CAPSTONE PROJECT

POWER SYSTEM FAULT DETECTION AND CLASSIFICATION

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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

Design a machine learning model to detect and classify faults in a power distribution system using electrical measurement data, such as voltage and current phasors. The model should distinguish between normal operating conditions and various fault types, including line-to-ground, line-to-line, and three-phase faults. The objective is to enable rapid and accurate fault identification to maintain power grid stability and reliability. Implementation must utilize IBM Cloud Lite services for model development and deployment. This solution aims to enhance the efficiency of fault management in power systems.

PROPOSED SOLUTION

This solution utilizes IBM Watson AI Studio and other IBM Cloud services to create a scalable system for detecting and classifying faults in power distribution systems, enhancing reliability and efficiency.

1. Data Acquisition

- Collect voltage and current phasor data from smart meters or SCADA systems.
- Store the data in **IBM Cloud Object Storage** in structured formats (e.g., CSV or JSON).

2. Data Preprocessing

- Clean the dataset by removing noise and outliers using **IBM Watson Studio**.
- Extract relevant features (RMS values, phase angles) and normalize the data.

3. Model Development

- Access the existing model in **IBM Watson Studio.**
- Update training data and adjust model parameters using **AutoAI**.
- Retrain the model with the updated dataset and parameters.

4. Model Evaluation

- Evaluate model performance using a validation dataset, assessing metrics like accuracy and F1-score.

5. Deployment

- Deploy the trained model as a REST API using **IBM Watson Machine Learning** for real-time fault detection.

6. Monitoring and Maintenance

- Monitor model performance and implement a feedback loop for continuous retraining with new data.

SYSTEM APPROACH

The "System Approach" section outlines the overall strategy and methodology for developing and implementing the Power System Fault detection and Classification . Here’s a Suggested structure for this Section:

- System requirements

  IBM Cloud.

  IBM Watson ai Studio for model development and deployment.

  IBM Cloud Object Storage for dataset Handling.

ALGORITHM & DEPLOYMENT

Algorithm Overview

The Random Forest algorithm is chosen for power system fault detection and classification due to its effectiveness in classification tasks and robustness against overfitting. It is well-suited for modeling complex relationships in high-dimensional electrical measurement data.

Data Input

Input features for the Random Forest algorithm include:

- Voltage and Current Measurements: Real-time phasor data from smart meters.
- RMS Values: Root Mean Square values for power quality assessment.
- Phase Angles: Differences indicating specific fault types.
- Frequency Components: Variations during fault conditions.
- Time Stamps: Temporal data capturing event sequences.

