
CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY THE CHALLENGE

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OUTLINE

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

PROBLEM STATEMENT

- 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.
- **Objective:** Develop a predictive maintenance model to anticipate machine failures.
- **Challenge:** Use sensor data to identify patterns that precede failures.
- Target : Failure or Not
- Failure Type : Type of Failure
- **Impact:** Reduce downtime and operational costs through proactive maintenance.

PROPOSED SOLUTION

- **1. Data Collection**:- Gather synthetic sensor data from industrial machines, including: Air temperature, process temperature, rotational speed, torque, tool wear, Product quality indicators (L/M/H), Machine failure labels and failure types, Integrate real-time operational data streams for future scalability.
- **2. Data Preprocessing**:- Clean and preprocess the dataset:- Handle missing values, outliers, and normalize sensor readings. Ensure no data leakage by excluding target labels from feature set, Perform feature engineering.
- **3. Machine Learning Algorithm**:-
 - - Binary classification: Failure vs. No Failure
 - - Multi-class classification: Type of failure (tool wear, heat dissipation, etc.)
 - - Algorithms considered:
 - - Random Forest, Logistic Regression
 - - Neural Networks for deeper pattern recognition
 - - Incorporate domain-specific features like product quality and operational stress indicators
- **4. Deployment (IBM Cloud Lite Services)**:- Use IBM Watson Studio for model development and training. Store data using IBM Cloud Object Storage. Deploy model as an API or web app using IBM Code Engine. Ensure scalability, low latency, and secure access for industrial stakeholders
- **5. Evaluation**:- Accuracy, Precision, Recall, F1 Score. Confusion matrix for classification clarity. Perform cross-validation and hyperparameter tuning. Continuously monitor prediction accuracy and retrain with updated data
- **6. Result**:- Achieve reliable prediction of machine failures and their types. Enable proactive maintenance scheduling, reducing unexpected breakdowns. Improve operational efficiency and cost savings for industrial operations. Demonstrate successful integration of ML with IBM Cloud Lite services.

SYSTEM APPROACH

The System Approach selection outlines strategy and methodology for developing and implementing the “Predictive Maintenance of Industrial Machinery The Challenge”. Here is suggested structure for this section.

System requirements:-

- Use IBM Watson Studio for model development and training.
- Store data using IBM Cloud Object Storage.
- IBM cloud object storage for dataset handling.
- Deploy model as an API or web app using IBM Code Engine.
- Ensure scalability, low latency, and secure access for industrial stakeholders.

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
 - Random Forest Classifier, Logistic Regression.
 - tool wear, heat dissipation, power failure.
 - Failure vs. No Failure and Overstrain Failure
- **Data Input:**
 - UID: unique identifier ranging from 1 to 10000
 - Product ID: consisting of a letter L, M, or H for low (50% of all products), medium (30%), and high (20%) as product quality variants and a variant-specific serial number
 - air temperature [K]: generated using a random walk process later normalized to a standard deviation of 2 K around 300 K
 - process temperature [K]: generated using a random walk process normalized to a standard deviation of 1 K, added to the air temperature plus 10 K.
 - rotational speed [rpm]: calculated from power of 2860 W, overlaid with a normally distributed noise
 - tool wear [min]: The quality variants H/M/L add 5/3/2 minutes of tool wear to the used tool in the process. and a
- **Training Process:**
 - 'machine failure' label that indicates, whether the machine has failed in this particular data point for any of the following failure modes are true.
- **Prediction Process:**
 - Algorithm makes predictions for Continuous input from live sensors (temperature, vibration, pressure)
 - Streaming data processed via edge computing or cloud platforms.

Result

The screenshot displays the IBM Watson AI Studio interface. The browser address bar shows the URL: `eu-gb.dataplatform.cloud.ibm.com/ml-runtime/models/88fc104f-c957-4bd3-b090-0f41546ed15c?project_id=2a2d34fa-4cb6-4e1d-b01d-c64fbbb4bbca&context=cpdaas`. The page title is "P8 - Snap Decision Tree Classifier: Predictive_Maintenance".

