Set up packages and Kaggle connection

In [4]:

```
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.ensemble import StackingClassifier
import xgboost as xgb
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import cv2
import os
from tqdm import tqdm
import xgboost as xgb
from lightgbm import LGBMClassifier
from scipy.stats import jarque_bera
from scipy.special import logit, expit
```

```
/opt/anaconda3/envs/tf2/lib/python3.7/importlib/_bootstrap.py:219: RuntimeWarn
ing: numpy.ufunc size changed, may indicate binary incompatibility. Expected 1
92 from C header, got 216 from PyObject
  return f(*args, **kwds)
```

In [5]:

```
import seaborn as sns
import gc
import logging
import datetime
import lightgbm as lgb
from tqdm import tqdm_notebook
from sklearn.metrics import mean_squared_error
from sklearn.metrics import roc_auc_score, roc_curve
from sklearn.model_selection import StratifiedKFold
from sklearn.model_selection import train_test_split

import warnings
warnings.filterwarnings('ignore')
```

```
/opt/anaconda3/envs/tf2/lib/python3.7/importlib/_bootstrap.py:219: RuntimeWarn
ing: numpy.ufunc size changed, may indicate binary incompatibility. Expected 1
92 from C header, got 216 from PyObject
  return f(*args, **kwds)
```

In [6]:
```
from sklearn.model_selection import cross_val_score, train_test_split
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay, Precisi
from sklearn.metrics import classification_report
from sklearn import preprocessing
from sklearn import linear_model
from sklearn import metrics
from sklearn.naive_bayes import CategoricalNB,GaussianNB

import scikitplot as skplt
import tensorflow as tf
import random

from tensorflow.keras import backend as K
from tensorflow.keras.models import Sequential
from tensorflow.keras.datasets import mnist
from tensorflow.keras.layers import Dense, Activation, Dropout
from tensorflow.keras.utils import to_categorical
```

In [2]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [3]:
```
from google.colab import files
files.upload()
```

选取文件 未选择文件 Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving kaggle.json to kaggle.json
```

Out[3]:
```
{'kaggle.json': b'{"username":"jacobbraun","key":"392939438edcd0495f527be30174
d4ca"}'}
```

In [4]:
```
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle/
!chmod 600 /root/.kaggle/kaggle.json

!kaggle competitions download -c santander-customer-transaction-prediction
```

```
Downloading santander-customer-transaction-prediction.zip to /content
 99% 247M/250M [00:03<00:00, 80.1MB/s]
100% 250M/250M [00:03<00:00, 68.2MB/s]
```

In [5]:
```
!unzip santander-customer-transaction-prediction
```

```
Archive:  santander-customer-transaction-prediction.zip
  inflating: sample_submission.csv
  inflating: test.csv
  inflating: train.csv
```

Data Exploration

In [6]:

```
train = pd.read_csv('train.csv')
test = pd.read_csv('test.csv')
```

Check for missing values:

In [7]:

```
train.isna().sum().sum(), test.isna().sum().sum()
```

Out[7]:

```
(0, 0)
```

Isolate the features (drop ID_code and outcome variable)

In [8]:

```
x_train = train.drop(['ID_code', 'target'], axis=1)
x_test = train.drop(['ID_code'], axis=1)
```

Check correlation matrices in the training and testing sets

In [9]:

```
# Create a correlation matrix for the features
corr_mat = x_train.corr()
# Fill the diagonal with 0's since each variable is correlated with itself
np.fill_diagonal(corr_mat.values, 0)
# Take the absolute value of the correlations and find the max
corr_mat = abs(corr_mat)
corr_mat.max().max()
```

Out[9]:

```
0.009844361358419583
```

In [10]:

```
# Create a correlation matrix for the features
corr_mat_test = x_test.corr()
# Fill the diagonal with 0's since each variable is correlated with itself
np.fill_diagonal(corr_mat_test.values, 0)
# Take the absolute value of the correlations and find the max
corr_mat_test = abs(corr_mat)
corr_mat_test.max().max()
```

Out[10]:

```
0.009844361358419583
```

Check the distributions of each variable

In [11]:

```
x_train.hist(figsize=(155,200))
```

Out[11]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x7f7924932990>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f792453b810>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f7924e89310>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f7924b01250>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f7924666ad0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f79242afd50>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f79241f0410>,
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        <matplotlib.axes._subplots.AxesSubplot object at 0x7f792142eed0>]],
      dtype=object)
```

