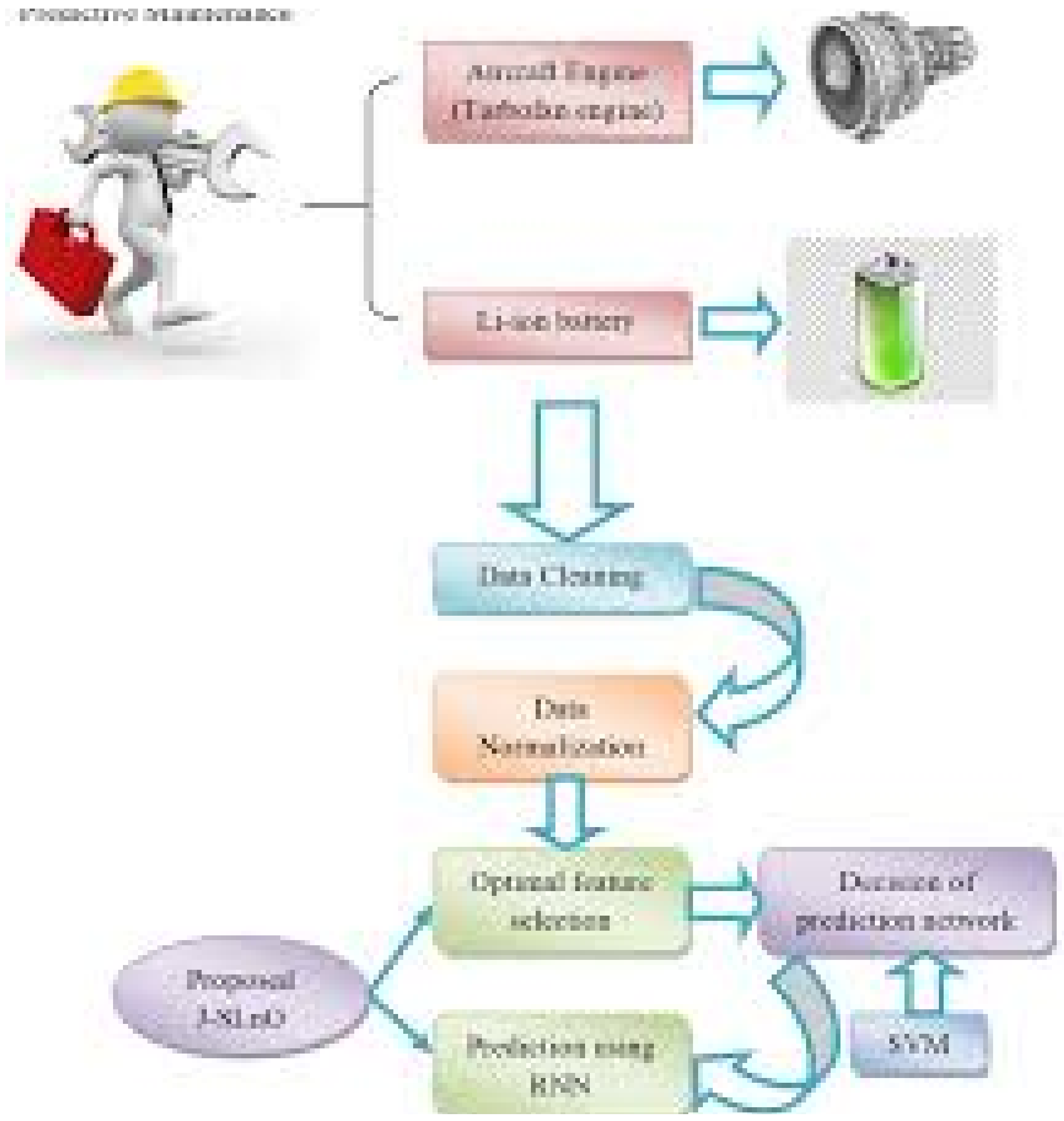
Proposed Solution (Methodology)

- Applied machine learning algorithms (e.g., Random Forest, XGBoost, LSTM) for failure prediction.
- Used anomaly detection techniques to identify early signs of equipment degradation.
- Implemented a pipeline for continuous monitoring and real-time data analysis.
- Integrated predictive models with a dashboard for maintenance alerts and visualization.
- Incorporated feedback from actual maintenance events to retrain and improve model accuracy.
- Ensured the solution supports energy efficiency and aligns with green manufacturing goals.

Model Performance Evaluation

- Evaluated models using metrics such as Accuracy, Precision, Recall, F1-Score, and AUC-ROC.
- Compared multiple algorithms to identify the best-performing model for failure prediction.
- Assessed model reliability using confusion matrix and cross-validation techniques.
- Monitored false positives and false negatives to minimize maintenance errors.
- Validated real-world applicability through historical failure event predictions.
- Measured impact on downtime reduction, maintenance cost savings, and energy efficiency.

Screenshots / Demonstration (video)



Future Scope

- Expand predictive maintenance systems to multiple factories or global manufacturing units.
- Integrate with IoT-enabled smart factories for real-time automated responses.
- Utilize edge computing for faster on-site decision-making and reduced latency.
- Incorporate carbon footprint monitoring and optimization in maintenance strategies.
- Leverage AI advancements for more accurate and adaptive predictive models.
- Collaborate with environmental monitoring systems for end-to-end sustainability tracking.
- Support predictive analytics across the entire supply chain for holistic green manufacturing.

Conclusion

- Predictive maintenance enhances equipment reliability and reduces unplanned downtime.
- Data-driven approaches improve accuracy in fault detection and maintenance planning.
- Integration with green manufacturing reduces energy waste and environmental impact.
- The system supports cost savings, operational efficiency, and sustainability goals.
- Demonstrates the potential of AI and IoT in driving intelligent, eco-friendly manufacturing.
- Sets a foundation for scalable, smart maintenance solutions in the future.