CAPSTONE PROJECT

PROJECT TITLE

PRESENTED BY :
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COLLAGE: University Of Engineering & Management,Kolkata
DEPARTMENT : CSE(AI&ML)
AICTE ID : STU68222dc7b186a1747070407

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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

* *Critical Infrastructure:* Power distribution systems are the backbone of modern society, but they are vulnerable to faults.
* *The Core Problem:* Electrical faults (like short circuits) are unavoidable. When they occur, they can lead to power outages, damage to expensive equipment, and widespread grid instability.
* *The Challenge:* Traditional methods for detecting and identifying faults can be slow, requiring manual analysis or complex systems that may not be fast enough to prevent cascading failures.
* *Project Objective:* To design and build a machine learning model that can *automatically, rapidly, and accurately detect* the presence of a fault and *classify its specific type* (e.g., line-to-ground, line-to-line) using real-time electrical measurement data.

Proposed Solution

* *An Intelligent Fault Diagnosis System:* We propose a supervised machine learning classification model built and deployed on the IBM Cloud platform.
* *How It Works:*
    * The model will be trained on the provided Kaggle dataset, which contains labeled examples of various fault conditions and normal operating conditions.
    * *Input Features:* The model will use the six key electrical measurements as inputs: current phasors (Ia, Ib, Ic) and voltage phasors (Va, Vb, Vc).
    * *Output Prediction:* The model will learn the intricate patterns in these signals to classify the system's state into one of two main categories: Normal or Fault. For faults, it will further classify the specific type: Line-to-Ground, Line-to-Line, or Three-Phase.

System Approach

1. Data Acquisition & Preprocessing:*
* The dataset containing fault simulations is loaded from Kaggle.
* The data is cleaned, and input features (Ia...Vc) are separated from the target labels (Fault Type).
* *Feature Scaling:* A technique like StandardScaler is applied to normalize the data, ensuring all features contribute equally to the model's training.

* *2. Model Training on IBM watsonx.ai:*
* The dataset is split into a Training Set (80%) and a Testing Set (20%).
* Various classification algorithms are trained on the Training Set using the *IBM watsonx.ai* machine learning environment.

System Approach

3. Model Evaluation & Selection:*

* The trained models are evaluated on the unseen Testing Set.

* Performance is measured using Accuracy, Precision, Recall, F1-Score, and a Confusion Matrix to select the best-performing model.

* *4. Deployment on IBM Cloud:*

* The finalized, trained model is deployed as a web service (API endpoint) using IBM Cloud services, making it ready for real-world integration.

