```
exit()
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

```
try:
  from google.colab import drive
  drive.mount('/content/gdrive/', force_remount=True)
  %cd '/content/gdrive/MyDrive/TEMPORATION/Tiểu luận/data'
except ImportError as e:
  print('Cannot mount to your folder')
```

```
Mounted at /content/gdrive/
/content/gdrive/MyDrive/TEMPORATION/Tiểu luận/data
```

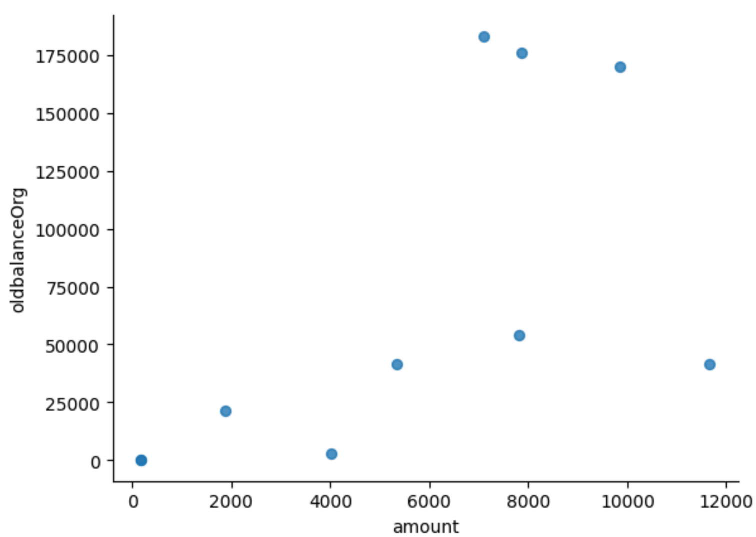
```
df = pd.read_csv('PS_log.csv')
df.head(10)
```

	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlaggedFraud
0	1	PAYMENT	9839.64	C1231006815	170136.00	160296.36	M1979787155	0.0	0.00	0	0
1	1	PAYMENT	1864.28	C1666544295	21249.00	19384.72	M2044282225	0.0	0.00	0	0
2	1	TRANSFER	181.00	C1305486145	181.00	0.00	C553264065	0.0	0.00	1	0
3	1	CASH_OUT	181.00	C840083671	181.00	0.00	C38997010	21182.0	0.00	1	0
4	1	PAYMENT	11668.14	C2048537720	41554.00	29885.86	M1230701703	0.0	0.00	0	0
5	1	PAYMENT	7817.71	C90045638	53860.00	46042.29	M573487274	0.0	0.00	0	0
6	1	PAYMENT	7107.77	C154988899	183195.00	176087.23	M408069119	0.0	0.00	0	0
7	1	PAYMENT	7861.64	C1912850431	176087.23	168225.59	M633326333	0.0	0.00	0	0
8	1	PAYMENT	4024.36	C1265012928	2671.00	0.00	M1176932104	0.0	0.00	0	0
9	1	DEBIT	5337.77	C712410124	41720.00	36382.23	C195600860	41898.0	40348.79	0	0

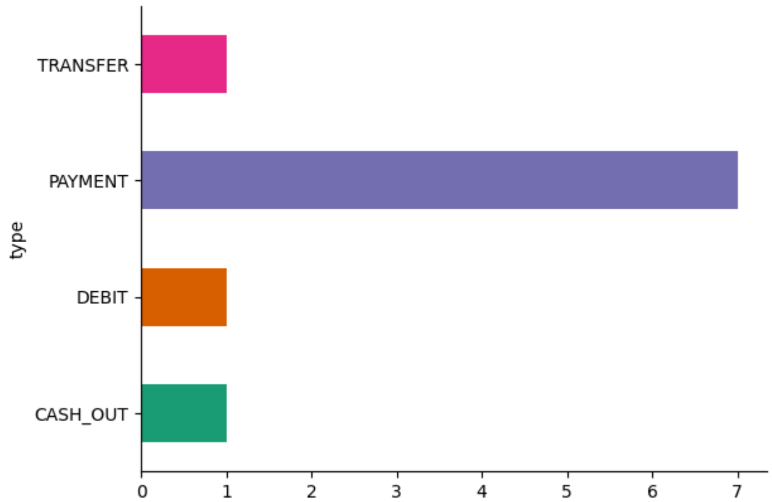
```
print('Step - from {} to {}'.format(df.step.min(), df.step.max()))
```

```
Step - from 1 to 743
```

```
from matplotlib import pyplot as plt
_df_5.plot(kind='scatter', x='amount', y='oldbalanceOrg', s=32, alpha=.8)
plt.gca().spines[['top', 'right',]].set_visible(False)
```




```
from matplotlib import pyplot as plt
import seaborn as sns
_df_4.groupby('type').size().plot(kind='barh', color=sns.palettes.mpl_palette('Dark2'))
plt.gca().spines[['top', 'right',]].set_visible(False)
```




```
from matplotlib import pyplot as plt
_df_0['amount'].plot(kind='hist', bins=20, title='amount')
plt.gca().spines[['top', 'right',]].set_visible(False)
```

```
df.duplicated().sum()
```

```
0
```

```
df.isnull().sum()
```

	0
step	0
type	0
amount	0
nameOrig	0
oldbalanceOrg	0
newbalanceOrig	0
nameDest	0
oldbalanceDest	0
newbalanceDest	0
isFraud	0
isFlaggedFraud	0

dtype: int64

```
df['type'].unique()
```

```
array(['PAYMENT', 'TRANSFER', 'CASH_OUT', 'DEBIT', 'CASH_IN'],
      dtype=object)
```

```
df['isFlaggedFraud'].unique()
```

```
array([0, 1])
```

```
df['isFraud'].unique()
```

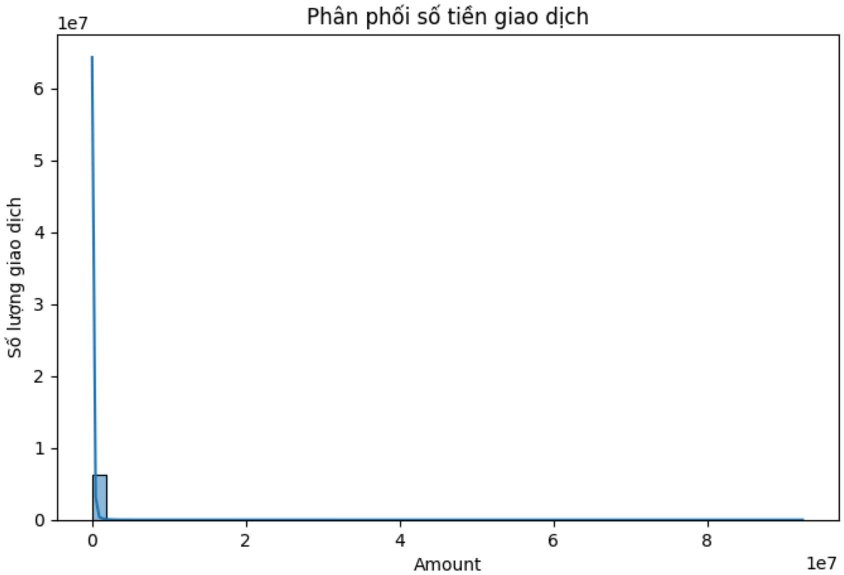
```
array([0, 1])
```

```
df['nameOrig'].unique()
```

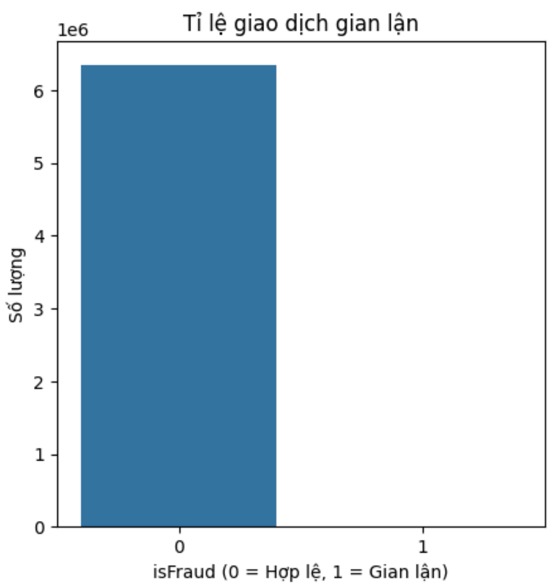
```
array(['C1231006815', 'C1666544295', 'C1305486145', ..., 'C1162922333',
       'C1685995037', 'C1280323807'], dtype=object)
```

```
# 1. Histogram - Phân phối số tiền giao dịch
plt.figure(figsize=(8, 5))
sns.histplot(df['amount'], bins=50, kde=True)
```

```
plt.title("Phân phối số tiền giao dịch")
plt.xlabel("Amount")
plt.ylabel("Số lượng giao dịch")
plt.show()
```

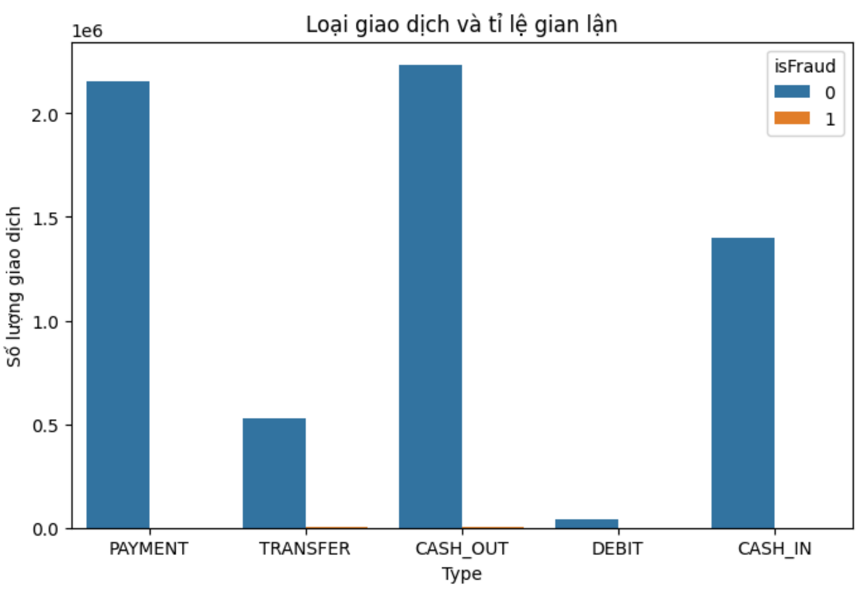



```
# 2. Bar Plot - Tỉ lệ giao dịch gian lận
plt.figure(figsize=(5, 5))
sns.countplot(data=df, x='isFraud')
plt.title("Tỉ lệ giao dịch gian lận")
plt.xlabel("isFraud (0 = Hợp lệ, 1 = Gian lận)")
plt.ylabel("Số lượng")
plt.show()
```

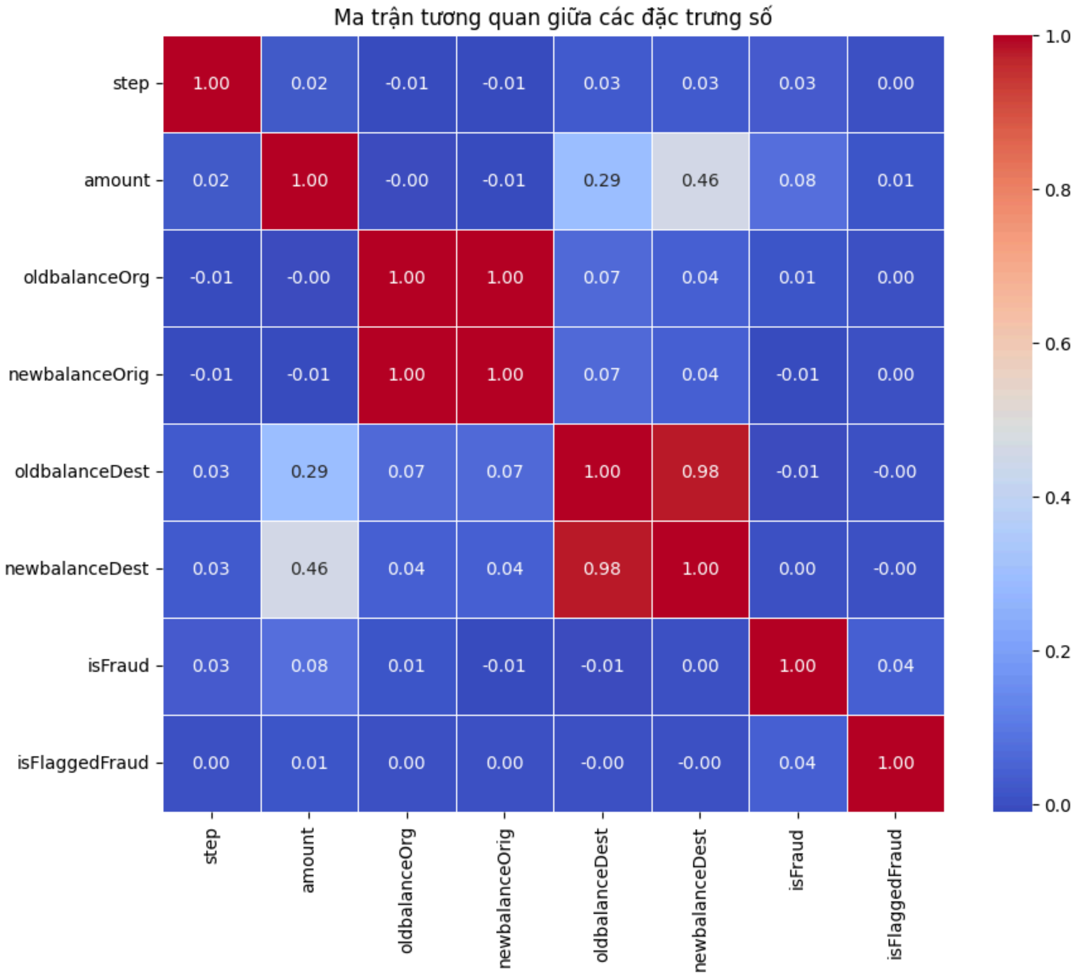



```
# 3. Scatter Plot - So sánh số dư trước và sau giao dịch
plt.figure(figsize=(8, 6))
sns.scatterplot(x='oldbalanceOrg', y='newbalanceOrig', hue='isFraud', data=df, alpha=0.6)
plt.title("Số dư trước và sau giao dịch (Gốc)")
plt.xlabel("oldbalanceOrg")
plt.ylabel("newbalanceOrig")
plt.legend(title="isFraud")
plt.show()
```


```
# 4. Bar Plot - Loại giao dịch và gian lận
plt.figure(figsize=(8, 5))
sns.countplot(data=df, x='type', hue='isFraud')
plt.title("Loại giao dịch và tỉ lệ gian lận")
plt.xlabel("Type")
plt.ylabel("Số lượng giao dịch")
plt.legend(title="isFraud")
plt.show()
```




```
# 5. Heatmap - Ma trận tương quan
import seaborn as sns
import matplotlib.pyplot as plt
plt.figure(figsize=(10, 8))
# Select only numerical features for correlation calculation
numerical_df = df.select_dtypes(include=['number'])
correlation_matrix = numerical_df.corr()
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt=".2f", linewidths=0.5)
plt.title("Ma trận tương quan giữa các đặc trưng số")
plt.show()
```



ISFRAUD

```
fraud_counts=df['isFraud'].value_counts()
print(fraud_counts)
```

```
isFraud
0    6354407
1       8213
Name: count, dtype: int64
```

ISFlaggedFRAUD

```
flag_fraud_counts=df['isFlaggedFraud'].value_counts()
print(flag_fraud_counts)
```

