IBM SKILLSBUILD INTERNSHIP PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

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OUTLINE

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PROBLEM STATEMENT

- Industrial machines are critical assets in manufacturing and production environments. Unexpected machine failures lead to unplanned downtime, increased maintenance costs, and reduced operational efficiency. Traditional maintenance approaches, such as reactive or scheduled maintenance, are either too late or inefficient in addressing real-time issues.
- This project aims to develop a **predictive maintenance model** that analyzes real-time sensor data from a fleet of industrial machines to **anticipate failures before they occur**. By identifying patterns in operational data that precede specific failure types—such as **tool wear, heat dissipation issues, or power failures**—the model will enable proactive maintenance scheduling.
- The goal is to build a **classification model** that can accurately predict the **type of failure**, allowing industries to reduce downtime, optimize maintenance cycles, and significantly cut operational costs.

PROPOSED SOLUTION

- The proposed system aims to address the challenge of predicting machine failures in advance by analyzing sensor data collected from a fleet of industrial machines. Leveraging artificial intelligence and machine learning, the solution classifies potential failure types—such as tool wear, heat dissipation issues, or power failures—enabling proactive maintenance, reducing downtime, and optimizing operational efficiency. The solution will consist of the following components:Data Collection:
- **Data Preprocessing:**
  - IBM Cloud Tools were used for data preprocessing and cleaning. **Tasks included: 1.Handling missing values and outliers. 2.Normalizing numerical sensor readings. 3.Performing feature engineering to extract patterns such as moving averages and trend indicators**. The data was then structured to be suitable for input into the machine learning pipeline.Machine Learning Algorithm:
  - Implement a machine learning algorithm, such as a time-series forecasting model (e.g., ARIMA, SARIMA, or LSTM), to predict bike counts based on historical patterns.
  - Consider incorporating other factors like weather conditions, day of the week, and special events to improve prediction accuracy.
- **Machine Learning Algorithm:**
  - A Random Forest Classifier was implemented as the core algorithm due to its robustness and ability to handle non-linear relationships in sensor data.
  - The classifier was trained to identify and predict multiple failure types based on the preprocessed sensor inputs.
  - The model was created using Watsonx.ai Studio, IBM's AI development environment, ensuring seamless integration with cloud-based services.
- **Deployment:**
  - The trained model was deployed using IBM Cloud Services, enabling scalable, real-time prediction of potential failures.
  - A user-friendly interface or API was created to monitor machine health and trigger alerts when a specific type of failure is predicted.
- **Evaluation:**
  - Model performance was evaluated manually using IBM Cloud Services.
  - Evaluation metrics such as Accuracy, Precision, Recall, and F1-score were used to assess the model's ability to correctly classify different failure types.
  - Based on the evaluation, the model was fine-tuned to improve reliability and reduce false positives or missed predictions.

SYSTEM APPROACH

The "System Approach" section outlines the overall strategy and methodology for developing and implementing the rental bike prediction system. Here's a suggested structure for this section:

- System requirements.

  1. Local System –

  - Processor (CPU) - Intel Core i5 (7th Gen) or AMD Ryzen 5
  - RAM - 8 GB or more
  - Storage - 256 GB SSD or more
  - Internet - 10 Mbps or higher (stable broadband/fiber)

