Project Title

Autonomous Real-Time Financial Fraud Detection using Continual Learning and Causal Explainability

Project Overview

This project presents an autonomous artificial intelligence system for detecting financial fraud in real time. The system continuously adapts to evolving transaction patterns while providing transparent explanations for its decisions using causal reasoning techniques.

Objectives

• Detect fraudulent transactions in real time
• Process continuous transaction streams
• Adapt to changing fraud patterns automatically
• Explain predictions using causal relationships
• Deploy the system with a web-based monitoring interface

System Architecture

1. Transaction stream ingestion
2. Real-time feature engineering
3. Fraud detection model
4. Continual learning engine
5. Causal explainability module
6. Risk scoring and alert system
7. Web-based monitoring dashboard
8. Deployment infrastructure

Data Ingestion and Processing

Transaction data includes amount, time, location, merchant category, device information, and user behavior signals. Each transaction is processed individually using event-driven pipelines and behavioral aggregation methods.

Fraud Detection Models

The system uses a combination of supervised and unsupervised learning techniques including gradient boosting models, deep neural networks, and autoencoders to assess fraud probability and behavioral deviation.

Continual Learning Mechanism

The model updates incrementally as new labeled transaction data becomes available. Techniques such as replay buffers, adaptive regularization, and drift detection are applied to preserve prior knowledge while learning new patterns.

Causal Explainability

Causal modeling techniques are used to identify cause-effect relationships behind fraud predictions. Structural causal models and counterfactual reasoning explain how changes in transaction behavior influence risk outcomes.

Risk Scoring and Decision Logic

Each transaction is assigned a fraud risk score, confidence level, and recommended action. Decision thresholds adapt dynamically based on feedback and evolving data distributions.

Web Application Development

The frontend is developed using HTML and CSS to display live transaction feeds, risk indicators, and explanation summaries. The interface supports responsive layouts and real-time updates.

Backend Integration

A Python-based backend using FastAPI handles transaction ingestion, model inference, continual updates, and explanation generation. Secure APIs ensure reliable communication between system components.

Deployment Process

1. Containerize system components using Docker
2. Deploy scalable services on cloud infrastructure
3. Configure real-time data streams
4. Monitor performance, drift, and latency
5. Ensure secure and compliant operation

Evaluation Metrics

• Fraud detection accuracy
• Precision and recall

• False positive stability
• Drift adaptation time
• Explanation consistency
• System latency

Tools and Technologies

• Python
• Scikit-learn
• PyTorch / TensorFlow
• Continual learning techniques
• Causal modeling methods
• HTML and CSS
• FastAPI
• Docker and Git

Conclusion

This project demonstrates a modern approach to financial fraud detection by integrating continual learning and causal explainability. The system supports real-time decision-making, adaptive intelligence, and transparent reasoning suitable for large-scale financial environments.