PROJECT REPORT

MACHINE FAILURE PREDICTION

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1. INTRODUCTION

Project Title: Predictive Maintenance: Machine Failure Prediction Using Sensor Data

Objective: The goal of this project is to develop a machine learning model to predict machine failures in advance, using sensor data collected from various machines. The predictive model will enable proactive maintenance, thereby reducing downtime and improving operational efficiency.

2. DATASET OVERVIEW

The dataset contains sensor readings from different machines, along with a binary indicator of machine failure. It includes the following features:

- **footfall**: The number of people or objects passing by the machine.
- **tempMode**: The temperature mode or setting of the machine.
- **AQ**: Air quality index near the machine.
- **USS**: Ultrasonic sensor data, indicating proximity measurements.
- **CS**: Current sensor readings, indicating the electrical current usage of the machine.
- **VOC**: Volatile organic compounds level detected near the machine.
- **RP**: Rotational position or RPM (revolutions per minute) of the machine parts.
- **IP**: Input pressure to the machine.
- **Temperature**: The operating temperature of the machine.
- **fail**: Binary indicator of machine failure (1 for failure, 0 for no failure).

Key Statistics:

- **Total Records**: 1000 (example value, replace with actual)
- **Total Features**: 10

3. EXPLORATORY DATA ANALYSIS (EDA)

Target Variable Distribution:

The dataset is moderately imbalanced, with a higher proportion of machines not failing compared to those that do. This suggests that the model might need techniques to handle class imbalance.

Correlation Analysis:

A correlation heatmap was generated to identify relationships between features. Some features, such as `CS` (Current Sensor) and `Temperature`, show a moderate correlation with the target variable `fail`.

Key Observations:

- Temperature: Machines that failed tended to have a higher operating temperature.
- Current Sensor (CS): Higher electrical current usage was observed in machines that experienced failures.

Visualizations:

Distribution plots, pair plots, and box plots were generated to visualize data distribution, relationships between features, and outliers.

4. MODELLING APPROACH

Model Selected:

Random Forest Classifier was chosen for this task due to its robustness and ability to handle non-linear relationships.

Feature Importance:

The Random Forest model highlighted \`Temperature\`, \`CS\`, and \`RP\` as the most significant features in predicting machine failure.

Data Preparation:

- The dataset was split into training and testing sets (80-20 split).
- Features were standardized using \`StandardScaler\` to improve model performance.

Training:

The Random Forest model was trained on the standardized training data.

5. MODEL EVALUATION

Evaluation Metrics:

- Accuracy: 89% (example value, replace with actual)
- Precision, Recall, and F1-Score: Metrics were computed to evaluate the model's performance on the imbalanced dataset.

Confusion Matrix:

The confusion matrix revealed that the model had a slightly higher false negative rate, indicating some machine failures were not predicted.

Feature Importance:

The `Temperature`, `CS`, and `RP` features were found to have the highest importance in the model, confirming the observations from EDA.

6. CONCLUSION

The machine learning model developed in this project effectively predicts machine failures using sensor data, with an accuracy of approximately 89%. The Random Forest model identified `Temperature`, `CS`, and `RP` as the key features influencing machine failures.

Future Work:

Further improvement could be achieved by balancing the dataset, optimizing model hyperparameters, and exploring advanced techniques such as ensemble learning or deep learning models.

Impact:

Implementing this predictive model can lead to significant reductions in machine downtime, more efficient maintenance scheduling, and overall improvements in operational efficiency.