CAPSTONE PROJECT

PROJECT TITLE

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OUTLINE

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PROBLEM STATEMENT

Maintenance of Industrial Machines is crucial for a Manufacturing Company. Machine Failure can be predicted by certain parameters like tool wear, rotational speed, heat dissipation and torque. Machines can be fitted with sensors which collect data for these parameters. This sensor data must be analysed to identify patters that precede a failure. The crucial part is to create a classification model that can predict the type of failure is (e.g., tool wear, heat dissipation, power failure). This will enable proactive maintenance, reducing downtime and operational costs.

PROPOSED SOLUTION

- The proposed system aims to address the challenge of predicting machine failures to minimise unplanned downtimes and improve operational efficiency. This involves leveraging data analytics and machine learning techniques to forecast failure patterns accurately. The solution will consist of the following components:
- Data Collection:
  - Gather historical data on machine failures, including air temperature, process temperature, rotational speed, torque, tool wear and other relevant factors.
  - Utilize real-time data sources to enhance prediction accuracy.
- Data Preprocessing:
  - Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies.
  - Feature engineering to extract relevant features from the data that might cause machine failure.
- Machine Learning Algorithm:
  - Implement a machine learning algorithm, either manually or IBM AutoAI (e.g. Random Forest, XGBoost, Support Vector Machine (SVM)), to predict machine failures based on historical patterns.
  - Train the model on labelled historical data.
- Deployment:
  - Create a deployment space in IBM Watson Studio.
  - Deploy the most efficient ML algorithm on the deployment space created.
- Evaluation:
  - Assess the model's performance using appropriate metrics such as Accuracy, Precision, Confusion matrix or other relevant metrics.
  - Fine-tune the model based on feedback and continuous monitoring of prediction accuracy.
  - Result: A reliable machine failure prediction is obtained, facilitating predictive maintenance.

SYSTEM APPROACH

- **System requirements**

Hardware Requirements:

1. A system with a minimum of 8 GB RAM
2. Internet connectivity

Software Requirements:

1. Operating System: Windows 10/Linux/macOS

IBM Cloud Services:

1. IBM Watson Studio
2. IBM Watson Machine Learning
3. IBM Cloud Object Storage

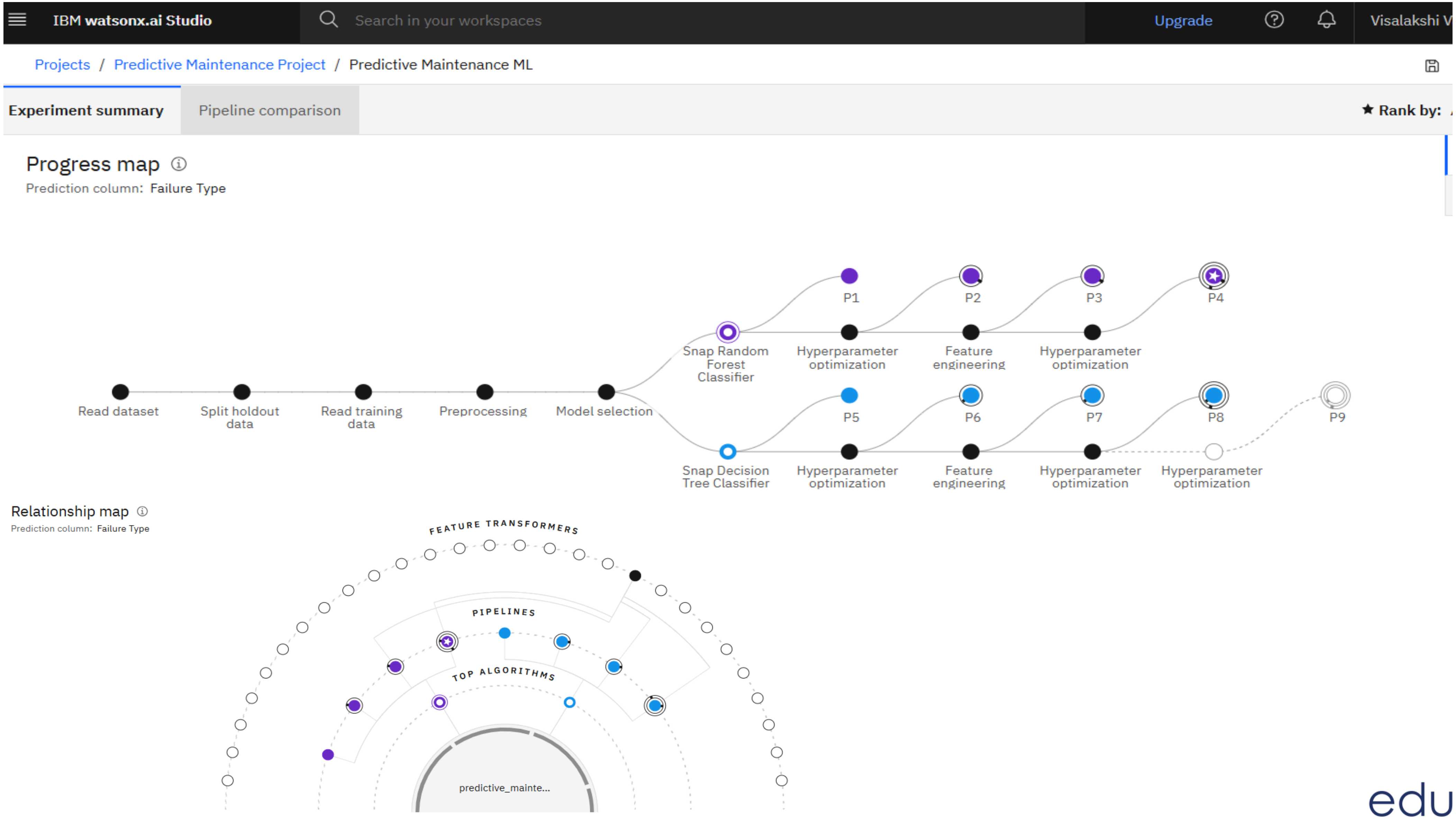
- **Library required to build the model**

1. pandas – Data preprocessing
2. numpy – Numerical computations
3. scikit-learn – Machine learning models & evaluation
4. matplotlib, seaborn – Data visualization
5. imblearn – Handling imbalanced datasets (e.g., SMOTE)
6. xgboost / lightgbm – Advanced classifiers
7. requests – API interaction
8. joblib / pickle – Model saving & loading

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - Random Forest Classifier is best suited for this project because it can handle high-dimensional sensor data. It reduces overfitting by averaging multiple decision trees. It is highly accurate, thus facilitating predictive maintenance of complex machines.
- **Data Input:**
  - Inputs used by the algorithm: Air temperature, Process temperature, Rotational speed, Torque and Tool wear.
- **Training Process:**
  - Data from Kaggle is uploaded to IBM Watson Studio.
  - IBM AutoAI generates Pipelines using different algorithms and tunes hyperparameters using grid search and cross-validation.
  - The various models are ranked based on accuracy and the model with the best performance is selected and deployed.
- **Prediction Process:**
  - Detail how the trained algorithm makes predictions for future bike counts. Discuss any real-time data inputs considered during the prediction phase.
  - The input file structured exactly like the original dataset used in training excluding the label column (Failure type) is uploaded in the test module.
  - Predictions are run by IBM cloud and the results obtained are in percentage and also in downloadable JSON file format.

