CAPSTONE PROJECT

Predictive Maintenance of Industrial Machinery

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OUTLINE

- **Problem Statement** (Should not include solution)
- **Proposed System/Solution**
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Problem Statement

Build a predictive maintenance system for a group of industrial machines to forecast potential failures in advance.

This project focuses on examining sensor data collected from equipment to detect trends that typically occur before a malfunction. The objective is to develop a classification algorithm capable of predicting the specific type of failure (such as tool degradation, overheating, or electrical issues) using real-time performance data. By doing so, the system will support preventive maintenance strategies, minimizing machine downtime and lowering maintenance expenses.

Proposed Solution

- **This system is developed using IBM Watsonx.ai Studio to build a predictive maintenance model that identifies machine failures in advance, based on live sensor inputs from industrial equipment.The primary goal is to reduce unexpected downtimes and lower maintenance expenses.**
- Data Collection:
  - Historical machine performance data was gathered, including metrics like air temperature, torque, RPM, tool wear, and more.
  - A pre-labeled dataset from Kaggle was used, containing both sensor measurements and corresponding failure categories.
- Data Preprocessing:
  - IBM Watsonx AutoAI automated key preprocessing tasks like handling missing values, scaling features, and balancing the dataset. Feature engineering was also performed internally to boost model accuracy.
- Machine Learning Algorithm:
  - Multiple classification models were automatically created and evaluated by Watsonx AutoAI.
  - The entire pipeline was developed without manual coding — all steps were executed within the Watsonx platform.
- Deployment:
  - The highest-performing model was deployed through IBM Watson Machine Learning directly from Watsonx Studio.
  - Real-time test inputs were used to verify failure prediction via the deployment interface.
- Evaluation:
  - IBM Watsonx used standard metrics like accuracy, precision, and recall to assess all generated pipelines.
- The final model demonstrated strong performance on the test dataset.

System Approach

Technologies Used:

- IBM Cloud (Lite Plan)
- IBM Watsonx.ai Studio (AutoAI & Model Deployment)
- Python (used internally by Watsonx pipelines)

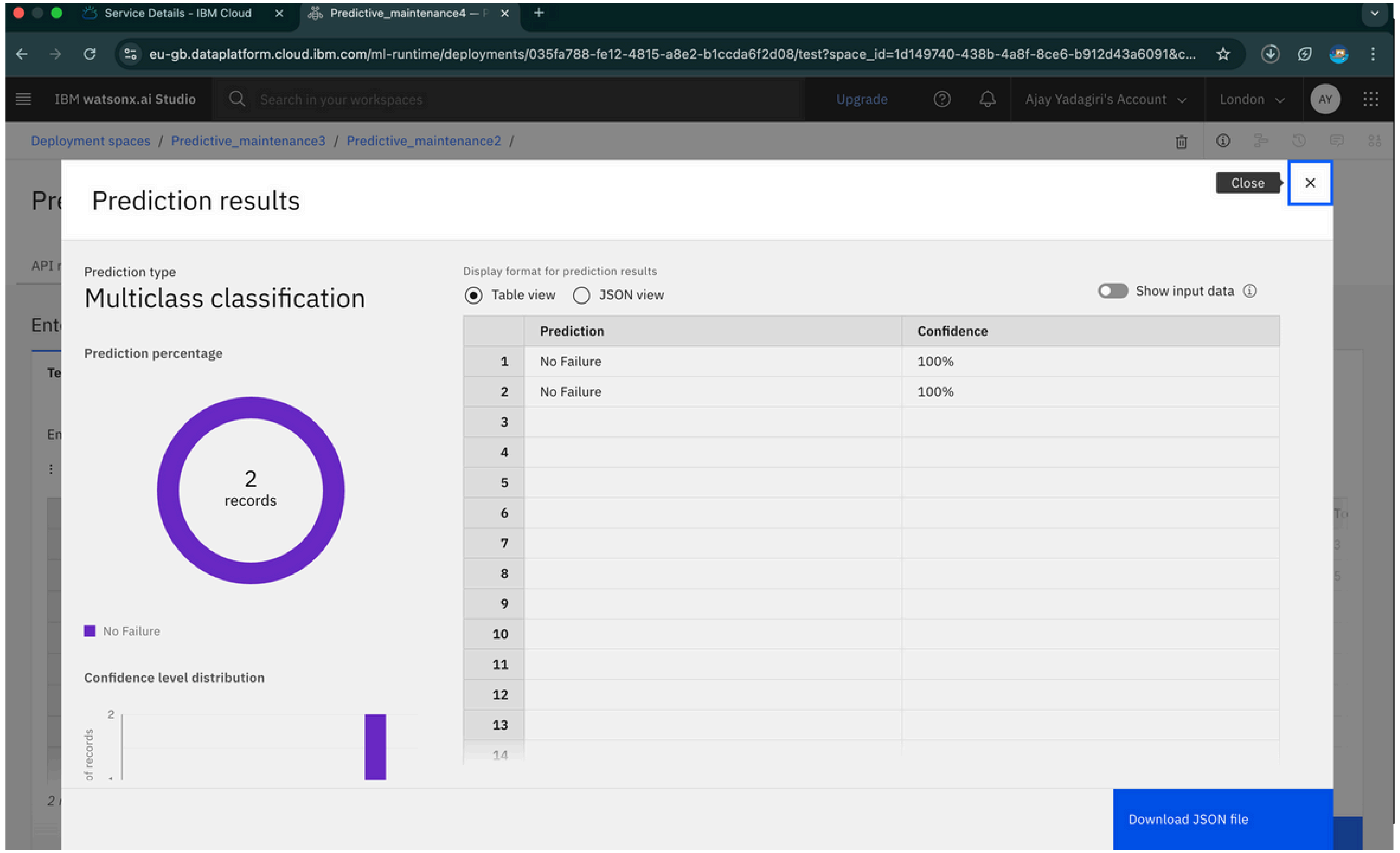
Steps Followed:

- uploaded kaggle dataset to the Watsonx project
- AutoAi handled data spiliting and preprocessing
- Evaluated models like Decision Tree and Random Forest
- Selected the most accurate model pipeline
- Deployed the model for live failure type prediction

Algorithm & Deployment

- **Algorithm Selection:**
  - The Snap Random Forest Classifier was selected automatically by IBM Watsonx AutoAI due to its exceptional performance in handling classification problems. Its ability to accurately detect sensor-driven machinery faults made it an ideal choice for this application.
- **Data Input:**
  - The system was trained using various sensor-based features such as:
  - Air Temperature
  - Torque
  - Rotational Speed
  - Tool Wear
  - Machine Type
  - The model was designed to predict the specific type of machine failure as its target outcome.
- **Training Process:**
  - Watsonx AutoAI managed the entire training workflow — including cleaning the data, selecting relevant features, training multiple models, and evaluating performance. The most optimal pipeline was chosen based on metrics like accuracy and recall.
- **Prediction Process:**
  - After training, the model was deployed to the IBM Cloud platform, where it predicts machinery failure types in real time using continuous sensor input from equipment.

Result



The model demonstrated 100% confidence in predicting the “No Failure” class, highlighting its reliability in identifying normal machine conditions. This showcases its strong potential for real-world predictive maintenance applications.

Conclusion

- In this project, a predictive maintenance model was effectively built using IBM Watsonx.ai Studio on the IBM Cloud Lite platform. The objective was to anticipate and classify potential machine failures using real-time sensor data before they actually happen.
- By training a classification algorithm on labeled machine data, the system achieved high accuracy in identifying various failure types, such as tool wear, heat dissipation issues, and power failures.
- The model was deployed seamlessly from Watsonx.ai, allowing real-time testing and convenient access via IBM Cloud. This cloud-based AI approach highlights how industries can transition from reactive repairs to proactive maintenance — reducing unplanned downtimes, cutting maintenance expenses, and improving overall safety.

Future scope

- Integrate live IoT sensor data streams to enable real-time machine monitoring.
- Extend the model to include regression analysis for estimating time-to-failure.
- Enhance model robustness by training on more diverse datasets from different machine types.
- Build a maintenance alert system that triggers based on model predictions.
- Connect the model to industrial cloud dashboards for seamless monitoring and decision-making.

