CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

Presented By:
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OUTLINE

- **Problem Statement**
- **Proposed System/Solution**
- **System Development Approach** (Technology Used)
- **Algorithm & Deployment**
- **Result (Output Image)**
- **Conclusion**
- **Future Scope**
- **References**

PROBLEM STATEMENT

The Challenge: 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

- Data Collection:
  - Gather historical sensor data from the machinery fleet, including Air temperature, Process temperature, Rotational speed, Torque, and Tool wear.
  - Ensure a steady stream of real-time operational data to feed into the predictive model.
- Data Preprocessing:
  - Clean and preprocess the collected sensor data to handle any outliers or inconsistencies.
  - Perform feature engineering to identify the most critical data signatures and interactions that signal an impending failure.
- Machine Learning Algorithm:
  - Implement a multi-class classification model (e.g., Random Forest, Gradient Boosting, or a Neural Network) using IBM Watson Studio.
  - Train the model to accurately predict the specific Failure Type (e.g., Tool Wear Failure, Heat Dissipation Failure, Power Failure) based on the input sensor data..
- Deployment:
  - Deploy the trained model as a real-time API endpoint using the IBM Watson Machine Learning service.
  - This allows for seamless integration with existing factory monitoring systems or a custom-built maintenance dashboard.
- Evaluation:
  - Assess the model's performance using classification metrics such as Accuracy, Precision, Recall, and F1-Score.
  - Utilize a Confusion Matrix to analyze the model's effectiveness in distinguishing between different failure types.
- Result:
  - The final result is a robust predictive maintenance system that enables proactive repairs, significantly reduces unplanned downtime, and lowers operational costs.

SYSTEM APPROACH

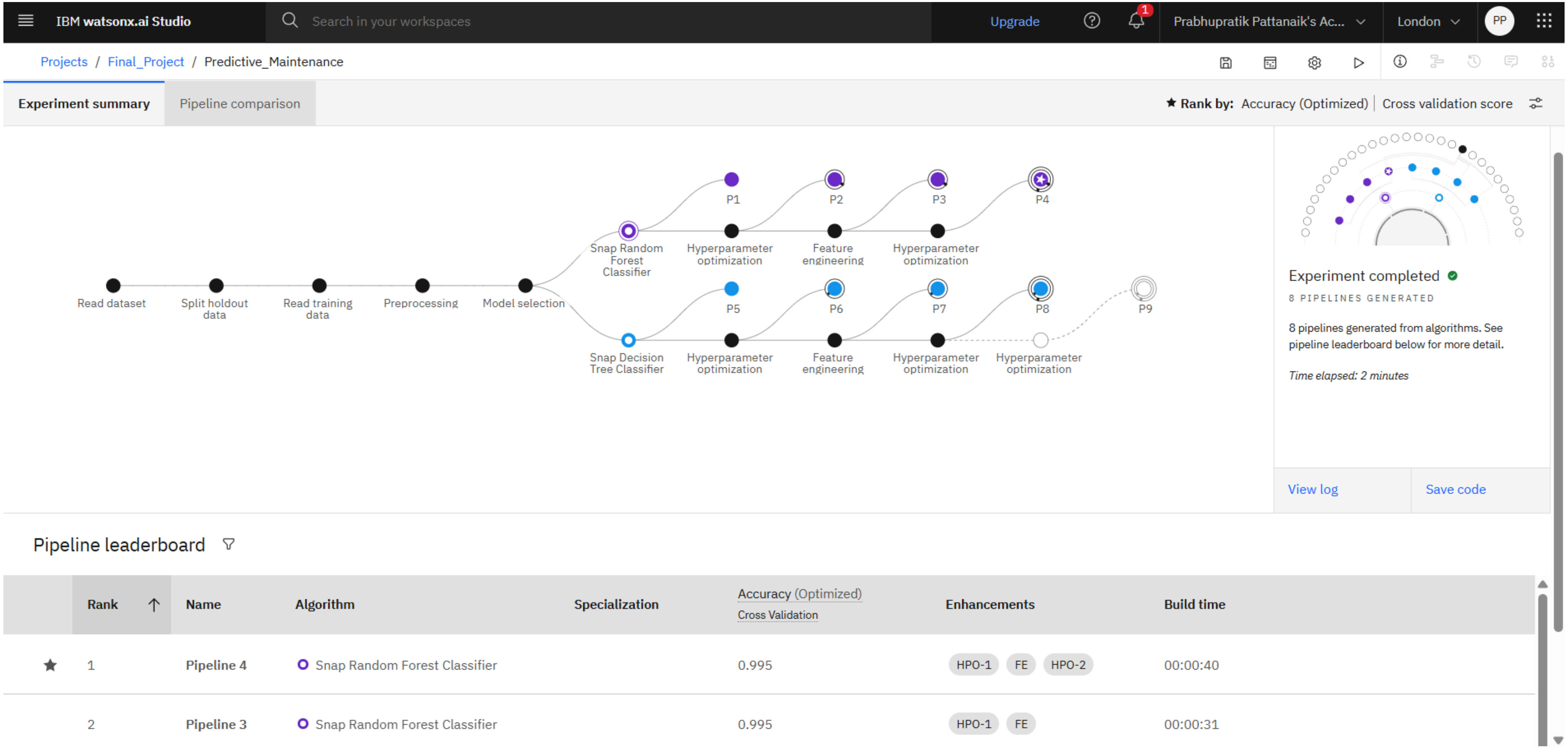
This section outlines the overall strategy, technical requirements, and methodology for developing and implementing the predictive maintenance system

