CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

Presented By:

Shubham Chaturvedi – GL Bajaj Group of Institutions – CSE

Github - Shubham-Chaturvedi-23/IBM-AICTE-Internship

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OUTLINE

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PROBLEM STATEMENT

- Modern industries rely heavily on a fleet of complex machines for production. Unexpected machine failures lead to increased downtime, higher maintenance costs, and reduced productivity.
- There is a critical need to predict machinery failures in advance so that proactive maintenance can be scheduled, minimizing disruptions. This project focuses on leveraging real-time sensor data from industrial machines to identify patterns that precede failures.
- The ultimate aim is to develop a robust classification model that can automatically predict the type of failure (such as tool wear, power outages, or overheating) and enable timely, cost-effective maintenance.

PROPOSED SOLUTION

Our proposed system offers a predictive maintenance solution for industrial machinery using machine learning and real-time sensor analytics. The system aims to:

- Collect and analyze vast amounts of sensor data from machinery (e.g., vibration, temperature, current, pressure).
- Identify and learn the critical patterns or signatures that typically precede common machine failures.
- Train a machine learning classification model to predict specific failure modes before they occur.
- Integrate the model into a real-time monitoring dashboard via IBM Cloud Lite, triggering proactive maintenance notifications to reduce unplanned downtime and operational expenses.

Components:

- Data Collection:
  - Aggregate machine sensor logs, operational records, and maintenance histories.
- Data Preprocessing:
  - Clean, normalize, and engineer relevant features (e.g., rolling averages, thresholds, anomaly flags).
- Model Building:
  - Implement robust machine learning algorithms for multi-class failure prediction using Auto AI.
- Cloud-based Deployment:
  - Deploy the solution using IBM Cloud Lite (Watsonx.ai Studio, Object Storage, Runtime).
- Performance Monitoring:
  - Evaluate live predictions and refine the model for accuracy and efficiency

SYSTEM APPROACH

System Requirements:

- Sensor-enabled industrial machines transmitting real-time operational data.
- Access to IBM Cloud Lite for data storage, model training, and deployment
- User interface for maintenance alerts and analytics.

Libraries Required:

- Python
- IBM Watsonx.ai Studio
- IBM Cloud Storage

Workflow:

- Sensor data ingestion and real-time storage (IBM Cloud Object Storage)
- Data preprocessing and feature extraction in Python notebooks (Watsonx.ai Studio)
- Model training and evaluation in AutoAI
- Deployment as an online service for live

ALGORITHM & DEPLOYMENT

Algorithm Selection:

- The core of the predictive maintenance system is a **Batched Tree Ensemble Classifier (ICNR specialization)**.
- This algorithm is specifically chosen for its ability to handle high-dimensional industrial sensor data, efficiently manage batch processing, and yield robust, interpretable classification results.
- Batched ensemble methods combine the predictive strength of multiple decision trees with specialized techniques for class imbalance and noise reduction

Data Input:

- The prediction model leverages the following real-time sensor features, namely, Air temperature, Process temperature, Rotational speed, Torque, Tool Wear, Fault Type.
- These features collectively capture the thermal, mechanical, and operational health of the machinery.

