Project 2: Real-Time Anomaly Detection for IoT Sensor Streams

Project Overview

Build a production anomaly detection system for streaming IoT sensor data (e.g., manufacturing or smart infrastructure). The system should:

- Detect anomalies in real time
- Scale in production
- Trigger alerts and dashboard updates

Milestone 1: Data Collection, Preprocessing, and Exploration

Objectives

• Collect multi-source time-series streams, clean and prepare

Tasks

1. **Data Collection**
    a. Ingest IoT streams via Azure Event Hubs or Kafka
    b. Store raw data in Azure Blob / Data Lake
2. **Preprocessing**
    a. Windowing, smoothing, feature extraction
    b. Handle missing streams and noise
3. **EDA**
    a. Statistical patterns and correlation analysis
    b. Identify anomaly patterns

Deliverables

- Processed Time-Series Dataset
- Preprocessing Pipeline Doc
- Anomaly Patterns EDA Report

Milestone 2: Model Development & Evaluation

Objectives

• Train models that detect anomalies

Tasks

1. **Modeling**
    a. Evaluate Autoencoders, Isolation Forests, LSTM-based approaches
2. **Evaluation**
    a. Precision, recall on anomaly detection
    b. Real-time detection simulation
3. **Optimization**
    a. Hyperparameter search

Deliverables

- Trained Anomaly Detection Models
- Evaluation Report

Milestone 3: Cloud Deployment & Integration

Objectives

• Deploy pipeline to production

Tasks

1. **Azure Deployment**
    a. Use Azure Stream Analytics + Functions for inference
    b. Containerize model
2. **Scalable API**
    a. Expose REST service for incoming sensor data
3. **Integration**
    a. Alerts via Azure Monitor, Logic Apps

Deliverables

- Azure ML Real-Time Anomaly Service
- API & Alert System

Milestone 4: MLOps & Monitoring Dashboard

Objectives

• Enable ongoing monitoring and automated reactions

Tasks

1. **Tracking & Versioning**
    a. Track experiments and retrains with MLflow
2. **Live Dashboard**
    a. Power BI or Grafana real-time
3. **Retraining Automation**
    a. Trigger retrain based on drift metrics

Deliverables

- Monitoring Dashboard
- MLOps Pipeline Doc

Milestone 5: Final Documentation & Presentation

Objectives

• Complete documentation and demonstration

Deliverables

- Full Final Report
- End-to-End Demo Presentation
- Future Enhancements Proposal