CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY USING MACHINE LEARNING

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OUTLINE

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

PROBLEM STATEMENT

Industrial machines are prone to unexpected failures, leading to costly downtime and inefficiencies. This project aims to develop a **predictive maintenance model** that uses data to identify patterns leading to machine failures such as **tool wear**, **power failure**, and **heat dissipation issues.** The goal is to build a **classification model** that predicts the **type of failure in advance**, enabling **proactive maintenance** and reducing operational costs.

PROPOSED SOLUTION

- The proposed solution aims to predict potential machinery failures in advance by analyzing real-time sensor data, enabling proactive maintenance and reducing downtime. The system will be developed using **IBM Watsonx.ai Studio** and deployed on the **IBM Cloud** platform. The key components include::
- **1. Data Collection**

  Use a labeled dataset containing historical **sensor readings** from industrial machines.

  Key features include: **air temperature**, **process temperature**, **torque**, **rotational speed**, and **tool wear**.

  The dataset also includes labels for types of failures such as **tool wear**, **power failure**, **heat dissipation failure**, and **no failure**.
- **2. Data Preprocessing**

  Handle **missing values**, **outliers**, and normalize the sensor data.

  Apply **label encoding** for categorical features (e.g., failure types).
- **3. Machine Learning Model (AutoAI)**

  Use **IBM Watsonx.ai Studio's AutoAI** to automate model training, testing, and pipeline creation.

  Multiple pipelines are generated and evaluated automatically.
- **4. Deployment**

  Deploy the selected model to **IBM Watson Machine Learning** as an **online REST API** service.

  Enable **real-time predictions** for use in production environments.

5. **Evaluation**

- Evaluate model performance using classification metrics such as: **Accuracy, Recall, Precision**
- **6 Result :** The solution enables industries to **predict specific types of failures** in advance, helping them schedule **proactive maintenance**, avoid **unexpected breakdowns**,

SYSTEM APPROACH

The **System Approach** section outlines the overall strategy and tools used to develop, train, and deploy a predictive maintenance model that can classify potential machine failures based on sensor data.**. Here's a suggested structure for this section:**

- System requirements –

1) IBM CLOUD (Mandatory)

2) IBM Watson studio for model development and deployment

3) IBM cloud object storage for data set handling

ALGORITHM & DEPLOYMENT

- This section describes the machine learning algorithm used for classifying machinery failures and the process of deploying the trained model using IBM Watsonx.ai.
- **Algorithm Selection:**
  - The project uses **IBM AutoAI** to automatically select and train the most effective machine learning classification algorithm based on the dataset, the chosen algorithm was **Decision Tree Classifier**, as it provided the highest accuracy for classifying failure types like tool wear, heat dissipation failure, and power failure.
- **Data Input:**

  The following features from the sensor data were used as input for training the model: **Air Temperature, Process Temperature, Rotational Speed, Torque, Tool Wear**
- **Training Process**

  Automatically split the data into **training and test sets**

  Performed **feature engineering** and **normalization**

  Applied **hyperparameter tuning**

  Evaluated multiple classification pipelines using metrics like **Accuracy**, **Precision**, **Recall**, and **F1-Score**
- **Prediction Process**

Once trained, the model predicts the **type of failure** that may occur given a set of real-time sensor inputs. The model analyzes these inputs and classifies them into predefined failure categories. The deployment is designed for **real-time prediction**, allowing industries to act before an actual failure happens.

- **Deployment**

  After training and selecting the best model pipeline:

  The model was **saved as an asset** in IBM Watsonx.ai Studio.

  It was then **promoted to a deployment space** using Watson Machine Learning (WML).

