Project Report

Predictive Maintenance of Machines using IoT Sensor Data and Machine Learning

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Declaration

I, **Aditya Kumar Sah**, declare that this project titled **"Predictive Maintenance of Machines using IoT Sensor Data and Machine Learning"** is the result of my own work carried out during July 2025 to November 2025, and has not been submitted to any other university or institution for any other purpose by me or any other person.

If I am found or caught as a defaulter of the above declaration, action may be taken against me as per the rules.

Aditya Kumar Sah
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Certificate of the Guide

This is to certify that **Aditya Kumar Sah** (Enrollment No.: 5116449724), student of **3rd Semester, CSE-AI**, has completed his Minor Project entitled

"Predictive Maintenance of Machines using IoT Sensor Data and Machine Learning."

He has submitted his Project Report under my guidance and supervision during the academic session 2025–26 in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology (CSE-AI)**.

(Signature of Guide)

Ms. Pooja Tyagi
Supervisor

Abstract

Objective: This project generates synthetic IoT sensor data (temperature, humidity, electricity fluctuations) for machines and builds predictive models to detect potential failures. The goal is to compute a machine Health Score and predict failure risks using Linear Regression and Random Forest models.
Methodology: Data is generated artificially, preprocessed, and features such as lagged sensor values and threshold-based health scores are computed. Linear Regression and Random Forest models are trained, and evaluation metrics MAE and RMSE are used.
Expected Outcomes: A validated predictive model with health score computation to alert on potential failures, including visualization of sensor trends and model predictions.

Overview

This project focuses on predictive maintenance using IoT sensor data. By monitoring temperature, humidity, and electricity fluctuations, machines' health scores are computed, and potential failures are predicted using machine learning models.

1. Introduction and Background

Industrial machines experience wear and risk of failure due to environmental stress (temperature, humidity) and operational stress (electricity fluctuations). Predictive maintenance aims to foresee failures before they occur, reducing downtime and costs.

1.1. IoT Sensor Monitoring

Sensors provide real-time temperature, humidity, and electrical data, enabling computation of a machine's health score and triggering alerts when thresholds are breached.

2. Literature Review

- Susto et al., 2015: Multiple classifier approaches for predictive maintenance.
- Lee et al., 2014: Industrial IoT and predictive maintenance strategies.
- Studies show ML models (Random Forest, regression) outperform manual thresholding.

3. Problem Statement and Objectives

Problem: Machines may fail unexpectedly due to cumulative environmental and operational stress. Traditional inspection is reactive and inefficient.

Objectives:

1. Generate artificial IoT sensor data for machines.
2. Compute Health Score based on sensor thresholds.
3. Train Linear Regression and Random Forest models to predict failures.
4. Evaluate model performance using MAE and RMSE.
5. Provide visualizations and failure alert mechanisms.

4. Methodology

4.1. Data Generation and Preprocessing

- Artificial dataset with 1000 records for temperature, humidity, electricity fluctuation.
- Missing values handled by forward-fill.
- Lag features created for temporal dependence.

4.2. Health Score Computation

The **Health Score** of a machine is calculated as:

$$HealthScore = 100 - \Big(w_T \cdot \max(0, T - T_{threshold}) + w_H \cdot \max(0, H - H_{threshold}) + w_E \cdot \max(0, E - E_{threshold})\Big) \tag{1}$$

Where:

- T, H, E = current temperature, humidity, and electricity fluctuation values
- $T_{threshold}$, $H_{threshold}$, $E_{threshold}$ = thresholds beyond which stress increases
- w_T, w_H, w_E = weights assigned to each factor
- Health Score ranges from 0 to 100; lower scores indicate higher risk of failure.

Machines are flagged for potential failure if Health Score falls below a critical value (e.g., 70).

4.3. Models

Linear Regression: Baseline, interpretable model for predicting health score.

Random Forest Regression: Ensemble tree-based model handling non-linear dependencies between sensor values and machine health.

4.4. Evaluation Metrics

- MAE (Mean Absolute Error)
- RMSE (Root Mean Squared Error)

5. Implementation and Workflow

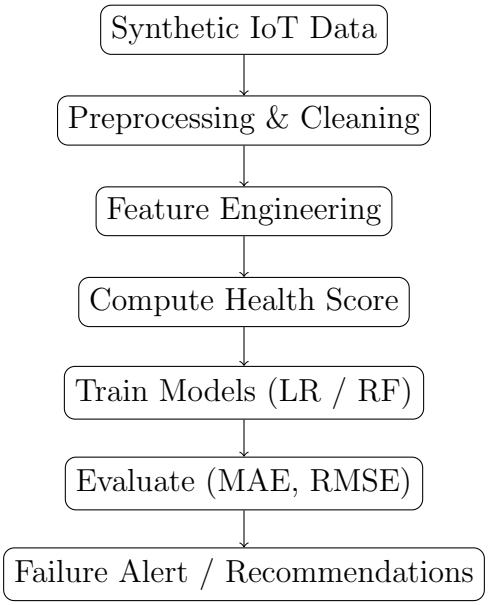

Figure 1: Workflow for predictive maintenance using IoT data.

