Содержание

Отток клиентов

Из «Бета-Банка» стали уходить клиенты. Каждый месяц. Немного, но заметно. Банковские маркетологи посчитали: сохранять текущих клиентов дешевле, чем привлекать новых.

Нужно спрогнозировать, уйдёт клиент из банка в ближайшее время или нет. Вам предоставлены исторические данные о поведении клиентов и расторжении договоров с банком.

Источник данных: https://www.kaggle.com/barelydedicated/bank-customer-churn-modeling

Подготовка данных

Нам представлены данные Банка, чтоб разобраться в действиях уходящих клиентов. целью данногь исследования является изучение поведения уходящих клиентов банка для удерживание их.

```
pip install pandas-profiling
```

```
Requirement already satisfied: pandas-profiling in /opt/conda/lib/python3.9/site-packages (3.6.6)
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Requirement already satisfied: packaging>=21.3 in /opt/conda/lib/python3.9/site-packages (from statsmodels<0.14,>=0.13.2-
Note: you may need to restart the kernel to use updated packages.
```

```
import pandas as pd
import matplotlib.pyplot as plt
from pandas_profiling import ProfileReport
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import f1_score
from sklearn.utils import shuffle
import numpy as np
from sklearn.metrics import precision_score, recall_score
from sklearn.metrics import roc_auc_score
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint
from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score
from sklearn import metrics
```

```
/tmp/ipykernel_122/1856855038.py:3: DeprecationWarning: `import pandas_profiling` is going to be deprecated by April 1st.
  from pandas_profiling import ProfileReport
```

Успех👍:

Хороший шаг - импортировать все необходимые библиотеки перед работой с проектом, ведь так ты точно не запутаешься в том, какие библиотеки ты уже импортировал, а какие стоит добавить. Молодец!

```
data = pd.read_csv('/datasets/Churn.csv')
```

```
data.head()
```

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActive
0	1	15634602	Hargrave	619	France	Female	42	2.0	0.00	1	1	
1	2	15647311	Hill	608	Spain	Female	41	1.0	83807.86	1	0	
2	3	15619304	Onio	502	France	Female	42	8.0	159660.80	3	1	
3	4	15701354	Boni	699	France	Female	39	1.0	0.00	2	0	
4	5	15737888	Mitchell	850	Spain	Female	43	2.0	125510.82	1	1	

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 14 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   RowNumber        10000 non-null  int64  
 1   CustomerId       10000 non-null  int64  
 2   Surname          10000 non-null  object 
 3   CreditScore      10000 non-null  int64  
 4   Geography        10000 non-null  object 
 5   Gender           10000 non-null  object 
 6   Age              10000 non-null  int64  
 7   Tenure           9091 non-null   float64
 8   Balance          10000 non-null  float64
 9   NumOfProducts    10000 non-null  int64  
 10  HasCrCard        10000 non-null  int64  
 11  IsActiveMember   10000 non-null  int64  
 12  EstimatedSalary  10000 non-null  float64
 13  Exited           10000 non-null  int64  
dtypes: float64(3), int64(8), object(3)
memory usage: 1.1+ MB
```

```
data.describe()
```

	RowNumber	CustomerId	CreditScore	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActiveMember
count	10000.00000	1.000000e+04	10000.000000	10000.000000	9091.000000	10000.000000	10000.000000	10000.00000	10000.000000

```
# ProfileReport(data)
```

в датасете около 9 процентов пропусков в столбце Tenure. заметим корреляцию между уходом клиентов и возростом и количеством используемых продуктов.

25%	2500.75000	1.562853e+07	584.000000	32.000000	2.000000	0.000000	1.000000	0.00000	0.000000

```
data.Tenure.isna().sum()
```

```
909
```

max	10000.00000	1.581569e+07	850.000000	92.000000	10.000000	250898.090000	4.000000	1.00000	1.000000

```
data.Tenure.describe()
```

```
count    9091.000000
mean        4.997690
std         2.894723
min         0.000000
25%         2.000000
50%         5.000000
75%         7.000000
max        10.000000
Name: Tenure, dtype: float64
```

```
data.loc[data.Exited == 0, 'Tenure'].isna().sum()
```

```
726
```

80% пропусков в столбце Tenure у клиентов, кто покинул банк.поэтому мыне можем удалить их, заменять средним значением не целеособразно, так как мы не можем сказать, после скольких лет клиент отказался от услаги банка, заполним эти данные 0

```
data = data.dropna(subset=['Tenure'])
```

удалим данные с пропусками, так как они составляют около 9 %

```
data.Tenure.isna().sum()
```

```
0
```

```
data.duplicated(subset='CustomerId').sum()
```

```
0
```

у нас нет дубликатов по Id клиентов

Исследование задачи

разделим выборки на три части: train, test, valid

```
data.Gender = pd.get_dummies(data.Gender, drop_first=True)
data.Geography = pd.get_dummies(data, drop_first=True)
```

```
features = data.drop(['Exited', 'Surname','RowNumber','CustomerId'], axis=1)
```

удалил категориальные переменные для проведения исследования

```
target = data.Exited
```

```
features_train, features_test, target_train, target_test =  train_test_split\
            (features, target, test_size=0.4, random_state=12345)
```

```
features_test, features_valid, target_test, target_valid = train_test_split\
            (features_test, target_test, test_size=0.5, random_state=12345)
```

```
numeric = ['CreditScore', 'Age', 'Tenure', 'Balance','EstimatedSalary','NumOfProducts']


pd.options.mode.chained_assignment = None
scaler = StandardScaler()
scaler.fit(features_train[numeric])

features_train[numeric] = scaler.transform(features_train[numeric])
features_valid[numeric] = scaler.transform(features_valid[numeric])
features_test[numeric] = scaler.transform(features_test[numeric])


features_test.shape
```

```
(1818, 10)
```

```
features_valid.shape
```

```
(1819, 10)
```

```
features_train.shape
```

```
(5454, 10)
```

```
best_result = 0
best_leaf = 0
for depth in range(2, 15, 3):
    for leaf in range(1, 201, 10):
        model_decision_tree = DecisionTreeClassifier(criterion = 'entropy',random_state=12345, max_depth=depth, min_samples_le
        model_decision_tree.fit(features_train, target_train)
        predictions_valid = model_decision_tree.predict(features_valid)
        result = f1_score(target_valid, predictions_valid)
        if result > best_result:
            best_result = result
            best_leaf = leaf

print('min_samples_leaf =', leaf)
print('max_depth =', depth, ':',best_result)
print("F1:", f1_score(target_valid, predictions_valid))
probabilities_valid = model_decision_tree.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]

auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
min_samples_leaf = 191
max_depth = 14 : 0.5403624382207578
F1: 0.46296296296296297
Roc-Auc: 0.7937539299937121
```

```
confusion_matrix(target_valid,predictions_valid)
```

```
array([[1404,   64],
       [ 226,  125]])
```

попробуем обучить модель без баланса классов

```
model = LogisticRegression(random_state=12345)
model.fit(features_train,target_train)
predicted_valid = model.predict(features_valid)
print("F1:", f1_score(target_valid, predicted_valid))
probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
F1: 0.2557077625570776
Roc-Auc: 0.7661857518805748
```

значение F1-меры снизилось

при дисбалансе классов значение F1-меры уменьшается

Борьба с дисбалансом

DecisionTreeClassifier

значение F1-меры низкое, попробуем ее увеличить

```
best_result = 0
best_leaf = 0
for depth in range(2, 15, 3):
    for leaf in range(1, 201, 10):
        model_decision_tree = DecisionTreeClassifier(criterion = 'entropy',class_weight='balanced',random_state=12345, max_dep
        model_decision_tree.fit(features_train, target_train)
        predictions_valid = model_decision_tree.predict(features_valid)
        result = f1_score(target_valid, predicted_valid)
        if result > best_result:
            best_result = result
            best_leaf = leaf

print('min_samples_leaf =', leaf)
print('max_depth =', depth, ':',best_result)
print("F1:", f1_score(target_valid, predicted_valid))
probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
min_samples_leaf = 191
max_depth = 14 : 0.2557077625570776
F1: 0.2557077625570776
Roc-Auc: 0.7661857518805748
```

```
def upsample(features, target, repeat):
    features_zeros = features[target == 0]
    features_ones = features[target == 1]
    target_zeros = target[target == 0]
    target_ones = target[target == 1]

    features_upsampled = pd.concat([features_zeros] + [features_ones] * repeat)
    target_upsampled = pd.concat([target_zeros] + [target_ones] * repeat)

    features_upsampled, target_upsampled = shuffle(
        features_upsampled, target_upsampled, random_state=12345)

    return features_upsampled, target_upsampled


best_result = 0
best_leaf = 0
for depth in range(2, 15, 3):
    for leaf in range(1, 201, 10):
        for ind in range(1,15,1):
            features_upsampled, target_upsampled = upsample(features_train, target_train, ind)
            model_decision_tree = DecisionTreeClassifier(criterion = 'entropy',random_state=12345, max_depth=depth, min_sample
            model_decision_tree.fit(features_upsampled,target_upsampled)
            predictions_valid = model_decision_tree.predict(features_valid)
            result = f1_score(target_valid, predictions_valid)
            if result > best_result:
                best_result = result
                best_leaf = leaf

print('min_samples_leaf =', leaf)
print('max_depth =', depth, ':',best_result)
print("F1:", f1_score(target_valid, predictions_valid))
probabilities_valid = model_decision_tree.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
min_samples_leaf = 191
max_depth = 14 : 0.5834502103786817
F1: 0.43983402489626555
Roc-Auc: 0.8203895836729624
```

обучим модель при помощи логистической регрессии

LogisticRegression

```
model = LogisticRegression(random_state=12345, class_weight='balanced', solver='liblinear')
model.fit(features_train, target_train)
predicted_valid = model.predict(features_valid)
print("F1:", f1_score(target_valid, predicted_valid))
probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
F1: 0.4738955823293173
Roc-Auc: 0.7706067522143817
```

значение F1-меры низкое, попробуем ее увеличить

увеличим выборки

```
for ind in range(1,15,1):
    features_upsampled, target_upsampled = upsample(features_train, target_train, ind)
    model = LogisticRegression( solver='liblinear', random_state=12345)
    model.fit(features_upsampled,target_upsampled)
    predicted_valid = model.predict(features_valid)
    result = f1_score(target_valid, predicted_valid)
    if result > best_result:
        best_result = result
print('optimal indicator =', ind, ':',best_result)
print("F1:", f1_score(target_valid, predicted_valid))
probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
optimal indicator = 14 : 0.5834502103786817
F1: 0.36012526096033404
Roc-Auc: 0.7678606084600635
```

значение F1-меры практически не изменилось

```
def downsample(features, target, fraction):
    features_zeros = features[target == 0]
    features_ones = features[target == 1]
    target_zeros = target[target == 0]
    target_ones = target[target == 1]
    fraction = 0.25
    features_downsampled = pd.concat(
        [features_zeros.sample(frac=fraction, random_state=12345)] + [features_ones])
    target_downsampled = pd.concat(
        [target_zeros.sample(frac=fraction, random_state=12345)] + [target_ones])
    return features_downsampled, target_downsampled

features_downsampled, target_downsampled = downsample(features_train, target_train, 0.25)
features_downsampled, target_downsampled= shuffle(features_downsampled,target_downsampled, random_state=12345)
```

```
model = LogisticRegression(random_state=12345,solver='liblinear')
model.fit(features_downsampled, target_downsampled)
predicted_valid = model.predict(features_valid)

print("F1:", f1_score(target_valid, predicted_valid))

probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
F1: 0.47420634920634924
```

значение F1-меры уменьшилось

```
model = LogisticRegression(class_weight='balanced',random_state=12345, solver='liblinear')
model.fit(features_train, target_train)
probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]

for threshold in np.arange(0.4, 0.64, 0.02):
    predicted_valid = probabilities_one_valid > threshold
```