RESULT

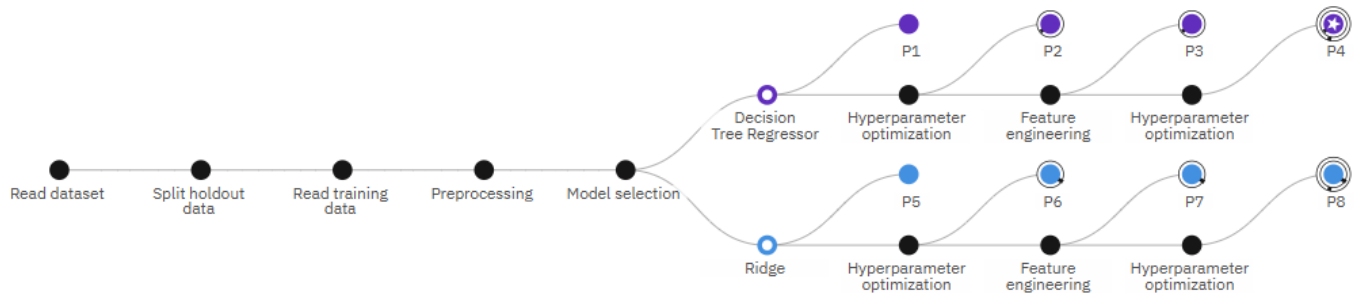
Projects / Predictive Maintenance ML model for Industrial Machinery / Predictive Maintenance ML Model

Experiment summary | Pipeline comparison

★ Rank by: Root mean squared error (RMSE) (... | Cross validation score

Progress map

Prediction column: Tool wear [min]