The main content area is titled "Input (1)" and contains a table with the following data:

Column	Type
UDI	double
Air temperature [K]	double
Process temperature [K]	double
Rotational speed [rpm]	double
Torque [Nm]	double
Tool wear [min]	double
Target	double
Product ID	other

On the right side, the "About this asset" panel is open, showing the following details:

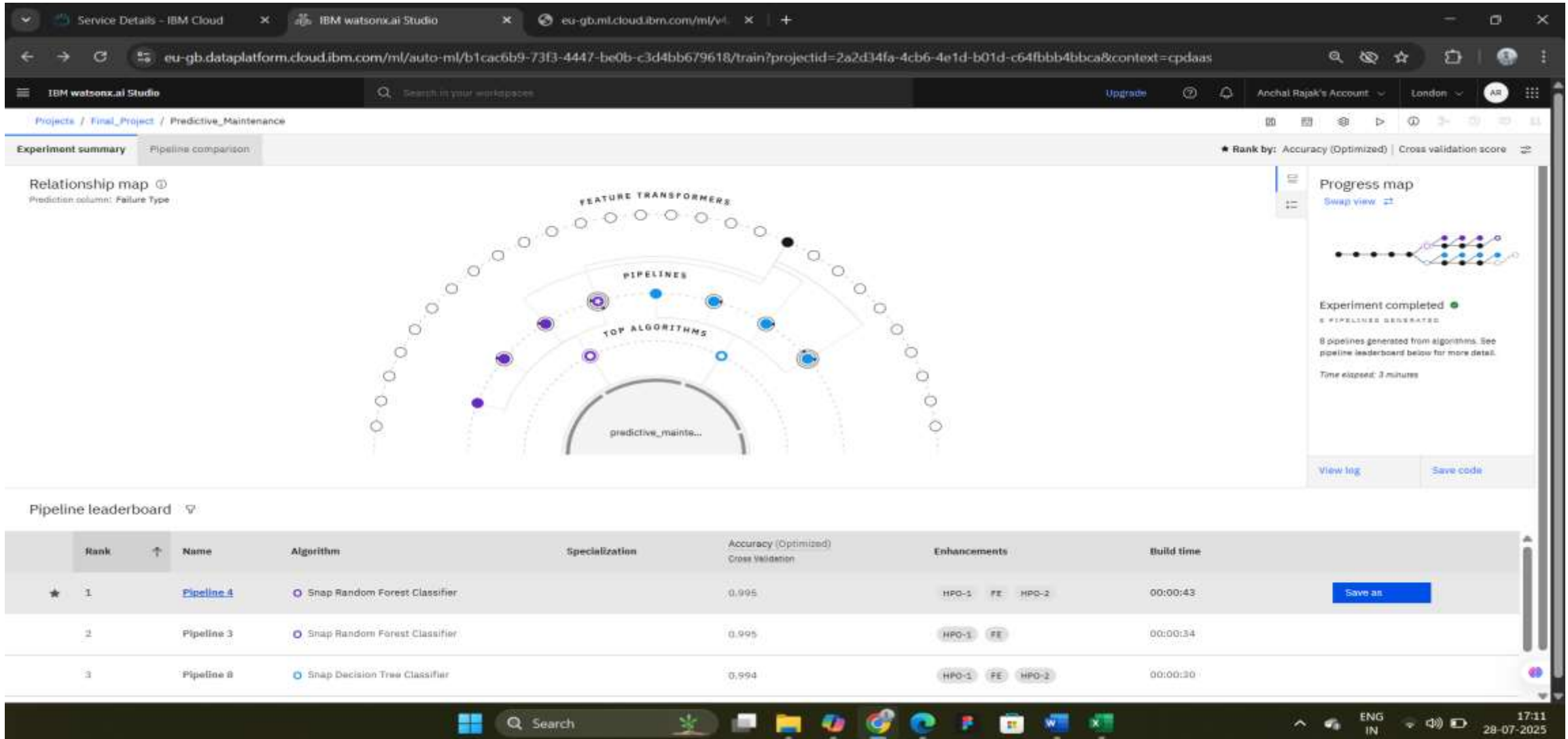
- Name:** P8 - Snap Decision Tree Classifier: Predictive_Maintenance
- Description:** No description provided.
- Asset Details:**
 - Type: wml-hybrid_0.1
 - Model ID: 88fc104f-c957-4b...
 - Software specification: [hybrid_0.1](#)
 - Hybrid pipeline software specifications: [autoai-kb_rt24.1-py3.11](#)
- Tags:** Add tags to make assets easier to find.
- Last modified:** 29 seconds ago by Anchal Rajak
- Created on:** Jul 28, 2025 by Anchal Rajak

The Windows taskbar at the bottom shows the time as 16:47 on 28-07-2025.

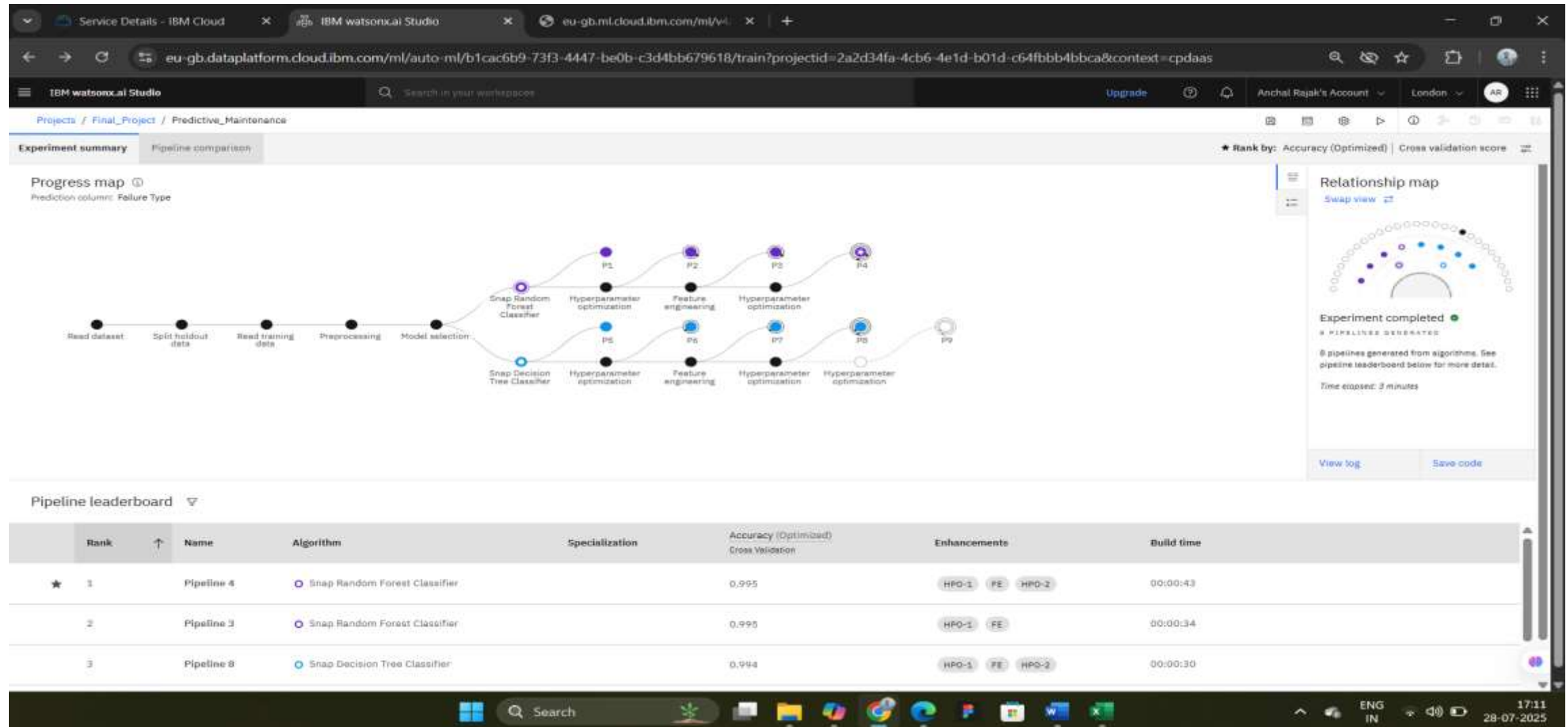
Result

The screenshot displays the IBM watsonx.ai Studio interface. The main window is titled "Promote to space" and contains a "Create a deployment space" section. A modal dialog box is open in the center, displaying the message "The space is being prepared..." and "Step 1 of 1. Creating deployment space." The background interface shows the "Define details" section for a deployment space named "Predictive_De". The "Name" field is filled with "Predictive_De". The "Description (Optional)" field is empty. The "Deployment stage" dropdown is set to "Select or enter a name that describes the purpose of the space". The "Tags" field is empty. The "Cancel" button is visible at the bottom right of the modal.