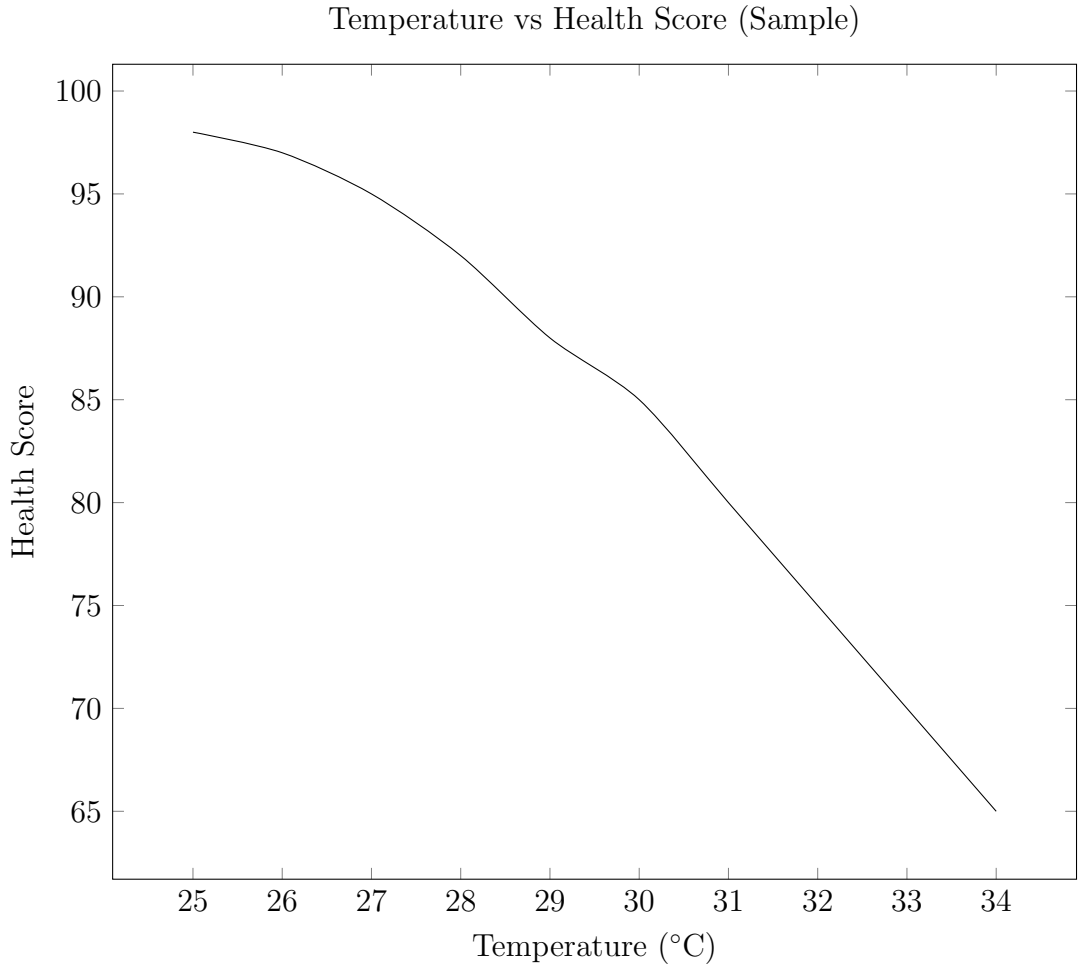

Figure 2: Sample Temperature vs Health Score relationship.

6. Results and Discussion

6.1. Sample Plots

6.2. Model Performance

Table 1: Representative model performance metrics.

Model	MAE	RMSE
Linear Regression	4.5	5.8
Random Forest	2.7	3.6

Random Forest outperforms Linear Regression, capturing non-linear sensor interactions better.

7. Conclusion and Future Work

The report demonstrates predictive maintenance using synthetic IoT data. Health Score computation allows proactive failure detection. Random Forest regression gives the best predictive performance. Future work includes real-time sensor integration, anomaly detection, and advanced models (XGBoost, LSTM).

References

1. Susto, G.A., et al. "Machine learning for predictive maintenance: A multiple classifier approach." IEEE Transactions on Industrial Informatics, 2015.

2. Lee, J., et al. "Industrial IoT and predictive maintenance." Journal of Manufacturing Systems, 2014.

3. Kaggle – Artificial IoT sensor datasets (temperature, humidity, electricity). `https://www.kaggle.com/datasets/yug201/artificial-iot-sensor-data`