CAPSTONE PROJECT

41.POWER SYSTEM FAULT DETECTION AND CLASSIFICATION

Presented By:
Gaurav Singh-University of Lucknow-Computer SCIENCE

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result
- Conclusion
- Future Scope

PROBLEM STATEMENT

Example: we design a machine learning model for identifying the faults in the power distribution system . Using the data provided ,the model should be able to differentiate different types of fault that occur .The main objective for this project is accurate fault type identification,which helps in maintaining the power grid stability and reliability.

PROPOSED SOLUTION

To detect and classify faults in a power distribution system, we propose a supervised machine learning-based solution that utilizes voltage and current phasor data collected from sensors such as Phasor Measurement Units (PMUs) or Intelligent Electronic Devices (IEDs). The solution includes the following steps:

- **1. Data Collection and Preprocessing** Collect time-series data of voltage and current phasors under both normal and various fault conditions (line-to-ground, line-to-line, and three-phase faults).Apply preprocessing techniques such as noise filtering, normalization, and feature extraction (e.g., magnitude, angle, rate of change).
- **2. Feature Engineering** Derive meaningful features such as sequence components, total harmonic distortion, and phase imbalances.Convert raw time-series into feature vectors or use sequence models to preserve temporal patterns.
- 3. **Model Selection and Training** Use machine learning algorithms like Random Forest, Support Vector Machine (SVM), or deep learning models like LSTM (Long Short-Term Memory) for temporal pattern recognition.Train the model using labeled data, where each sample is tagged as normal or a specific fault type.
- 4. **Fault Detection and Classification** Deploy the trained model to monitor real-time data and classify the system state.Upon detection of a fault, trigger alerts and identify the type of fault for appropriate corrective actions.
- **5. Evaluation and Deployment** Evaluate the model using accuracy, precision, recall, and confusion matrix to ensure high reliability.Integrate the system into the grid's monitoring infrastructure for real-time use and automate protection responses.

SYSTEM APPROACH

To complete the mentioned project we need the following different things with them creating the project becomes easier we also need dataset to enter for the following problem statement.

- System requirements

  ibm cloud
- Library required to build the model

  watson.ai

  (associate resource)watson.ai.runtime
- Dataset

  Fault_data.csv

ALGORITHM & DEPLOYMENT

- **1. Data Collection**: Acquire real-time voltage and current phasor data under normal and fault conditions using PMUs or IEDs.
- **2. Preprocessing & Feature Extraction**: Clean and normalize the data, extract key features like magnitude, phase angle, and sequence components.
- **3. Model Selection & Training**: Choose and train a suitable machine learning model (e.g., Random Forest, SVM, LSTM) using labeled data, and validate its performance.
- **4. Fault Detection & Classification**: Use the trained model to classify input data into normal operation or specific fault types (line-to-ground, line-to-line, or three-phase).
- **5. System Integration**: Deploy the model within SCADA or substation automation systems to monitor and respond in real-time.
- **6. Data Streaming & Inference**: Enable continuous data flow via communication protocols (like IEC 61850) to the deployed model.
- **7. Real-Time Alerts & Protection**: Upon fault detection, automatically trigger alarms, isolate faults, or activate protective measures.
- **8. Monitoring & Continuous Improvement**: Monitor the system's accuracy and retrain the model periodically with updated data to adapt to grid changes.

RESULT

IBM watsonx.ai Studio

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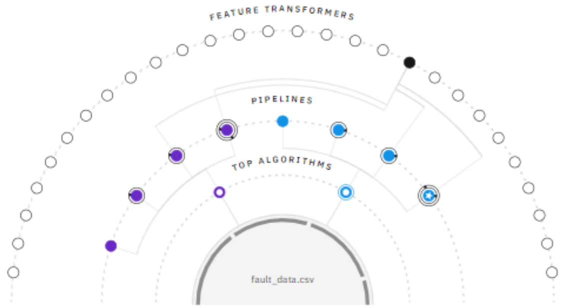
Experiment summary | Pipeline comparison

★ Rank by: Accuracy (Optimized) | Cross validation score

Relationship map

Prediction column: Fault Type



Progress map

Swap view

Experiment completed

8 PIPELINES GENERATED

8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.