Relationship map

Swap view

Experiment completed

8 PIPELINES GENERATED

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

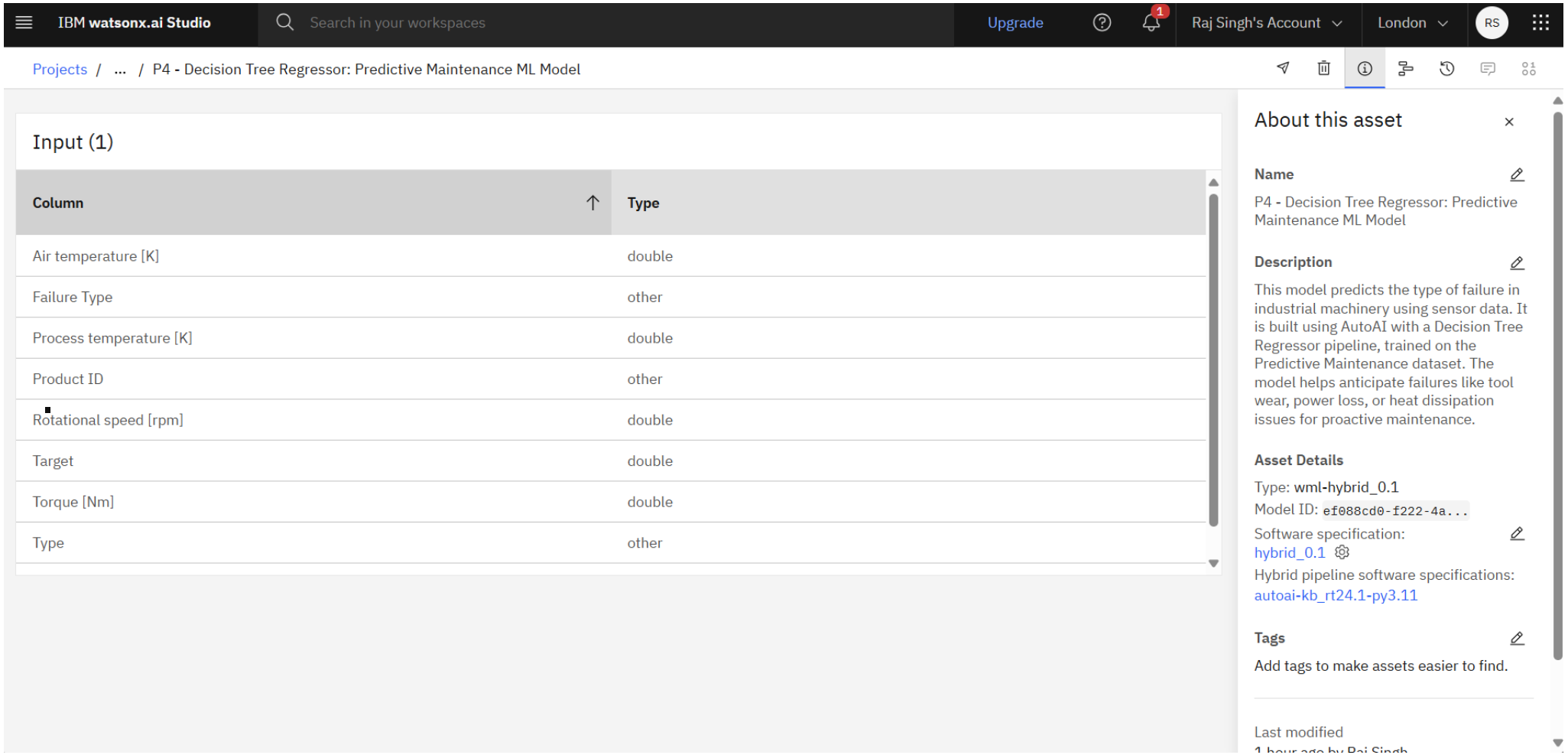
Time elapsed: 3 minutes

View log | Save code

Pipeline leaderboard

	Rank	Name	Algorithm	RMSE (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 4	Decision Tree Regressor	62.145	HPO-1 FE HPO-2	00:00:34
	2	Pipeline 3	Decision Tree Regressor	62.171	HPO-1 FE	00:00:29
	3	Pipeline 2	Decision Tree Regressor	62.171	HPO-1	00:00:05

RESULT



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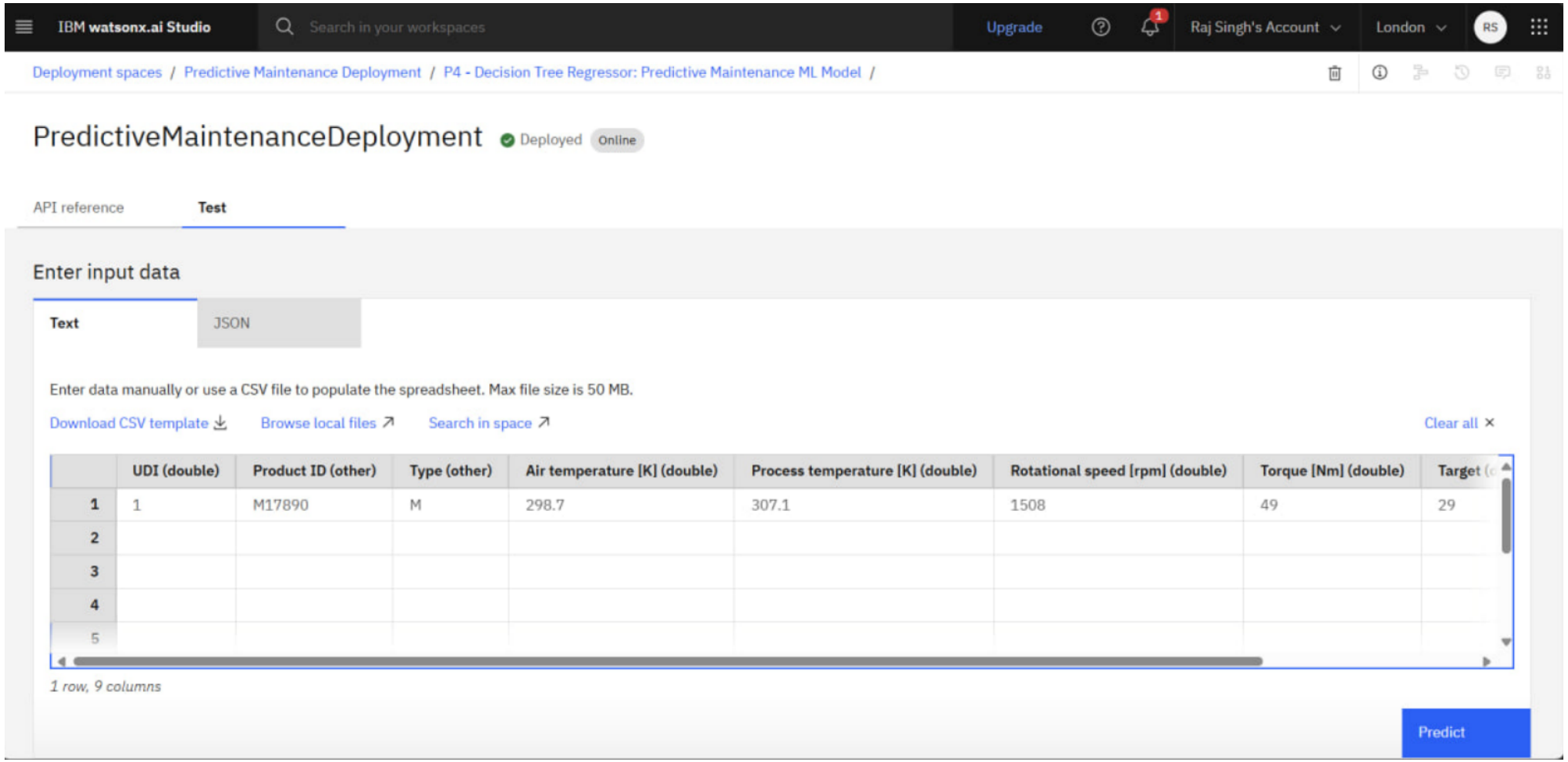
RESULT



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RESULT

IBM watsonx.ai Studio | Search in your workspaces | Upgrade | Raj Singh's Account | London | RS

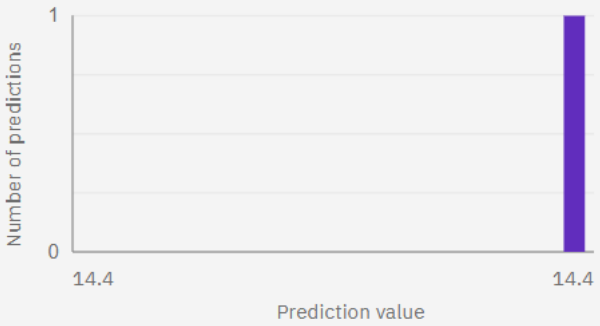
Deployment spaces / Predictive Maintenance Deployment / P4 - Decision Tree Regressor: Predictive Maintenance ML Model /

Prediction results

Prediction type

Regression

Prediction distribution



Display format for prediction results

(•) Table view ( ) JSON view

Show input data

	Prediction	UDI	Product ID	Type	Air temperatu
1	14.4	1	M17890	M	298.7
2					
3					
4					
5					
6					
7					
8					
9					
10					

Download JSON file

CONCLUSION

- In this project, a **predictive maintenance model** was successfully developed using IBM Watsonx.ai's **AutoAI** capabilities to classify machinery failures based on sensor data. By inputting various operational parameters (such as air temperature, torque, and rotational speed), the system was able to provide a prediction
- The model offers significant potential for **reducing machine downtime**, minimizing operational costs, and enabling **proactive maintenance scheduling**. The AutoAI pipeline efficiently automated the processes of model selection, training, and hyperparameter optimization, allowing for a robust and scalable solution.

FUTURE SCOPE

- The system can eventually become a core component of **smart factories** and **Industry 4.0** solutions, where machines autonomously monitor their health and request maintenance, enabling near-zero downtime and optimized operational efficiency. the predictive maintenance system can be enhanced by integrating real-time IoT sensor data and historical maintenance records to improve accuracy.

