CAPSTONE PROJECT

POWER SYSTEMFAULT DETECTION AND CLASSIFICATION USING MACHINE LEARNING

Presented By:
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GitHub Link - https://github.com/msaofficio/AICTE-AI-and-Cloud-Internship

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OUTLINE

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

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 ma chine 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

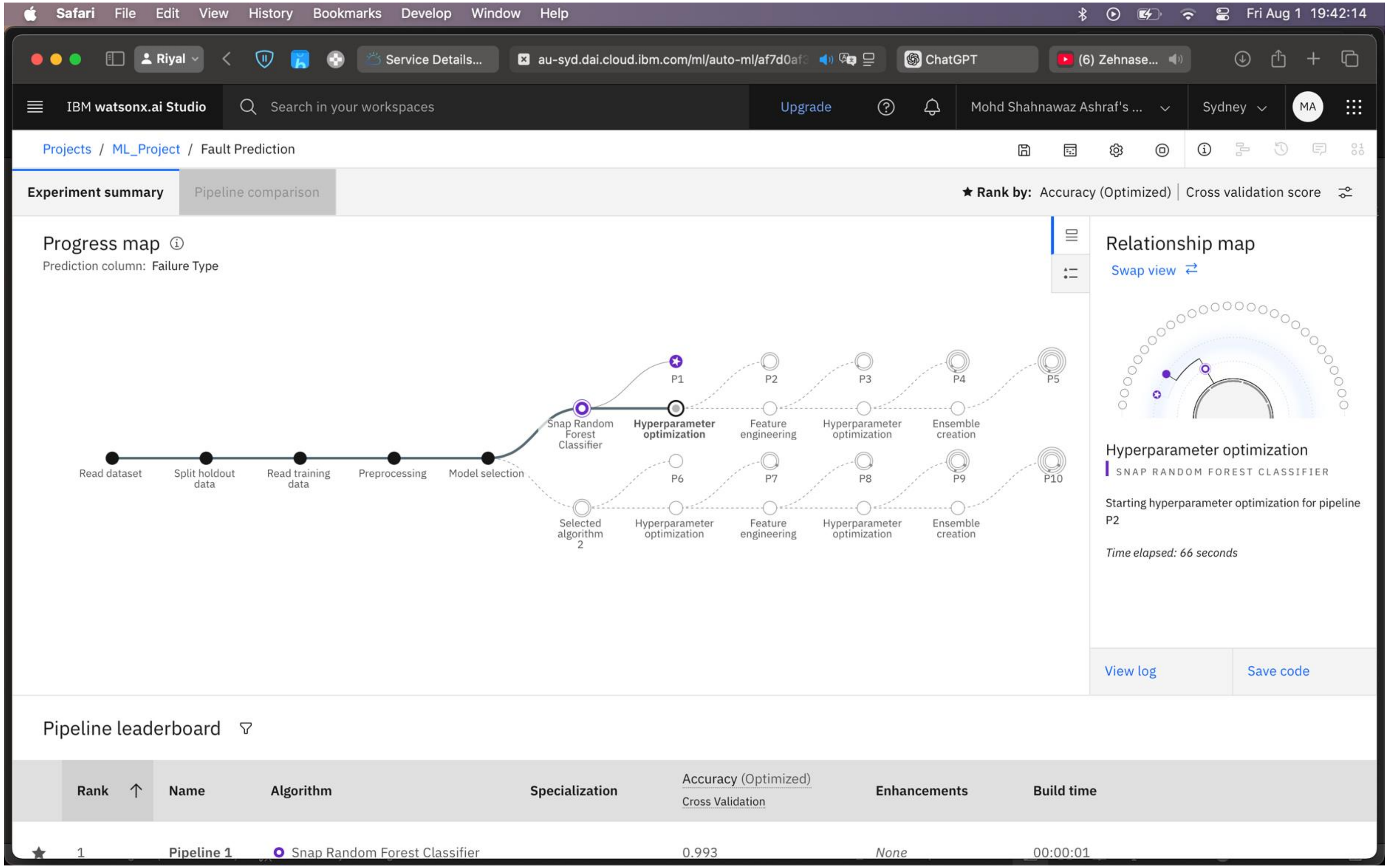
- System requirements
  - A machine learning environment with support for AutoAI workflows
  - Cloud platform for model training, deployment, and testing (IBM Cloud Lite)
  - Tools for data refinement and visualization (Data Refinery)
  - Internet access for dataset retrieval from Kaggle

- 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


Safari File Edit View History Bookmarks Develop Window Help
Fri Aug 1 19:42:14
Riyal
Service Details...
au-syd.dai.cloud.ibm.com/ml/auto-ml/af7d0af
ChatGPT
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IBM watsonx.ai Studio
Search in your workspaces
Upgrade
Mohd Shahnawaz Ashraf's ...
Sydney
MA
Projects / ML_Project / Fault Prediction
Experiment summary
Pipeline comparison
★ Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Failure Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Random Forest Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Ensemble creation
P1
P2
P3
P4
P5
Selected algorithm 2
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Ensemble creation
P6
P7
P8
P9
P10
Relationship map
Swap view
View log
Save code
Pipeline leaderboard

