CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result
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PROBLEM STATEMENT

- The aim is to use sensor data collected from machines—such as temperature, pressure, vibration, and rotational speed—to predict the type of failure that might occur. These failures could include tool wear, power failure, or issues with heat dissipation. By analyzing this data, the model should be able to detect early warning signs of mechanical problems and classify the likely type of failure before it happens. This proactive approach will help reduce unexpected machine breakdowns, minimize downtime, and lower maintenance costs. The project involves building a classification model that can learn from historical machine data and support real-time decision-making for industrial operation

PROPOSED SOLUTION

- The proposed system aims to address the challenge of predicting machine failure using sensor data such as air temperature, process temperature, rotational speed, and torque, was uploaded and explored.
- Data Collection:
  - Gather historical data based on parts wearout phase.
  - Utilize real-time data sources, air temperature, process temperature, rotational speed, and torque.
- Data Preprocessing:
  - Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies.
  - Feature engineering to extract relevant features from the data.
- Machine Learning Algorithm:
  - Random Forest Algorithm is used to accurately classify different types of machine failures based on sensor data patterns.
  - Consider incorporating additional factors like machine age, maintenance history, and operating environment to improve the accuracy of failure predictions.
- Deployment:
  - The predictive maintenance model was deployed on IBM Cloud .
  - Deploy the solution on a scalable and reliable platform, considering factors like server infrastructure, response time, and user accessibility.
- Evaluation:
  - Assess the model's performance using appropriate metric(Accuracy).
  - Result: Accuracy = 0.995

SYSTEM APPROACH

- System Approach
  - The "System Approach" outlines the overall methodology and technical framework used to develop and deploy the predictive maintenance model for industrial machinery.

- System Requirements
  - **IBM Cloud Lite Account** (for Watson Studio and Machine Learning services)
  - **Internet Browser** (Chrome/Firefox for accessing IBM Watson Studio)
  - **Cloud Storage** (IBM Cloud Object Storage for data storage and access)
  - **Optional:** Local Python environment (for exploratory data analysis and offline experimentation)

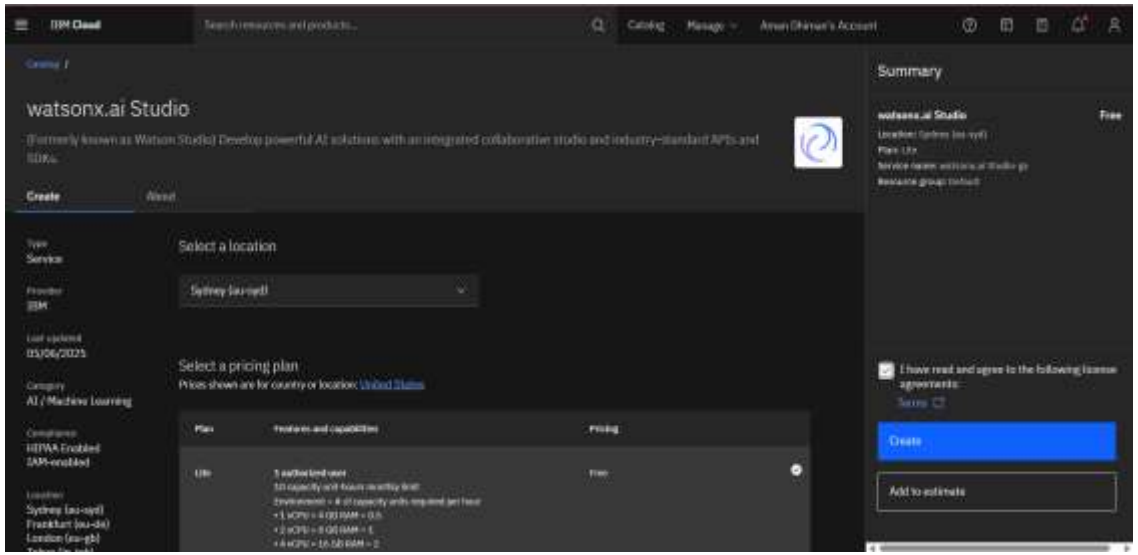
ALGORITHM & DEPLOYMENT

- Algorithm Selection
  - Random Forest was chosen for its high accuracy, robustness to noise, and ability to handle complex, non-linear data.
- Data Input
  - Input features included air temperature, process temperature, torque, rotational speed, tool wear, and machine type
- Training Process
  - The model was trained using labeled failure data with cross-validation and hyperparameter tuning to prevent overfitting and improve generalization.