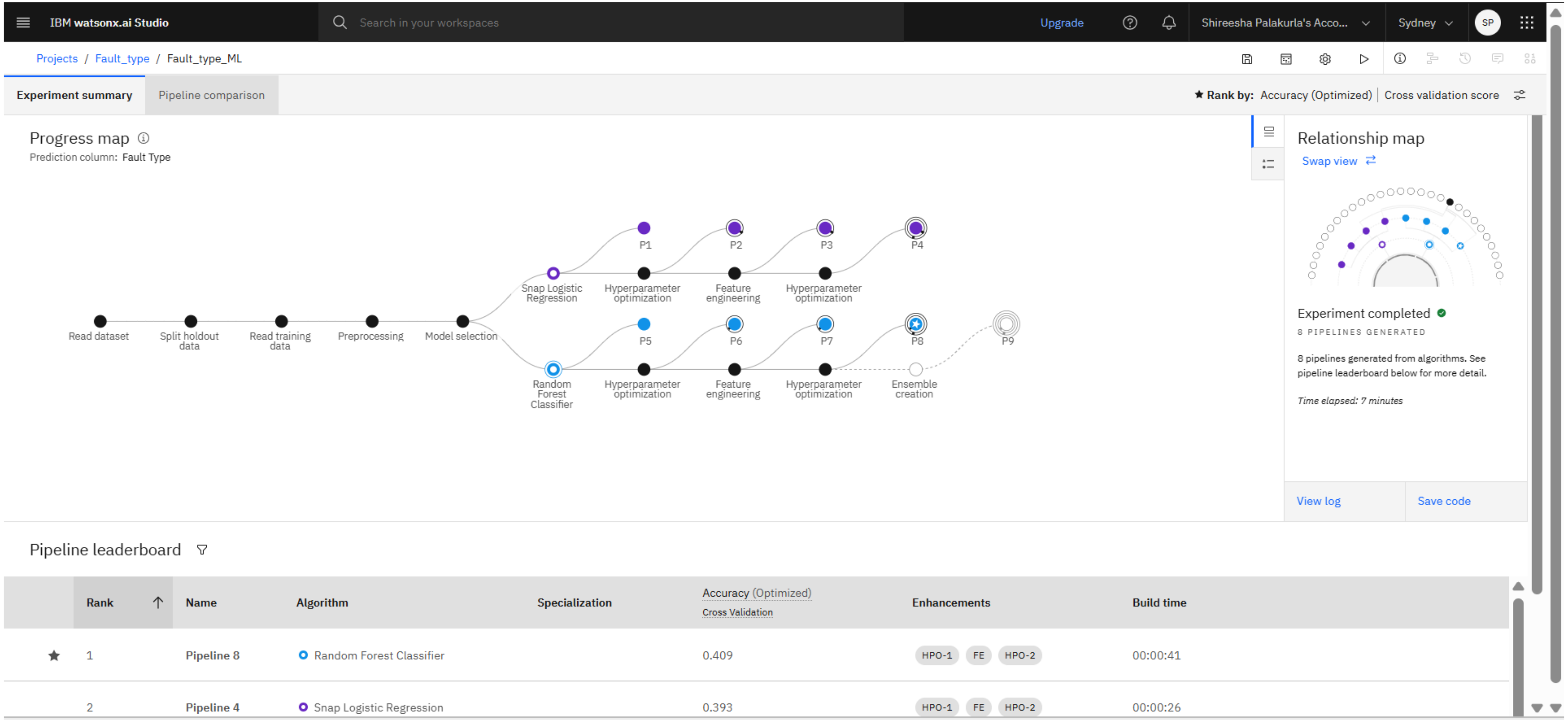
Training Process

- Training the Random Forest model involves:
- Data Preparation: Splitting the dataset into training and validation sets.
- Feature Selection: Identifying relevant features using importance scores.
- Cross-Validation: Using K-fold cross-validation for performance evaluation.
- Hyperparameter Tuning: Optimizing parameters like the number of trees and tree depth.