Find the unique values in the training dataset:

In [12]:

```
# Training set
num_unique = x_train.nunique(axis=0)
prop_unique = x_train.nunique(axis=0)/200000
num_unique.mean(), prop_unique.mean()
```

Out[12]:

```
(97906.72, 0.4895336000000001)
```

Find the unique values in the test dataset:

In [13]:

```
# Testing set
num_unique = x_test.nunique(axis=0)
prop_unique = x_test.nunique(axis=0)/200000
num_unique.mean(), prop_unique.mean()
```

Out[13]:

```
(97419.63184079602, 0.4870981592039802)
```

Feature Engineering

In [14]:

```
train = pd.read_csv('train.csv')
test = pd.read_csv('test.csv')
```

In [15]:

```
# Generate new features to check if each value is unique within each original
# column

col_names = [f'var_{i}' for i in range(200)]
for column in tqdm(col_names):
  c = test[column].value_counts()
  u = c.index[c == 1]
  test[column + '_u'] = test[column].isin(u)
```

```
 48%|████▊     | 96/200 [00:01<00:02, 49.99it/s]/usr/local/lib/python3.7/dist-
packages/ipykernel_launcher.py:8: PerformanceWarning: DataFrame is highly frag
mented.  This is usually the result of calling `frame.insert` many times, whic
h has poor performance.  Consider joining all columns at once using pd.concat(
axis=1) instead.  To get a de-fragmented frame, use `newframe = frame.copy()`

100%|██████████| 200/200 [00:04<00:00, 48.08it/s]
```

In [16]:

```
# Add a column checking if at least one feature is unique for each row
test['unique'] = test[[column + '_u' for column in col_names]].any(axis=1)
```

In [17]:

```
# Separate out real test data and fake test data
test_real = test.loc[test.unique, ['ID_code'] + col_names]
test_fake = test.loc[~test.unique, ['ID_code'] + col_names]
```

In [18]:

```
len(test_real), len(test_fake)
```

Out[18]:

```
(100000, 100000)
```

In [19]:

```
# Combine all the 'real' data from the training and testing set so we can see
# there are any fakes once they're combined

realTrTe = pd.concat([train, test_real], axis = 0)
```

In [20]:

```
# Generate another set of binary features to check if each value is unique
# within each original feature column
for column in tqdm(col_names):
  c = realTrTe[column].value_counts()
  u = c.index[c == 1]
  realTrTe[column + '_unique'] = realTrTe[column].isin(u)*1
  test_fake[column + '_unique'] = 0
```

```
 48%|█████      | 97/200 [00:03<00:03, 26.44it/s]/usr/local/lib/python3.7/dist-
packages/ipykernel_launcher.py:6: PerformanceWarning: DataFrame is highly frag
mented.  This is usually the result of calling `frame.insert` many times, whic
h has poor performance.  Consider joining all columns at once using pd.concat(
axis=1) instead.  To get a de-fragmented frame, use `newframe = frame.copy()`

/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:7: PerformanceWar
ning: DataFrame is highly fragmented.  This is usually the result of calling `
frame.insert` many times, which has poor performance.  Consider joining all co
lumns at once using pd.concat(axis=1) instead.  To get a de-fragmented frame,
use `newframe = frame.copy()`
  import sys
100%|██████████| 200/200 [00:08<00:00, 24.53it/s]
```

In [21]:

```
# From the combined set, isolate the real test values
test_real = realTrTe[realTrTe['ID_code'].str.contains('test')].copy()
test_real.drop(['target'], axis=1, inplace=True)

# Create a 'train' df with the new unique identifying features
# Create a 'test' df, combining the real and fake testing features
train = realTrTe[realTrTe['ID_code'].str.contains('train')].copy()
test = pd.concat([test_real, test_fake], axis=0)
```

Create training, validation and testing splits

In [22]:

```
df_train, df_val = train_test_split(train, random_state=123, train_size=0.85)

# Split the training data into X and Y dataframes
X = df_train.iloc[:, 2:]
Y = df_train['target']

X_val = df_val.iloc[:, 2:]
Y_val = df_val['target']



# Create the testing dataset for prediction
X_test = test.drop('ID_code', axis=1)

# scaler = StandardScaler()

# X = scaler.fit_transform(X)
# X_test = scaler.fit_transform(X)
```

Model Building

We tried 5 techniques and built 16 models. For brevity, we only listed best models for each technique. We can provide other model's code if in need.