Prediction Process

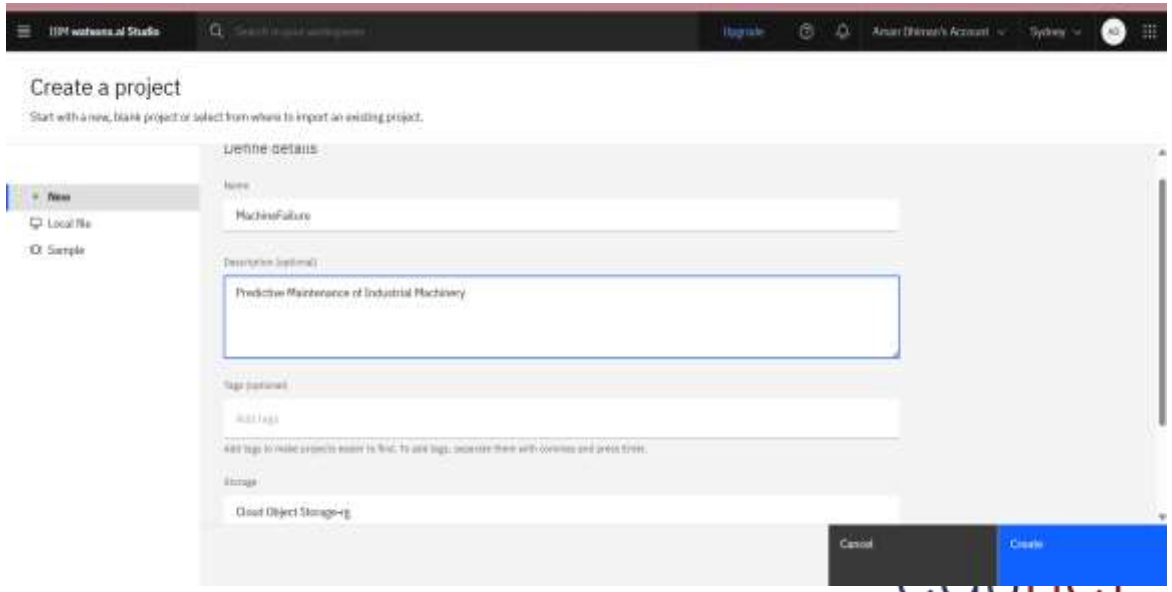
- The trained Random Forest model predicts the type of machine failure based on live sensor data, enabling real-time, proactive maintenance decisions.

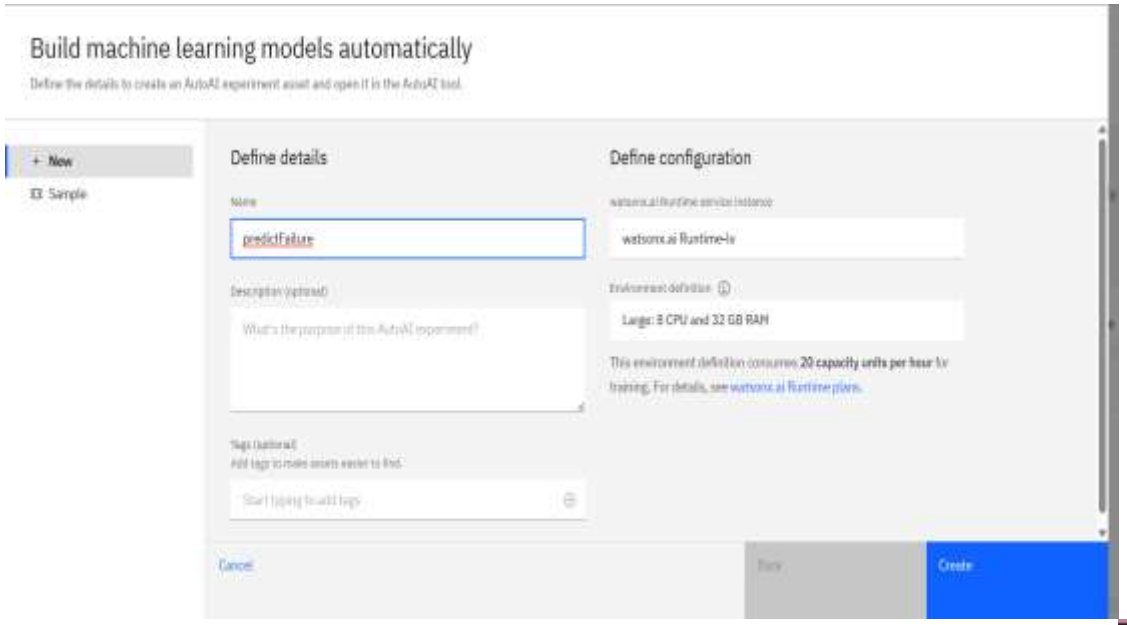
RESULT



IBM's **watsonx.ai Studio** is an end-to-end generative AI and ML development environment, enabling AI builders to build, train, fine-tune and deploy foundation models—including IBM's Granite and open-source LLMs—via Prompt Lab, Tuning Studio, AutoAI, SDKs and REST APIs.

