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AI Enabled Real-Time Financial Transaction Fraud Detection System

Ms.Sindhuja.R, Aravind Kumar.R, Jeeva.G, Saravana Surya

Assistant Professor, Department of AI&DS, Sir Issac Newton College of Engineering and Technology Pappakovil,
Nagapatinam, India

B. Tech Final Year, Department of AI&DS, Sir Issac Newton College of Engineering and Technology Pappakovil,
Nagapatinam, India

ABSTRACT: Financial fraud has become a major concern for organizations and financial institutions due to the rapid growth of digital transactions and online financial platforms. Traditional fraud detection mechanisms are often slow, reactive, and unable to identify complex fraudulent activities in real time. These limitations increase financial risks and reduce organizational transparency. This paper proposes an AI Enabled Real-Time Financial Transaction Fraud Detection System designed to monitor financial activities such as expenses, profits, investments, and losses through live spreadsheet integration. The proposed system utilizes machine learning algorithms to identify abnormal transaction patterns and detect suspicious financial behavior instantly. The system incorporates an Isolation Forest anomaly detection model to analyze transaction data and identify outliers that may represent fraudulent activities. Additionally, a Retrieval-Augmented Generation (RAG) model is integrated to provide intelligent financial insights, recommendations, and contextual analysis based on financial data. To improve verification and transparency, the system includes a document verification module that allows users to upload invoices and billing documents. These documents are processed using Optical Character Recognition (OCR) to extract relevant financial information and validate it against recorded transactions. Furthermore, the system integrates a Telegram chatbot notification system to send real-time alerts whenever suspicious financial activities are detected. This enables administrators to respond quickly and take preventive actions. The proposed solution improves financial monitoring, increases fraud detection accuracy, enhances transparency in financial management, and provides intelligent AI-driven financial insights for organizations.

KEYWORDS: Financial Fraud Detection, Machine Learning, Real-Time Monitoring, RAG System, Financial Analytics, AI-Based Fraud Detection.

I. INTRODUCTION

The rapid adoption of digital banking, online payment platforms, and electronic financial systems has significantly increased the number of financial transactions conducted worldwide. While these technologies provide convenience and efficiency, they also create new opportunities for fraudulent activities such as transaction manipulation, financial misreporting, and unauthorized financial operations. Organizations today manage large volumes of financial data, including expenses, investments, revenues, and operational costs. Monitoring these financial activities manually is both time-consuming and error-prone. In many cases, fraudulent transactions remain undetected until significant financial damage has already occurred. Traditional fraud detection methods typically rely on **rule-based systems or manual auditing processes**. These approaches use predefined thresholds or rules to detect suspicious transactions. However, fraud patterns are continuously evolving, making rule-based systems insufficient for detecting sophisticated fraud schemes. Recent advancements in **Artificial Intelligence (AI)** and **Machine Learning (ML)** have introduced more effective techniques for fraud detection. Machine learning models can analyze large financial datasets, identify hidden patterns, and detect abnormal behaviors that may indicate fraudulent activities. AI-based fraud detection systems use **anomaly detection algorithms** to detect transactions that deviate from normal financial behavior. These models continuously learn from financial data and improve their detection capabilities over time. This research proposes an **AI Enabled Real-Time Financial Transaction Fraud Detection System** that integrates real-time financial data monitoring with machine learning-based anomaly detection. The system also incorporates **Retrieval-Augmented Generation (RAG)** to generate intelligent financial insights and recommendations based on financial transaction records. In addition, the proposed system includes **OCR-based document verification** and **Telegram-based alert notifications**, enabling organizations to monitor financial activities efficiently and detect fraud instantly. The primary

goal of this research is to develop an intelligent, automated, and real-time fraud detection system that enhances financial transparency and improves decision-making processes.

