CAPSTONE PROJECT

POWER SYSTEM FAULT DETECTION AND CLASSIFICATION 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

Power distribution systems are prone to various faults such as line-to-ground, line-to-line, and three-phase faults, which can disrupt grid stability and reliability. This project aims to develop a machine learning model that can detect and classify these faults using electrical measurement data. The challenge is to ensure accurate and real-time fault detection using complex input data (e.g., voltage and current phasors). Automating fault diagnosis with ML techniques can enhance system response, reduce downtime, and improve overall grid performance.

PROPOSED SOLUTION

- **Design** a machine learning model capable of identifying and categorizing power system faults based on the given dataset. The model will analyze electrical signals to swiftly and accurately detect fault types. This intelligent classification will streamline fault detection and support faster system recovery, enhancing overall grid reliability.
- **Key components:**
- **Data Acquisition:** Utilize a publicly available dataset (e.g., from Kaggle) containing labeled power system fault scenarios.
- **Data Preparation:** Preprocess the data by cleaning, scaling, and transforming it into suitable input formats.
- **Model Development:** Implement and train classification algorithms such as Decision Tree, Random Forest, or Support Vector Machine (SVM).
- **Performance Assessment:** Evaluate the model using metrics like accuracy, precision, recall, and F1-score to ensure its effectiveness.