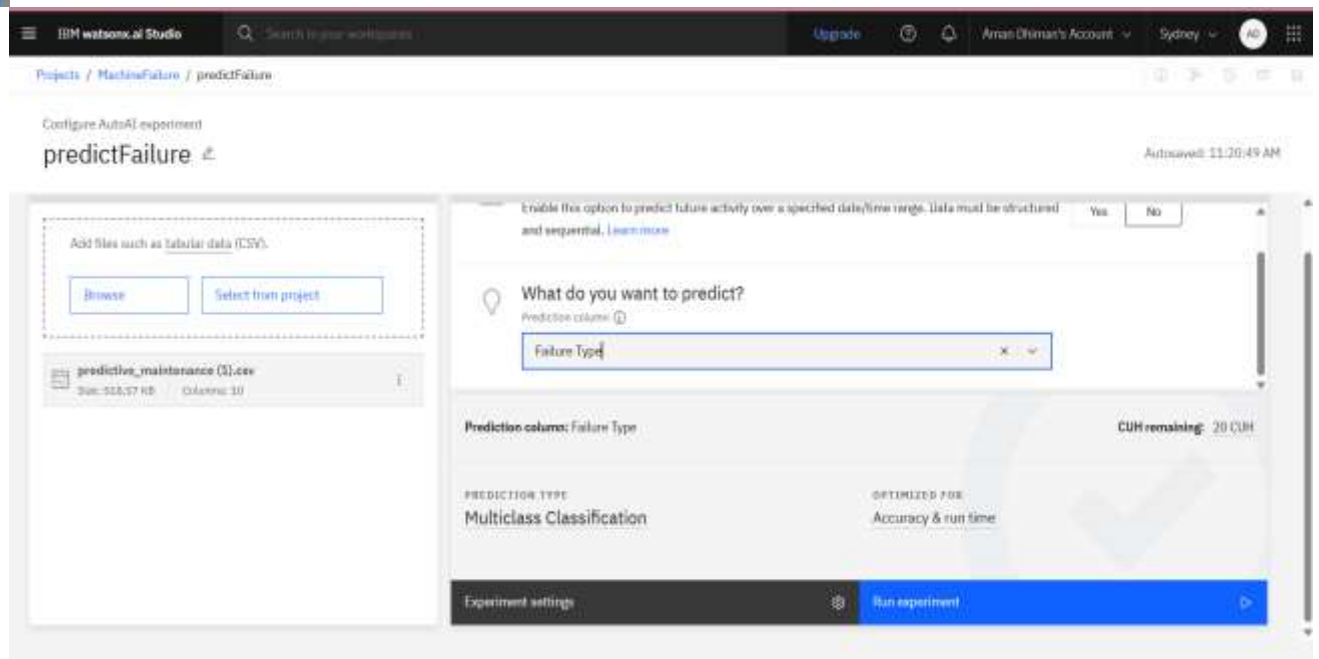
Creating a project in IBM Cloud helps organize and manage resources, services, and team collaboration under a single workspace. It allows you to track usage, assign roles, and structure workflows efficiently across AI, data, and app development environments.

