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# **CAPSTONE PROJECT**

## **PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY THE CHALLENGE**

**Presented By:**

**Mekala Karthik- Chaitanya Bharathi Institute of Technology(CBIT)-  
Artificial Intelligence and Machine Learning**

# OUTLINE

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

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# 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.

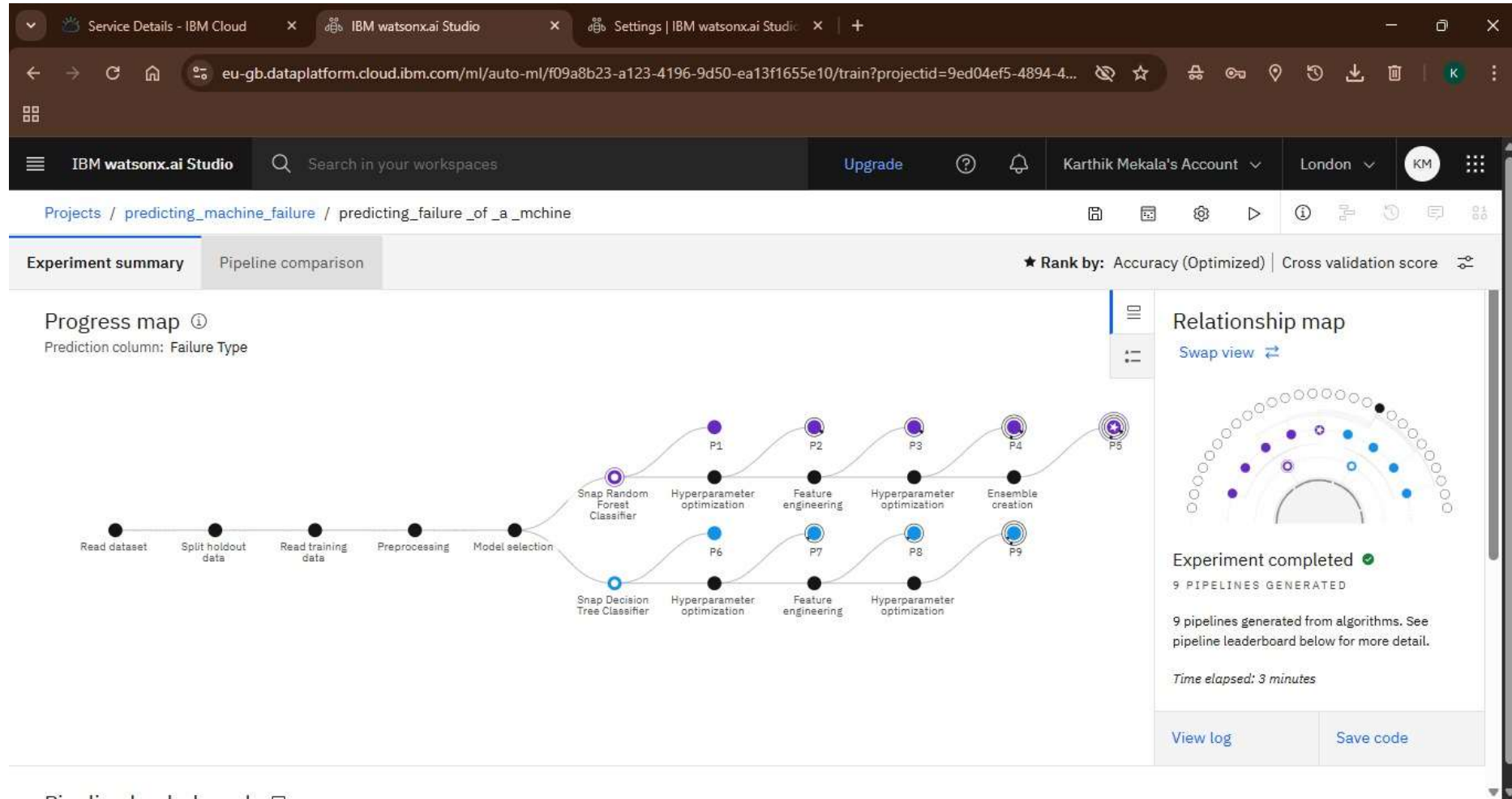
# PROPOSED SOLUTION

- The proposed system aims to address the challenge of predicting the type of failure in industrial machinery before it occurs. This involves leveraging data analytics and machine learning techniques to accurately forecast failure patterns. The solution will consist of the following components:
  - **Data Collection:**
    - Gather historical sensor data from industrial machinery, including relevant operational parameters.
    - The solution uses a Kaggle dataset specifically for machine predictive maintenance classification.
  - **Data Preprocessing:**
    - Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies.
    - Feature engineering is applied to extract relevant features from the data that might impact machine failure.
  - **Machine Learning Algorithm:**
    - The solution implements a multiclass classification model to predict the type of machine failure.
    - An auto-ML experiment in IBM Watsonx.ai Studio was used to generate and evaluate multiple pipelines.
    - The top-performing algorithms were the Batched Free Ensemble Classifier and the Snap Random Forest Classifier, both achieving a high accuracy of 0.995.
  - **Deployment:**
    - The final model, "P5-Snap Random Forest Classifier", was deployed as an "Online" deployment on the IBM Cloud Lite services platform.
    - The deployed model, named "failure\_deploy", is configured to accept real-time requests via a web service.
  - **Evaluation:**
    - The model's performance was assessed using accuracy, with the best models achieving an optimized cross-validation accuracy of 0.995.
    - The system is designed for continuous monitoring and fine-tuning based on real-world data to maintain high prediction accuracy.
