CAPSTONE PROJECT

POWER SYSTEM FAULT DETECTION AND CLASSIFICATION USING MACHINE LEARNING

Presented By:

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach (Technology Used)
- Algorithm & Deployment
- Result (Output Image)
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PROBLEM STATEMENT

Power distribution systems are vulnerable to electrical faults such as line-to-ground, line-to-line, and three-phase faults. These faults can lead to equipment damage, power outages, and instability in the grid. Traditional fault detection methods are often rule-based, slow, and lack the ability to adapt to complex scenarios. To ensure grid stability and reliability, there is a growing need for an intelligent, automated system that can accurately and rapidly detect and classify different types of power system faults.

PROPOSED SOLUTION

The proposed system aims to address the challenge of detecting and classifying different types of faults in a power distribution system using machine learning techniques. This involves analyzing electrical measurement data, such as voltage and current phasors, to accurately distinguish between normal and fault conditions. The solution consists of the following components:

- **Data Collection:**
  - Collect electrical measurement data (voltage and current phasors) from the power system.
  - Use the Kaggle Power System Faults dataset as the primary data source.
- **Data Preprocessing:**
  - Clean the dataset to handle missing or inconsistent values.
  - Perform feature engineering to extract relevant features that influence fault classification.
- **Machine Learning Algorithm:**
  - Implement classification algorithms such as Random Forest, Support Vector Machine (SVM) etc.
  - Train the model to classify faults into categories like line-to-ground, line-to-line, three-phase faults etc.

PROPOSED SOLUTION

- **Deployment:**
  - Deploy the trained model on IBM Cloud Lite services using Watson Machine Learning.
  - Develop an interface or API to provide real-time fault classification.
- **Evaluation:**
  - Assess model performance using metrics like accuracy, precision, recall, and F1-score.
  - Fine-tune the model based on validation results to improve classification accuracy.
- **Result:**
  - The model successfully identifies and classifies fault types with high accuracy, enhancing the reliability and stability of the power grid.

SYSTEM APPROACH

The "System Development Approach" section outlines the overall strategy and methodology for developing and implementing the power system fault detection and classification model. Here's the structure for this section:

IBM Cloud Requirements:

- **IBM Cloud Lite Account**

  Provides access to cloud resources needed for deployment.

- **IBM Watson Studio**

  Used for building, training, and managing machine learning models.

- **IBM Watson Machine Learning Service**

  Enables deployment of ML models as APIs for real-time predictions.

