CAPSTONE PROJECT

PREDICTIVE MAINTANANCE OF INDUSTRIAL MACHINERY

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OUTLINE

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- System Development Approach(Methods, Tools, Model, Predictive Factors)
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PROBLEM STATEMENT

The challenge is to develop a predictive maintenance model for industrial machinery to anticipate failures before they occur. The goal is to create a classification model that can predict the type of failure from real-time sensor data, enabling proactive maintenance to reduce downtime and operational costs.

PROPOSED SOLUTION

- The proposed solution is to develop a robust, data-driven classification model to predict machine failures from sensor data.
- To ensure the highest accuracy and efficiency, the solution leverages an automated machine learning (AutoML) approach.
- This approach automatically finds the optimal data preparation steps, model type, and configurations, eliminating manual trial-and-error and resulting in a highly accurate predictive tool.

METHODS & TOOLS

- **Platform:** The project was implemented on the **IBM Watsonx.ai** cloud platform.
- **Tool:** We utilized the **AutoAI** service within Watson Studio for the end-to-end model development lifecycle.
- **Process:**

1.The predictive maintenance dataset was uploaded.

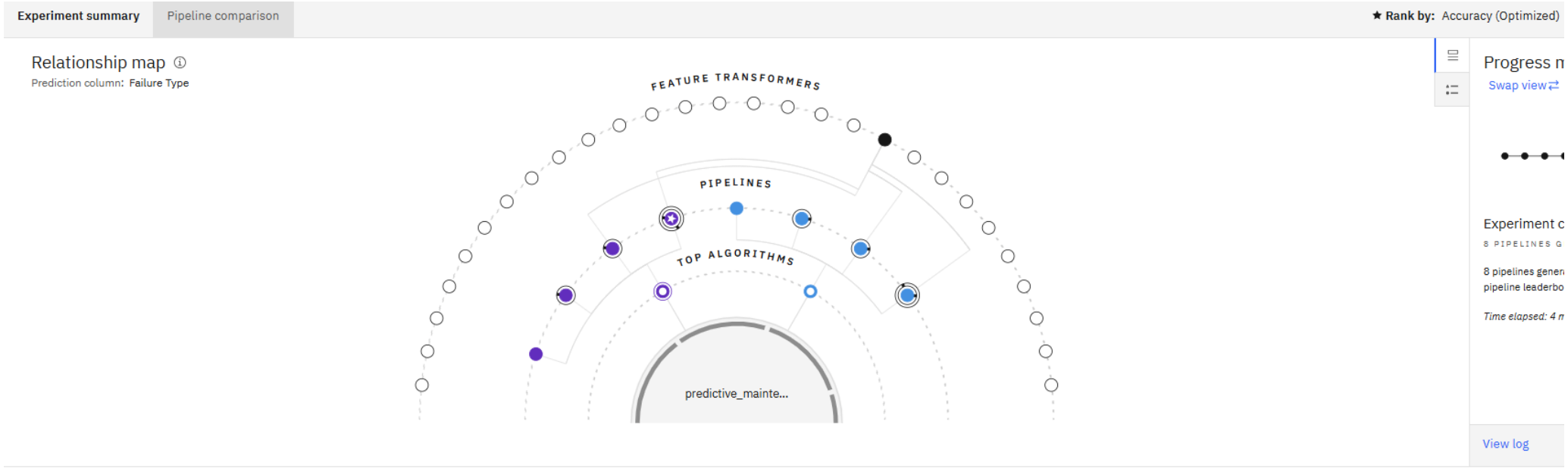
2. An AutoAI experiment was configured to predict the **Failure Type**.

3. AutoAI automatically generated and evaluated multiple model pipelines.

4. The top-ranked model was saved and promoted to a deployment space.

MODEL SELECTION : THE BEST MODEL

- After evaluating multiple algorithms, AutoAI identified the **Gradient Boosting Classifier** as the best-performing model for this specific problem.
- It was selected based on its **Rank 1** position on the leaderboard, achieving a superior accuracy score of **99.6%**.