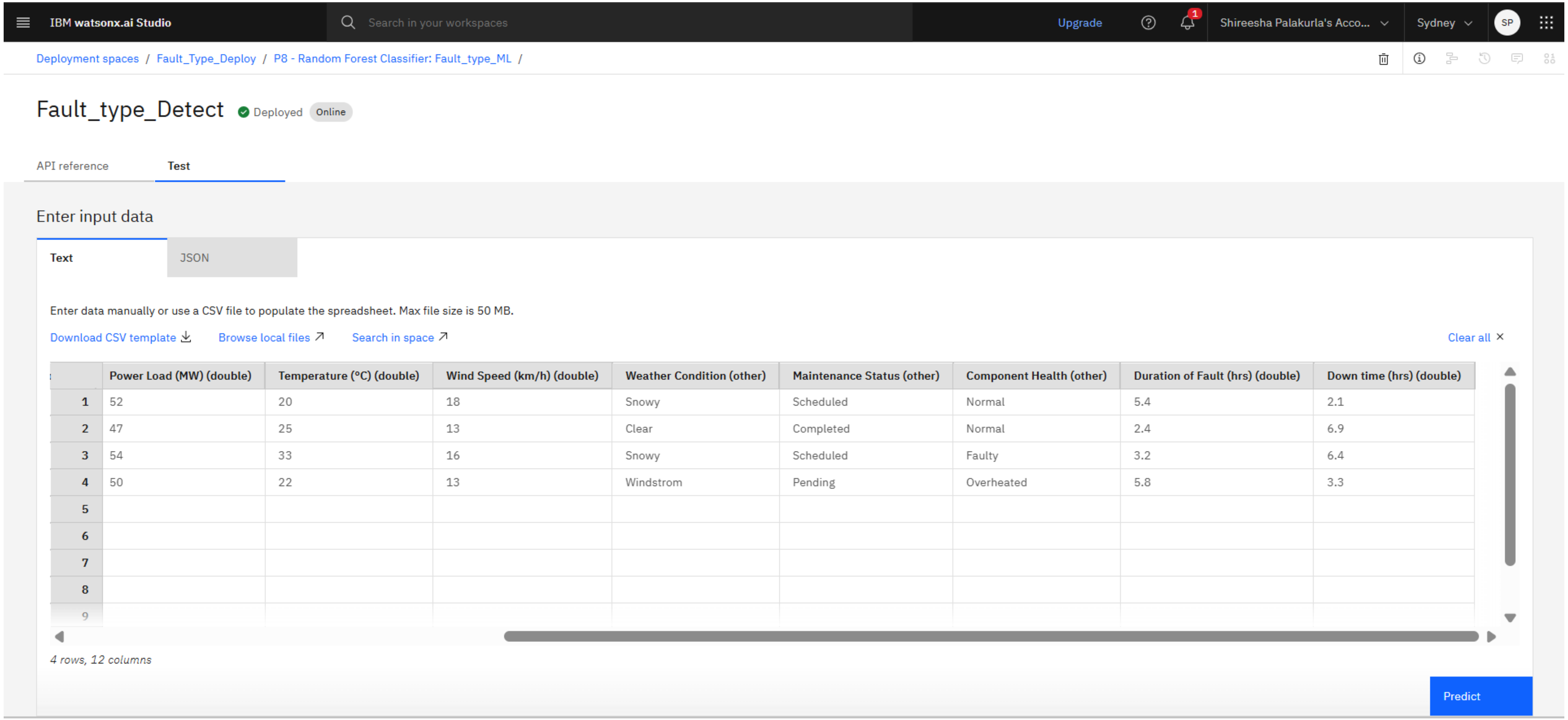
Prediction Process

- During prediction, the trained Random Forest model:
- Input Data: Takes real-time voltage and current measurements.
- Real-Time Data Integration: Utilizes current measurements to assess system state.
- Output: Predicts fault types (e.g., normal, L-G fault, L-L fault, 3-phase fault) for rapid response.