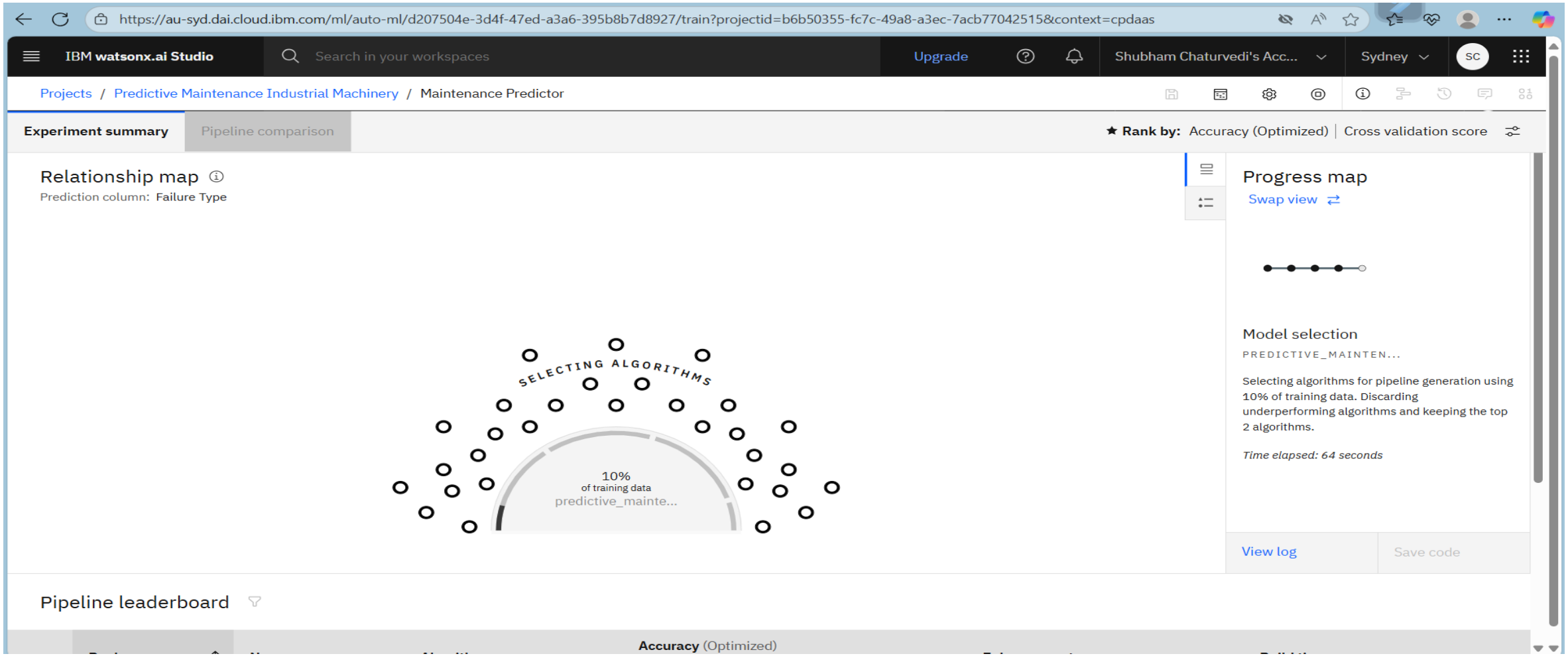
Training Process:

- Model Training**:** The Batched Tree Ensemble Classifier (ICNR) is trained using labeled historical data. The process includes stratified cross-validation and hyperparameter tuning to optimize performance for imbalanced classes and noisy signals.
- Evaluation**:** The model's performance is assessed via standard metrics—accuracy, precision, recall, and F1-score.

Prediction & Deployment:

- The final trained model is saved and promoted within IBM Watsonx.ai Studio.
- Deployment is performed in an online (real-time) mode, enabling instant predictions for incoming machine data streams.
- Sensor readings (air temperature, process temperature, rotational speed, torque, and tool wear) are input live into the deployed model.