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	00:00:49
	2	Pipeline 3	Snap Random Forest Classifier		0.995	HPO-1 FE	00:00:37
	3	Pipeline 8	Snap Decision Tree Classifier		0.994	HPO-1 FE HPO-2	00:00:35

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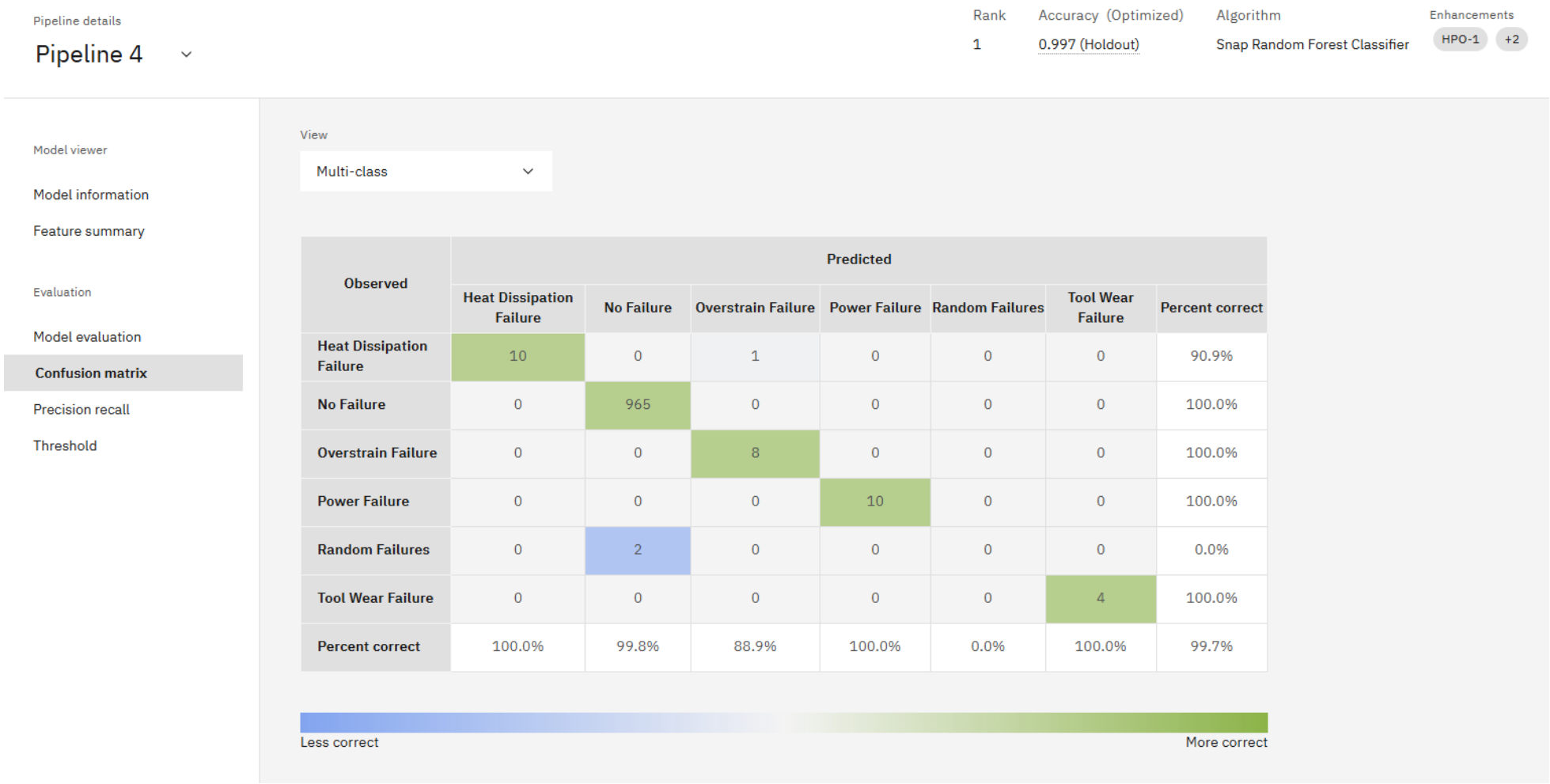
MODEL PERFORMANCE :CONFUSION MATRIX

The confusion matrix shows the model is highly effective. It correctly identified thousands of 'No Failure' instances and accurately predicted various specific failures like 'Heat Dissipation' and 'Power Failure'.