AUTO AI MACHINE LEARNING PIPELINE



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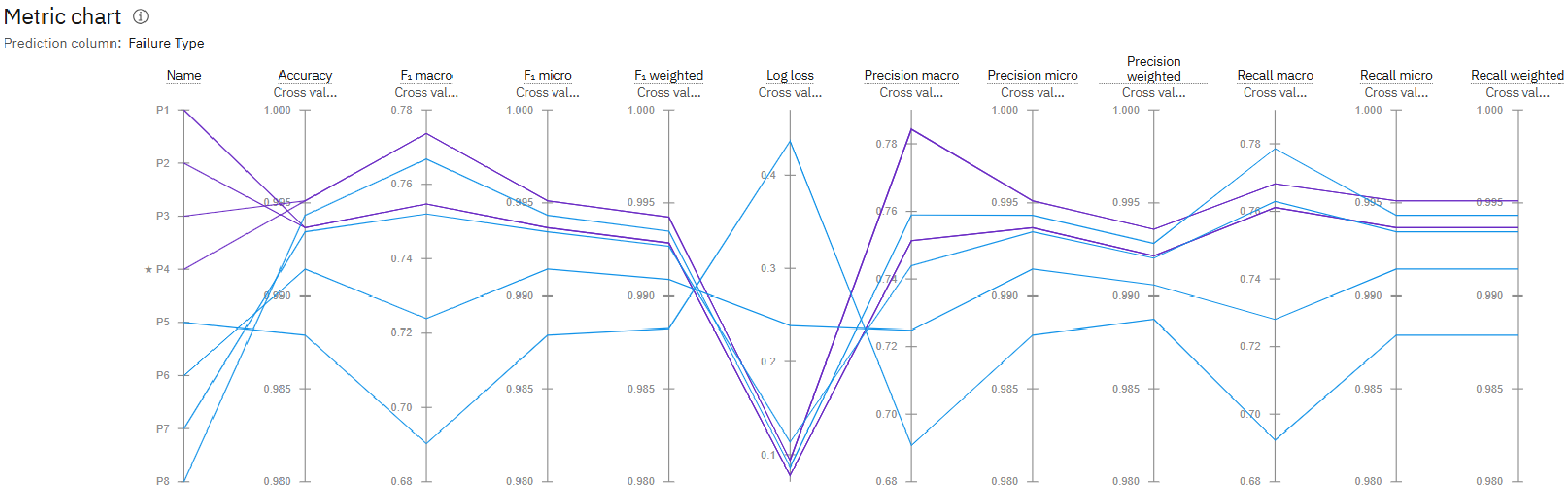
Pipeline leaderboard

	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	00:00:47
	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	00:00:29
	4	**Pipeline 2**	Snap Random Forest Classifier		0.994	HPO-1	00:00:09
	5	**Pipeline 1**	Snap Random Forest Classifier		0.994	*None*	00:00:03
	6	**Pipeline 7**	Snap Decision Tree Classifier		0.993	HPO-1 FE	00:00:25
	7	**Pipeline 6**	Snap Decision Tree Classifier		0.991	HPO-1	00:00:04
	8	**Pipeline 5**	Snap Decision Tree Classifier		0.988	*None*	00:00:02

I HAVE CHOOSEN PIPELINE FOUR DUE TO ITS HIGH ACCURACY AND ENHANCEMENTS FOR MY PREDICTIVE MAINTENANCE PROJECT.

PIPELINE COMPARISON



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RESULT

Present the results of the machine learning model in terms of its accuracy and effectiveness in predicting bike counts. Include visualizations and comparisons between predicted and actual counts to highlight the model's performance.