REFERENCES

Here is a sample **References** section tailored for your **Predictive Maintenance ML Project**, using AutoAI and IBM Cloud, with citations relevant to **machine learning**, **predictive maintenance**, and **data science best practices:**

1) **IBM Watsonx.ai Documentation**
   https://www.ibm.com/docs/en/watsonx

2) 2) IBM cloud link - IBM watsonx.ai Studio

3) *Machine Predictive Maintenance Classification Dataset*, Kaggle-
   https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification

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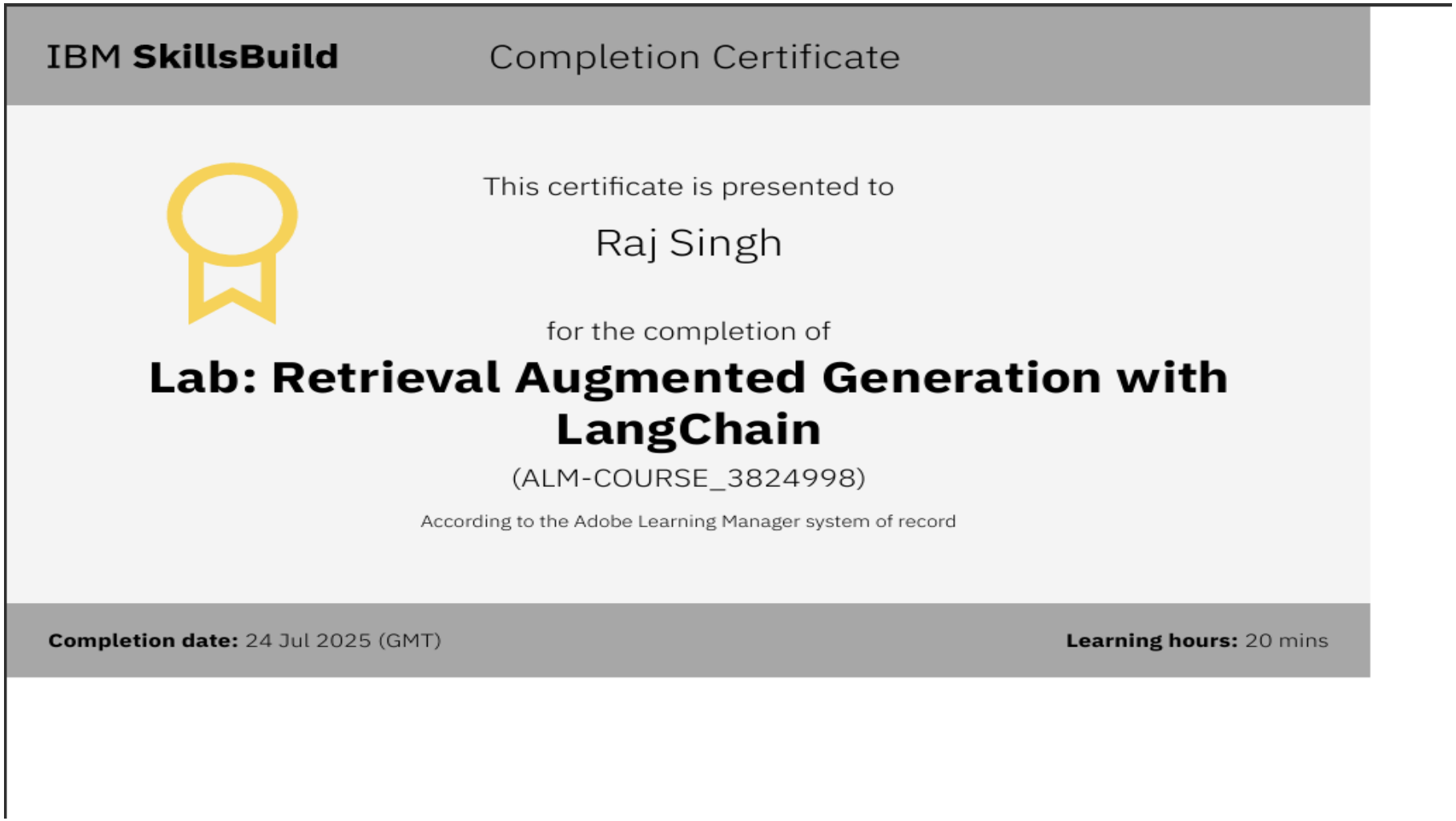

IBM **SkillsBuild** Completion Certificate

This certificate is presented to

Raj Singh

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

THANK YOU

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