    - **Result:**The developed system successfully predicts machine failures, enabling proactive maintenance. Testing demonstrated the model's ability to accurately classify various failure types, such as "No Failure" and "Power Failure", with high confidence. This capability is expected to significantly reduce downtime and operational costs for industrial machinery. The entire solution was built and deployed using IBM Watsonx.ai Studio on IBM Cloud Lite services.

# SELECTING DATA

The screenshot displays the IBM Watsonx.ai Studio web interface. The browser tabs at the top include 'Service Details - IBM Cloud', 'IBM watsonx.ai Studio', and 'Predicting machine failure'. The address bar shows the URL: `eu-gb.dataplatform.cloud.ibm.com/ml/auto-ml/f09a8b23-a123-4196-9d50-ea13f1655e10/configure?projectid=9ed04ef5-48...`. The navigation bar features the 'IBM watsonx.ai Studio' logo, a search bar, an 'Upgrade' button, and user account information for 'Karthik Mekala's Account' in 'London'. The breadcrumb trail indicates the current location: 'Projects / predicting\_machine\_failure / predicting\_failure\_of\_a\_mchine'. Below the breadcrumb, the text 'Configure AutoAI experiment' is followed by the experiment name 'predicting\_failure\_of\_a\_mchine'. The main content area is titled 'Add data source' and contains a large dashed box for file upload. Inside this box, there is an illustration of a person standing next to a computer monitor displaying a data table. To the right of the illustration, the text reads: 'Drop data files here or browse for files to upload' and 'Add files such as tabular data (CSV)'. At the bottom of this section, there are two buttons: 'Browse' and 'Select from project'.

# UPLOADED DATADASE



# SYSTEM APPROACH

The system approach for this predictive maintenance solution is a structured, end-to-end process that leverages IBM Cloud services to move from raw data to a fully deployed and validated machine learning model.

- **System requirements**

- Platform: The solution must be developed and deployed on IBM Cloud, with the use of IBM Cloud Lite services being mandatory.
- Core Service: IBM Watsonx.ai Studio is the essential service required for model development, training, and deployment.
- Data: The system requires a dataset containing operational sensor data from industrial machinery.
- Problem Type: The system must handle a multiclass classification problem, where the goal is to predict one of several possible failure types.
- Deployment: The final model must be deployed as an "Online" web service to enable real-time predictions.
- Performance: The model must achieve a high level of accuracy in predicting machine failures.