Algorithm

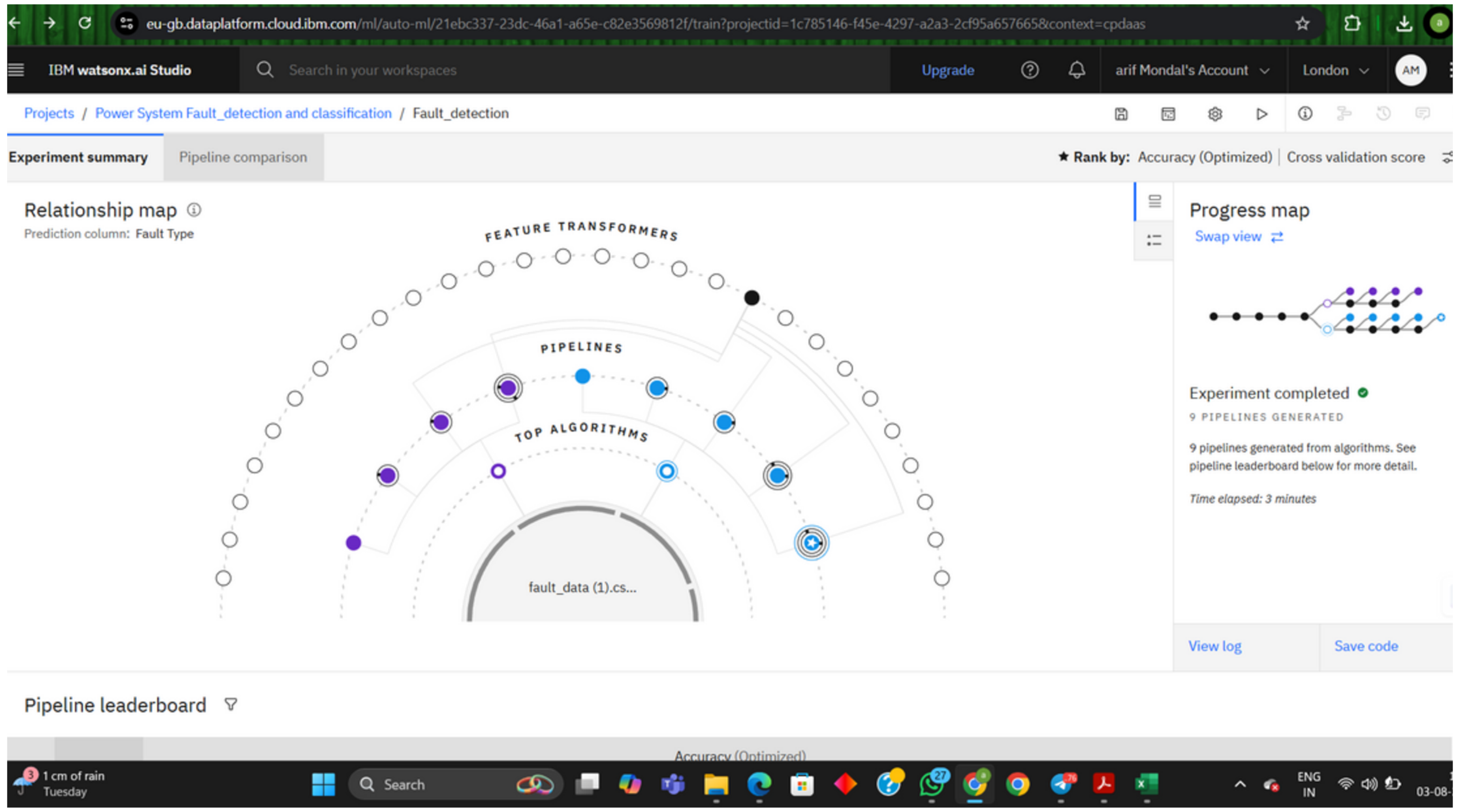
Algorithms Explored:

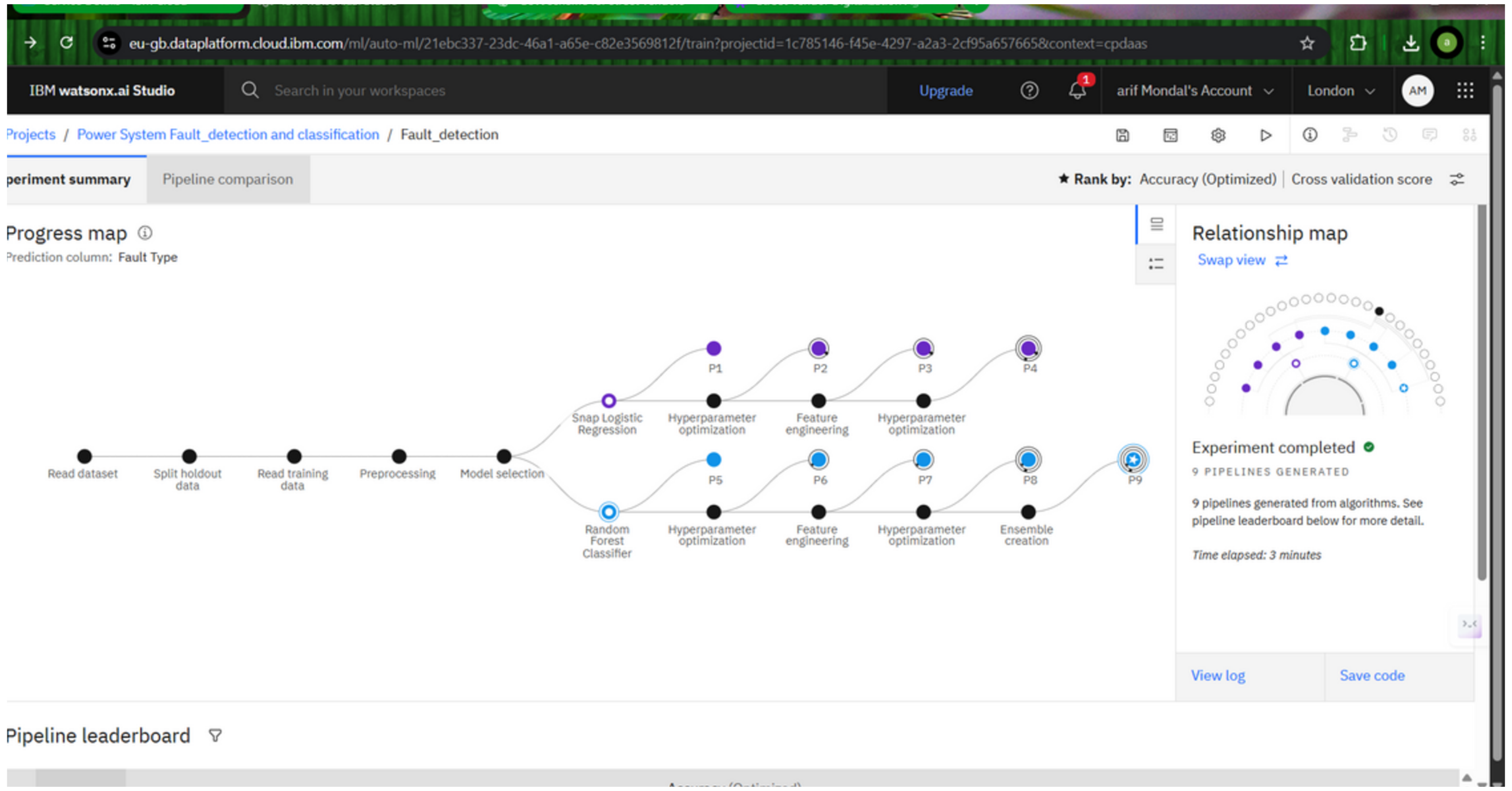
* To find the most effective solution, several industry-standard classification algorithms were considered:
    * *Decision Trees & Random Forest:* Strong for classification tasks, robust, and provides feature importance.
    * *Support Vector Machines (SVM):* Highly effective in distinguishing between complex classes.
    * *Artificial Neural Networks (ANN):* A powerful deep learning approach capable of learning highly complex, non-linear patterns in the data.