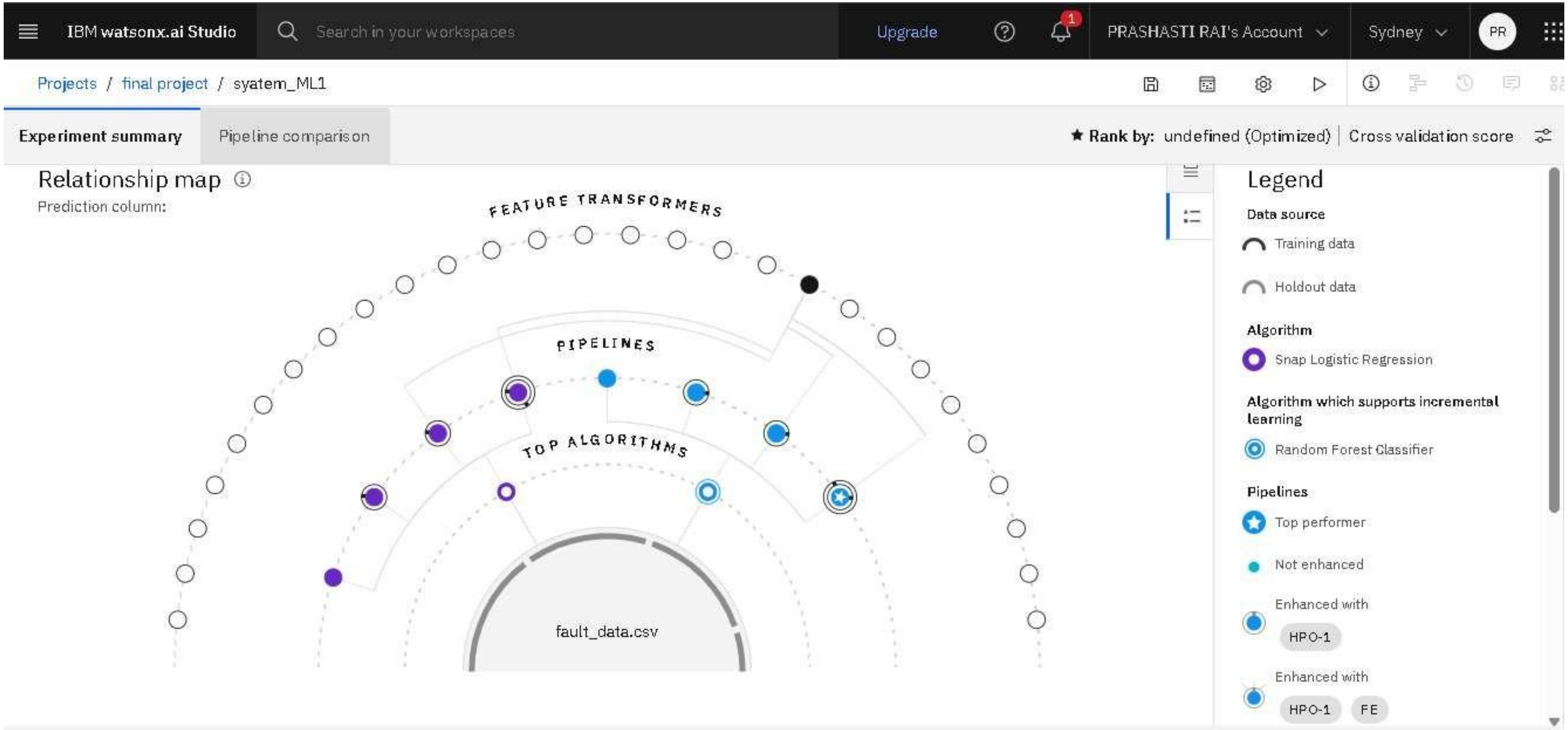
Time elapsed: 3 minutes

View log | Save code

Pipeline leaderboard

	Rank	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 8	Random Forest Classifier		0.409	HPO-1 FE HPO-2	00:00:56
	2	Pipeline 4	Snap Logistic Regression		0.393	HPO-1 FE HPO-2	00:00:37
	3	Pipeline 3	Snap Logistic Regression		0.393	HPO-1 FE	00:00:31
	4	Pipeline 7	Random Forest Classifier		0.376	HPO-1 FE	00:00:42
	5	Pipeline 6	Random Forest Classifier		0.369	HPO-1	00:00:07
	6	Pipeline 2	Snap Logistic Regression		0.367	HPO-1	00:00:06
	7	Pipeline 5	Random Forest Classifier		0.360	*None*	00:00:01
	8	Pipeline 1	Snap Logistic Regression		0.358	*None*	00:00:02