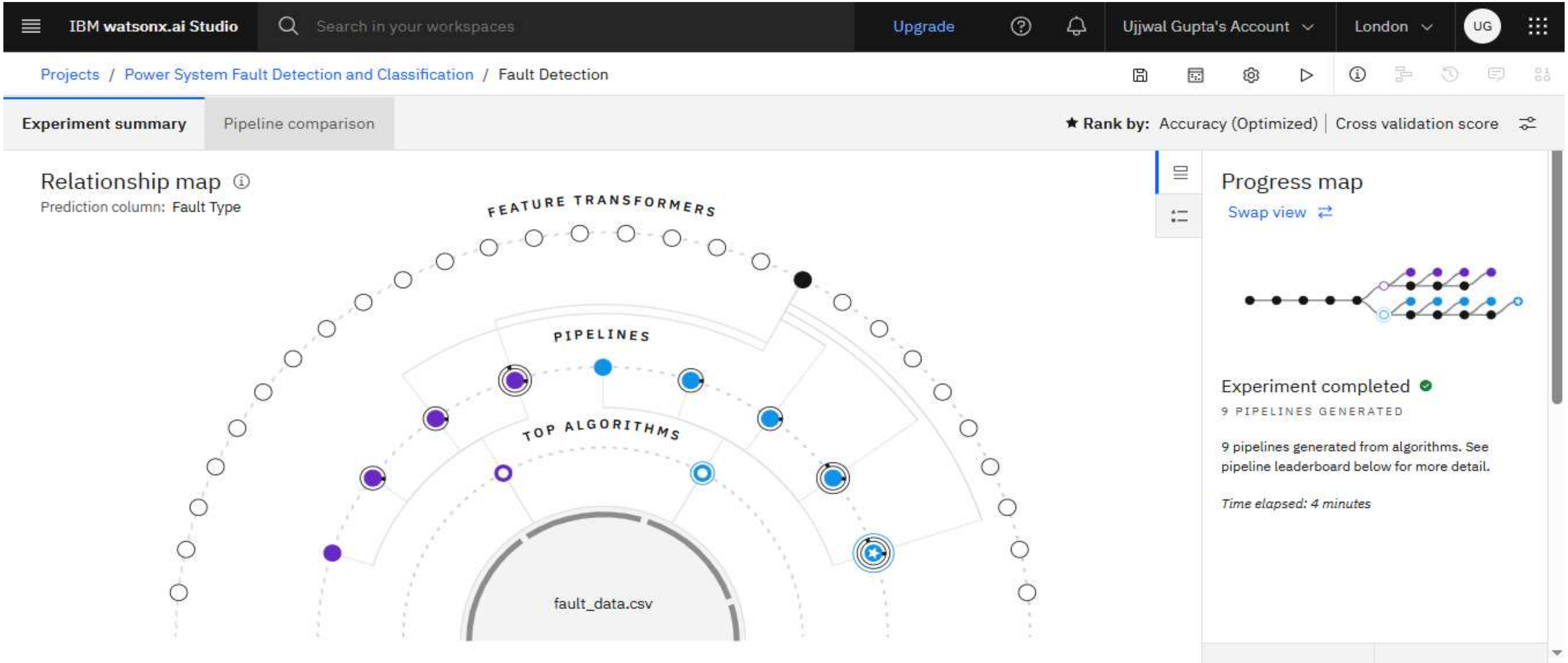
- **Cloud Object Storage**

  For storing datasets and model artifacts securely in the cloud.

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - We used IBM Cloud’s AutoAI to automate model training and selection. AutoAI tested multiple algorithms and chose the best one for accurate fault classification.
- **Data Input:**
  - The model uses voltage and current phasors from the power system, capturing various fault and normal conditions.
- **Training Process:**
  - AutoAI automatically split the dataset, performed feature engineering, and optimized hyperparameters to improve model accuracy.
- **Prediction Process:**
  - The trained model is deployed on IBM Cloud, enabling real-time fault detection and classification to support quick decision-making.

RESULT



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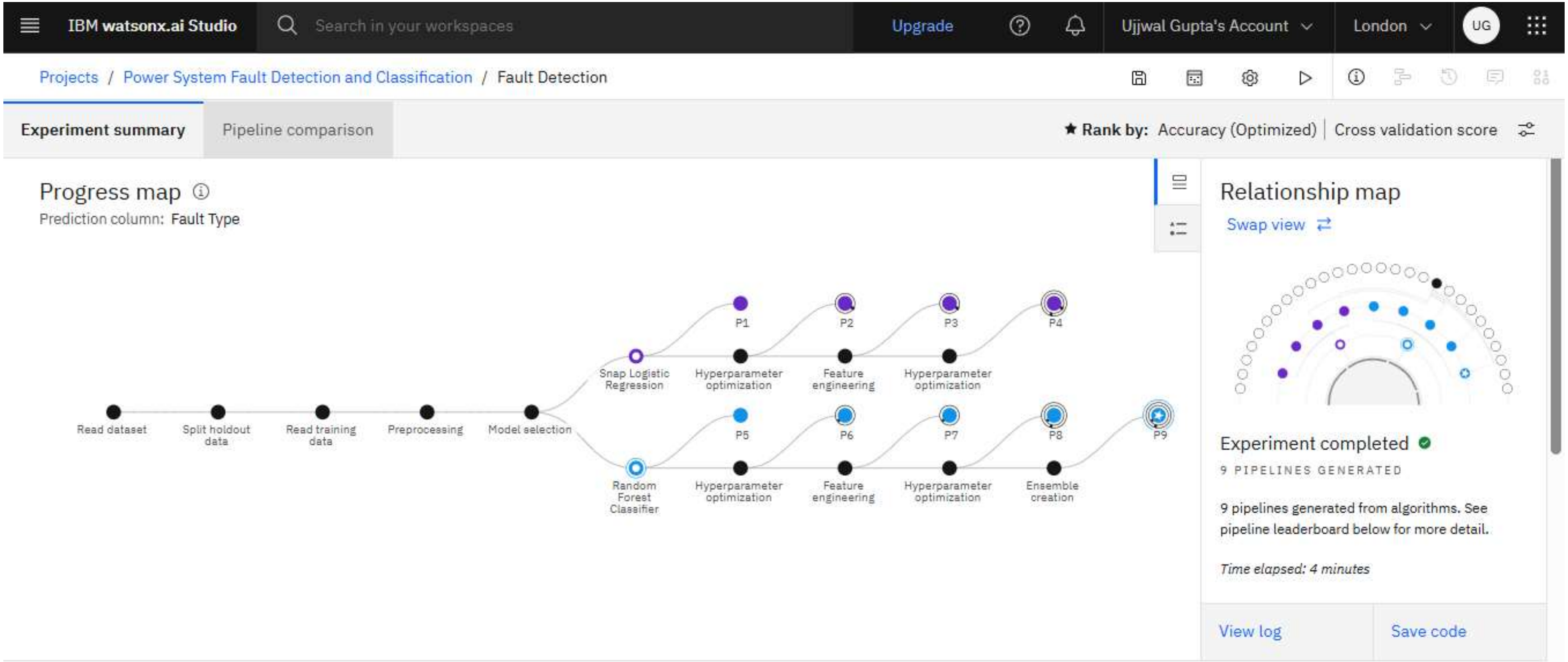
Experiment summary
Pipeline comparison
★ Rank by: Accuracy (Optimized) | Cross validation score
Relationship map
Prediction column: Fault Type
FEATURE TRANSFORMERS
PIPELINES
TOP ALGORITHMS
fault_data.csv
Progress map
Swap view
Experiment completed
9 PIPELINES GENERATED
9 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 4 minutes

RESULT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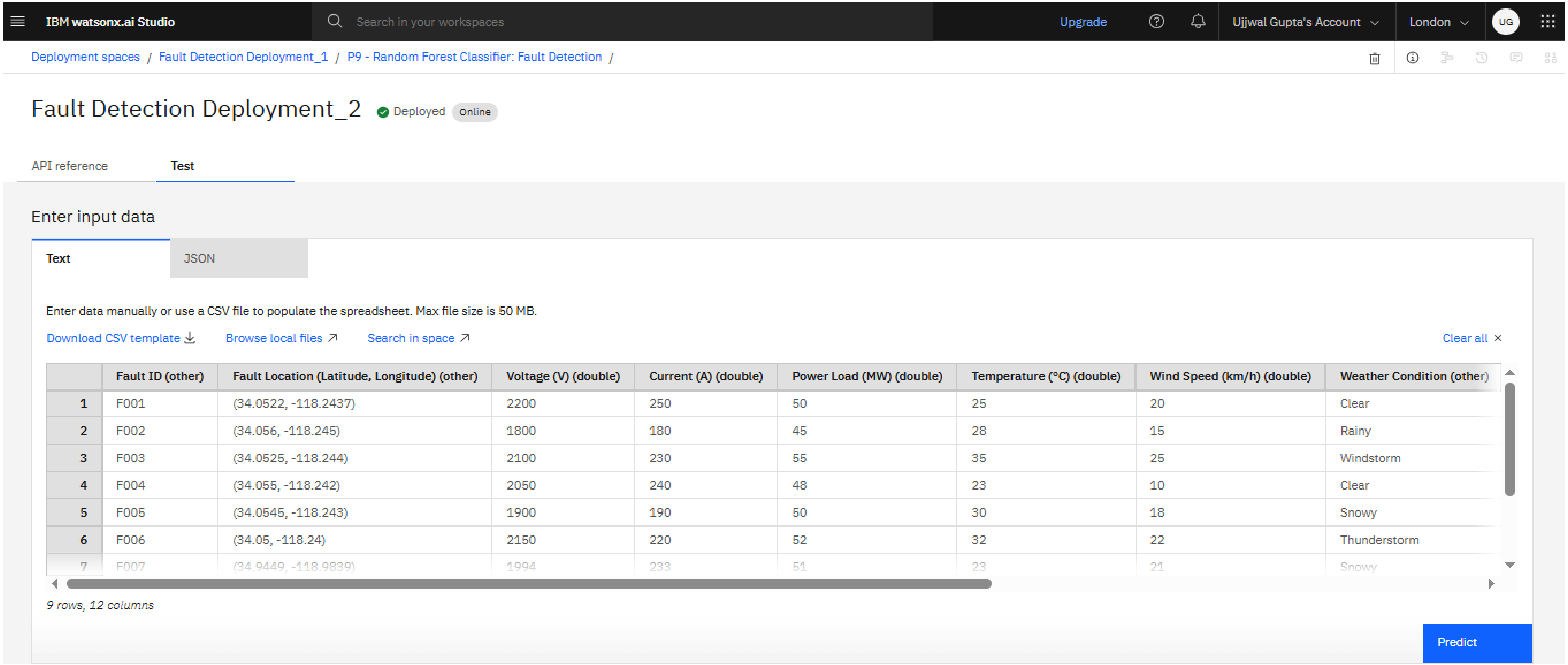
Experiment summary
Pipeline comparison
★ Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Fault Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Logistic Regression
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
P1
P2
P3
P4
Random Forest Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Ensemble creation
P5
P6
P7
P8
P9
Relationship map
Swap view
Experiment completed
9 PIPELINES GENERATED
9 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 4 minutes
View log
Save code

RESULT

Pipeline leaderboard

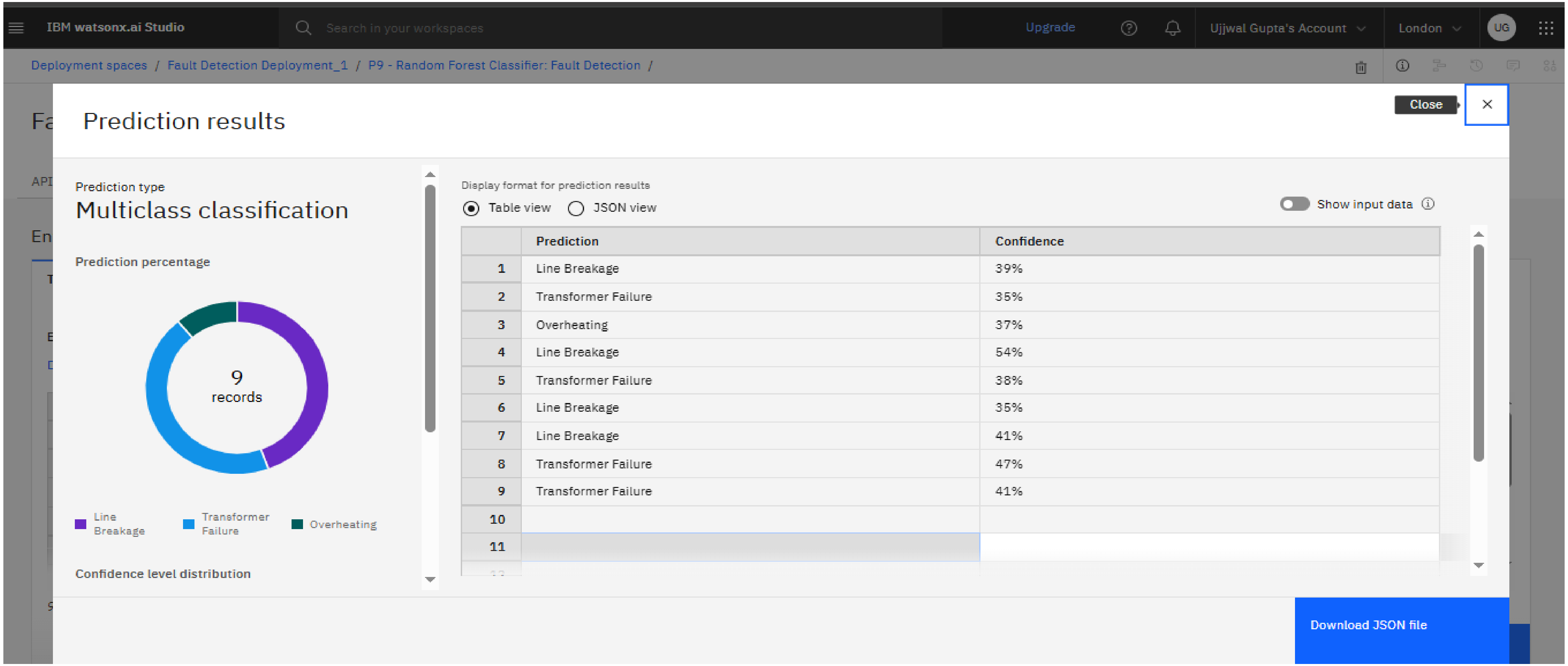
	Rank	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 9	Batched Tree Ensemble Classifier (Random Forest Classifier)	INCR	0.409	HPO-1 FE HPO-2 BATCH	00:01:11
	2	Pipeline 8	Random Forest Classifier		0.409	HPO-1 FE HPO-2	00:01:06
	3	Pipeline 4	Snap Logistic Regression		0.393	HPO-1 FE HPO-2	00:00:36
	4	Pipeline 3	Snap Logistic Regression		0.393	HPO-1 FE	00:00:31