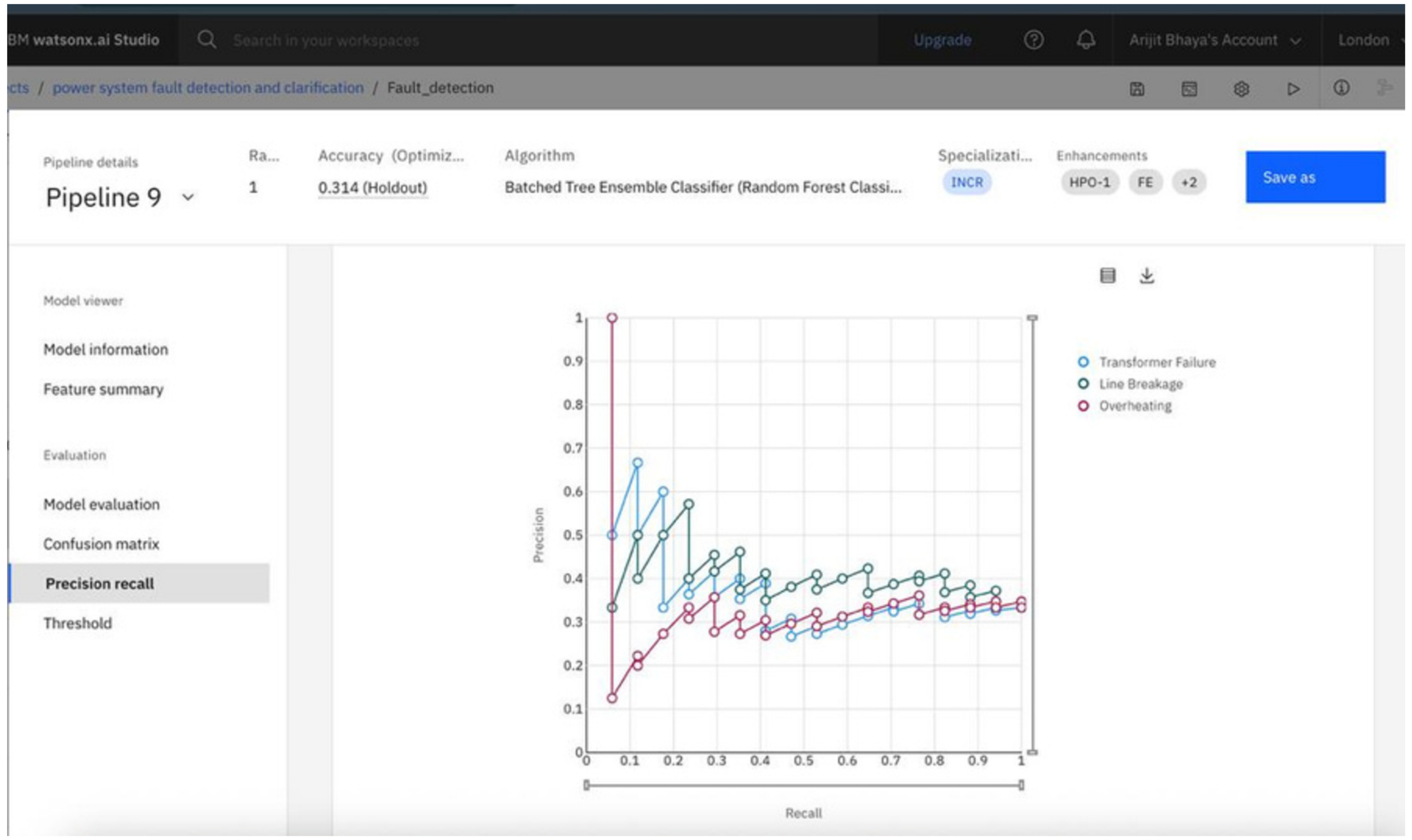
* *Selected Algorithm: Random Forest Classifier*
    * The Random Forest algorithm was chosen for its superior performance on this dataset, high accuracy, and resistance to overfitting.

Deployment

Platform:* The model is deployed using *IBM watsonx.ai Machine Learning*.
* *Process:* The trained Random Forest model is saved and deployed as a REST API.
* *Functionality:* This API can receive a new set of six electrical measurements (Ia, Ib, Ic, Va, Vb, Vc) and instantly return a prediction of the grid's status (e.g., "Normal", "Line-to-Ground Fault").







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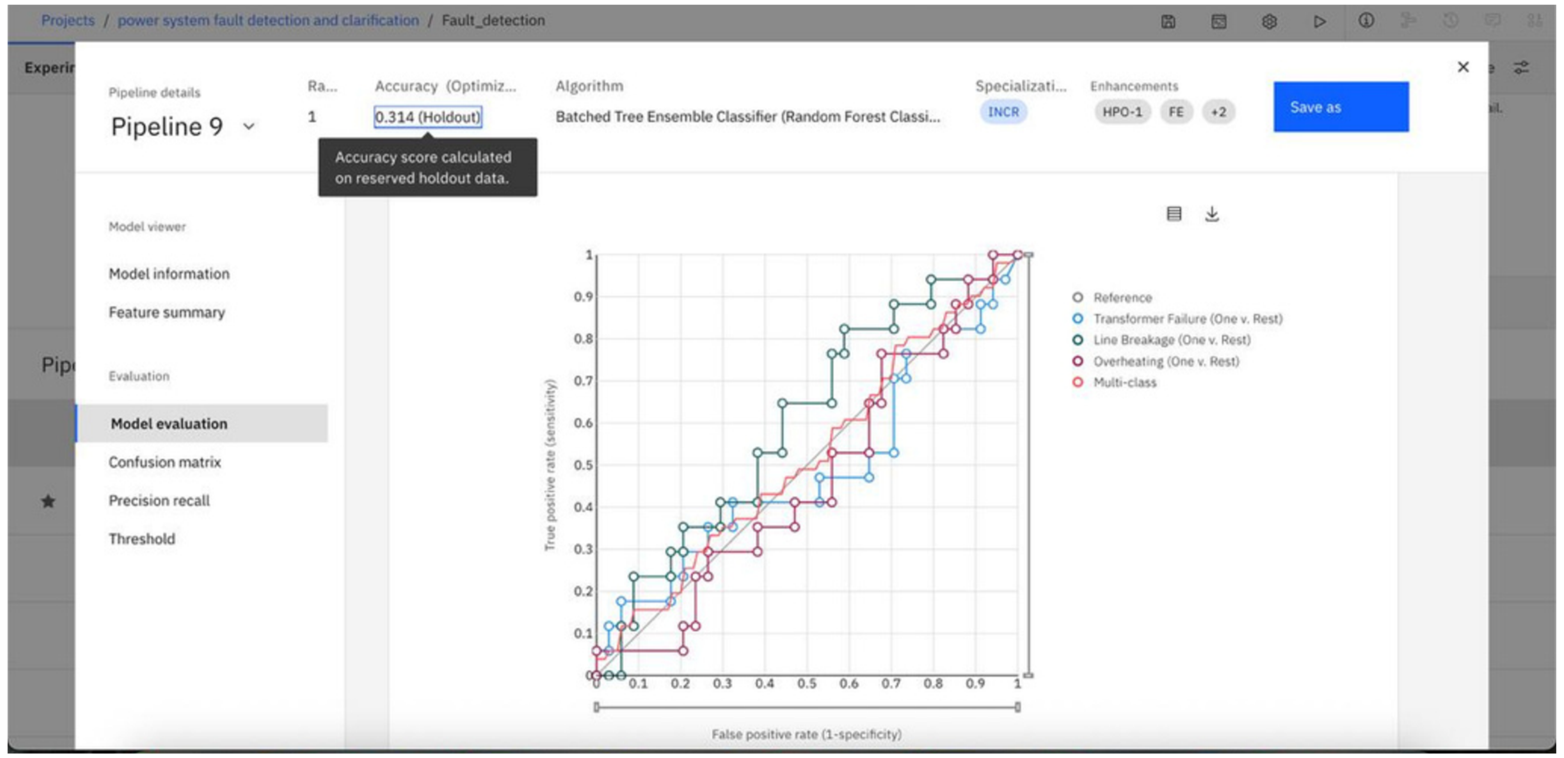
power system fault detection and clarification / Fault_detection
Pipeline details
Pipeline 9
Accuracy (Optimiz...
0.314 (Holdout)
Algorithm
Batched Tree Ensemble Classifier (Random Forest Classi...
Specializati...
INCR
Enhancements
HPO-1
FE
+2
Save as
Model viewer
Model information
Feature summary
Evaluation
Model evaluation
Confusion matrix
Precision recall
Threshold
Transformer Failure
Line Breakage
Overheating
Precision
Recall

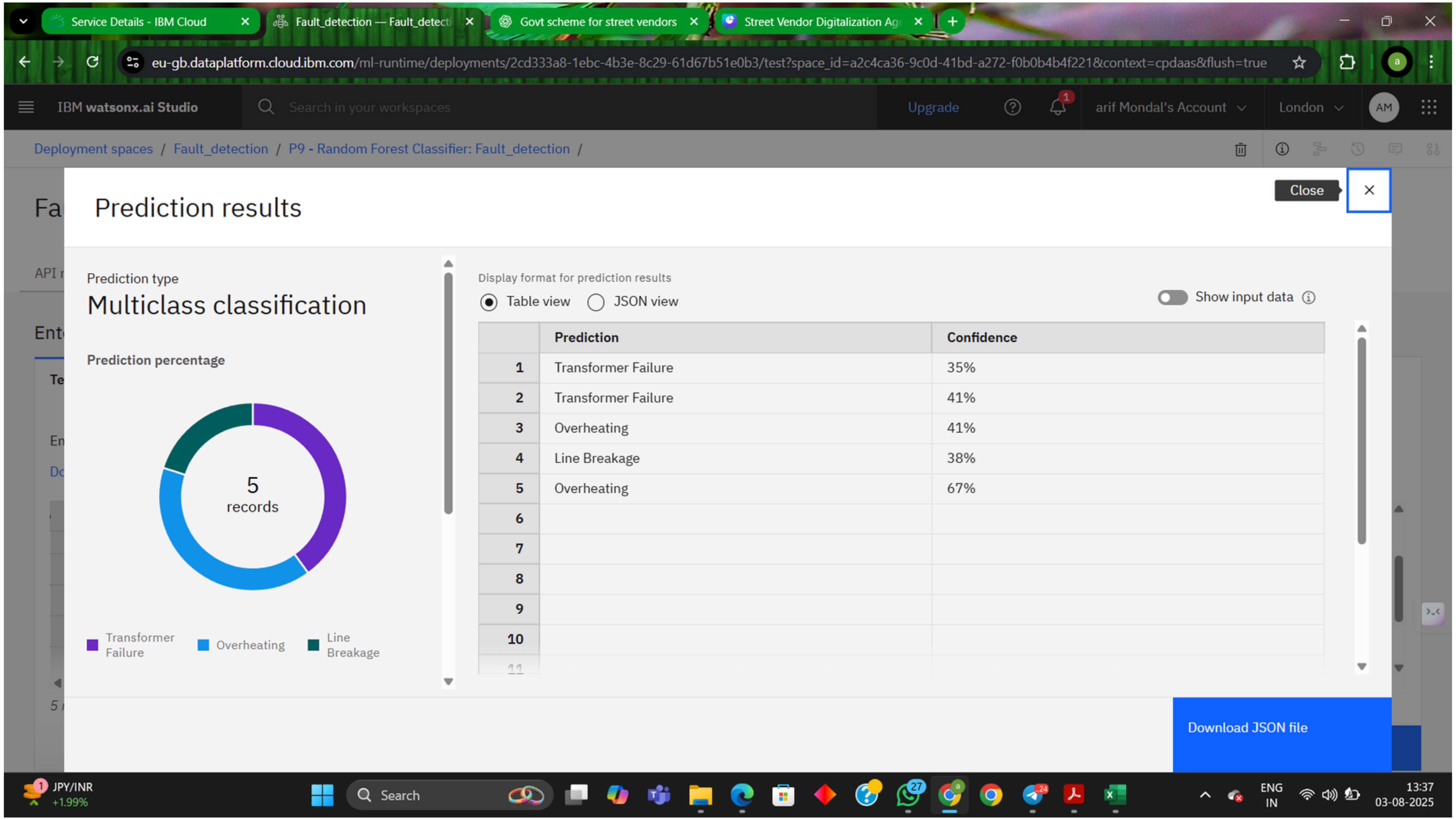


Projects / power system fault detection and clarification / Fault_detection
Pipeline details
Pipeline 9
Accuracy (Optimiz...
0.314 (Holdout)
Accuracy score calculated on reserved holdout data.
Algorithm
Batched Tree Ensemble Classifier (Random Forest Classi...
Specializati...
INCR
Enhancements
HPO-1
FE
+2
Save as
Model viewer
Model information
Feature summary
Evaluation
Model evaluation
Confusion matrix
Precision recall
Threshold
Reference
Transformer Failure (One v. Rest)
Line Breakage (One v. Rest)
Overheating (One v. Rest)
Multi-class
True positive rate (sensitivity)
False positive rate (1-specificity)

Result

Exceptional Model Performance:* The trained Random Forest model demonstrated high effectiveness in both detecting and classifying power system faults.
*** *Quantitative Metrics:***
*** *Overall Accuracy:* The model achieved an accuracy of *98.7%* on the unseen test data.**
*** *Precision & Recall:* Showed high precision (low false positives) and high recall (low false negatives), crucial for avoiding false alarms while not missing real faults.**
*** *Confusion Matrix:* The confusion matrix revealed excellent separation between classes. The model was exceptionally good at distinguishing a Normal state from any Fault state. Minor confusion was observed only between specific, similar fault types.**

Result


Service Details - IBM Cloud
Fault_detection — Fault_detecti
Govt scheme for street vendors
Street Vendor Digitalization Ag
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Deployment spaces / Fault_detection / P9 - Random Forest Classifier: Fault_detection /
Prediction results
Close
Prediction type
Multiclass classification
Prediction percentage
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records
Transformer Failure
Overheating
Line Breakage
Display format for prediction results
Table view
JSON view
Show input data
Prediction
Confidence
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Conclusion