Prediction results

isplay format for prediction results

Table view JSON view

	prediction	probability	UDI	Product ID	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target
1	No Failure	[0,1,0,0,0,0]	1	M14860	M	298.1	308.6	1551	42.8	0	0
2	Tool Wear Failure	[0,0,0,0,0,1]	0	L47257	L	298.8	308.9	1455	41.3	208	1
3	No Failure	[0,1,0,0,0,0]	2	L47181	L	298.2	308.7	1408	46.3	3	0
4	No Failure	[0,1,0,0,0,0]	3	L47182	L	298.1	308.5	1498	49.4	5	0
5	No Failure	[0,1,0,0,0,0]	4	L47183	L	298.2	308.6	1433	39.5	7	0
6	No Failure	[0,1,0,0,0,0]	5	L47184	L	298.2	308.7	1408	40	9	0
7	No Failure	[0,1,0,0,0,0]	6	M14865	M	298.1	308.6	1425	41.9	11	0
8	No Failure	[0,1,0,0,0,0]	7	L47186	L	298.1	308.6	1558	42.4	14	0
9	No Failure	[0,1,0,0,0,0]	8	L47187	L	298.1	308.6	1527	40.2	16	0
10	No Failure	[0,1,0,0,0,0]	9	M14868	M	298.3	308.7	1667	28.6	18	0
11	No Failure	[0,1,0,0,0,0]	10	M14869	M	298.5	309	1741	28	21	0
12	No Failure	[0,1,0,0,0,0]	11	H29424	H	298.4	308.9	1782	23.9	24	0

	prediction	probability	UDI	Product ID	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target
71	Power Failure	[0,0,0,1,0,0]	70	L47249	L	298.9	309	1410	65.7	191	1
72	No Failure	[0,0.99988...	71	M14930	M	298.9	309	1924	22.6	193	0
73	No Failure	[0,1,0,0,0,0]	72	L47251	L	298.9	309.1	1452	45.5	196	0
74	No Failure	[0,0.99887...	73	L47252	L	298.9	309.1	1369	44.4	198	0
75	No Failure	[0,0.99988...	74	L47253	L	299	309.1	1592	35	200	0
76	No Failure	[0,1,0,0,0,0]	75	L47254	L	298.9	309	1601	32.3	202	0
77	No Failure	[0,1,0,0,0,0]	76	L47255	L	298.8	308.9	1379	46.7	204	0
78	No Failure	[0,0.99979...	77	L47256	L	298.8	308.9	1461	47.9	206	0
79	Tool Wear Failure	[0,0,0,0,0,1]	78	L47257	L	298.8	308.9	1455	41.3	208	1
80	No Failure	[0,1,0,0,0,0]	79	L47258	L	298.8	308.9	1398	51.5	0	0
81	No Failure	[0,1,0,0,0,0]	80	L47259	L	298.8	308.9	1402	37.9	2	0
82	No Failure	[0,1,0,0,0,0]	81	H29494	H	298.8	308.8	1445	49.9	4	0

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CONCLUSION

- Machine Failures like tool wear, power failure, overstrain failure, and random failures are predicted accurately using this Predictive Maintenance Machine Learning model developed using IBM AutoAI services. Challenges encountered during the implementation of this project were proper formatting of the input data, selecting the most accurate Machine learning algorithm and API configuration errors. These challenges were overcome to produce a precise predictive maintenance model.

FUTURE SCOPE

- Advancements in Artificial intelligence can be integrated with Internet of things (IoT), Edge computing, Cloud computing, Computerized Maintenance Management System (CMMS), Human-Machine Interfaces (HMI) and Automation Systems to actually perform the predictive maintenance in real time.
- Prescriptive maintenance can be executed using machine data, Artificial intelligence, and Machine learning to predict equipment failures and recommend specific actions to prevent them. Instead of simply predicting when a failure might occur, it offers instructions on what maintenance tasks to perform and when, thus improving performance and minimizing downtime.

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IBM CERTIFICATIONS

Getting Started with Artificial Intelligence
IBM SkillsBuild
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In recognition of the commitment to achieve professional excellence

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IBM **SkillsBuild** Completion Certificate

This certificate is presented to

Visalakshi V

for the completion of

Lab: Retrieval Augmented Generation with LangChain

(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 25 Jul 2025 (GMT)

Learning hours: 20 mins

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THANK YOU

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