- **Library required to build the model**

- Snap Random Forest Classifier: A powerful ensemble learning algorithm that builds multiple decision trees and merges them to get a more accurate and stable prediction.
- Batched Free Ensemble Classifier (Snap Random Forest Classifier): A variation of the Random Forest algorithm, which further enhances performance by training the model on batches of data.
- Snap Decision Tree Classifier: A fundamental classification algorithm used in some of the generated pipelines.

[Resource list](#) /

watsonx.ai Studio-zw



[Add tags](#)

[Details](#)

[Actions](#)



Manage

Plan



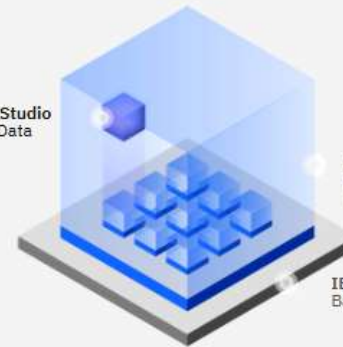
## watsonx.ai Studio in Cloud Pak for Data and watsonx

Build and deploy machine learning models on either platform. Work with foundation models on watsonx as a Service.

Launch in



IBM watsonx.ai Studio  
in Cloud Pak for Data  
and watsonx



IBM Cloud Pak for Data,  
watsonx  
Unifying platforms

IBM Cloud  
Base cloud infrastructure

IBM watsonx.ai Studio is part of IBM Cloud Pak for Data and watsonx, and serves as the AI capability of the data fabric architecture.



## Create a project

Start with a new, blank project or select from where to import an existing project.

+ New

Local file

Sample

predicting eligibility for NSAP program

Description (optional)

What's the purpose of this project?

Tags (optional)

Add tagsAdd tags

Add tags to make projects easier to find. To add tags, separate them with commas and press Enter.






Storage

Cloud Object Storage-ri

Cancel

Create

Project

-  General
-  Access control
-  Environments
-  Resource usage
-  **Services & integrations**

Tools

-  Pipeline


## Services & integrations


### IBM services (1)

### Third-party integrations

Associate IBM Cloud services with this project to add tools, compute environments, or other capabilities. [Learn more.](#)

 Find services

Associate service 

<input type="checkbox"/>	Name		Service type
<input type="checkbox"/>	watsonx.ai Runtime-sq		watsonx.ai Runtime

Service Details - IBM Cloud

IBM watsonx.ai Studio

Settings | IBM watsonx.ai Studio

Predicting machine failure

eu-gb.dataplatform.cloud.ibm.com/ml/auto-ml/f09a8b23-a123-4196-9d50-ea13f1655e10/train?projectid=9ed04ef5-4894-4...

IBM watsonx.ai Studio

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Projects / predicting\_machine\_failure / predicting\_failure\_of\_a\_mchine

Experiment summary

Pipeline comparison

★ Rank by: Accuracy (Optimized) | Cross validation score

Progress map ⓘ  
Prediction column: Failure Type

Read dataset

Split holdout data


Read training data

Preprocessing

Model selection

Relationship map

Swap view ↔



Pending  
PREDICTIVE\_MAINTEN...

Starting the AutoAI experiment

Time elapsed: 3 seconds

View log

Save code

Service Details - IBM Cloud

IBM watsonx.ai Studio

Settings | IBM watsonx.ai Studio

Predicting machine failure

eu-gb.dataplatform.cloud.ibm.com/ml/auto-ml/f09a8b23-a123-4196-9d50-ea13f1655e10/train?projectid=9ed04ef5-4...

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Prediction column: Failure Type

Read dataset


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Read training data

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Model selection

Relationship map  
[Swap view](#)



Model selection

PREDICTIVE\_MAINTEN...

Selecting algorithms for pipeline generation using 10% of training data. Discarding underperforming algorithms and keeping the top 2 algorithms.

