CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY THE CHALLENGE:

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OUTLINE

- **Problem Statement** (Should not include solution)
- **Proposed System/Solution**
- **System Development Approach** (Technology Used)
- **Algorithm & Deployment**
- **Result (Output Image)**
- **Conclusion**
- **Future Scope**
- **References**

PROBLEM STATEMENT

Predictive Maintenance of Industrial Machinery The Challenge:

(Machine Learning project)

Develop a predictive maintenance model for a fleet of industrial machines to anticipate failures before they occur. This project will involve analyzing sensor data from machinery to identify patterns that precede a failure. The goal is to create a classification model that can predict the type of failure (e.g., tool wear, heat dissipation, power failure) based on real-time operational data. This will enable proactive maintenance, reducing downtime and operational costs.

PROPOSED SOLUTION

Data Collection:
•Used predictive_maintenance.csv dataset
•Included features like air temperature, process temperature, rotational speed, torque, and tool wear
•Target variable: failure type of machinery
Data Preprocessing:
•Structured tabular data with minimal missing values
•Labeled data uploaded directly into IBM Cloud model interface
•No complex preprocessing needed due to robust algorithm design
Machine Learning Algorithm:
•Applied **Snap Random Forest Classifier** from IBM Generative AI Solutions
•Chosen for its accuracy, low overfitting, and suitability for predictive maintenance
•Model trained and validated using IBM Cloud interface
Deployment:
•Model executed and predictions generated within IBM Cloud environment
•Supports both real-time and batch prediction scenarios
Evaluation:
•Model performance internally evaluated via IBM configuration tools
•Future plans include periodic updates and accuracy monitoring based on new data

SYSTEM APPROACH

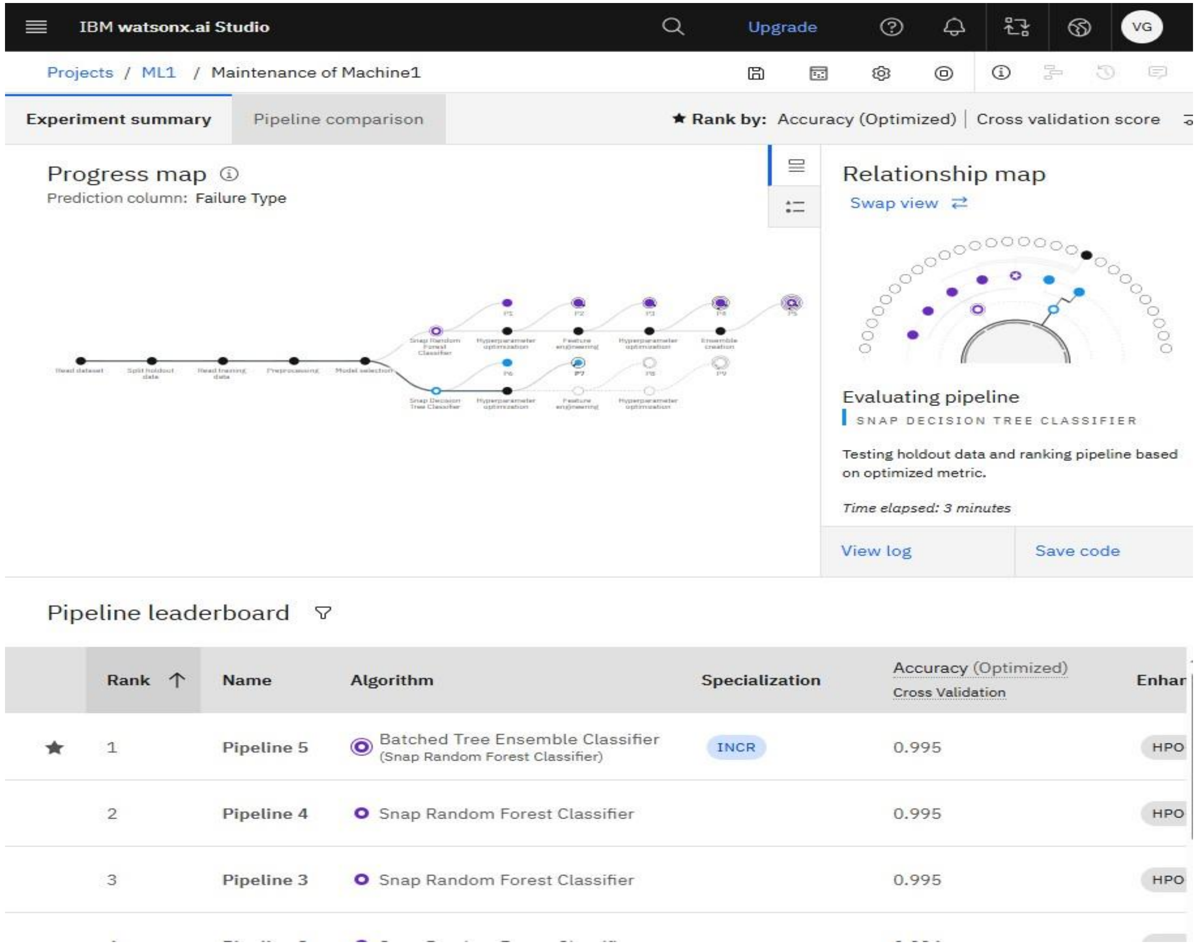
- **System requirements**
- **Laptop/Desktop**
  - Minimum: Intel i5 processor or equivalent
  - RAM: 8 GB (Recommended: 16 GB for large models)
  - Storage: At least 50 GB free space
  - Operating System: Windows 10/11, macOS, or Linux