RESULT



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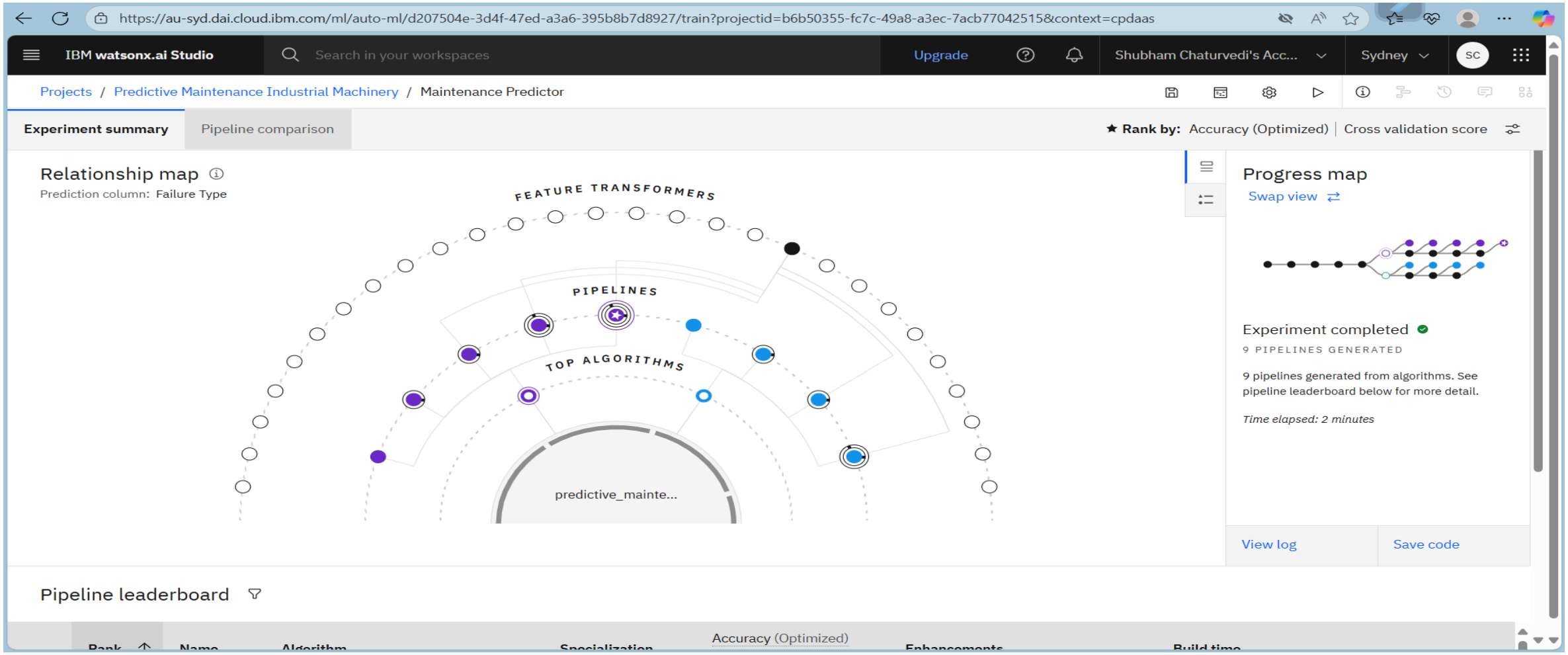
RESULT