- System requirements:
  - Platform & Services: An IBM Cloud Lite account with the following provisioned services: Watson Studio, Cloud Object Storage, and Watson Machine Learning
- Libraries:
  - Core Libraries: Pandas and NumPy for data handling, Matplotlib/Seaborn for visualization, and Scikit-learn for building and evaluating the classification model.

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - The Snap Random Forest Classifier was automatically selected by IBM's AutoAI for its high accuracy (99.5%) in identifying complex failure patterns within the sensor data.
- **Data Input:**
  - The model bases its predictions on five key input features: Air Temperature, Process Temperature, Rotational Speed, Torque, and Tool Wear.
- **Training Process:**
  - The model was trained using an automated pipeline that included data preprocessing, automated feature engineering, and hyperparameter optimization to maximize predictive performance.
- **Prediction Process:**
  - The deployed API receives real-time sensor data and returns a JSON response containing the predicted failure type and a confidence score for that prediction.

RESULT



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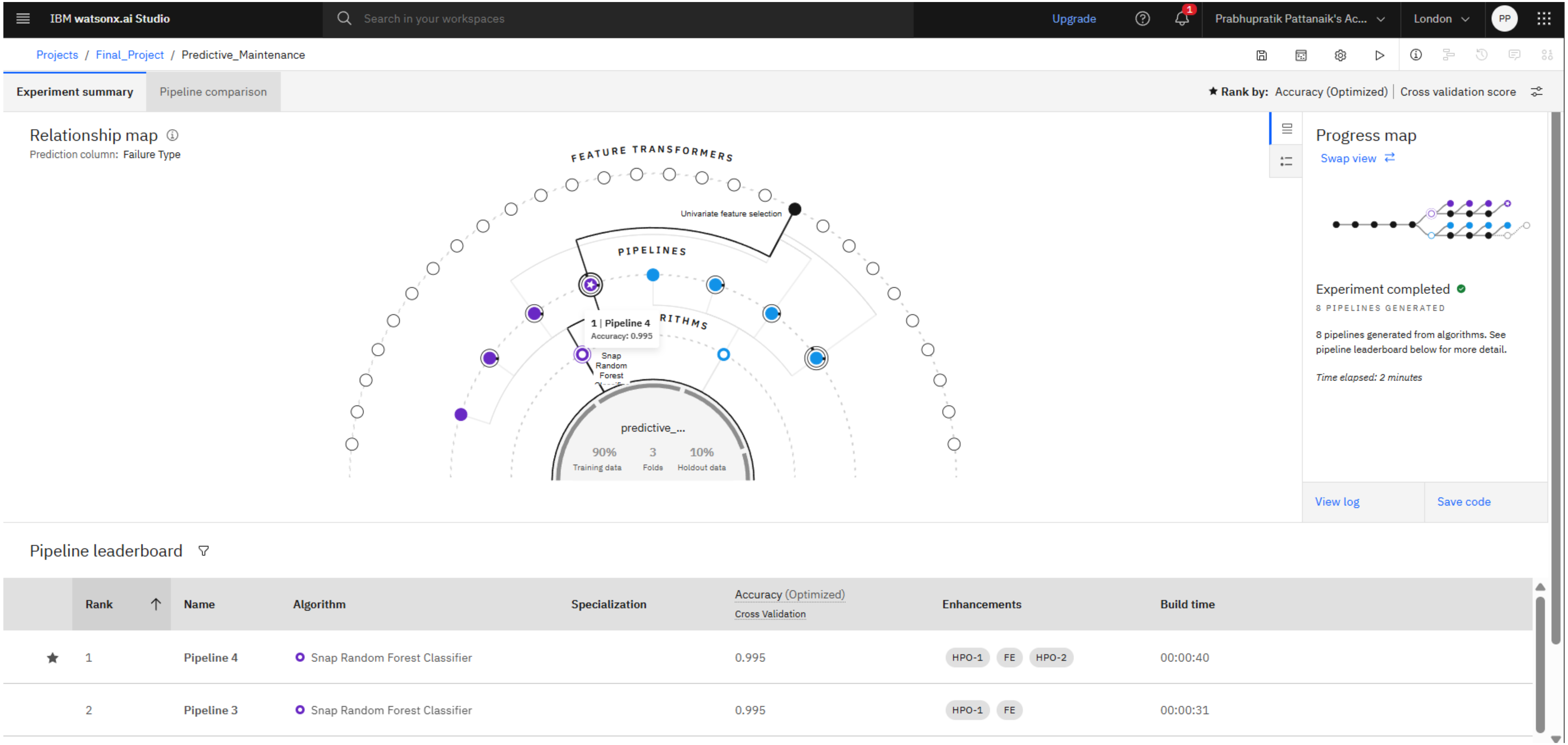
Projects / Final_Project / Predictive_Maintenance
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Random Forest Classifier
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
P1
P2
P3
P4
P5
P6
P7
P8
P9
Experiment completed
8 PIPELINES GENERATED
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 2 minutes
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized)
Cross Validation
Enhancements
Build time
1
Pipeline 4
Snap Random Forest Classifier
0.995
HPO-1
FE
HPO-2
00:00:40
2
Pipeline 3
Snap Random Forest Classifier
0.995
HPO-1
FE
00:00:31