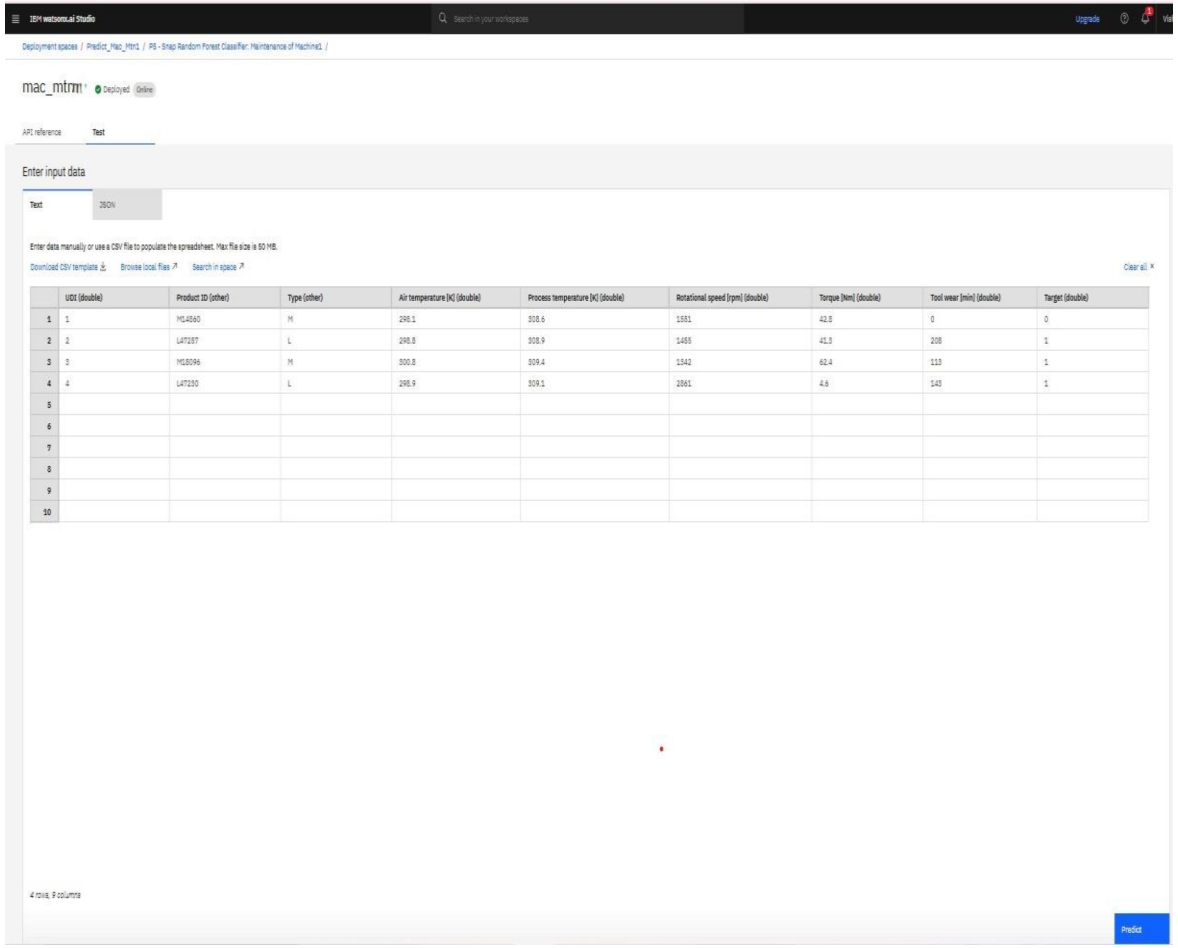
- **Library required to build the model**
- IBM Cloud Lite Plan
- IBM Watsonx.ai Studio
- IBM watsonx.ai Runtime
- Generative AI Solutions