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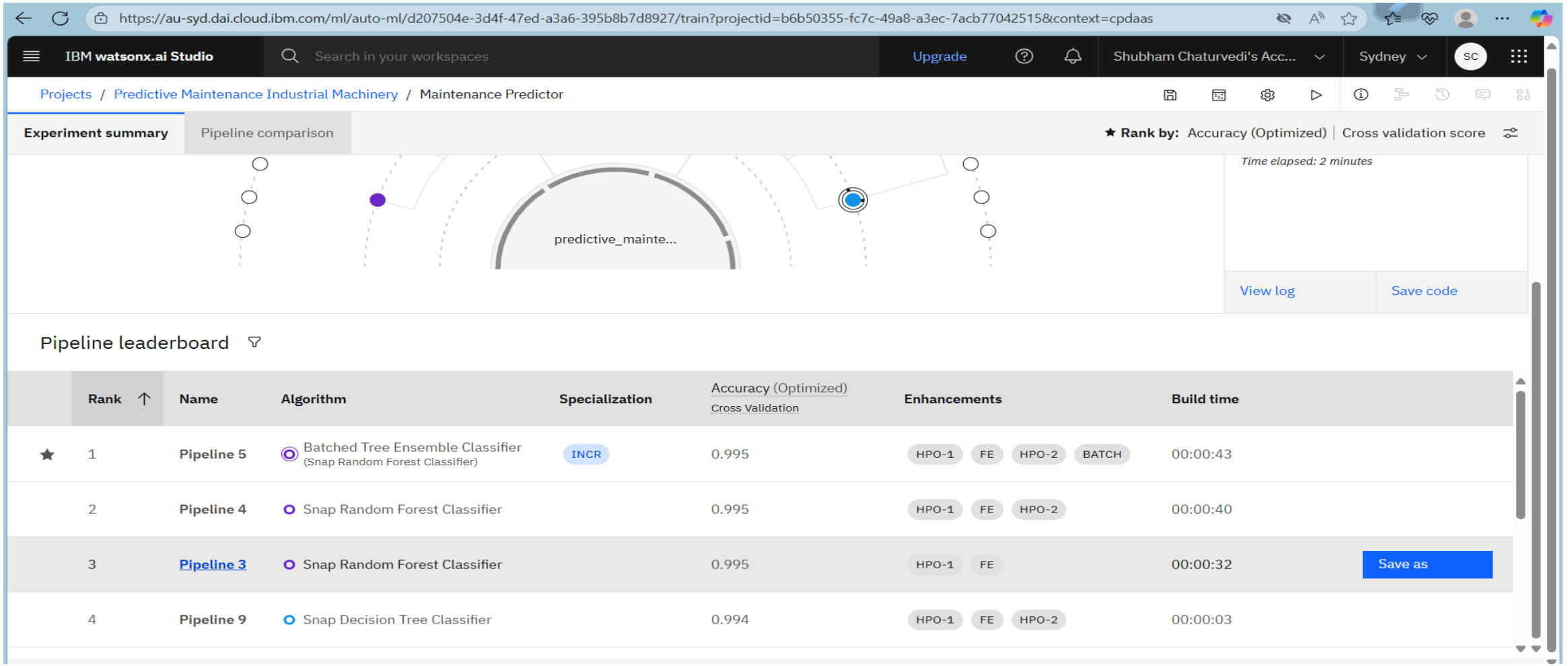