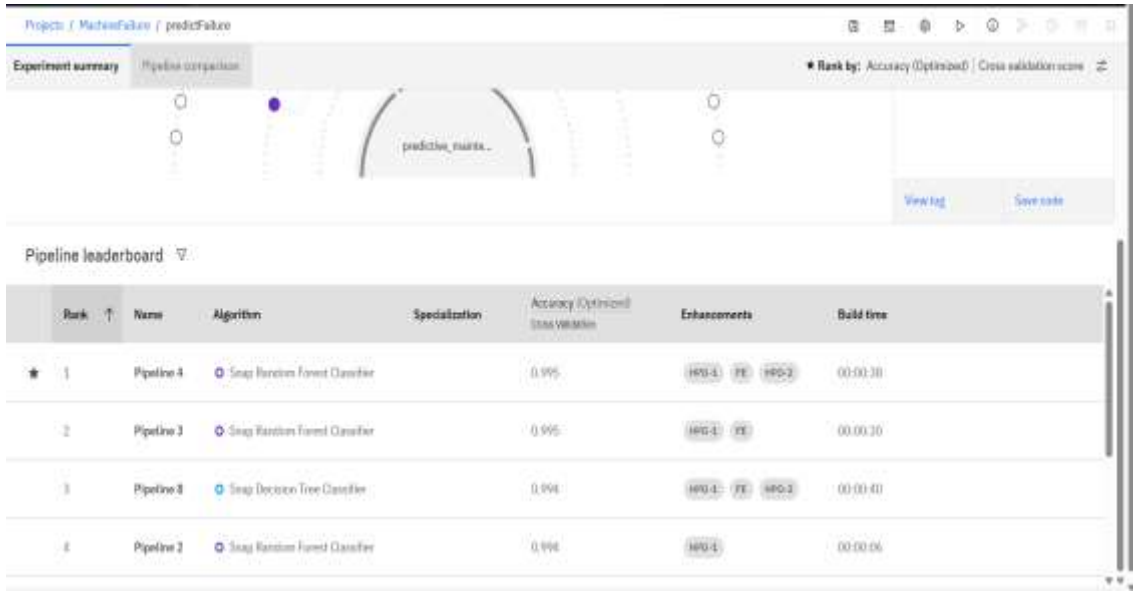




Build machine learning model automatically help to build machine learning model on ibm cloud without any prior knowledge of machine learning and coding.

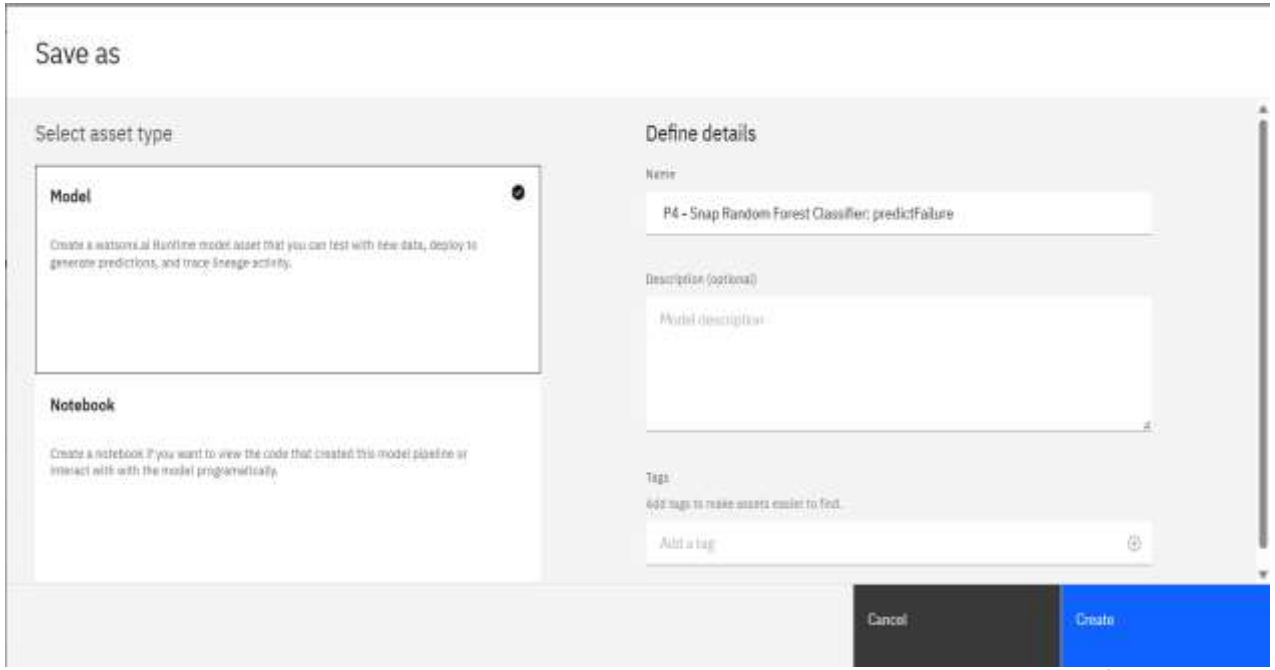
predictFailure is the name of the machine learning model used to predict Failure Type In industrial machines to predict the faults in machine before they occurs.

