CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

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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

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 goal is to build a predictive maintenance system using machine learning to anticipate industrial machine failures and reduce unplanned downtime. The solution involves:
- Data Collection:
  - Use historical sensor data from machines, including air temperature, process temperature, rotational speed, torque, and tool wear.
  - Label data with failure types such as tool wear failure, heat dissipation failure, power failure, overstrain, and random failure.
- Data Preprocessing:
  - Clean the dataset, handle any outliers, and normalize sensor values.
  - Encode failure types and prepare features for training.
- Machine Learning Algorithm:
  - Train a classification model (e.g., Random Forest, XGBoost) to predict specific failure types.
  - Evaluate model performance using metrics like accuracy, precision, recall, and F1-score.
- Deployment:
  - Deploy the trained model using IBM Cloud lite services such as Watson AI.X Studio.
  - Future integration can allow real-time monitoring and predictive alerts for timely maintenance actions.
- Outcome:
  - Reduce unexpected breakdowns, optimize maintenance schedules, and improve overall equipment efficiency.

SYSTEM APPROACH

The "System Approach" section outlines the overall strategy and methodology for developing and implementing the rental bike prediction system. Here's a suggested structure for this section:

- System requirements
- A machine with Python installed (Jupyter Notebook or IBM Watson Studio)
- Minimum 8 GB RAM and stable internet connection
- IBM Cloud account with access to:
- IBM Watson Studio
- IBM Cloud Object Storage
- IBM Machine Learning service
- Kaggle dataset (Predictive Maintenance Data)

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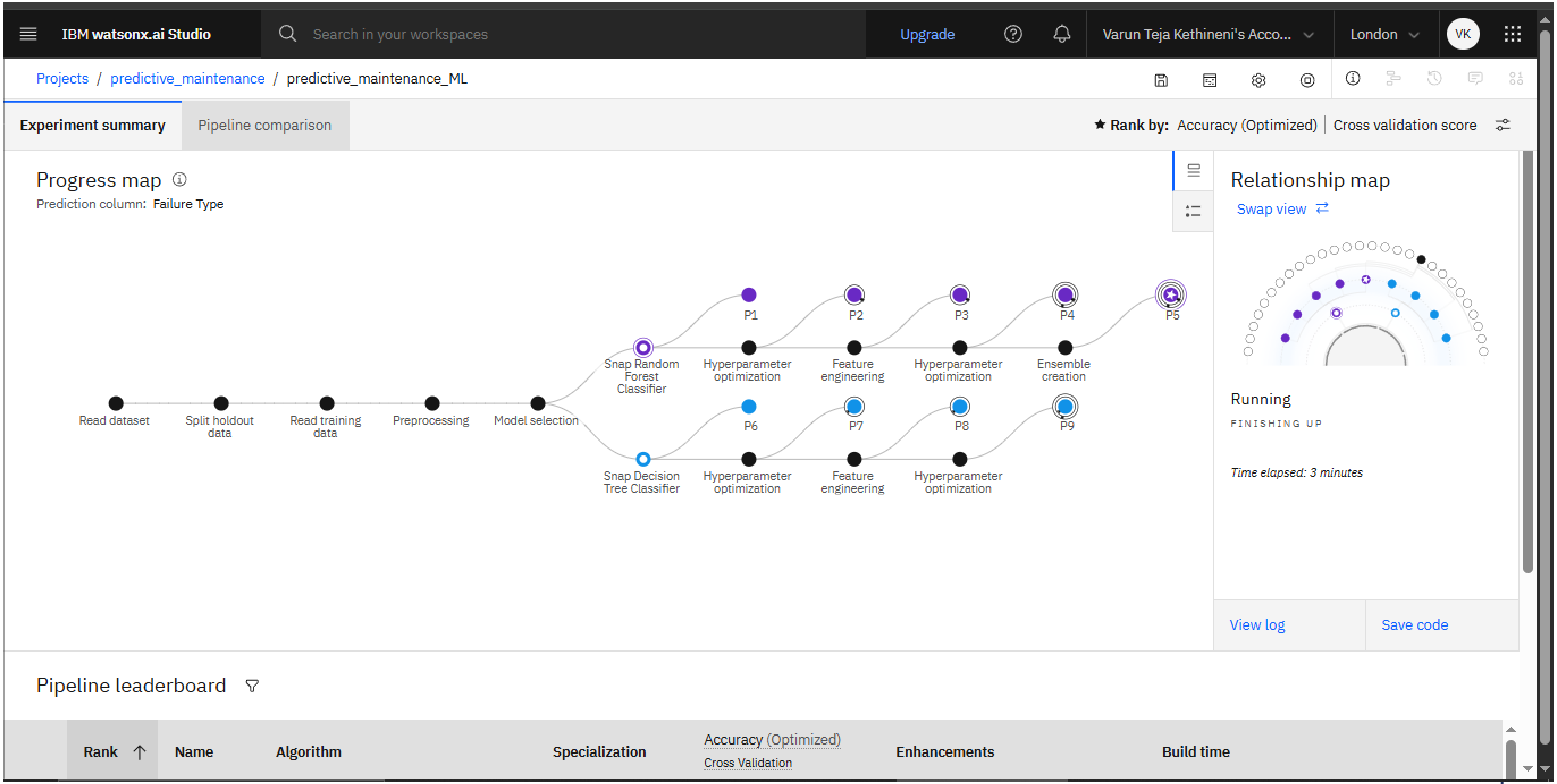
ALGORITHM & DEPLOYMENT

- In the Algorithm section, describe the machine learning algorithm chosen for predicting bike counts. Here's an example structure for this section:
- **Algorithm Selection:**
  - Random Forest Classifier was selected for its accuracy, ability to handle sensor data, and interpretability.
  - Compared with XGBoost and Logistic Regression, it gave the best results for our dataset.
- **Data Input:**
  - Features used: Air temperature, Process temperature, Rotational speed, Torque, Tool wear.
  - Target: Failure type (e.g., Tool wear, Heat dissipation, Power failure)..
- **Training Process:**
  - Data split: 80% training, 20% testing.
  - Preprocessing included feature scaling and encoding.
  - Model tuned using Grid Search and evaluated using Accuracy and F1-Score..
- **Prediction Process:**
  - Real-time sensor data is fed to the model.
  - The model predicts the failure type and triggers alerts for timely maintenance..

RESULT



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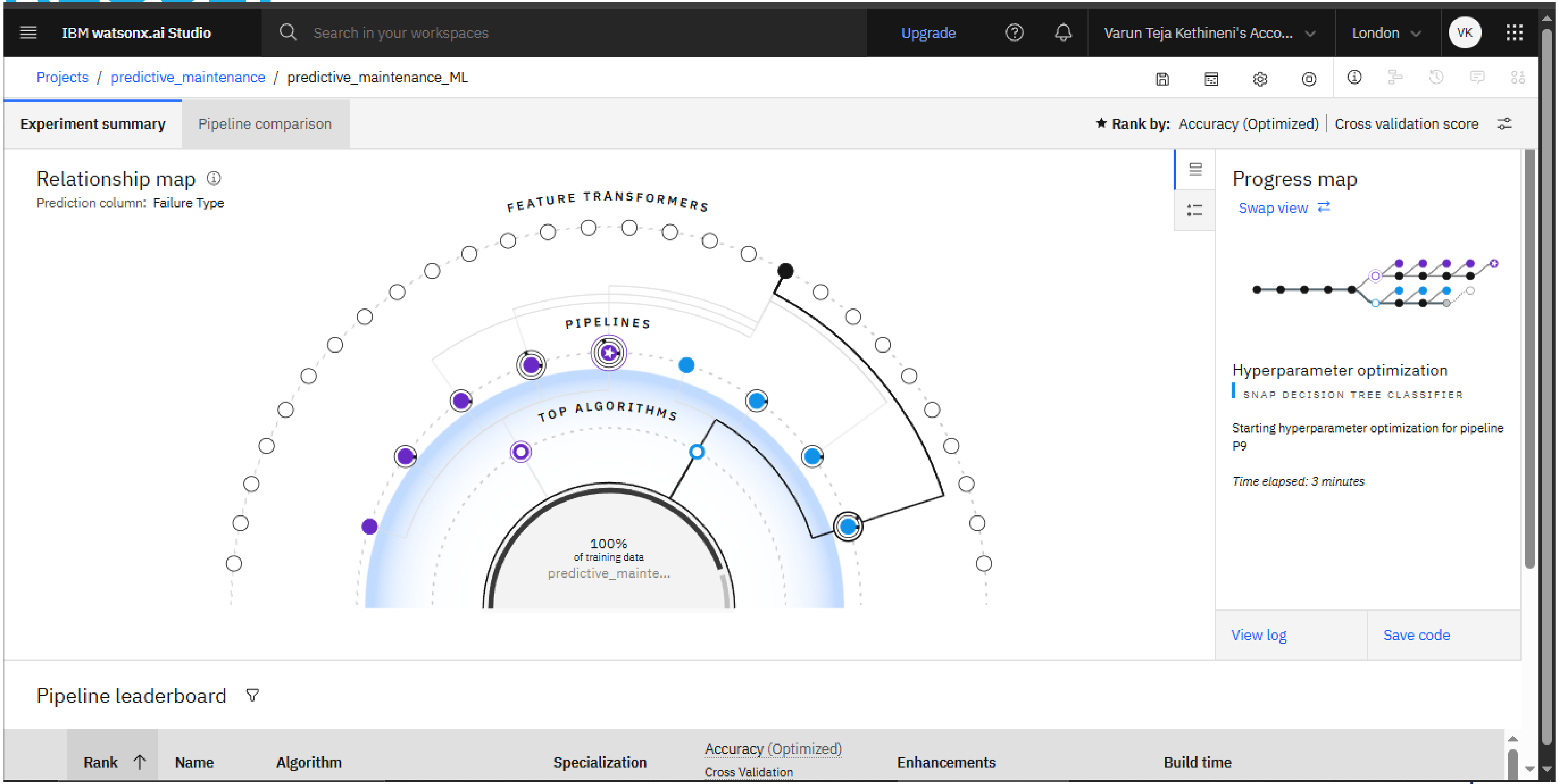
Projects / predictive_maintenance / predictive_maintenance_ML
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Failure Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Random Forest Classifier
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Ensemble creation
P1
P2
P3
P4
P5
P6
P7
P8
P9
Relationship map
Swap view
Running
FINISHING UP
Time elapsed: 3 minutes
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized)
Cross Validation
Enhancements
Build time

RESULT



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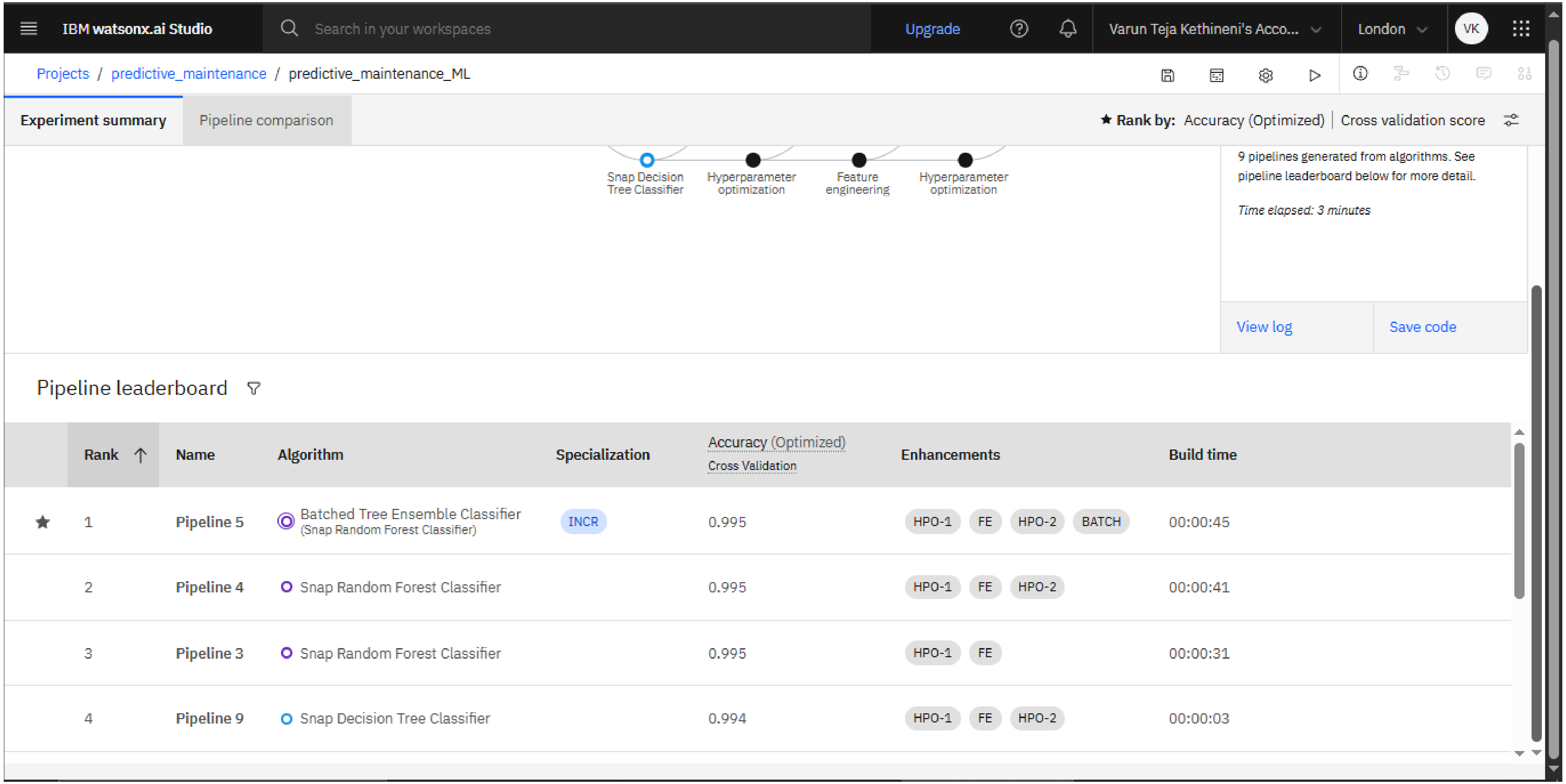
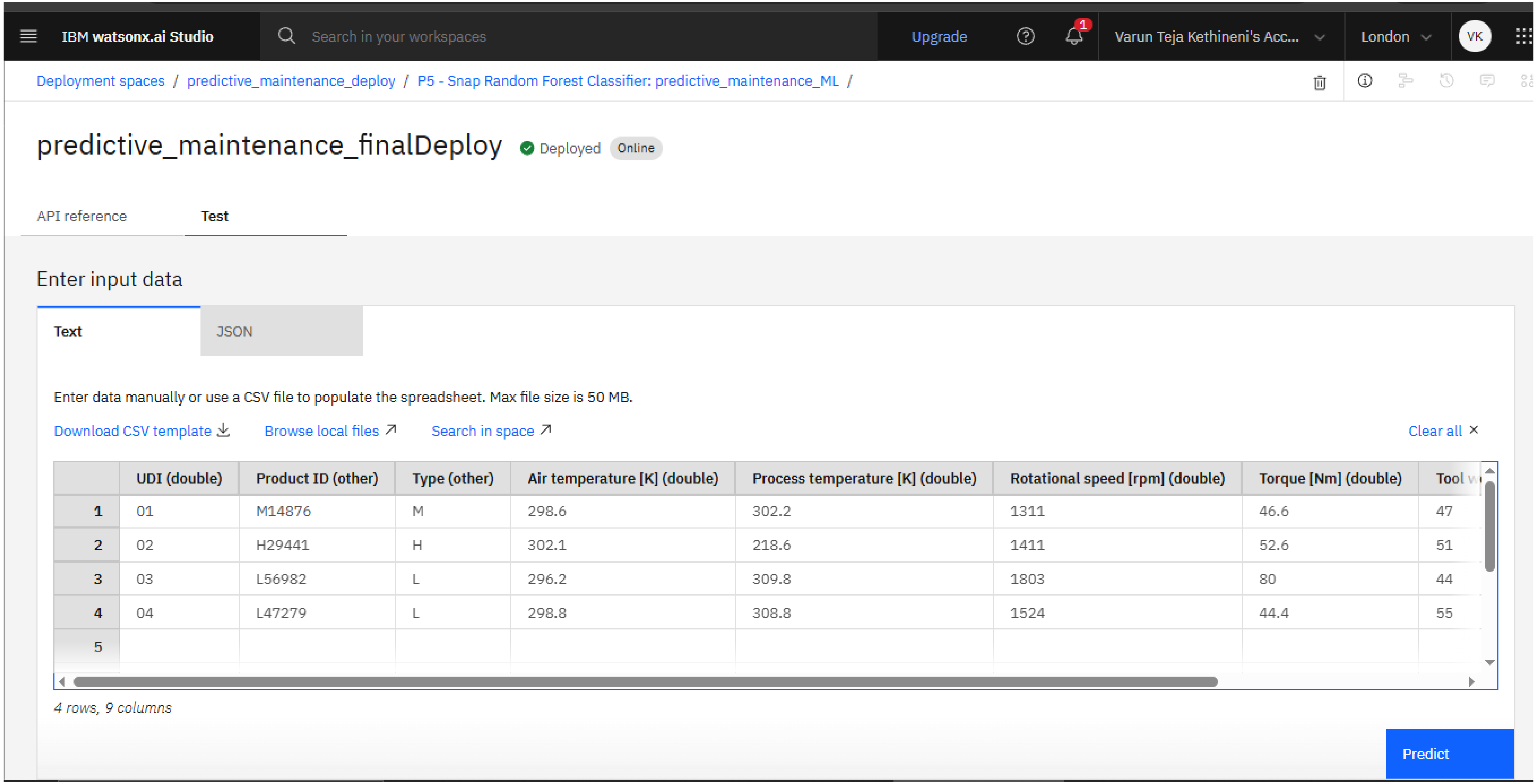
RESULT



	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	00:00:45
	2	Pipeline 4	Snap Random Forest Classifier		0.995	HPO-1 FE HPO-2	00:00:41
	3	Pipeline 3	Snap Random Forest Classifier		0.995	HPO-1 FE	00:00:31
	4	Pipeline 9	Snap Decision Tree Classifier		0.994	HPO-1 FE HPO-2	00:00:03

RESULT



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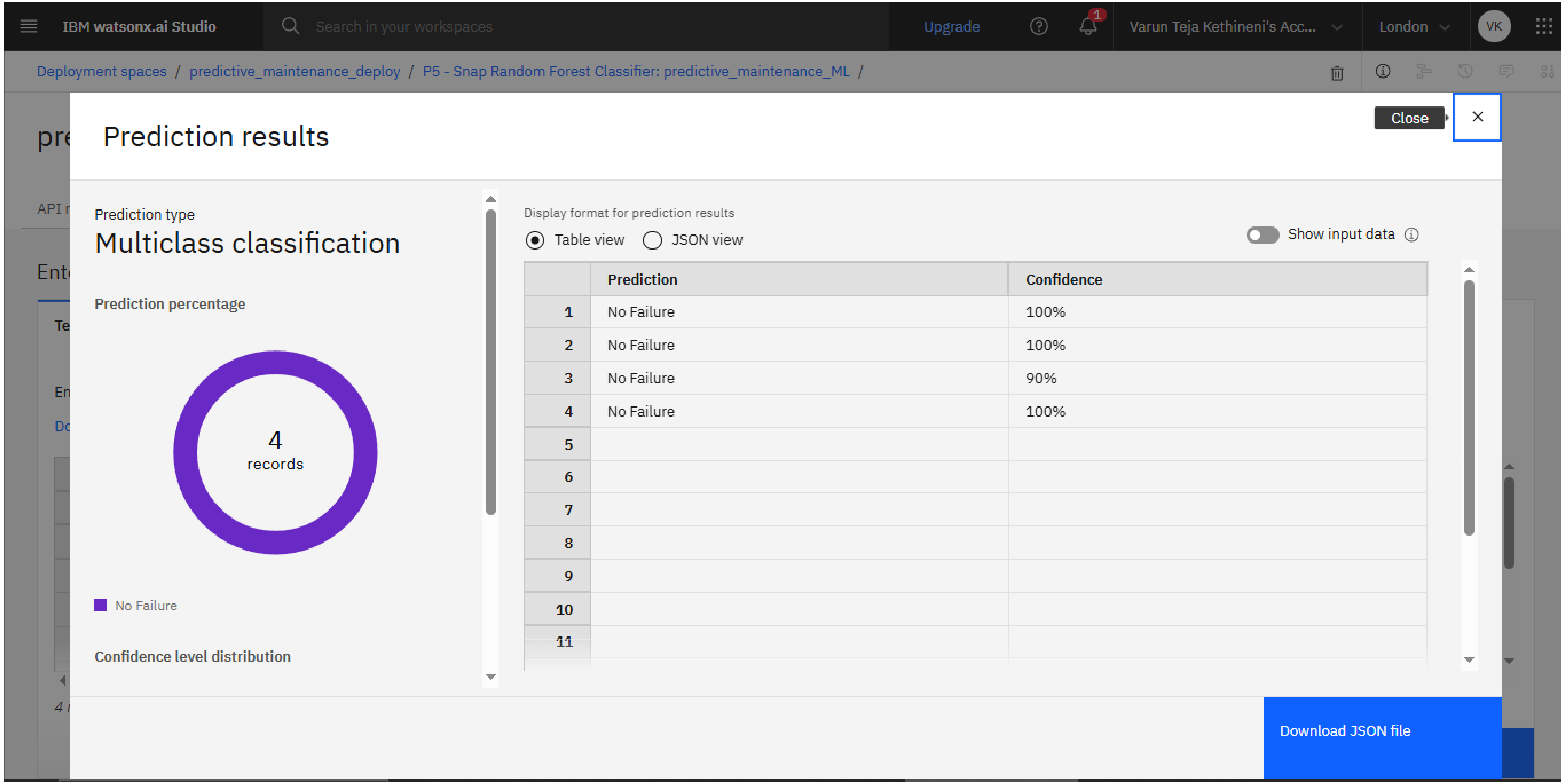
RESULT



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CONCLUSION

- This project successfully demonstrates the use of machine learning to predict industrial machine failures using sensor data. By training a classification model on a Kaggle-sourced dataset, we were able to identify failure types in advance based on key features like temperature, torque, and tool wear.
- The solution enables timely maintenance decisions, reduces unplanned downtime, and improves operational efficiency. With deployment on IBM Cloud, the model can be integrated into real-time systems, making it scalable and industry-ready.
- This approach highlights the potential of predictive maintenance in smart manufacturing and supports the shift toward data-driven maintenance strategies

FUTURE SCOPE

- Integrate live sensor data for real-time failure prediction using IoT.
- Explore deep learning models to improve prediction accuracy.
- Automate maintenance scheduling based on failure type and urgency.
- Optimize the model for edge deployment to reduce response time.
- Adapt the system for other industries like aviation or automotive.

REFERENCES

- Kaggle Dataset – Predictive Maintenance Dataset
  https://www.kaggle.com/datasets/shivamb/machinepredictive-maintenance-classification

- IBM Cloud – Watson Studio & Model Deployment
  https://www.ibm.com/cloud/watson-studio

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