RESULT



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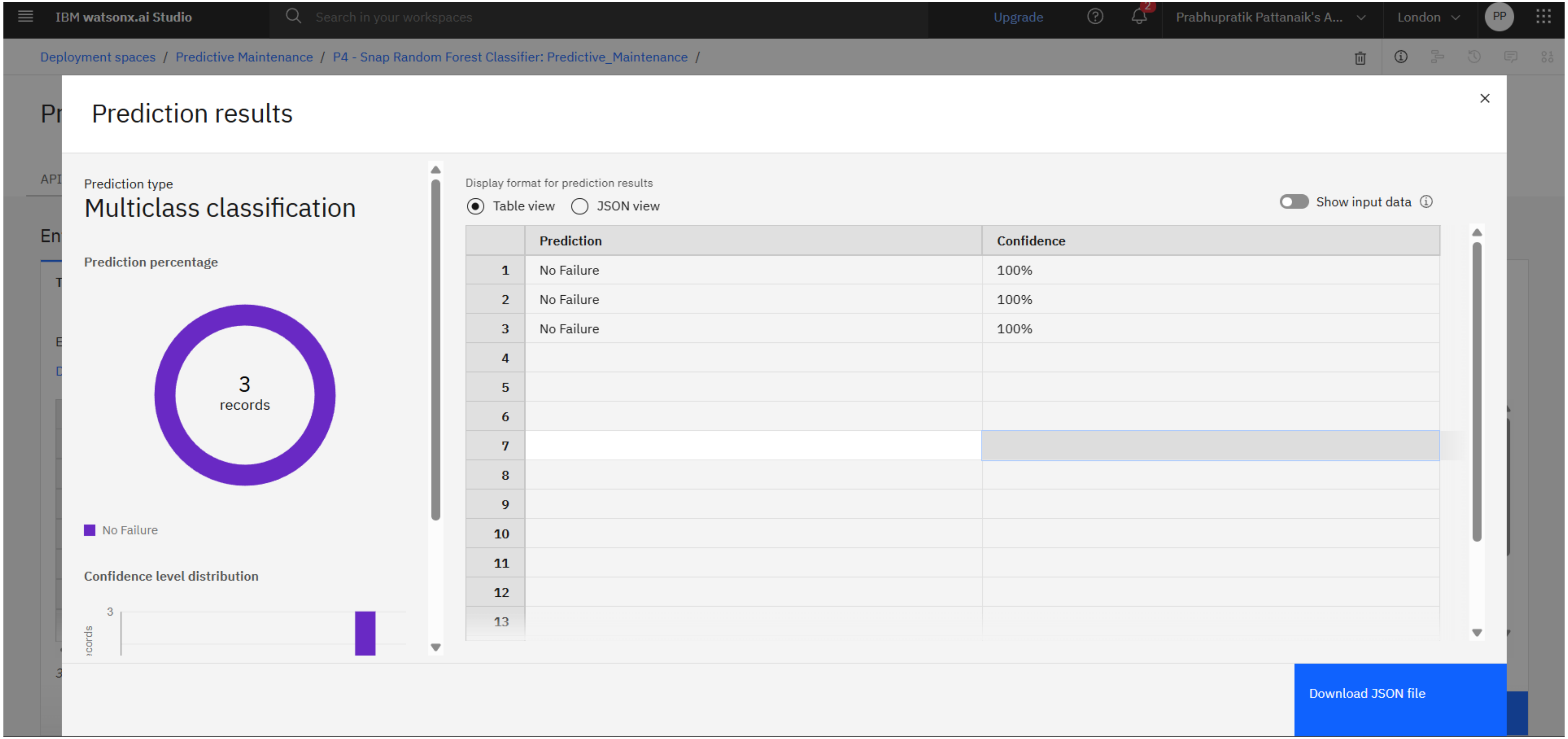
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Relationship map
Prediction column: Failure Type
FEATURE TRANSFORMERS
Univariate feature selection
PIPELINES
RITHMS
1 | Pipeline 4
Accuracy: 0.995
Snap Random Forest
predictive_...
90% Training data
3 Folds
10% Holdout data
Progress map
Swap view
Experiment completed
8 PIPELINES GENERATED
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 2 minutes
View log
Save code
Pipeline leaderboard
Rank | Name | Algorithm | Specialization | Accuracy (Optimized) Cross Validation | Enhancements | Build time
1 | Pipeline 4 | Snap Random Forest Classifier | 0.995 | HPO-1 FE HPO-2 | 00:00:40
2 | Pipeline 3 | Snap Random Forest Classifier | 0.995 | HPO-1 FE | 00:00:31

RESULT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Deployment spaces / Predictive Maintenance / P4 - Snap Random Forest Classifier: Predictive_Maintenance /
Prediction results
Prediction type
Multiclass classification
Prediction percentage
3
records
No Failure
Confidence level distribution
Display format for prediction results
Table view
JSON view
Show input data
Prediction
Confidence
1 No Failure 100%
2 No Failure 100%
3 No Failure 100%
Download JSON file

CONCLUSION

- This project successfully demonstrated the development and deployment of a highly effective predictive maintenance model, achieving 99.5% accuracy in forecasting machine failures using IBM Watson Studio. While interpreting complex sensor data is always a challenge, future improvements could involve integrating a wider variety of machine data and enhancing the user dashboard for maintenance teams. Ultimately, this work underscores the critical importance of data-driven decision-making in modern industry. By enabling a shift from reactive to proactive maintenance, this solution directly contributes to reducing operational downtime, lowering costs, and improving overall plant efficiency and safety.