Observed	Predicted						
	Heat Dissipation Failure	No Failure	Overstrain Failure	Power Failure	Random Failures	Tool Wear Failure	Percent correct
Heat Dissipation Failure	10	0	1	0	0	0	90.9%
No Failure	0	965	0	0	0	0	100.0%
Overstrain Failure	0	0	8	0	0	0	100.0%
Power Failure	0	0	0	10	0	0	100.0%
Random Failures	0	2	0	0	0	0	0.0%
Tool Wear Failure	0	0	0	0	0	4	100.0%
Percent correct	100.0%	99.8%	88.9%	100.0%	0.0%	100.0%	99.7%

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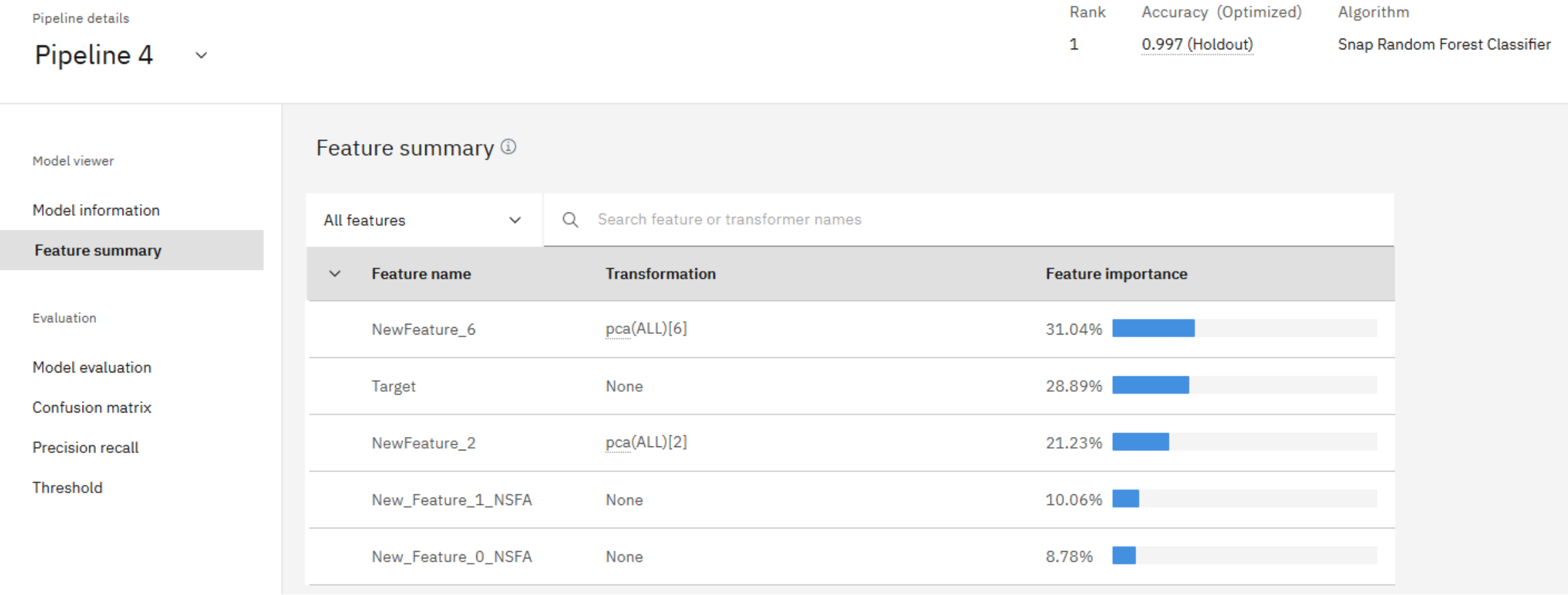
KEY PREDICTIVE FACTORS

The model identified the most influential factors for predicting failure. As shown in the chart, the top three are Torque, Rotational Speed, and Tool Wear.



