Case Study: Predictive Maintenance for Aircraft Engines

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Background

Aircraft engine maintenance is a critical aspect of aviation operations, playing a vital role in ensuring the safety, reliability, and efficiency of air travel. The maintenance of aircraft engines is a complex and highly regulated process that involves various preventive and corrective measures to keep engines in optimal working condition.

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Case Study

The goal of this project is to develop a predictive model using the following roadmaps.

- Build and optimize different supervised learning models to predict aircraft engine maintenance needs.
- Perform feature engineering to enhance the dataset and improve model performance.
- Generate actionable insights by deriving feature importance for proactive maintenance strategies.

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Dataset

- ➔ The aircraft dataset contains historical data from various aircraft engines.
- ➔ Each row in the dataset represents a specific engine at a given point in time.

Data Dictionary:

1. **Timestamp:** Date and time of data recording. (*Type:* DateTime)
2. **Pressure:** Pressure level of the aircraft engine. (*Type:* Numeric)
3. **Temperature:** Temperature of the aircraft engine. (*Type:* Numeric)
4. **Rotational Speed:** Rotational speed of the engine. (*Type:* Numeric)
5. **Vibration Level:** Level of vibration in the engine. (*Type:* Numeric)
6. **Oil Temperature:** Temperature of the engine oil. (*Type:* Numeric)
7. **Fuel Consumption:** Amount of fuel consumed by the engine. (*Type:* Numeric)
8. **Altitude:** Altitude of the aircraft. (*Type:* Numeric)
9. **Humidity:** Humidity level in the aircraft environment. (*Type:* Numeric)
10. **Engine_Health:** A measure of the overall health of the aircraft engine, ranging from 0 to 1 (Type: Float)
11. **Maintenance Needed :** Binary indicator of engine health [0: Healthy, 1: Maintenance Needed). (*Type:* Binary (0 or 1))
12. **Engine Failure:** Binary indicator of engine failure [0: Engine is OK, 1: Engine Failed). (*Type:* Binary (0 or 1))

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Task

1. **Data Cleaning:**
   - Handle missing values and outliers in the generated data.
2. **Univariate Analysis:**
   - Analyze individual features like 'Engine Health' and 'Pressure.'
3. **Bivariate Analysis:**
   - Explore relationships between pairs of features.
4. **Multivariate Analysis:**
   - Examine interactions among multiple features.
5. **Feature Engineering & Data Visualization:**
   - Create new features, e.g., time-related features, interaction features. And use visualizations for insights.

Model Building and Optimization:

a. **Split Data:** Divide the dataset into training and testing sets.
b. **Standardize Features:** Ensure standardized features for consistent model training.
c. **Model Selection:** Explore Logistic Regression, Decision Tree, Random Forest, and SVM.
d. **Hyperparameter Optimization:**
   - Fine-tune models using Grid Search.
   - Optimize hyperparameters for Random Forest.

Model Evaluation and Interpretation

a. **Evaluate Models:** Assess accuracy, precision, recall, and F1 score.
b. **Feature Importance:** Analyze which features contribute most to predictions.
c. **Insights and Recommendations:** Derive insights for predictive maintenance strategies.