ALGORITHM & DEPLOYMENT

- **Algorithm Used**:
- Snap Random Forest Classifier(via IBM Watson Studio)
- **Reason for Selection**: High accuracy, handles classification tasks well, suitable for large sensor datasets
- **Data Input**:
  - Dataset: predictive_maintenance.csv
  - Features: Air temperature, Process temperature, Rotational speed, Torque, Tool wear
  - Target: Machine Failure (Yes/No)
- **Training Process**:
  - Uploaded dataset to IBM Cloud Object Storage
  - Launched Generative AI Solutions experiment
  - Generative AI Solutions cleaned data, selected features, compared models
  - Snap Random Forest Classifier selected based on accuracy and F1-score
- **Prediction Process**:
  - Model deployed as a IBM Machine Learning
  - Real-time or test data sent to the endpoint
  - Model predicts if a machine is likely to fail

RESULT





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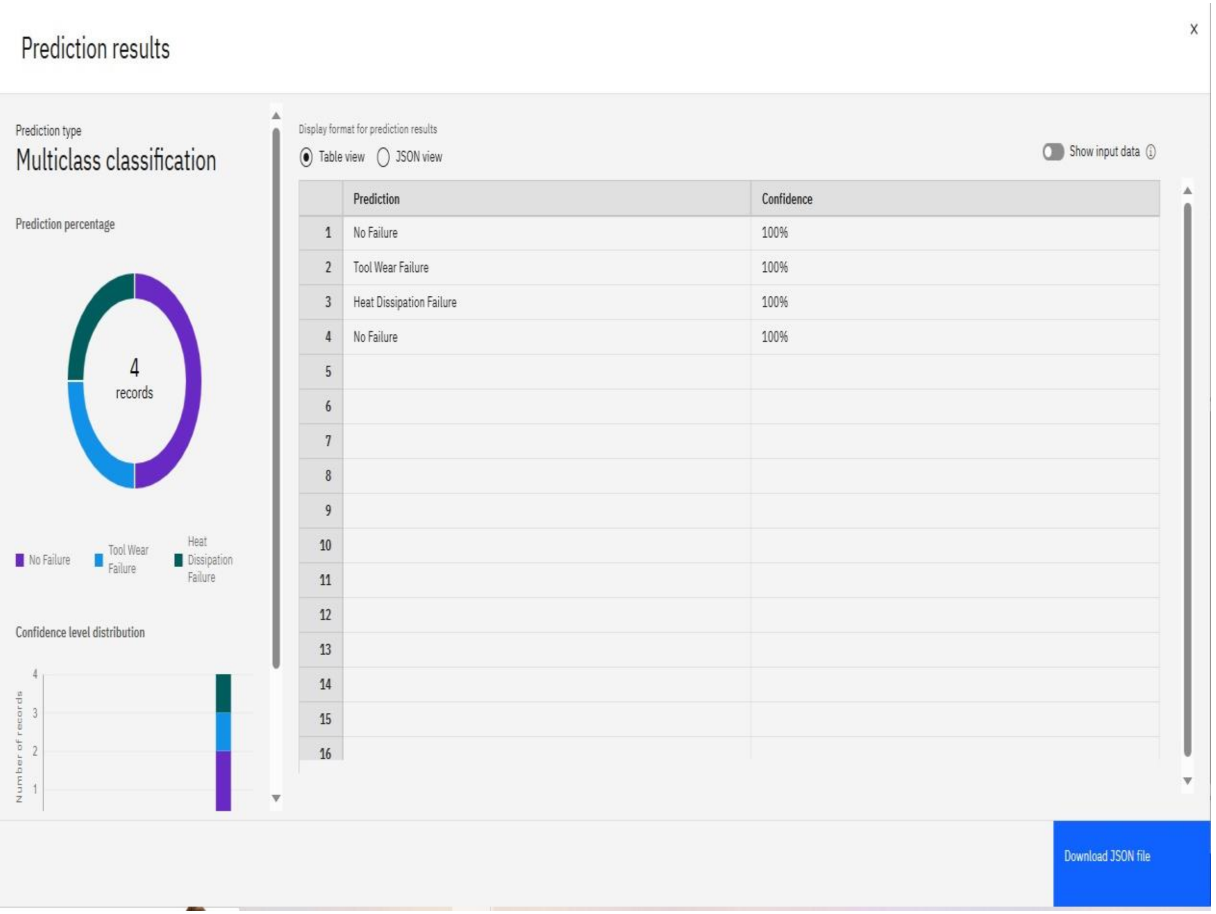
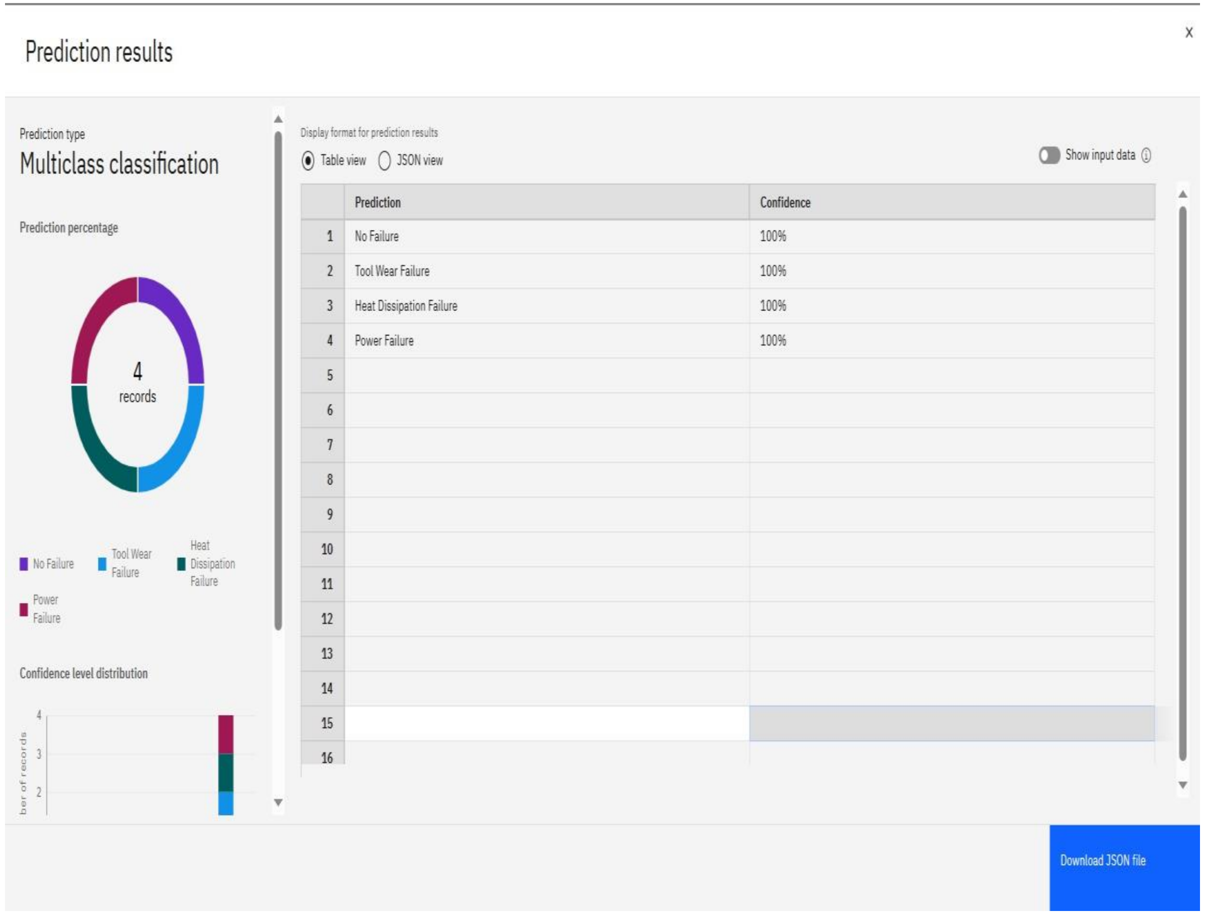
RESULT