Hyperparameter optimization

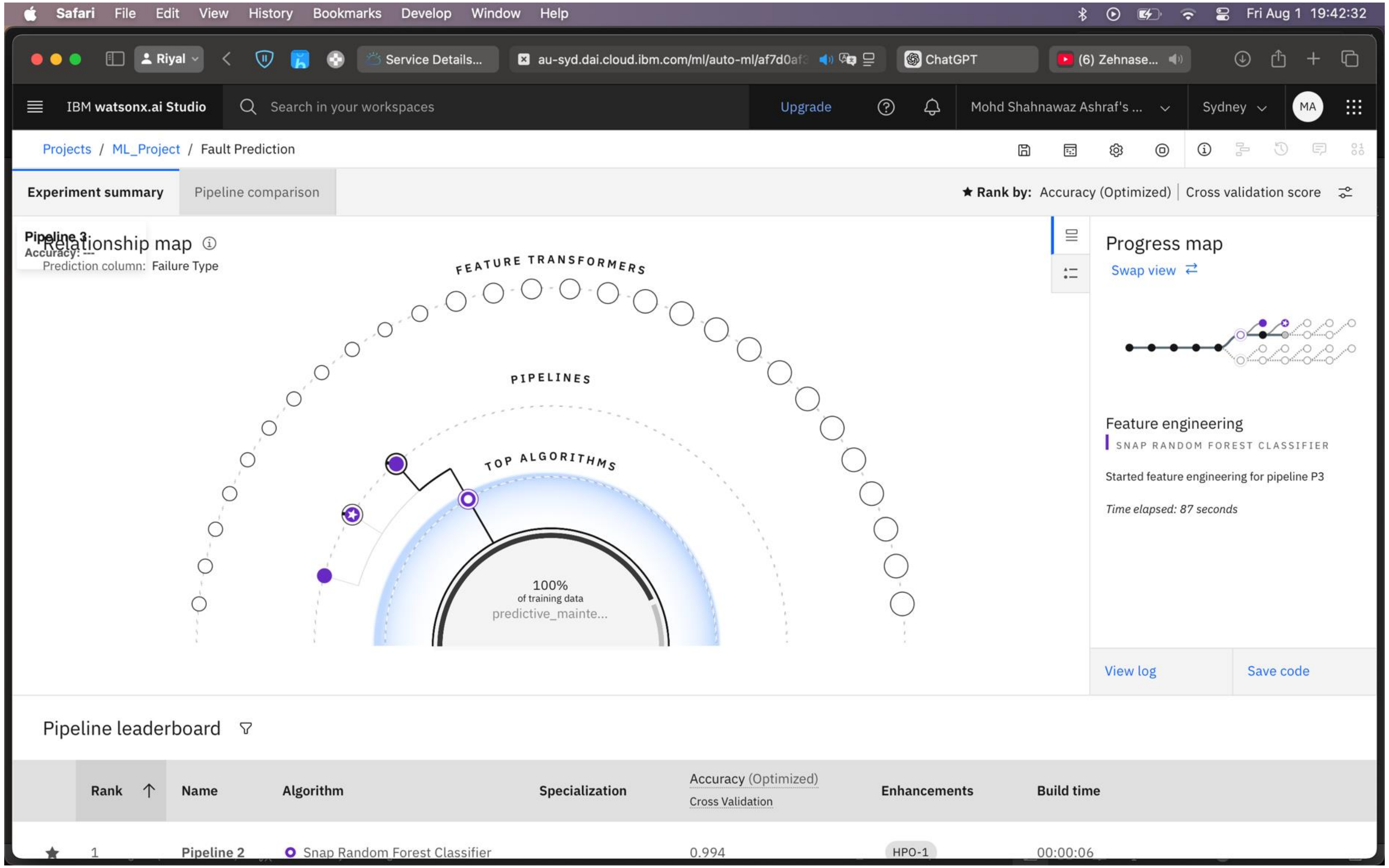
SNAP RANDOM FOREST CLASSIFIER

Starting hyperparameter optimization for pipeline P2

Time elapsed: 66 seconds

	Rank	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 1	Snap Random Forest Classifier		0.993	None	00:00:01

ALGORITHM & DEPLOYMENT



Prediction column: Failure Type

Feature engineering

SNAP RANDOM FOREST CLASSIFIER

Started feature engineering for pipeline P3

Time elapsed: 87 seconds

	Rank	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 2	○ Snap Random Forest Classifier		0.994	HPO-1	00:00:06