Time elapsed: 68 seconds

[View log](#)

Save code

Service Details - IBM Cloud

IBM watsonx.ai Studio

Settings | IBM watsonx.ai Studio

eu-gb.dataplatform.cloud.ibm.com/ml/auto-ml/f09a8b23-a123-4196-9d50-ea13f1655e10/train?projectid=9ed04ef5-4894-4...

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★ Rank by: Accuracy (Optimized) | Cross validation score

Progress map ⓘ  
Prediction column: Failure Type

Read dataset

Split holdout data

Read training data

Preprocessing

Model selection

Selected algorithm 1

Hyperparameter optimization

Feature engineering

Hyperparameter optimization

Ensemble creation

Selected algorithm 3

Hyperparameter optimization

Feature engineering

Hyperparameter optimization

Ensemble creation

P1

P2

P3

P4

P5

P6

P7

P8

P9

P10

Relationship map  
Swap view ↔

Pipeline generation

SELECTED ALGORITHM 1

Composing pipeline P1

Time elapsed: 89 seconds

View log

Save code

Service Details - IBM Cloud

IBM watsonx.ai Studio

Settings | IBM watsonx.ai Studio

eu-gb.dataplatform.cloud.ibm.com/ml/auto-ml/f09a8b23-a123-4196-9d50-ea13f1655e10/train?projectid=9ed04ef5-4894-4...

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Experiment summary

Pipeline comparison

★ Rank by: Accuracy (Optimized) | Cross validation score

Progress map ⓘ  
Prediction column: Failure Type

```
graph LR; A[Read dataset] --> B[Split holdout data]; B --> C[Read training data]; C --> D[Preprocessing]; D --> E[Model selection]; E --> F[Snap Random Forest Classifier]; E --> G[Snap Decision Tree Classifier]; F --> H[Hyperparameter optimization]; G --> I[Hyperparameter optimization]; H --> J[Feature engineering]; I --> K[Feature engineering]; J --> L[Hyperparameter optimization]; K --> M[Hyperparameter optimization]; L --> N[Ensemble creation]; M --> N; N --> P1; N --> P2; N --> P3; N --> P4; N --> P5; N --> P6; N --> P7; N --> P8; N --> P9;
```

Relationship map  
Swap view

Experiment completed ✓  
9 PIPELINES GENERATED

9 pipelines generated from algorithms. See pipeline leaderboard below for more detail.

Time elapsed: 3 minutes

View log

Save code

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IBM watsonx.ai Studio

Settings | IBM watsonx.ai Studio

eu-gb.dataplatform.cloud.ibm.com/ml/auto-ml/f09a8b23-a123-4196-9d50-ea13f1655e10/train?projectid=9ed04ef5-4894-4...

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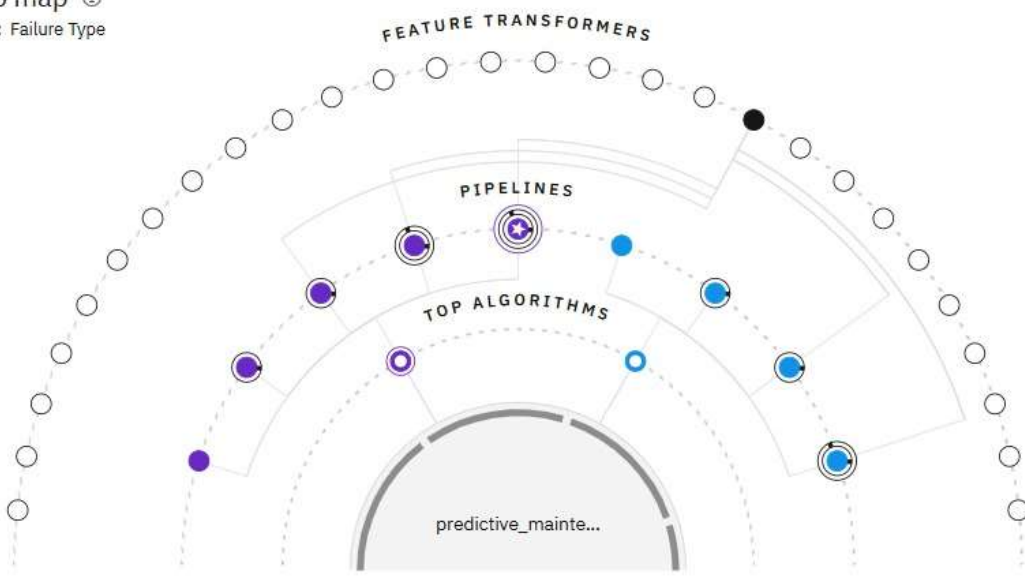
Experiment summary

