CAPSTONE PROJECT

POWER SYSTEMFAULT DETECTION AND CLASSIFICATION USING MACHINE LEARNING

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OUTLINE

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PROBLEM STATEMENT

Faults in power systems like Line-to-Ground (L-G), Line-to-Line (L-L), and 3-phase faults can damage equipment and cause blackouts.

There is a need for a system that can **automatically detect and classify these faults** using voltage and current phasor data.

The goal is to build a machine learning model to accurately identify fault types for maintaining grid stability.

PROPOSED SOLUTION

- The proposed system aims to address the challenge of detecting and classifying faults in a power distribution system using machine learning. The solution leverages voltage and current data to predict whether the system is operating normally or experiencing a specific type of fault. The system is designed to enable fast, accurate fault identification, enhancing the stability and reliability of the power grid.
- Data Collection:
  - Use the publicly available dataset from Kaggle which includes labeled electrical measurements under different fault and normal operating conditions.
  - Focused columns include: Air temperature, Process temperature, Rotational speed, Torque, Tool wear, and Type.
- Data Preprocessing:
  - **Removed irrevelant columns from the dataset like Id's and Names.**
  - **Performed data refinement using IBM Watsonx.ai Data Refinery**
- Machine Learning Algorithm:
  - Use IBM Watsonx.ai's AutoAI tool to automatically generate pipelines and selecting the best-performing pipeline (Snap Random Forest Classifier)
  - **Multiple Algorithms evaluated including Decision Trees and Random Forest Classifier.**
- Deployment:
  - Use the Watsonx.ai interface to test the model with live inputs and visualize the prediction results.
  - Deploy the best model on IBM Cloud using the online deployment option. Expose REST API endpoints for real-time testing and predictions.
- Evaluation:
  - Assess model performance based on accuracy, F1-score, precision, and recall. Top model achieved 99.4% accuracy with high precision across all classes.
  - Predictions successfully distinguish between "No Failure" and various fault types with high confidence.

SYSTEM APPROACH

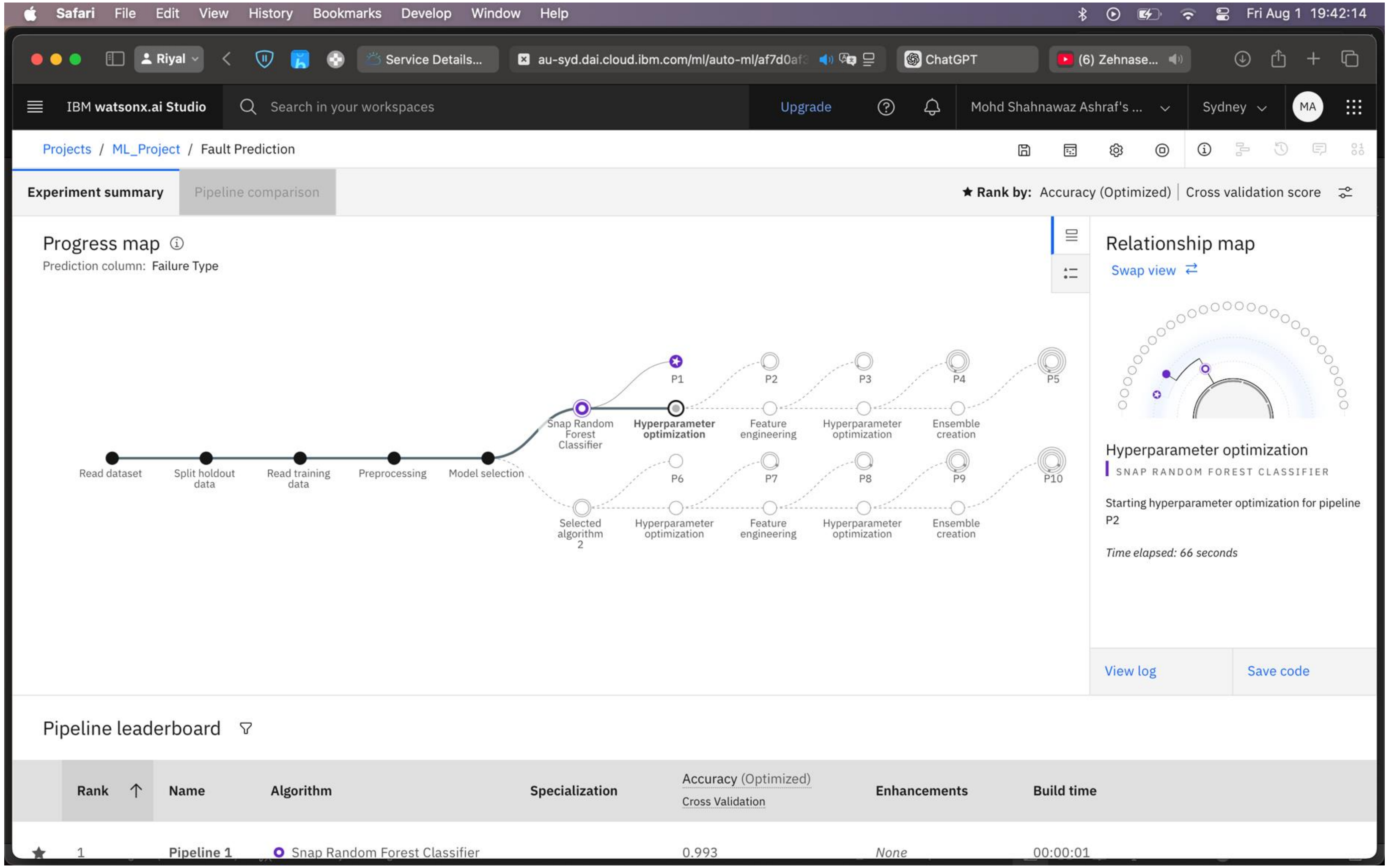
- System requirements
  - A machine learning environment with support for AutoAI workflows
  - Cloud platform for model training, deployment, and testing (IBM Cloud Lite)
  - Tools for data refinement and visualization (Data Refinery)
  - Internet access for dataset retrieval from Kaggle

