CAPSTONE PROJECT

PREDICTIVE MAINTENANCE MODEL FOR MACHINE FAILURE PREDICTION

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
- Conclusion
- Future Scope
- References

PROBLEM STATEMENT

•**Challenge**: Machines in industrial settings are prone to various typesof failures, leading to costly downtime and maintenance.

•**Objective**: Predict the type of machine failure (e.g., No Failure, Overstrain Failure) based on sensor data to enable proactive maintenance and ensure operational efficiency.

•**Key Issue**: Accurate prediction of failure types using sensor data (e.g., air temperature, process temperature, rotational speed, torque, tool wear) is critical to minimize downtime and optimize resource allocation.

PROPOSED SOLUTION

- The proposed system uses machine learning to predict machine failure types, ensuring timely maintenance. Key components include:
- **Data Collection**:
  - Gather sensor data (air/process temperature, rotational speed, torque, tool wear) from IBM Cloud Object Storage (predictive_maintenance.csv).
  - Include machine type and failure type labels.
- **Data Preprocessing**:
  - Encode categorical variables (Type, Failure Type) using LabelEncoder.
  - Scale numerical features using StandardScaler.
  - Handle class imbalance using SMOTE (Synthetic Minority Oversampling Technique)

PROPOSED SOLUTION

- **Machine Learning Algorithm**:
  - Train a Decision Tree Classifier to predict failure types based on processed sensor data.
- **Deployment**:
  - Deploy the model using IBM Watson Machine Learning for scalable, real-time predictions.
  - Provide a user-friendly prediction function for new data points.
- **Evaluation**:
  - Assess model performance using accuracy, classification report, and confusion matrix.

SYSTEM APPROACH

- **System Requirements**:
  - Python 3.11 (runtime-24.1) environment.
  - IBM Cloud Object Storage for dataset access.
  - IBM Watson Machine Learning for model deployment.
- **Libraries Required**:
  - Python
  - Scikit-learn==1.4.2
  - Pandas==2.1.4
  - Numpy==1.26.4
  - Matplotlib==3.8.4
  - Seaborn==0.13.2
  - Imbalanced-learn==0.12.3
  - Ibm-watson-machine-learning==1.0.360

ALGORITHM & DEPLOYMENT

- **Algorithm Selection**:
  - **Decision Tree Classifier**: Chosen for its interpretability and ability to handle both numerical and categorical data.
  - Suitable for multi-class classification of failure types.
- **Data Input**:
  - Features: Type, Air temperature [K], Process temperature [K], Rotational speed [rpm], Torque [Nm], Tool wear [min].
  - Target: Failure Type (e.g., No Failure, Overstrain Failure).
- **Training Process**:
  - Split data into training (80%) and testing (20%) sets.
  - Apply SMOTE to balance classes.
  - Train the Decision Tree Classifier with cross-validation for robustness.

ALGORITHM & DEPLOYMENT

- **Prediction Process**:
  - Scale and encode new data points using trained StandardScaler and LabelEncoder.
  - Use the trained model to predict failure types.
- **Deployment**:
  - Model stored in IBM Watson Machine Learning with ID: df9879f4-294a-4789-b82d-0a5455cd7aa6.
  - Prediction function (predict_failure) implemented for real-time use.