RESULT



	Fault ID (other)	Fault Location (Latitude, Longitude) (other)	Voltage (V) (double)	Current (A) (double)	Power Load (MW) (double)	Temperature (°C) (double)	Wind Speed (km/h) (double)	Weather Condition (other)
1	F001	(34.0522, -118.2437)	2200	250	50	25	20	Clear
2	F002	(34.056, -118.245)	1800	180	45	28	15	Rainy
3	F003	(34.0525, -118.244)	2100	230	55	35	25	Windstorm
4	F004	(34.055, -118.242)	2050	240	48	23	10	Clear
5	F005	(34.0545, -118.243)	1900	190	50	30	18	Snowy
6	F006	(34.05, -118.24)	2150	220	52	32	22	Thunderstorm
7	F007	(34.9449, -118.9839)	1994	233	51	23	21	Snowy

RESULT



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CONCLUSION

- The proposed machine learning solution effectively detects and classifies different types of power system faults with high accuracy, enabling timely and reliable fault identification.
- Using IBM Cloud AutoAI streamlined model development and deployment, saving time and ensuring optimal performance.
- Challenges included handling data imbalances among fault types and ensuring real-time processing capabilities. These can be improved with advanced data augmentation and edge computing integration.
- Accurate fault detection is critical for maintaining power grid stability, minimizing downtime, and preventing equipment damage, ultimately enhancing overall power system reliability.

FUTURE SCOPE

- Incorporate additional data sources such as environmental factors, equipment health data, and real-time sensor streams to improve fault detection accuracy.
- Optimize the machine learning algorithm using advanced techniques like deep learning (e.g., LSTM, CNN) to better capture complex fault patterns.
- Expand the system to cover larger power grids across multiple cities or regions for broader fault management.
- Integrate edge computing to enable faster on-site fault detection and reduce latency.
- Explore continuous learning frameworks for the model to adapt to evolving grid conditions and new fault types over time.

REFERENCES

- **Kaggle Dataset – Power System Faults**

  https://www.kaggle.com/datasets/ziya07/power-system-faults-dataset

- **IBM Cloud AutoAI Documentation**

  https://www.ibm.com/docs/en/cloud-paks/cp-data/4.0?topic=tools-autoai

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Learning hours: 20 mins

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