- Library and Platform Stack:
  - **Platform**: IBM Watsonx.ai Studio
  - **Model Builder:** IBM AutoAI (AutoML tool within Watsonx.ai)
  - **Data Refinement**: IBM Data Refinery (within Watsonx.ai)
  - **Deployment & Testing**: IBM Cloud Deployment Space
  - **Underlying Tech**: Python-based ML backend using scikit-learn inside AutoAI

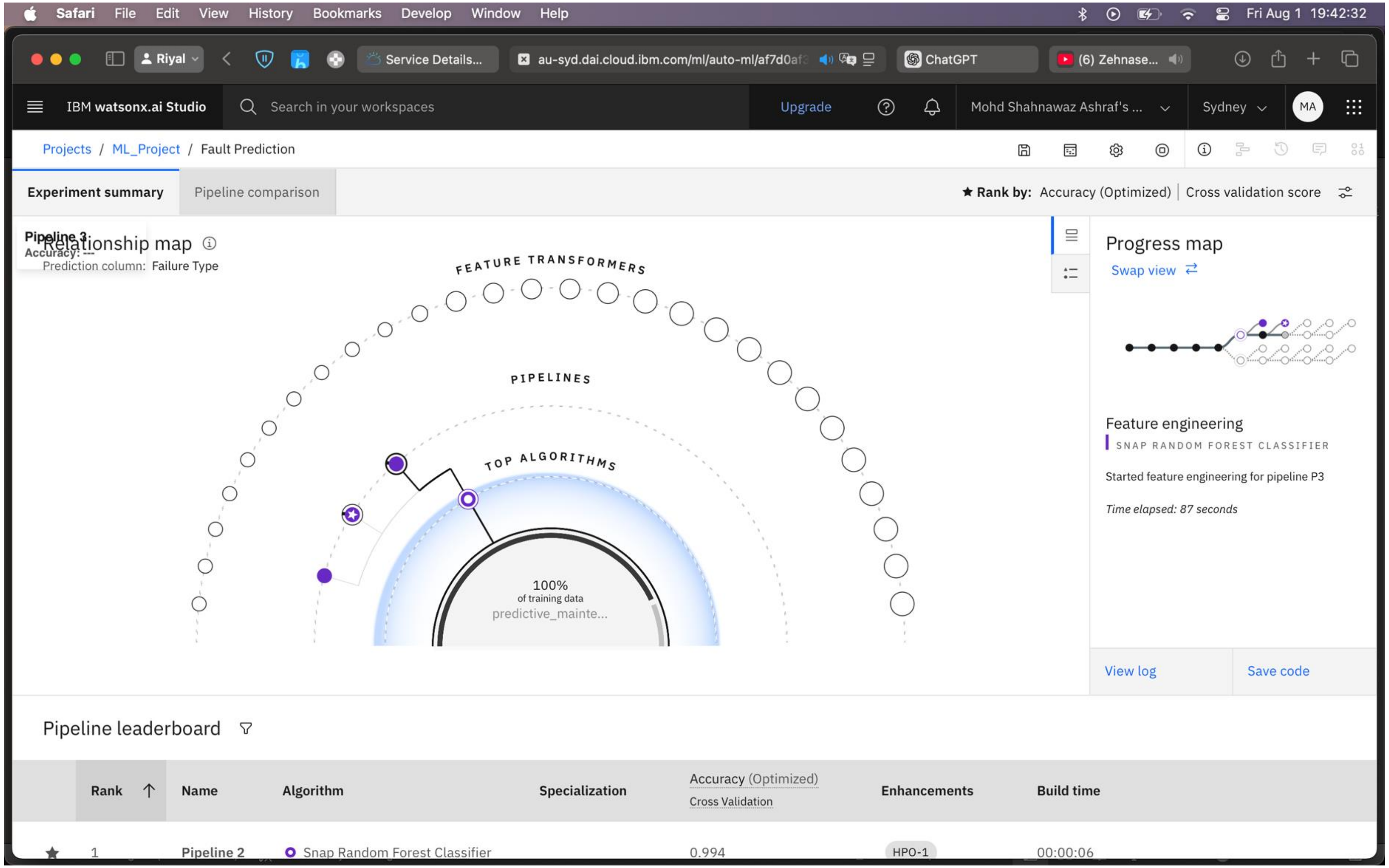
ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - The selected algorithm is the **Snap Random Forest Classifier**, automatically chosen by IBM Watsonx.ai AutoAI based on its superior accuracy and robustness.
    Random Forest was preferred due to its ability to handle high-dimensional input data and its proven effectiveness in multiclass classification problems like fault detection
- **Data Input:**
  - The algorithm takes the following as the input – **Type** (String/Categorical), **Air Temperature** (Decimal), **Process Temperature** (Decimal), **Rotational Speed** (Integer), **Torque [Nm]** (Decimal), **Tool Wear [min]** (Integer).
- **Training Process:**
  - The dataset was split into training and holdout sets using IBM AutoAI's default split. AutoAI automatically performed:
    - Feature Engineering
    - Hyperparameter Optimization
    - Model Selection using Cross-Validation
      - Each pipeline was built and validated independently, and the best-performing model was Pipeline 2 (Snap Random Forest Classifier) with cross-validated performance metrics.
- **Prediction Process:**
  - In the test phase, the model correctly classified inputs with up to **100% confidence**, demonstrating strong generalization.

