CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY USING MACHINE LEARNING

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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

Unexpected failures in industrial machinery can lead to significant operational disruptions, increased maintenance costs, and reduced productivity. Traditional maintenance strategies often fail to detect early signs of equipment degradation. There is a critical need to identify and classify the types of failures—such as tool wear, heat dissipation issues, and power failures—before they occur, using the vast amount of real-time sensor data generated by these machines.

PROPOSED SOLUTION

- Develop a predictive maintenance system that uses real-time sensor data from industrial machines to detect early signs of failure. By analyzing historical data, the model will learn to recognize patterns and unusual behavior that occur before specific issues like tool wear, overheating, or power failures. The solution will consist of the following components:
- Data Collection:
  - Used Kaggle dataset on predictive maintenance of machinery
- Data Preprocessing:
  - Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies.
- Feature Extraction:
  - Identifying important patterns and signals from the data that indicate possible failures.
- Model Training:
  - Using machine learning algorithms to teach the model how to recognize different types of failures.
- Evaluation:
  - Assess the model's performance using appropriate metrics such as Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), or other relevant metrics.
  - Fine-tune the model based on feedback and continuous monitoring of prediction accuracy.

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SYSTEM APPROACH

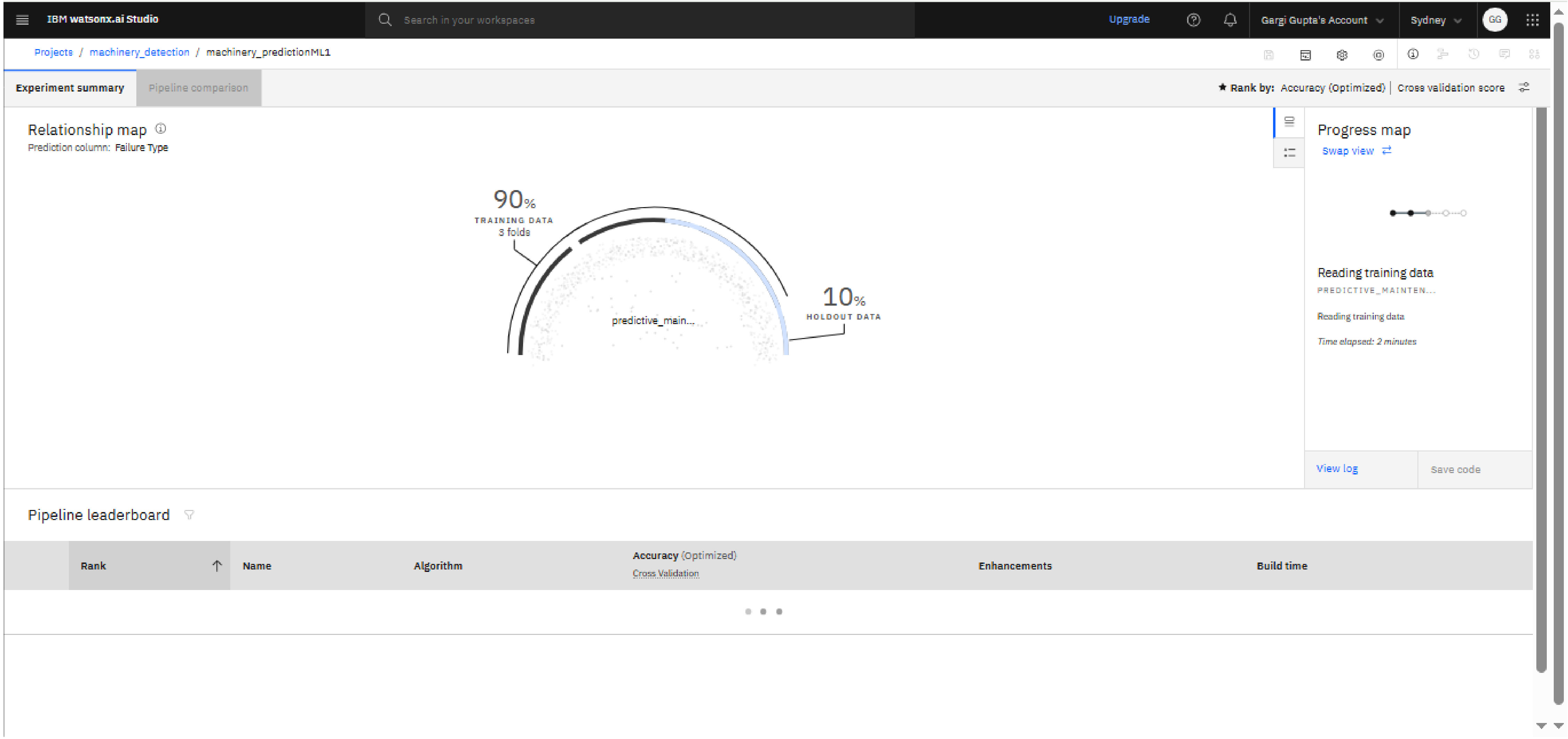
The "System Approach" section outlines the overall strategy and methodology for developing and implementing the predictive maintenance model for industrial machines. Here's a suggested structure for this section:

- System requirements:
  - ✓ IBM Cloud (mandatory)
  - ✓ IBM watsonx.ai studio for model development and deployment
  - ✓ IBM cloud object storage for dataset handling

ALGORITHM & DEPLOYMENT

- Algorithm Selection:
  - Random Forest Classifier (or Decision Tree Classifier based on performance)
- Data Input:
  - UDI, Product ID, Type, Air Temperature[K], Process Temperature[K], Rotational Speed[rpm], Torque[Nm], Tool Wear[min], Target
- Training Process:
  - Supervised machine learning using labelled machinery failure types
- Prediction Process:
  - Model deployed on IBM Watson Studio with API endpoint for real-time predictions

RESULT



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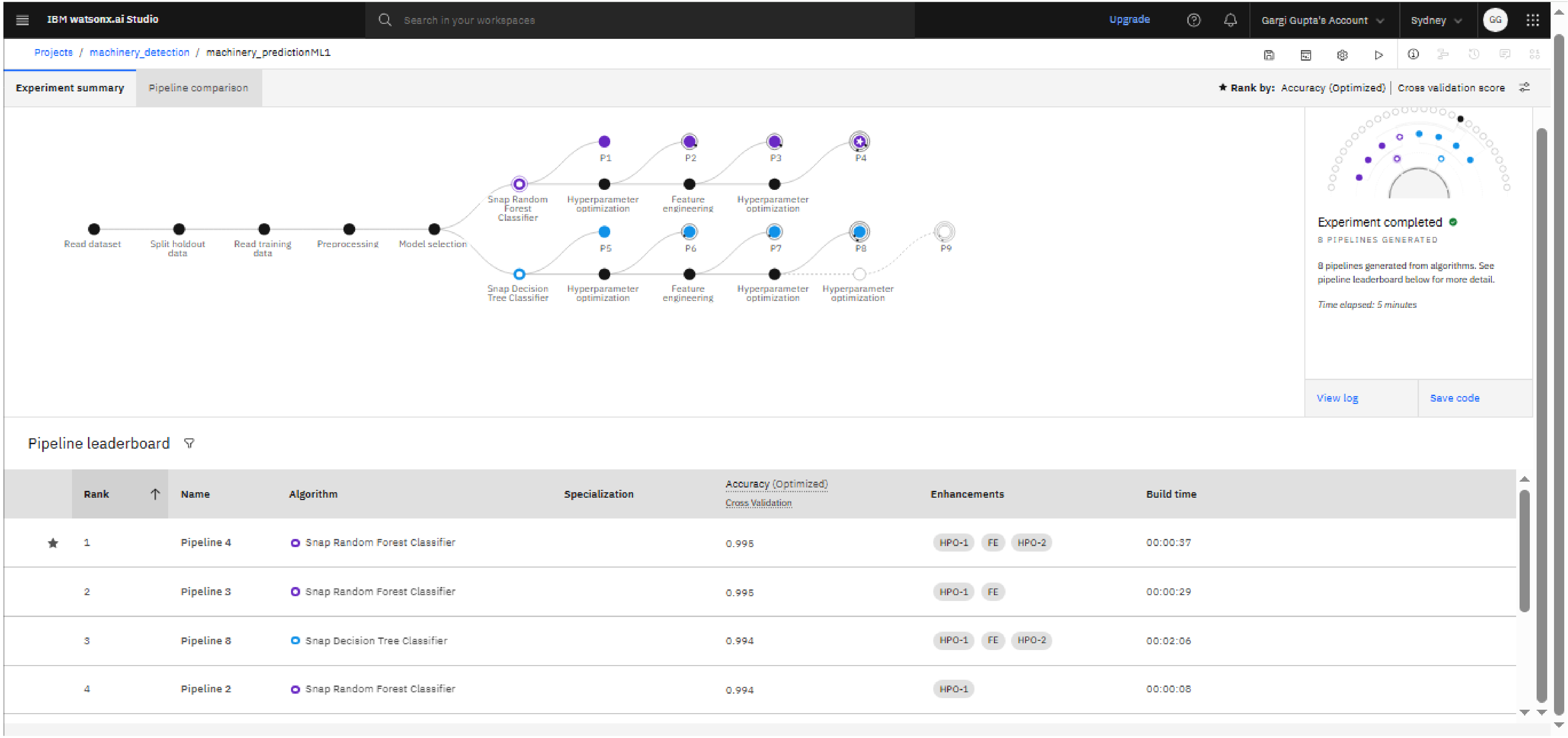
IBM watsonx.ai Studio
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Gargi Gupta's Account