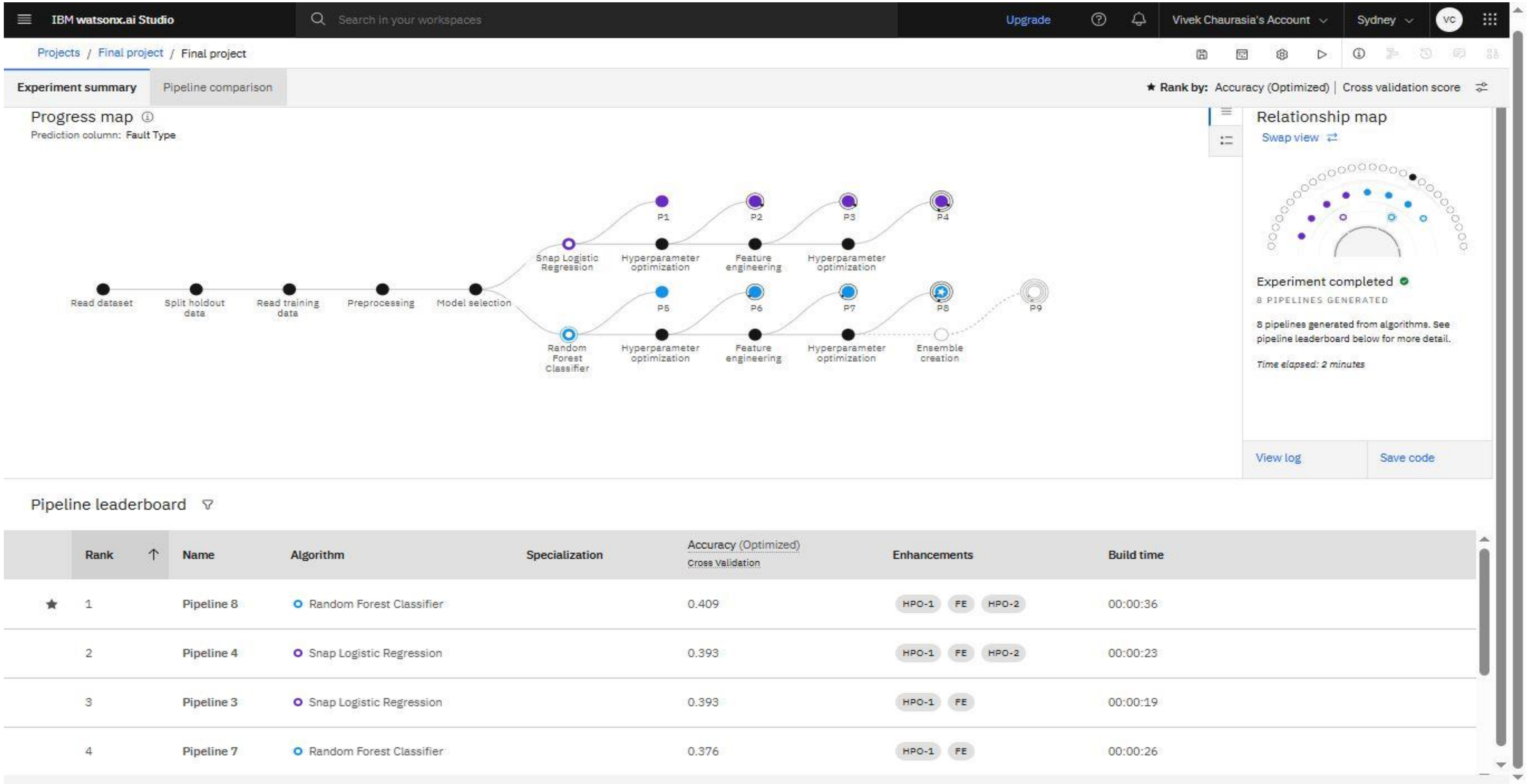
SYSTEM APPROACH

- The "System Approach" section outlines the overall framework and tools used for developing and deploying the machine learning model for fault detection in power systems. Below are the system requirements:
- System requirements:
  - IBM Cloud (required for deployment)
  - IBM Watson Studio for model development and deployment
  - IBM Cloud Object Storage for managing and accessing datasets

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  Random Forest Classifier (or SVM, depending on model performance)
- **Data Input:**
  Voltage, current, and phasor measurements extracted from the dataset
- **Training Process:**
  Supervised learning approach using labeled fault data for model training
- **Prediction Process:**