II. RELATED WORK

Financial fraud detection has been an important research area in data mining, artificial intelligence, and financial analytics. Several studies have explored different techniques for identifying fraudulent financial activities using statistical methods, machine learning models, and deep learning approaches. Early fraud detection systems were primarily based on **rule-based approaches**, where predefined conditions and thresholds were used to identify suspicious transactions. Although these systems were simple to implement, they lacked flexibility and were unable to detect complex or evolving fraud patterns. With the advancement of machine learning techniques, researchers began exploring **supervised learning models** such as **Random Forest, Support Vector Machines (SVM), Logistic Regression, and Neural Networks** for fraud detection. These models are trained using labeled transaction data and learn to classify transactions as legitimate or fraudulent. Another important approach used in financial fraud detection is **anomaly detection**. Anomaly detection techniques focus on identifying unusual patterns in transaction data that deviate from normal financial behavior. Algorithms such as **Isolation Forest, Local Outlier Factor (LOF), and Autoencoders** have been widely used for detecting anomalies in financial datasets. Isolation Forest has gained significant attention due to its efficiency in detecting anomalies in high-dimensional datasets. The algorithm isolates abnormal data points by constructing random decision trees, making it suitable for large-scale financial monitoring systems. Recent developments in artificial intelligence have also introduced **Retrieval-Augmented Generation (RAG)** models. RAG systems combine information retrieval techniques with generative AI models to provide contextual analysis and intelligent recommendations based on available data sources. However, many existing fraud detection systems focus primarily on analyzing historical transaction data rather than monitoring financial activities in real time. In addition, many systems lack automated alert mechanisms and document verification capabilities. The proposed system addresses these limitations by integrating **real-time financial monitoring, anomaly detection, document verification, and AI-driven financial insights** into a unified platform.

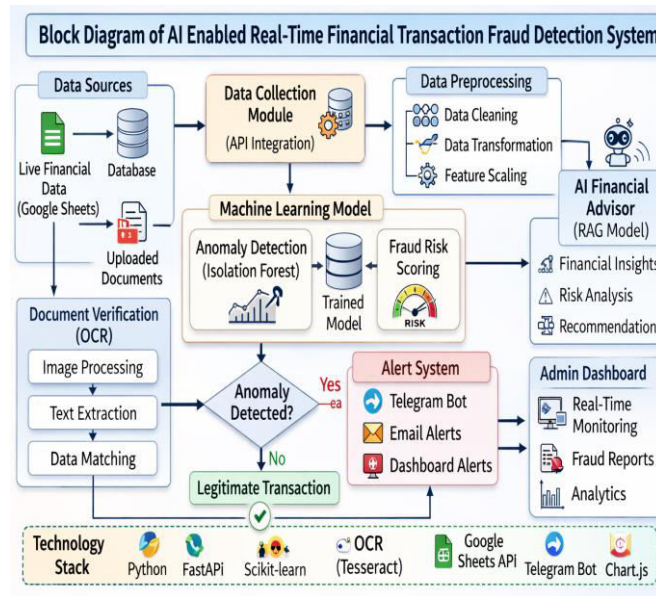
1. AI-Based Fraud Detection Framework

The proposed **AI-Based Fraud Detection Framework** is designed to monitor financial transactions continuously and identify suspicious activities using machine learning techniques. The framework consists of several interconnected components that work together to collect, process, analyze, and interpret financial transaction data. The first component of the framework is the **data collection module**, which gathers financial transaction data from live spreadsheets connected through application programming interfaces (APIs). These spreadsheets contain financial information such as transaction date, transaction amount, expense category, profit values, investment records, and other financial metrics. Once the financial data is collected, it is passed to the **data preprocessing module**. In this stage, the system performs several data cleaning operations such as handling missing values, removing duplicate records, and correcting inconsistent data formats. Feature normalization and transformation techniques are applied to ensure that the dataset is suitable for machine learning analysis. The core component of the framework is the **anomaly detection engine**, which analyzes financial transaction patterns to detect abnormal activities. The system utilizes the **Isolation Forest algorithm**, which isolates anomalies by recursively partitioning the dataset into smaller subsets. Transactions that require fewer partitions to be isolated are considered anomalies and are assigned higher anomaly scores. In addition to anomaly detection, the framework includes a **document verification module** that enables users to upload financial documents such as invoices, receipts, and billing statements. These documents are processed using **Optical Character Recognition (OCR)** to extract textual information such as invoice numbers, transaction amounts, and dates. The extracted information is then compared with the recorded financial transactions to identify inconsistencies. Another key component of the framework is the **AI financial analysis module**, which uses a **Retrieval-Augmented Generation (RAG) model** to provide intelligent financial insights. The RAG model retrieves relevant financial records and generates contextual explanations, recommendations, and analytical summaries based on transaction data. Finally, the system integrates a **Telegram chatbot alert system** that sends real-time notifications whenever suspicious financial activities are detected. This feature allows administrators to respond immediately and investigate potentially fraudulent transactions.