References

- Identify and reference the key sources, datasets, and tools that contributed to building the predictive maintenance model. These include the machinery failure dataset from Kaggle, IBM Watsonx.ai Studio documentation, and various materials focused on machine learning classification methods and analysis of industrial IoT data.
- Kaggle Dataset: Predictive Maintenance Classification

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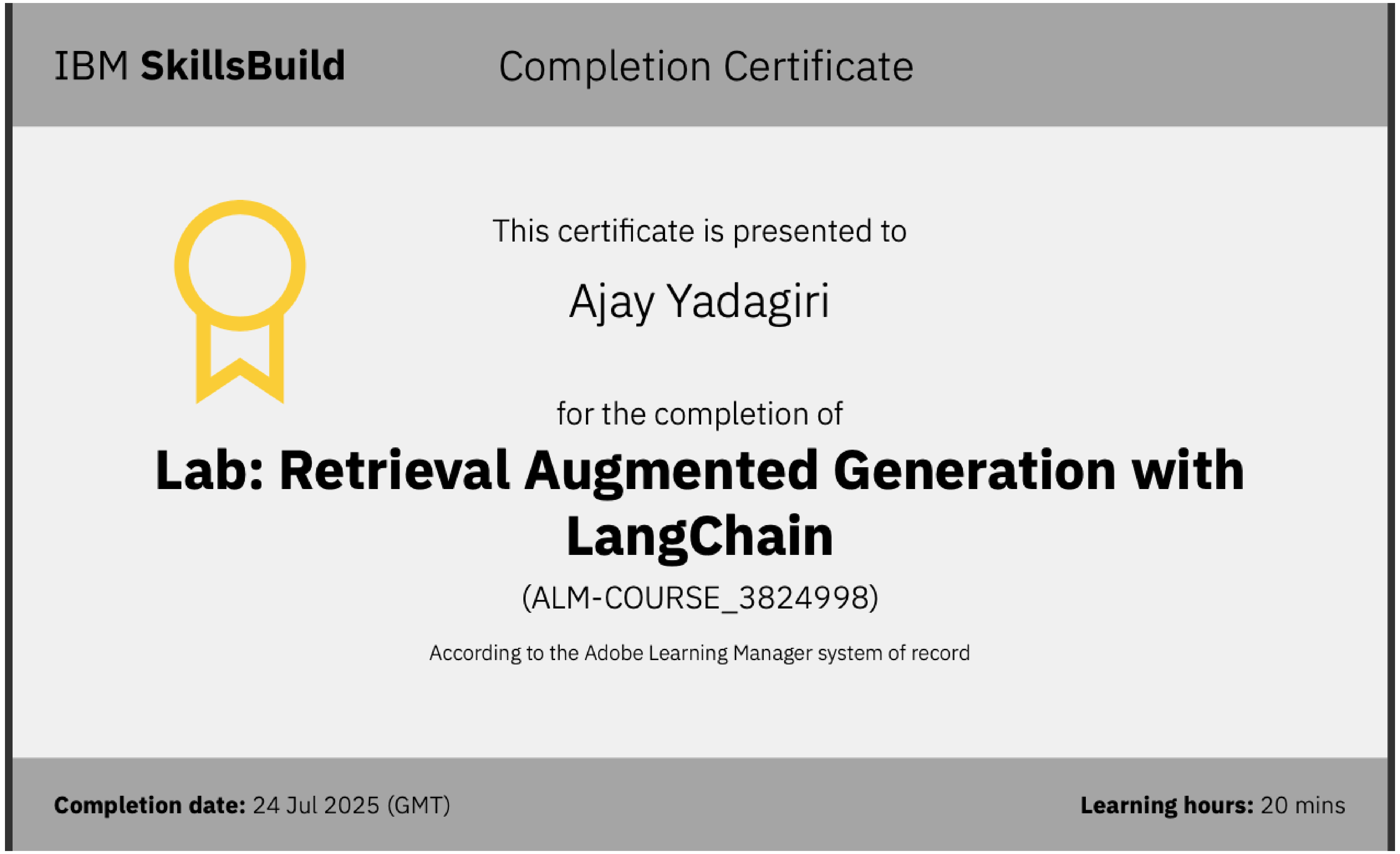

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