Boosting -- LightGBM

Score: 0.89484

In [ ]:

```
lgbm_model = LGBMClassifier(**{
     'learning_rate': 0.04,
     'num_leaves': 31,
     'max_bin': 1023,
     'min_child_samples': 1000,
     'reg_alpha': 0.1,
     'reg_lambda': 0.2,
     'feature_fraction': 1.0,
     'bagging_freq': 1,
     'bagging_fraction': 0.85,
     'objective': 'binary',
     'n_jobs': -1,
     'n_estimators':400,
     'class_weight':{0:1, 1:0.1}})
```

In [ ]:

```
lgbm_model.fit(X, Y)
```

In [ ]:

```
y_pred_lgbm = lgbm_model.predict_proba(X_test)[:,1]
submission_lgbm = pd.DataFrame({"ID_code": test.iloc[:,0]})
submission_lgbm["target"] = y_pred_lgbm
submission_lgbm.to_csv("submission_lgbm.csv", index=False)
```

Boosting -- CatBoost

Score: 0.89870

In [ ]:

```
from catboost import CatBoostClassifier

cat_model = CatBoostClassifier(scale_pos_weight=1/11)
cat_model.fit(X, Y)

y_pred_cat = cat_model.predict_proba(X_test)[:,1]
submission_cat = pd.DataFrame({"ID_code": test.iloc[:,0]})
submission_cat["target"] = y_pred_cat
submission_cat.to_csv("submission_cat.csv", index=False)
```

Neural Network -- CNN

Score: 0.87297

In [ ]:

```
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=.3,random_
```

In [ ]:

```
N_units = 400
kernel_size=2
strides=2
cnn_model = Sequential()
cnn_model.add(Conv1D(N_units, kernel_size=kernel_size, strides=strides, paddi
                     activation='relu', input_shape=(X.shape[1], 1)))
cnn_model.add(Flatten())
cnn_model.add(Dense(1, activation = 'sigmoid'))

cnn_model.summary()
```

In [ ]:

```
epochs = 10
LR_callback = keras.callbacks.ReduceLROnPlateau(monitor='val_accuracy', patie
EarlyStop_callback = keras.callbacks.EarlyStopping(monitor='val_accuracy', pa
my_callback=[EarlyStop_callback, LR_callback]

cnn_model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['acc
cnn_model.fit(X_train, y_train,
              validation_data=(X_test, y_test),
              epochs=epochs,
              verbose=2,
              callbacks = my_callback,
              )
```

In [ ]:

```
y_pred_cnn = cnn_model.predict(X_test)
```

In [ ]:

```
submission_cnn = pd.DataFrame({"ID_code": test.iloc[:,0]})
submission_cnn["target"] = y_pred_cnn
submission_cnn.to_csv("submission_cnn.csv", index=False)
# score: 0.875
```

Stacking Model

Score: 0.89434

In [ ]:

```
# initializing all the base model objects with default parameters
model_1 = xgb.XGBClassifier(max_depth=25,
                            verbose=1)

model_2 = LGBMClassifier(**{
     'learning_rate': 0.04,
     'n_estimators':200})

model_3 = RandomForestClassifier()

# putting all base model objects in one list
all_models = [('xgb', model_1), ('lgbm', model_2), ('rf', model_3)]

# create meta model
final_lr = LogisticRegression(class_weight='balanced', # Help with imbalanced
                              solver='newton-cg')

# stacked model
stack = StackingClassifier(estimators=all_models,
                           final_estimator=final_lr,
                           cv=3,
                           stack_method='predict_proba',
                           passthrough=True, # Train final model on predictio
                           verbose=1)
```

In [ ]:

```
# Fit the stacking model
stack.fit(X, Y)
```

In [ ]:

```
# Generate predictions from the testing dataset
y_pred = stack.predict_proba(X_test)[:,1]
```

In [ ]:

```
# Create the submission file
submission = pd.DataFrame({"ID_code": test.iloc[:,0]})
submission["target"] = y_pred
submission.to_csv("submission.csv", index=False)
```

Ensemble 200 Models

Score: 0.88764

- each time use one original feature and corresponding frequency feature to build a model
- then use logit transfer the prediction of probability got from one model and sum up these result from 200 models
- then get mean of these result from 200 models and use exp to transfer into probability