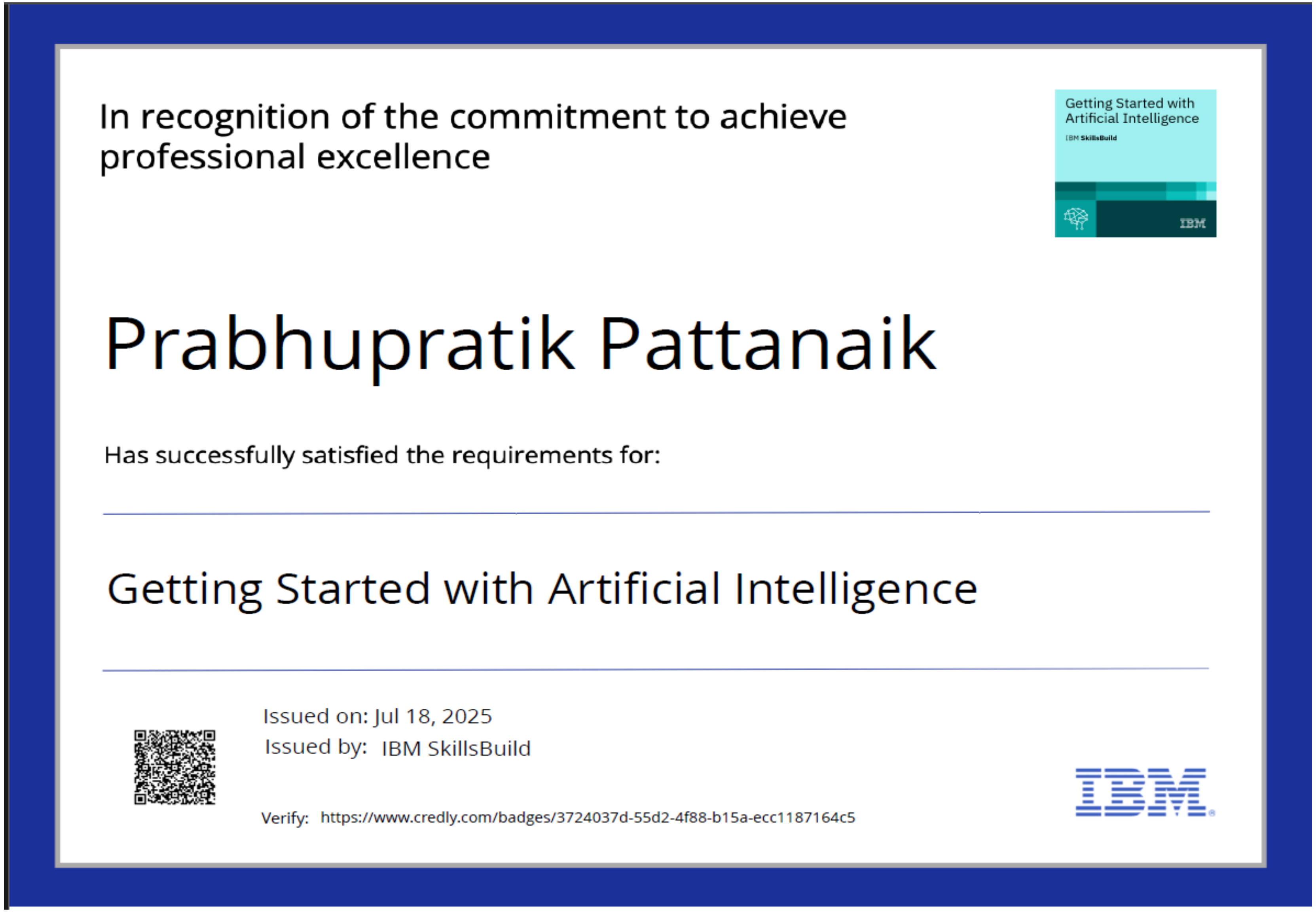
FUTURE SCOPE

- The future scope for this project is extensive. The model could be expanded to cover **different types of industrial machinery** or an entire factory floor, creating a plant-wide monitoring system. Future versions could incorporate more diverse data sources, such as **vibration analysis, acoustic data, and historical maintenance logs**, for a more holistic view of machine health. We could also explore advanced **deep learning models like LSTMs** to better capture time-series patterns in the sensor data. Ultimately, the system can evolve from a predictive tool into a complete **prescriptive maintenance platform** that not only forecasts failures but also recommends specific actions and optimal repair schedules.

REFERENCES

- **Academic Literature:** Research papers and articles focusing on **Predictive Maintenance (PdM)**, **industrial fault diagnosis**, and **condition-based monitoring** of machinery.
- **Machine Learning:** Technical documentation on **ensemble classification algorithms**, specifically the **Random Forest model,** which was instrumental in building the final solution.
- **Data Science Practices:** Articles and tutorials covering best practices for **preprocessing time-series sensor data** and robust **model evaluation techniques** for classification problems.
- **Dataset Source:** The project utilized the "Machine Predictive Maintenance Classification" dataset, publicly available on the **Kaggle** platform.

IBM CERTIFICATIONS



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