  Deploy the trained model on IBM Watson Studio using API endpoints for real-time fault classification

RESULT



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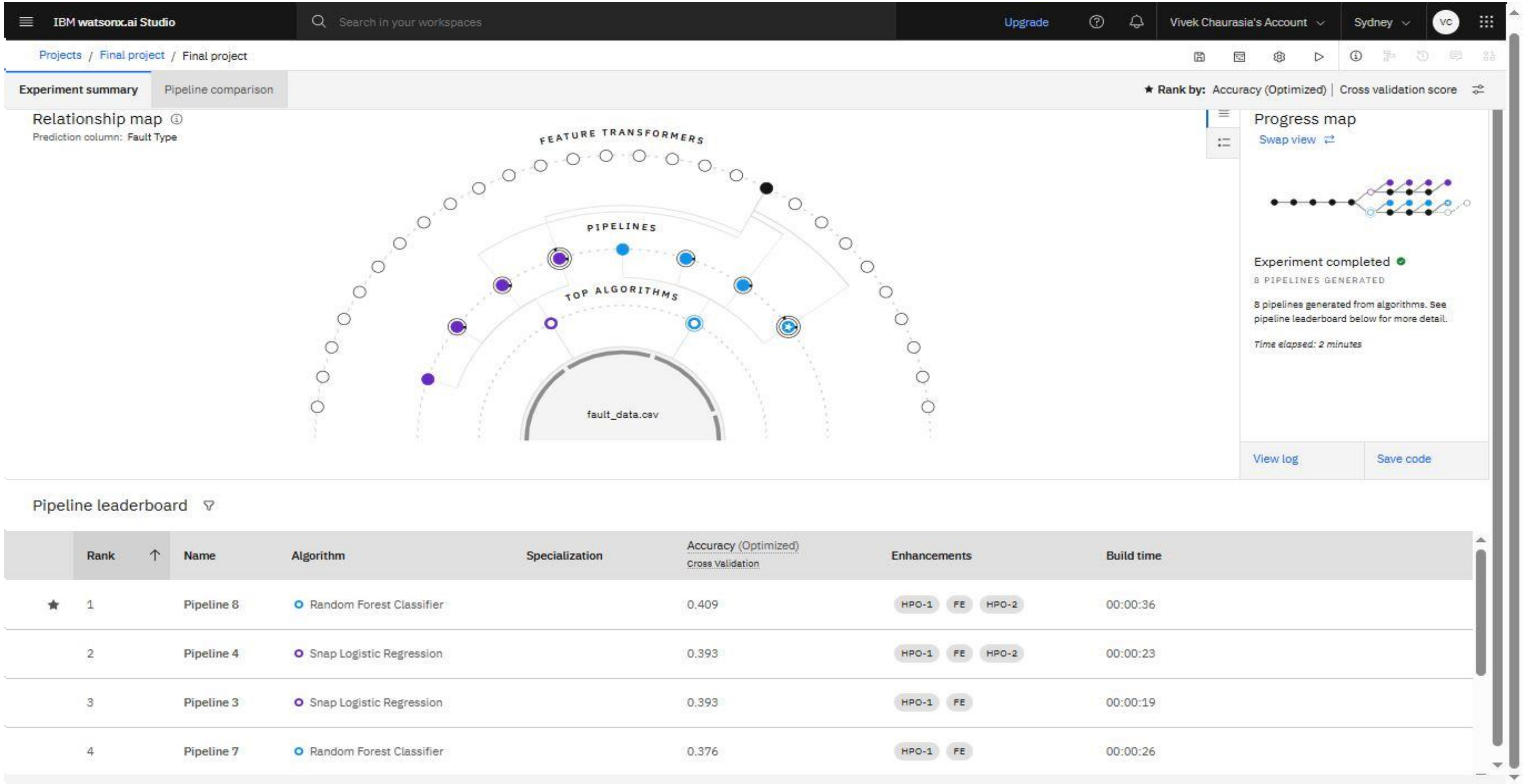
Experiment summary
Pipeline comparison
★ Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Fault Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Logistic Regression
Random Forest Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Ensemble creation
P1
P2
P3
P4
P5
P6
P7
P8
P9
Relationship map
Swap view
Experiment completed
8 PIPELINES GENERATED
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 2 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	00:00:36
	2	Pipeline 4	Snap Logistic Regression		0.393	HPO-1 FE HPO-2	00:00:23
	3	Pipeline 3	Snap Logistic Regression		0.393	HPO-1 FE	00:00:19
	4	Pipeline 7	Random Forest Classifier		0.376	HPO-1 FE	00:00:26