```
isFlaggedFraud
0    6362604
1         16
Name: count, dtype: int64
```

Double-click (or enter) to edit

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6362620 entries, 0 to 6362619
Data columns (total 11 columns):
 #   Column          Dtype
---  ------          -----
 0   step            int64
 1   type            object
 2   amount          float64
 3   nameOrig        object
```

```
 4   oldbalanceOrg   float64
 5   newbalanceOrig  float64
 6   nameDest        object
 7   oldbalanceDest  float64
 8   newbalanceDest  float64
 9   isFraud         int64
 10  isFlaggedFraud  int64
dtypes: float64(5), int64(3), object(3)
memory usage: 534.0+ MB
```

Number of transactions which were considered to be fraudulent

```
df_flagged = df.loc[df.isFlaggedFraud == 1]
print('Sum of isFlaggedFraud = 1: ', len(df_flagged))
df_flagged
```

```
Sum of isFlaggedFraud = 1:  16
```

	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlagg
2736446	212	TRANSFER	4953893.08	C728984460	4953893.08	4953893.08	C639921569	0.0	0.0	1	
3247297	250	TRANSFER	1343002.08	C1100582606	1343002.08	1343002.08	C1147517658	0.0	0.0	1	
3760288	279	TRANSFER	536624.41	C1035541766	536624.41	536624.41	C1100697970	0.0	0.0	1	
5563713	387	TRANSFER	4892193.09	C908544136	4892193.09	4892193.09	C891140444	0.0	0.0	1	
5996407	425	TRANSFER	10000000.00	C689608084	19585040.37	19585040.37	C1392803603	0.0	0.0	1	
5996409	425	TRANSFER	9585040.37	C452586515	19585040.37	19585040.37	C1109166882	0.0	0.0	1	
6168499	554	TRANSFER	3576297.10	C193696150	3576297.10	3576297.10	C484597480	0.0	0.0	1	
6205439	586	TRANSFER	353874.22	C1684585475	353874.22	353874.22	C1770418982	0.0	0.0	1	
6266413	617	TRANSFER	2542664.27	C786455622	2542664.27	2542664.27	C661958277	0.0	0.0	1	
6281482	646	TRANSFER	10000000.00	C19004745	10399045.08	10399045.08	C1806199534	0.0	0.0	1	
6281484	646	TRANSFER	399045.08	C724693370	10399045.08	10399045.08	C1909486199	0.0	0.0	1	
6296014	671	TRANSFER	3441041.46	C917414431	3441041.46	3441041.46	C1082139865	0.0	0.0	1	
6351225	702	TRANSFER	3171085.59	C1892216157	3171085.59	3171085.59	C1308068787	0.0	0.0	1	
6362460	730	TRANSFER	10000000.00	C2140038573	17316255.05	17316255.05	C1395467927	0.0	0.0	1	
6362462	730	TRANSFER	7316255.05	C1869569059	17316255.05	17316255.05	C1861208726	0.0	0.0	1	
6362584	741	TRANSFER	5674547.89	C992223106	5674547.89	5674547.89	C1366804249	0.0	0.0	1	

Show the total of transactions that were considered to be fraudulent and the previous and new balance is 0

```
df_total_transfer = df.loc[(df.type == 'TRANSFER')]
df_total_transactions = df_total_transfer.loc[(df_total_transfer.oldbalanceDest == 0) & (df_total_transfer.newbalanceDest == 0)]
print('Sum of transactions that were considered to be fraudulent and the previous and new balance is 0: ', len(df_total_transactions))
df_total_transactions
```

```
Sum of transactions that were considered to be fraudulent and the previous and new balance is 0:  4174
```

	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlagge
2	1	TRANSFER	181.00	C1305486145	181.00	0.0	C553264065	0.0	0.0	1	
251	1	TRANSFER	2806.00	C1420196421	2806.00	0.0	C972765878	0.0	0.0	1	
680	1	TRANSFER	20128.00	C137533655	20128.00	0.0	C1848415041	0.0	0.0	1	
969	1	TRANSFER	1277212.77	C1334405552	1277212.77	0.0	C431687661	0.0	0.0	1	
1115	1	TRANSFER	35063.63	C1364127192	35063.63	0.0	C1136419747	0.0	0.0	1	
...	...	...	...	...	...	...	...	...	...	...	
6362610	742	TRANSFER	63416.99	C778071008	63416.99	0.0	C1812552860	0.0	0.0	1	
6362612	743	TRANSFER	1258818.82	C1531301470	1258818.82	0.0	C1470998563	0.0	0.0	1	
6362614	743	TRANSFER	339682.13	C2013999242	339682.13	0.0	C1850423904	0.0	0.0	1	
6362616	743	TRANSFER	6311409.28	C1529008245	6311409.28	0.0	C1881841831	0.0	0.0	1	
6362618	743	TRANSFER	850002.52	C1685995037	850002.52	0.0	C2080388513	0.0	0.0	1	

4174 rows × 11 columns

Further investigation whether isFlaggedFraud is a useful column in the dataset

```
print(df_flagged.amount.min())
print(df_total_transfer.loc[df_total_transfer.isFlaggedFraud == 0].amount.max())

transfers = df_total_transfer.loc[df_total_transfer.amount > 200000]

transfers.loc[transfers.isFlaggedFraud == 0]
```

```
353874.22
92445516.64
```

	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlagge
19	1	TRANSFER	215310.30	C1670993182	705.00	0.0	C1100439041	22425.00	0.00	0	
24	1	TRANSFER	311685.89	C1984094095	10835.00	0.0	C932583850	6267.00	2719172.89	0	
82	1	TRANSFER	224606.64	C873175411	0.00	0.0	C766572210	354678.92	0.00	0	
84	1	TRANSFER	379856.23	C1449772539	0.00	0.0	C1590550415	900180.00	19169204.93	0	
85	1	TRANSFER	1505626.01	C926859124	0.00	0.0	C665576141	29031.00	5515763.34	0	
...	...	...	...	...	...	...	...	...	...	...	
6362608	742	TRANSFER	258355.42	C1226129332	258355.42	0.0	C1744173808	0.00	0.00	1	
6362612	743	TRANSFER	1258818.82	C1531301470	1258818.82	0.0	C1470998563	0.00	0.00	1	
6362614	743	TRANSFER	339682.13	C2013999242	339682.13	0.0	C1850423904	0.00	0.00	1	
6362616	743	TRANSFER	6311409.28	C1529008245	6311409.28	0.0	C1881841831	0.00	0.00	1	
6362618	743	TRANSFER	850002.52	C1685995037	850002.52	0.0	C2080388513	0.00	0.00	1	

409094 rows × 11 columns

Get the minimum and maximum amount of where fraud is flagged and not flagged

```
round(df_flagged.oldbalanceOrg.min())
print('Min, Max of oldBalanceOrg for isFlaggedFraud = 1 TRANSFERs: {}, {}'.format(round(df_flagged.oldbalanceOrg.min()), round(df_flagged.oldbalance
print('Min, Max of oldBalanceOrg for isFlaggedFraud = 0 TRANSFERs where oldBalanceOrg = newBalanceOrig: {}'.format([round(df_total_transfer.loc[(df_
```

```
Min, Max of oldBalanceOrg for isFlaggedFraud = 1 TRANSFERs: 353874, 19585040
Min, Max of oldBalanceOrg for isFlaggedFraud = 0 TRANSFERs where oldBalanceOrg = newBalanceOrig: [0, 575668]
```

Check if duplicate customers exist based on the isFlaggedFraud status

```
df_flagged = df.loc[df.isFlaggedFraud == 1]
df_not_flagged = df.loc[df.isFlaggedFraud == 0]
```

```
print('In the transaction\'s nameOrig flagged as fraud more than once? {}\n'.format(df_flagged.nameOrig.isin(pd.concat([df_not_flagged.nameOrig, df_

print('Have destinations for transactions flagged as fraud initiated other transactions: {}\n'.format((df_flagged.nameDest.isin(df_not_flagged.nameO

print('How many destination accounts of transactions flagged as fraud have been destination accounts more than once? {}\n'.format(sum(df_flagged.nam
```

```
In the transaction's nameOrig flagged as fraud more than once? False

Have destinations for transactions flagged as fraud initiated other transactions: False

How many destination accounts of transactions flagged as fraud have been destination accounts more than once? 2
```

Check if merchants are involved in different types of transactions

Merchants ('M') are not involved in CASH_IN (paid by the merchant) transactions to customers ('C'). There are also no merchants among destination accounts for CASH_OUT transactions (paying a merchant). However, merchants exist for all PAYMENTs transactions in nameDest.

```
print('Are there any merchants in nameOrif for CASH_IN transactions? {}\n'.format(df.loc[df.type == 'CASH_IN'].nameOrig.str.contains('M').any()))

print('Are there any merchants in nameDest for CASH_OUT transactions? {}\n'.format(df.loc[df.type == 'CASH_OUT'].nameDest.str.contains('M').any()))

print('Are there any transactions do not have merchants in nameDest in the PAYMENT type? {}\n'.format((df.loc[df.nameDest.str.contains('M')].type !=
```

```
Are there any merchants in nameOrif for CASH_IN transactions? False

Are there any merchants in nameDest for CASH_OUT transactions? False

Are there any transactions do not have merchants in nameDest in the PAYMENT type? False
```

Check for transactions where the destination for Transfer transactions matches for CASH OUT

```
df_fraud_transfer = df.loc[(df.isFlaggedFraud == 1) & (df.type == 'TRANSFER')]
df_fraud_cash_out = df.loc[(df.type == 'CASH_OUT')]
print('Are there any transactiosn where nameDest for TRANSFER and nameOrig for CASH OUT match? {}\n'.format((df_fraud_transfer.nameDest.isin(df_frau

df.loc[df.isFraud == 1]
```

```
Are there any transactiosn where nameDest for TRANSFER and nameOrig for CASH OUT match? False
```

	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlagge
2	1	TRANSFER	181.00	C1305486145	181.00	0.0	C553264065	0.00	0.00	1	
3	1	CASH_OUT	181.00	C840083671	181.00	0.0	C38997010	21182.00	0.00	1	
251	1	TRANSFER	2806.00	C1420196421	2806.00	0.0	C972765878	0.00	0.00	1	
252	1	CASH_OUT	2806.00	C2101527076	2806.00	0.0	C1007251739	26202.00	0.00	1	
680	1	TRANSFER	20128.00	C137533655	20128.00	0.0	C1848415041	0.00	0.00	1	
...	...	...	...	...	...	...	...	...	...	...	
6362615	743	CASH_OUT	339682.13	C786484425	339682.13	0.0	C776919290	0.00	339682.13	1	
6362616	743	TRANSFER	6311409.28	C1529008245	6311409.28	0.0	C1881841831	0.00	0.00	1	
6362617	743	CASH_OUT	6311409.28	C1162922333	6311409.28	0.0	C1365125890	68488.84	6379898.11	1	
6362618	743	TRANSFER	850002.52	C1685995037	850002.52	0.0	C2080388513	0.00	0.00	1	
6362619	743	CASH_OUT	850002.52	C1280323807	850002.52	0.0	C873221189	6510099.11	7360101.63	1	

8213 rows × 11 columns

Get fraudulent transactions that have a genuine CASH OUT status

```
df_genuine_cash_out = df.loc[(df.isFraud == 0) & (df.type == 'CASH_OUT')]
df_fraudulent_transfer = df.loc[(df.isFraud == 1) & (df.type == 'TRANSFER')]

print('Fraudulent TRANSFERs where the destination accounts initially had genuine CASH OUTs.\n\n')
```

```
df_fraud_transfer.loc[df_fraud_transfer.nameDest.isin(df_genuine_cash_out.nameDest.drop_duplicates())]
```

```
Fraudulent TRANSFERs where the destination accounts initially had genuine CASH OUTs.
```

	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlagge
2736446	212	TRANSFER	4953893.08	C728984460	4953893.08	4953893.08	C639921569	0.0	0.0	1	
3247297	250	TRANSFER	1343002.08	C1100582606	1343002.08	1343002.08	C1147517658	0.0	0.0	1	

DATA ENCODING

In order to apply different machine learning algorithms to the data, the fields need to be numbers. TRANSFERs are denoted by 0 and CASH_OUTs by 1.

```
df = pd.read_csv('PS_log.csv')
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6362620 entries, 0 to 6362619
Data columns (total 11 columns):
 #   Column          Dtype  
---  ------          -----  
 0   step            int64  
 1   type            object 
 2   amount          float64
 3   nameOrig        object 
 4   oldbalanceOrg   float64
 5   newbalanceOrig  float64
 6   nameDest        object 
 7   oldbalanceDest  float64
 8   newbalanceDest  float64
 9   isFraud         int64  
 10  isFlaggedFraud  int64  
dtypes: float64(5), int64(3), object(3)
memory usage: 534.0+ MB
```

```
from sklearn.preprocessing import LabelEncoder
le_orig = LabelEncoder()
le_dest = LabelEncoder()

df['nameOrig'] = le_orig.fit_transform(df['nameOrig'])
df['nameDest'] = le_dest.fit_transform(df['nameDest'])
```

```
df['balanceChangeOrig'] = df['oldbalanceOrg'] - df['newbalanceOrig']
df['balanceChangeDest'] = df['newbalanceDest'] - df['oldbalanceDest']
```

```
df.drop(['oldbalanceOrg', 'newbalanceOrig', 'oldbalanceDest', 'newbalanceDest'], axis=1, inplace=True)
```

```
le_type = LabelEncoder()
df['type'] = le_type.fit_transform(df['type'])
```

```
X = df.drop(['isFraud'], axis=1)
y = df['isFraud']
```

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X_scaled, y, test_size=0.2, random_state=42, stratify=y)
```

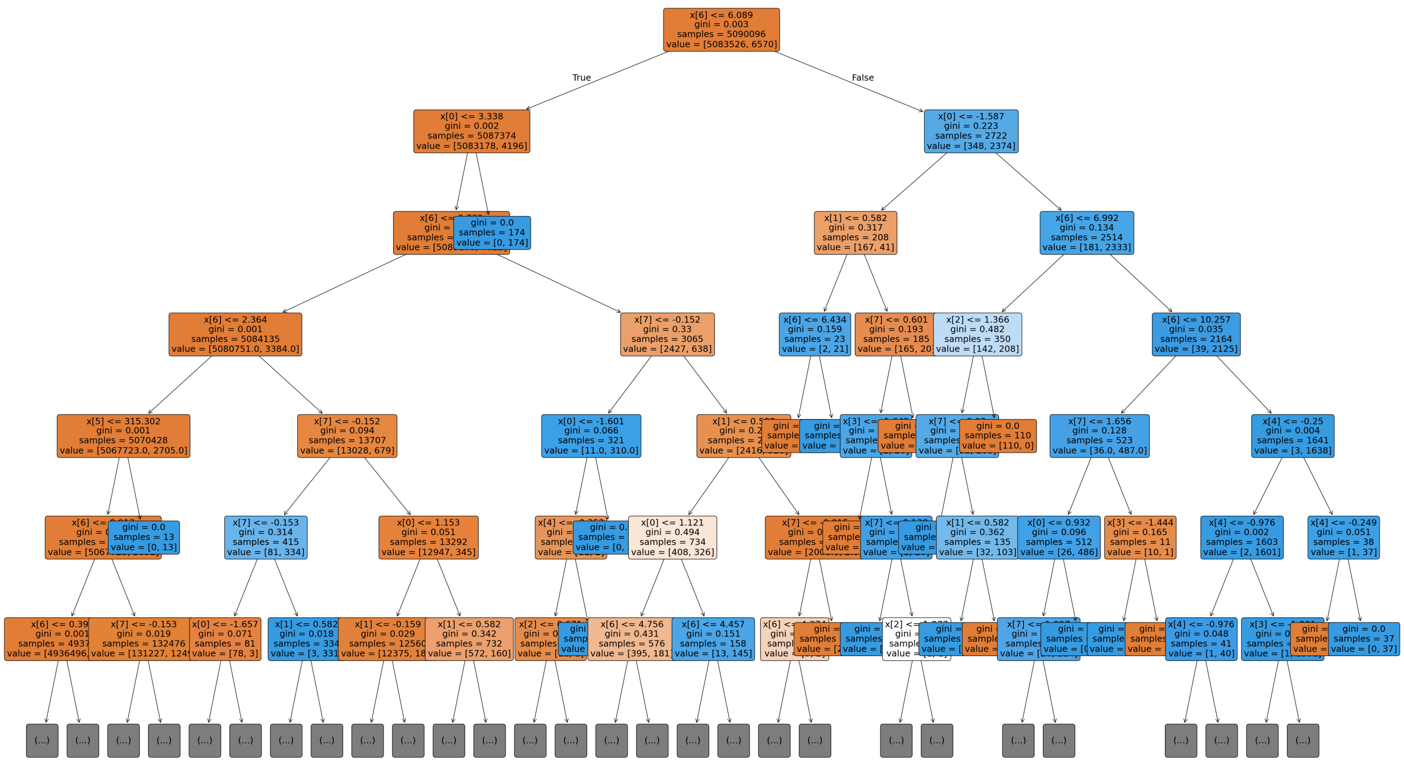
Decision Tree

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report, confusion_matrix, roc_curve, auc
```

```
from sklearn import tree
import time


start_time = time.time()

dt_model = DecisionTreeClassifier(random_state=42)
dt_model.fit(X_train, y_train)
y_pred_dt = dt_model.predict(X_test)

end_time = time.time()


training_time = end_time - start_time
print(f"Thời gian chạy Decision Tree: {training_time:.4f} giây")
```

Thời gian chạy Decision Tree: 85.3670 giây

```
#plot tree
plt.figure(figsize=(50,30))
tree.plot_tree(dt_model, filled=True, rounded=True, fontsize= 18, max_depth=6)
plt.show()
```

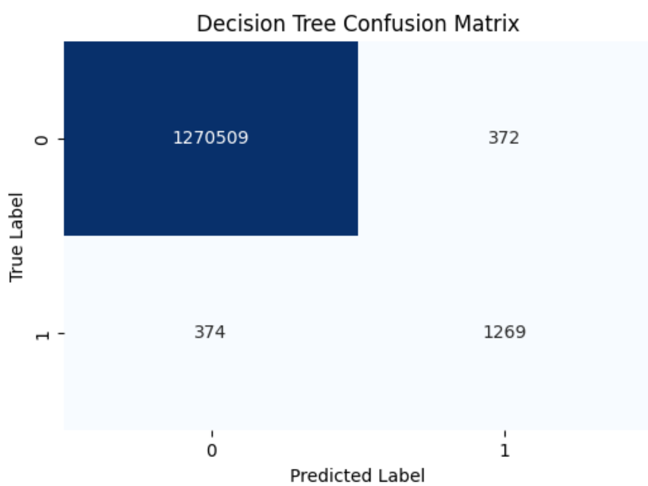



```
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score

accuracy_dt = accuracy_score(y_test, y_pred_dt)
precision_dt = precision_score(y_test, y_pred_dt)
recall_dt = recall_score(y_test, y_pred_dt)
f1_dt = f1_score(y_test, y_pred_dt)
```

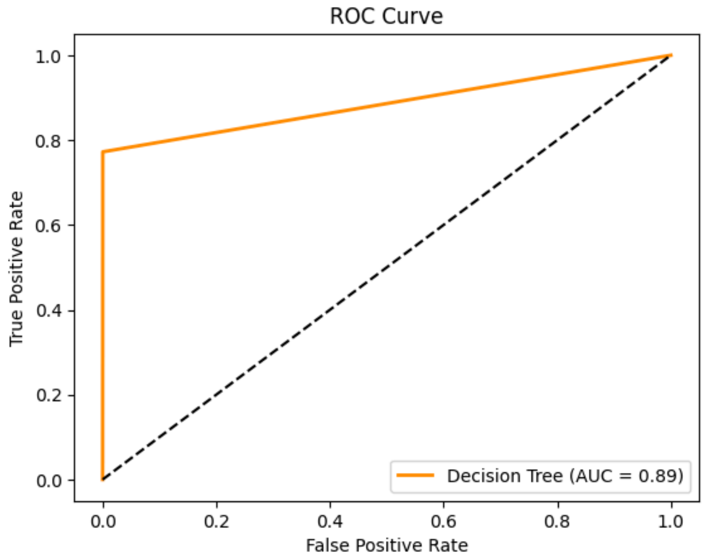
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Decision Tree"]
table.add_row(["Accuracy", accuracy_dt])
table.add_row(["Precision", precision_dt])
table.add_row(["Recall", recall_dt])
table.add_row(["F1 Score", f1_dt])

print(table)
```

```
+-----------+--------------------+
|   Metric  |   Decision Tree    |
+-----------+--------------------+
|  Accuracy | 0.9994137635125153 |
| Precision | 0.773308957952468  |
|   Recall  | 0.7723676202069385 |
|  F1 Score | 0.7728380024360536 |
+-----------+--------------------+
```

```
import matplotlib.pyplot as plt
import seaborn as sns

# Function to plot a confusion matrix
def plot_confusion_matrix(y_true, y_pred, title):
    cm = confusion_matrix(y_true, y_pred)
    plt.figure(figsize=(6,4))
    sns.heatmap(cm, annot=True, fmt="d", cmap="Blues", cbar=False)
    plt.title(title)
    plt.xlabel("Predicted Label")
    plt.ylabel("True Label")
    plt.show()

# Decision Tree Confusion Matrix
plot_confusion_matrix(y_test, y_pred_dt, "Decision Tree Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_dt_prob = dt_model.predict_proba(X_test)
fpr_dt, tpr_dt, _ = roc_curve(y_test, y_pred_dt_prob[:, 1])
roc_auc_dt = auc(fpr_dt, tpr_dt)

plt.figure()
plt.plot(fpr_dt, tpr_dt, color='darkorange', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



Random Forest

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time

start_time = time.time()
rf_model = RandomForestClassifier(random_state=42)
rf_model.fit(X_train, y_train)
y_pred_rf = rf_model.predict(X_test)
end_time = time.time()
```

```
training_time = end_time - start_time
print(f"Thời gian chạy Random Forest: {training_time:.4f} giây")
```

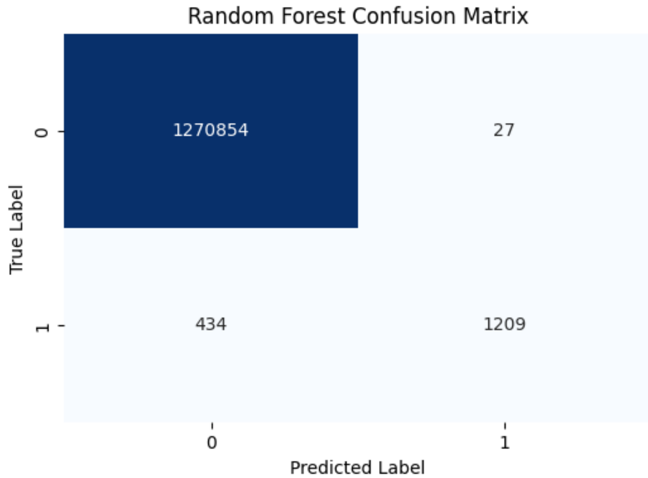
```
Thời gian chạy Random Forest: 1575.8560 giây
```

```
accuracy_rf = accuracy_score(y_test, y_pred_rf)
precision_rf = precision_score(y_test, y_pred_rf)
recall_rf = recall_score(y_test, y_pred_rf)
f1_rf = f1_score(y_test, y_pred_rf)
```

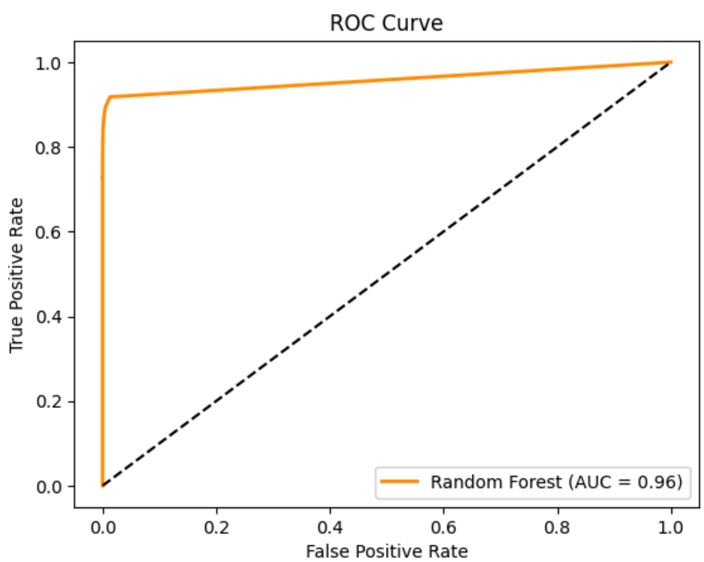
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Random Forest"]
table.add_row(["Accuracy", accuracy_rf])
table.add_row(["Precision", precision_rf])
table.add_row(["Recall", recall_rf])
table.add_row(["F1 Score", f1_rf])

print(table)
```

```
+-----------+--------------------+
|   Metric  |   Random Forest    |
+-----------+--------------------+
|  Accuracy | 0.9996377278542488 |
| Precision | 0.9781553398058253 |
|   Recall  | 0.7358490566037735 |
|  F1 Score | 0.8398749565821466 |
+-----------+--------------------+
```

```
plot_confusion_matrix(y_test, y_pred_rf, "Random Forest Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_rf_prob = rf_model.predict_proba(X_test)
fpr_rf, tpr_rf, _ = roc_curve(y_test, y_pred_rf_prob[:, 1])
roc_auc_rf = auc(fpr_rf, tpr_rf)

plt.figure()
plt.plot(fpr_rf, tpr_rf, color='darkorange', lw=2, label=f'Random Forest (AUC = {roc_auc_rf:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



Naive Bayes

```
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time

start_time = time.time()
nb_model = GaussianNB()
nb_model.fit(X_train, y_train)
y_pred_nb = nb_model.predict(X_test)
end_time = time.time()


training_time = end_time - start_time
print(f"Thời gian chạy Naive Bayes: {training_time:.4f} giây")
```

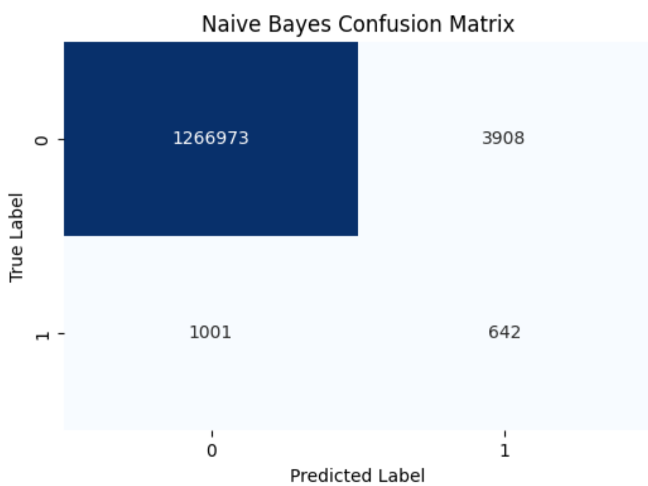
```
Thời gian chạy Naive Bayes: 1.9841 giây
```

```
accuracy_nb = accuracy_score(y_test, y_pred_nb)
precision_nb = precision_score(y_test, y_pred_nb)
recall_nb = recall_score(y_test, y_pred_nb)
f1_nb = f1_score(y_test, y_pred_nb)
```

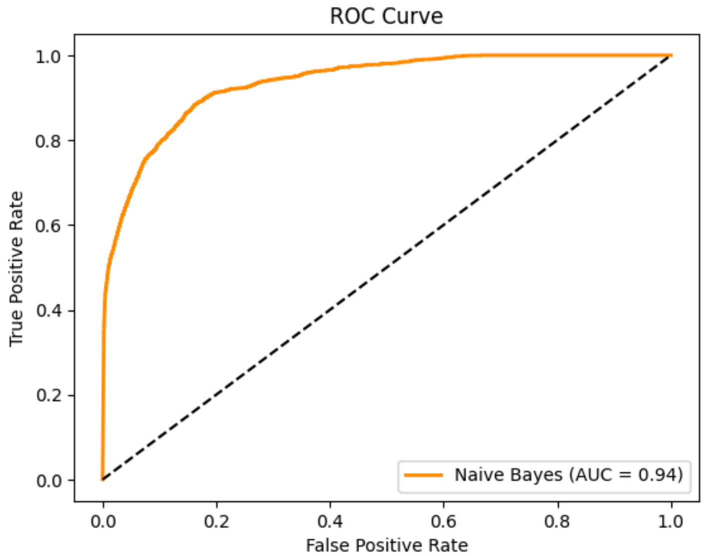
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Naive Bayes"]
table.add_row(["Accuracy", accuracy_nb])
table.add_row(["Precision", precision_nb])
table.add_row(["Recall", recall_nb])
table.add_row(["F1 Score", f1_nb])

print(table)
```

```
+-----------+---------------------+
|   Metric  |     Naive Bayes     |
+-----------+---------------------+
|  Accuracy |  0.996142312443616  |
| Precision |  0.1410989010989011 |
|   Recall  |  0.3907486305538649 |
|  F1 Score | 0.20733085741966736 |
+-----------+---------------------+
```

```
plot_confusion_matrix(y_test, y_pred_nb, "Naive Bayes Confusion Matrix")
```

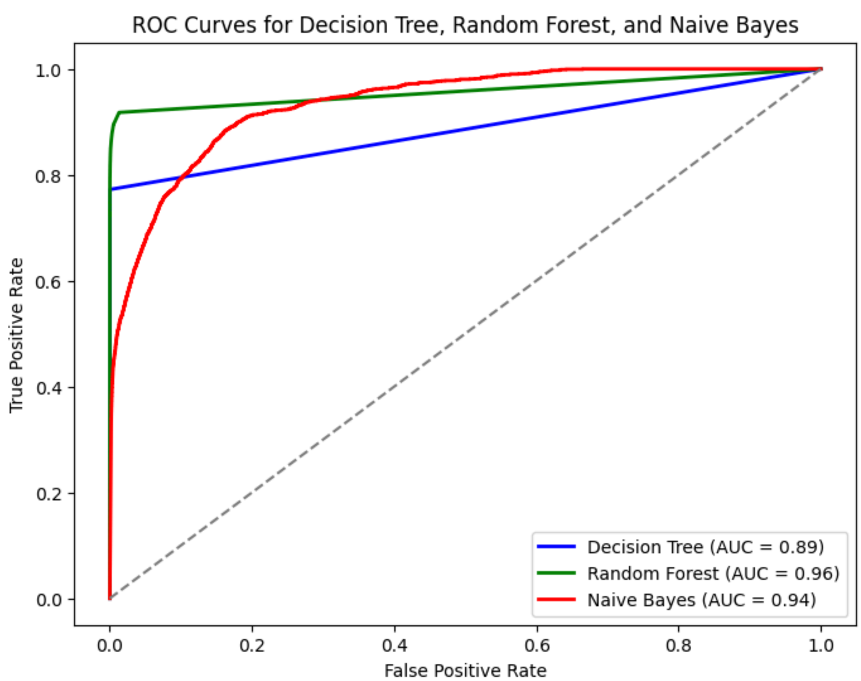



```
from sklearn.metrics import roc_curve, auc

y_pred_nb_prob = nb_model.predict_proba(X_test)
fpr_nb, tpr_nb, _ = roc_curve(y_test, y_pred_nb_prob[:, 1])
roc_auc_nb = auc(fpr_nb, tpr_nb)


plt.figure()
plt.plot(fpr_nb, tpr_nb, color='darkorange', lw=2, label=f'Naive Bayes (AUC = {roc_auc_nb:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



##

```
# Plot ROC curves on the same plot
plt.figure(figsize=(8, 6))  # Adjust figure size if needed
plt.plot(fpr_dt, tpr_dt, color='blue', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt:.2f})')
plt.plot(fpr_rf, tpr_rf, color='green', lw=2, label=f'Random Forest (AUC = {roc_auc_rf:.2f})')
plt.plot(fpr_nb, tpr_nb, color='red', lw=2, label=f'Naive Bayes (AUC = {roc_auc_nb:.2f})')
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')  # Diagonal line for reference
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curves for Decision Tree, Random Forest, and Naive Bayes')
plt.legend(loc='lower right')
plt.show()
```



Feature Importance

```
importances = rf_model.feature_importances_
feature_names = X.columns
feature_importance_df = pd.DataFrame({'Feature': feature_names, 'Importance': importances}).sort_values(by='Importance', ascending=False)
print(feature_importance_df)

# Loại bỏ các cột có Importance thấp (tùy ngưỡng, ví dụ < 0.01)
```

```
selected_features = feature_importance_df[feature_importance_df['Importance'] > 0.01]['Feature']
X = df[selected_features]
```

```
             Feature  Importance
6  balanceChangeOrig    0.352139
7  balanceChangeDest    0.307780
0               step    0.120235
2             amount    0.095995
3           nameOrig    0.043436
4           nameDest    0.042908
1               type    0.036058
5     isFlaggedFraud    0.001448
```

Hyperparameter Tuning

Dùng GridSearchCV hoặc RandomizedSearchCV để tìm siêu tham số tốt nhất cho mô hình.

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
from sklearn.metrics import roc_curve, auc, confusion_matrix, classification_report, roc_auc_score
import matplotlib.pyplot as plt

def evaluate_model(model, X_test, y_test, y_pred):
    print(confusion_matrix(y_test, y_pred))
    print(classification_report(y_test, y_pred))
    print("Accuracy:", accuracy_score(y_test, y_pred))
    # AUC-ROC
    y_pred_proba = model.predict_proba(X_test)[:, 1]
    auc_score = roc_auc_score(y_test, y_pred_proba)
    print("AUC-ROC Score:", auc_score)
    fpr, tpr, thresholds = roc_curve(y_test, y_pred_proba)
    plt.plot(fpr, tpr, label=f"AUC = {auc_score:.2f}")
    plt.xlabel("False Positive Rate")
    plt.ylabel("True Positive Rate")
    plt.title("ROC Curve")
    plt.legend(loc="best")
    plt.show()
```

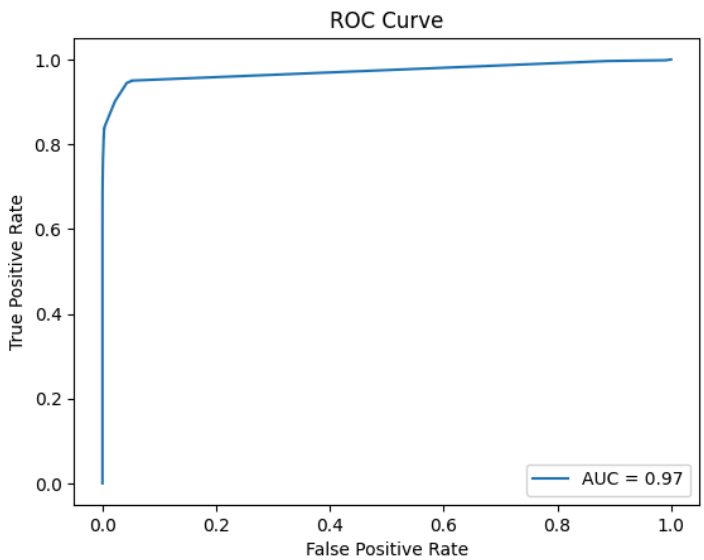
```
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
from sklearn.metrics import roc_curve, auc, confusion_matrix, classification_report, roc_auc_score
import matplotlib.pyplot as plt
import time


# Xác định các giá trị siêu tham số
param_grid = {
    'n_estimators': [50, 100, 200],
    'max_depth': [10, 20, 30, None],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4],
}

# GridSearchCV
grid_search = GridSearchCV(estimator=RandomForestClassifier(random_state=42), param_grid=param_grid, cv=3, scoring='roc_auc', verbose=2, n_jobs=-1)
grid_search.fit(X_train, y_train)

# Tìm siêu tham số tốt nhất
best_rf_model = grid_search.best_estimator_
print("Best Parameters:", grid_search.best_params_)

# Đánh giá mô hình tốt nhất
y_pred_best_rf = best_rf_model.predict(X_test)
print("\nOptimized Random Forest:")
evaluate_model(best_rf_model, X_test, y_test, y_pred_best_rf)
```

```
Fitting 3 folds for each of 108 candidates, totalling 324 fits
```

```
param_grid_dt = {
    'max_depth': [5, 10, 20, None],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4],
}
start_time = time.time()
```

```
grid_search_dt = GridSearchCV(estimator=DecisionTreeClassifier(random_state=42), param_grid=param_grid_dt, cv=3, scoring='roc_auc', verbose=2, n_job
grid_search_dt.fit(X_train, y_train)

# Decision Tree tốt nhất
best_dt_model = grid_search_dt.best_estimator_
print("Best Parameters:", grid_search_dt.best_params_)

y_pred_best_dt = best_dt_model.predict(X_test)
end_time = time.time()

print(f"Thời gian chạy Decision Tree using GridSearchCV: {end_time - start_time:.4f} giây")
print("\nOptimized Decision Tree:")
evaluate_model(best_dt_model, X_test, y_test, y_pred_best_dt)
```

```
Fitting 3 folds for each of 36 candidates, totalling 108 fits
Best Parameters: {'max_depth': 10, 'min_samples_leaf': 4, 'min_samples_split': 2}
Thời gian chạy Decision Tree using GridSearchCV: 1240.1013 giây

Optimized Decision Tree:
[[1270844      37]
              precision    recall  f1-score   support

           0       1.00      1.00      1.00   1270881
           1       0.97      0.63      0.77      1643

    accuracy                           1.00   1272524
   macro avg       0.98      0.82      0.88   1272524
weighted avg       1.00      1.00      1.00   1272524

Accuracy: 0.9994986342104353
AUC-ROC Score: 0.9721285218564073
```




```
accuracy_dt_gs = accuracy_score(y_test, y_pred_best_dt)
precision_dt_gs = precision_score(y_test, y_pred_best_dt)
recall_dt_gs = recall_score(y_test, y_pred_best_dt)
f1_dt_gs = f1_score(y_test, y_pred_best_dt)
```

```
!pip install prettytable
```

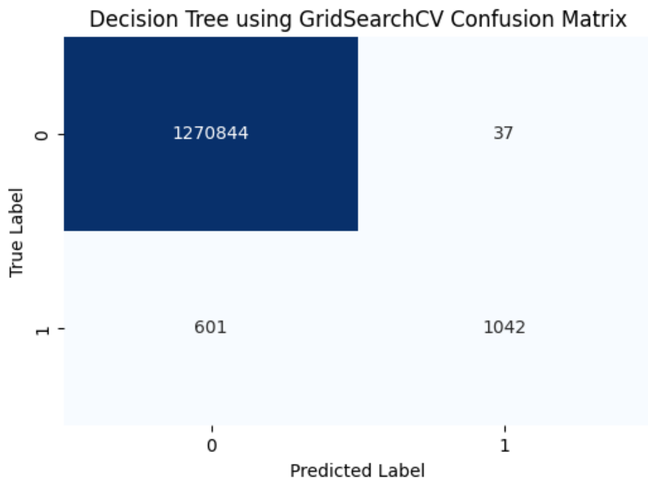
```
Collecting prettytable
  Downloading prettytable-3.12.0-py3-none-any.whl.metadata (30 kB)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.10/dist-packages (from prettytable) (0.2.13)
Downloading prettytable-3.12.0-py3-none-any.whl (31 kB)
Installing collected packages: prettytable
Successfully installed prettytable-3.12.0
```

```
from prettytable import PrettyTable

table = PrettyTable()

table.field_names = ["Metric", "Decision Tree","Decision Tree using GridSearchCV"]
table.add_row(["Accuracy", accuracy_dt, accuracy_dt_gs])
table.add_row(["Precision", precision_dt, precision_dt_gs])
table.add_row(["Recall", recall_dt, recall_dt_gs])
table.add_row(["F1 Score", f1_dt, f1_dt_gs])
```

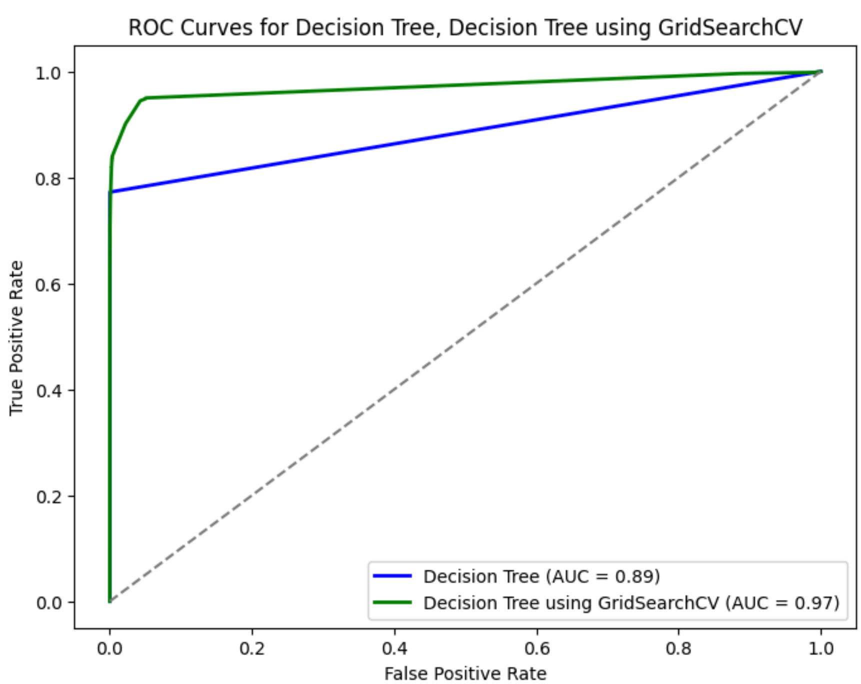
```
print(table)
```

```
+-----------+--------------------+---------------------------------+
|   Metric  |   Decision Tree    | Decision Tree using GridSearchCV |
+-----------+--------------------+---------------------------------+
|  Accuracy | 0.9994137635125153 |        0.9994986342104353       |
| Precision | 0.773308957952468  |        0.9657089898053753       |
|   Recall  | 0.7723676202069385 |        0.6342057212416312       |
|  F1 Score | 0.7728380024360536 |        0.7656135194709772       |
+-----------+--------------------+---------------------------------+
```

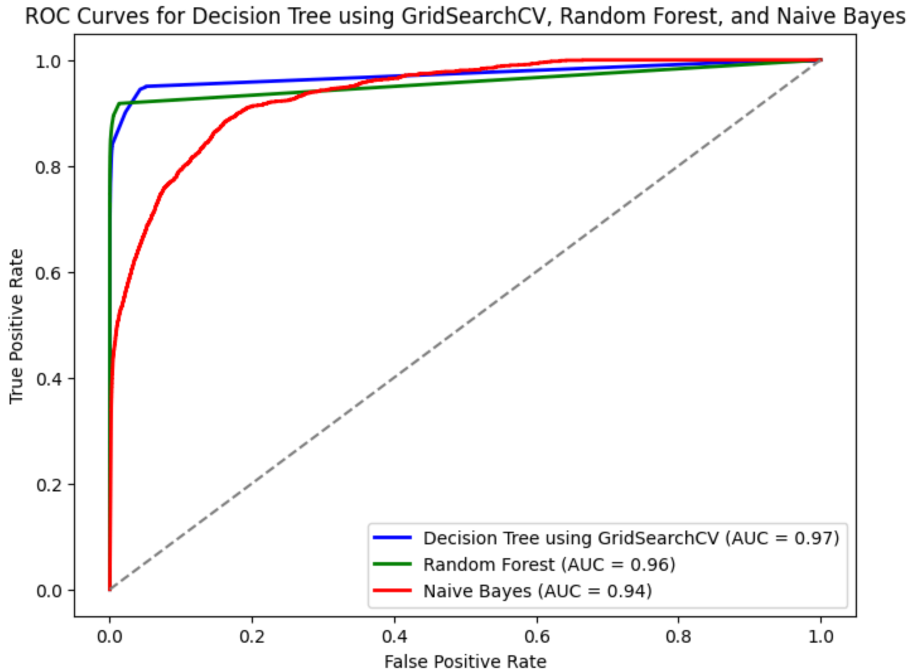
```
plot_confusion_matrix(y_test, y_pred_best_dt, "Decision Tree using GridSearchCV Confusion Matrix")
```




```
y_pred_best_dt_prob = best_dt_model.predict_proba(X_test)
fpr_dt_gs, tpr_dt_gs, _ = roc_curve(y_test, y_pred_best_dt_prob[:, 1])

roc_auc_dt_gs = auc(fpr_dt_gs, tpr_dt_gs)


plt.figure(figsize=(8, 6))  # Adjust figure size if needed
plt.plot(fpr_dt, tpr_dt, color='blue', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt:.2f})')
plt.plot(fpr_dt_gs, tpr_dt_gs, color='green', lw=2, label=f'Decision Tree using GridSearchCV (AUC = {roc_auc_dt_gs:.2f})')
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')  # Diagonal line for reference
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curves for Decision Tree, Decision Tree using GridSearchCV')
plt.legend(loc='lower right')
plt.show()
```



```
plt.figure(figsize=(8, 6))  # Adjust figure size if needed
plt.plot(fpr_dt_gs, tpr_dt_gs, color='blue', lw=2, label=f'Decision Tree using GridSearchCV (AUC = {roc_auc_dt_gs:.2f})')
plt.plot(fpr_rf, tpr_rf, color='green', lw=2, label=f'Random Forest (AUC = {roc_auc_rf:.2f})')
plt.plot(fpr_nb, tpr_nb, color='red', lw=2, label=f'Naive Bayes (AUC = {roc_auc_nb:.2f})')
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')  # Diagonal line for reference
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curves for Decision Tree using GridSearchCV, Random Forest, and Naive Bayes')
plt.legend(loc='lower right')
plt.show()
```



BALANCED

```
from sklearn.model_selection import train_test_split
```

#plot confusion matrix

```
import matplotlib.pyplot as plt
import seaborn as sns

# Function to plot a confusion matrix
def plot_confusion_matrix(y_true, y_pred, title):
    cm = confusion_matrix(y_true, y_pred)
    plt.figure(figsize=(6,4))
    sns.heatmap(cm, annot=True, fmt="d", cmap="Blues", cbar=False)
    plt.title(title)
    plt.xlabel("Predicted Label")
    plt.ylabel("True Label")
    plt.show()
```

```
!pip install imblearn
```

```
Requirement already satisfied: imblearn in /usr/local/lib/python3.10/dist-packages (0.0)
Requirement already satisfied: imbalanced-learn in /usr/local/lib/python3.10/dist-packages (from imblearn) (0.12.4)
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.10/dist-packages (from imbalanced-learn->imblearn) (1.26.4)
Requirement already satisfied: scipy>=1.5.0 in /usr/local/lib/python3.10/dist-packages (from imbalanced-learn->imblearn) (1.13.1)
Requirement already satisfied: scikit-learn>=1.0.2 in /usr/local/lib/python3.10/dist-packages (from imbalanced-learn->imblearn) (1.6.0)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from imbalanced-learn->imblearn) (1.4.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from imbalanced-learn->imblearn) (3.5.0)
```

```
!pip install prettytable
```

```
Requirement already satisfied: prettytable in /usr/local/lib/python3.10/dist-packages (3.12.0)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.10/dist-packages (from prettytable) (0.2.13)
```

```
df_balanced = pd.read_csv('PS_log.csv')
```

```
df_balanced['isFraud'].value_counts()
```

isFraud	count
0	6354407
1	8213

dtype: int64

```
from sklearn.preprocessing import LabelEncoder
le_orig = LabelEncoder()
le_dest = LabelEncoder()

df_balanced['nameOrig'] = le_orig.fit_transform(df_balanced['nameOrig'])
df_balanced['nameDest'] = le_dest.fit_transform(df_balanced['nameDest'])

df_balanced['balanceChangeOrig'] = df_balanced['oldbalanceOrg'] - df_balanced['newbalanceOrig']
df_balanced['balanceChangeDest'] = df_balanced['newbalanceDest'] - df_balanced['oldbalanceDest']

df_balanced.drop(['oldbalanceOrg', 'newbalanceOrig', 'oldbalanceDest', 'newbalanceDest'], axis=1, inplace=True)

le_type = LabelEncoder()
df_balanced['type'] = le_type.fit_transform(df_balanced['type'])
```

```
X_balanced = df_balanced.drop(['isFraud'], axis=1)
y_balanced = df_balanced['isFraud']
```

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_scaled_balanced = scaler.fit_transform(X_balanced)
```

undersampling

```
from imblearn.under_sampling import RandomUnderSampler

rus = RandomUnderSampler(random_state=42)
X_resampled, y_resampled = rus.fit_resample(X_scaled_balanced, y_balanced)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to 'ensure_all_finite' i
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:484: FutureWarning: `BaseEstimator._check_n_features` is deprecated in 1.6 and will be r
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:493: FutureWarning: `BaseEstimator._check_feature_names` is deprecated in 1.6 and will b
  warnings.warn(
```

```
X_train_balanced, X_test_balanced, y_train_balanced, y_test_balanced = train_test_split(X_resampled, y_resampled, test_size=0.2, random_state=42, st
```

```
from collections import Counter
print(sorted(Counter(y_resampled).items()))
```

```
[(0, 8213), (1, 8213)]
```

```
y_resampled.value_counts()
```

isFraud	count
0	8213
1	8213

dtype: int64

```
X_resampled
```

```
array([[-5.71883122e-01, -5.28954357e-01,  6.53202450e-03, ...,
        -1.58577857e-03,  2.77009392e-01,  7.32054767e-02],
       [-7.47528845e-01,  9.52399323e-01, -2.96991145e-01, ...,
        -1.58577857e-03,  1.44776939e-01, -1.52895517e-01],
       [-4.52444031e-01,  9.52399323e-01, -2.92094615e-01, ...,
        -1.58577857e-03,  1.68495586e-01, -1.52895517e-01],
       ...,
       [ 3.51012348e+00, -5.28954357e-01,  1.01539526e+01, ...,
        -1.58577857e-03,  4.31839772e+01,  7.61079787e+00],
       [ 3.51012348e+00,  1.69307616e+00,  1.10976490e+00, ...,
        -1.58577857e-03,  5.94117313e+00, -1.52895517e-01],
       [ 3.51012348e+00, -5.28954357e-01,  1.10976490e+00, ...,
        -1.58577857e-03,  5.94117313e+00,  8.92696467e-01]])
```

undersampling - Decision Tree

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report, confusion_matrix, roc_curve, auc
from sklearn import tree
import time


start_time_balanced = time.time()

dt_model_balanced = DecisionTreeClassifier(random_state=42)
dt_model_balanced.fit(X_resampled, y_resampled)
y_pred_dt_balanced = dt_model_balanced.predict(X_test_balanced)

end_time_balanced = time.time()


training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Decision Tree: {training_time:.4f} giây")
```

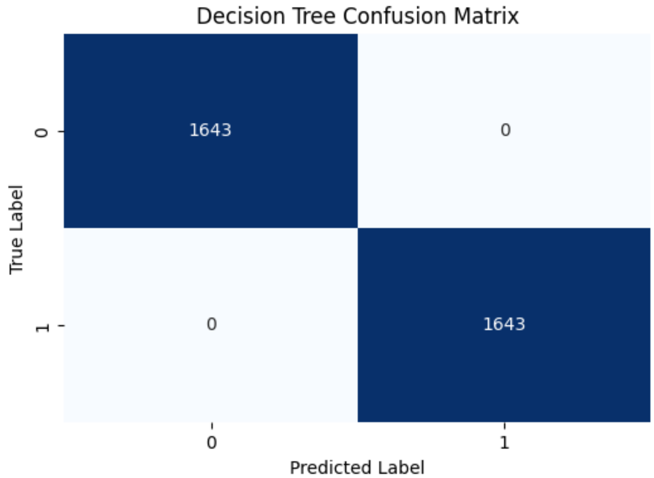
```
Thời gian chạy Decision Tree: 0.1848 giây
```

```
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score

accuracy_dt_balanced = accuracy_score(y_test_balanced, y_pred_dt_balanced)
precision_dt_balanced = precision_score(y_test_balanced, y_pred_dt_balanced)
recall_dt_balanced = recall_score(y_test_balanced, y_pred_dt_balanced)
f1_dt_balanced = f1_score(y_test_balanced, y_pred_dt_balanced)
```

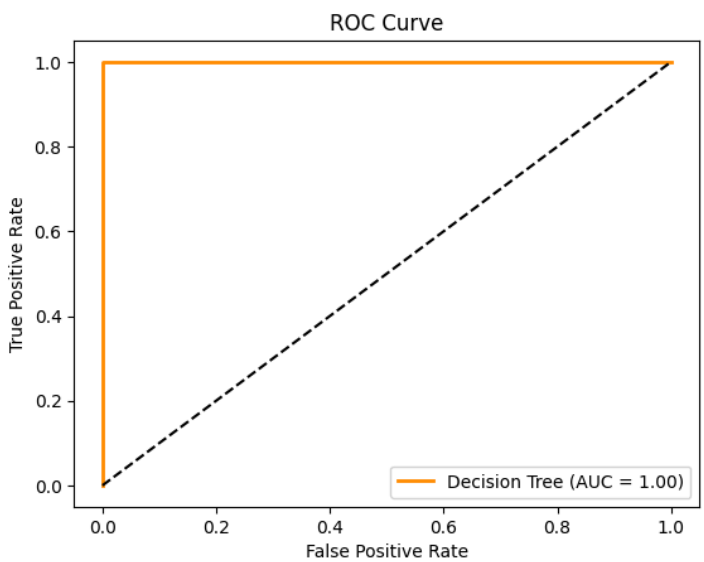
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Decision Tree"]
table.add_row(["Accuracy", accuracy_dt_balanced])
table.add_row(["Precision", precision_dt_balanced])
table.add_row(["Recall", recall_dt_balanced])
table.add_row(["F1 Score", f1_dt_balanced])

print(table)
```

```
+-----------+---------------+
|   Metric  | Decision Tree |
+-----------+---------------+
|  Accuracy |      1.0      |
| Precision |      1.0      |
|   Recall  |      1.0      |
|  F1 Score |      1.0      |
+-----------+---------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_dt_balanced, "Decision Tree Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_dt_prob = dt_model_balanced.predict_proba(X_test_balanced)
fpr_dt_us, tpr_dt_us, _ = roc_curve(y_test_balanced, y_pred_dt_prob[:, 1])
roc_auc_dt_us = auc(fpr_dt_us, tpr_dt_us)

plt.figure()
plt.plot(fpr_dt_us, tpr_dt_us, color='darkorange', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt_us:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



undersampling - Random Forest

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time


start_time_balanced = time.time()

rf_model_balanced = RandomForestClassifier(random_state=42)
rf_model_balanced.fit(X_resampled, y_resampled)
y_pred_rf_balanced = rf_model_balanced.predict(X_test_balanced)

end_time_balanced = time.time()
```

```
training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Random Forest: {training_time:.4f} giây")
```

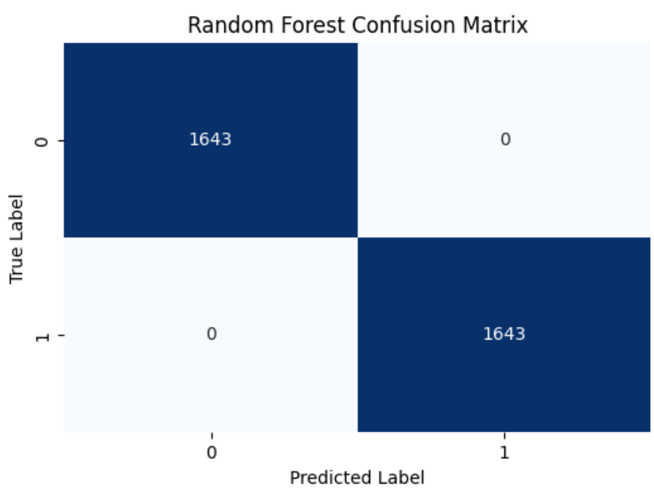
```
Thời gian chạy Random Forest: 3.7461 giây
```

```
accuracy_rf_balanced = accuracy_score(y_test_balanced, y_pred_rf_balanced)
precision_rf_balanced = precision_score(y_test_balanced, y_pred_rf_balanced)
recall_rf_balanced = recall_score(y_test_balanced, y_pred_rf_balanced)
f1_rf_balanced = f1_score(y_test_balanced, y_pred_rf_balanced)
```

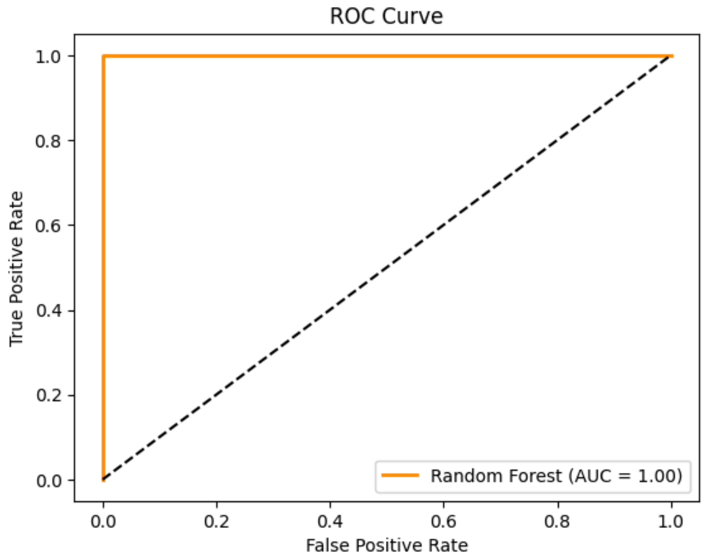
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Random Forest"]
table.add_row(["Accuracy", accuracy_rf_balanced])
table.add_row(["Precision", precision_rf_balanced])
table.add_row(["Recall", recall_rf_balanced])
table.add_row(["F1 Score", f1_rf_balanced])

print(table)
```

```
+-----------+---------------+
|   Metric  | Random Forest |
+-----------+---------------+
|  Accuracy |      1.0      |
| Precision |      1.0      |
|   Recall  |      1.0      |
|  F1 Score |      1.0      |
+-----------+---------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_rf_balanced, "Random Forest Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_rf_prob = rf_model_balanced.predict_proba(X_test_balanced)
fpr_rf_us, tpr_rf_us, _ = roc_curve(y_test_balanced, y_pred_rf_prob[:, 1])
roc_auc_rf_us = auc(fpr_rf_us, tpr_rf_us)

plt.figure()
plt.plot(fpr_rf_us, tpr_rf_us, color='darkorange', lw=2, label=f'Random Forest (AUC = {roc_auc_rf_us:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



undersampling - Naive Bayes

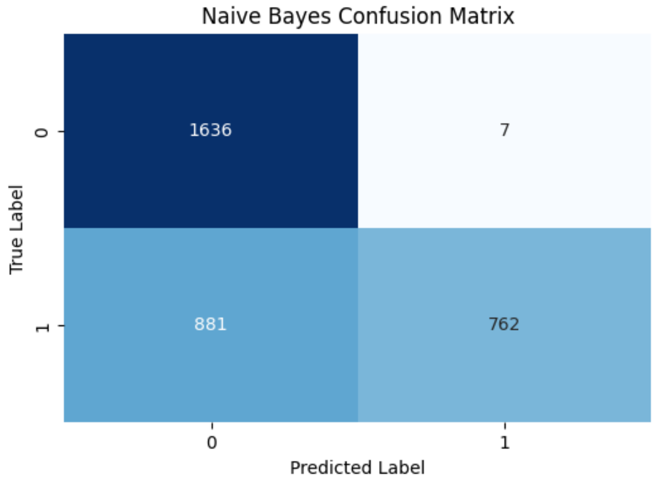
```
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time

start_time_balanced = time.time()
nb_model_balanced = GaussianNB()
nb_model_balanced.fit(X_resampled, y_resampled)
y_pred_nb_balanced = nb_model_balanced.predict(X_test_balanced)
end_time_balanced = time.time()


training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Naive Bayes: {training_time:.4f} giây")
```

```
Thời gian chạy Naive Bayes: 0.0126 giây
```

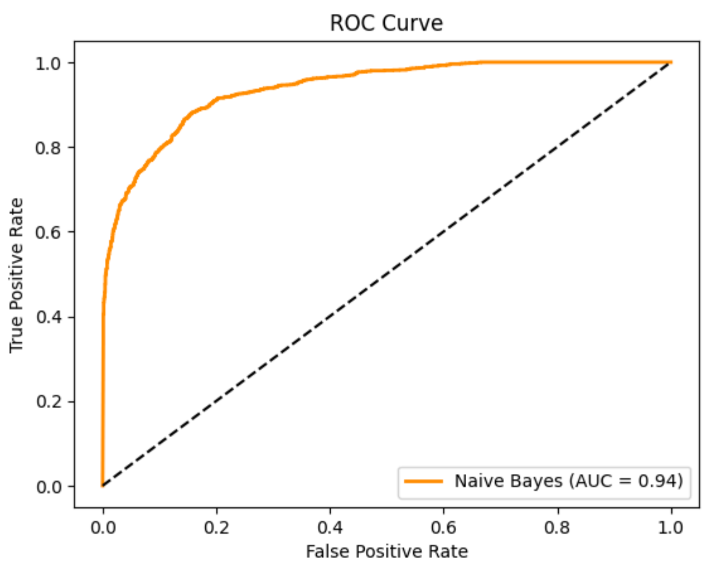
```
accuracy_nb_balanced = accuracy_score(y_test_balanced, y_pred_nb_balanced)
precision_nb_balanced = precision_score(y_test_balanced, y_pred_nb_balanced)
recall_nb_balanced = recall_score(y_test_balanced, y_pred_nb_balanced)
f1_nb_balanced = f1_score(y_test_balanced, y_pred_nb_balanced)


from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Naive Bayes"]
table.add_row(["Accuracy", accuracy_nb_balanced])
table.add_row(["Precision", precision_nb_balanced])
table.add_row(["Recall", recall_nb_balanced])
table.add_row(["F1 Score", f1_nb_balanced])

print(table)
```

```
+-----------+---------------------+
|   Metric  |     Naive Bayes     |
+-----------+---------------------+
|  Accuracy |  0.7297626293365794 |
| Precision |  0.9908972691807543 |
|   Recall  | 0.46378575776019476 |
|  F1 Score |  0.6318407960199005 |
+-----------+---------------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_nb_balanced, "Naive Bayes Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_nb_prob = nb_model_balanced.predict_proba(X_test_balanced)
fpr_nb_us, tpr_nb_us, _ = roc_curve(y_test_balanced, y_pred_nb_prob[:, 1])
roc_auc_nb_us = auc(fpr_nb_us, tpr_nb_us)


plt.figure()
plt.plot(fpr_nb_us, tpr_nb_us, color='darkorange', lw=2, label=f'Naive Bayes (AUC = {roc_auc_nb_us:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



oversampling

```
from imblearn.over_sampling import RandomOverSampler

ros = RandomOverSampler(random_state=42)
X_resampled_ros, y_resampled_ros = ros.fit_resample(X_scaled_balanced, y_balanced)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/utils/deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to 'ensure_all_finite' i
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:484: FutureWarning: `BaseEstimator._check_n_features` is deprecated in 1.6 and will be r
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:493: FutureWarning: `BaseEstimator._check_feature_names` is deprecated in 1.6 and will b
  warnings.warn(
```

```
X_train_balanced, X_test_balanced, y_train_balanced, y_test_balanced = train_test_split(X_resampled_ros, y_resampled_ros, test_size=0.2, random_stat
```

```
from collections import Counter
print(sorted(Counter(y_resampled_ros).items()))
```

```
[(0, 6354407), (1, 6354407)]
```

```
y_resampled_ros.value_counts()
```

isFraud	count
0	6354407
1	6354407

dtype: int64

oversampling - Decision Tree

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report, confusion_matrix, roc_curve, auc
from sklearn import tree
import time
```

```
start_time_balanced = time.time()

dt_model_balanced = DecisionTreeClassifier(random_state=42)
dt_model_balanced.fit(X_resampled_ros, y_resampled_ros)
y_pred_dt_balanced = dt_model_balanced.predict(X_test_balanced)

end_time_balanced = time.time()
```

```
training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Decision Tree: {training_time:.4f} giây")
```

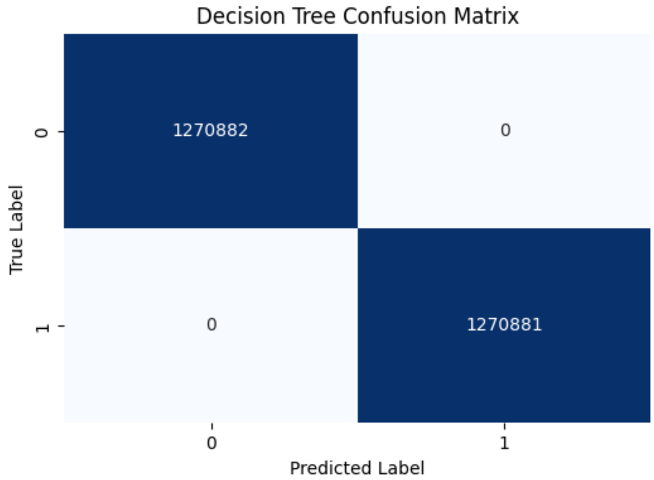
```
Thời gian chạy Decision Tree: 368.8052 giây
```

```
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score

accuracy_dt_balanced = accuracy_score(y_test_balanced, y_pred_dt_balanced)
precision_dt_balanced = precision_score(y_test_balanced, y_pred_dt_balanced)
recall_dt_balanced = recall_score(y_test_balanced, y_pred_dt_balanced)
f1_dt_balanced = f1_score(y_test_balanced, y_pred_dt_balanced)
```

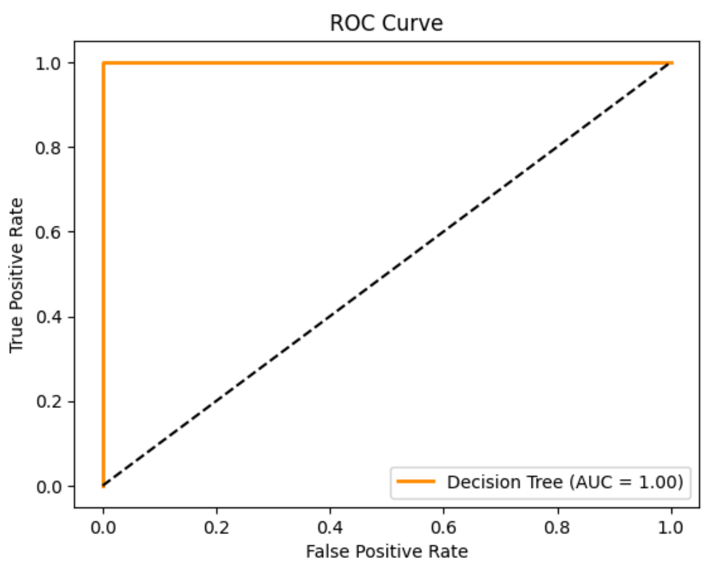
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Decision Tree"]
table.add_row(["Accuracy", accuracy_dt_balanced])
table.add_row(["Precision", precision_dt_balanced])
table.add_row(["Recall", recall_dt_balanced])
table.add_row(["F1 Score", f1_dt_balanced])

print(table)
```

```
+-----------+---------------+
|   Metric  | Decision Tree |
+-----------+---------------+
|  Accuracy |      1.0      |
| Precision |      1.0      |
|   Recall  |      1.0      |
|  F1 Score |      1.0      |
+-----------+---------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_dt_balanced, "Decision Tree Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_dt_prob = dt_model_balanced.predict_proba(X_test_balanced)
fpr_dt_os, tpr_dt_os, _ = roc_curve(y_test_balanced, y_pred_dt_prob[:, 1])
roc_auc_dt_os = auc(fpr_dt_os, tpr_dt_os)

plt.figure()
plt.plot(fpr_dt_os, tpr_dt_os, color='darkorange', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt_os:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



oversampling - Random Forest

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time


start_time_balanced = time.time()

rf_model_balanced = RandomForestClassifier(random_state=42)
rf_model_balanced.fit(X_resampled_ros, y_resampled_ros)
y_pred_rf_balanced = rf_model_balanced.predict(X_test_balanced)

end_time_balanced = time.time()
```

```
training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Random Forest: {training_time:.4f} giây")
```

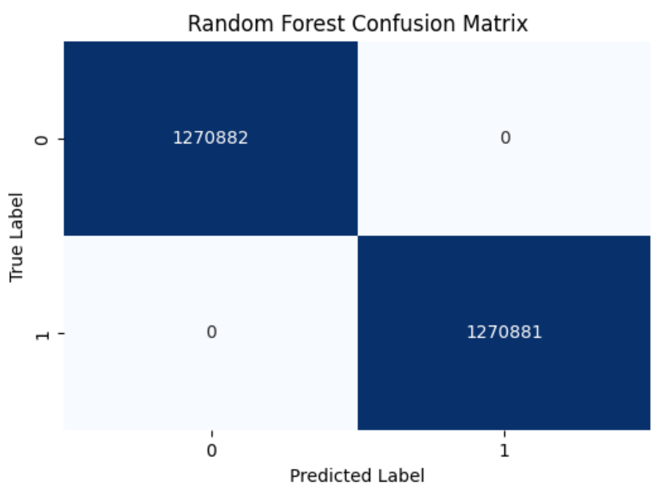
```
Thời gian chạy Random Forest: 6627.0217 giây
```

```
accuracy_rf_balanced = accuracy_score(y_test_balanced, y_pred_rf_balanced)
precision_rf_balanced = precision_score(y_test_balanced, y_pred_rf_balanced)
recall_rf_balanced = recall_score(y_test_balanced, y_pred_rf_balanced)
f1_rf_balanced = f1_score(y_test_balanced, y_pred_rf_balanced)
```

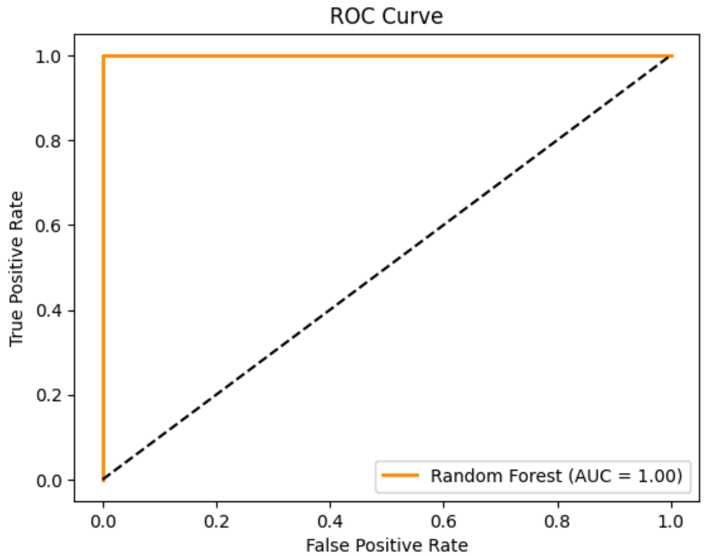
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Random Forest"]
table.add_row(["Accuracy", accuracy_rf_balanced])
table.add_row(["Precision", precision_rf_balanced])
table.add_row(["Recall", recall_rf_balanced])
table.add_row(["F1 Score", f1_rf_balanced])

print(table)
```

```
+-----------+---------------+
|   Metric  | Random Forest |
+-----------+---------------+
|  Accuracy |      1.0      |
| Precision |      1.0      |
|   Recall  |      1.0      |
|  F1 Score |      1.0      |
+-----------+---------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_rf_balanced, "Random Forest Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_rf_prob = rf_model_balanced.predict_proba(X_test_balanced)
fpr_rf_os, tpr_rf_os, _ = roc_curve(y_test_balanced, y_pred_rf_prob[:, 1])
roc_auc_rf_os = auc(fpr_rf_os, tpr_rf_os)

plt.figure()
plt.plot(fpr_rf_os, tpr_rf_os, color='darkorange', lw=2, label=f'Random Forest (AUC = {roc_auc_rf_os:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



oversampling - Naive Bayes

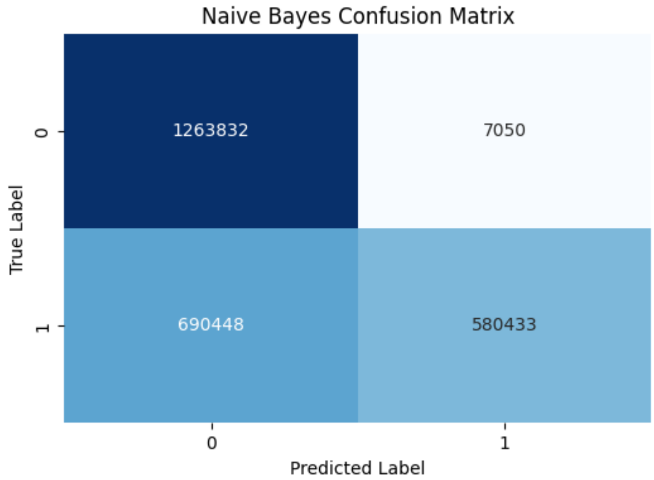
```
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time

start_time_balanced = time.time()
nb_model_balanced = GaussianNB()
nb_model_balanced.fit(X_resampled_ros, y_resampled_ros)
y_pred_nb_balanced = nb_model_balanced.predict(X_test_balanced)
end_time_balanced = time.time()


training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Naive Bayes: {training_time:.4f} giây")
```

```
Thời gian chạy Naive Bayes: 5.6703 giây
```

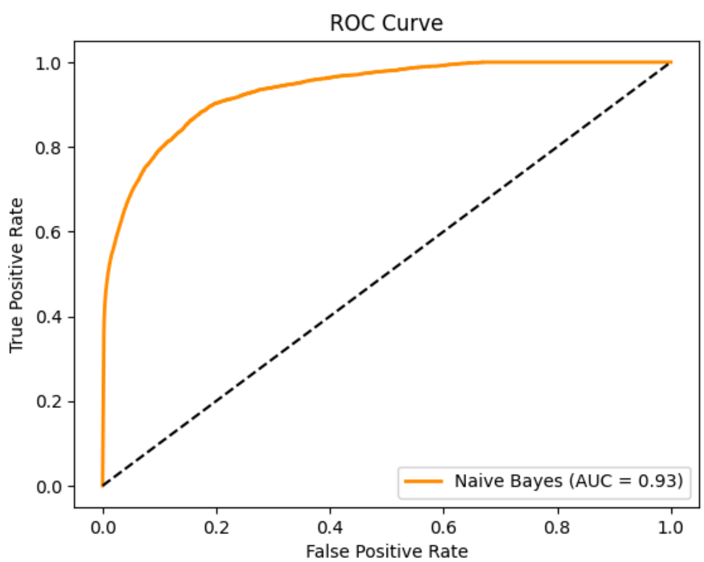
```
accuracy_nb_balanced = accuracy_score(y_test_balanced, y_pred_nb_balanced)
precision_nb_balanced = precision_score(y_test_balanced, y_pred_nb_balanced)
recall_nb_balanced = recall_score(y_test_balanced, y_pred_nb_balanced)
f1_nb_balanced = f1_score(y_test_balanced, y_pred_nb_balanced)


from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Naive Bayes"]
table.add_row(["Accuracy", accuracy_nb_balanced])
table.add_row(["Precision", precision_nb_balanced])
table.add_row(["Recall", recall_nb_balanced])
table.add_row(["F1 Score", f1_nb_balanced])

print(table)
```

```
+-----------+--------------------+
|   Metric  |    Naive Bayes     |
+-----------+--------------------+
|  Accuracy | 0.7255849581569958 |
| Precision | 0.9879996527559095 |
|   Recall  | 0.4567170333020952 |
|  F1 Score | 0.624670947134146  |
+-----------+--------------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_nb_balanced, "Naive Bayes Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_nb_prob = nb_model_balanced.predict_proba(X_test_balanced)
fpr_nb_os, tpr_nb_os, _ = roc_curve(y_test_balanced, y_pred_nb_prob[:, 1])
roc_auc_nb_os = auc(fpr_nb_os, tpr_nb_os)


plt.figure()
plt.plot(fpr_nb_os, tpr_nb_os, color='darkorange', lw=2, label=f'Naive Bayes (AUC = {roc_auc_nb_os:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



SMOTE

```
from imblearn.over_sampling import SMOTE

smote = SMOTE(random_state=42)
X_resampled_smote, y_resampled_smote = smote.fit_resample(X_scaled_balanced, y_balanced)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:474: FutureWarning: `BaseEstimator._validate_data` is deprecated in 1.6 and will be remo
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/utils/_tags.py:354: FutureWarning: The SMOTE or classes from which it inherits use `_get_tags` a
  warnings.warn(
```

```
X_train_balanced, X_test_balanced, y_train_balanced, y_test_balanced = train_test_split(X_resampled_smote, y_resampled_smote, test_size=0.2, random_
```

```
from collections import Counter
print(sorted(Counter(y_resampled_smote).items()))
```

```
[(0, 6354407), (1, 6354407)]
```

```
y_resampled_smote.value_counts()
```

isFraud	count
0	6354407
1	6354407

dtype: int64

smote - DT

```
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report, confusion_matrix, roc_curve, auc
from sklearn import tree
import time
```

```
start_time_balanced = time.time()

dt_model_balanced = DecisionTreeClassifier(random_state=42)
dt_model_balanced.fit(X_resampled_smote, y_resampled_smote)
y_pred_dt_balanced = dt_model_balanced.predict(X_test_balanced)

end_time_balanced = time.time()
```

```
training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Decision Tree: {training_time:.4f} giây")
```

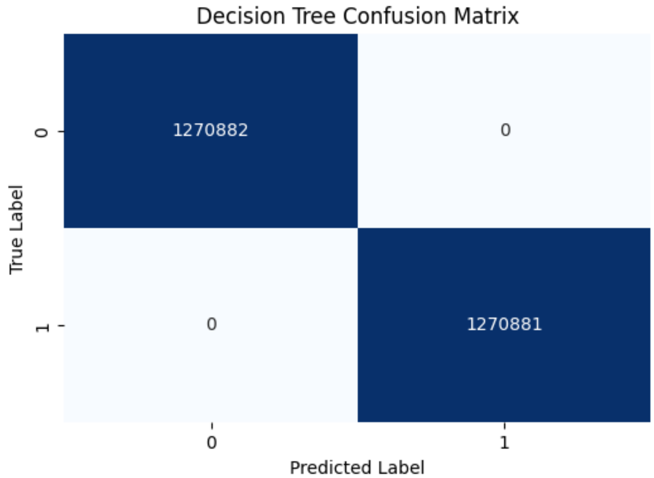
```
Thời gian chạy Decision Tree: 412.0620 giây
```

```
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score

accuracy_dt_balanced = accuracy_score(y_test_balanced, y_pred_dt_balanced)
precision_dt_balanced = precision_score(y_test_balanced, y_pred_dt_balanced)
recall_dt_balanced = recall_score(y_test_balanced, y_pred_dt_balanced)
f1_dt_balanced = f1_score(y_test_balanced, y_pred_dt_balanced)
```

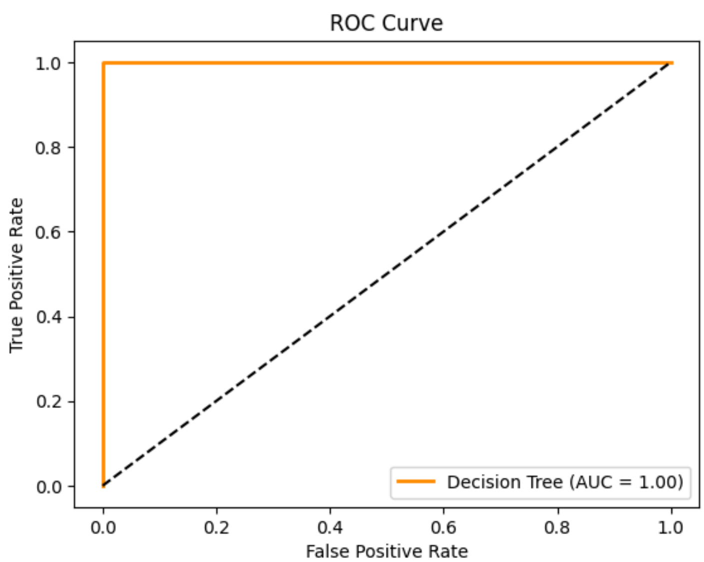
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Decision Tree"]
table.add_row(["Accuracy", accuracy_dt_balanced])
table.add_row(["Precision", precision_dt_balanced])
table.add_row(["Recall", recall_dt_balanced])
table.add_row(["F1 Score", f1_dt_balanced])

print(table)
```

```
+-----------+---------------+
|   Metric  | Decision Tree |
+-----------+---------------+
|  Accuracy |      1.0      |
| Precision |      1.0      |
|   Recall  |      1.0      |
|  F1 Score |      1.0      |
+-----------+---------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_dt_balanced, "Decision Tree Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_dt_prob = dt_model_balanced.predict_proba(X_test_balanced)
fpr_dt_smote, tpr_dt_smote, _ = roc_curve(y_test_balanced, y_pred_dt_prob[:, 1])
roc_auc_dt_smote = auc(fpr_dt_smote, tpr_dt_smote)

plt.figure()
plt.plot(fpr_dt_smote, tpr_dt_smote, color='darkorange', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt_smote:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



smote - RF

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time


start_time_balanced = time.time()

rf_model_balanced = RandomForestClassifier(random_state=42)
rf_model_balanced.fit(X_resampled_smote, y_resampled_smote)
y_pred_rf_balanced = rf_model_balanced.predict(X_test_balanced)

end_time_balanced = time.time()
```

```
training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Random Forest: {training_time:.4f} giây")
```

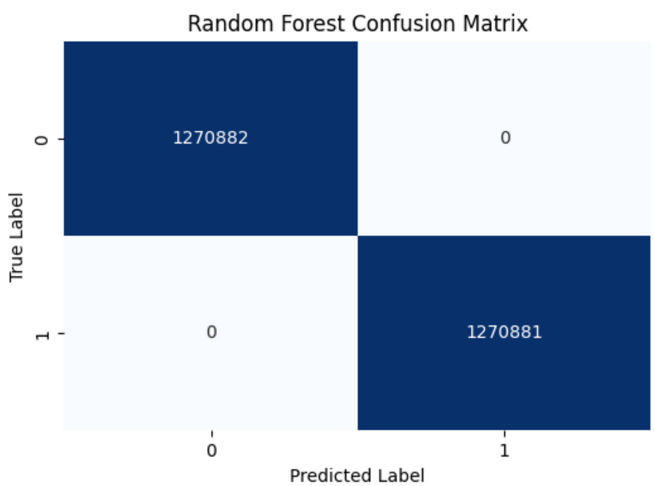
```
Thời gian chạy Random Forest: 9036.3916 giây
```

```
accuracy_rf_balanced = accuracy_score(y_test_balanced, y_pred_rf_balanced)
precision_rf_balanced = precision_score(y_test_balanced, y_pred_rf_balanced)
recall_rf_balanced = recall_score(y_test_balanced, y_pred_rf_balanced)
f1_rf_balanced = f1_score(y_test_balanced, y_pred_rf_balanced)
```

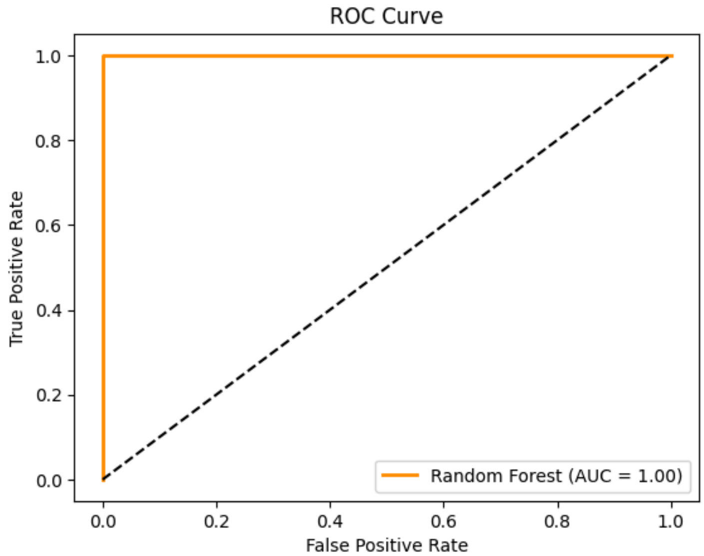
```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Random Forest"]
table.add_row(["Accuracy", accuracy_rf_balanced])
table.add_row(["Precision", precision_rf_balanced])
table.add_row(["Recall", recall_rf_balanced])
table.add_row(["F1 Score", f1_rf_balanced])

print(table)
```

```
+-----------+---------------+
|   Metric  | Random Forest |
+-----------+---------------+
|  Accuracy |      1.0      |
| Precision |      1.0      |
|   Recall  |      1.0      |
|  F1 Score |      1.0      |
+-----------+---------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_rf_balanced, "Random Forest Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_rf_prob = rf_model_balanced.predict_proba(X_test_balanced)
fpr_rf_smote, tpr_rf_smote, _ = roc_curve(y_test_balanced, y_pred_rf_prob[:, 1])
roc_auc_rf_smote = auc(fpr_rf_smote, tpr_rf_smote)

plt.figure()
plt.plot(fpr_rf_smote, tpr_rf_smote, color='darkorange', lw=2, label=f'Random Forest (AUC = {roc_auc_rf_smote:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



smote - NB

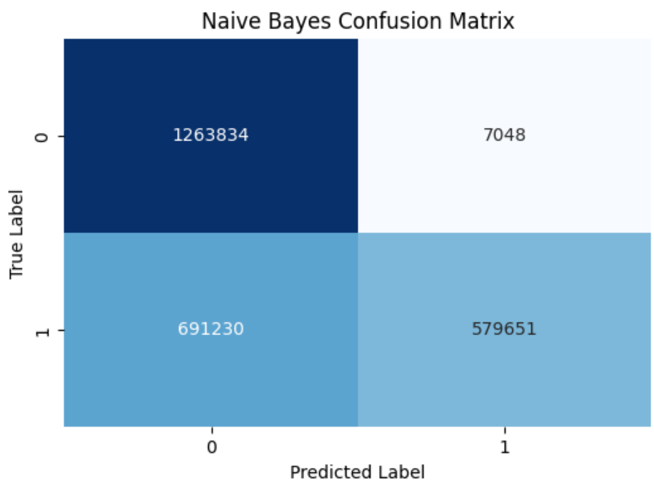
```
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
import time

start_time_balanced = time.time()
nb_model_balanced = GaussianNB()
nb_model_balanced.fit(X_resampled_smote, y_resampled_smote)
y_pred_nb_balanced = nb_model_balanced.predict(X_test_balanced)
end_time_balanced = time.time()


training_time = end_time_balanced - start_time_balanced
print(f"Thời gian chạy Naive Bayes: {training_time:.4f} giây")
```

```
Thời gian chạy Naive Bayes: 4.9128 giây
```

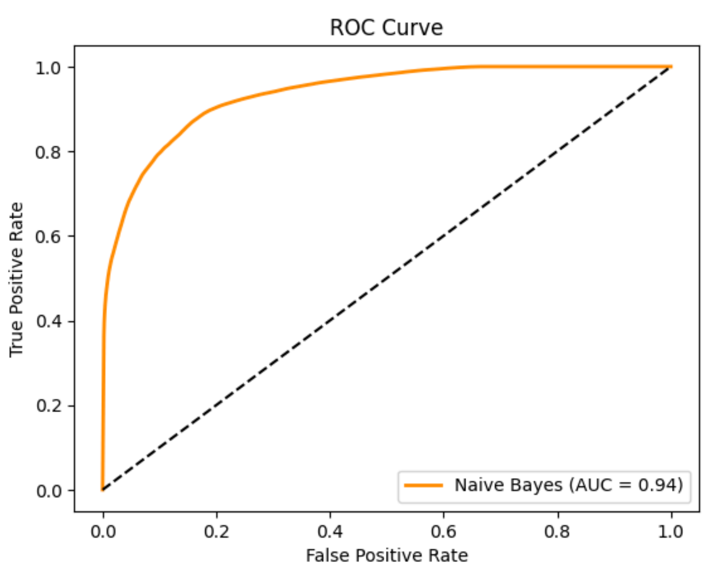
```
accuracy_nb_balanced = accuracy_score(y_test_balanced, y_pred_nb_balanced)
precision_nb_balanced = precision_score(y_test_balanced, y_pred_nb_balanced)
recall_nb_balanced = recall_score(y_test_balanced, y_pred_nb_balanced)
f1_nb_balanced = f1_score(y_test_balanced, y_pred_nb_balanced)


from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Metric", "Naive Bayes"]
table.add_row(["Accuracy", accuracy_nb_balanced])
table.add_row(["Precision", precision_nb_balanced])
table.add_row(["Recall", recall_nb_balanced])
table.add_row(["F1 Score", f1_nb_balanced])

print(table)
```

```
+-----------+---------------------+
|   Metric  |     Naive Bayes     |
+-----------+---------------------+
|  Accuracy |  0.7252780845421072 |
| Precision |   0.98798702571506  |
|   Recall  | 0.45610171211938805 |
|  F1 Score |  0.6240926366562948 |
+-----------+---------------------+
```

```
plot_confusion_matrix(y_test_balanced, y_pred_nb_balanced, "Naive Bayes Confusion Matrix")
```




```
from sklearn.metrics import roc_curve, auc

y_pred_nb_prob = nb_model_balanced.predict_proba(X_test_balanced)
fpr_nb_smote, tpr_nb_smote, _ = roc_curve(y_test_balanced, y_pred_nb_prob[:, 1])
roc_auc_nb_smote = auc(fpr_nb_smote, tpr_nb_smote)


plt.figure()
plt.plot(fpr_nb_smote, tpr_nb_smote, color='darkorange', lw=2, label=f'Naive Bayes (AUC = {roc_auc_nb_smote:.2f})')
plt.plot([0, 1], [0, 1], 'k--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(loc='lower right')
plt.show()
```



Visualize Data

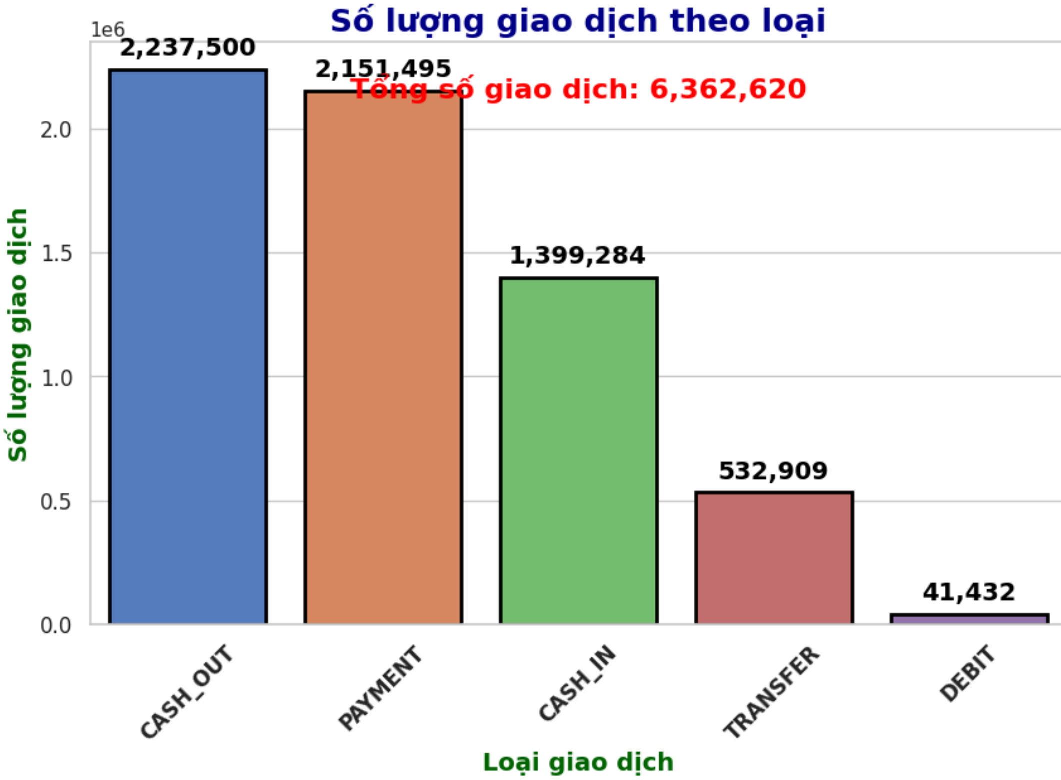
```
df = pd.read_csv('PS_log.csv')
```

số lượng dl

```
import matplotlib.pyplot as plt
import seaborn as sns

# Giả sử bạn có dataframe 'df' với cột 'type' chứa các loại giao dịch
```

```
# Tính số lượng giao dịch theo từng loại
transaction_counts_by_type = df['type'].value_counts()

# Tính tổng số giao dịch
total_transactions = len(df)

# Vẽ biểu đồ số lượng giao dịch theo từng loại
plt.figure(figsize=(10, 6))

# Vẽ biểu đồ cột với màu sắc đẹp
sns.set(style="whitegrid")  # Cải thiện kiểu nền
ax = sns.barplot(x=transaction_counts_by_type.index, y=transaction_counts_by_type.values, palette='muted')

# Tăng độ bóng đổ cho các cột
for patch in ax.patches:
    patch.set_edgecolor('black')  # Đặt màu viền cột là đen
    patch.set_linewidth(2)  # Đặt độ dày viền cột

# Thêm các giá trị số vào các cột và điều chỉnh vị trí
for p in ax.patches:
    height = p.get_height()
    ax.annotate(f'{height:,.0f}',
                (p.get_x() + p.get_width() / 2., height),
                ha='center', va='bottom', fontsize=14, color='black', fontweight='bold', xytext=(0, 5), textcoords='offset points')

# Thêm tổng số giao dịch vào biểu đồ với vị trí phù hợp
ax.annotate(f'Tổng số giao dịch: {total_transactions:,}',
            xy=(0.5, 0.92),  # Đặt tại vị trí phù hợp để tránh đè lên cột
            xycoords='axes fraction',
            ha='center', va='center',
            fontsize=16, color='red', fontweight='bold')

# Thiết lập tiêu đề và nhãn trục
plt.title('Số lượng giao dịch theo loại', fontsize=18, fontweight='bold', color='darkblue')
plt.xlabel('Loại giao dịch', fontsize=14, fontweight='bold', color='darkgreen')
plt.ylabel('Số lượng giao dịch', fontsize=14, fontweight='bold', color='darkgreen')

# Tăng khoảng cách cho các nhãn
plt.xticks(rotation=45, fontsize=12, fontweight='bold')
plt.yticks(fontsize=12)

# Hiển thị biểu đồ
plt.show()
```

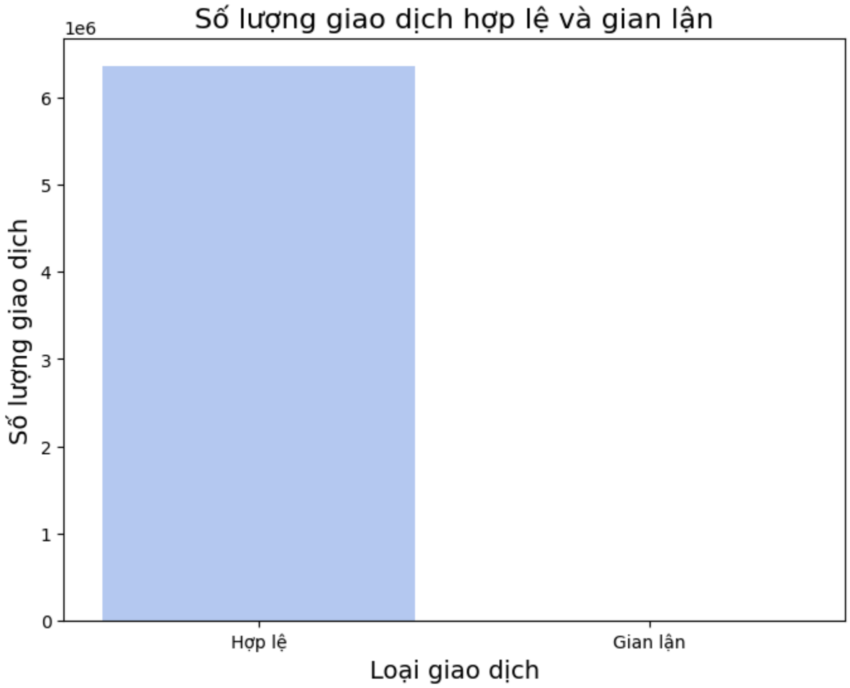
```
<ipython-input-12-1eb2a51b9204>:17: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False`

  ax = sns.barplot(x=transaction_counts_by_type.index, y=transaction_counts_by_type.values, palette='muted')
```



giao dịch hợp lệ và gian lận

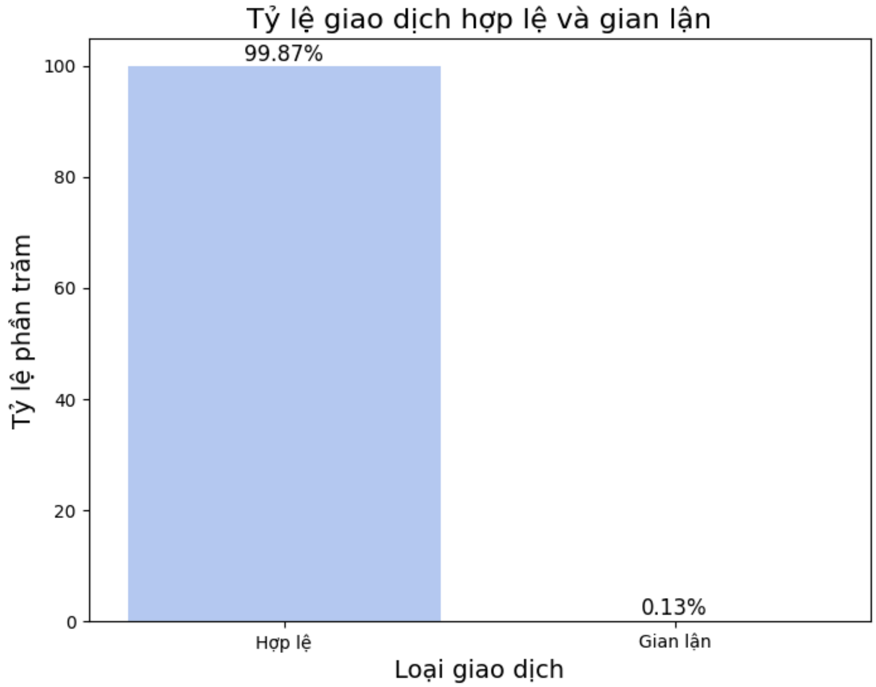
```
# Tính số lượng giao dịch hợp lệ và gian lận
transaction_counts = df['isFraud'].value_counts()

# Vẽ biểu đồ số lượng giao dịch hợp lệ và gian lận
plt.figure(figsize=(8, 6))

# Bar plot - Số lượng giao dịch
sns.barplot(x=transaction_counts.index, y=transaction_counts.values, palette='coolwarm')

# Thiết lập tiêu đề và nhãn trục
plt.title('Số lượng giao dịch hợp lệ và gian lận', fontsize=16)
plt.xlabel('Loại giao dịch', fontsize=14)
plt.ylabel('Số lượng giao dịch', fontsize=14)
plt.xticks([0, 1], ['Hợp lệ', 'Gian lận'])

# Hiển thị biểu đồ
plt.show()
```

```
<ipython-input-7-6a1dd13408a7>:8: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False`

  sns.barplot(x=transaction_counts.index, y=transaction_counts.values, palette='coolwarm')
```

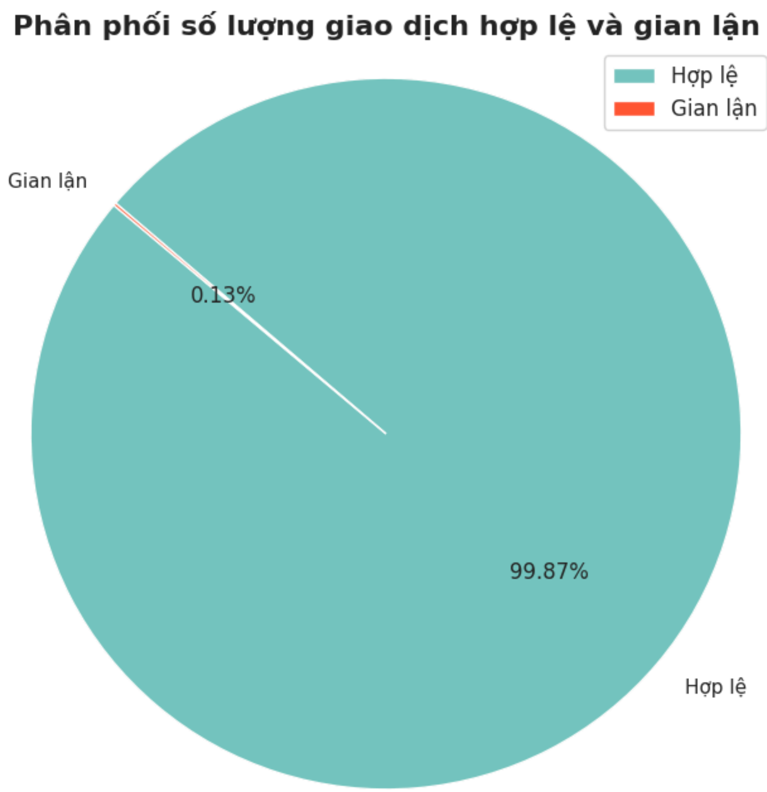



```
# Tính tỷ lệ giao dịch gian lận và hợp lệ
fraud_ratio = transaction_counts[1] / transaction_counts.sum() * 100
valid_ratio = transaction_counts[0] / transaction_counts.sum() * 100

# Vẽ biểu đồ tỷ lệ phần trăm
plt.figure(figsize=(8, 6))

# Vẽ biểu đồ cột cho tỷ lệ giao dịch
sns.barplot(x=['Hợp lệ', 'Gian lận'], y=[valid_ratio, fraud_ratio], palette='coolwarm')

# Thiết lập tiêu đề và nhãn trục
plt.title('Tỷ lệ giao dịch hợp lệ và gian lận', fontsize=16)
plt.xlabel('Loại giao dịch', fontsize=14)
plt.ylabel('Tỷ lệ phần trăm', fontsize=14)

# Hiển thị tỷ lệ phần trăm lên trên cột
for i, value in enumerate([valid_ratio, fraud_ratio]):
    plt.text(i, value + 1, f'{value:.2f}%', ha='center', fontsize=12)

# Hiển thị biểu đồ
plt.show()
```

```
<ipython-input-8-9952e9df6c55>:9: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False`

  sns.barplot(x=['Hợp lệ', 'Gian lận'], y=[valid_ratio, fraud_ratio], palette='coolwarm')
```



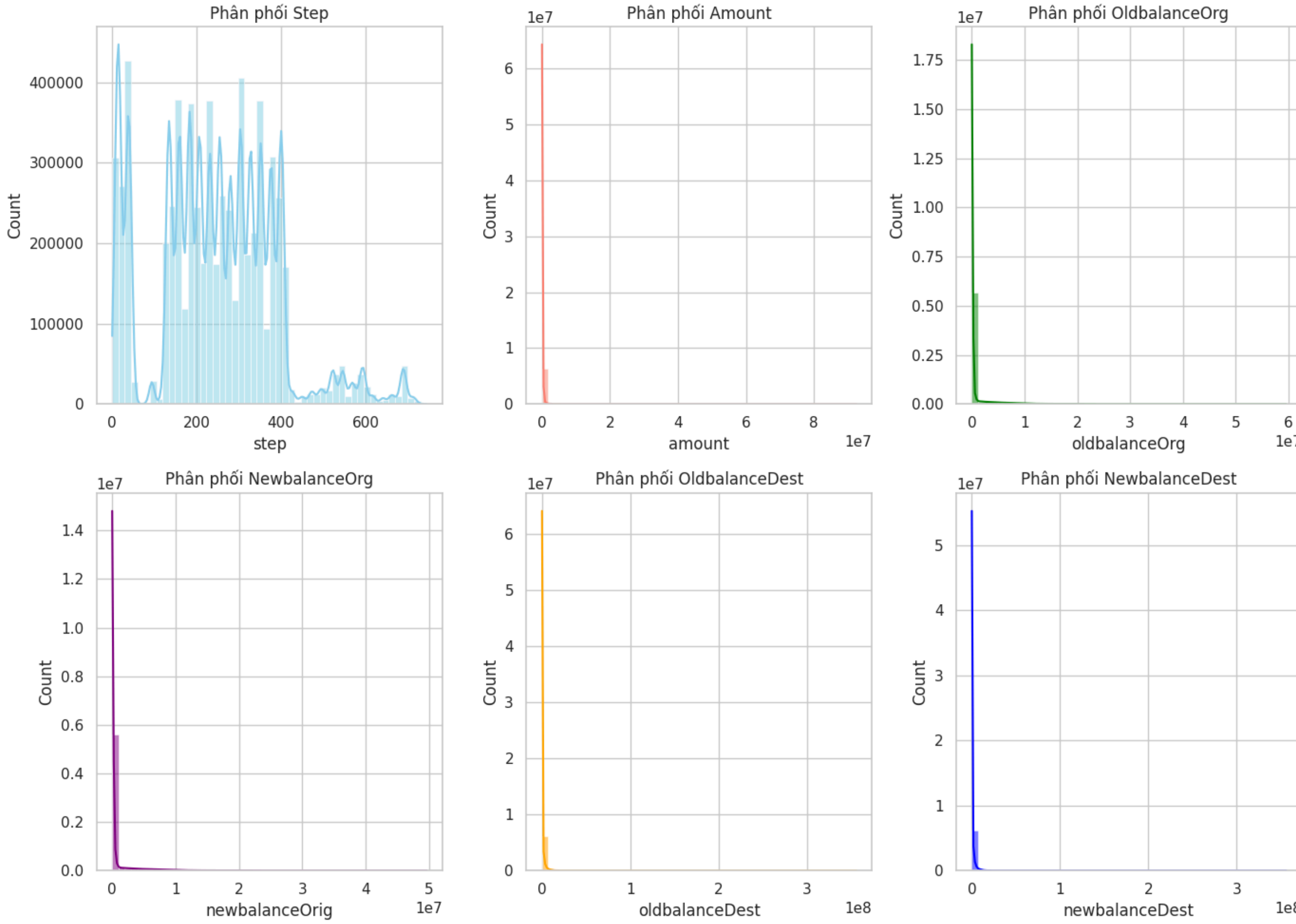

```
import matplotlib.pyplot as plt

fraud_counts = df['isFraud'].value_counts()

# Tạo biểu đồ hình tròn
plt.figure(figsize=(8, 8))
plt.pie(fraud_counts, labels=['Hợp lệ', 'Gian lận'], autopct='%1.2f%%', startangle=140, colors=['#76c7c0', '#ff5733'])

# Đảm bảo biểu đồ có tỷ lệ bằng nhau để hình tròn không bị méo
plt.axis('equal')

# Thêm tiêu đề
plt.title('Phân phối số lượng giao dịch hợp lệ và gian lận', fontsize=16, fontweight='bold')

plt.legend(fontsize=12)
# Hiển thị biểu đồ
plt.show()
```



phân phối dl

```
import matplotlib.pyplot as plt
import seaborn as sns

# Thiết lập cho seaborn và matplotlib
sns.set(style="whitegrid")

# 1. Biểu đồ phân phối cho các trường số
plt.figure(figsize=(14, 10))

# Đặt số lượng các biểu đồ cần vẽ
plt.subplot(2, 3, 1)
sns.histplot(df['step'], bins=50, kde=True, color='skyblue')
plt.title('Phân phối Step')

plt.subplot(2, 3, 2)
sns.histplot(df['amount'], bins=50, kde=True, color='salmon')
plt.title('Phân phối Amount')

plt.subplot(2, 3, 3)
sns.histplot(df['oldbalanceOrg'], bins=50, kde=True, color='green')
plt.title('Phân phối OldbalanceOrg')

plt.subplot(2, 3, 4)
sns.histplot(df['newbalanceOrig'], bins=50, kde=True, color='purple')
plt.title('Phân phối NewbalanceOrg')

plt.subplot(2, 3, 5)
sns.histplot(df['oldbalanceDest'], bins=50, kde=True, color='orange')
plt.title('Phân phối OldbalanceDest')

plt.subplot(2, 3, 6)
sns.histplot(df['newbalanceDest'], bins=50, kde=True, color='blue')
plt.title('Phân phối NewbalanceDest')

plt.tight_layout()
plt.show()

# 2. Biểu đồ phân loại cho trường 'type'
plt.figure(figsize=(8, 6))
sns.countplot(x='type', data=df, palette='viridis')
```

```
plt.title('Số lượng giao dịch theo loại', fontsize=16)
plt.xlabel('Loại giao dịch', fontsize=14)
plt.ylabel('Số lượng giao dịch', fontsize=14)
plt.xticks(rotation=45)
plt.show()

# 3. Biểu đồ scatter plot mối quan hệ giữa Amount và OldbalanceOrg
plt.figure(figsize=(8, 6))
sns.scatterplot(x='oldbalanceOrg', y='amount', data=df, hue='isFraud', palette='coolwarm', alpha=0.5)
plt.title('Mối quan hệ giữa Amount và OldbalanceOrg', fontsize=16)
plt.xlabel('OldbalanceOrg', fontsize=14)
plt.ylabel('Amount', fontsize=14)
plt.show()

# 4. Biểu đồ Boxplot cho mối quan hệ giữa Amount và isFraud
plt.figure(figsize=(8, 6))
sns.boxplot(x='isFraud', y='amount', data=df, palette='coolwarm')
plt.title('Mối quan hệ giữa Amount và isFraud', fontsize=16)
plt.xlabel('Gian lận (isFraud)', fontsize=14)
plt.ylabel('Amount', fontsize=14)
plt.show()

# 5. Biểu đồ Violin plot cho mối quan hệ giữa Type và Amount
plt.figure(figsize=(8, 6))
sns.violinplot(x='type', y='amount', data=df, palette='muted')
plt.title('Mối quan hệ giữa Type và Amount', fontsize=16)
plt.xlabel('Loại giao dịch', fontsize=14)
plt.ylabel('Amount', fontsize=14)
plt.show()

# 6. Biểu đồ mối quan hệ giữa isFraud và Type
plt.figure(figsize=(8, 6))
sns.countplot(x='type', hue='isFraud', data=df, palette='Set1')
plt.title('Sự phân bố giao dịch hợp lệ và gian lận theo loại giao dịch', fontsize=16)
plt.xlabel('Loại giao dịch', fontsize=14)
plt.ylabel('Số lượng giao dịch', fontsize=14)
plt.show()
```




```
<ipython-input-17-f917abfe30f1>:40: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False

  sns.countplot(x='type', data=df, palette='viridis')
```