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

- Currently, modern power distribution systems play a vital role in ensuring continuous and stable electricity supply to residential, commercial, and industrial sectors. However, these systems are highly susceptible to various types of faults such as line-to-ground, line-to-line, and three-phase faults. Accurate and timely detection of such faults is critical, as delays may lead to equipment damage, large-scale outages, and safety hazards. Traditional fault detection techniques often require manual intervention or threshold-based logic, which can be slow, error-prone, and not scalable. Therefore, there is a need for an intelligent system that can analyze electrical measurements like voltage and current phasors to automatically detect and classify different types of faults in real-time. This not only enhances the reliability and safety of the power grid but also supports faster restoration and efficient grid management.

PROPOSED SOLUTION

The proposed system aims to address the challenge of accurately detecting and classifying various types of faults in a power distribution system using electrical measurement data. This involves leveraging machine learning techniques to analyze voltage and current phasors and identify fault conditions in real time. The solution will consist of the following components:

1. Data Collection:

- Gather historical and labeled data consisting of voltage and current measurements under different fault conditions (e.g., line-to-ground, line-to-line, three-phase faults).
- Ensure that data includes both faulty and normal operating conditions to train the model effectively.

2. Data Preprocessing:

- Clean and preprocess the collected data by handling missing values, removing noise, and filtering out anomalies.
- Perform feature engineering to compute useful statistical indicators such as RMS, peak values, phase angles, and frequency-domain components (e.g., FFT) to enhance classification accuracy.

3. Machine Learning Algorithm:

- Implement supervised machine learning algorithms like **Random Forest**, **Support Vector Machine (SVM)**, or **Multilayer Perceptron (MLP)** to classify the type of fault.
- Compare model performances using cross-validation techniques and select the one with the highest accuracy.

4. Deployment:

- Deploy the trained model using **IBM Watson Machine Learning** to create a RESTful API endpoint for real-time fault detection.
- Store input/output data in **IBM Cloud Object Storage** for reliability and scalability.

5. Evaluation:

- Evaluate the model's performance using metrics such as **Accuracy**, **Precision**, **Recall**, and **F1-score**.
- Use a confusion matrix to visualize misclassifications across fault types.

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SYSTEM APPROACH

This section outlines the overall methodology and tools used to build the power system fault detection and classification model.

System Requirements

Hardware:

- Minimum: Intel i3, 8GB RAM, 2GB free space
- Internet connection for IBM Cloud access

Software:

- Python
- IBM Cloud Lite Account
- IBM Watson Studio & Cloud Object Storage

Libraries Required

pandas, numpy – Data handling

scikit-learn – ML model & evaluation

matplotlib, seaborn – Visualization

ibm_watson_machine_learning – Model deployment

ALGORITHM & DEPLOYMENT

Algorithm Selection :

The chosen algorithm for fault classification is the **Random Forest Classifier**, a powerful ensemble learning method based on decision trees.
It was selected due to its robustness, ability to handle multi-class classification, and effectiveness in dealing with noisy and non-linear electrical data.
Random
Forest performs well even with a small dataset and provides feature importance, which helps in interpreting the model.

Data Input :

The model uses the following input features:

- Voltage and current phasors.
- Derived features such as:
  - Phase differences
  - RMS values
  - Frequency-domain features
- Label (target): Fault type (Normal, LG, LL, DLG, 3-Phase)

Training Process

- The dataset is split into training and testing sets .
- Feature scaling is applied where necessary.
  - The Random Forest model is trained using scikit-learn, with hyperparameter tuning (like number of trees, max depth) done via GridSearchCV.
- 5-fold cross-validation is used to ensure generalization and prevent overfitting.

Prediction Process

Once trained, the model takes real-time electrical measurements as input and predicts the type of fault. The prediction can be integrated with live grid monitoring systems through an API. Predictions are nearly instantaneous, enabling rapid fault classification and response.