RESULT



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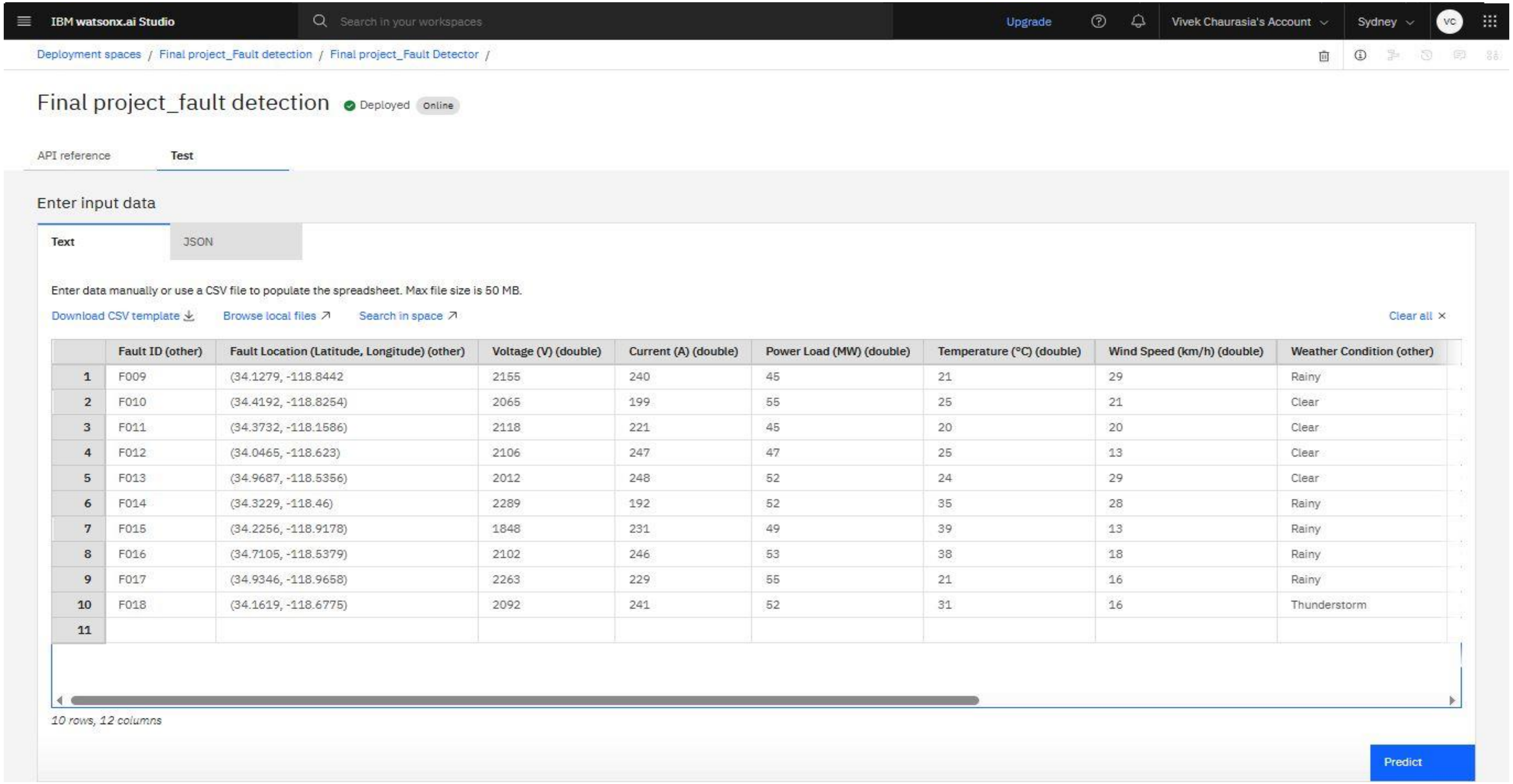
RESULT