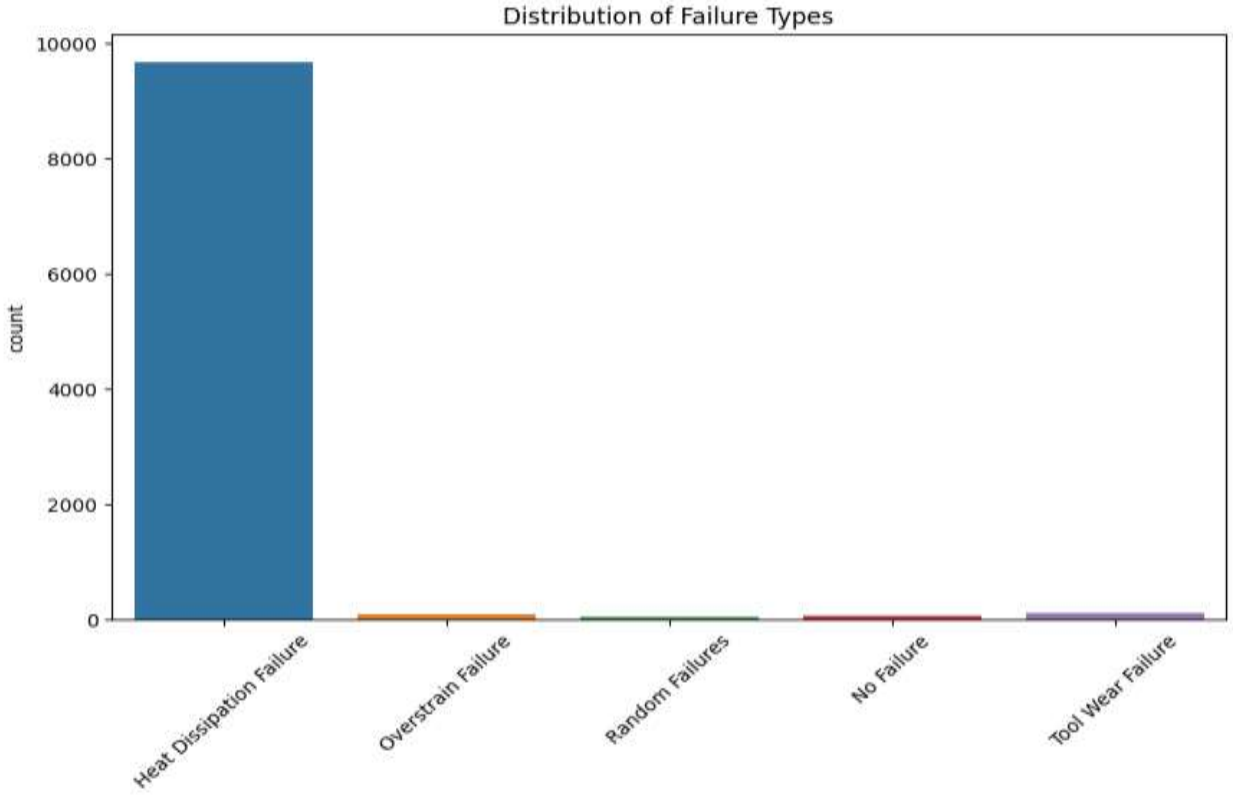
RESULT

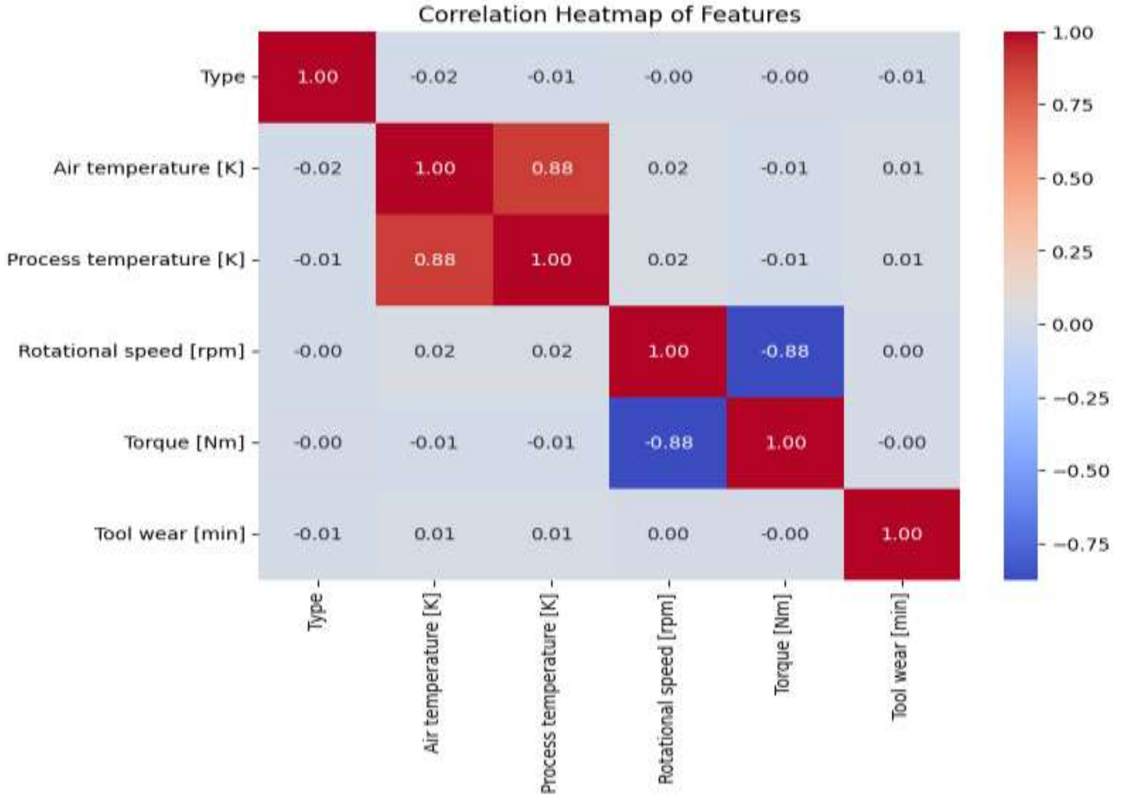
- **Model Performance**:
  - **Accuracy**: 0.93 (93% correct predictions on the test set).
- **Evaluation Metrics**:
  - Classification report includes precision, recall, and F1-score for each failure type.
  - Confusion matrix saved as an image for detailed analysis.