```
    precision = precision_score(target_valid,predicted_valid) # < напишите код здесь >
    recall = recall_score(target_valid,predicted_valid)# < напишите код здесь >
    probabilities_valid = model.predict_proba(features_valid)
    probabilities_one_valid = probabilities_valid[:, 1]

    auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
    f1 = f1_score(target_valid, predicted_valid)
    print("Порог = {:.2f} | Точность = {:.3f}, Полнота = {:.3f}, auc_roc = {:.3f}, F1 = {:.3f}".format(
        threshold, precision, recall,auc_roc, f1))
```

```
Порог = 0.40 | Точность = 0.313, Полнота = 0.843, auc_roc = 0.771, F1 = 0.456
Порог = 0.42 | Точность = 0.327, Полнота = 0.818, auc_roc = 0.771, F1 = 0.467
Порог = 0.44 | Точность = 0.330, Полнота = 0.778, auc_roc = 0.771, F1 = 0.463
Порог = 0.46 | Точность = 0.341, Полнота = 0.738, auc_roc = 0.771, F1 = 0.467
Порог = 0.48 | Точность = 0.358, Полнота = 0.715, auc_roc = 0.771, F1 = 0.477
Порог = 0.50 | Точность = 0.366, Полнота = 0.672, auc_roc = 0.771, F1 = 0.474
Порог = 0.52 | Точность = 0.373, Полнота = 0.638, auc_roc = 0.771, F1 = 0.471
Порог = 0.54 | Точность = 0.383, Полнота = 0.607, auc_roc = 0.771, F1 = 0.470
Порог = 0.56 | Точность = 0.399, Полнота = 0.573, auc_roc = 0.771, F1 = 0.470
Порог = 0.58 | Точность = 0.410, Полнота = 0.553, auc_roc = 0.771, F1 = 0.471
Порог = 0.60 | Точность = 0.425, Полнота = 0.527, auc_roc = 0.771, F1 = 0.471
Порог = 0.62 | Точность = 0.438, Полнота = 0.487, auc_roc = 0.771, F1 = 0.462
```

RandomForestClassifier

```
best_model = None
best_result = 0
for est in range(1, 61,20):
    for depth in range(1,11,3):
        for leaf in range(1,15,3):
            model_random_forrest = RandomForestClassifier( class_weight='balanced', random_state=12345, n_estimators=est, max_
            model_random_forrest.fit(features_train, target_train)
            result = model_random_forrest.score(features_valid, target_valid)
            if result > best_result:
                best_model = model_random_forrest
                best_result = result
print(best_model)
print('min_samples_leaf =', leaf)
print('max_depth =', depth, ':',best_result)
print("F1:", f1_score(target_valid, predictions_valid))
print("Accuracy наилучшей модели :", best_result)
print('F1 :', f1_score(target_valid, predicted_valid))
probabilities_valid = model.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('auc_roc :', auc_roc)
```

```
RandomForestClassifier(class_weight='balanced', max_depth=10, n_estimators=41,
                       random_state=12345)
min_samples_leaf = 13
max_depth = 10 : 0.8240791643760308
F1: 0.43983402489626555
Accuracy наилучшей модели : 0.8240791643760308
F1 : 0.4615384615384615
auc_roc : 0.7706067522143817
```

```
best_result = 0
best_leaf = 0
for est in range(50, 101,20):
    for depth in range(55,65,3):
        for leaf in range(10,21,3):
            for ind in range(1,15,5):
                features_upsampled, target_upsampled = upsample(features_train, target_train, ind)
                model_random_tree = RandomForestClassifier(random_state=12345, n_estimators=est, max_depth=depth, min_samples_
                model_random_tree.fit(features_upsampled,target_upsampled)
                predictions_valid = model_random_tree.predict(features_valid)
                result = f1_score(target_valid, predictions_valid)
                if result > best_result:
                    best_result = result
                    best_leaf = leaf

print('min_samples_leaf =', leaf)
print('max_depth =', depth, ':',best_result)
print("F1:", f1_score(target_valid, predictions_valid))
probabilities_valid = model_random_tree.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

```
min_samples_leaf = 19
max_depth = 64 : 0.5577523413111342
F1: 0.5082781456953642
Roc-Auc: 0.8479373840409263
```

```
best_result = 0
best_leaf = 0
for est in range(50, 101,20):
    for depth in range(55,65,3):
        for leaf in range(10,21,3):
            for ind in range(1,15,5):
                features_upsampled, target_upsampled = upsample(features_train, target_train, ind)
                model_random_tree = RandomForestClassifier(random_state=12345, n_estimators=est, max_depth=depth, min_samples_
                model_random_tree.fit(features_downsampled,target_downsampled)
                predictions_valid = model_random_tree.predict(features_valid)
                result = f1_score(target_valid, predictions_valid)
                if result > best_result:
                    best_result = result
                    best_leaf = leaf

print('min_samples_leaf =', leaf)
print('max_depth =', depth, ':',best_result)
print("F1:", f1_score(target_valid, predictions_valid))
probabilities_valid = model_random_tree.predict_proba(features_valid)
probabilities_one_valid = probabilities_valid[:, 1]
auc_roc = roc_auc_score(target_valid,probabilities_one_valid)
print('Roc-Auc:', auc_roc)
```

Таким образом, наибольший результат показала модель случайного дерева

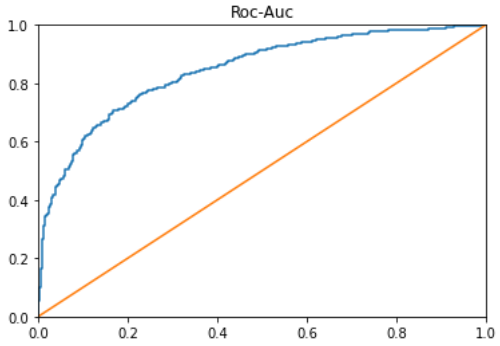
Тестирование модели

протестируем модель с наибольшем f1-мерой на тестовой выборке

```
model_random_forrest = RandomForestClassifier(class_weight='balanced',random_state=12345, n_estimators = 120, max_depth = 10,
model_random_forrest.fit(features_train, target_train)
predicted_test = model_random_forrest.predict(features_test)
print('F1:',f1_score(target_test, predicted_test))
probabilities_test = model_random_forrest.predict_proba(features_test)
probabilities_one_test = probabilities_test[:, 1]
auc_roc = roc_auc_score(target_test,probabilities_one_test)
print('Roc-Auc:',auc_roc)
```

```
F1: 0.6053921568627451
Roc-Auc: 0.844169518294288
```

```
fpr,tpr,thresholds=metrics.roc_curve(target_test,probabilities_one_test)
plt.figure()
plt.plot(fpr,tpr)
plt.plot([0,1],[0,1])
plt.xlim(0, 1)
plt.ylim(0, 1)
plt.title('Roc-Auc');
```




```
#model_decision_tree = DecisionTreeClassifier(class_weight='balanced',random_state=12345, max_depth = 14, min_samples_leaf = 1
#model_decision_tree.fit(features_train, target_train)
#predictions_test = model_decision_tree.predict(features_test)
#result = f1_score(target_test, predicted_test)
```

```
#print('F1:',result)
```

```
#print('F1:',f1score)
#probabilities_test = model.predict_proba(features_test)
#probabilities_one_test = probabilities_test[:, 1]
#auc_roc = roc_auc_score(target_test,probabilities_one_test)
#print('Roc-Auc:', auc_roc)
```

вывод: Были изучены данные, проведена подготовка данных(были удалилены пропуски в столбце Tenure, которых оказалось менее 10%), были исключены категориальные переменные для проведения исследования, преобразованы выборки методом стандартизации. В исследовании были рассмотрены три модели, в результате чего, были отобраны наибольшими показателями F1-меры. на тестовый выборке модели случайного леса показала лучший результат. На тестовой выборке значение F1-меры оказалось равным 0.6, а Roc-Auc 0,84, что продемонстрировано на графике