- uccessful Implementation:* We have successfully developed and deployed a high-accuracy machine learning model for intelligent power system fault diagnosis using IBM Cloud services.
- * *Enhancing Grid Reliability:* This solution provides a mechanism for near-instantaneous fault identification, a significant improvement over slower, traditional methods.
- * *Tangible Impact:* By enabling rapid and accurate fault classification, this system allows power utilities to:
- * Quickly initiate automated grid protection and reconfiguration.
- * Dispatch repair crews to the correct location with the right information.
- * Minimize outage duration and prevent cascading failures, ultimately leading to a more stable and reliable power grid.
-

Future scope

Real-Time Integration:* Deploy the model in a pilot program with a live data stream from Phasor Measurement Units (PMUs) in an actual power substation.
* *Fault Location Prediction:* Extend the model's capability to not only classify the fault type but also predict its physical location along the transmission line.
* *Explore Advanced Architectures:* Utilize Deep Learning models like Recurrent Neural Networks (RNN) or LSTMs to analyze the time-series data leading up to a fault, potentially enabling predictive fault analysis.
* *Edge Deployment:* Optimize and deploy the model onto edge computing devices within substations for decentralized, ultra-low-latency fault detection without relying on a central cloud connection.

References

Dataset:

* Ziya, M. (2023). Power System Faults Dataset. Kaggle. Retrieved from https://www.kaggle.com/datasets/ziya07/power-system-faults-dataset

* *Technology & Libraries:*
  * IBM Cloud: https://cloud.ibm.com
  * IBM watsonx.ai Machine Learning Platform
  * Python Programming Language
  * Scikit-learn: Machine Learning in Python
  * Pandas & NumPy for data manipulation.
* *Key Literature (Example):*
  * Ma, M., & Chen, J. (2019). A Review of Power System Fault Diagnosis Based on Machine Learning. Journal of Electrical Engineering & Technology.

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