CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

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OUTLINE

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- System Development Approach
- Algorithm & Deployment
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PROBLEM STATEMENT

Industrial machinery is prone to unexpected failures that lead to unplanned downtime, increased maintenance costs, and reduced operational efficiency. Traditional reactive maintenance approaches are inefficient and costly. To address this issue, we aim to develop a **predictive maintenance model** that can accurately anticipate machine failures **before they occur**, using real-time sensor data. The objective is to build a **classification model** capable of identifying the **type of failure**—such as tool wear, heat dissipation issues, or power failure—by analyzing historical and live operational data. This solution will enable proactive maintenance strategies, thereby minimizing machine downtime and optimizing overall productivity.

PROPOSED SOLUTION

- To proactively detect and classify potential machine failures, we propose the development of a data-driven machine learning system using sensor data collected from industrial machinery. The proposed solution involves the following components:
- **Key Components:**

1. Data Collection:

Use the Kaggle dataset on the type of failures.

2. Data Preprocessing:
Clean data, handle missing values, create time-based features, label failure types, and normalize the dataset.

3. Model Training:
Train supervised classification models (e.g., Random Forest, XGBoost, LSTM) to predict failure types using labeled data.

4. Model Evaluation:
Use metrics like accuracy, precision, recall, and F1-score to evaluate performance on test data.

SYSTEM APPROACH

Industrial machines often fail unexpectedly, leading to downtime and costly repairs. The objective is to build a **predictive maintenance system** that uses sensor data to detect failure patterns and predict the **type of failure** in advance, enabling timely maintenance.

- **System Requirements:**

Service	**Purpose**
IBM Watson Studio	Develop notebooks, process data, and train ML models
IBM Cloud Object Storage	Store sensor data, logs, and model files
IBM Watson Machine Learning	Deploy models as REST APIs and manage deployments

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**

  Random Forest Classifier, (Support Vector Machine (SVM))

- **Data Input:**

  Air Temperature, Process Temperature, Rotational Speed, Torque, Tool Wear, Target measurements from the dataset.

