

fraud-detection-in-transactions

April 10, 2024

1 Fraud Detection on Transactions

Data base: <https://www.kaggle.com/code/llabhishekll/fraud-transaction-detection/input>

The objective of this analysis, is to develop a model that can be capable of identifying if a transaction is a fraud or not. For that we'll do the following steps:

- Exploratory Analysis;
- Finding the features that have an important imoact to the fraud detection;
- Presenting the confusion matrix, accuracy, precision and recall scores;
- Develop models based on the KNN, Logistic Regression and Decision Tree algorithms;
- Make ajustments to the models so it can have a improved performance.

First things first we'll import the first tools and libraries that we will use, which are:

```
[1]: import pandas as pd
      import numpy as np
      import seaborn as sns
      import matplotlib.pyplot as plt
```

Now we are going to import our database and save it as **df**, short for DataFrame. And now we will see the first columns and rows with the **df.head()** method.

```
[2]: df = pd.read_csv('/kaggle/input/fraud-detection-on-transactions/
                     ↴PS_20174392719_1491204439457_log.csv')
      df.head()
```

```
[2]:   step      type    amount   nameOrig  oldbalanceOrg  newbalanceOrig \
0      1    PAYMENT  9839.64  C1231006815       170136.0      160296.36
1      1    PAYMENT  1864.28  C1666544295       21249.0      19384.72
2      1   TRANSFER   181.00  C1305486145        181.0         0.00
3      1   CASH_OUT   181.00  C840083671        181.0         0.00
4      1    PAYMENT  11668.14  C2048537720       41554.0      29885.86

      nameDest  oldbalanceDest  newbalanceDest  isFraud  isFlaggedFraud
0  M1979787155          0.0          0.0          0            0
1  M2044282225          0.0          0.0          0            0
2  C553264065           0.0          0.0          1            0
3  C38997010          21182.0          0.0          1            0
4  M1230701703          0.0          0.0          0            0
```

```
[3]: df.describe()
```

```
[3]:
```

	step	amount	oldbalanceOrg	newbalanceOrig	\
count	6.362620e+06	6.362620e+06	6.362620e+06	6.362620e+06	
mean	2.433972e+02	1.798619e+05	8.338831e+05	8.551137e+05	
std	1.423320e+02	6.038582e+05	2.888243e+06	2.924049e+06	
min	1.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	
25%	1.560000e+02	1.338957e+04	0.000000e+00	0.000000e+00	
50%	2.390000e+02	7.487194e+04	1.420800e+04	0.000000e+00	
75%	3.350000e+02	2.087215e+05	1.073152e+05	1.442584e+05	
max	7.430000e+02	9.244552e+07	5.958504e+07	4.958504e+07	

	oldbalanceDest	newbalanceDest	isFraud	isFlaggedFraud
count	6.362620e+06	6.362620e+06	6.362620e+06	6.362620e+06
mean	1.100702e+06	1.224996e+06	1.290820e-03	2.514687e-06
std	3.399180e+06	3.674129e+06	3.590480e-02	1.585775e-03
min	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
25%	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
50%	1.327057e+05	2.146614e+05	0.000000e+00	0.000000e+00
75%	9.430367e+05	1.111909e+06	0.000000e+00	0.000000e+00
max	3.560159e+08	3.561793e+08	1.000000e+00	1.000000e+00

```
[4]: df.columns
```

```
[4]: Index(['step', 'type', 'amount', 'nameOrig', 'oldbalanceOrg', 'newbalanceOrig',  
         'nameDest', 'oldbalanceDest', 'newbalanceDest', 'isFraud',  
         'isFlaggedFraud'],  
         dtype='object')
```

```
[5]: 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
```

To see if we have null values in the dataset lets use the `.isnull()` combined with `.any()` method, that will give us the following:

```
[6]: df.isnull().any()
```

```
[6]: step      False
type       False
amount     False
nameOrig   False
oldbalanceOrg  False
newbalanceOrig  False
nameDest    False
oldbalanceDest  False
newbalanceDest  False
isFraud     False
isFlaggedFraud  False
dtype: bool
```

Here we see our first big information, we do not have **any** null data on our dataset. For learning purposes, this is something you will probably not see in a day to day analysis, but if you do, that would save a lot of time, since you won't need to replace the data.

For better understanding of the data and to see where we can find fraudulent transactions, lets see all the types of Transactions that we have, using the `.unique()` method on the column type.