Pipeline comparison

★ Rank by: Accuracy (Optimized) | Cross validation score

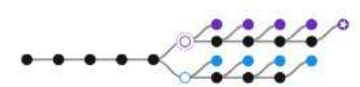
Relationship map ⓘ

Prediction column: Failure Type



Progress map

Swap view ↕



Experiment completed ✓

9 PIPELINES GENERATED

9 pipelines generated from algorithms. See pipeline leaderboard below for more detail.

Time elapsed: 3 minutes

View log

Save code

Service Details - IBM Cloud

IBM watsonx.ai Studio

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Experiment summary

Pipeline comparison

★ Rank by: Accuracy (Optimized) | Cross validation score

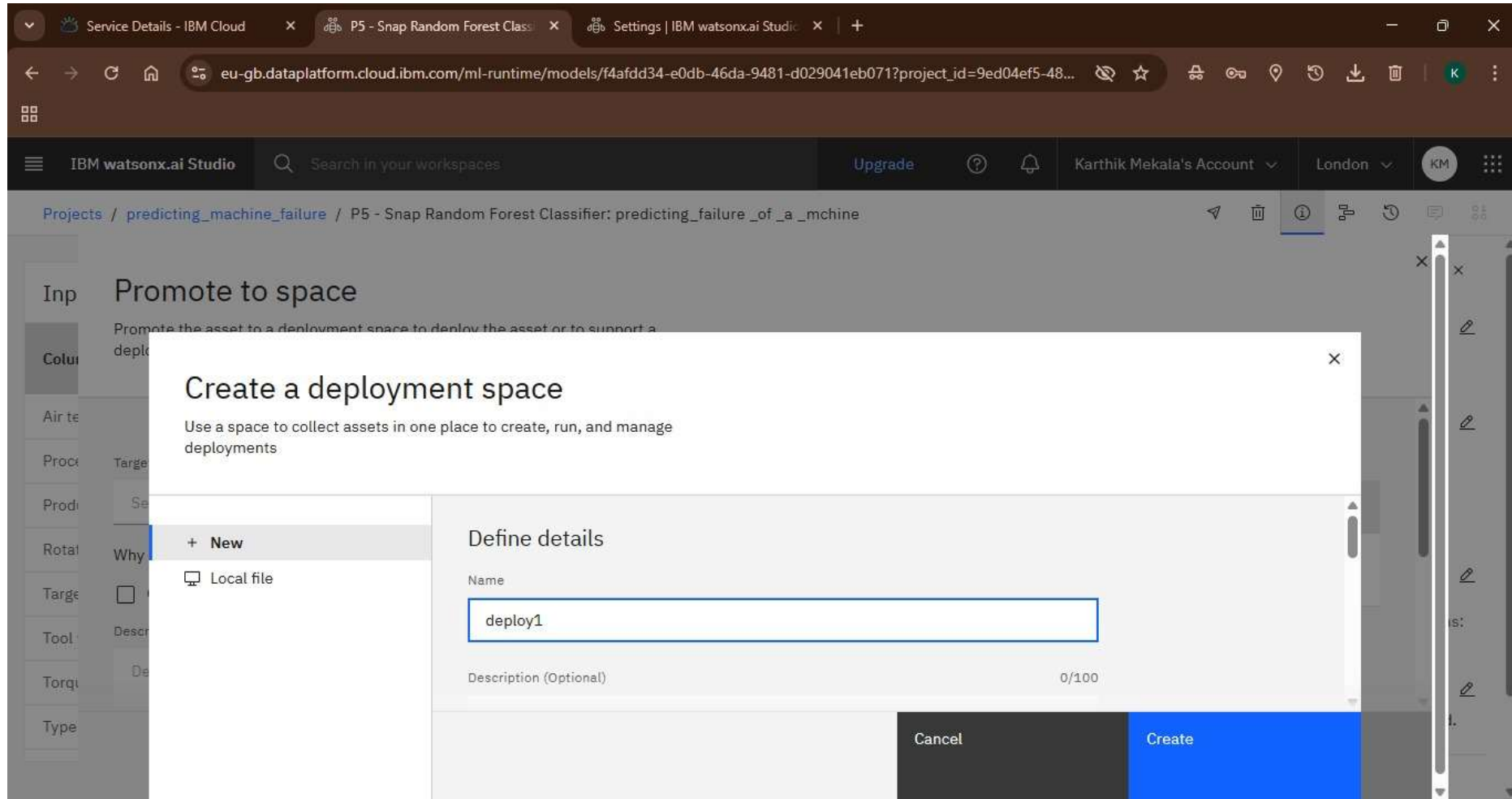
View log

Save code

Pipeline leaderboard

	Rank ↑	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 5	🌀 Batched Tree Ensemble Classifier (Snap Random Forest Classifier)	INCR	0.995	HPO-1 FE HPO-2 BATCH	00:00:53
	2	Pipeline 4	🌀 Snap Random Forest Classifier		0.995	HPO-1 FE HPO-2	00:00:50
	3	Pipeline 3	🌀 Snap Random Forest Classifier		0.995	HPO-1 FE	00:00:40
	4	Pipeline 9	🌀 Snap Decision Tree Classifier		0.994	HPO-1 FE HPO-2	00:00:05





# ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**

- The machine learning algorithm chosen for this predictive maintenance solution is a Batched Free Ensemble Classifier, specifically a variant of the Snap Random Forest Classifier. This algorithm was automatically selected by IBM Watsonx.ai's AutoAI feature due to its superior performance on the given dataset, achieving an optimized cross-validation accuracy of 0.995. The ensemble nature of the algorithm, which combines multiple decision trees, makes it highly effective for complex multiclass classification problems like predicting machine failure, providing robust and stable predictions.