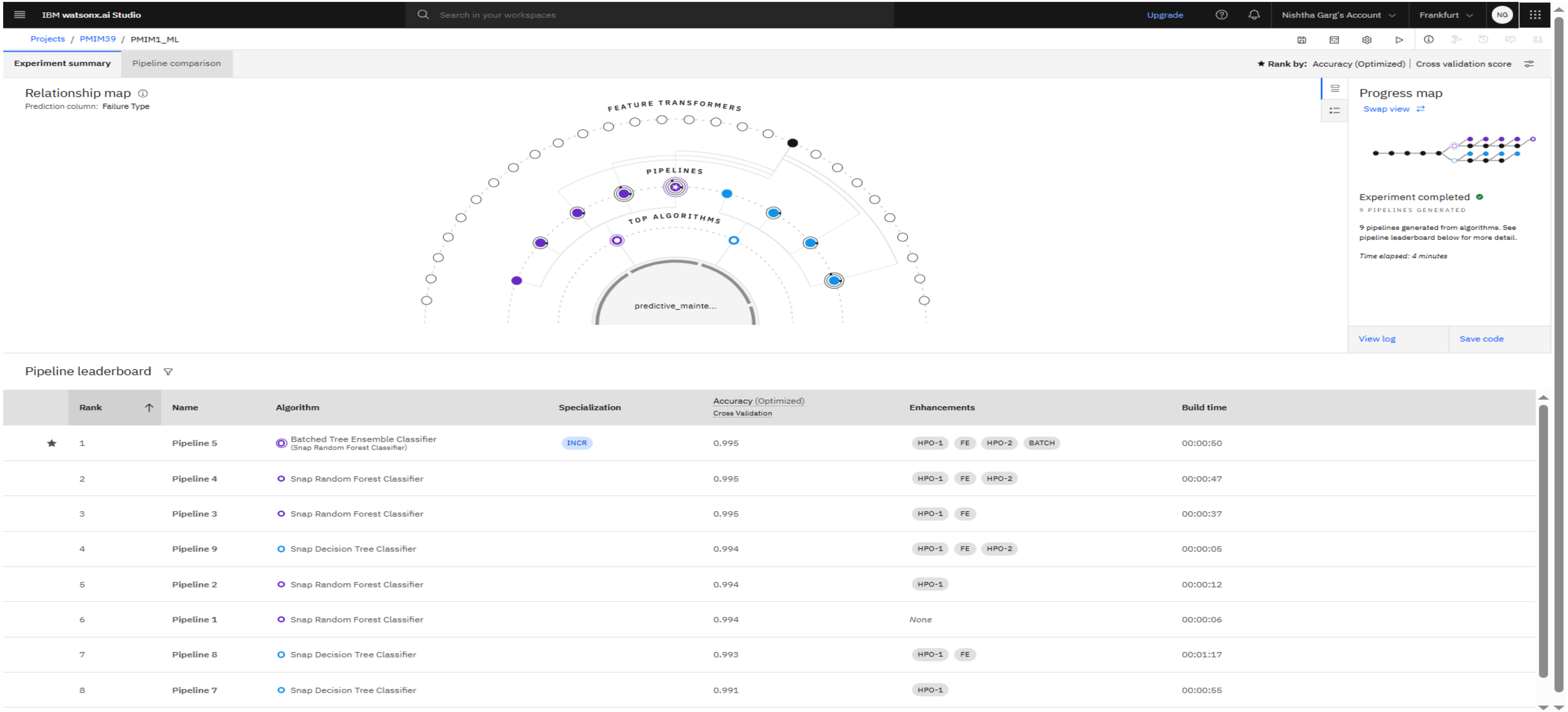
- **Training Process:**

  Supervised Learning using the labelled failure types.

- **Prediction Process:**

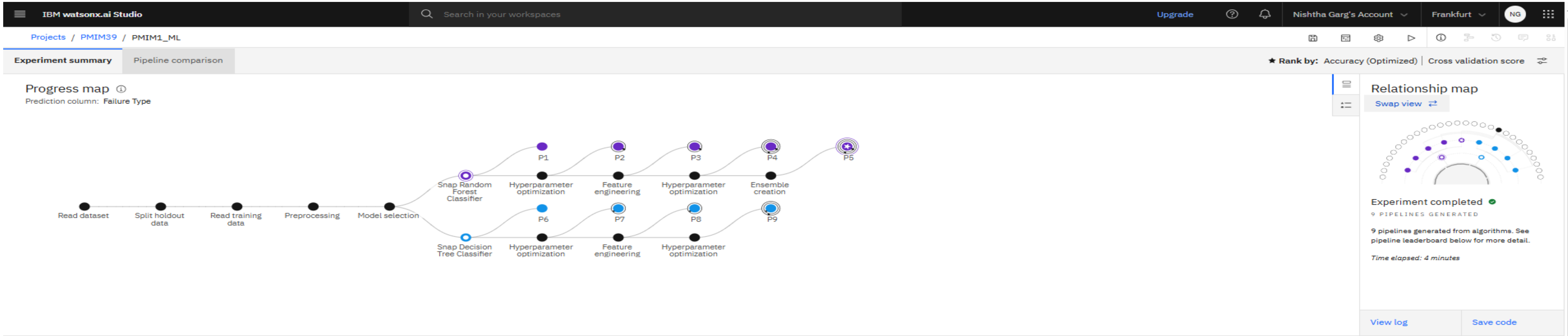
  Model deployed on IBM Watson Studio with API endpoint for real-time predictions.

RESULT



	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	00:00:50
	2	Pipeline 4	Snap Random Forest Classifier		0.995	HPO-1 FE HPO-2	00:00:47
	3	Pipeline 3	Snap Random Forest Classifier		0.995	HPO-1 FE	00:00:37
	4	Pipeline 9	Snap Decision Tree Classifier		0.994	HPO-1 FE HPO-2	00:00:05
	5	Pipeline 2	Snap Random Forest Classifier		0.994	HPO-1	00:00:12
	6	Pipeline 1	Snap Random Forest Classifier		0.994	*None*	00:00:06
	7	Pipeline 8	Snap Decision Tree Classifier		0.993	HPO-1 FE	00:01:17
	8	Pipeline 7	Snap Decision Tree Classifier		0.991	HPO-1	00:00:55