https://github.com/mdubaid04/Predictive_Maintenanceuisng_ML.git

Predictive Maintenance Github LInk

RESULT

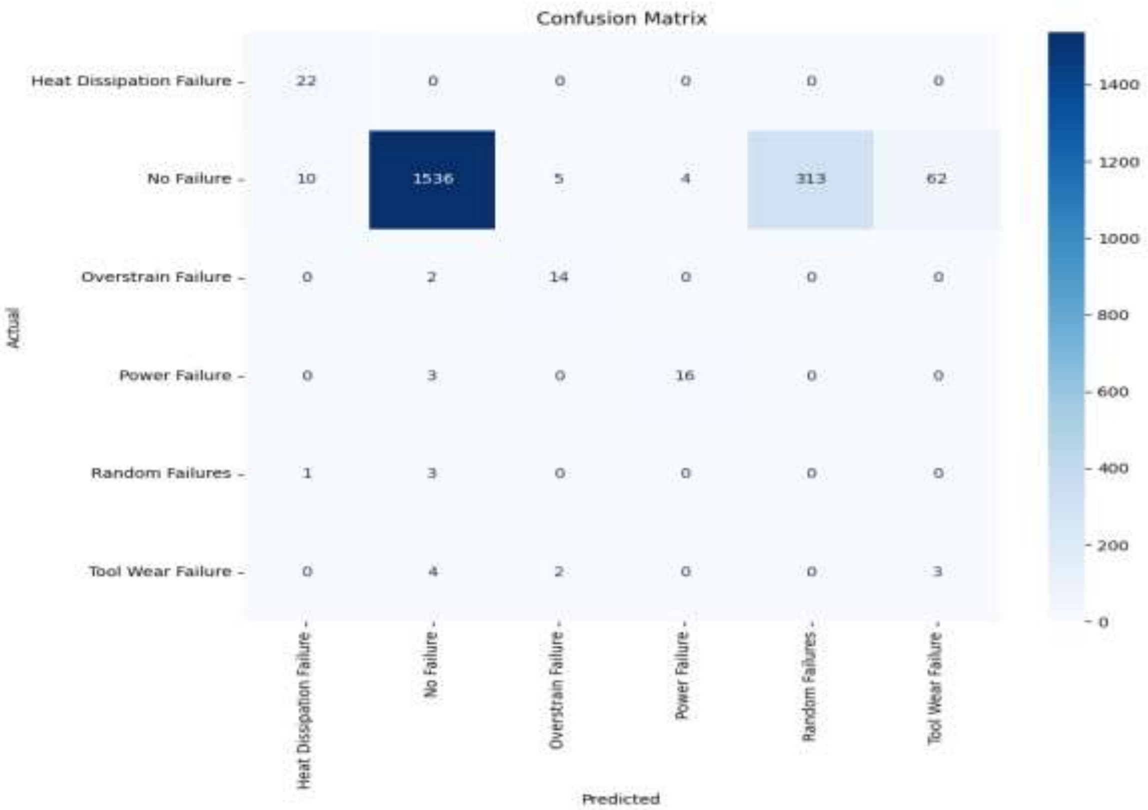




Distribution of Failure Types

Correlation Heatmap of Features

RESULT




```python
sample_data = {
    'Type': 'L',
    'Air temperature [K]': 298.9,
    'Process temperature [K]': 309.1,
    'Rotational speed [rpm]': 2861,
    'Torque [Nm]': 4.6,
    'Tool wear [min]': 143
}
Predicted Failure Type: Overstrain Failure
```

Confussion Matrix

Predicted Result

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CONCLUSION

- **Summary**:
  - The Decision Tree Classifier effectively predicts machine failure types with 93% accuracy.
  - SMOTE successfully addressed class imbalance, improving model robustness.
  - Deployment on IBM Watson Machine Learning enables scalable, real-time predictions.
- **Challenges**:
  - Ensuring compatibility with Python 3.11 and specific library versions.
  - Handling imbalanced classes required careful preprocessing.
- **Impact**:
  - Enables proactive maintenance, reducing downtime and costs in industrial settings.