2. Proposed Methodology

The proposed **AI Enabled Real-Time Financial Transaction Fraud Detection System** follows a structured methodology that integrates data collection, preprocessing, anomaly detection, document verification, and intelligent

financial analysis. The goal of this methodology is to detect fraudulent financial activities in real time while providing organizations with intelligent insights into their financial transactions.



The methodology begins with the **collection of financial transaction data** from live spreadsheets connected through Application Programming Interfaces (APIs). These spreadsheets contain financial information such as transaction date, transaction amount, expense category, investment details, profit values, and other financial indicators. Since financial data is continuously updated in real time, the system can monitor transactions dynamically without requiring manual data entry.

After collecting the transaction data, the system performs **data preprocessing** to ensure the dataset is clean and suitable for machine learning analysis. This stage involves removing duplicate entries, handling missing values, correcting inconsistent data formats, and transforming categorical information into numerical representations where necessary. Feature scaling techniques such as normalization are applied to ensure that all financial attributes are within a comparable range, which improves the accuracy of machine learning models.

Once the data is prepared, the system applies an **anomaly detection model** to identify suspicious transactions. The proposed system uses the **Isolation Forest algorithm**, which is designed to detect anomalies in large datasets efficiently. Unlike traditional classification models, Isolation Forest works by isolating abnormal data points through random partitioning. Transactions that require fewer partitions to be isolated are considered anomalies and are assigned higher anomaly scores. These transactions are then flagged as potentially fraudulent and sent for further verification.

In addition to anomaly detection, the system includes a **document verification module** to validate financial records. Users can upload supporting documents such as invoices, receipts, or billing statements related to transactions. The system uses **Optical Character Recognition (OCR)** technology to extract textual information from these documents. Extracted details such as invoice numbers, transaction amounts, and dates are compared with the financial records stored in the database. Any mismatch between the document data and transaction records is flagged as a potential fraud indicator.

To enhance decision-making capabilities, the system incorporates an **AI Financial Advisor module based on Retrieval-Augmented Generation (RAG)**. The RAG model retrieves relevant financial records from the database and generates intelligent insights regarding financial patterns, spending behavior, and potential financial risks. This feature helps administrators understand financial trends and identify suspicious financial behavior more effectively.

The final stage of the methodology is the **real-time alert and notification system**. When the anomaly detection model identifies suspicious transactions or when inconsistencies are detected in document verification, the system automatically generates alerts. These alerts are sent through a **Telegram chatbot**, which immediately notifies

administrators or financial managers about the detected anomalies. This enables organizations to respond quickly and investigate potentially fraudulent activities before significant financial losses occur.

Overall, the proposed methodology integrates **real-time financial monitoring, machine learning-based anomaly detection, document verification, and AI-driven financial insights** to create a comprehensive fraud detection system. This approach improves financial transparency, enhances fraud detection accuracy, and enables organizations to maintain secure and efficient financial management systems.