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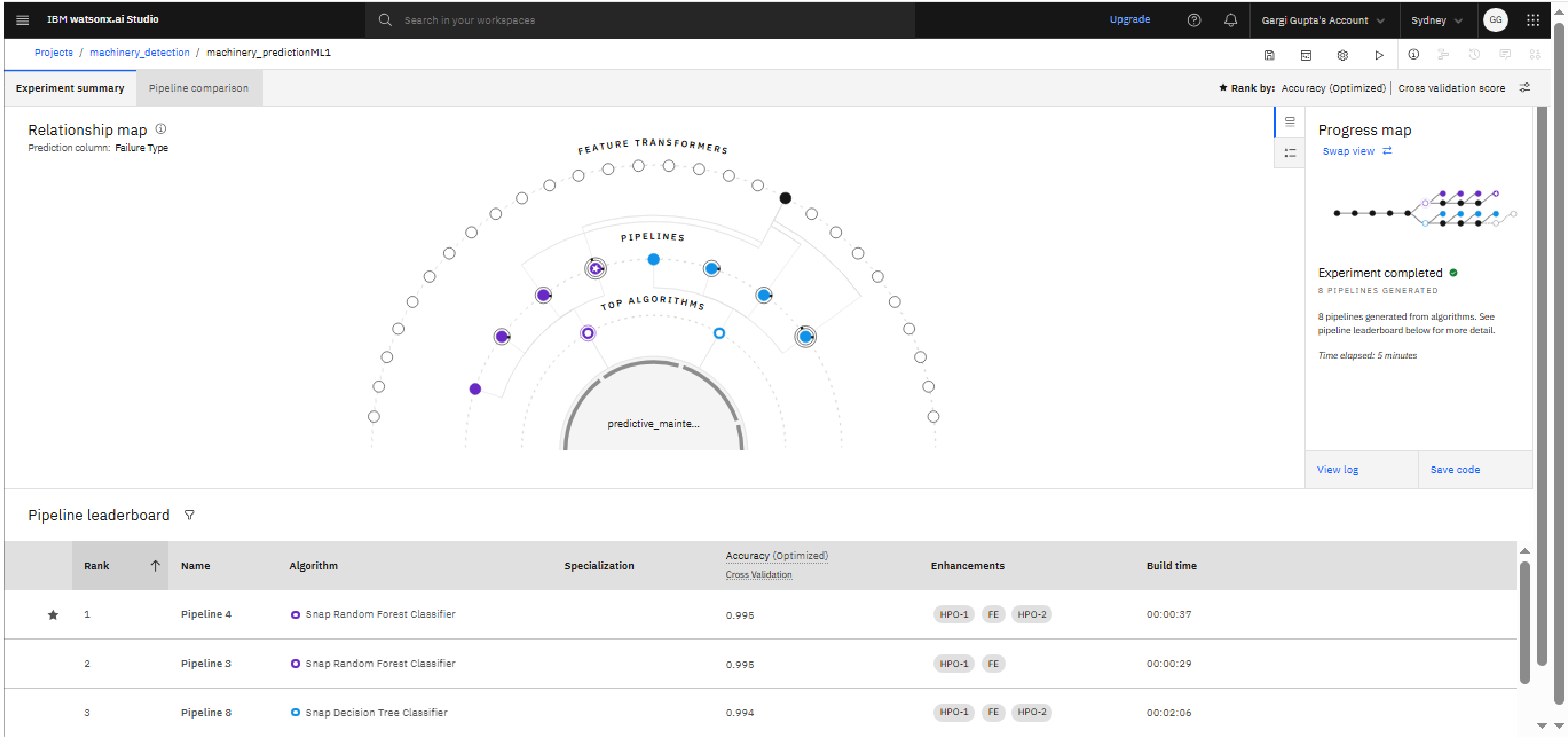
Projects / machinery_detection / machinery_predictionML1
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
P1
P2
P3
P4
Snap Random Forest Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
P5
P6
P7
P8
P9
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Hyperparameter optimization
Experiment completed
8 PIPELINES GENERATED
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 5 minutes
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized) Cross Validation
Enhancements
Build time
1 Pipeline 4 Snap Random Forest Classifier 0.995 HPO-1 FE HPO-2 00:00:37
2 Pipeline 3 Snap Random Forest Classifier 0.995 HPO-1 FE 00:00:29
3 Pipeline 8 Snap Decision Tree Classifier 0.994 HPO-1 FE HPO-2 00:02:06
4 Pipeline 2 Snap Random Forest Classifier 0.994 HPO-1 00:00:08