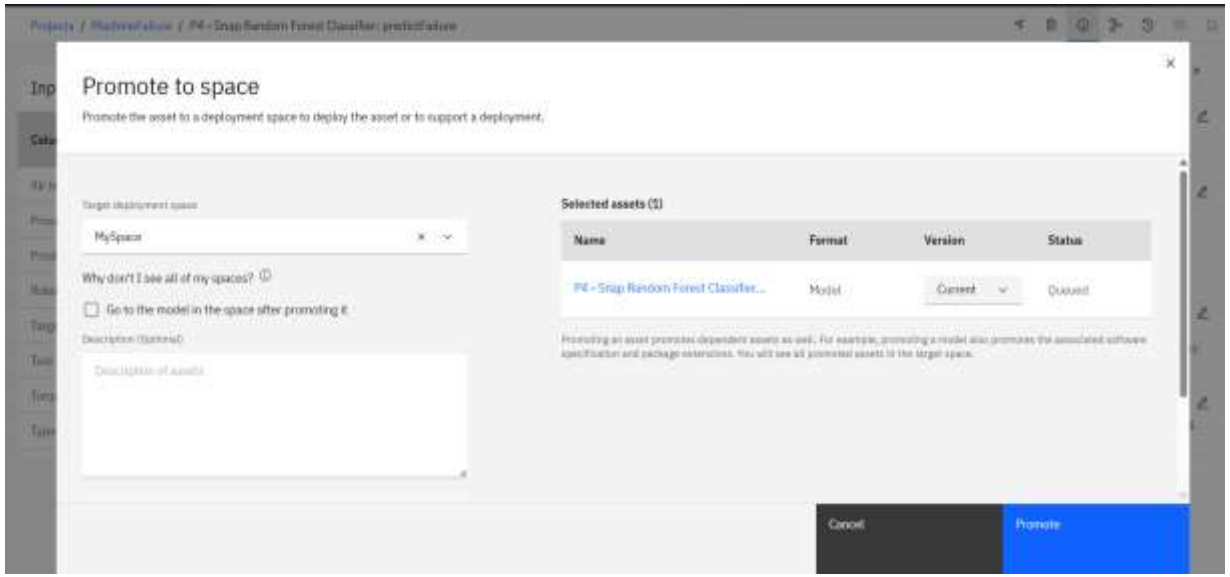




It ranks different machine learning pipelines by their optimized cross-validation accuracy. The top-performing models use the **Snap Random Forest Classifier**, with accuracies up to **0.995**, and include enhancements like **hyperparameter optimization (HPO)** and **feature engineering (FE)**.

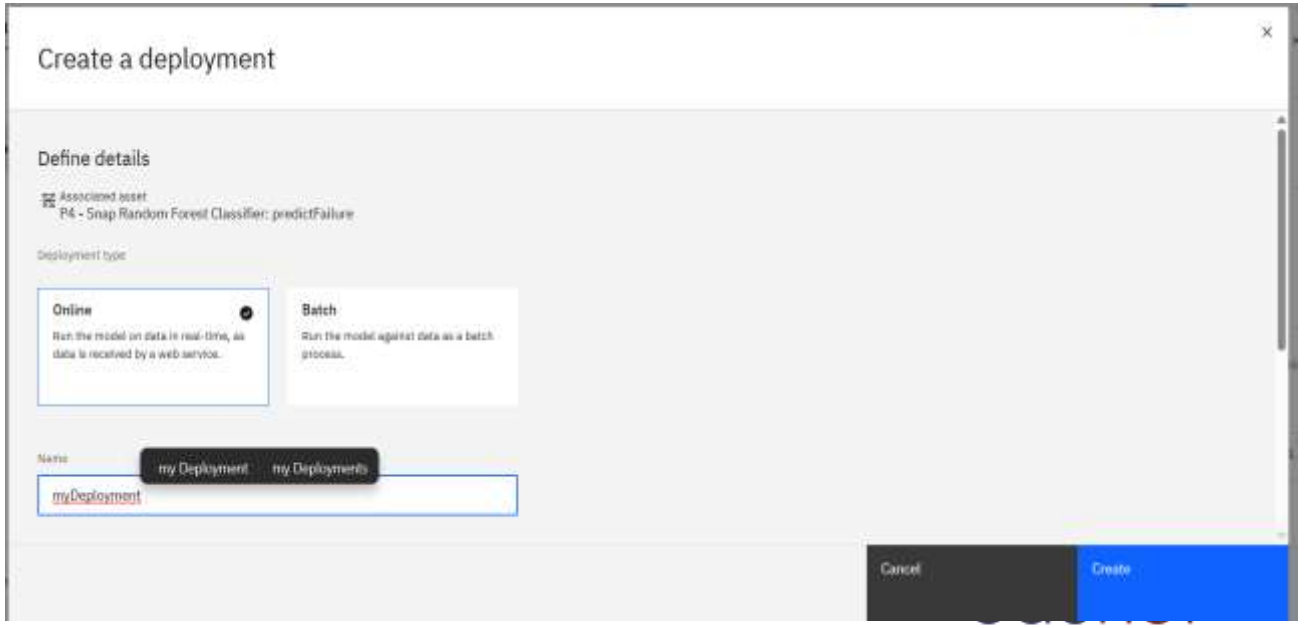
Save as interface in IBM watsonx.ai, where a trained model pipeline is being saved as a **Model asset.** The selected pipeline, **P4 - Snap Random Forest Classifier: predictFailure**, will be saved for future use—enabling deployment for predictions, testing with new data, and lineage tracking.