- **Data Input:**

- The model uses sensor data including temperature, rotational speed, torque, and tool wear.

- **Training Process:**

- The training was automated by IBM Watsonx.ai's AutoAI feature, which handled feature engineering and hyperparameter tuning.

- **Prediction Process:**

- The deployed model accepts real-time data inputs and provides instant predictions of failure types and their probabilities.

- **Deployment:**

- The final model was deployed as an Online Deployment on IBM Cloud Lite services, creating a REST API for real-time predictions.

Service Details - IBM Cloud x P5 - Snap Random Forest Class x Settings | IBM watsonx.ai Studio x +

eu-gb.dataplatform.cloud.ibm.com/ml-runtime/models/53cb52db-6650-474e-981a-ad34166a5abb/deployments?space\_id=...

IBM watsonx.ai Studio Search in your workspaces Upgrade ? 1 Karthik Mekala's Account London KM

Deployment spaces / deploy1 / P5 - Snap Random Forest Classifier: predicting\_failure\_of\_a\_mchine

Deployments Model details

Search

New deployment

Name	Type	Status	Tags	Last modified
failure_deploy	Online	Deployed		38 seconds ago Karthik Mekala (You)

Items per page: 20 1-1 of 1 items 1 of 1 pages

Online deployment ready

The online deployment failure\_deploy in space deploy1 is ready to accept requests

Today 2:18 PM

Description

No description provided.

Asset Details

Type: wml-hybrid\_0.1

Model ID: 53cb52db-6650-47...

Software specification: hybrid\_0.1

Hybrid pipeline software specifications: autoai-kb\_rt24.1-py3.11

Tags

Add tags to make assets easier to find.