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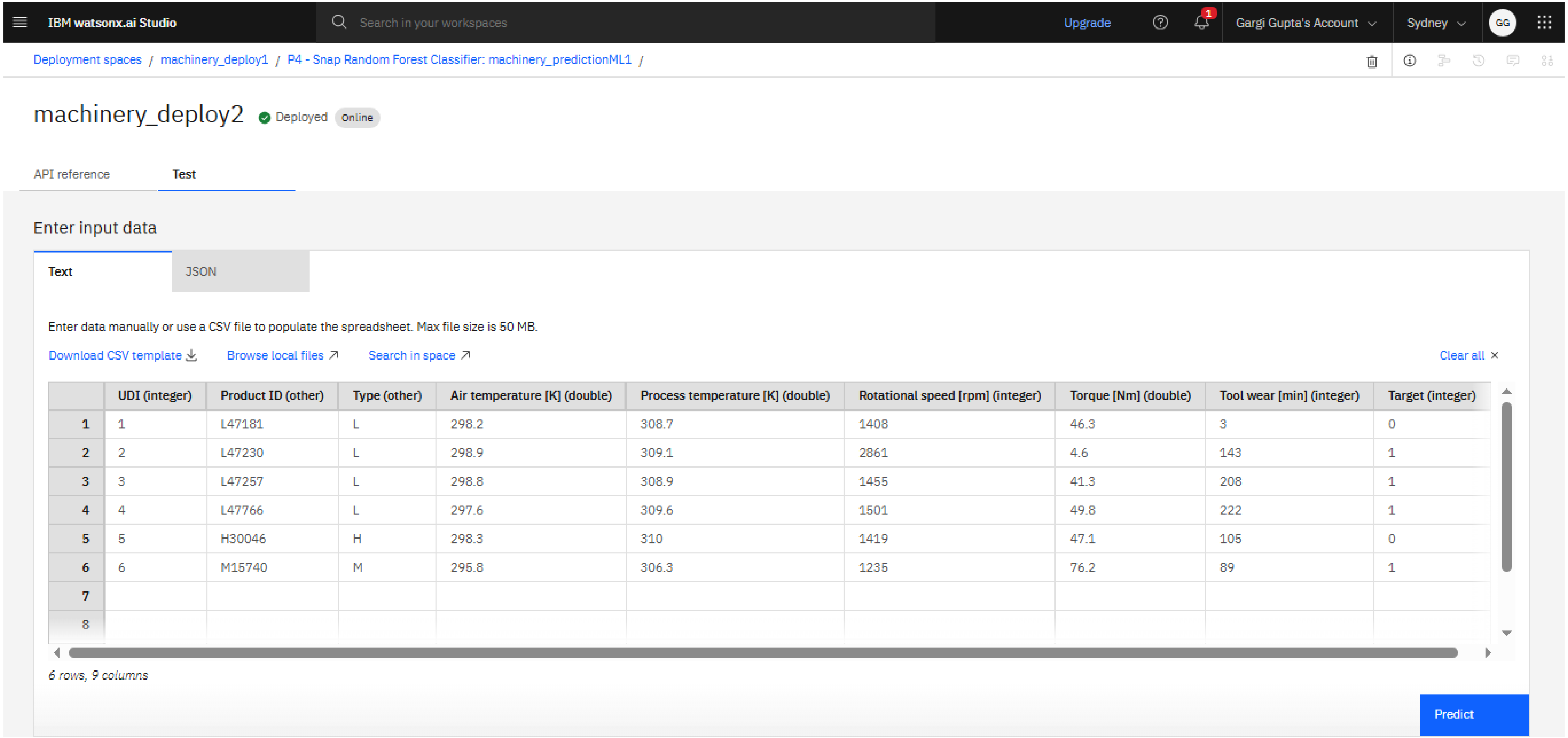
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Deployment spaces / machinery_deploy1 / P4 - Snap Random Forest Classifier: machinery_predictionML1 /
machinery_deploy2
Deployed
Online
API reference
Test
Enter input data
Text
JSON
Enter data manually or use a CSV file to populate the spreadsheet. Max file size is 50 MB.
Download CSV template
Browse local files
Search in space
Clear all

