CAPSTONE PROJECT

Predictive Maintenance of Industrial Machinery

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OUTLINE

- **Problem Statement** (Should not include solution)
- **Proposed System/Solution**
- **System Development Approach** (Technology Used)
- **Algorithm & Deployment**
- **Result (Output Image)**
- **Conclusion**
- **Future Scope**
- **References**

Problem Statement

Develop a predictive maintenance model for a fleet of industrial machines to anticipate failures before they occur. This project will involve analyzing sensor data from machinery to identify patterns that precede a failure. The goal is to create a classification model that can predict the type of failure (e.g., tool wear, heat dissipation, power failure) based on real-time operational data. This will enable proactive maintenance, reducing downtime and operational costs.

Proposed Solution

- The proposed system uses IBM Watsonx.ai Studio to develop a predictive maintenance model that can classify the type of machine failure before it occurs, using real-time sensor data from industrial machinery. The main objective is to prevent unplanned downtimes and reduce maintenance costs.
- Data Collection:
  - Collected historical operational data from industrial machines, including parameters such as air temperature, torque, rotational speed, tool wear, etc.
  - Used a labeled dataset from Kaggle, which includes both sensor readings and failure types.
- Data Preprocessing:
  - IBM Watsonx AutoAI automatically handled preprocessing, such as: Removing null or missing values, Normalizing and scaling input features, Detecting data imbalances
  - Feature engineering was done internally by AutoAI to enhance prediction accuracy.
- Machine Learning Algorithm:
  - Multiple classification algorithms were auto-generated and tested by Watsonx AutoAI.
  - No manual code was required — the model was built end-to-end in IBM Watsonx.
- Deployment:
  - The best-performing model was deployed on IBM Watson Machine Learning directly from Watsonx Studio.
  - Model was tested using new input records to predict real-time failure types through the Watsonx deployment interface.
- Evaluation:
  - IBM Watsonx automatically evaluated pipelines using metrics like Accuracy, Precision, and Recall.
- The selected pipeline achieved high accuracy on the test data.

System Approach

Technologies Used:

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

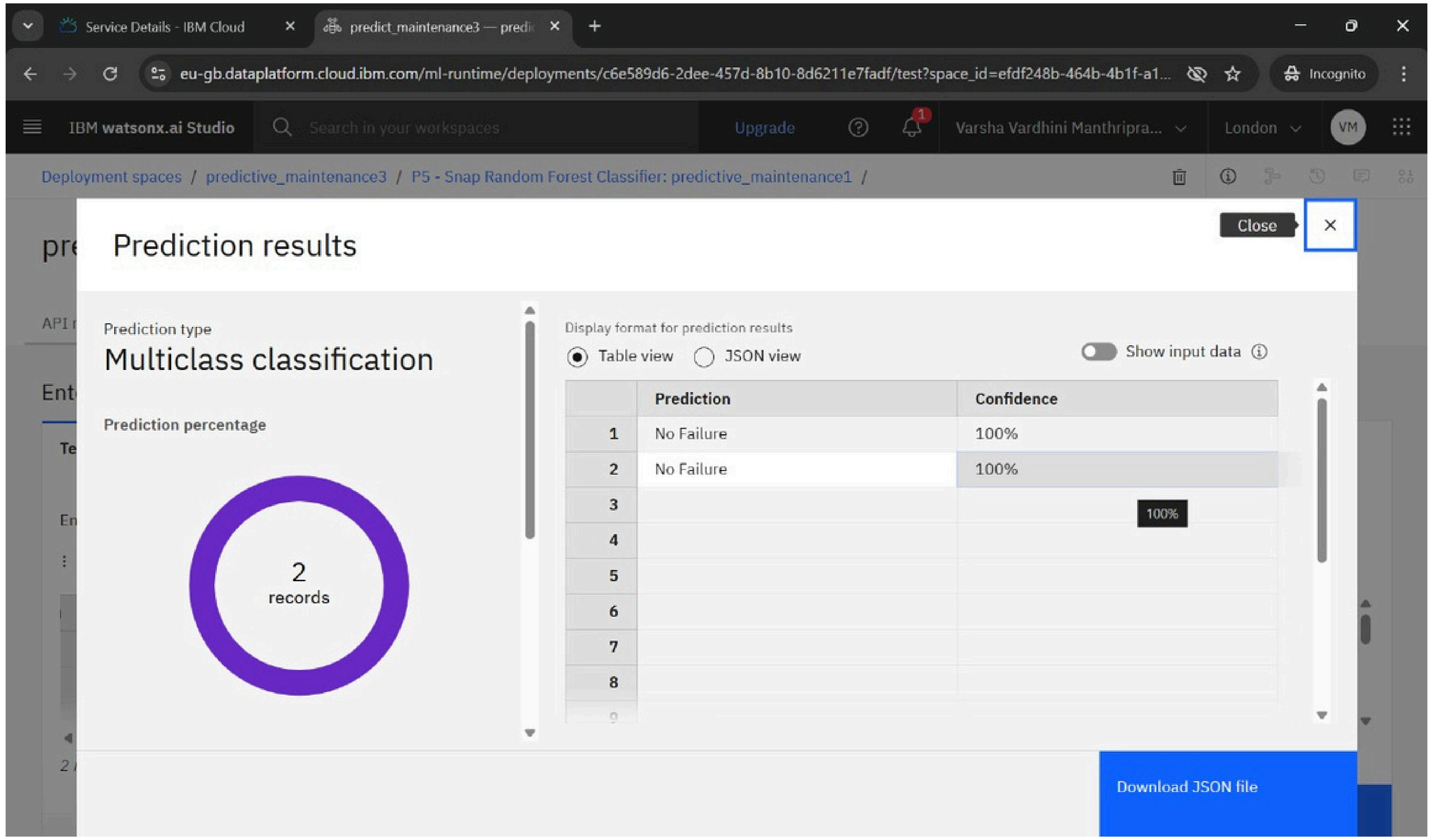
Steps Followed:

- Imported dataset from Kaggle into Watsonx project
- AutoAI automatically split data and performed preprocessing
- Multiple models like Random Forest and Decision Tree were evaluated
- Best pipeline was selected based on accuracy
- Deployed model for real-time prediction of failure types

Algorithm & Deployment

- In the Algorithm section, describe the machine learning algorithm chosen for predicting bike counts. Here's an example structure for this section:
- **Algorithm Selection:**
  - The model was built using Snap Random Forest Classifier, automatically selected by IBM Watsonx AutoAI. It was chosen because it performs well with high-dimensional data and effectively handles classification tasks like predicting various machine failure types based on sensor data patterns.
- **Data Input:**
  - The input features included real-time sensor readings such as air temperature, torque, rotational speed, tool wear, and machine type. The target output was the failure type, categorized as No Failure, Tool Wear, Heat Dissipation Failure, Power Failure, etc.
- **Training Process:**
  - The training was conducted automatically in Watsonx AutoAI using a stratified train-test split. AutoAI optimized the pipelines, tuned hyperparameters, and compared multiple algorithms. It selected the pipeline with the best performance on classification accuracy.
- **Prediction Process:**
  - The trained model, once deployed, accepts new sensor inputs and predicts the type of failure in real time. Predictions are displayed with confidence levels, helping maintenance teams identify and respond to likely failures before they occur.

Result



The model accurately predicted “No Failure” with 100% confidence, showing its reliability in detecting machine status. This confirms its effectiveness for predictive maintenance in real scenarios.

Conclusion

- In this project, a Predictive Maintenance model was successfully developed using IBM Watsonx.ai Studio on IBM Cloud Lite. The goal was to detect and classify possible machinery failures before they occur, using real-time sensor data.
- By training a classification model on labeled operational data, we were able to accurately predict different types of failures — including tool wear, power failure, and heat dissipation — with high confidence.
- The model was deployed directly from Watsonx.ai, enabling live testing and easy accessibility through IBM Cloud. This cloud-based solution demonstrates how industries can leverage AI to shift from reactive to proactive maintenance, significantly reducing:
    - Unplanned downtime
    - Maintenance costs
    - Safety risks

Future scope

- Connect live IoT sensor data streams to the model for real-time monitoring.
- Expand the model to include regression for predicting time to failure.
- Improve generalizability using more diverse datasets from various machines.
- Develop a maintenance alert dashboard linked to the model's predictions.
- Integrate with cloud-based dashboards for industrial use.

References

- List and cite relevant sources, datasets, and tools that supported the development of the predictive maintenance model. This includes the Kaggle dataset on machinery failures, IBM Watsonx.ai Studio documentation, and resources on machine learning classification techniques and industrial IoT data analysis.
- Kaggle Dataset: Predictive Maintenance Classification

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