In [ ]:

```
#features = [x for x in X_train.columns if x.startswith("var")]
features = X.columns[0:200].to_list()

pred = 0
for var in features:
    model = lgb.LGBMClassifier(**{'learning_rate': 0.05,
                                  'max_bin': 165,
                                  'max_depth': 5,
                                  'min_child_samples': 150,
                                  'min_child_weight': 0.1,
                                  'min_split_gain': 0.0018,
                                  'n_estimators': 41,
                                  'num_leaves': 6,
                                  'reg_alpha': 2.0,
                                  'reg_lambda': 2.54,
                                  'objective': 'binary',
                                  'n_jobs': -1})
    var_count_name = var + '_unique'
    model = model.fit(np.hstack([X[var].values.reshape(-1, 1),
                           X[var_count_name].values.reshape(-1, 1)]), Y.values)
    pred += logit(model.predict_proba(np.hstack([X_test[var].values.reshape(-
                      X_test[var_count_name].values.reshape(-1, 1)]))[:, 1])

#pd.DataFrame({"ID_code": test_id, "target": pred}).to_csv("submission3.csv",
b = pd.DataFrame({"ID_code": test['ID_code'], "target": pred})
```

In [ ]:

```
b['target'] = np.exp(b['target']/200)
```

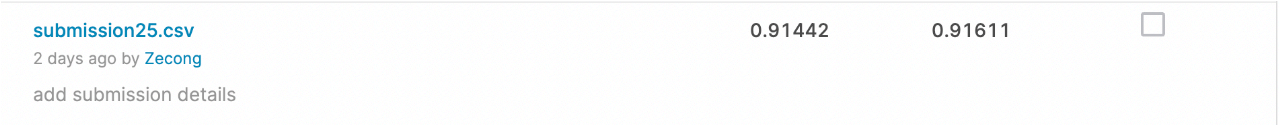
In [ ]:

```
b.to_csv("submission8.csv", index = False)
```

Best Model

Ensemble 200 Stacking Models

Score: 0.91611



submission25.csv 0.91442 0.91611 □
2 days ago by Zecong
add submission details

In [ ]:

```
#features = [x for x in X_train.columns if x.startswith("var")]
features = X.columns[0:200].to_list()

pred = 0
for var in features:
    print(var)
    model_1 = CatBoostClassifier(scale_pos_weight=1/11)
    #model_1 = LogisticRegression(class_weight='balanced',solver='newton-cg',

    model_2 = xgb.XGBClassifier()
    #model_3 = RandomForestClassifier(n_estimators=250, min_samples_split=20)
    model_4 = LGBMClassifier()

    var_count_name = var + '_unique'
    all_models = [('cat', model_1), ('xgb', model_2), ('lgbm', model_4)]
    #all_models = [('lr', model_1), ('xgb', model_2), ('rf', model_3), ('lgbm
     # create meta model
    final_lr = LogisticRegression(class_weight='balanced', solver='newton-cg'

    # stacked model
    stack = StackingClassifier(estimators=all_models,
                           final_estimator=final_lr,
                           cv=None,
                           stack_method='predict_proba',
                           n_jobs=-1,
                           passthrough=True, # Train final model on predictio
                           verbose=1)

    model = stack.fit(np.hstack([X[var].values.reshape(-1, 1),
                      X[var_count_name].values.reshape(-1, 1)]), Y.values)
    #print(model.predict_proba(np.hstack([X_test[var].values.reshape(-1, 1),X

    val_pred += model.predict_proba(np.hstack([X_val[var].values.reshape(-1,
                  X_val[var_count_name].values.reshape(-1, 1)]))[:, 1]
    val_pred_prob = val_pred/200
    pred += model.predict_proba(np.hstack([X_test[var].values.reshape(-1, 1),
                  X_test[var_count_name].values.reshape(-1, 1)]))[:, 1]
    #pred_prob = pred/200
```

In [ ]:

```
b = pd.DataFrame({"ID_code": test['ID_code'], "target": pred/200})
```

In [ ]:

```
b.to_csv("submission25.csv", index = False)
```

Business Value Analysis

draw ROC curve on validation dataset

In [23]:

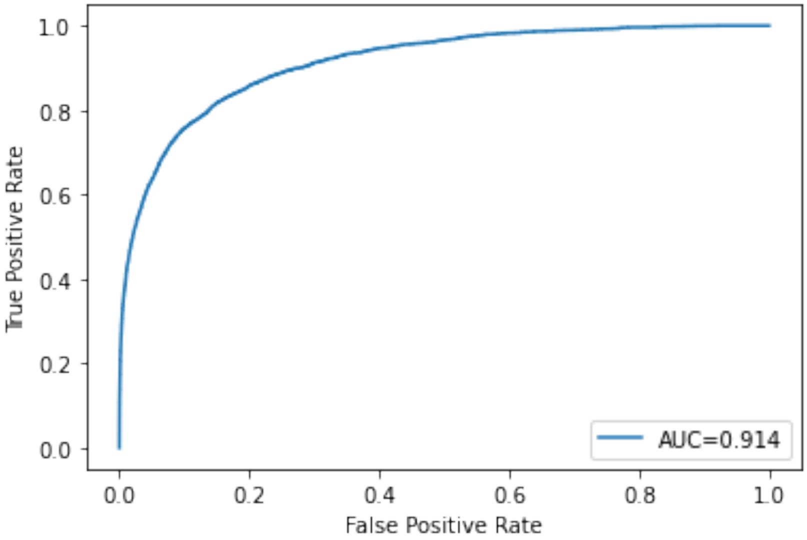
```
fpr, tpr, thresholds = metrics.roc_curve(Y_val, val_pred_prob, pos_label=1)
auc_score = round(metrics.auc(fpr, tpr), 4)
print('AUC score:', auc_score)
```

```
AUC score: 0.9138
```

In [16]:

```
auc = metrics.roc_auc_score(Y_val, val_pred_prob)

#create ROC curve
plt.plot(fpr,tpr,label="AUC="+str(round(auc,3)))
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.legend(loc=4)
plt.show()
```



In [102…

```
cost_matrix = np.array([[10, -100], [-20, 100]])
```

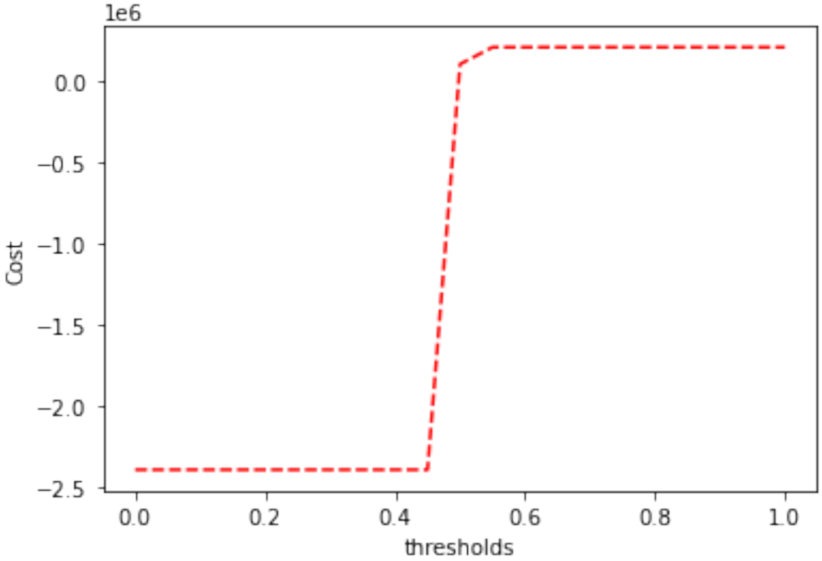
In [103…

```
Cost_List=np.linspace(0, 1.0, num=21)
thresholds = np.linspace(0, 1.0, num=21)
index=0

for t in thresholds:
    predict_thre = np.where(val_pred_prob > t, 1, 0)  ##prediction based on t
    clf_matrix = confusion_matrix(Y_val, predict_thre)
    Cost_List[index] = clf_matrix[0][0]*cost_matrix[0][0]+clf_matrix[0][1]*co
    index+=1
    #print(predict_thre)
#y_pred = np.where(y_pred_prob>=0.5, 1, 0)
plt.figure(1)
plt.plot(thresholds, Cost_List, 'r--')
plt.xlabel("thresholds")
plt.ylabel("Cost")
plt.show()

cost_tb = pd.DataFrame({'threshold':thresholds, 'cost':Cost_List}).sort_value
min_thres = cost_tb['threshold'].iloc[0]
min_cost = cost_tb['cost'].iloc[0]

print('Minimal cost is: {} with using threshold {}'.format(min_cost, min_thre
```



```
Minimal cost is: -2394800.0 with using threshold 0.0
```

In [ ]: