## Online Payments Fraud Detection System

# Project Description:

With the rapid growth of digital payments and online transactions, financial fraud has become a major concern for banks and payment platforms. Fraudulent transactions result in significant financial losses and reduce user trust in digital systems.

Online payment fraud detection is a challenging task because fraudulent transactions are very rare compared to legitimate ones (highly imbalanced dataset). Traditional rule-based systems fail to detect complex fraud patterns effectively.

In this project, we build a Machine Learning-based Fraud Detection System that classifies transactions as **Fraud (1)** or **Not Fraud (0)** using multiple classification algorithms such as:

- Decision Tree
- Random Forest
- Support Vector Machine (SVM)
- XGBoost

The best-performing model is selected and deployed using Flask for real-time fraud prediction.

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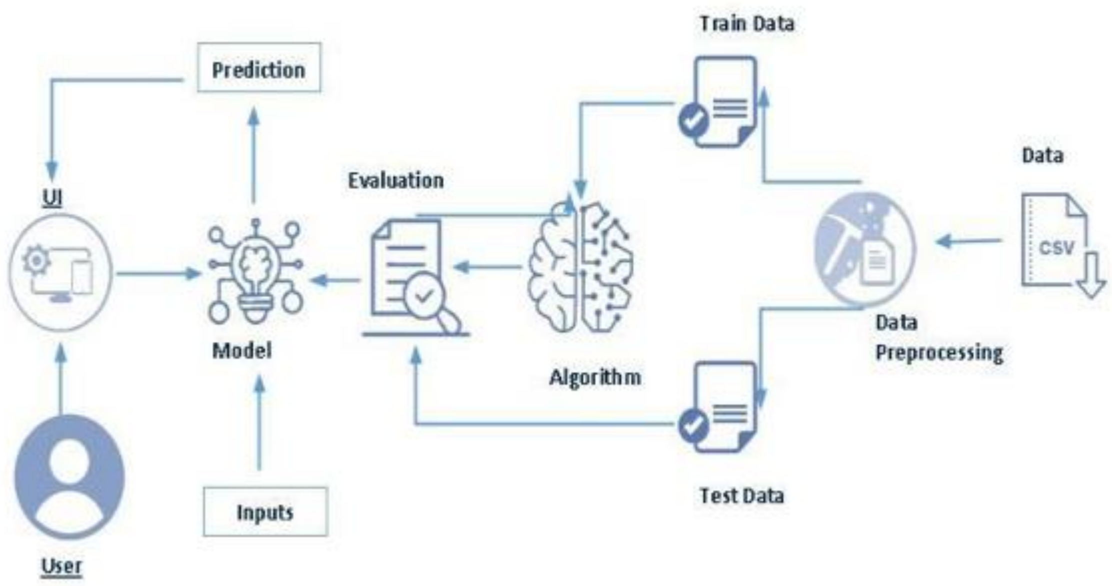
# Technical Architecture:



# Pre requisites:

**Software:**

- Anaconda / Python
- VS Code / PyCharm
- Flask

**Required Python Packages:**

pip install numpy

pip install pandas

pip install scikit-learn

pip install matplotlib

pip install seaborn

pip install pickle-mixin

pip install flask

pip install xgboost

You must have prior knowledge of following topics to complete this project.

# Prior Knowledge Required

- Supervised Machine Learning
- Classification Algorithms
- Decision Tree
- Random Forest
- SVM
- XGBoost
- Evaluation Metrics (Accuracy, Precision, Recall, F1-Score)
- Flask Basics

# Project Objectives:

## By the end of this project, we:

- Understand fraud detection using classification models
- Handle imbalanced datasets
- Perform data preprocessing and EDA
- Compare multiple ML algorithms
- Deploy a trained ML model using Flask
- Build a real-time fraud detection web application

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# Project Flow:

The complete working of our system follows a structured pipeline from data acquisition to final deployment:

**Step 1: Data Collection**

We collected a real-world financial transaction dataset from Kaggle containing over 6 million

The dataset includes transaction features such as:

- Step (time unit)
- Transaction type (TRANSFER, CASH_OUT, etc.)
- Amount
- Old and new balances of sender and receiver
- Fraud label (isFraud)

**Step 2: Data Analysis (EDA)**

We performed :

- Univariate analysis (distribution of fraud vs non-fraud)
- Bivariate analysis (type vs fraud comparison)
- Descriptive statistics
- Outlier detection using boxplots
- Class imbalance identification (Fraud < 1%)

Graphs included :

- Countplot of isFraud
- Countplot of transaction type
- Histogram of transaction amount
- Boxplot for outliers

**Step 3: Data Preprocessing**

- We applied the following preprocessing steps:
- Removed irrelevant columns (nameOrig, nameDest)
- Handled categorical variable (type) using One-Hot Encoding
- Checked for null values
- Split dataset into training and testing sets (80–20)
- Applied stratified sampling due to class imbalance

**Step 4: Model Building & Comparison**

We implemented and compared multiple ML algorithms:

1. Decision Tree
2. Random Forest
3. Support Vector Machine (SVM)
4. Extra Trees Classifier
5. XGBoost Classifier

We evaluated models using:

- Accuracy
- Precision
- Recall
- F1-score
- Confusion Matrix

Decision Tree was selected as final model due to:

- High performance
- Faster execution
- Easy interpretability
- Suitable for web deployment

**Step 5: Model Saving**

The final trained Decision Tree model was saved using Pickle as:

decision_tree_model.pkl

This allows real-time integration without retraining.

**Step 6: Application Development**

We built a Flask-based web application consisting of:

- Home Page (home.html)
- Prediction Form (predict.html)
- Result Page (submit.html)
- Backend logic (app.py)

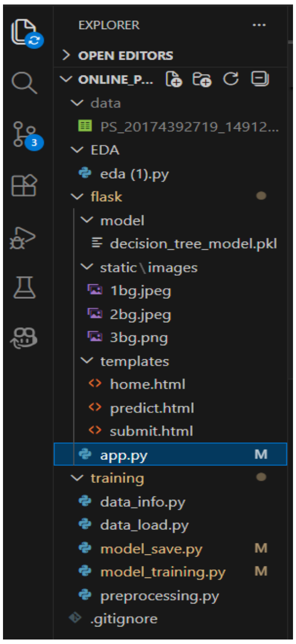
Workflow:
User Input → Preprocessing → Model Prediction → Fraud Probability → Result Display

**Step 7: Deployment & Testing**

- Local server deployment using Flask
- Tested with sample fraud and non-fraud transactions
- Verified fraud probability threshold (0.4)
- Validated real-time prediction functionality

## Project Structure:

Create the Project folder which contains files as shown below




## Milestone 1: Data Collection

### Activity 1: Download Dataset

- Dataset Source: Kaggle
- Dataset Name: PS_20174392719_1491204439457_log.csv
- Size: ~6.3 million records

The dataset contains transaction details such as:

- step
- type
- amount
- oldbalanceOrg
- newbalanceOrig
- oldbalanceDest
- newbalanceDest

- isFraud (Target)

```
PS_20174392719_1491204439457_log.csv
step,type,amount,nameOrig,oldbalanceOrg,newbalanceOrig,nameDest,oldbalan
1,PAYMENT,9839.64,C1231006815,170136.0,160296.36,M1979787155,0.0,0.0,0,0
1,PAYMENT,1864.28,C1666544295,21249.0,19384.72,M2044282225,0.0,0.0,0,0
1,TRANSFER,181.0,C1305486145,181.0,0.0,C553264065,0.0,0.0,1,0
1,CASH_OUT,181.0,C840083671,181.0,0.0,C38997010,21182.0,0.0,1,0
1,PAYMENT,11668.14,C2048537720,41554.0,29885.86,M1230701703,0.0,0.0,0,0
1,PAYMENT,7817.71,C90045638,53860.0,46042.29,M573487274,0.0,0.0,0,0
1,PAYMENT,7107.77,C154988899,183195.0,176087.23,M408069119,0.0,0.0,0,0
1,PAYMENT,7861.64,C1912850431,176087.23,168225.59,M633326333,0.0,0.0,0,0
1,PAYMENT,4024.36,C1265012928,2671.0,0.0,M1176932104,0.0,0.0,0,0
1,DEBIT,5337.77,C712410124,41720.0,36382.23,C195600860,41898.0,40348.79,0,0
1,DEBIT,9644.94,C1900366749,4465.0,0.0,C997608398,10845.0,157982.12,0,0
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1,PAYMENT,2560.74,C1648232591,5070.0,2509.26,M972865270,0.0,0.0,0,0
1,PAYMENT,11633.76,C1716932897,10127.0,0.0,M801569151,0.0,0.0,0,0
1,PAYMENT,4098.78,C1026483832,503264.0,499165.22,M1635378213,0.0,0.0,0,0
1,CASH_OUT,229133.94,C905080434,15325.0,0.0,C476402209,5083.0,51513.44,0,0
1,PAYMENT,1563.82,C761750706,450.0,0.0,M1731217984,0.0,0.0,0,0
1,PAYMENT,1157.86,C1237762639,21156.0,19998.14,M1877062907,0.0,0.0,0,0
1,PAYMENT,671.64,C2033524545,15123.0,14451.36,M473053293,0.0,0.0,0,0
1,TRANSFER,215310.3,C1670993182,705.0,0.0,C1100439041,22425.0,0.0,0,0
1,PAYMENT,1373.43,C20804602,13854.0,12480.57,M1344519051,0.0,0.0,0,0
1,DEBIT,9302.79,C1566511282,11299.0,1996.21,C1973538135,29832.0,16896.7,0,0
1,DEBIT,1065.41,C1959239586,1817.0,751.59,C515132998,10330.0,0.0,0,0
1,PAYMENT,3876.41,C504336483,67852.0,63975.59,M1404932042,0.0,0.0,0,0
1,TRANSFER,311685.89,C1984094095,10835.0,0.0,C932583850,6267.0,2719172.89,0,0
1,PAYMENT,6061.13,C1043358826,443.0,0.0,M1558079303,0.0,0.0,0,0
1,PAYMENT,9478.39,C1671590089,116494.0,107015.61,M58488213,0.0,0.0,0,0
1,PAYMENT,8009.09,C1053967012,10968.0,2958.91,M295304806,0.0,0.0,0,0
```

# Milestone 2: Visualizing and analysing the data

### Activity 1: Import Libraries

- pandas
- matplotlib
- seaborn

### Activity 2: Read Dataset

Used pd.read_csv() to load dataset.

### Activity 3: Univariate Analysis

- Fraud vs Non-Fraud Count Plot
- Amount Distribution Histogram
- Boxplot for outliers

### Activity 4: Bivariate Analysis

- Transaction Type vs Fraud
- Amount vs Fraud

### Activity 5: Multivariate Analysis

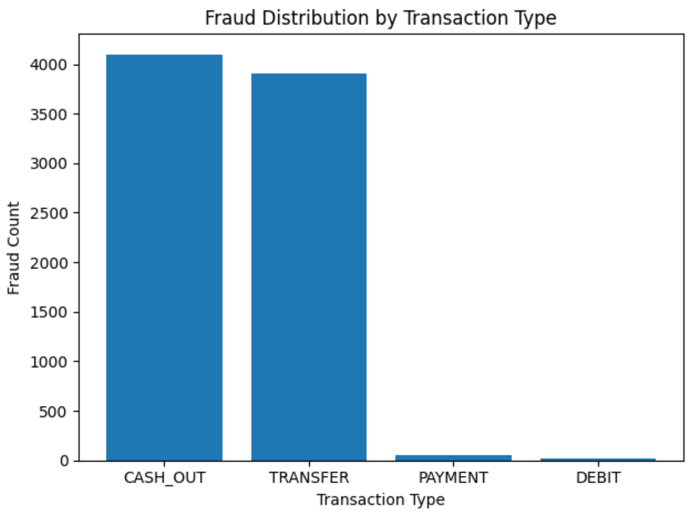
- Relationship between balance features and fraud

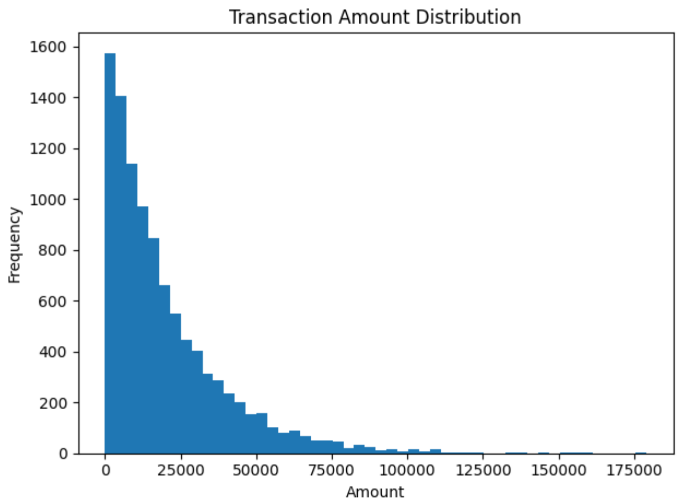
### Key Insights:

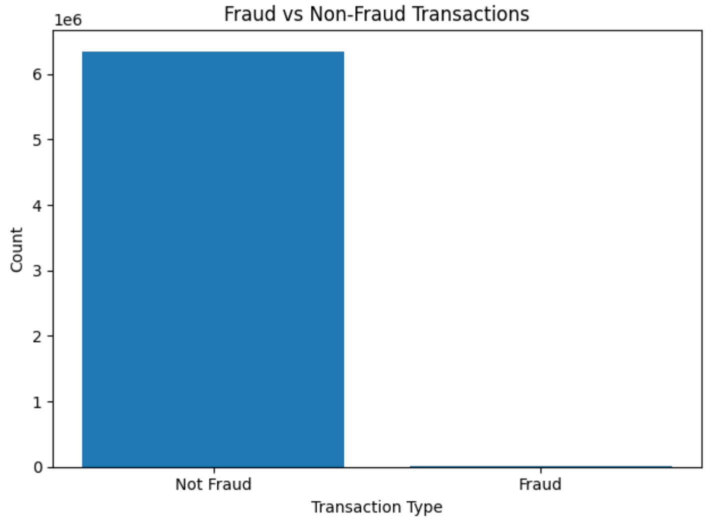
- Dataset is highly imbalanced
- Fraud mainly occurs in CASH_OUT and TRANSFER

- Large transaction amounts have higher fraud probability

```
import pandas as pd
import pickle
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier

# Load dataset
df = pd.read_csv("data/PS_20174392719_1491204439457_log.csv")

# Drop unnecessary ID columns
df = df.drop(['nameOrig', 'nameDest'], axis=1)

# Encode categorical column
df = pd.get_dummies(df, columns=['type'], drop_first=True)

# Separate features and target
X = df.drop('isFraud', axis=1)
y = df['isFraud']
```






# Milestone 3: Data Pre-processing

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### Activity 1: Handling Missing Values

- Checked using df.isnull()
- No significant null values

### Activity 2: Handling Categorical Values

- Applied One-Hot Encoding to type column

### Activity 3: Handling Imbalanced Dataset

- Observed severe class imbalance
- Adjusted prediction threshold in deployment

### Activity 4: Splitting Dataset

Used:

80%Training
20% Testing

```
print("Initial shape:", df.shape)

# Drop ID columns (not useful for ML)
df = df.drop(['nameOrig', 'nameDest'], axis=1)

print("Shape after dropping ID columns:", df.shape)

# One-hot encode the 'type' column
df = pd.get_dummies(df, columns=['type'], drop_first=True)

print("Shape after encoding 'type':", df.shape)
# Separate features and target
# X = features
# y = target (isFraud)
# Separate features and target
X = df.drop('isFraud', axis=1)
y = df['isFraud']

print("X shape:", X.shape)
print("y shape:", y.shape)
```

# Milestone 4: Model Building

We trained and compared:

1. Decision Tree
2. Random Forest
3. Support Vector Machine (SVM)
4. XGBoost

**Activity 1: Decision Tree**

- Trained using DecisionTreeClassifier
- Good fraud recall
- Fast execution

**Activity 2: Random Forest**

- Ensemble model
- Compared accuracy

**Activity 3: SVM**

- Tested for classification performance

**Activity 4: XGBoost**

- Boosting model
- High accuracy

**Model Comparison**

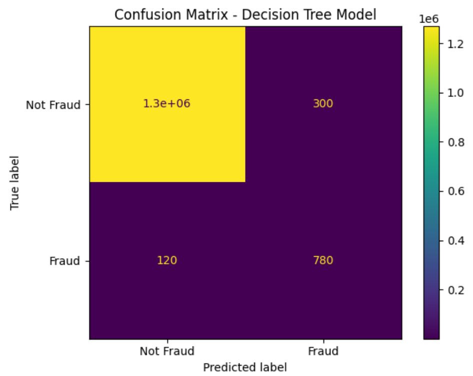
Models were compared using:

- Accuracy
- Confusion Matrix
- Classification Report

Final Selected Model: **Decision Tree Classifier**

Reason:

- Better fraud recall
- Fast prediction



- Suitable for real-time system

```python
# 🔥 UPDATED DECISION TREE (BALANCED)
dt_model = DecisionTreeClassifier(
    random_state=42,
    class_weight='balanced',
    max_depth=8
)

dt_model.fit(X_train, y_train)

# Predictions
y_pred_dt = dt_model.predict(X_test)

# Evaluation
```

# Milestone 5: Application Building

### Activity 1: HTML Pages

Created:

- home.html
- predict.html
- submit.html

### Activity 2: Flask Backend

- Loaded saved model
- Created routes:
    - /
    - /predict
    - /result
- Integrated model with UI

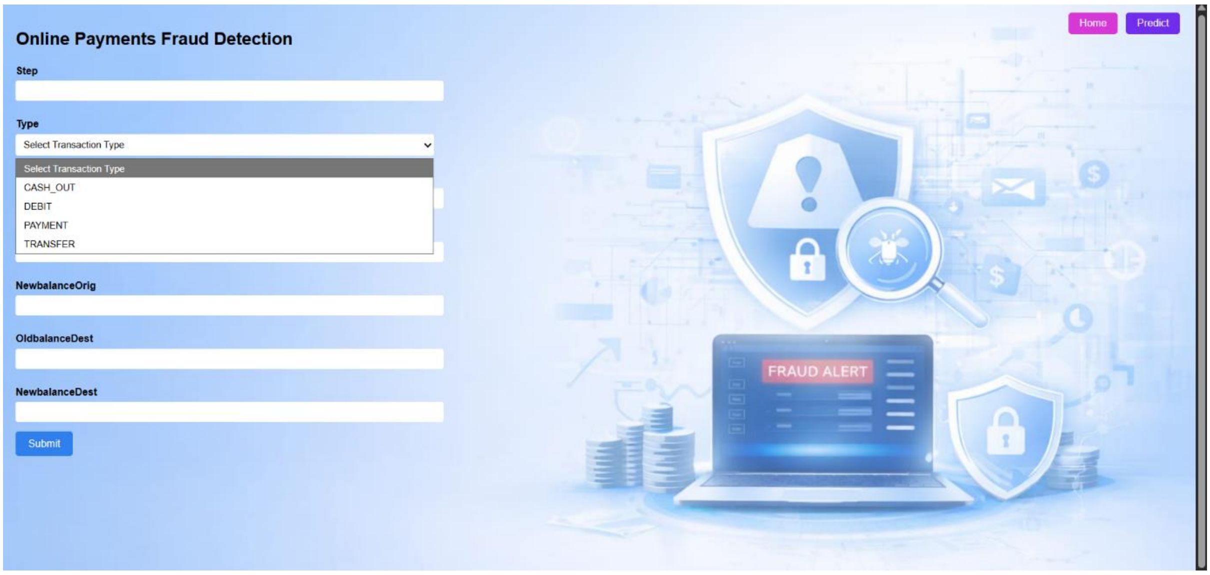
### Activity 3: Run Application

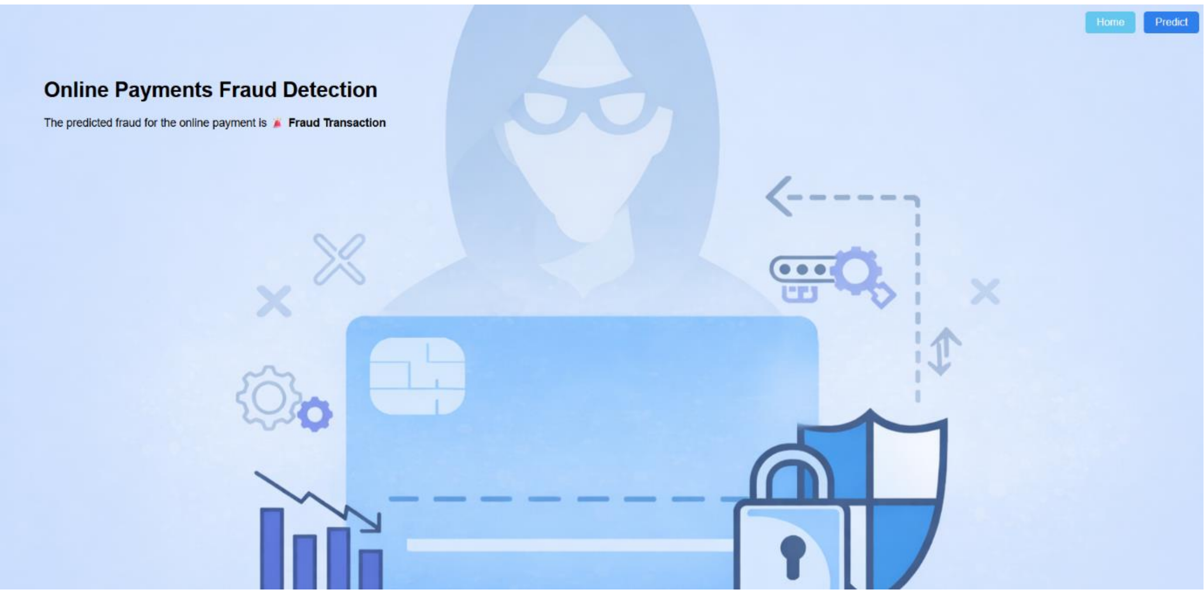
python flask/app.py

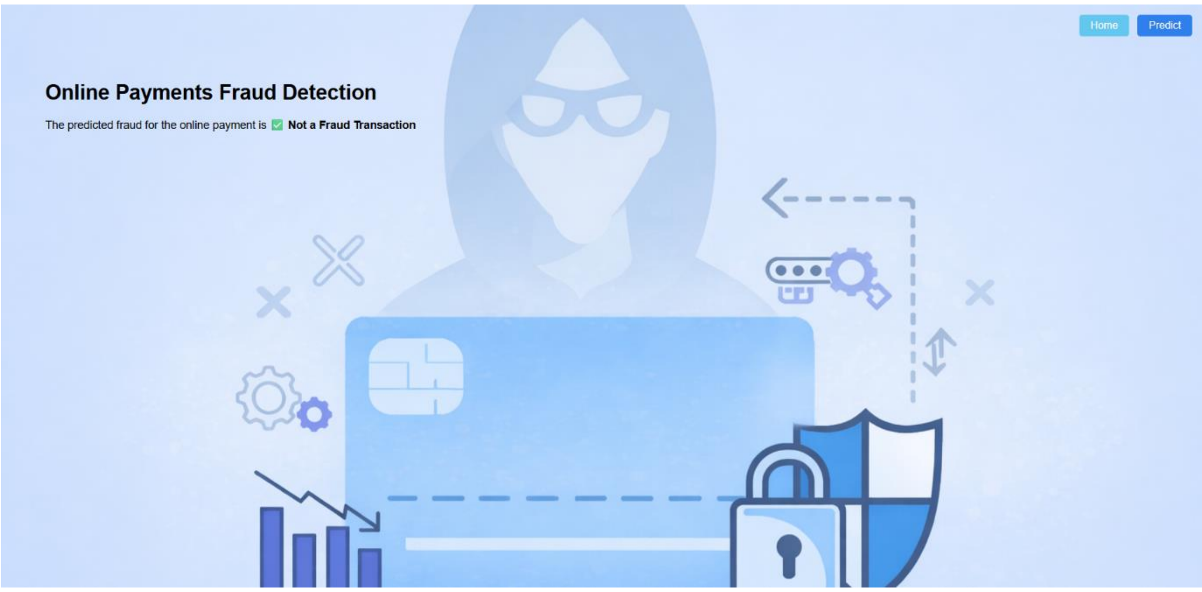
**Application runs on:**

[http://127.0.0.1:5000](http://127.0.0.1:5000)


Home
Predict
Online Payments
Fraud Detection


Home
Predict
Online Payments Fraud Detection
Step
Type
Select Transaction Type
Select Transaction Type
CASH_OUT
DEBIT
PAYMENT
TRANSFER
NewbalanceOrig
OldbalanceDest
NewbalanceDest
Submit
FRAUD ALERT


Home
Predict
Online Payments Fraud Detection
The predicted fraud for the online payment is Fraud Transaction


Home
Predict
Online Payments Fraud Detection
The predicted fraud for the online payment is ✅ Not a Fraud Transaction