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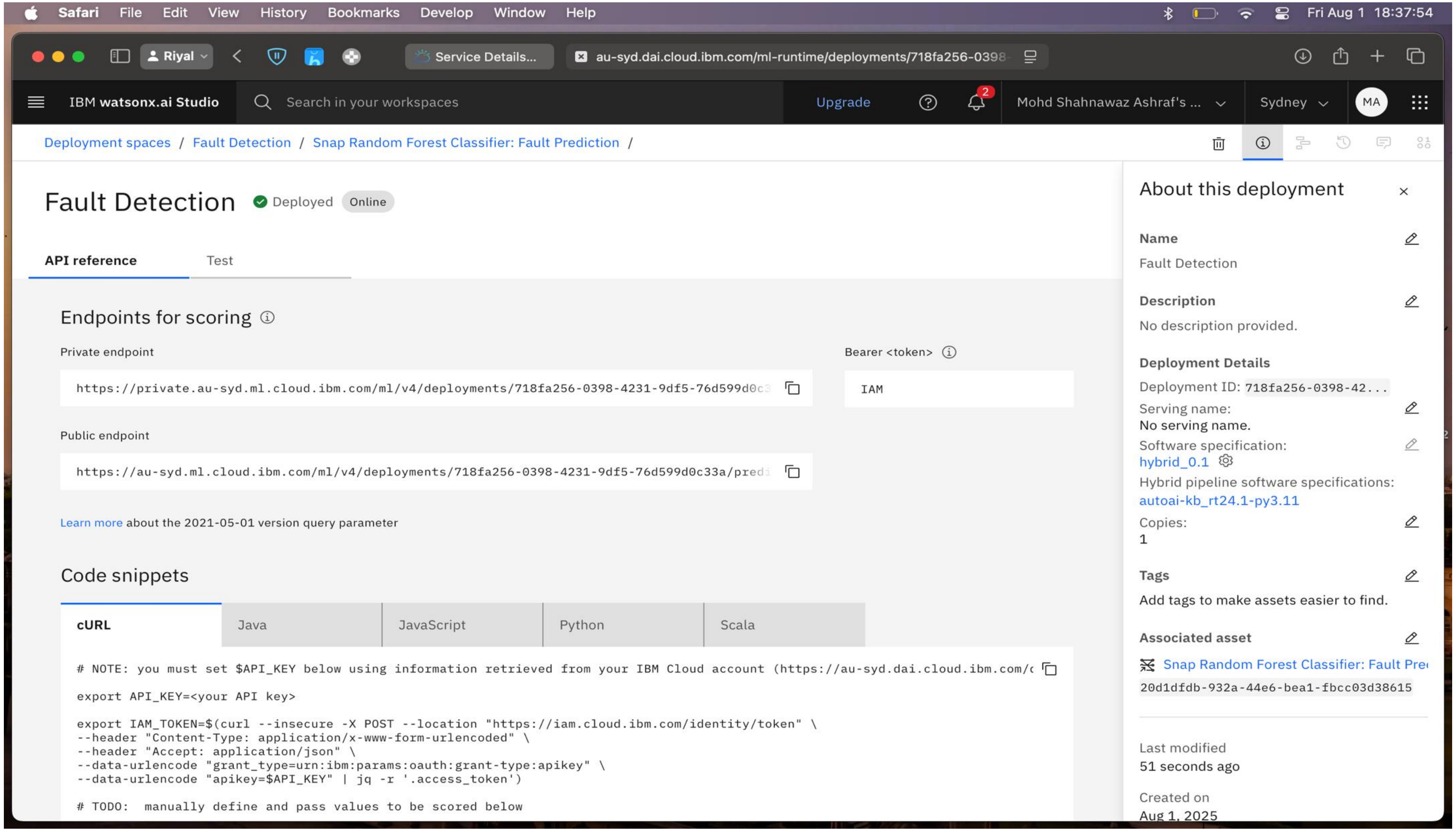
ALGORITHM & DEPLOYMENT


Safari File Edit View History Bookmarks Develop Window Help
Fri Aug 1 18:37:54
Riyal
Service Details...
au-syd.dai.cloud.ibm.com/ml-runtime/deployments/718fa256-0398
IBM watsonx.ai Studio
Search in your workspaces
Upgrade
2
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Deployment spaces / Fault Detection / Snap Random Forest Classifier: Fault Prediction /

Fault Detection

Deployed Online

API reference | Test

Endpoints for scoring

Private endpoint

```
https://private.au-syd.ml.cloud.ibm.com/ml/v4/deployments/718fa256-0398-4231-9df5-76d599d0c
```

Bearer <token>

```
IAM
```

Public endpoint

```
https://au-syd.ml.cloud.ibm.com/ml/v4/deployments/718fa256-0398-4231-9df5-76d599d0c33a/predi
```

Learn more about the 2021-05-01 version query parameter

Code snippets

cURL | Java | JavaScript | Python | Scala

```
# NOTE: you must set $API_KEY below using information retrieved from your IBM Cloud account (https://au-syd.dai.cloud.ibm.com/c

export API_KEY=<your API key>

export IAM_TOKEN=$(curl --insecure -X POST --location "https://iam.cloud.ibm.com/identity/token" \
--header "Content-Type: application/x-www-form-urlencoded" \
--header "Accept: application/json" \
--data-urlencode "grant_type=urn:ibm:params:oauth:grant-type:apikey" \
--data-urlencode "apikey=$API_KEY" | jq -r '.access_token')

# TODO:  manually define and pass values to be scored below
```

About this deployment

Name
Fault Detection

Description
No description provided.

Deployment Details
Deployment ID: 718fa256-0398-42...
Serving name:
No serving name.
Software specification:
hybrid_0.1
Hybrid pipeline software specifications:
autoai-kb_rt24.1-py3.11
Copies:
1

Tags
Add tags to make assets easier to find.