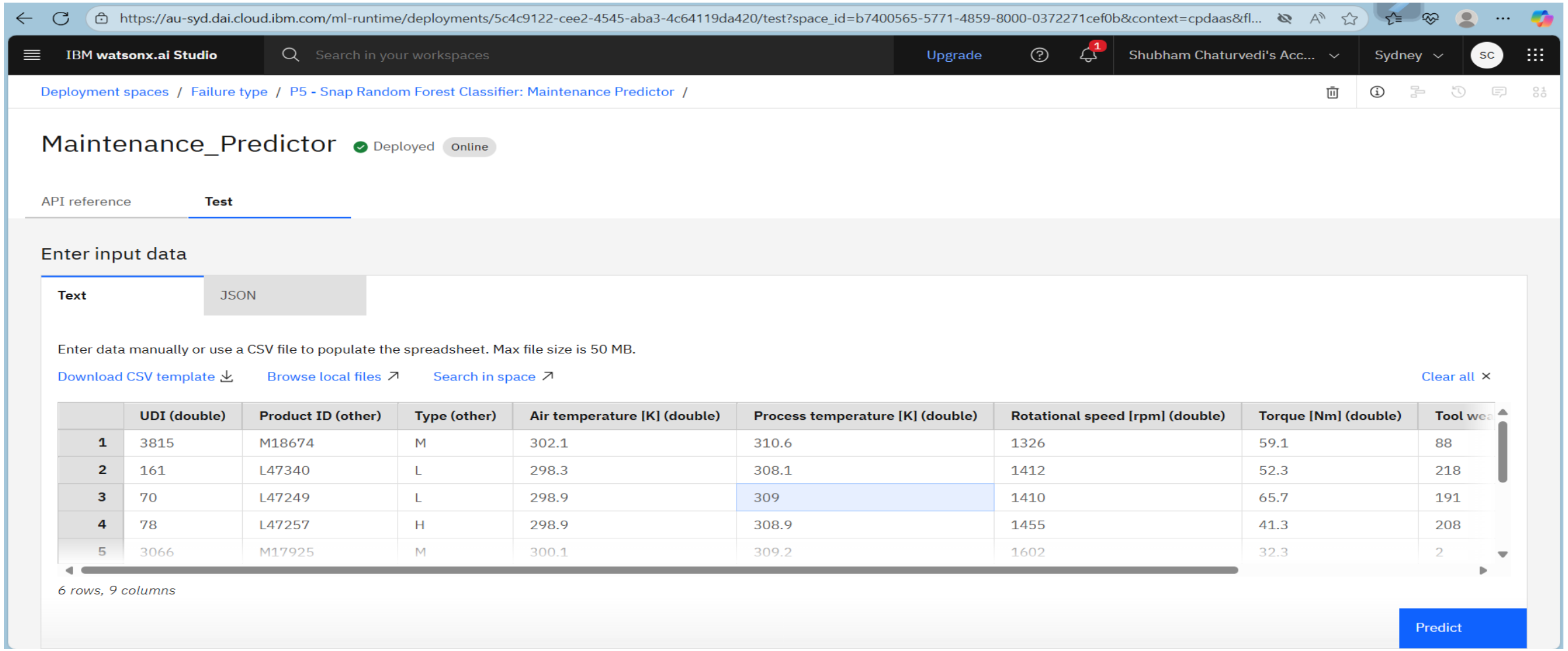
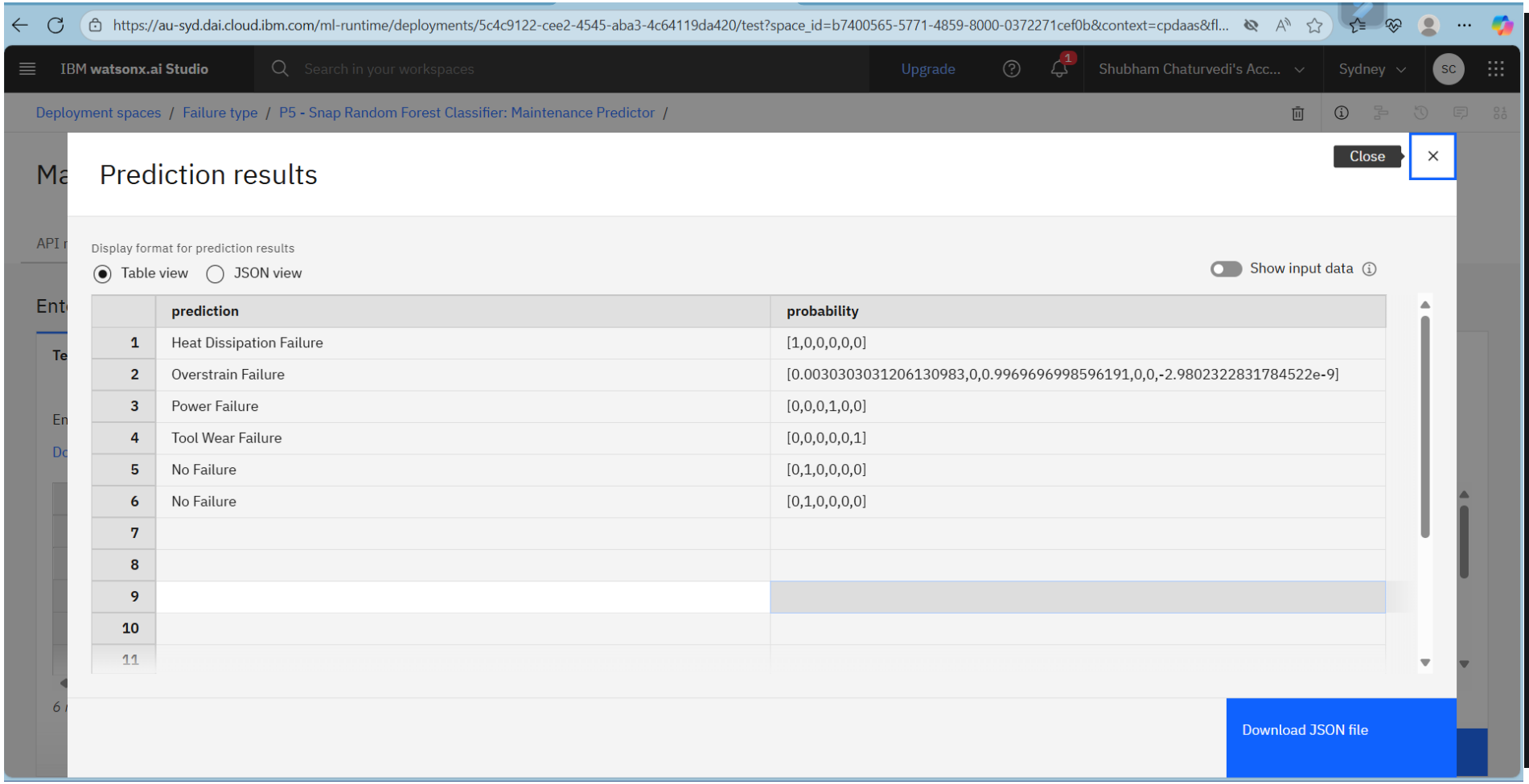
RESULT