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Deployment spaces / Final project_Fault detection / Final project_Fault Detector /

Final project_fault detection 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

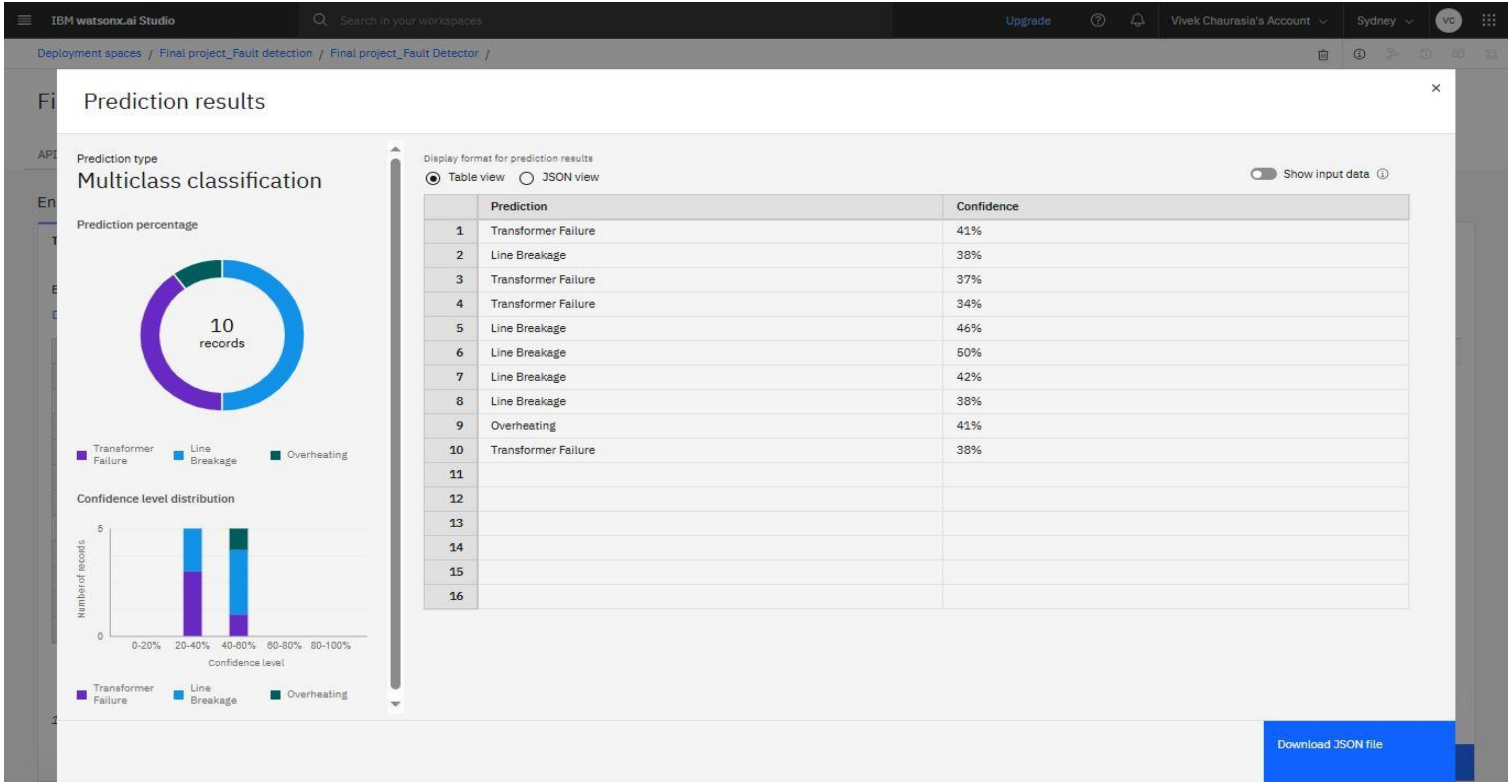
Clear all ×

	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	F009	(34.1279, -118.8442	2155	240	45	21	29	Rainy
2	F010	(34.4192, -118.8254)	2065	199	55	25	21	Clear
3	F011	(34.3732, -118.1586)	2118	221	45	20	20	Clear
4	F012	(34.0465, -118.623)	2106	247	47	25	13	Clear
5	F013	(34.9687, -118.5356)	2012	248	52	24	29	Clear
6	F014	(34.3229, -118.46)	2289	192	52	35	28	Rainy
7	F015	(34.2256, -118.9178)	1848	231	49	39	13	Rainy
8	F016	(34.7105, -118.5379)	2102	246	53	38	18	Rainy
9	F017	(34.9346, -118.9658)	2263	229	55	21	16	Rainy
10	F018	(34.1619, -118.6775)	2092	241	52	31	16	Thunderstorm
11								

10 rows, 12 columns

Predict

RESULT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Prediction results
Prediction type
Multiclass classification
Prediction percentage
10 records
Transformer Failure
Line Breakage
Overheating
Confidence level distribution
Number of records
5
0
0-20%
20-40%
40-60%
60-80%
80-100%
Confidence level
Transformer Failure
Line Breakage
Overheating
Display format for prediction results
Table view
JSON view
Show input data
Prediction
Confidence
1 Transformer Failure 41%
2 Line Breakage 38%
3 Transformer Failure 37%
4 Transformer Failure 34%
5 Line Breakage 46%
6 Line Breakage 50%
7 Line Breakage 42%
8 Line Breakage 38%
9 Overheating 41%
10 Transformer Failure 38%
11
12
13
14
15
16
Download JSON file

CONCLUSION

- The implementation of a machine learning model for fault detection and classification in power distribution systems enhances the speed and accuracy of identifying faults such as line-to-ground, line-to-line, and three-phase disturbances. By leveraging IBM Cloud tools like Watson Studio and Object Storage, the solution ensures efficient data handling, model training, and real-time prediction. This automated approach not only improves grid reliability but also minimizes downtime and supports quicker decision-making for fault management.

FUTURE SCOPE

- **Algorithm Optimization:**
  Fine-tune hyperparameters, implement feature selection techniques, and experiment with ensemble models or hybrid approaches to enhance prediction speed and accuracy.
- **Geographical Expansion:**
  Scale the system to monitor power grids across multiple cities or regions by building a distributed model that adapts to location-specific grid behavior and fault types.
- **Edge Computing Integration:**
  Deploy models on edge devices close to substations or transformers, allowing for low-latency fault detection and reducing dependence on central cloud servers.
- **Advanced Machine Learning Techniques:**
  Utilize deep learning models like Convolutional Neural Networks (CNN) for waveform analysis and Long Short-Term Memory (LSTM) networks for temporal fault pattern recognition.

REFERENCES

- IBM Cloud – https://www.ibm.com/cloud/
- IBM Watson Studio – https://www.ibm.com/cloud/watson-studio
- Kaggle Datasets – https://www.kaggle.com/

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