ALGORITHM & DEPLOYMENT



ALGORITHM & DEPLOYMENT



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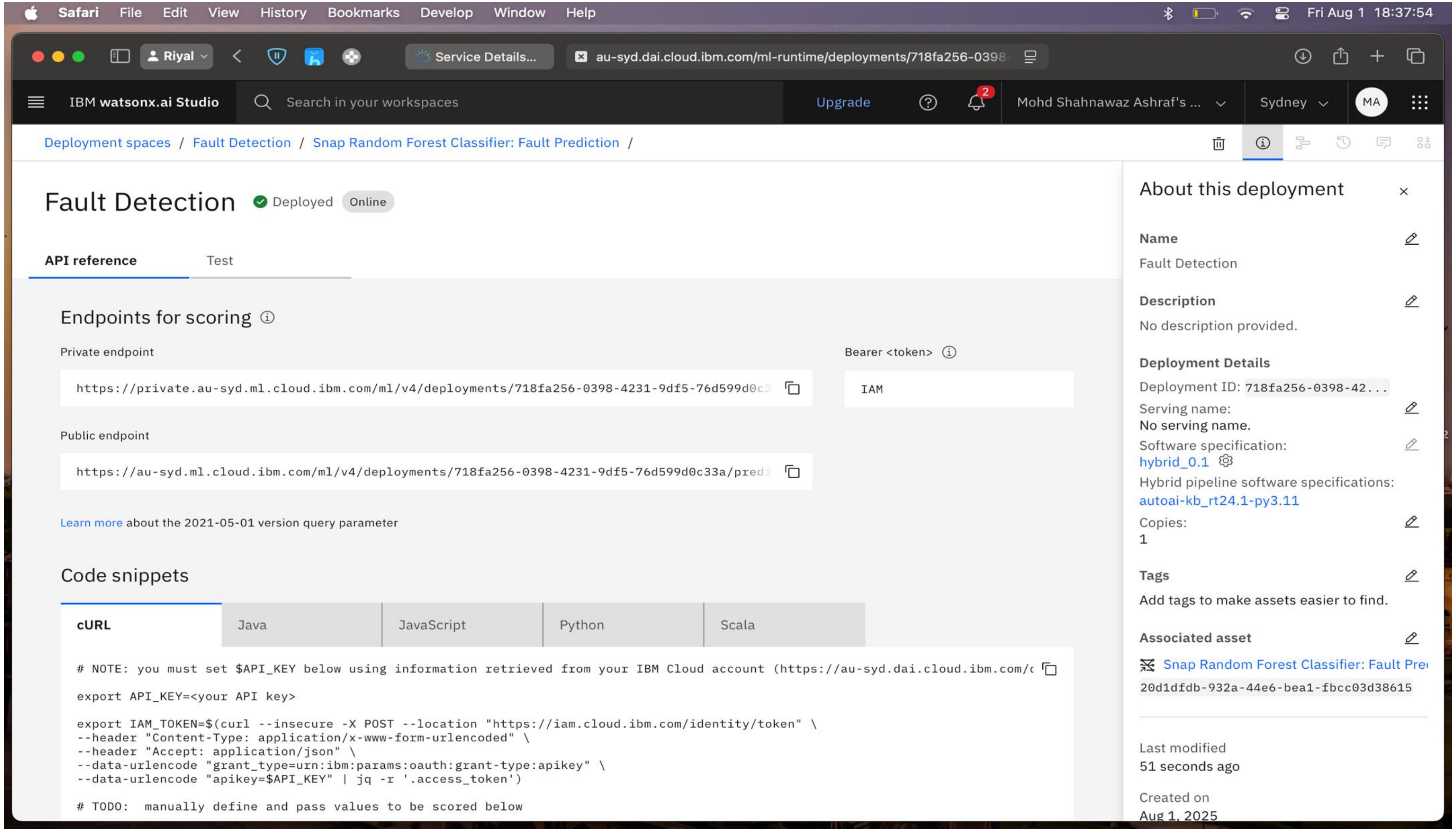
ALGORITHM & DEPLOYMENT



