CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- 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 machine learning model that predicts equipment failures before they occur, using real-time sensor data from industrial machines. This enables proactive maintenance, reducing downtime and optimizing operational efficiency.
- **Data Utilization**
  - Use sensor data such as air temperature, process temperature, torque, rotational speed, and tool wear.
  - The target variable is the type of failure (e.g., Tool Wear, Heat Dissipation, Power Failure, Overstrain, Random Failure).
- **Data Preprocessing**
  - Clean and transform data to address missing values and inconsistencies.
  - Apply feature engineering techniques to improve model accuracy.
- **Model Building**
  - Use IBM Watson AutoAI to automatically test, select, and optimize machine learning models.
  - The Snap Random Forest Classifier was selected based on its superior performance in multiclass classification.
- **Deployment**
  - Deploy the trained model to predict failures in real-time using incoming sensor data.
  - Integrate predictions into a dashboard or alert system for maintenance teams.
- **Expected Outcome**
  - Early detection of potential failures.
  - Reduced unplanned downtime and maintenance costs.
  - Enhanced decision-making through data-driven insights.

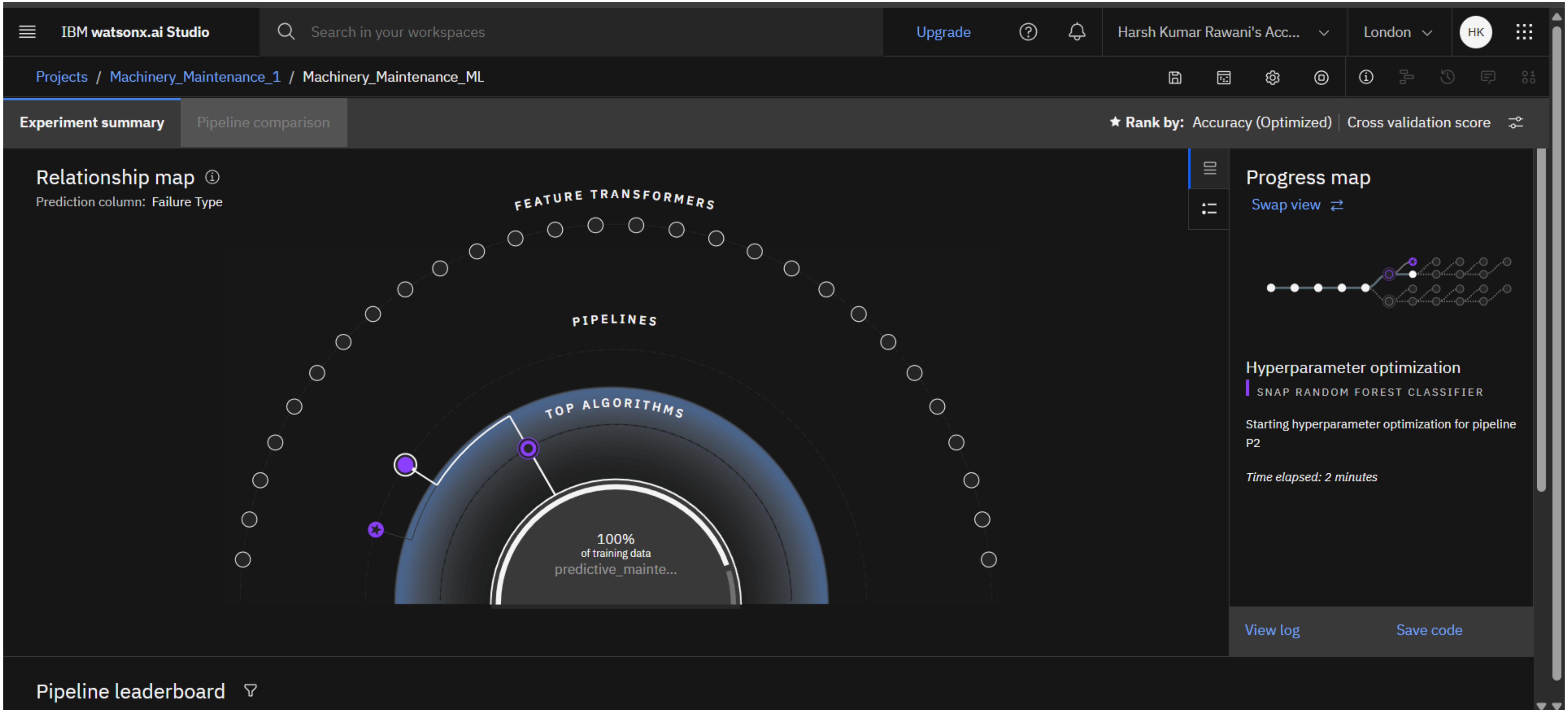
SYSTEM APPROACH

- The overall strategy and methodology for developing and implementing the power system fault detection and classification. Here's a suggested structure for this section :
- System requirements :
  - IBM Cloud(mandatory)
  - IBM Watson studio for model development and deployment
  - IBM cloud object storage for dataset handling