	UDI (integer)	Product ID (other)	Type (other)	Air temperature [K] (double)	Process temperature [K] (double)	Rotational speed [rpm] (integer)	Torque [Nm] (double)	Tool wear [min] (integer)	Target (integer)
1	1	L47181	L	298.2	308.7	1408	46.3	3	0
2	2	L47230	L	298.9	309.1	2861	4.6	143	1
3	3	L47257	L	298.8	308.9	1455	41.3	208	1
4	4	L47766	L	297.6	309.6	1501	49.8	222	1
5	5	H30046	H	298.3	310	1419	47.1	105	0
6	6	M15740	M	295.8	306.3	1235	76.2	89	1
7									
8									

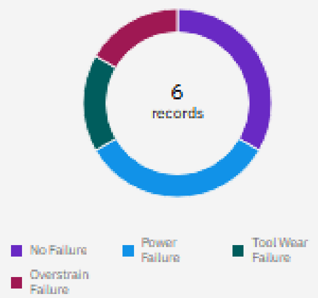
6 rows, 9 columns
Predict

Prediction results

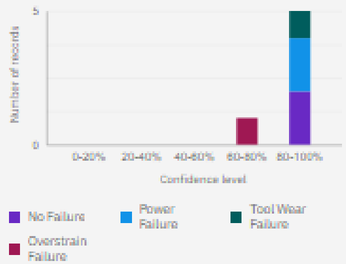
Prediction type

Multiclass classification

Prediction percentage



Confidence level distribution



Display format for prediction results

Table view JSON view

Show input data

	Prediction	Confidence
1	No Failure	100%
2	Power Failure	100%
3	Tool Wear Failure	100%
4	Overstrain Failure	60%
5	No Failure	100%
6	Power Failure	100%
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

CONCLUSION

- The project focused on developing a predictive maintenance model that uses real-time sensor data from industrial machines to anticipate failures before they occur. By analyzing historical and operational data, the model effectively identified early warning signs of issues like tool wear, heat dissipation problems, and power failures. This enabled timely maintenance actions, reducing unexpected downtime and improving operational efficiency.
- The solution demonstrated strong performance, but challenges such as noisy sensor data, feature selection, and real-time integration were encountered. Addressing these through better data preprocessing and model optimization can further enhance the system. Overall, the project highlights the value of predictive maintenance in increasing machine reliability and reducing costs in industrial environments.