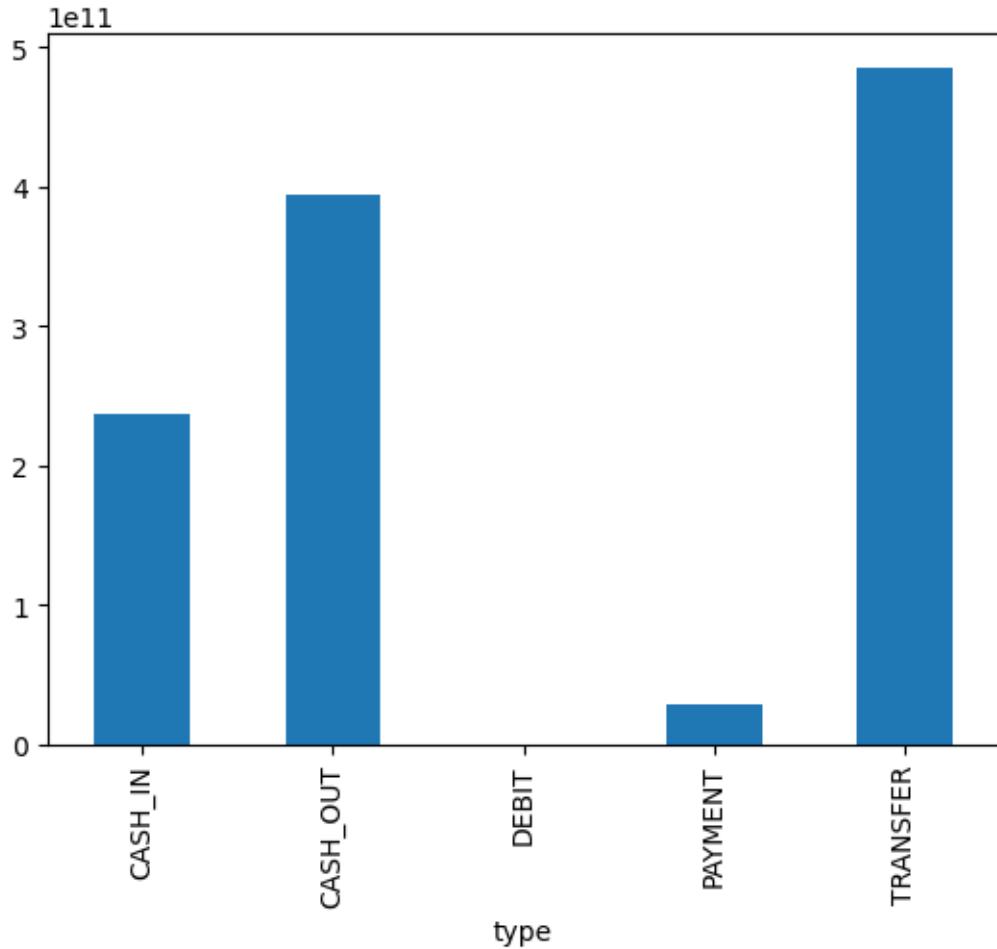
```
[7]: df['type'].unique()
```

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

Now that we know that there are only 5 types of payment on all the transactions, we can analyse the amount of money of each transaction on the dataset. With this we can have a better idea of where most of the frauds are happening. We will be using a bar plot to see this amounts, since it is easy to see 5 values in a bar chart.

```
[8]: barplot = df.groupby('type').amount.sum()
fig = plt.figure()
ex = fig.add_subplot(1,1,1)
barplot.plot(kind='bar')
```

```
[8]: <Axes: xlabel='type'>
```



Presumably we can notice that the payment and debit types are pretty much non present on our dataset, for better understanding, it means that they are more likely to not contain the fraudulent transactions since they are small in comparison to the others, debit in specific we can't even see.