RESULT



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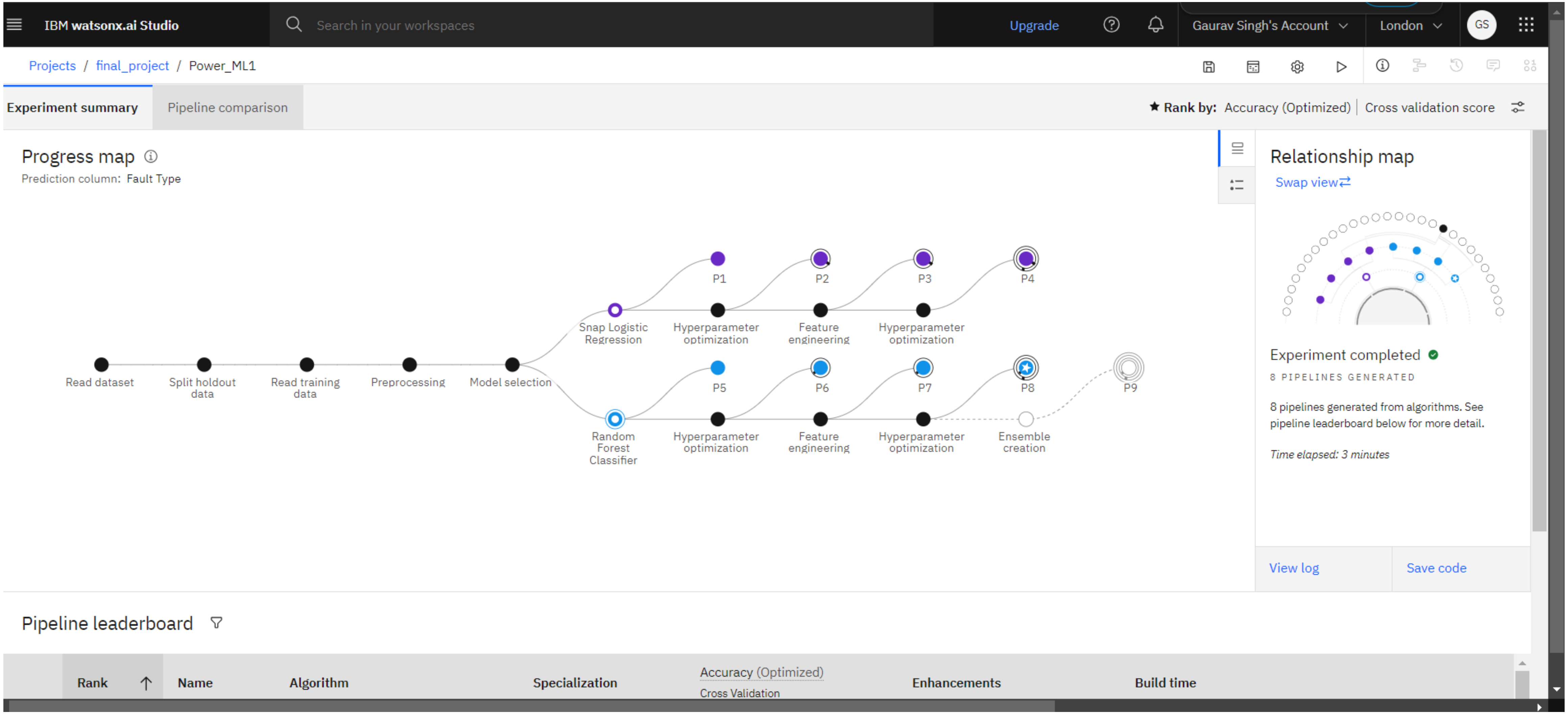
RESULT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Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Fault Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Logistic Regression
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
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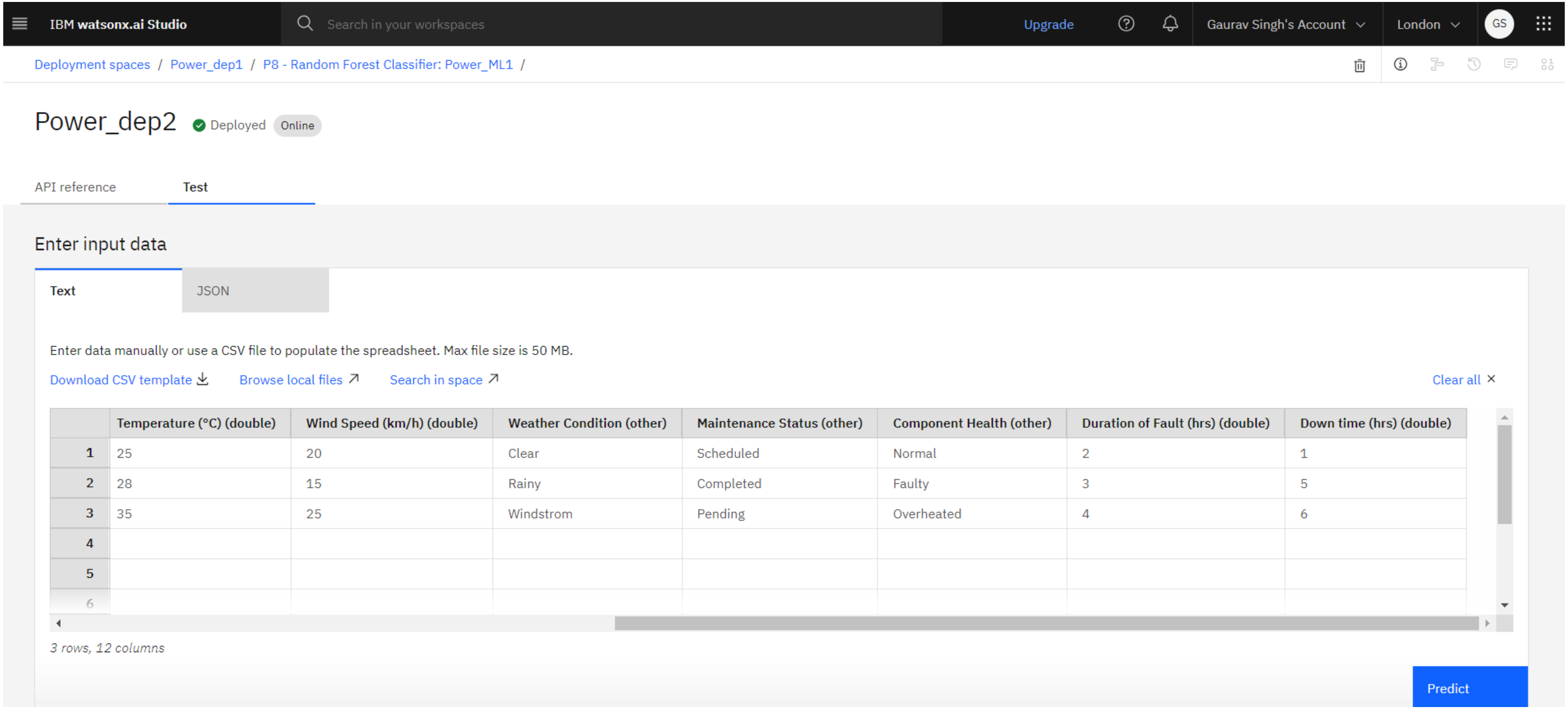
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized)
Cross Validation
Enhancements
Build time

RESULT



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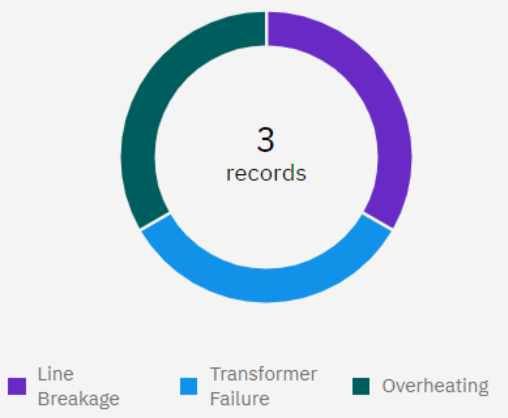
RESULT

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	Line Breakage	39%
2	Transformer Failure	35%
3	Overheating	37%
4		
5		
6		
7		
8		
9		
10		
11		
12		

Download JSON file

CONCLUSION

- This machine learning model brings a smart and reliable way to protect our power systems. By learning from real electrical signals-llike voltage and current – it can quickly telll the difference between normal operations and different types of faults. This means faster responses to issues, less damage to equipment, and fewer power outages for people and businesses.It's a step toward making our electricity grid more resilient and future-ready.As we continue to improve and integrate it with modern infrastructure,this technology can play a key role in keeping the lights on-safely and efficiently-for everyone.

FUTURE SCOPE

- The proposed machine learning model holds significant potential for future advancement in smart power systems. Integration with IoT-enabled smart grids and edge computing can enable real-time, decentralized fault detection with minimal latency. Adaptive learning and explainable AI will make the system more intelligent, transparent, and responsive to changing grid conditions. By incorporating data from multiple sources—such as environmental sensors or maintenance logs—the model can become even more accurate and predictive. Additionally, expanding to wide-area monitoring systems and integrating cybersecurity awareness will make the grid more secure and resilient. These innovations pave the way for a more automated, reliable, and intelligent power distribution network.

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