RESULT



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	00:00:50
	2	Pipeline 4	Snap Random Forest Classifier		0.995	HPO-1 FE HPO-2	00:00:47
	3	Pipeline 3	Snap Random Forest Classifier		0.995	HPO-1 FE	00:00:37
	4	Pipeline 9	Snap Decision Tree Classifier		0.994	HPO-1 FE HPO-2	00:00:05
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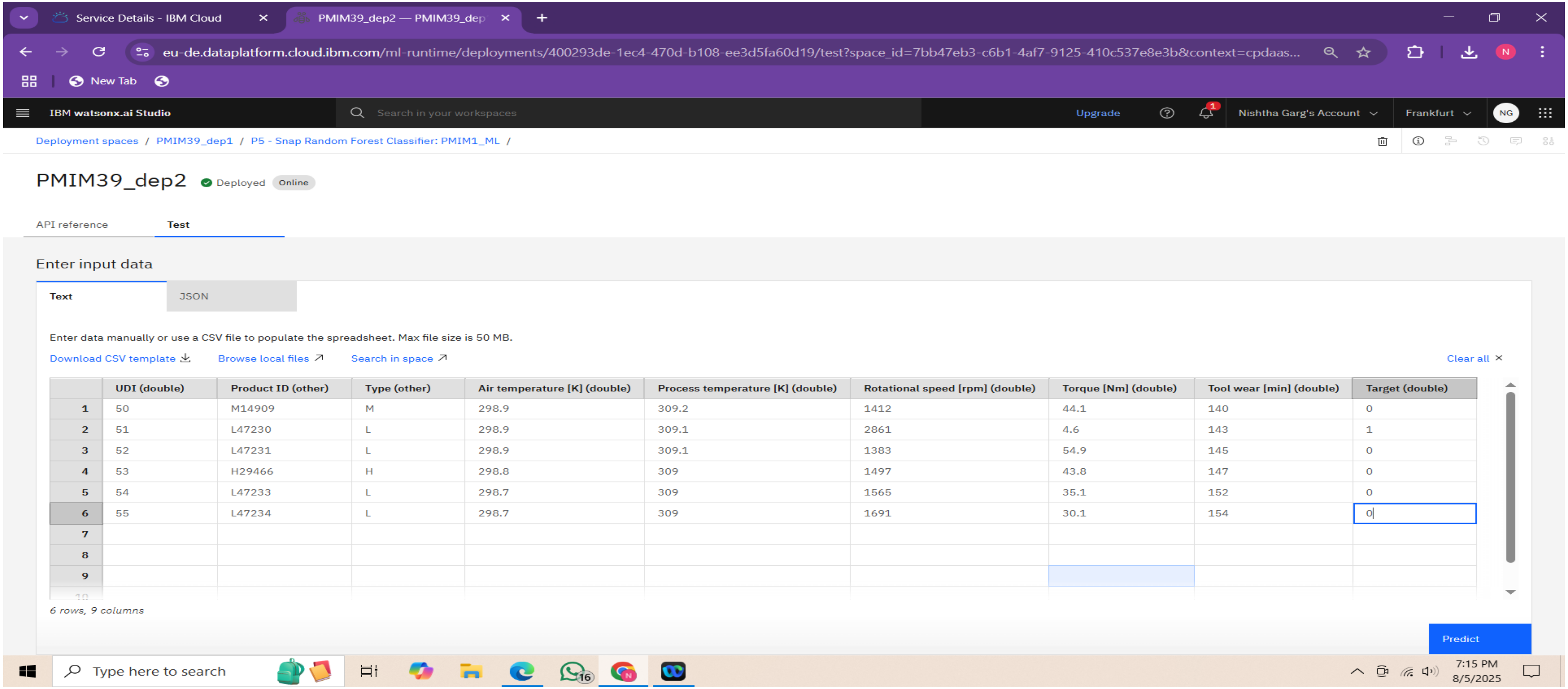
RESULT