RESULT



RESULT



	prediction	probability
1	Heat Dissipation Failure	[1,0,0,0,0,0]
2	Overstrain Failure	[0.0030303031206130983,0,0.9969696998596191,0,0,-2.9802322831784522e-9]
3	Power Failure	[0,0,0,1,0,0]
4	Tool Wear Failure	[0,0,0,0,0,1]
5	No Failure	[0,1,0,0,0,0]
6	No Failure	[0,1,0,0,0,0]
7		
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10		
11		

The deployed predictive maintenance model achieves high cross validation accuracy of **99.5%** in predicting machine failure types before they occur as per IBM Watson AutoAI pipeline leaderboard.

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CONCLUSION

- The predictive maintenance solution successfully demonstrates the power of machine learning in anticipating machine failures using real sensor data.
- Deployment on IBM Cloud Lite ensures scalability, accessibility, and ease of integration within industrial environments.
- The system enables industries to move from reactive to proactive maintenance, delivering measurable improvements in uptime and operational efficiency.
- Continuous data collection and retraining further enhance accuracy over time.

FUTURE SCOPE

- Expand sensor integration (add more sensor types and data sources).
- Apply advanced algorithms (deep learning, anomaly detection, edge deployment).
- Generalize the solution for other types of industrial equipment and processes.
- Integration with enterprise maintenance management systems (CMMS).
- Explore predictive maintenance at scale (multi-site, multi-factory deployments).
- Use AI explainability tools to interpret failure causes and suggest specific maintenance actions.

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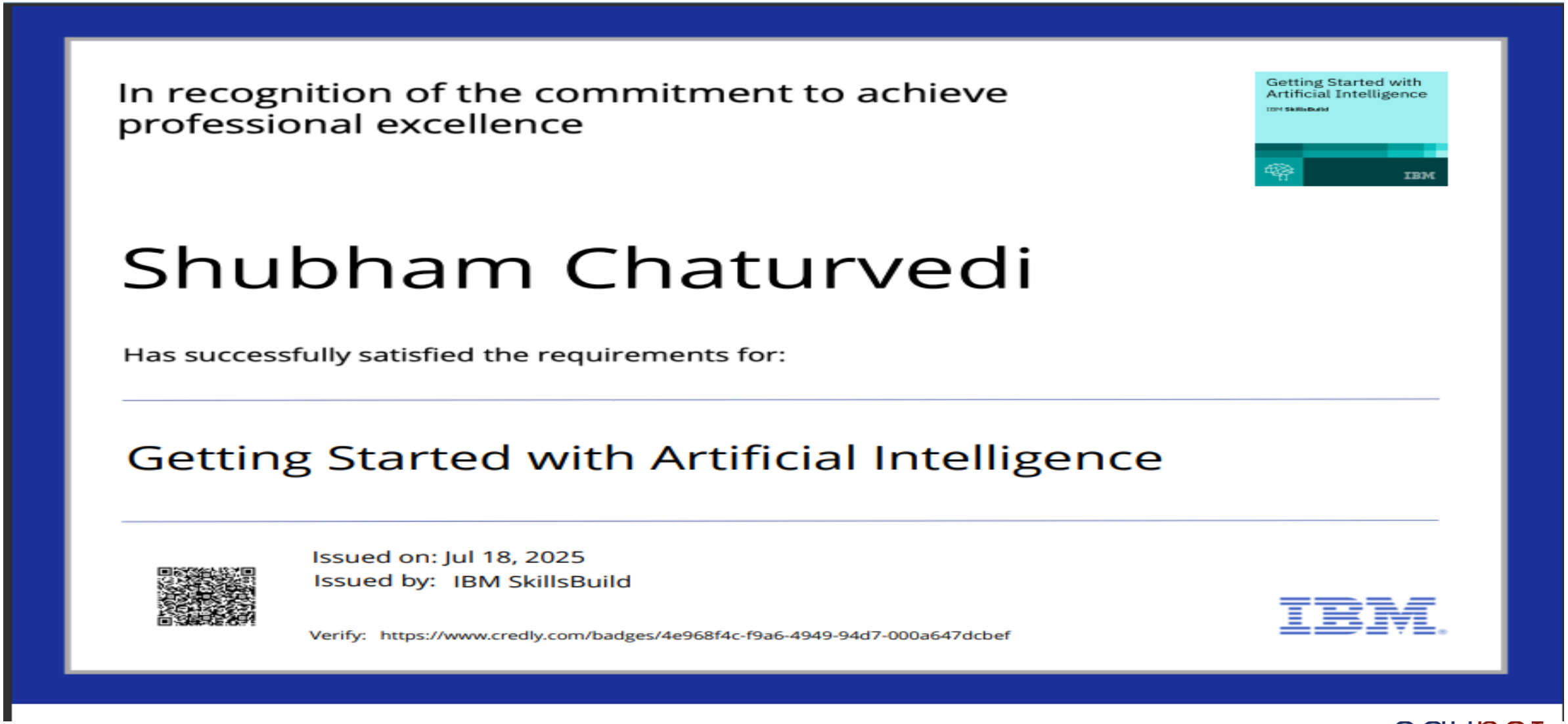
IBM CERTIFICATIONS



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IBM **SkillsBuild** Completion Certificate

This certificate is presented to

Shubham Chaturvedi

for the completion of

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

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THANK YOU

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