To confirm that we can see how many frauds actually happen in these types of transactions compared to all of the frauds, let's do the following:

- Transform the data from Strings to Int so we can better analyse. We can make that with the method `.replace`
- Check and save how many frauds there is on our dataset and save it to the variable `sum_frauds`;
- Then, compare this total to the (debit + payment) sum of frauds.

```
[9]: df = df.replace(to_replace={'PAYMENT':1, 'TRANSFER':2, 'CASH_OUT':3, 'CASH_IN':4, 'DEBIT':5, 'No':0, 'Yes':1})
```

/tmp/ipykernel_18/3048883558.py:1: FutureWarning: Downcasting behavior in `replace` is deprecated and will be removed in a future version. To retain the

```
old behavior, explicitly call `result.infer_objects(copy=False)`. To opt-in to  
the future behavior, set `pd.set_option('future.no_silent_downcasting', True)`  
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':4,  
'DEBIT':5,'No':0,'Yes':1})
```

```
[10]: sum_frauds = (df["isFraud"] == 1).sum()  
print("Total frauds on the dataset: {}".format(sum_frauds))
```

Total frauds on the dataset: 8213.

```
[11]: debit_fraud_sum = df[(df['type'] == 5) & (df['isFraud'] == 1)].isFraud.sum()  
payment_fraud_sum = df[(df["type"] == 1) & (df["isFraud"] == 1)].isFraud.sum()  
sum_debit_payment = debit_fraud_sum + payment_fraud_sum  
print("Total sum of debit + payment frauds is: {}".format(sum_debit_payment))  
print("So for all the debits and payments we have a ratio of: 0:{} frauds.".format(sum_frauds))
```

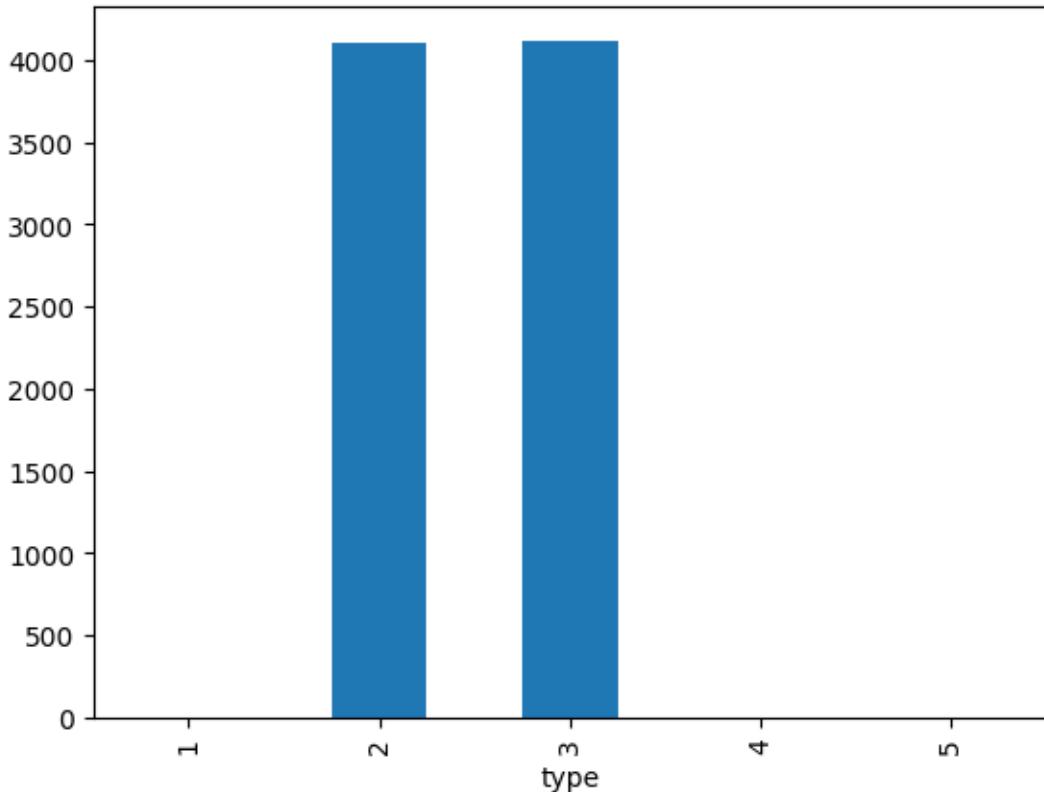
Total sum of debit + payment frauds is: 0.

So for all the debits and payments we have a ratio of: 0:8213 frauds.

Now, is there a better way to see if this also happens to the other types of transactions even if they are much more used? There actually is a way, we'll simply use the same bar plot as above to see this. But here, we will use the **isFraud** column to see each one of the types and if they are impacted by the frauds.

```
[12]: barplot = df.groupby('type').isFraud.sum()  
fig = plt.figure()  
ex = fig.add_subplot(1,1,1)  
barplot.plot(kind='bar')
```

```
[12]: <Axes: xlabel='type'>
```



Wow, that's interesting.