Source asset details

---

# RESULT

The developed system successfully predicts machine failures, enabling proactive maintenance. Testing demonstrated the model's ability to accurately classify various failure types, such as "No Failure" and "Power Failure," with high confidence. This capability is expected to significantly reduce downtime and operational costs for industrial machinery. The entire solution was built and deployed using IBM Watsonx.ai Studio on IBM Cloud Lite services.

Service Details - IBM Cloud

failure\_deploy — deploy1 | IBM

Settings | IBM watsonx.ai Studio

eu-gb.dataplatform.cloud.ibm.com/ml-runtime/deployments/7a25225c-a11d-4971-8f12-464eb7a165a6/test?space\_id=28ee...

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Deployment spaces / deploy1 / P5 - Snap Random Forest Classifier: predicting\_failure\_of\_a\_mchine

failure\_deploy ✓ 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.

:

Clear all ×

	perature [K] (double)	Process temperature [K] (double)	Rotational speed [rpm] (double)	Torque [Nm] (double)	Tool wear [min] (double)	Target (double)
1		308.6	1551	42.8	0	0

1 row, 9 columns

Predict

Service Details - IBM Cloud

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New chat

eu-gb.dataplatform.cloud.ibm.com/ml-runtime/deployments/7a25225c-a11d-4971-8f12-464eb7a165a6/test?space\_id=28ee...

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Prediction results

Close

X

Prediction type

Multiclass classification

Prediction percentage

1 record

Display format for prediction results

☒ Table view ☐ JSON view

☐ Show input data

	Prediction	Confidence
1	Power Failure	100%
2		
3		
4		
5		
6		

Download JSON file

# CONCLUSION

- In conclusion, the predictive maintenance solution for industrial machinery, developed using IBM Watsonx.ai Studio on IBM Cloud Lite services, successfully addresses the challenge of anticipating equipment failures. By leveraging an advanced multiclass classification model (Batched Free Ensemble Classifier), the system achieves a remarkable accuracy of 0.995. The real-time online deployment of this model enables proactive maintenance decisions, which are crucial for minimizing downtime, reducing operational costs, and improving overall industrial efficiency. The project demonstrates the effectiveness of automated machine learning platforms in rapidly developing and deploying high-performance predictive solutions for complex industrial problems.

# FUTURE SCOPE

- **Integration with CMMS:** The model could be integrated with a Computerized Maintenance Management System (CMMS) to automatically generate maintenance work orders when a high probability of failure is predicted.
- **Real-time Dashboard:** A real-time monitoring dashboard could be developed to visualize sensor data, model predictions, and alerts, providing a comprehensive overview of the fleet's health.
- **Prescriptive Maintenance:** The solution could be enhanced to not only predict failures but also recommend specific maintenance actions to prevent them, moving from predictive to prescriptive maintenance.
- **Continuous Improvement:** A feedback loop could be implemented to automatically retrain the model with new failure data, ensuring the model's accuracy continuously improves over time.



# REFERENCES

- Kaggle Dataset: Shivam. (n.d.). Machine Predictive Maintenance Classification. Retrieved from <https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification>
- IBM Cloud: IBM. (n.d.). IBM Cloud Lite. Retrieved from <https://www.ibm.com/cloud/lite>
- IBM watsonx.ai Studio: IBM. (n.d.). watsonx.ai Studio. Retrieved from <https://www.ibm.com/products/watsonx-ai>

# IBM CERTIFICATIONS



# IBM CERTIFICATIONS



# IBM CERTIFICATIONS

8/4/25, 10:07 PM

Completion Certificate | SkillsBuild

IBM **SkillsBuild**

Completion Certificate



This certificate is presented to

Karthik Mekala

for the completion of

**Lab: Retrieval Augmented Generation with  
LangChain**

(ALM-COURSE\_3824998)

According to the Adobe Learning Manager system of record

**Completion date:** 03 Aug 2025 (GMT)

**Learning hours:** 20 mins



**THANK YOU**