RESULT



RESULT



RESULT

Service Details - IBM Cloud x Predictive_Deployment_1 - Pr x eu-gb.ml.cloud.ibm.com/ml/v4 x +

eu-gb.dataplatform.cloud.ibm.com/ml-runtime/deployments/1458547f-5745-4eff-aae5-e4752b8522d6/test?space_id=99e9cf07-48ce-4658-897d-e2988c9ef6ed&context=cpdaas&fl...

IBM watsonx.ai Studio Search in your workspaces Upgrade ? 3 Anchal Rajak's Account London AR

Deployment spaces / Predictive_Deployment / P8 - Snap Decision Tree Classifier: Predictive_Maintenance /

Predictive_Deployment_1 Deployed Online

API reference **Test**

Enter input data

Text **JSON**

Enter data manually or use a CSV file to populate the spreadsheet. Max file size is 50 MB.

[Download CSV template](#) [Browse local files](#) [Search in space](#) [Clear all](#)

	UDI (double)	Product ID (other)	Type (other)	Air temperature [K] (double)	Process temperature [K] (double)	Rotational speed [rpm] (double)	Torque [Nm] (double)	Tool wear [min] (double)	Target (double)
1	1	M14S60	M	298.1	308.6	1551	42.8	0	0
2	10	M14S69	M	298.5	309	1741	28	21	0
3	11	M29424	H	298.4	308.9	1782	23.9	24	0
4	51	L47230	L	298.9	309.1	2861	4.6	143	1
5	52	L57924	L	298.9	309.1	3856	4.586	145	0
6	243	L47421	L	298	308.2	1348	58.8	202	1
7									
8									
9									
10									

6 rows, 9 columns

Predict

17:10 28-07-2025 ENG IN

RESULT

Service Details - IBM Cloud | Predictive_Deployment_1 | eu-gb.ml.cloud.ibm.com/ml/v4 |

eu-gb.dataplatform.cloud.ibm.com/ml-runtime/deployments/1458547f-5745-4eff-aae5-e4752b8522d6/test?space_id=99e9cf07-48ce-4658-897d-e2988c9ef6ed&context=cpdaas&fl...

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Deployment spaces / Predictive_Deployment / PB - Snap Decision Tree Classifier: Predictive_Maintenance /

Prediction results

Display format for prediction results
☒ Table view ☐ JSON view Show input data ⓘ

	prediction	probability
1	No Failure	[0,0.9997920989990234,0,0,0.00020790021517314017,7.8580342233181e-10]
2	No Failure	[0,0.9997920989990234,0,0,0.00020790021517314017,7.8580342233181e-10]
3	No Failure	[0,0.991150438785553,0,0,0.008849557489156723,3.725290298461914e-9]
4	Power Failure	[0,0,0,1,0,0]
5	No Failure	[0,0.9898580312728882,0,0,0.010141988284885883,-1.955777406692505e-8]
6	Overstrain Failure	[0.12820513546466827,0.012820512987673283,0.8333333134651184,0,0,0.025641038082540...
7		
8		
9		
10		
11		
12		
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Download JSON file

CONCLUSION

- This project demonstrates the power of machine learning in mechanical systems—whether predicting industrial failures or urban mobility trends. The predictive maintenance model enhances equipment longevity, while bike count forecasting supports smart city initiatives.

FUTURE SCOPE

- **Predictive Maintenance:**
 - Extend to other domains like HVAC systems or automotive diagnostics.
 - Integrate with IoT platforms for real-time monitoring and alerts.
- **Bike Demand Forecasting:**
 - Collaborate with municipal bodies for deployment.
 - Explore reinforcement learning for adaptive bike rebalancing strategies.

REFERENCES

- IBM Cloud Lite Services documentation.
- <https://cloud.ibm.com/>
- Email ID:- anchalrajak16@edunetmail.com
- Password:- Test@12345678
- My Github ID:- <https://github.com/anchal-rajak4260?tab=repositories>
- Kaggle Dataset:- Machine Predictive Maintenance Classification.
- Demonstrate successful integration of ML with IBM Cloud Lite services.

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Has successfully satisfied the requirements for:

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Completion Certificate



This certificate is presented to

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for the completion of

Lab: Retrieval Augmented Generation with LangChain

(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 17 Jul 2025 (GMT)

Learning hours: 20 mins



THANK YOU