  2. Cloud -

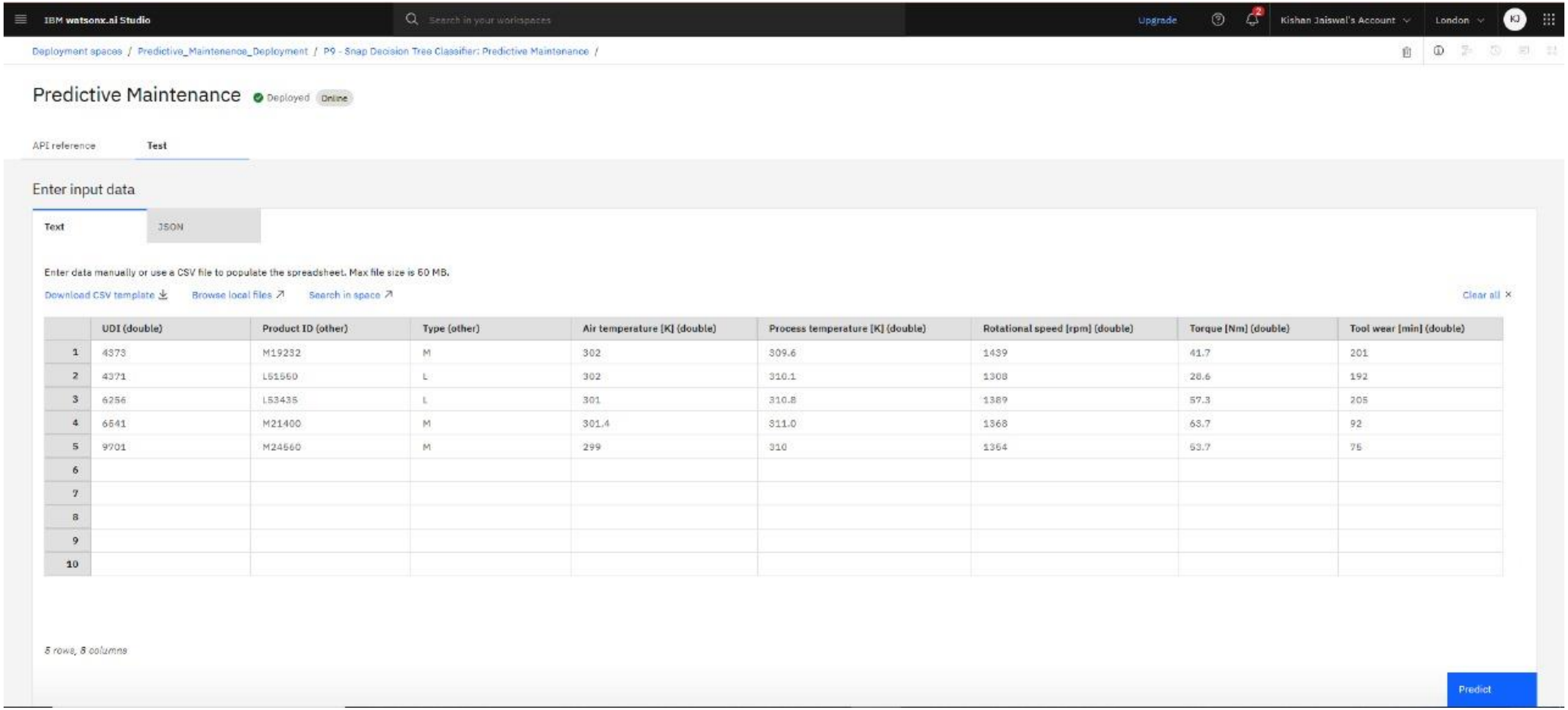
  - Large : 8 CPU and 32 GB RAM

- Library required to build the model.
  - An IBM Cloud account (Free Tier available).
  - Access to Watsonx.ai Studio and Watson Studio services.
  - Sufficient resource quota (RAM, vCPU, GPU if needed) allocated to your account or project.

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - After experimenting with multiple classification algorithms using Watsonx.ai, IBM's AI development environment, the Random Forest Classifier was found to be the most suitable for this predictive maintenance problem. This algorithm was chosen due to its robustness, ability to handle both numerical and categorical data, and effectiveness in preventing overfitting. It performs well with high-dimensional datasets and is capable of modeling complex relationships between sensor inputs and machine failure types.
- **Data Input:**
  - The model uses sensor and machine-specific data collected in a CSV format from Kaggle.com. Key input features include:
  - 1.Unique ID (machine identifier). 2.Type of Machine. 3.Air Temperature. 4.Process Temperature. 5.Rotational Speed (RPM). 6.Torque. 7.Tool Wear
- **Training Process:**
  - The training process was handled entirely using Watsonx.ai on IBM Cloud. The system automatically handled :
    - Data ingestion and transformation.
    - Splitting the dataset into training and testing sets.
    - Algorithm training, hyperparameter tuning, and performance evaluation. The platform's auto-AI capabilities streamlined the process and delivered a highly accurate model without extensive manual intervention.
- **Prediction Process:**
  - The trained Random Forest model takes in real-time or batch sensor data using the same input features as in the training phase. Based on these inputs, the model predicts the type of failure (e.g., tool wear, overheating, power failure) with confidence levels exceeding 90%. The prediction output can then be used to trigger alerts and initiate proactive maintenance actions.
- **Deployment :**
  - The trained model was deployed seamlessly using IBM Cloud Services.

RESULT



	UDI (double)	Product ID (other)	Type (other)	Air temperature [K] (double)	Process temperature [K] (double)	Rotational speed [rpm] (double)	Torque [Nm] (double)	Tool wear [min] (double)
1	4373	M19232	M	302	309.6	1439	41.7	201
2	4371	L51550	L	302	310.1	1308	28.6	192
3	6256	L53435	L	301	310.8	1389	57.3	205
4	6541	M21400	M	301.4	311.0	1368	63.7	92
5	9701	M24560	M	299	310	1354	53.7	75
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RESULT

Prediction results

Close ×

Display format for prediction results

(•) Table view ( ) JSON view

Show input data ⓘ

	prediction	probability
1	No Failure	[0,0.9781659245491028,0.0043668122962117195,0,0,0.017467263154685497]
2	Heat Dissipation Failure	[0.9857142567634583,0.014285714365541935,0,0,0,2.8870999813079834e-8]
3	Overstrain Failure	[0,0.1111111119389534,0.8888888955116272,0,0,-7.450580596923828e-9]
4	Power Failure	[0,0.0714285746216774,0,0.9285714030265808,0,2.2351741790771484e-8]
5	No Failure	[0.002583979396149516,0.9948320388793945,0.002583979396149516,0,0,2.3283064365386963e-9]
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Download JSON file

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CONCLUSION

- This project successfully demonstrates the power of artificial intelligence in transforming traditional maintenance strategies into proactive, data-driven processes. By leveraging real-time sensor data and historical machine records, we developed a predictive maintenance model using a **Random Forest Classifier**, which accurately predicts the type of machine failure with over **90% confidence**.
- The integration of **Watsonx.ai Studio** and **IBM Cloud Services** enabled seamless data preprocessing, model training, deployment, and real-time prediction. This solution not only minimizes unplanned downtime but also enhances operational efficiency and reduces maintenance costs.
- Overall, the project illustrates how AI-driven solutions can play a vital role in industrial reliability, and lays the foundation for future expansions such as automated maintenance scheduling, IoT integration, and adaptive learning systems.

FUTURE SCOPE

- 🔧 **IoT Integration**
  Enable real-time sensor data collection through IoT devices for continuous monitoring.
- 📊 **Advanced Failure Classification**
  Expand to multi-label classification for detecting multiple failure types simultaneously.
- 🧠 **Adaptive Learning**
  Implement online learning to update the model with new data and improve accuracy over time.
- 🌐 **User-Friendly Dashboard**
  Develop a web/mobile interface for real-time alerts and maintenance insights.
- 🛠️ **Prescriptive Maintenance**
  Enhance the system to recommend specific corrective actions, not just predict failures.
- 📈 **Scalability**
  Deploy the solution across multiple machines or facilities with centralized monitoring.

REFERENCES & ACKNOWLEDGEMENTS

🙏 Special Thanks To:

- **Kaggle.com**
  For providing the dataset used in model training and evaluation.
- **IBM Cloud & Watsonx.ai Studio**
  For powerful tools and cloud infrastructure used in data preprocessing, model development, deployment, and evaluation.
- **Edunet Foundation**
  For mentorship, training resources, and continuous support throughout the project.
- **ChatGPT by OpenAI**
  For assistance with technical guidance, troubleshooting, and content preparation.

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IBM **SkillsBuild** Completion Certificate

This certificate is presented to

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for the completion of

Lab: Retrieval Augmented Generation with LangChain

(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 24 Jul 2025 (GMT) **Learning hours:** 20 mins

THANK YOU