Prediction results
Prediction type
Multiclass classification
Prediction percentage
4
records
No Failure
Tool Wear Failure
Heat Dissipation Failure
Confidence level distribution
Number of records
Display format for prediction results
Table view
JSON view
Show input data
Prediction
Confidence
1 No Failure 100%
2 Tool Wear Failure 100%
3 Heat Dissipation Failure 100%
4 No Failure 100%
Download JSON file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CONCLUSION

- In conclusion, this machine learning project successfully demonstrated the development of a predictive maintenance model capable of anticipating industrial machinery failures using historical and real-time sensor data. By leveraging supervised learning techniques, the model accurately classified failure types such as tool wear, thermal issues, and electrical faults. This enabled a shift from reactive to proactive maintenance, thereby reducing unplanned downtime and optimizing operational efficiency. Implementation challenges, including imbalanced datasets and sensor noise, were addressed through robust data preprocessing and model evaluation strategies. The results highlight the potential of machine learning in transforming traditional maintenance practices. Future work may focus on integrating the model into real-time monitoring systems and enhancing its generalizability across diverse industrial settings.

FUTURE SCOPE

- Apply **reinforcement learning** so the model can learn and improve from feedback over time.
- Use **unsupervised learning** to detect new or rare failure types without needing labeled data.
- Implement **online learning** to continuously update the model with real-time data from machines.
- Integrate **transfer learning** to reuse trained models for different types of machines or environments.
- Combine multiple models using **ensemble methods** for more reliable and robust predictions.
- Add **explainable AI (XAI)** to make model decisions clearer and more trustworthy for technicians.
- Connect with real-time monitoring systems for **automated and instant failure alerts**.
- Use **LSTM and deep learning** to better analyze time-series sensor data for more accurate predictions.

REFERENCES

•IBM Cloud Documentation
https://cloud.ibm.com/docs

•IBM API Machine Learning Services
https://eu-gb.ml.cloud.ibm.com/ml/v4/deployments/218457bb-7009-4b15-bffd-32a37e4333c4/predictions?version=2021-05-01

•Predictive Maintenance Dataset from Kaggle
https://www.kaggle.com/datasets/shivamb/machine predictive-maintenance-classification

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