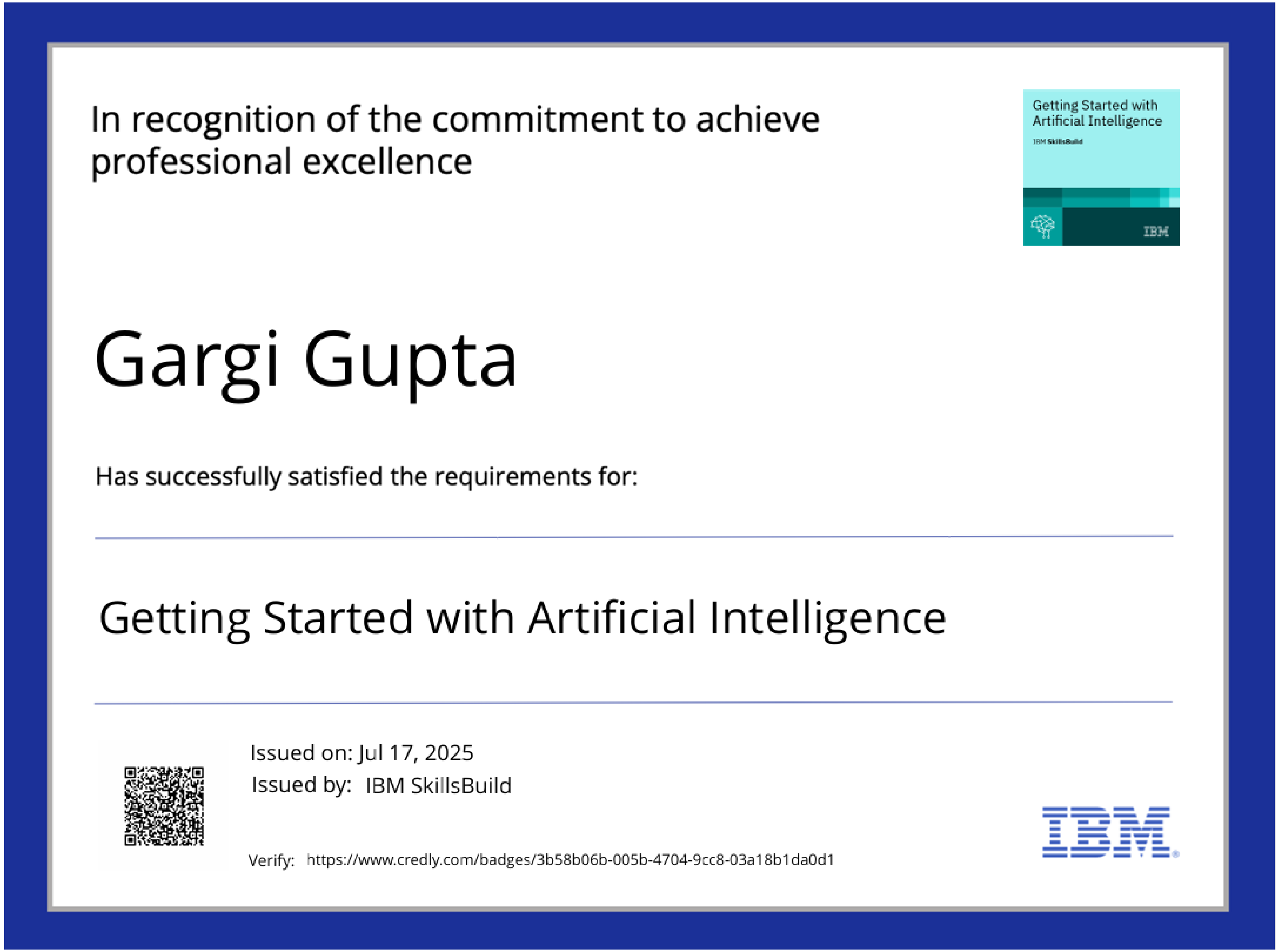
FUTURE SCOPE

- To improve the system’s accuracy and scalability, several enhancements can be considered:
  - Additional Data Sources: Including maintenance logs and environmental data to improve prediction accuracy.
  - Advanced Algorithms: Using deep learning or ensemble models for better performance.
  - Scalability: Expanding the system to monitor machines across multiple locations or regions.
  - Edge Computing: Deploying models on local devices for real-time predictions with low latency.
  - User Interface: Adding dashboards and alerts for easier monitoring and faster response.

REFERENCES

- Kaggle Datasets. *Predictive Maintenance Dataset*. Retrieved from: https://www.kaggle.com/datasets/shivamb/machine predictive-maintenance-classification
- IBM Developer. (2020). *Predictive maintenance using machine learning*. Retrieved from: https://developer.ibm.com/patterns/predictive-maintenance-using-machine-learning/

IBM CERTIFICATIONS



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Learning hours: 20 mins

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