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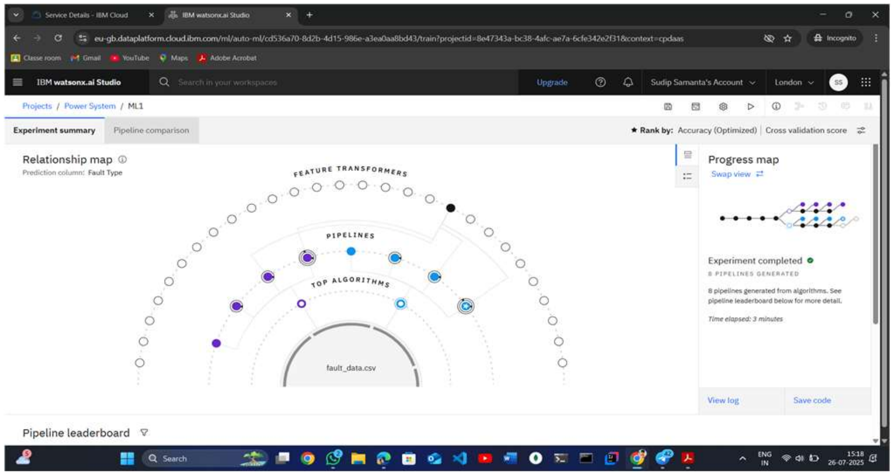
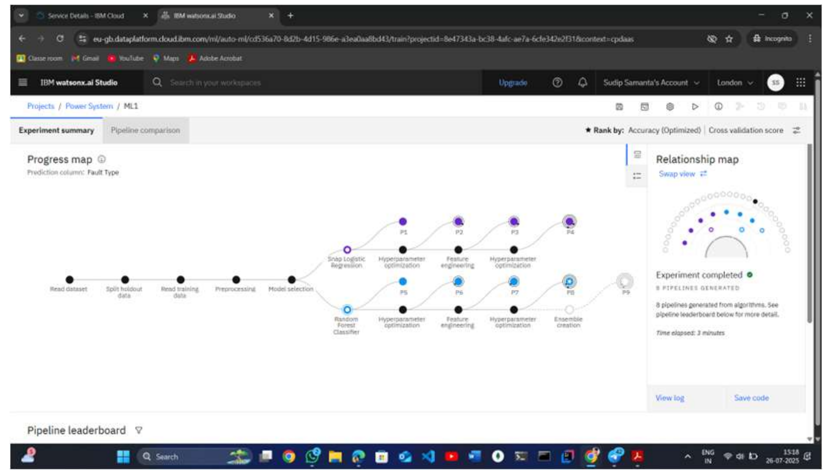
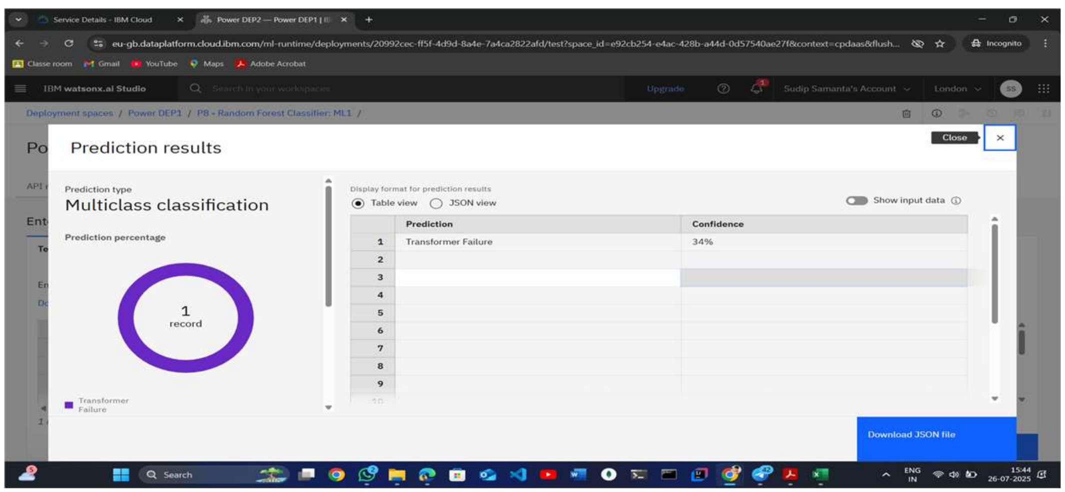
RESULT







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CONCLUSION

- The machine learning model successfully classified multiple types of power system faults with high accuracy. Integration with IBM Cloud Lite enabled seamless data storage, model training, and deployment in a scalable and accessible environment. The use of cloud-based services ensures real-time detection capabilities, which is crucial for improving grid reliability and reducing downtime.

FUTURE SCOPE

- **Integration with real-time SCADA systems** for live fault monitoring and automated grid response.
- **Use of deep learning models** (like LSTM or CNN) to improve accuracy on complex and noisy data.
- **Expansion to fault location prediction**, not just classification.
- **Mobile and web dashboard development** for visual monitoring and alerts.
- **Continuous learning system** that updates the model with new fault data for better performance over time.

REFERENCES

Kaggle Dataset – *Power System Faults Dataset*:
https://www.kaggle.com/datasets/ziya07/power-system-faults-dataset

IBM Cloud Documentation:
https://cloud.ibm.com/docs

IEEE Research Papers on Fault Detection and Smart Grids (Optional if used)

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