So why is this so discrepant? Some arguments for that, can be that, **Transfer** transactions are one of the most common practices of frauds in the world, which can happen in situations of impersonating families and friends asking for money, thieves stealing personal cards and cellphones, and so on. For the **Cash outs**, we have a lot of impersonating and ATM's devices to capture user cards information.

Lets sum all the fraud data and find out how many frauds there are in the Transfer and Cash_out methods.

Once there are just these two types of methods which are fraudulent, we can use the **sum_frauds** we used earlier.

So lets see how is the ratio of this frauds to the data that is not fraud, we can do that by dividing the **isFraud == 0**, by the **isFraud == 1** or the **sum_frauds** we saw earlier.

```
[13]: all_isFraud_data = (df["isFraud"] == 0).sum()
print("Ratio of frauds vs the whole data is 1:{}.".format(all_isFraud_data//
    sum_frauds))
```

Ratio of frauds vs the whole data is 1:773.

This is kinda concerning to the models we are going to train further on, since this shows that only

one fraud happens in each 773 cases, this can lead us to fall in a **overfitting** condition where our model will train with a disbalanced dataset, leading us to one side, the non fraudulent transaction, missclassifying our new data in the future.

Once we have a column **isFlaggedFraud** lets see if this is something that is already happening.

We can do this by divding **sum_frauds** by **isFlaggedFraud** and find the ratio just like we did above.

```
[14]: is_Flagged_Fraud = (df["isFlaggedFraud"] == 1).sum()
print("Ratio of flagged frauds vs the actual amount of frauds is 1:{}.".format(sum_frauds//is_Flagged_Fraud))
```

Ratio of flagged frauds vs the actual amount of frauds is 1:513.

Building our first model

For our first model, we will use our whole dataset, for training and testing, without any type of cleaning or changes to it. For comparison measures we will be using the 3 model type we saw at the beggining (KNN, Logistic Regression and Decision Tree). Lets import again our dataset and just transform the column types to numeric values so we can train the dataset.

```
[15]: df = pd.read_csv('/kaggle/input/fraud-detection-on-transactions/
                     PS_20174392719_1491204439457_log.csv')
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':
                           4,'DEBIT':5,'No':0,'Yes':1})
```

```
/tmp/ipykernel_18/3828529680.py:2: FutureWarning: Downcasting behavior in
`replace` is deprecated and will be removed in a future version. To retain the
old behavior, explicitly call `result.infer_objects(copy=False)`. To opt-in to
the future behavior, set `pd.set_option('future.no_silent_downcasting', True)`
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':4,
                           'DEBIT':5,'No':0,'Yes':1})
```

Now we import the libraries we will use. And we'll drop the 3 columns that do not have any impact on the data, which are:

- namOrig
- nameDest
- isFlaggedFraud

For explanation, the names' columns don't have any impact on the prediction, once frauds do not occur due to the name of the person. And the flaggedFraud is so irrelevant to the whole data that we can exclude it.

```
[16]: from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import mean_absolute_error
from sklearn.model_selection import train_test_split
from sklearn.metrics import average_precision_score
df.drop(["nameOrig", "nameDest", "isFlaggedFraud"], axis = 1, inplace = True)
```

```
[17]: X = df.drop(["isFraud"], axis =1)
y = df["isFraud"]

train_X, val_X, train_y, val_y = train_test_split(X, y, test_size = 0.20,random_state = 42)

dt_model = DecisionTreeClassifier()

dt_probabilities = dt_model.fit(train_X, train_y).predict(val_X)

print(average_precision_score(val_y, dt_probabilities))
```

0.785681084007651

```
[18]: from sklearn.neighbors import KNeighborsClassifier
knn_model = KNeighborsClassifier(n_neighbors=3)
knn_probabilities = knn_model.fit(X, y).predict(val_X)

print(average_precision_score(val_y, knn_probabilities))

#3 minutos e 21 segundos
```

0.7249732424412186

```
[19]: from sklearn.linear_model import LogisticRegression
lr_model = LogisticRegression(random_state = 42).fit(X, y)
lr_probabilities = lr_model.predict(val_X)

print(average_precision_score(val_y, lr_probabilities))

#51 segundos
```

0.14861328106736818

Insights

So, we saw that the best model is the decision tree classifier, since we were able to get a 78% score, which is actually a good score. But when we are dealing with frauds, we need it to be as close to 100% as possible so we can identify the frauds and act on it before its too late to do something.

How can we get better Scores?

Well we can act on various ways, such as:

- Delete some of our data that represents the side of the rating which is the non frauds data, to get a better ratio than 1:773;
- Add more data to our side of the rating which is the frauds data, making the rating go lower as well. We can do this by using methods like **SMOTE**, that creates syntactic data by taking the difference between a sample and its nearest neighbour multiplying the difference by a random number between 0-1 then add this difference to the sample to generate a new

synthetic example then continue on with next nearest neighbour up to user-defined number. We can even a rating that we aim.

- Study what the company wants and focus on only part of the data, getting better results, by stratifying the data. We can do that with the **stratified sample** statistic method.

We will try 2 out of the 3 strategies, the deleting of some of our data, and the SMOTE strategy.

Deleting Data This is not the safest bet to most of the cases but here we saw that we have some types of transactions that don't even have frauds, so we will be experimenting with deleting those types to see if we have a better ratio and a better model.

```
[20]: type_cashin = df[(df["type"] == 4)]
type_cashin = type_cashin.type.count()
print(type_cashin)
```

1399284

```
[21]: type_payment = df[(df["type"] == 1)]
type_payment = type_payment.type.count()
print(type_payment)
```

2151495

```
[22]: type_debit = df[(df["type"] == 5)]
type_debit = type_debit.type.count()
print(type_debit)
```

41432

```
[23]: sum_types = type_cashin + type_payment + type_debit
```

```
[24]: print("Ratio of frauds vs the whole data is 1:{}.".format(all_isFraud_data//sum_frauds))
print("New ratio of frauds vs the whole data is 1:{}.".format(sum_types//sum_frauds))
```

Ratio of frauds vs the whole data is 1:773.

New ratio of frauds vs the whole data is 1:437.

Right, we were able to reduce the ratio by 336, but is this enough to get our model to make a improvement? Lets check it.

```
[25]: df = pd.read_csv('/kaggle/input/fraud-detection-on-transactions/
                     PS_20174392719_1491204439457_log.csv')
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':
                           4,'DEBIT':5,'No':0,'Yes':1})
```

```
/tmp/ipykernel_18/3828529680.py:2: FutureWarning: Downcasting behavior in
`replace` is deprecated and will be removed in a future version. To retain the
old behavior, explicitly call `result.infer_objects(copy=False)`. To opt-in to
```

```
the future behavior, set `pd.set_option('future.no_silent_downcasting', True)`  
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':4,  
'DEBIT':5,'No':0,'Yes':1})
```

```
[26]: from sklearn.tree import DecisionTreeClassifier  
from sklearn.metrics import mean_absolute_error  
from sklearn.model_selection import train_test_split  
from sklearn.metrics import average_precision_score  
df.drop(["nameOrig", "nameDest", "isFlaggedFraud"], axis = 1, inplace = True)
```

Lets Drop the types which we analysed above to improve our ratio.

```
[27]: types_to_drop = [1, 4, 5]  
df = df.drop(df[df['type'].isin(types_to_drop)].index)
```

```
[28]: # DEFINING OUR TRAIN / TEST SPLIT  
X = df.drop(["isFraud"], axis =1)  
y = df["isFraud"]  
  
train_X, val_X, train_y, val_y = train_test_split(X, y, test_size = 0.20,  
random_state = 42)
```

```
[29]: # DECISION TREE  
dt_model = DecisionTreeClassifier()  
  
dt_probabilities = dt_model.fit(train_X, train_y).predict(val_X)  
  
print(average_precision_score(val_y, dt_probabilities))
```

0.7755177688209872

```
[30]: # KNN  
from sklearn.neighbors import KNeighborsClassifier  
knn_model = KNeighborsClassifier(n_neighbors=3)  
knn_probabilities = knn_model.fit(X, y).predict(val_X)  
  
print(average_precision_score(val_y, knn_probabilities))
```

0.7607221082855989

```
[31]: # LOGISTIC REGRESSION  
from sklearn.linear_model import LogisticRegression  
lr_model = LogisticRegression(random_state = 42).fit(X, y)  
lr_probabilities = lr_model.predict(val_X)  
  
print(average_precision_score(val_y, lr_probabilities))
```

0.21774139061899442

Thats something

Here we notice something strange, two of our models have now improved in the precision but the regression tree didn't, and why is that?

- Decision Tree, **was** 78% —> **now** 77%.
- KNN, **was** 72% —> **now** 76%.
- Logistic Regression, **was** 14% —> **now** 21%.

Well this can be a good example to show that each type of model has its own proprieties, one of this is the Randomness. Basically, a tree is a boolean decision making algorithm so for some reason if the data we deleted impacted in one of these decisions, it can change the whole scheme of a tree, making it not balanced, overfittet, or even underfittet and much more. So we can maybe infer that deleting a big chunk of the dataset can impact negatively in some of our models.

NEXT

Because this is a try and error exercise, we will continue to try the next method the **SMOTE**, and of course because we want to get our best model the **decision tree** to improve and not otherwise.

```
[32]: df = pd.read_csv('/kaggle/input/fraud-detection-on-transactions/  
    ↪PS_20174392719_1491204439457_log.csv')  
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':  
    ↪4,'DEBIT':5,'No':0,'Yes':1})
```

```
/tmp/ipykernel_18/3828529680.py:2: FutureWarning: Downcasting behavior in  
`replace` is deprecated and will be removed in a future version. To retain the  
old behavior, explicitly call `result.infer_objects(copy=False)`. To opt-in to  
the future behavior, set `pd.set_option('future.no_silent_downcasting', True)`  
df = df.replace(to_replace={'PAYMENT':1,'TRANSFER':2,'CASH_OUT':3,'CASH_IN':4,  
'DEBIT':5,'No':0,'Yes':1})
```

```
[33]: from sklearn.tree import DecisionTreeClassifier  
from sklearn.metrics import mean_absolute_error  
from sklearn.model_selection import train_test_split  
from sklearn.metrics import average_precision_score  
from imblearn.over_sampling import SMOTE  
df.drop(["nameOrig", "nameDest", "isFlaggedFraud"], axis = 1, inplace = True)
```

```
[34]: # Ratio of non-fraud to fraud data points  
ratio = 300  
  
# Separate features (X) and target variable (y)  
X = df.drop(["isFraud"], axis=1)  
y = df["isFraud"]  
  
# Apply SMOTE to balance the classes  
smote = SMOTE(sampling_strategy={1: len(df[df['isFraud'] == 0]) // ratio})  
X_resampled, y_resampled = smote.fit_resample(X, y)
```

```
# Split data into training and validation sets
train_X, val_X, train_y, val_y = train_test_split(X_resampled, y_resampled, test_size=0.20, random_state=42)
```

```
[35]: # Train Decision Tree model
dt_model = DecisionTreeClassifier()

dt_val_predictions = dt_model.fit(train_X, train_y).predict(val_X)

# Calculate average precision score
print(average_precision_score(val_y, dt_val_predictions))
```

0.878169859109426

```
[36]: # KNN
from sklearn.neighbors import KNeighborsClassifier
knn_model = KNeighborsClassifier(n_neighbors=3)
knn_probabilities = knn_model.fit(train_X, train_y).predict(val_X)

print(average_precision_score(val_y, knn_probabilities))
```

0.7313364967923548

```
[37]: # LOGISTIC REGRESSION
from sklearn.linear_model import LogisticRegression
lr_model = LogisticRegression(random_state = 42).fit(X, y)
lr_probabilities = lr_model.predict(val_X)

print(average_precision_score(val_y, lr_probabilities))
```

0.25456153180892327

Now Thats Better

We now saw that we have a huge improvement in the decision tree model and the logistic regression as well.

- Decision Tree, **was** 78% —> **now** 88%
- KNN, **was** 72% —> **now** 72%
- Logistic Regression, **was** 14% —> **now** 25%

And why did we have such a big improvement?

Well here is the basic on how SMOTE works and how we've implemented it:

- We define a variable **ratio** which represents an int number that we want the model to be within 1:**ratio** variable.

- Defining the ratio to 300 we already improved our past try where we got a 1:437 ratio. But didnt we see that only this doesn't prove that the model will improve?
- **Right**, but that's where SMOTE comes in, smote is a technique where it creates syntetic data for the part of the ratio that is on disadvantage.
- So we didn't delete any data like before, we actually created data to balance the dataset.
- With that we can improve the ratio to a satisfying margin where we don't fall into the overfitting as well.

At last, lets see the Confusion Matrix, precision, recall and accuracy of our model

```
[38]: from sklearn.metrics import confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
```

```
[39]: # FOR THE DECISION TREE MODEL
print("DECISION TREE")
print("Confusion Matrix: \n", confusion_matrix(val_y, dt_val_predictions))
print("-" * 20)
print("Accuracy Score: ", accuracy_score(val_y, dt_val_predictions))
print("-" * 20)
print("Precision Score: ", precision_score(val_y, dt_val_predictions))
print("-" * 20)
print("Recall Score: ", recall_score(val_y, dt_val_predictions))
```

DECISION TREE
Confusion Matrix:
[[1270622 291]
 [242 3963]]

Accuracy Score: 0.9995819994698529

Precision Score: 0.9315937940761636

Recall Score: 0.9424494649227111

```
[40]: # FOR THE KNN MODEL
print("KNN")
print("Confusion Matrix: \n", confusion_matrix(val_y, knn_probabilities))
print("-" * 20)
print("Accuracy Score: ", accuracy_score(val_y, knn_probabilities))
print("-" * 20)
print("Precision Score: ", precision_score(val_y, knn_probabilities))
print("-" * 20)
print("Recall Score: ", recall_score(val_y, knn_probabilities))
```

KNN

```

Confusion Matrix:
[[1270296      617]
 [   605     3600]]
-----
Accuracy Score:  0.9990416573211264
-----
Precision Score:  0.8536874555371117
-----
Recall Score:  0.8561236623067776

```

```
[41]: # FOR THE LOGISTIC REGRESSION MODEL
print("LOGISTIC REGRESSION")
print("Confusion Matrix: \n", confusion_matrix(val_y, lr_probabilities))
print("-" * 20)
print("Accuracy Score: ", accuracy_score(val_y, lr_probabilities))
print("-" * 20)
print("Precision Score: ", precision_score(val_y, lr_probabilities))
print("-" * 20)
print("Recall Score: ", recall_score(val_y, lr_probabilities))
```

```

LOGISTIC REGRESSION
Confusion Matrix:
[[1269692      1221]
 [   2417     1788]]
-----
Accuracy Score:  0.9971469307154318
-----
Precision Score:  0.5942173479561316
-----
Recall Score:  0.4252080856123662

```

WHAT DO WE SEE HERE?

Well here we see 4 measures the confusion matrix, the accuracy score, precision score and the recall score, lets find out what each one of them represents. For that we will use the 4 measures of the **decision tree** which was the best model out of the 3 we used.

- **Confusion Matrix:** Here, we can see 4 numbers representing the following

```

[[TN FP]
 [ FN TP]]
```

That means that our model correctly predicted 1270631 Actually negative data and 3932 actually positive data. That shows us first that the model is clearly still misbalanced were we have a lot more negative values, but that our model was able to predict a good amount of actually positive fraudulent data, much better than the initial stats we had at the beginning.

- **Accuracy Score:** The accuracy score is a beautiful number to look at but doesn't necessarily shows us the impact of our model, that is, because the accuracy is highly influenced by the imbalanced data, which is our case, so even when we fail to correctly classify a data, the

model is still pending to the other side of the data.

- **Precision Score:** This score tells us how often our Positive class actually was correct, by taking all of the True positive data that it classified and dividing by the sum of TP + FP, with a closer answer to 1 we can infer that the model is getting a lot of correct classification which is good for our business. And it is a good measurement for imbalanced data.
- **Recall Score:** Recall is one of the best measurements to know how well our model is actually doing. It takes all the TP data and divide it by the sum of TP + FN, that basically gives us the true percentage of how many true positives data we could identify within all the actually positive data. With the 93% we could idendify 93 percent of the data that was frauded. And it also works well with imbalanced data.

The End

We saw and extracted a lot of information from this database and this situation here is some of the important data:

- Cash-IN, Debit and Payment doesn't have any fraud to their name. That can show the client where to focus and where to act on frauds.
- We have an extremly imbalanced data, that can be bad for our model. But with strategies like SMOTE we were able to get the dataset to a better ratio and was able to get a better performance model.
- We saw the problem of the current strategies implemented to detect frauds where it detected only 1:513 frauds that acutually was happening.
- We were able to eliminate columns that didn't have nothing to do with our fraud identification, like the names of the people doing the transaction and the isFlaggedFraud columns.