Associated asset
Snap Random Forest Classifier: Fault Pre
20d1dfdb-932a-44e6-bea1-fbcc03d38615

Last modified
51 seconds ago

Created on
Aug 1, 2025

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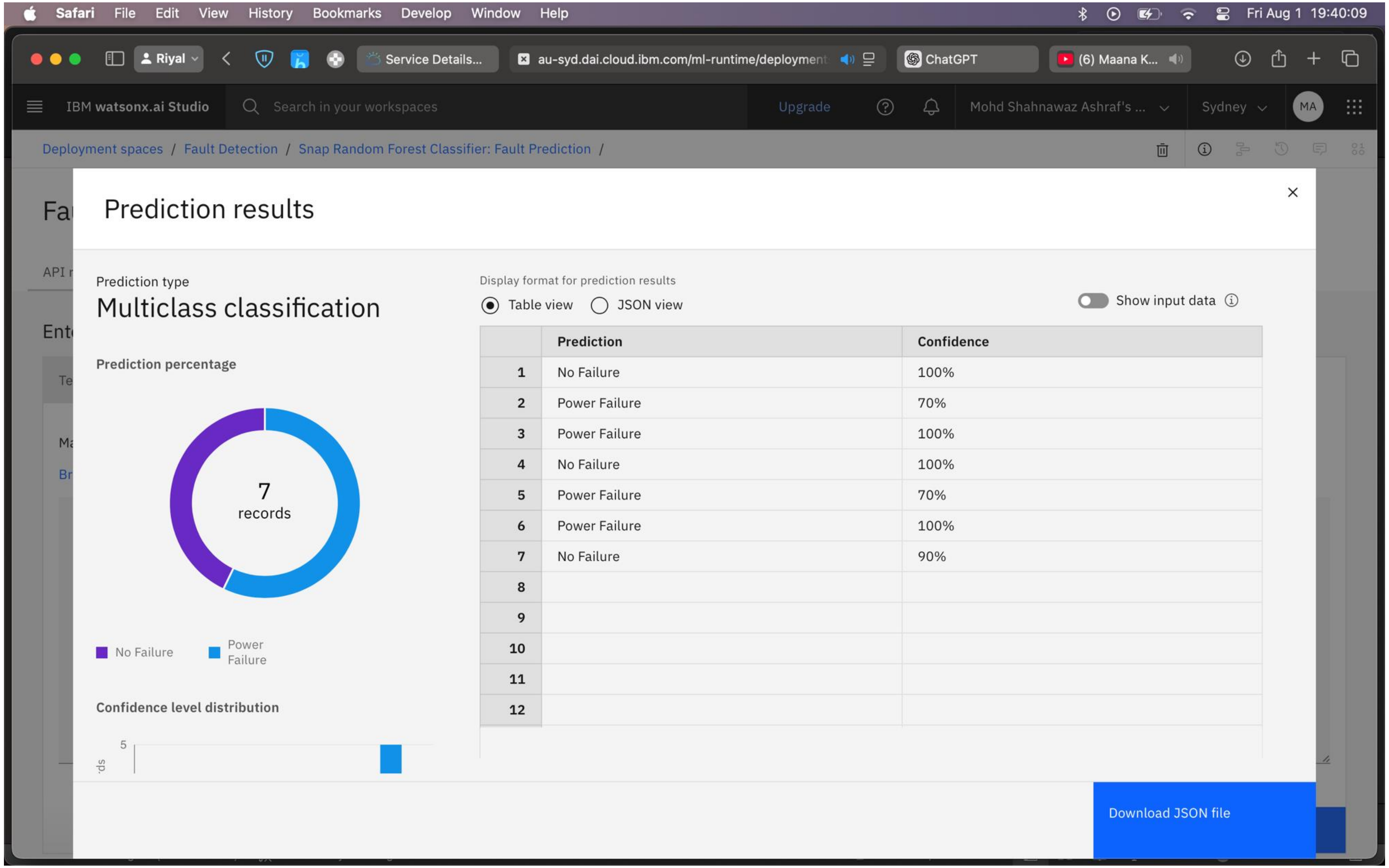
RESULT


Safari File Edit View History Bookmarks Develop Window Help
Fri Aug 1 19:40:09
Riyal
Service Details...
au-syd.dai.cloud.ibm.com/ml-runtime/deployment
ChatGPT
(6) Maana K...
IBM watsonx.ai Studio
Search in your workspaces
Upgrade
Mohd Shahnawaz Ashraf's ...
Sydney
MA
Deployment spaces / Fault Detection / Snap Random Forest Classifier: Fault Prediction /
7
records
No Failure
Power Failure
5
Download JSON file