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - IBM watsonx.ai Studio tested multiple models. The Snap Random Forest Classifier was chosen for its high accuracy in predicting failure types.
- **Data Input:**
  - Sensor data like air/process temperature, torque, rotational speed, and tool wear were used as input. The target was the Failure Type.
- **Training Process:**
  - IBM watsonx.ai Studio handled data preprocessing, feature engineering, and hyperparameter tuning automatically across 8 pipelines. The best-performing model was selected using cross-validation.
- **Prediction Process:**
  - The final model predicts specific machine failures in real-time and can be integrated into dashboards for proactive maintenance alerts.

RESULT



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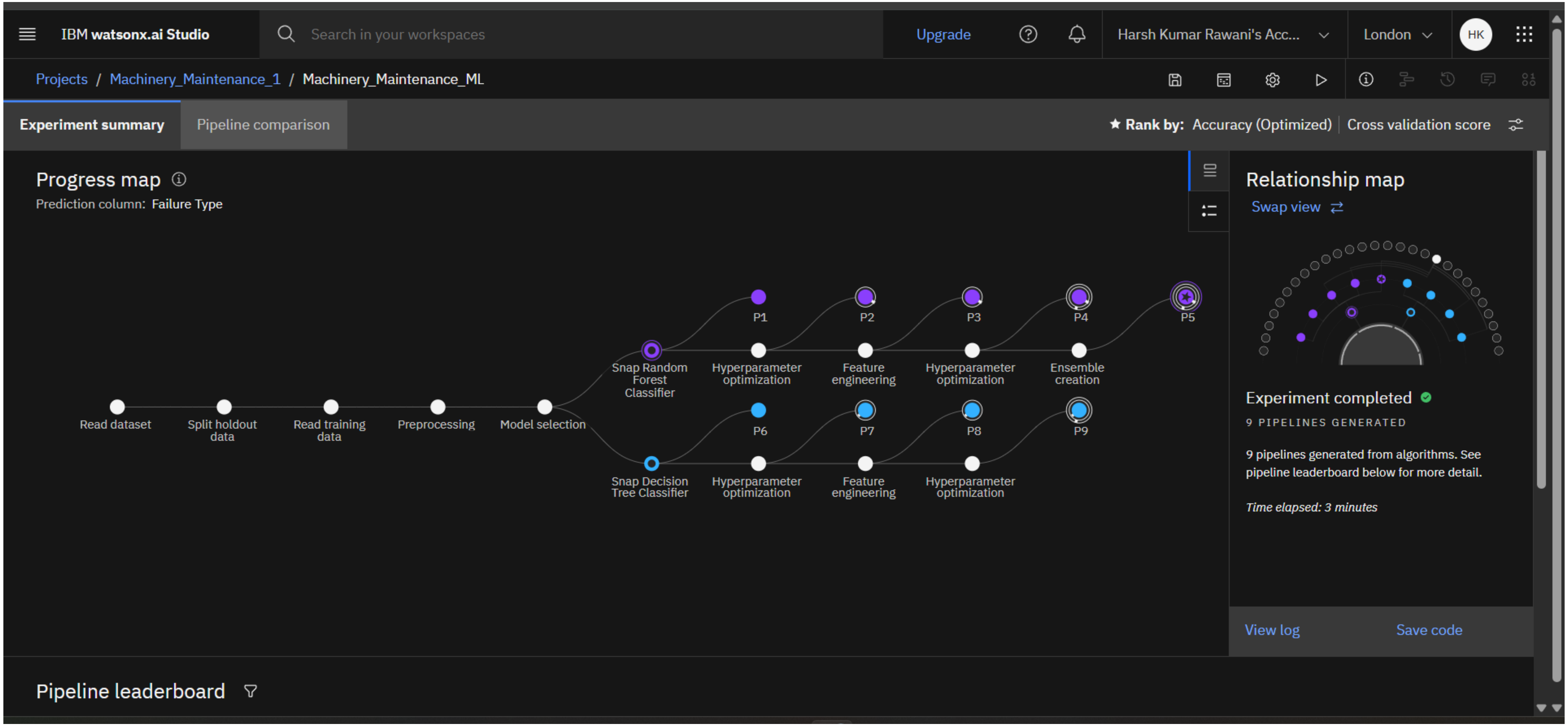
RESULT



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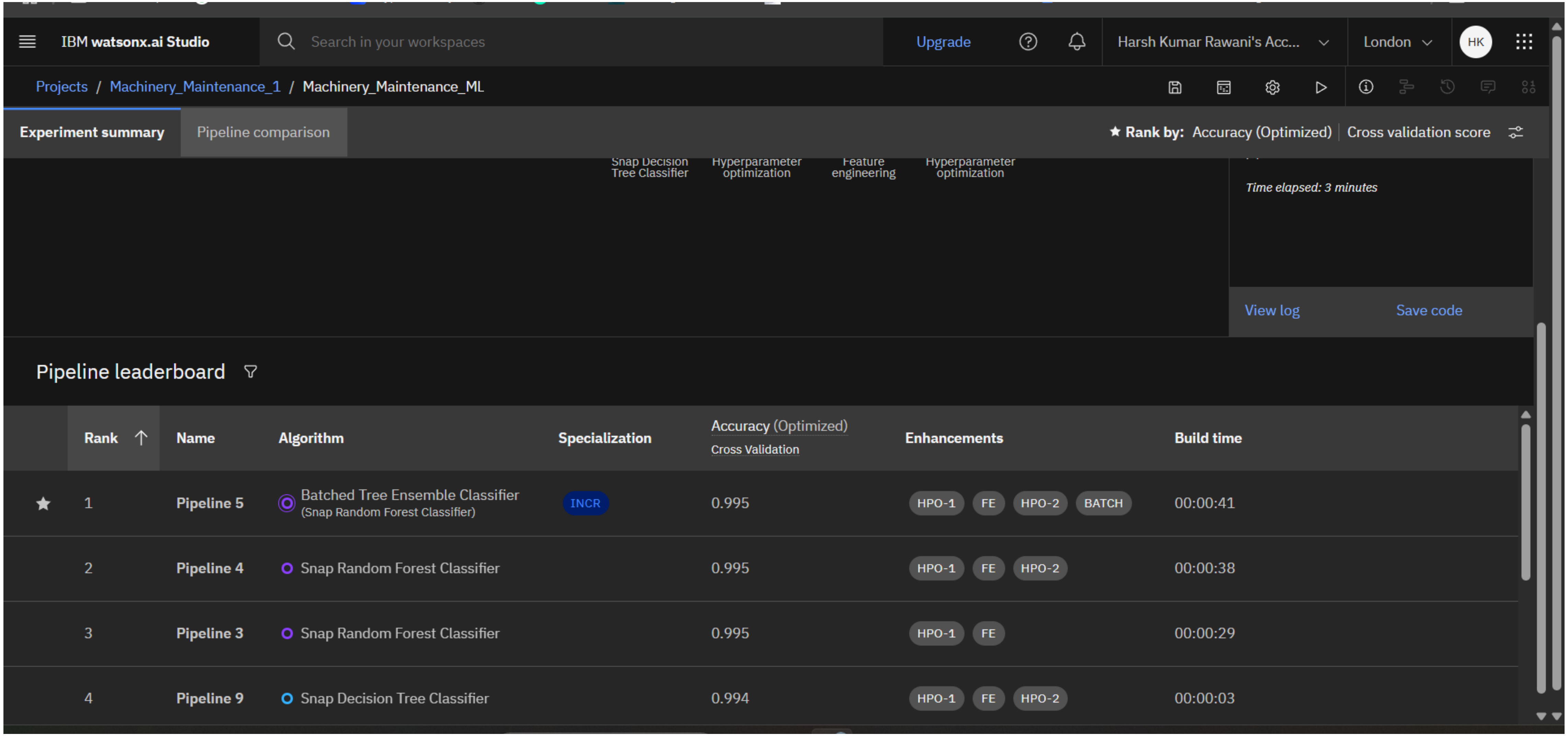
RESULT


IBM watsonx.ai Studio
Search in your workspaces
Upgrade
Harsh Kumar Rawani's Acc...
London
HK
Projects / Machinery_Maintenance_1 / Machinery_Maintenance_ML
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Time elapsed: 3 minutes
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
00:00:41
2
Pipeline 4
Snap Random Forest Classifier
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HPO-1 FE HPO-2
00:00:38
3
Pipeline 3
Snap Random Forest Classifier
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4
Pipeline 9
Snap Decision Tree Classifier
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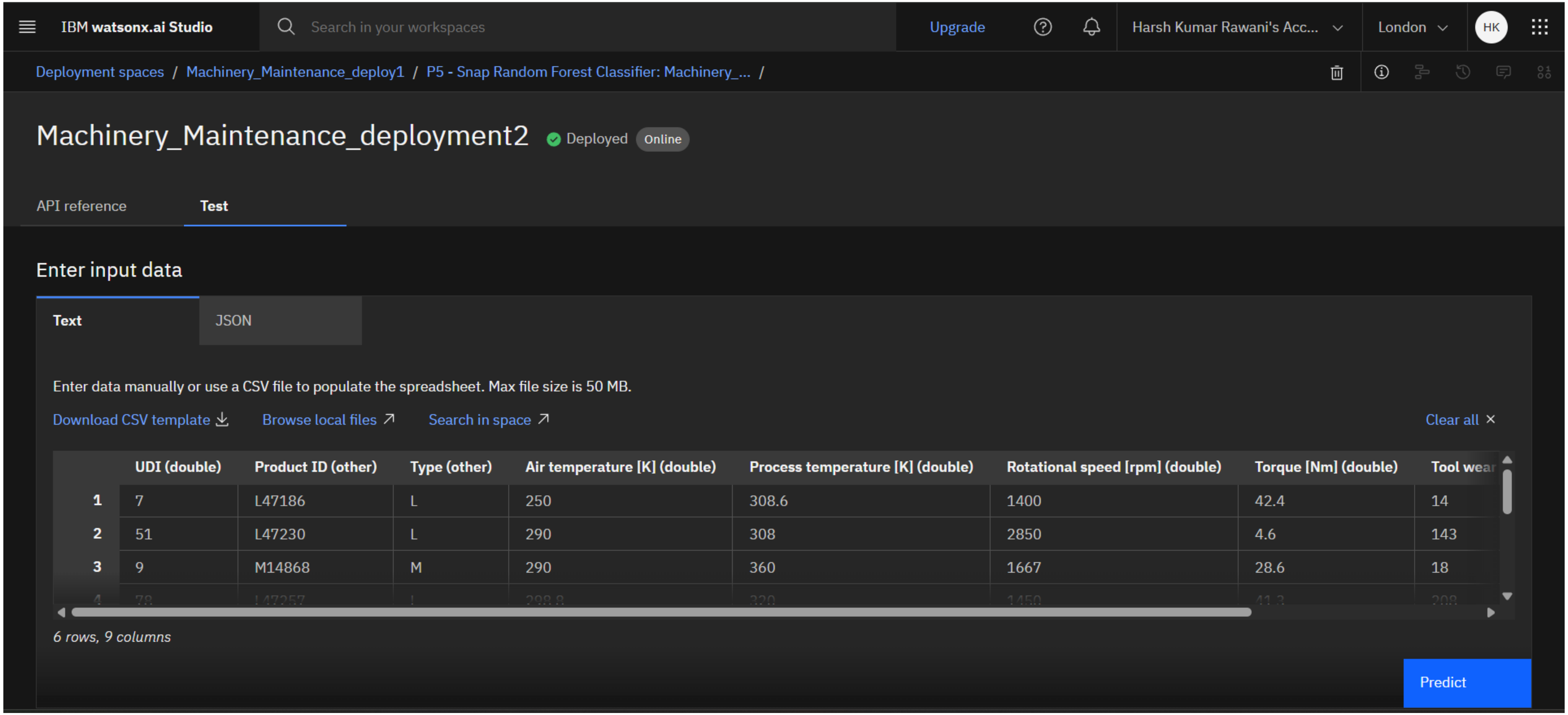
HPO-1 FE HPO-2
00:00:03

RESULT



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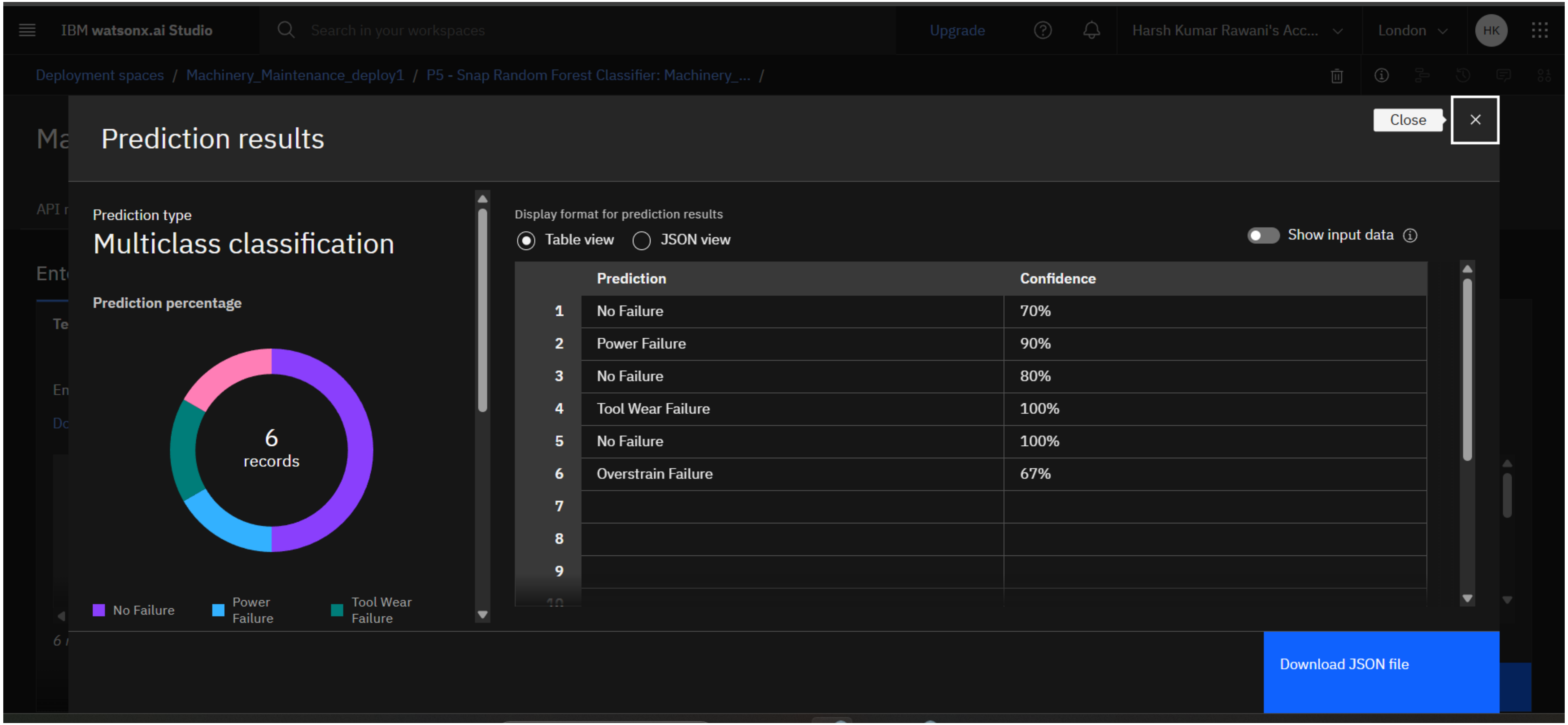
RESULT



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CONCLUSION

- The predictive maintenance model accurately predicts machine failure types like tool wear, heat dissipation, and power failure using real-time sensor data. It enables proactive maintenance, reducing downtime and costs.
- Effectiveness:
  - The model, built using IBM watsonx.ai Studio, showed strong performance and streamlined deployment.
- Challenges:
  - Faced issues like class imbalance, real-time integration, and sensor data quality.
- Improvements:
  - Use more diverse data, apply balancing techniques, and deploy a real-time alert system.
- Importance:
  - This solution helps industries shift from reactive to predictive maintenance, boosting efficiency, safety, and cost savings.

FUTURE SCOPE

- Explore potential improvements and extensions of the predictive maintenance system. This includes integrating additional sensor types (e.g., vibration, pressure), enhancing model accuracy through advanced algorithms like deep learning, and adapting the system for different types of machinery across industries.

- Further expansion could involve real-time deployment using edge devices, cloud integration for centralized monitoring, and scaling the solution to manage multiple factories or industrial sites. Incorporating automated retraining pipelines and IoT-based streaming data will further strengthen the system's adaptability and long-term effectiveness.

REFERENCES

- List and cite relevant sources, datasets, and tools used in developing the predictive maintenance model. This includes research on machine failure prediction, classification algorithms, and model evaluation techniques.
- Kaggle Dataset:
  - https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification
- IBM watsonx.ai Studio Documentation – Model automation and optimization
- Academic literature on Random Forest and ensemble learning for fault detection
- Articles on best practices in sensor data preprocessing and handling class imbalance in industrial datasets

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