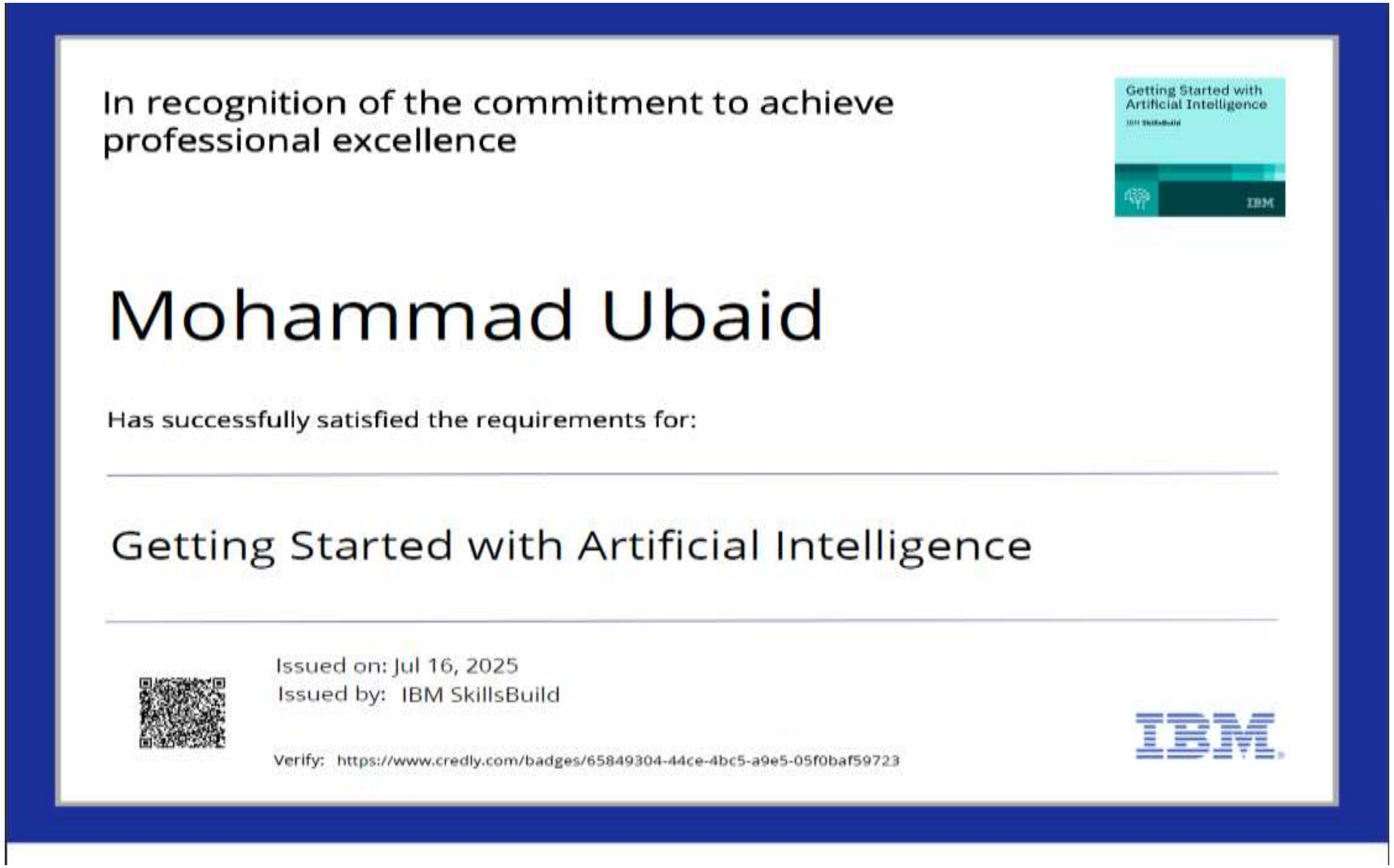
FUTURE SCOPE

- **Enhancements**:
  - Incorporate additional sensor data (e.g., vibration, noise levels) for improved predictions.
  - Explore advanced algorithms (e.g., Random Forest, XGBoost) for higher accuracy.
  - Implement real-time data streaming for dynamic predictions.
- **Scalability**:
  - Extend the model to multiple machine types or industrial facilities.
  - Integrate with IoT devices for automated monitoring.
- **Emerging Technologies**:
  - Use edge computing for faster on-device predictions.
  - Explore deep learning models (e.g., LSTM) for time-series-based failure prediction

REFERENCES

- Scikit-learn Documentation: https://scikit-learn.org/stable/
- Imbalanced-learn Documentation: https://imbalanced-learn.org/stable/
- IBM Watson Machine Learning Documentation: https://cloud.ibm.com/docs/watson-machine-learning
- Dataset Source: IBM Cloud Object Storage (predictive_maintenance.csv)
- Research Papers:
- "Predictive Maintenance Using Machine Learning: A Review" (Journal of Industrial Systems, 2023).
- "Decision Trees for Classification: A Machine Learning Approach" (IEEE Transactions, 2022).
- Chatgpt

IBM CERTIFICATIONS



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THANK YOU