Service Details - IBM Cloud
PMIM39_dep2 — PMIM39_dep
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IBM watsonx.ai Studio
Search in your workspaces
Upgrade
Nishtha Garg's Account
Frankfurt
Deployment spaces / PMIM39_dep1 / P5 - Snap Random Forest Classifier: PMIM1_ML /
PMIM39_dep2
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 | 50 | M14909 | M | 298.9 | 309.2 | 1412 | 44.1 | 140 | 0
2 | 51 | L47230 | L | 298.9 | 309.1 | 2861 | 4.6 | 143 | 1
3 | 52 | L47231 | L | 298.9 | 309.1 | 1383 | 54.9 | 145 | 0
4 | 53 | H29466 | H | 298.8 | 309 | 1497 | 43.8 | 147 | 0
5 | 54 | L47233 | L | 298.7 | 309 | 1565 | 35.1 | 152 | 0
6 | 55 | L47234 | L | 298.7 | 309 | 1691 | 30.1 | 154 | 0
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Predict
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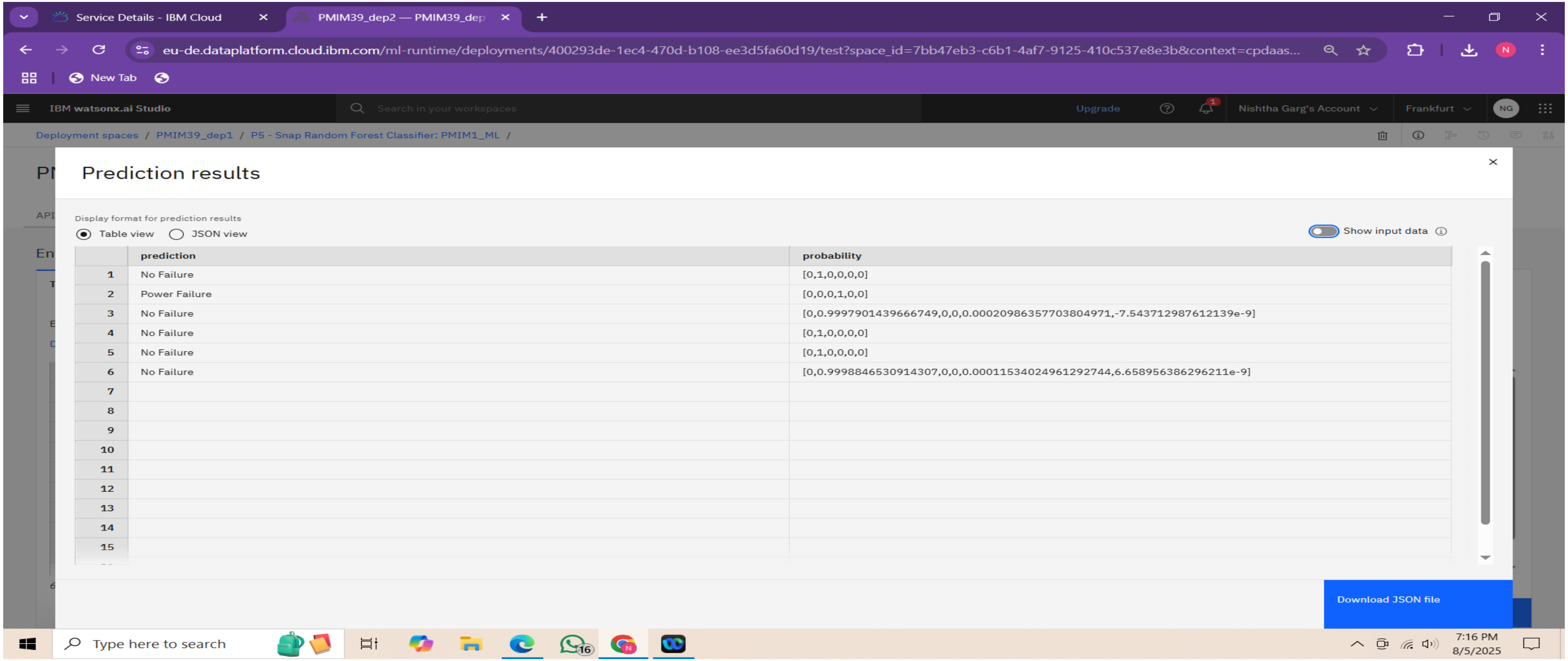
8/5/2025

RESULT



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CONCLUSION

The predictive maintenance system built on IBM Cloud efficiently combines machine learning with cloud services to forecast equipment failures using sensor data. Leveraging Watson Studio, Cloud Object Storage, and Watson Machine Learning, we developed, trained, and deployed a real-time failure prediction model. The solution reduces downtime, supports proactive maintenance, and offers a scalable, cloud-based foundation for future enhancements like automated alerts and retraining pipelines.

FUTURE SCOPE

The predictive maintenance system built on IBM Cloud has strong potential for future growth and enhancement. With a solid cloud-based foundation, the project can be expanded and optimized in several impactful ways:

- **Incorporate Additional Data Sources:** Integrating environmental data, operator behavior, and real-time third-party APIs can enhance prediction accuracy.
- **Algorithm Optimization:** Advanced techniques like XGBoost, LSTM, and AutoML can improve model performance. Hyperparameter tuning can further refine results.
- **Geographical Expansion:** The system can be scaled to monitor equipment across multiple cities or regions, with localized models and centralized cloud monitoring.
- **Edge Computing Integration:** Deploying models on edge devices using IBM Edge Application Manager can enable real-time, low-latency predictions even in remote locations.
- **Advanced Machine Learning Techniques:** Using anomaly detection, transfer learning, and federated learning can improve adaptability and privacy in distributed environments.

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REFERENCES

- Kaggle dataset link - https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification
- IBM Cloud - https://cloud.ibm.com
- IBM Watson Studio - https://cloud.ibm.com/catalog/services/watsonxai-studio
- IBM Watson Machine Learning
- IBM Cloud Object Storag

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Completion date: 23 Jul 2025 (GMT)

Learning hours: 20 mins

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