Prediction results

Prediction type

Multiclass classification

Prediction percentage

Confidence level distribution

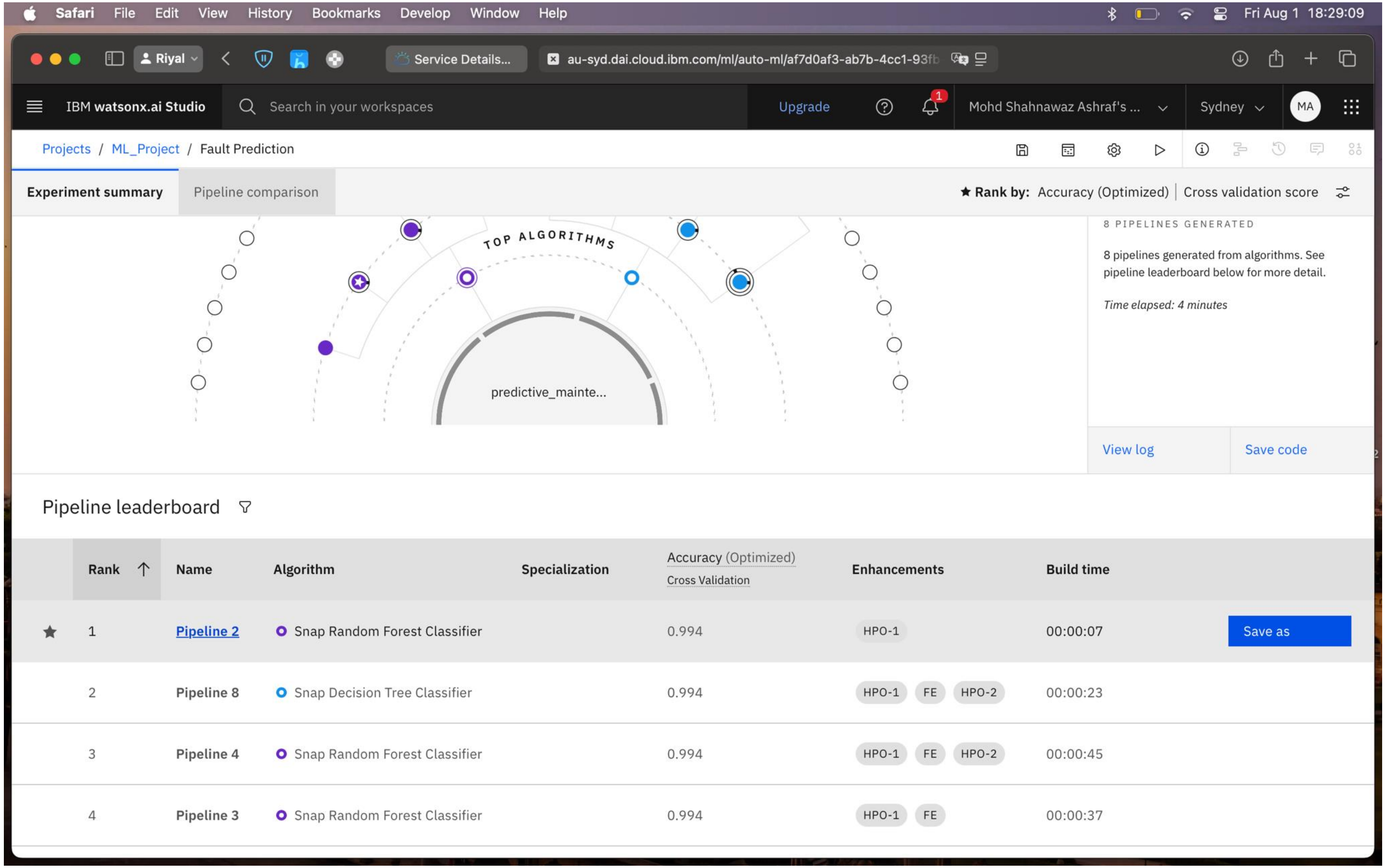
Display format for prediction results

● Table view ○ JSON view

Show input data

	Prediction	Confidence
1	No Failure	100%
2	Power Failure	70%
3	Power Failure	100%
4	No Failure	100%
5	Power Failure	70%
6	Power Failure	100%
7	No Failure	90%
8		
9		
10		
11		
12		

RESULT



8 PIPELINES GENERATED

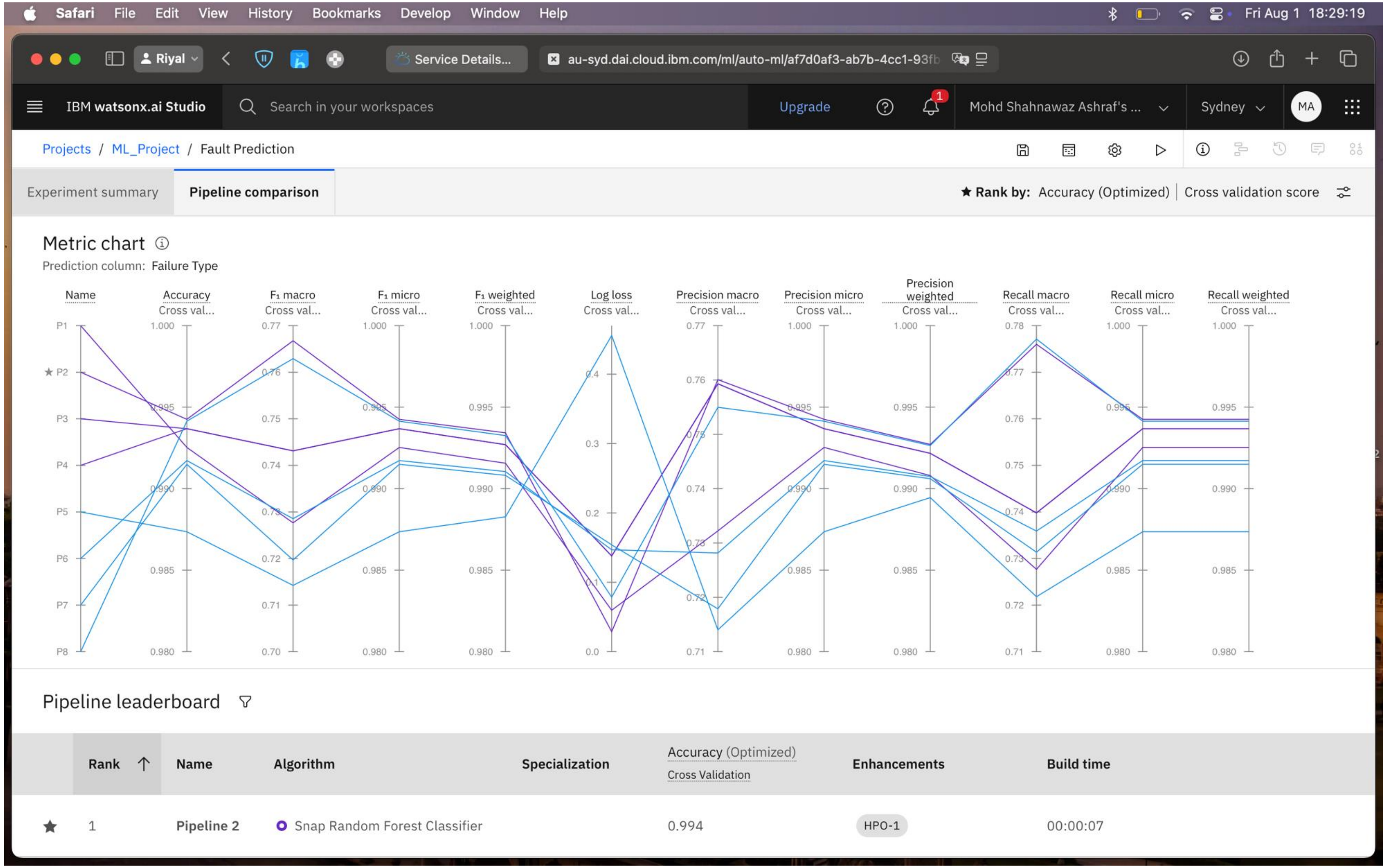
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.

Time elapsed: 4 minutes

Pipeline leaderboard

	Rank ↑	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 2	○ Snap Random Forest Classifier		0.994	HPO-1	00:00:07
	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
	4	Pipeline 3	○ Snap Random Forest Classifier		0.994	HPO-1 FE	00:00:37

RESULT


Safari
File
Edit
View
History
Bookmarks
Develop
Window
Help
Fri Aug 1 18:29:19
Riyal
Service Details...
au-syd.dai.cloud.ibm.com/ml/auto-ml/af7d0af3-ab7b-4cc1-93fb
IBM watsonx.ai Studio
Search in your workspaces
Upgrade
Mohd Shahnawaz Ashraf's ...
Sydney
MA
Projects / ML_Project / Fault Prediction
Experiment summary
Pipeline comparison
★ Rank by: Accuracy (Optimized) | Cross validation score
Name
Accuracy Cross val...
F1 macro Cross val...
F1 micro Cross val...
F1 weighted Cross val...
Log loss Cross val...
Precision macro Cross val...
Precision micro Cross val...
Precision weighted Cross val...
Recall macro Cross val...
Recall micro Cross val...
Recall weighted Cross val...
P1
★ P2
P3
P4
P5
P6
P7
P8
1.000
0.995
0.990
0.985
0.980
0.77
0.76
0.75
0.74
0.73
0.72
0.71
0.70
0.4
0.3
0.2
0.1
0.0
0.78

Metric chart

Prediction column: Failure Type

Pipeline leaderboard

Rank	Name	Algorithm	Specialization	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★ 1	Pipeline 2	○ Snap Random Forest Classifier		0.994	HPO-1	00:00:07

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

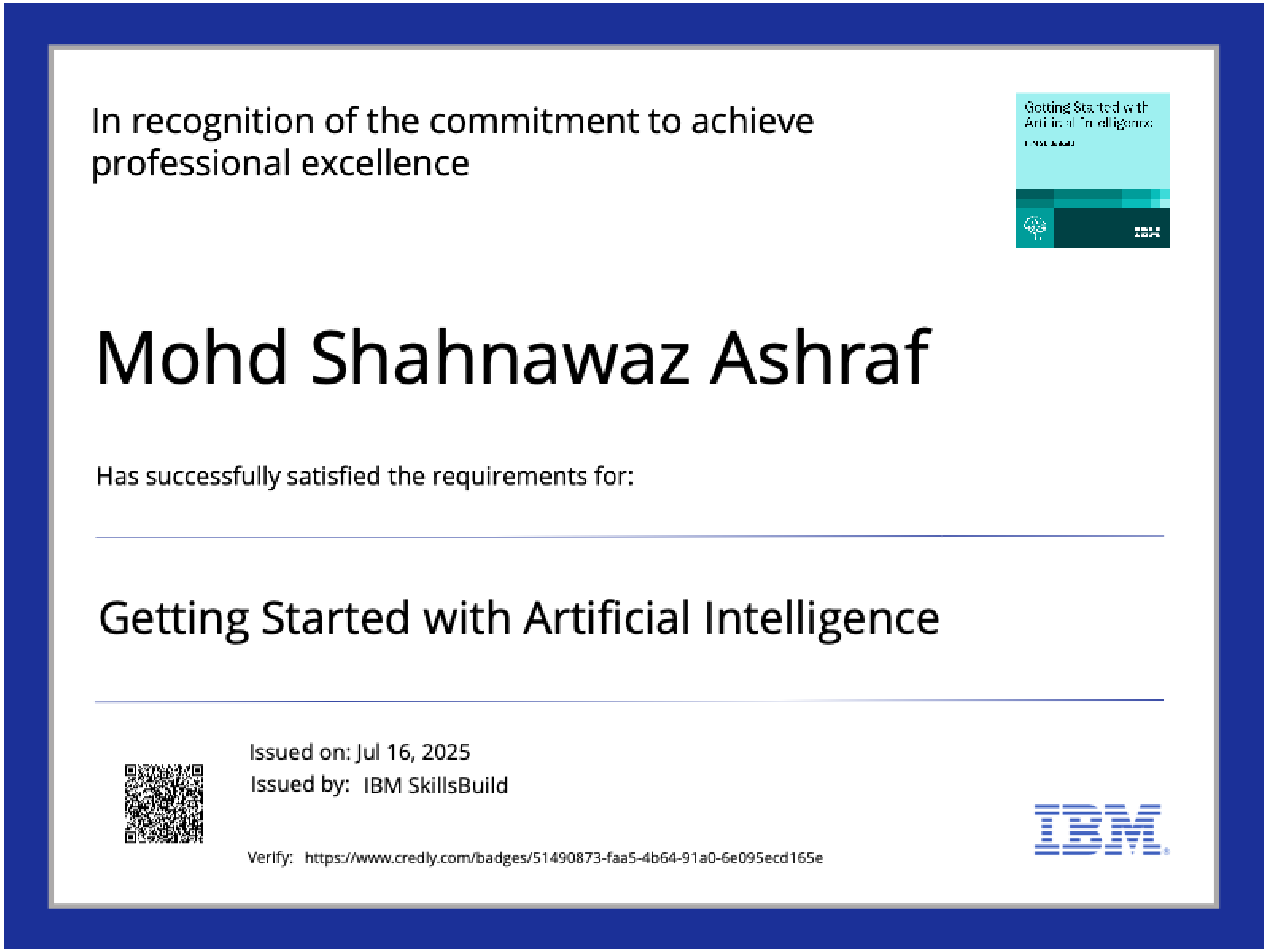
- The system can be enhanced and expanded in several ways:
  - **Real-Time Data Integration**: Incorporate IoT sensor data from the grid for real-time fault detection.
  - **Algorithm Improvements**: Explore deep learning models like LSTM or ensemble methods for better accuracy.
  - **Wider Deployment**: 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

- GitHub Link - https://github.com/msaofficio/AICTE-AI-and-Cloud-Internship

IBM CERTIFICATIONS



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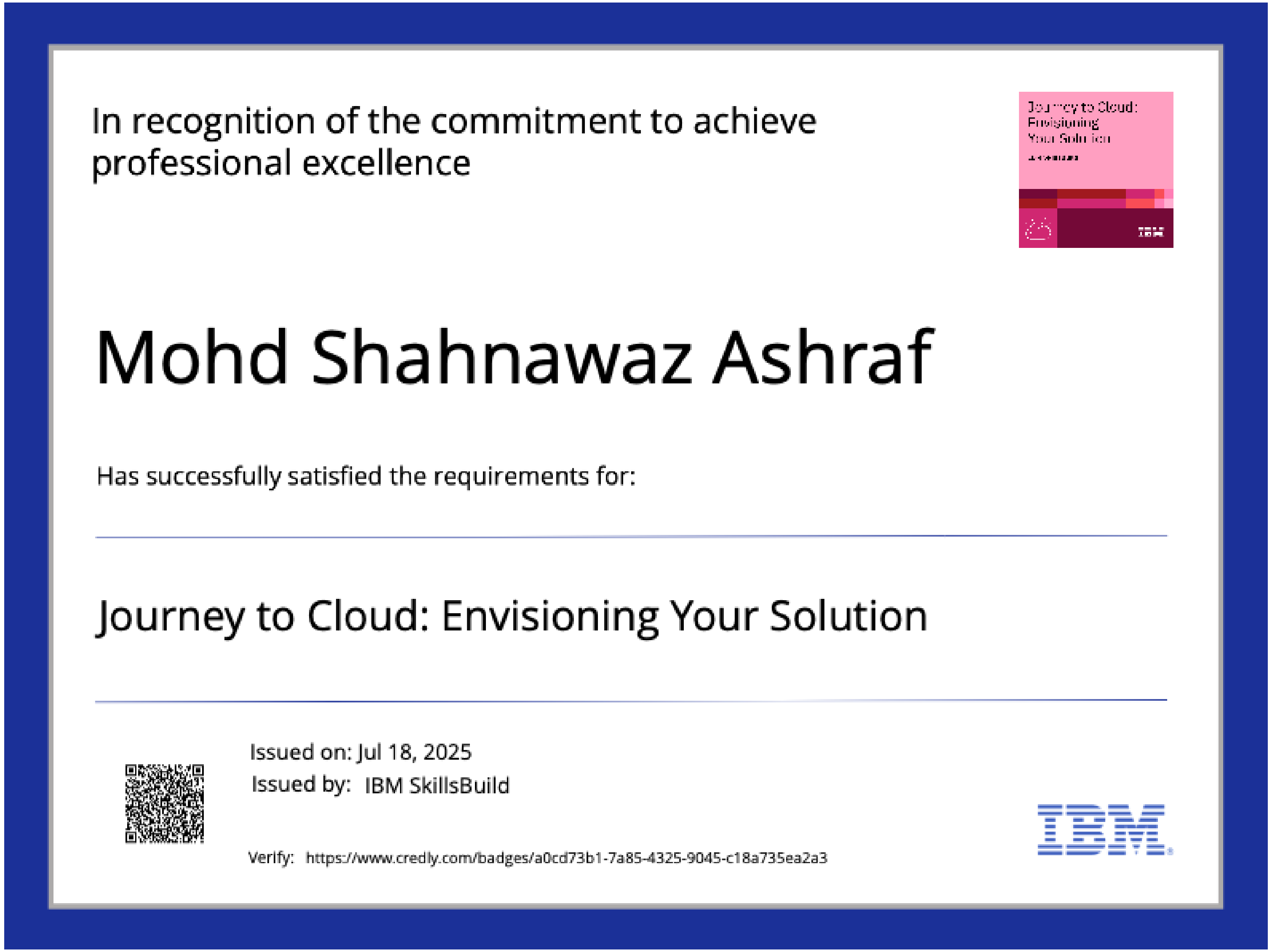