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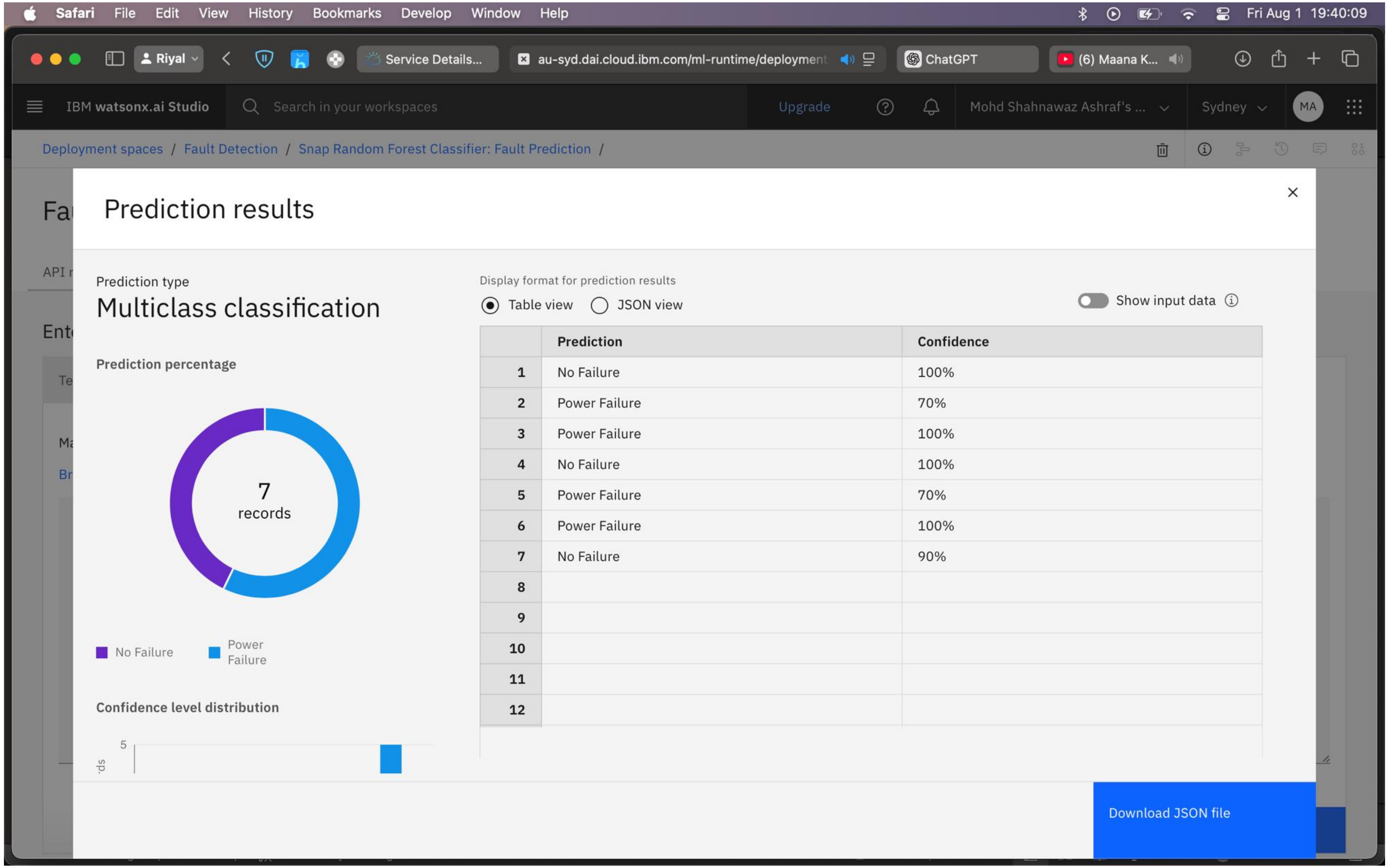
RESULT



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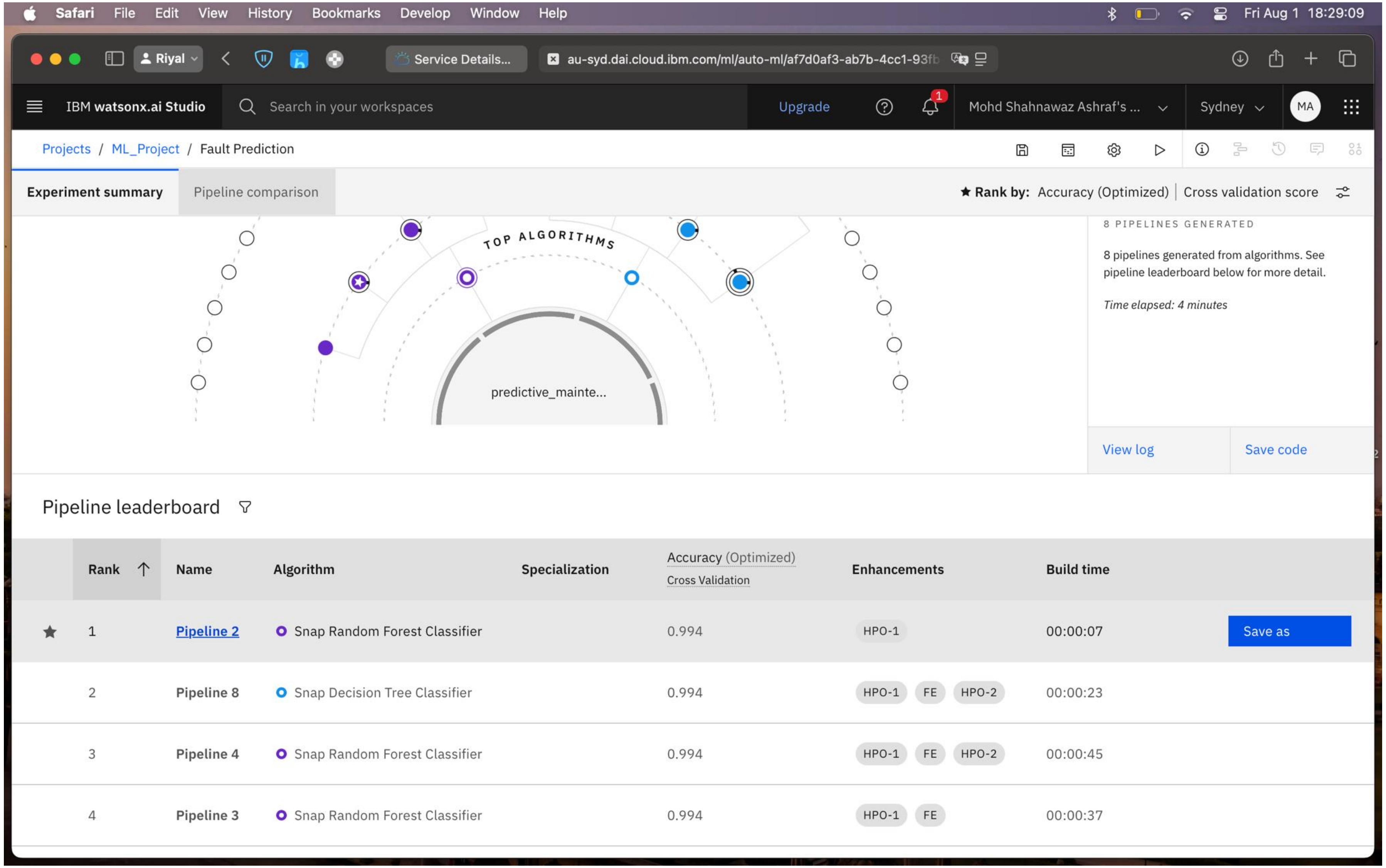
RESULT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2 | Pipeline 8 | Snap Decision Tree Classifier | | 0.994 | HPO-1 FE HPO-2 | 00:00:23
3 | Pipeline 4 | Snap Random Forest Classifier | | 0.994 | HPO-1 FE HPO-2 | 00:00:45
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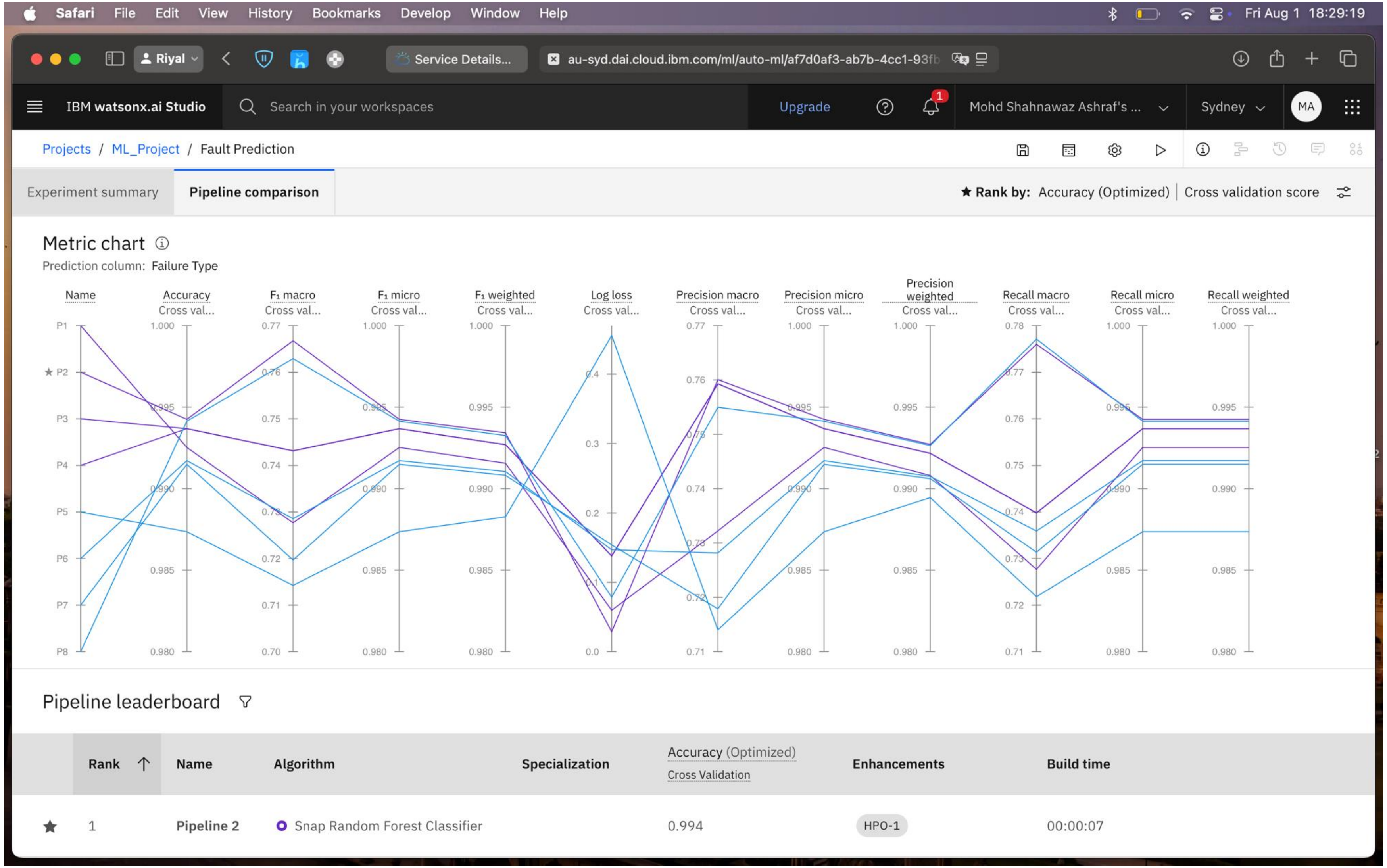
RESULT