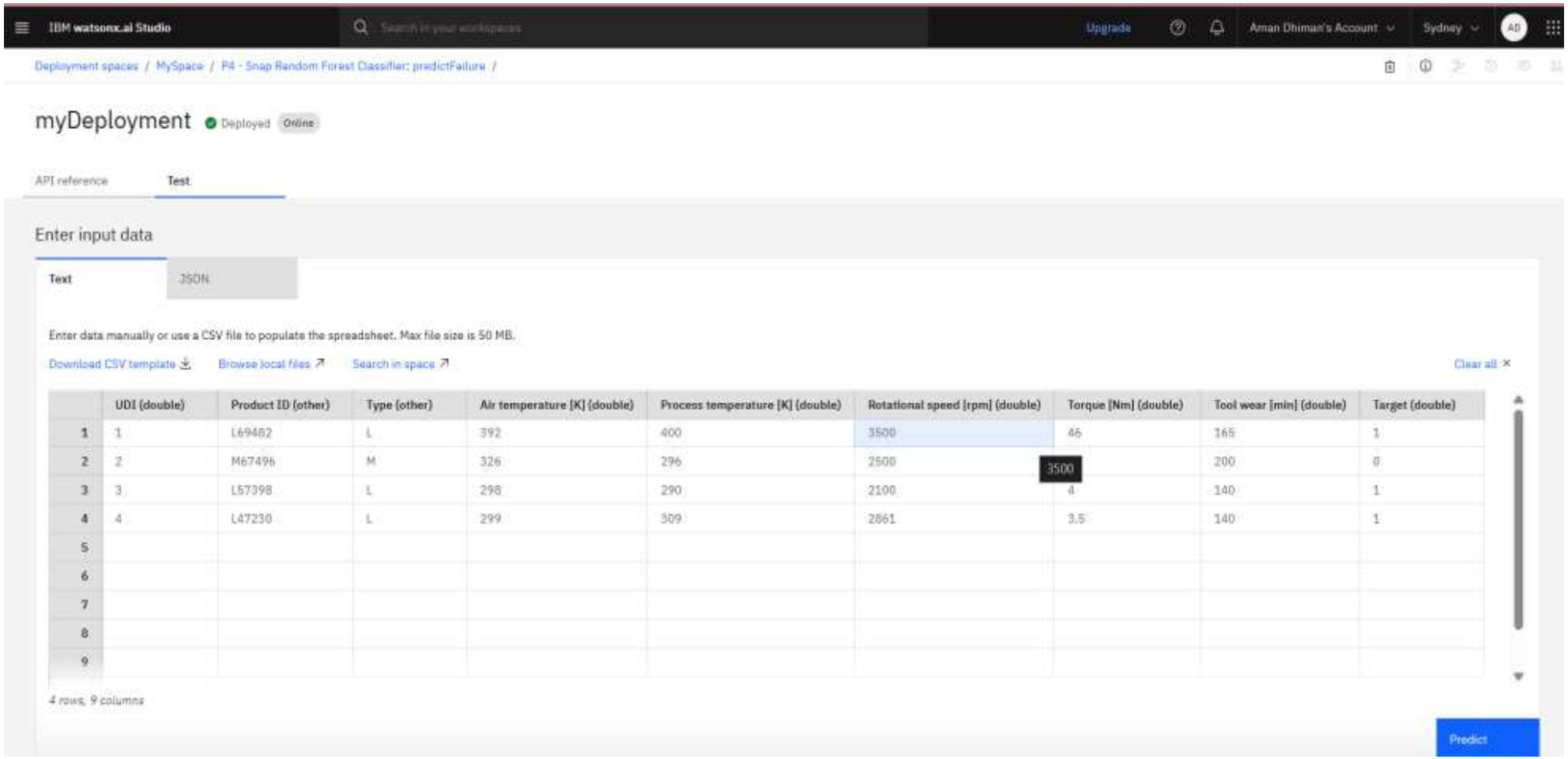




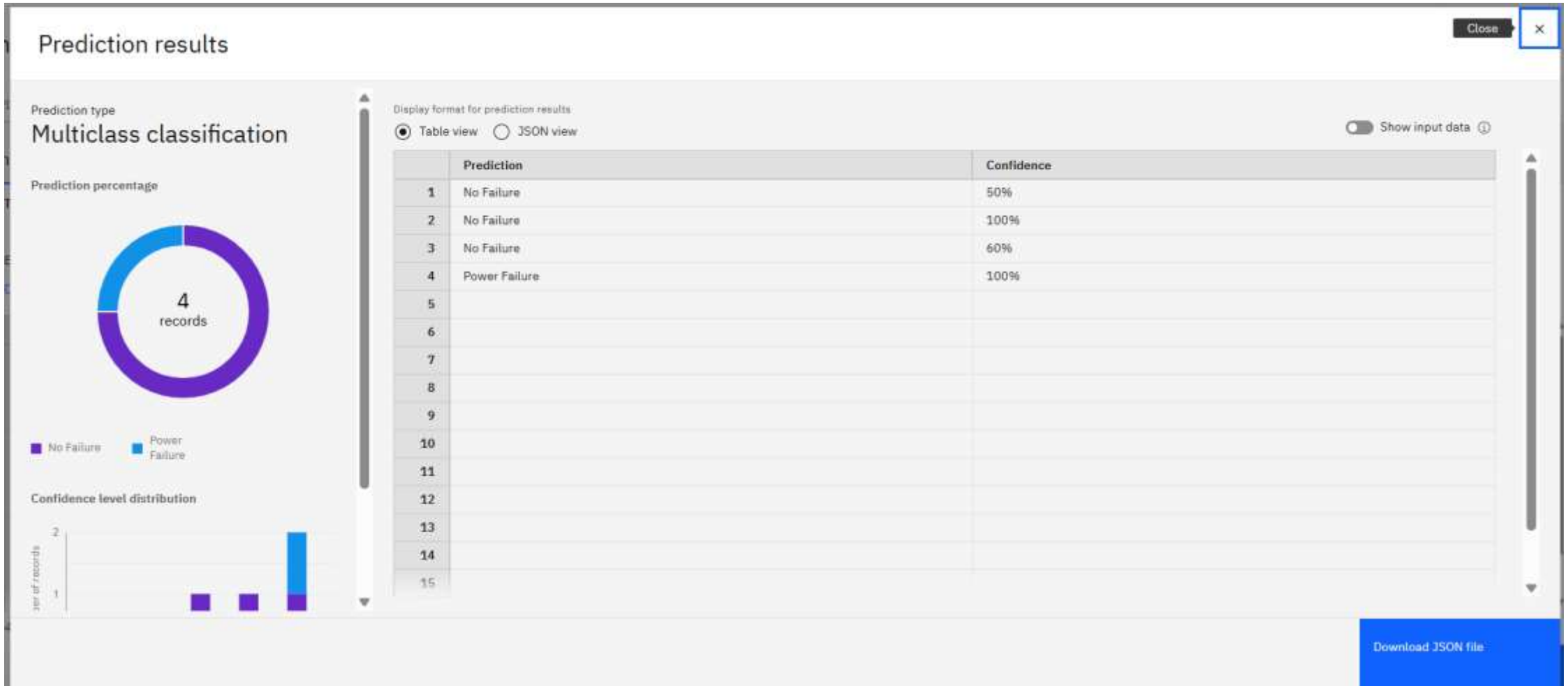
"Promote to space" step in IBM watsonx.ai, where the saved model asset (**P4 - Snap Random Forest Classifier**) is being promoted to a **deployment space** (in this case, *MySpace*). This step is essential to enable the model's deployment, allowing it to serve predictions and be managed in a production-like environment.

"Create a deployment" interface in IBM watsonx.ai. The selected model asset (**P4 - Snap Random Forest Classifier**) is being deployed using the **Online** option, which allows real-time predictions via a web service endpoint.





The **testing phase of a deployed model** in IBM watsonx.ai Studio. The deployed asset, **myDeployment**, is set to **Online**, allowing real-time predictions. Users can manually input or upload tabular data (like a CSV) to test the model. In this example, input variables such as **air temperature, process temperature, rotational speed, torque**, and **tool wear** are provided. After populating the data, clicking **Predict** will generate failure predictions using the trained **Snap Random Forest Classifier** model.



The **prediction results** from an IBM watsonx.ai model deployed for **multiclass classification**. Out of four test records, three were predicted as **"No Failure"**, and one as **"Power Failure"**, with corresponding confidence levels shown alongside. The donut chart and confidence distribution graph on the left provide a quick visual summary of outcomes, while the **table view** on the right details predictions per input. These insights help evaluate how well the model is performing on real or simulated data.

CONCLUSION

- The predictive maintenance model developed using the Random Forest algorithm successfully identifies potential machine failures before they occur. By leveraging real-time sensor data and deploying the model on IBM Cloud using watsonx.ai Studio services, the solution enables timely maintenance actions, minimizes unexpected downtimes, and enhances operational efficiency. The automated approach ensures scalability and can be integrated seamlessly into industrial systems for continuous monitoring and decision-making.

