REAL-TIME FAULT DETECTION AND CLASSIFICATION IN GAS/OIL PIPELINES

**OBJECTIVE :-**

* Generating realistic synthetic sensor data for gas/oil pipelines
* Injecting various fault types (single, combined, self-recovering) across multiple modes
* Detecting anomalies in real-time using an LSTM Autoencoder
* Classifying fault types using a CNN/LSTM-based classifier
* Evaluating model performance with accuracy, F1-score, and confusion matrix

**Methodology :-**

1. **Synthetic Data Generation**

* Simulate normal behavior of pressure, temperature, and vibration sensors
* Inject faults: leak, blockage, temperature rise, sensor noise, flatlines, etc.
* Modes: Start, Random, Snippet, Recover, Rear
* Varying fault intensity (low/high) and speed (slow/fast)

1. **Anomaly Detection (Stage 1)**

* Train an LSTM Autoencoder on clean data
* Detect deviations during inference as anomalies

1. **Fault Classification (Stage 2)**

* Extract anomaly segments
* Train a CNN - LSTM classifier to label fault types

1. **Evaluation**

* Accuracy, F1-Score, Confusion Matrix
* Visualize anomaly scores and classification results

**Dataset Used :-**

This project uses a custom-generated synthetic dataset simulating real-time sensor readings in gas/oil pipelines. The dataset includes time-series data from three virtual sensors:

* Pressure Sensor
* Temperature Sensor
* Vibration Sensor

**Tools and Libraries :-**

* **Programming Language**: Python
* **Libraries**: NumPy, Pandas, Matplotlib, PyTorch, Scikit-learn
* **Modeling**: LSTM Autoencoder, CNN-LSTM Classifier
* **Development Environment**: VS Code
* **Data**: Synthetic sensor data (vibration, pressure, temperature)

**Expected Outcomes :-**

* Accurate real-time detection of pipeline anomalies
* Robust classification of different fault types
* Scalable codebase for industrial deployment