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CONCLUSION

- The project successfully demonstrated the use of machine learning, specifically IBM Watsonx.ai's AutoAI, for accurate and efficient classification of power system faults. By training the model on a labeled dataset of electrical parameters such as voltage, current, torque, and temperature, the system was able to distinguish between normal conditions and fault scenarios with a high degree of precision.
- The proposed solution proved effective, with the best-performing model (Snap Random Forest Classifier) achieving **99.4% accuracy**. This high accuracy enables near real-time identification of critical faults like Line-to-Ground or Power Failures, which is essential for maintaining power grid reliability and minimizing downtime.
- Accurate fault detection is crucial in electrical systems, just as accurate bike count predictions are vital for managing urban transportation. This system demonstrates how AI can play a key role in creating smarter, more resilient power infrastructure.

FUTURE SCOPE

- The system can be enhanced and expanded in several ways:
  - **Real-Time Data Integration**: Incorporate IoT sensor data from the grid for real-time fault detection.
  - **Algorithm Improvements**: Explore deep learning models like LSTM or ensemble methods for better accuracy.
  - **Wider Deployment**: Extend the model to support multiple regions or substations with different operating conditions.
  - **Edge Computing**: Deploy the model on edge devices for faster local predictions without relying on cloud latency.
  - **Scalability**: Integrate with dashboard tools for centralized fault monitoring across multiple sites.

REFERENCES

- **Ziya Uddin (2020).**
  Power System Faults Dataset – Kaggle.
  https://www.kaggle.com/datasets/ziya07/power-system-faults-dataset
- **IBM Watsonx.ai Documentation.**
  Build, train, and deploy machine learning models using AutoAI.
  https://www.ibm.com/docs/en/watsonx

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According to the Adobe Learning Manager system of record

Completion date: 24 Jul 2025 (GMT)

Learning hours: 20 mins

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