RESULT

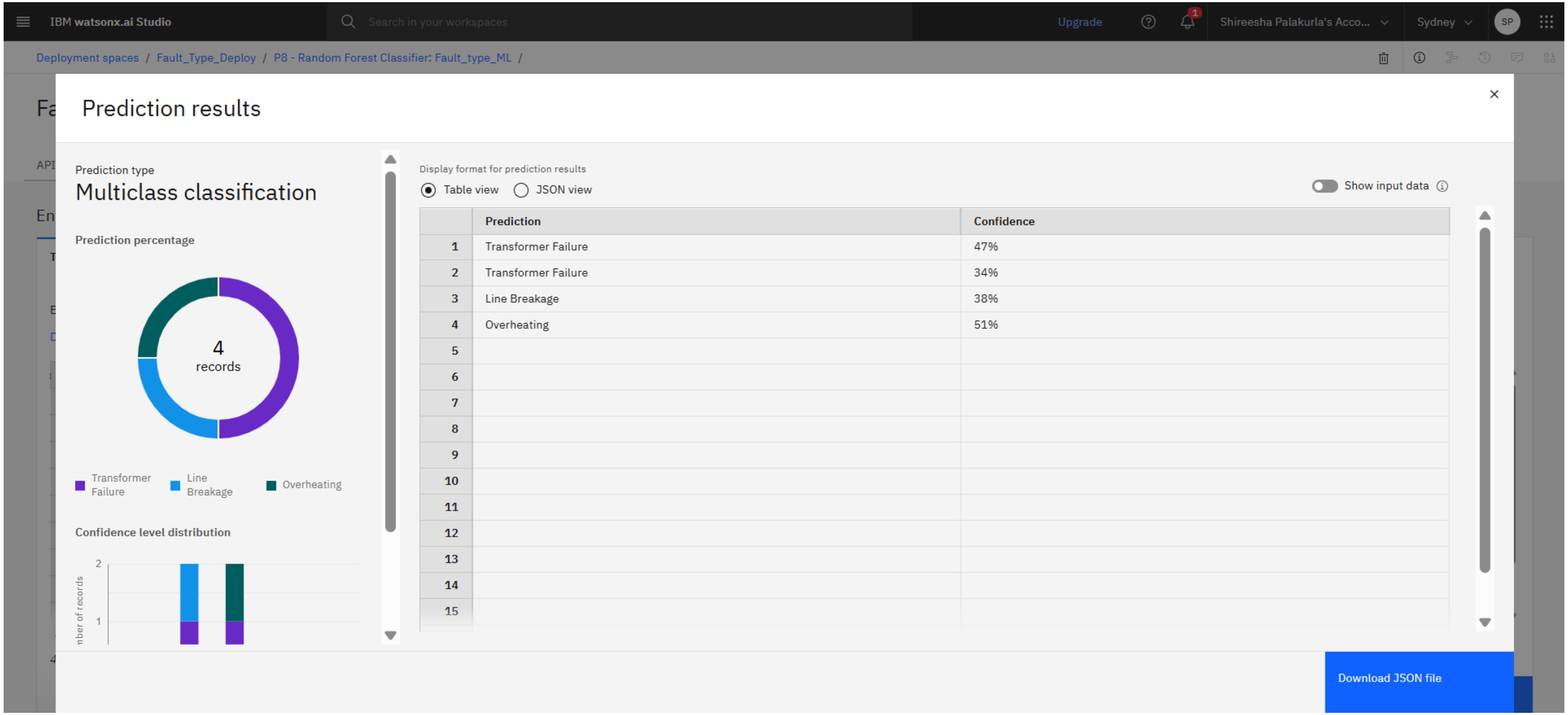

IBM watsonx.ai Studio
Search in your workspaces
Upgrade
Shireesha Palakurla's Acco...
Sydney
SP
Projects / Fault_type / Fault_type_ML
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Fault Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Logistic Regression
Random Forest Classifier
Hyperparameter optimization
Feature engineering
Ensemble creation
P1
P2
P3
P4
P5
P6
P7
P8
P9
Relationship map
Swap view
Experiment completed
8 PIPELINES GENERATED
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 7 minutes
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized)
Cross Validation
Enhancements
Build time
1
Pipeline 8
Random Forest Classifier
0.409
HPO-1
FE
HPO-2
00:00:41
2
Pipeline 4
Snap Logistic Regression
0.393
HPO-1
FE
HPO-2
00:00:26

RESULT



	Power Load (MW) (double)	Temperature (°C) (double)	Wind Speed (km/h) (double)	Weather Condition (other)	Maintenance Status (other)	Component Health (other)	Duration of Fault (hrs) (double)	Down time (hrs) (double)
1	52	20	18	Snowy	Scheduled	Normal	5.4	2.1
2	47	25	13	Clear	Completed	Normal	2.4	6.9
3	54	33	16	Snowy	Scheduled	Faulty	3.2	6.4
4	50	22	13	Windstrom	Pending	Overheated	5.8	3.3
5								
6								
7								
8								
9								

RESULT



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CONCLUSION

The project successfully developed a machine learning model using the Random Forest algorithm for power system fault detection and classification. By analyzing real-time voltage and current measurements, the model effectively distinguishes between normal conditions and various fault types. Its robust performance is achieved through careful feature selection and hyperparameter tuning. The integration of real-time data allows for rapid fault identification, enhancing grid stability and reliability. This solution demonstrates the potential of machine learning in improving power distribution systems. Future enhancements could include exploring additional algorithms and optimizing model performance further. Overall, this project lays a strong foundation for advancing fault detection methodologies in the energy sector.

FUTURE SCOPE

- Explore additional machine learning algorithms, such as Support Vector Machines and Deep Learning models, to improve classification accuracy.
- Incorporate diverse data sources, including weather conditions and historical fault data, to enhance model robustness.
- Develop a real-time monitoring system that integrates the model with existing grid management for continuous fault detection.
- Implement advanced hyperparameter tuning and feature engineering techniques to optimize model performance.
- Adapt the model for larger power systems to handle increased data volumes and complex fault scenarios.
- Create a user-friendly interface for operators to visualize predictions and system status for quicker decision-making.
- Conduct field trials to validate the model's performance in real-world conditions and make necessary adjustments.

REFERENCES

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