FUTURE SCOPE

- **Integration with IoT platforms** to automate data collection and real-time model inference.

- **Addition of new features** such as machine age, maintenance history, and environmental conditions to improve prediction accuracy.

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- **Model retraining pipelines** for continuous learning as new data is generated.

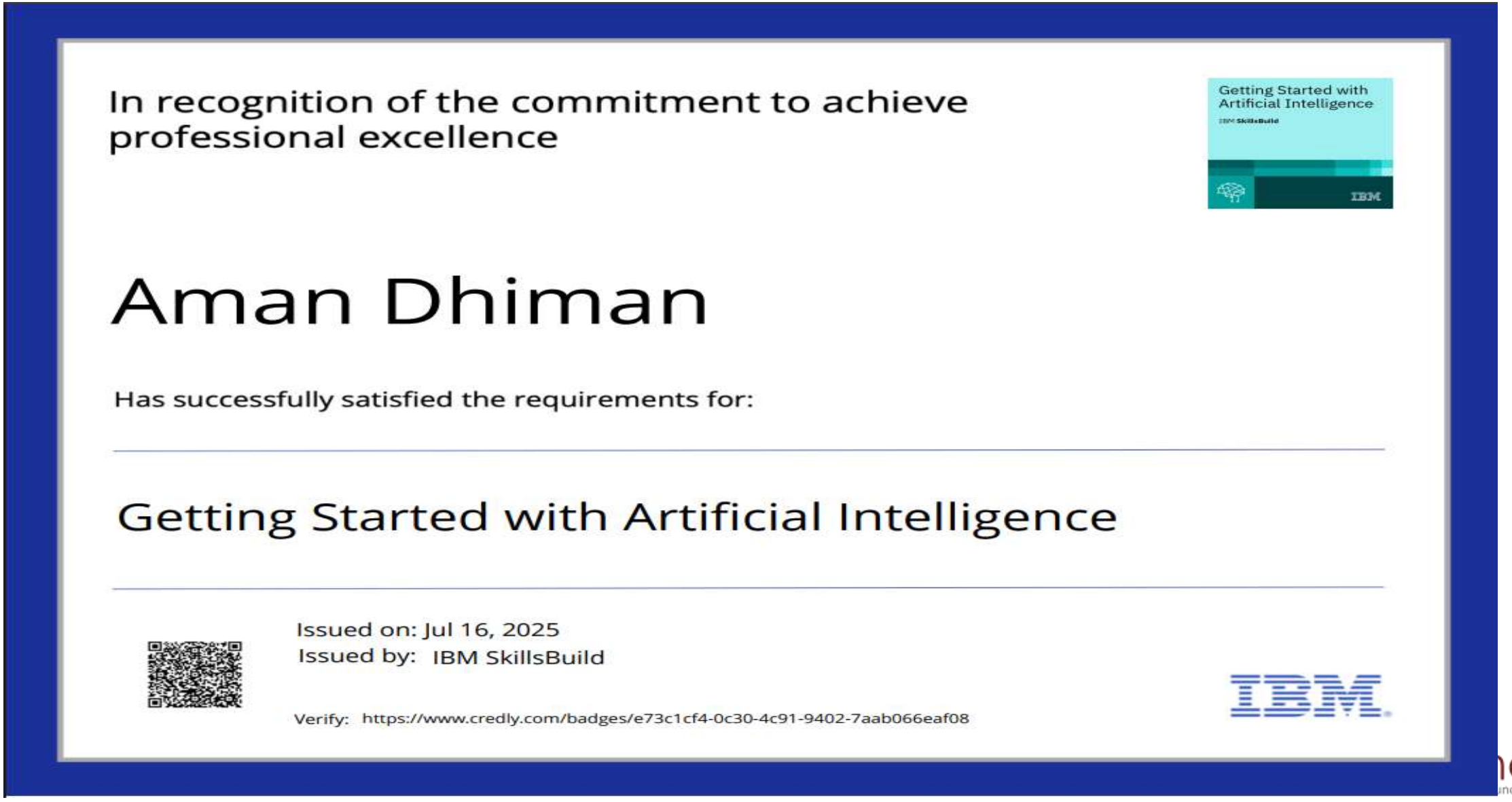
- **Expansion to multiple machine types** and failure modes across diverse industrial environments

REFERENCES

- **Kaggle Dataset – Machine Predictive Maintenance Classification**
  https://www.kaggle.com/datasets/shivamb/machinepredictive-maintenance-classification
  – The dataset used to train and evaluate the failure prediction model.

- **IBM AutoAI Documentation**
  https://www.ibm.com/cloud/watson-studio/autoai
  – Official documentation for IBM AutoAI, used to automate model training and selection.

IBM CERTIFICATIONS



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