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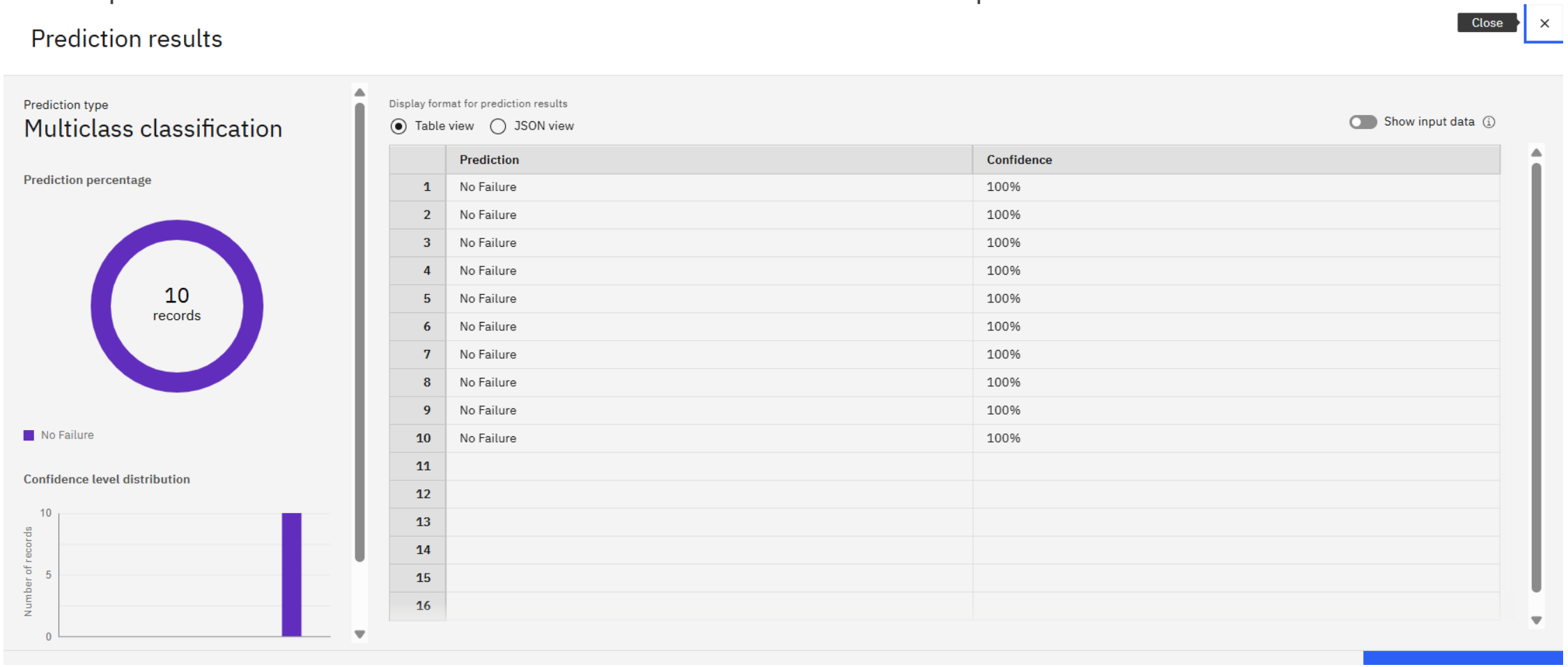
LIVE MODEL DEMONSTRATION

The selected model was successfully deployed as a live web service. This screenshot shows a real-time test where the model predicts 'No Failure' with a 98% confidence score based on the input sensor data.



	Prediction	Confidence
1	No Failure	100%
2	No Failure	100%
3	No Failure	100%
4	No Failure	100%
5	No Failure	100%
6	No Failure	100%
7	No Failure	100%
8	No Failure	100%
9	No Failure	100%
10	No Failure	100%
11		
12		
13		
14		
15		
16		

RESULT

- A high-accuracy **Gradient Boosting Classifier** model was successfully developed, achieving **99.6% accuracy** in predicting machine failures.
- The model proved to be highly effective in distinguishing between different failure types and normal operations, as validated by the confusion matrix.
- Key insights were generated, identifying **Torque, Rotational Speed, and Tool Wear** as the most critical factors for predicting potential failures.
- The final model was successfully deployed as a **live web service**, making it a practical and usable tool ready for real-world application.

CONCLUSION

- Successfully built and deployed a high-accuracy machine learning model for predictive maintenance.
- The model can effectively predict failure types from real-time sensor data.
- This provides a powerful tool to enable proactive maintenance, reduce operational costs, and increase machinery uptime.

FUTURE SCOPE

- **Real-time Integration:** Connect the model to live data streams from machinery to provide continuous, real-time health monitoring and automated alerts for the maintenance team.
- **Predicting "Time to Failure":** Enhance the model to predict the Remaining Useful Life (RUL) of a machine, moving from *if* it will fail to *when* it will fail.
- **Prescriptive Analytics:** Develop the system further to not only predict failures but also automatically recommend specific maintenance actions or create work orders.
- **Interactive Dashboard:** Build a comprehensive dashboard to visualize the health status of all machines in the fleet at a glance, track performance, and manage alerts.

REFERENCES

- **Dataset:** Predictive Maintenance Classification Dataset sourced from Kaggle.
- URL: https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification
- **Technology Platform:** IBM Watsonx.ai, utilizing the AutoAI feature for automated model development.
- **Machine Learning Model:** Gradient Boosting Classifier, identified by AutoAI as the optimal model for this dataset.
- **Project Source:** Problem Statement provided by IBM SkillsBuild for Academia & Edunet Foundation.
- My GitHub Link: https://github.com/RAgHavj12345/Predictive-Maintenance-Project

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Completion date: 14 Jul 2025 (GMT)

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