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Journey to Cloud: Envisioning Your Solution
IBM

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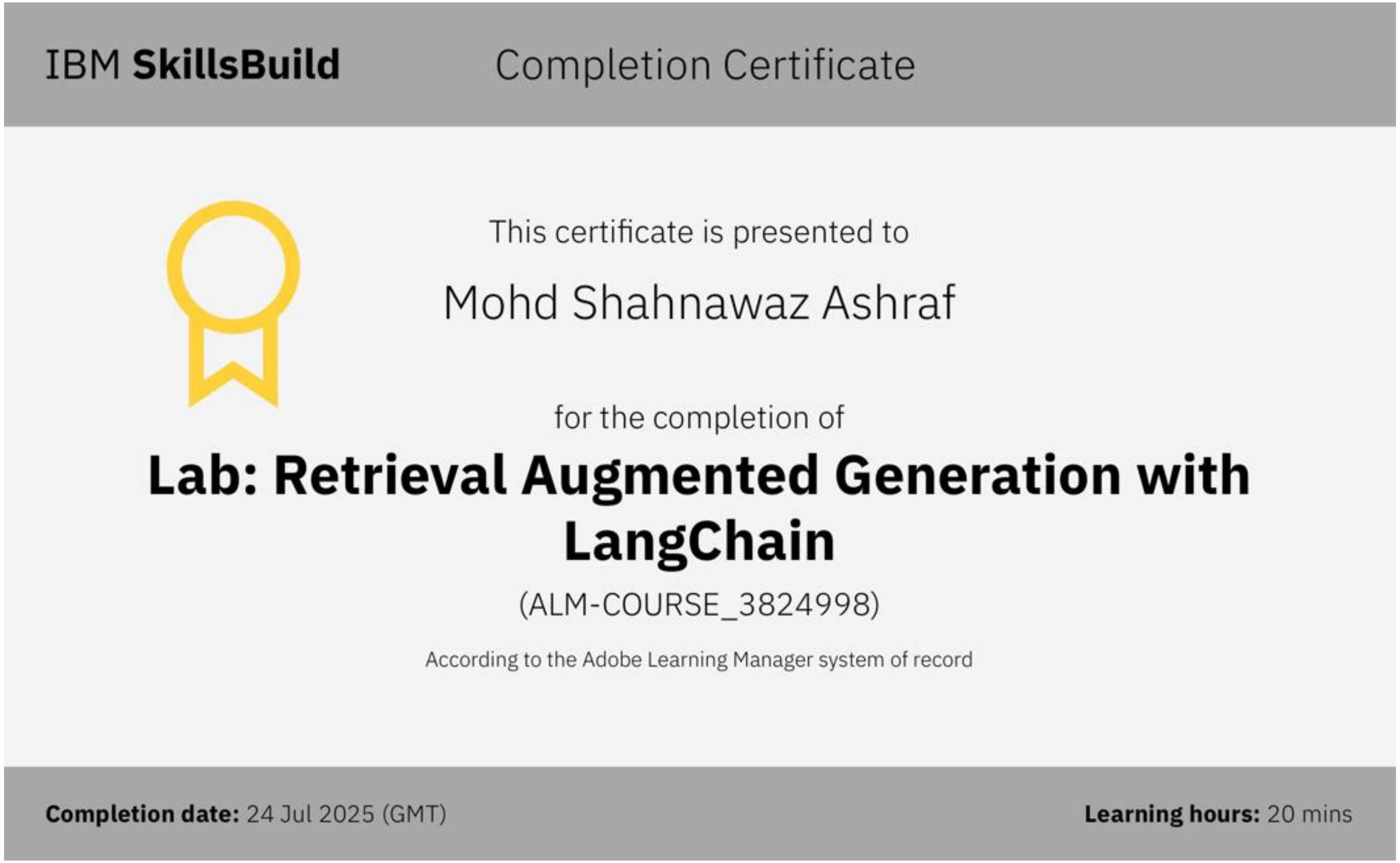

IBM **SkillsBuild** Completion Certificate

This certificate is presented to

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Lab: Retrieval Augmented Generation with LangChain

(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 24 Jul 2025 (GMT)

Learning hours: 20 mins

THANK YOU

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