Implementation

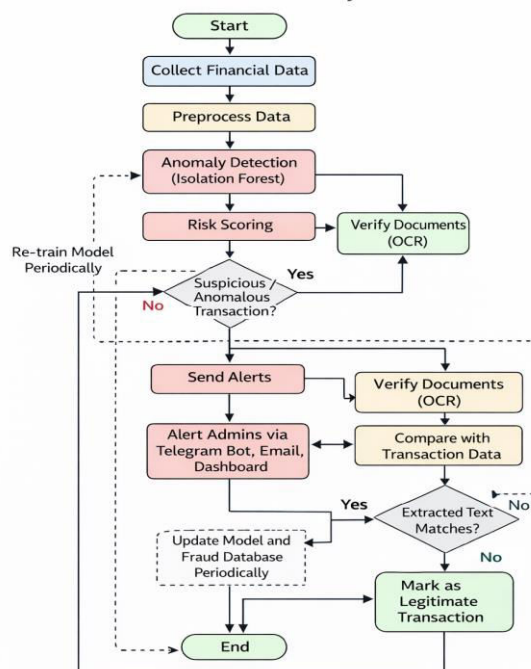
The proposed **AI Enabled Real-Time Financial Transaction Fraud Detection System** is implemented using a combination of modern web technologies, machine learning frameworks, and real-time data integration tools. The implementation focuses on building a scalable system capable of processing financial transactions, detecting fraudulent activities, verifying documents, and generating intelligent financial insights.

The system architecture consists of multiple modules including **data integration, machine learning processing, document verification, visualization dashboard, and alert notification system**. Each module performs a specific function to ensure efficient monitoring and analysis of financial transactions.

The backend of the system is developed using **Python with the FastAPI framework**. FastAPI is chosen because of its high performance, asynchronous capabilities, and ability to create efficient RESTful APIs. These APIs handle the communication between the frontend interface, machine learning models, and the financial data sources. The backend processes incoming transaction data, performs anomaly detection, and manages alerts and document verification.

For financial data monitoring, the system integrates with **Google Sheets using the Google Sheets API**. This integration allows financial data such as transaction dates, transaction amounts, expense categories, profits, investments, and financial summaries to be updated in real time. Whenever new data is added to the spreadsheet, the system retrieves the updated records and processes them automatically. This approach enables continuous monitoring of financial activities without requiring manual database updates.

Flowchart of AI Enabled Real-Time Financial Transaction Fraud Detection System



III. EXPERIMENTAL RESULTS

The proposed system was evaluated using financial transaction datasets containing various types of expenses, investments, and revenue records. The anomaly detection model successfully identified abnormal transaction patterns and flagged suspicious financial activities.

The system demonstrated improved fraud detection performance by detecting irregular transaction patterns that were not easily identifiable through manual monitoring. Performance metrics such as **Accuracy, Precision, and Recall** were used to evaluate the model performance.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

The results show that the proposed system effectively identifies fraudulent transactions and provides real-time financial monitoring capabilities.

IV. CONCLUSION

In this research, an **AI Enabled Real-Time Financial Transaction Fraud Detection System** was proposed to address the growing challenges associated with financial fraud in digital financial environments. With the increasing use of online banking, digital payments, and automated financial systems, organizations require intelligent solutions that can continuously monitor financial activities and detect suspicious transactions in real time.

The proposed system integrates **machine learning, real-time financial monitoring, document verification, and AI-based financial analysis** to create an effective fraud detection framework. The implementation of the **Isolation Forest anomaly detection algorithm** enables the system to identify abnormal financial patterns and detect potential fraudulent transactions automatically. By analyzing financial datasets containing information such as expenses, investments, profits, and transaction records, the model can identify unusual behavior that may indicate financial irregularities.

In addition to anomaly detection, the system incorporates **OCR-based document verification**, which allows uploaded financial documents such as invoices and receipts to be analyzed and validated against transaction records. This feature improves the reliability of financial monitoring and reduces the risk of fraudulent document submissions.

Another important contribution of the system is the integration of **Retrieval-Augmented Generation (RAG)** for intelligent financial analysis. The RAG module provides contextual insights and recommendations based on financial data, enabling administrators to understand financial trends and make informed decisions.

The system also includes a **real-time alert notification mechanism using a Telegram chatbot**, which ensures that administrators are immediately notified when suspicious transactions are detected. This rapid alert mechanism allows organizations to respond quickly and prevent potential financial losses.

The experimental results demonstrate that the proposed system effectively identifies abnormal financial patterns and provides reliable fraud detection capabilities. By combining real-time monitoring, anomaly detection, document verification, and AI-based financial insights, the system significantly improves financial transparency and security.

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