In [599…

```
# Kaggle Competitions: Outflow of user (DeepLearningSchool)
# https://www.kaggle.com/competitions/advanced-dls-spring-2021
```

In [ ]:

```
# Install library
!pip install catboost
!pip install xgboost
```

In [601…

```
# imports
import pandas as pd
import numpy as np
import re

import seaborn as sns
from matplotlib import pyplot as plt
%matplotlib inline
```

Load data

In [602…

```
# pathes/filenames
PATH_PROJECT = ""
PATH_DATASET = PATH_PROJECT + "dataset/"

train_filename = PATH_DATASET + "train.csv"
test_filename = PATH_DATASET + "test.csv"
submission_filename = PATH_DATASET + "test_submission.csv"
```

In [603…

```
# Load dataset
outflow_users_df = pd.read_csv(train_filename)
test_outflow_users_df = pd.read_csv(test_filename)

# Numeric columns
num_cols = ['ClientPeriod', 'MonthlySpending', 'TotalSpent']
# Categorical columns
cat_cols = ['Sex', 'IsSeniorCitizen', 'HasPartner', 'HasChild',
           'HasPhoneService',
           'HasMultiplePhoneNumbers',
           'HasInternetService',
           'HasOnlineSecurityService',
           'HasOnlineBackup', 'HasDeviceProtection', 'HasTechSupportAccess', 'HasOr
           'HasMovieSubscription','HasContractPhone', 'IsBillingPaperless', 'Paymer
           ]
# Target column
target_colname = "Churn"

# show shape
print(outflow_users_df.shape, test_outflow_users_df.shape)
outflow_users_df.head(3)
```

```
(5282, 20) (1761, 19)
```

Out[603]:

	ClientPeriod	MonthlySpending	TotalSpent	Sex	IsSeniorCitizen	HasPartner	HasChild	HasPh
0	55	19.50	1026.35	Male	0	Yes	Yes	
1	72	25.85	1872.2	Male	0	Yes	No	
2	1	75.90	75.9	Male	0	No	No	

Data preprocessing

In [604…

```
# Change synonyms test/train datasets
def remove_synonyms(df):
    # remove synonyms phone service
    list_phone_service = ["HasMultiplePhoneNumbers"]
    for phone_service in list_phone_service:
        df[phone_service] = np.where(df[phone_service] == "No phone service", "No",

    # remove synonyms internet service
    list_internet_service = ["HasOnlineSecurityService", "HasOnlineBackup", "HasDev
                             "HasTechSupportAccess", "HasOnlineTV", "HasMovieSubscr
                            ]
    for internet_service in list_internet_service:
        df[internet_service] = np.where(df[internet_service] == "No internet servic
    return df

outflow_users_df = remove_synonyms(outflow_users_df)
test_outflow_users_df = remove_synonyms(test_outflow_users_df)
```

In [605…

```
# Correct Column "TotalSpent" contains spaces (" ") and ClientPeriod with zeros val
def correct_total_spent(df):
    total_spent_column = "TotalSpent"
    period_column = "ClientPeriod"
    monthly_spending_column = "MonthlySpending"

    # replace empty string on zero value (0)
    df[total_spent_column] = [float(re.sub(r"\s+", "0", x)) for x in df[total_spent

    # replace zero value on calc value
    df[total_spent_column] = np.where(df[total_spent_column] == 0, df[period_column

    # if exist zero -> replace zero value on mean value
    df[total_spent_column] = np.where(df[total_spent_column] == 0, df[total_spent_c
    # if "ClientPeriod" exist zero -> replace zero value on TotalSpent // MonthlySp
    df[period_column] = np.where(df[period_column] == 0, df[total_spent_column] //
    return df

outflow_users_df = correct_total_spent(outflow_users_df)
test_outflow_users_df = correct_total_spent(test_outflow_users_df)
```

In [606…

```
outflow_users_df.info()
outflow_users_df.describe()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5282 entries, 0 to 5281
Data columns (total 20 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   ClientPeriod              5282 non-null   float64
 1   MonthlySpending           5282 non-null   float64
 2   TotalSpent                5282 non-null   float64
 3   Sex                       5282 non-null   object 
 4   IsSeniorCitizen           5282 non-null   int64  
 5   HasPartner                5282 non-null   object 
 6   HasChild                  5282 non-null   object 
 7   HasPhoneService           5282 non-null   object 
 8   HasMultiplePhoneNumbers   5282 non-null   object 
 9   HasInternetService        5282 non-null   object 
 10  HasOnlineSecurityService  5282 non-null   object 
 11  HasOnlineBackup           5282 non-null   object 
 12  HasDeviceProtection       5282 non-null   object 
 13  HasTechSupportAccess      5282 non-null   object 
 14  HasOnlineTV               5282 non-null   object 
 15  HasMovieSubscription      5282 non-null   object 
 16  HasContractPhone          5282 non-null   object 
 17  IsBillingPaperless        5282 non-null   object 
 18  PaymentMethod             5282 non-null   object 
 19  Churn                     5282 non-null   int64  
dtypes: float64(3), int64(2), object(15)
memory usage: 825.4+ KB
```

Out[606]:

	ClientPeriod	MonthlySpending	TotalSpent	IsSeniorCitizen	Churn
count	5282.000000	5282.000000	5282.000000	5282.000000	5282.000000
mean	32.507952	64.924754	2291.383808	0.159409	0.262022
std	24.591755	30.176464	2267.079962	0.366092	0.439776
min	1.000000	18.250000	18.800000	0.000000	0.000000
25%	9.000000	35.462500	401.587500	0.000000	0.000000
50%	29.000000	70.400000	1413.650000	0.000000	0.000000
75%	55.000000	90.050000	3795.212500	0.000000	1.000000
max	116.000000	118.750000	8684.800000	1.000000	1.000000

In [607…

```
# Check is NaN values
outflow_users_df.isna().sum(), test_outflow_users_df.isna().sum()
```

```
Out[607]: (ClientPeriod               0
           MonthlySpending            0
           TotalSpent                 0
           Sex                        0
           IsSeniorCitizen            0
           HasPartner                 0
           HasChild                   0
           HasPhoneService            0
           HasMultiplePhoneNumbers    0
           HasInternetService         0
           HasOnlineSecurityService   0
           HasOnlineBackup            0
           HasDeviceProtection        0
           HasTechSupportAccess       0
           HasOnlineTV                0
           HasMovieSubscription       0
           HasContractPhone           0
           IsBillingPaperless         0
           PaymentMethod              0
           Churn                      0
           dtype: int64,
           ClientPeriod               0
           MonthlySpending            0
           TotalSpent                 0
           Sex                        0
           IsSeniorCitizen            0
           HasPartner                 0
           HasChild                   0
           HasPhoneService            0
           HasMultiplePhoneNumbers    0
           HasInternetService         0
           HasOnlineSecurityService   0
           HasOnlineBackup            0
           HasDeviceProtection        0
           HasTechSupportAccess       0
           HasOnlineTV                0
           HasMovieSubscription       0
           HasContractPhone           0
           IsBillingPaperless         0
           PaymentMethod              0
           dtype: int64)
```

```
In [608…  # Show columns name
          cat_cols, num_cols
```

Out[608]:

```
([ 'Sex',
  'IsSeniorCitizen',
  'HasPartner',
  'HasChild',
  'HasPhoneService',
  'HasMultiplePhoneNumbers',
  'HasInternetService',
  'HasOnlineSecurityService',
  'HasOnlineBackup',
  'HasDeviceProtection',
  'HasTechSupportAccess',
  'HasOnlineTV',
  'HasMovieSubscription',
  'HasContractPhone',
  'IsBillingPaperless',
  'PaymentMethod'],
 ['ClientPeriod', 'MonthlySpending', 'TotalSpent'])
```

One-Hot Encoder Categorical columns

In [609…

```python
# One-Hot Encoder ("OneHotEncoder" better than "get_dummies")
from sklearn.preprocessing import OneHotEncoder

sk_ohe = OneHotEncoder(handle_unknown="ignore", drop="first", sparse=False, dtype=i
sk_ohe = sk_ohe.fit(outflow_users_df[cat_cols])
df_cat_ohe_sklearn = pd.DataFrame(sk_ohe.transform(outflow_users_df[cat_cols]), col
df_cat_ohe_sklearn_testfile = pd.DataFrame(sk_ohe.transform(test_outflow_users_df[c

# show shape
print(df_cat_ohe_sklearn.shape)
df_cat_ohe_sklearn.head(3)
```

```
(5282, 20)
```

Out[609]:

	Sex_Male	IsSeniorCitizen_1	HasPartner_Yes	HasChild_Yes	HasPhoneService_Yes	HasMultiplePh
0	1	0	1	1	1	
1	1	0	1	0	1	
2	1	0	0	0	1	

Data analysis

In [610…

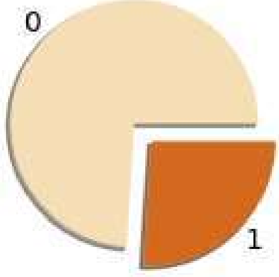
```python
df_analysis = pd.concat([outflow_users_df[num_cols], df_cat_ohe_sklearn, y_data],ax
```

Count values

Target disbalanced!

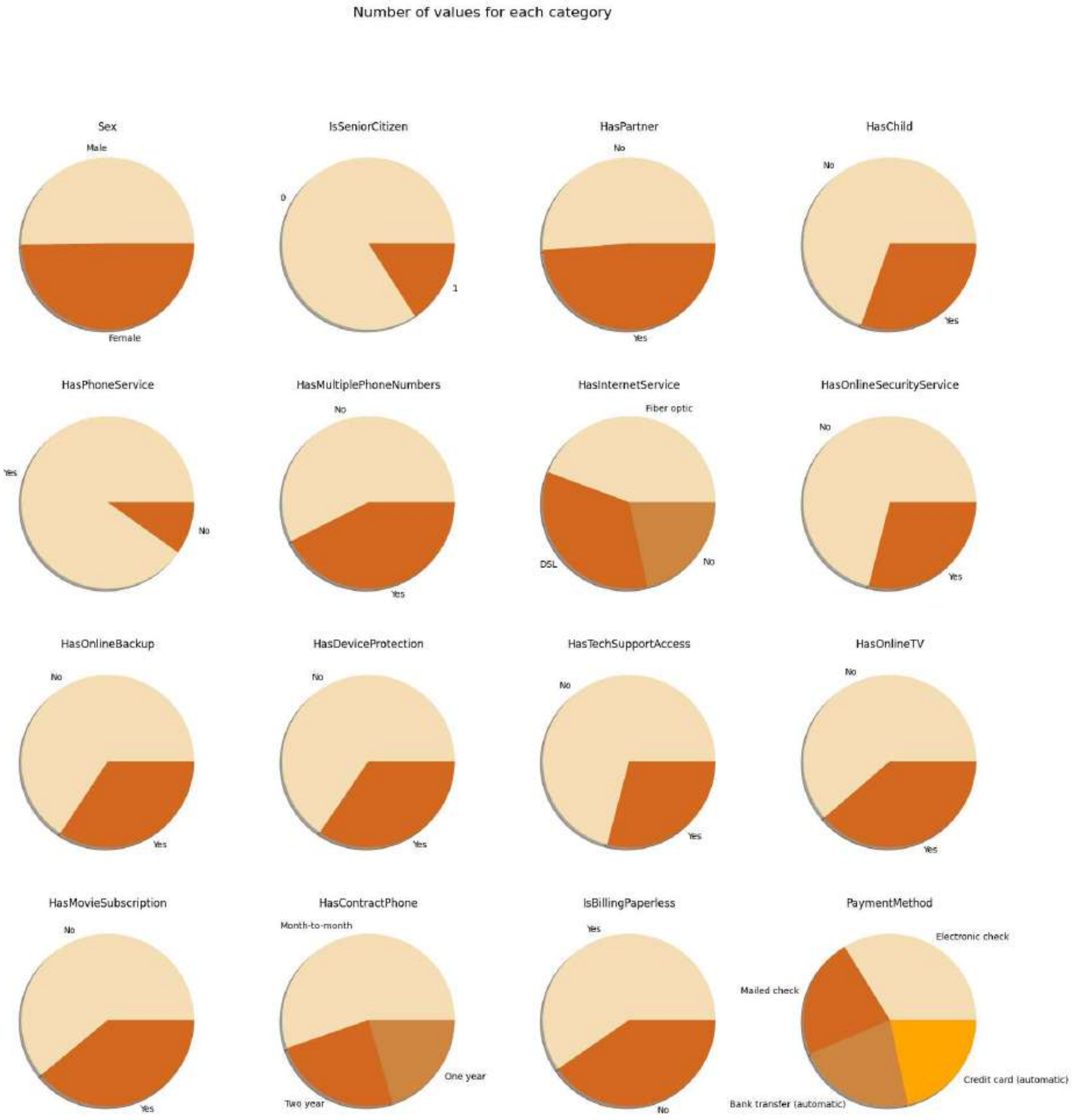
In [611…

```python
# Show target counts
plt.figure(figsize=(2,2))
plt.pie(y_data.value_counts(), labels=[0, 1], colors=['wheat', 'chocolate'], exploc
plt.show()
```



In [612…

```
# Show count values for categorical
fig, axes = plt.subplots(4, 4, figsize=(20, 20))
ax = axes.ravel()
fig.suptitle('Number of values for each category', fontsize=16)
for i, cat in enumerate(cat_cols):
    x = outflow_users_df[cat].value_counts()
    index = x.index
    ax[i].pie(labels=index, x=x, colors=['wheat', 'chocolate', 'peru', 'orange'], s
    ax[i].set_title(cat)
```


Number of values for each category

Sex

IsSeniorCitizen

HasPartner

HasChild

HasPhoneService

HasMultiplePhoneNumbers

HasInternetService

HasOnlineSecurityService

HasOnlineBackup

HasDeviceProtection

HasTechSupportAccess

HasOnlineTV

HasMovieSubscription

HasContractPhone

IsBillingPaperless

PaymentMethod

Histogram analysis

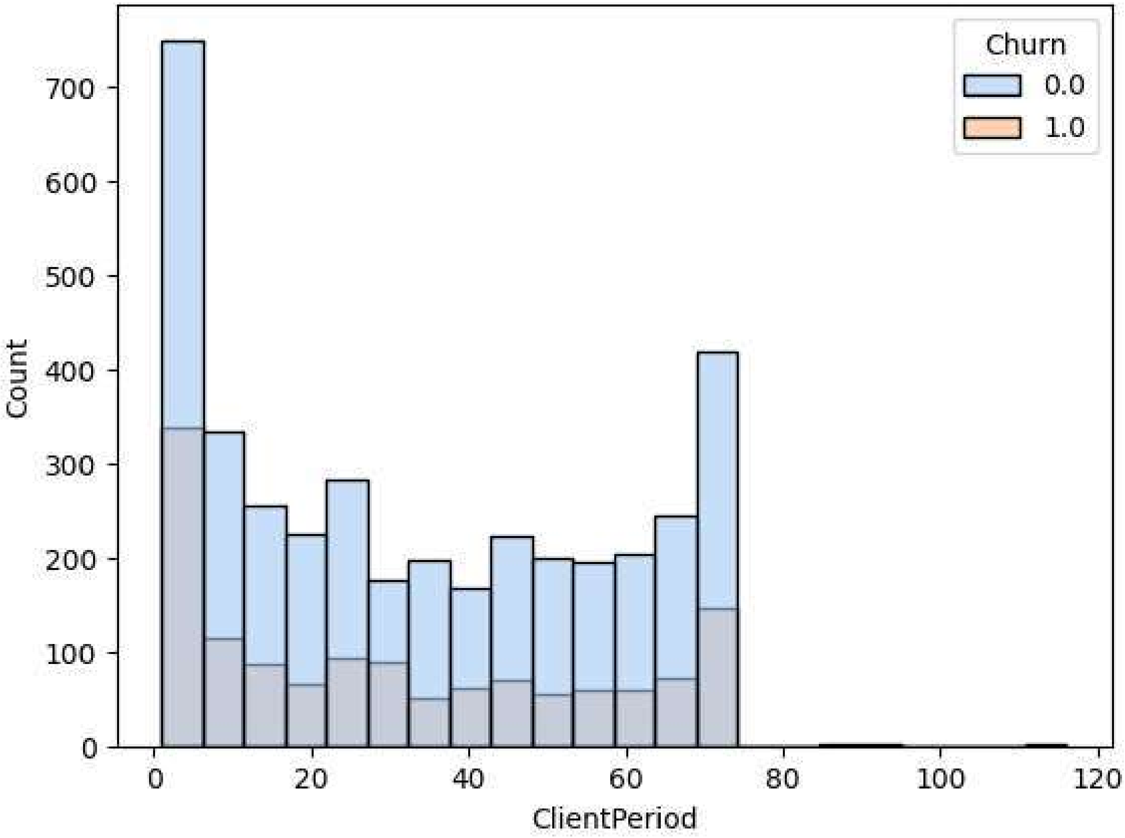
Result:

1. The longer the ClientPeriod, the less the Churn. The largest churn of customers is observed in the first months
2. Most regular customers enjoy inexpensive tariffs.
3. Regular customers bring more profit.

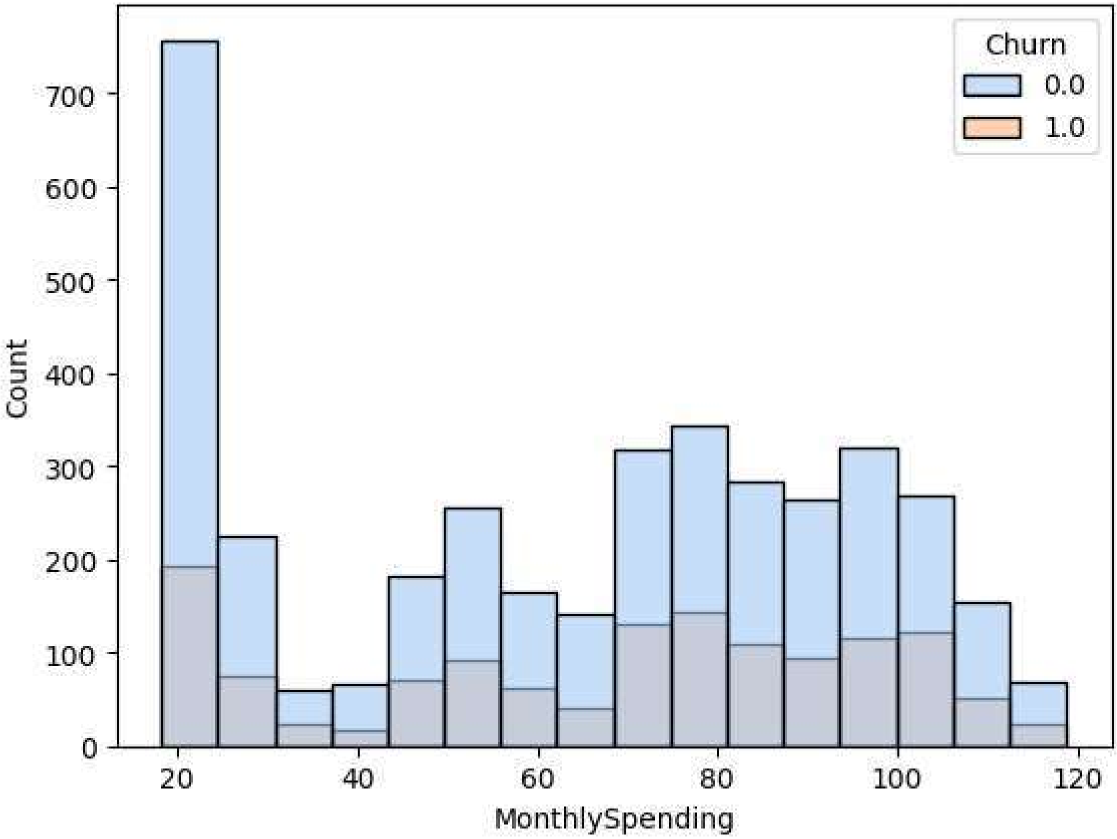
In [613…

```
# Show histplot for numeric columns
for column in num_cols:
    print(f"Column name: {column}")
    sns.histplot(data=df_analysis, x=column, hue=target_colname, palette="pastel",
    plt.show()

# Show boxplot for numeric columns
for column in num_cols:
    print(f"Column name: {column}")
    sns.boxplot(df_analysis[column], palette='pastel')
    plt.show()
```

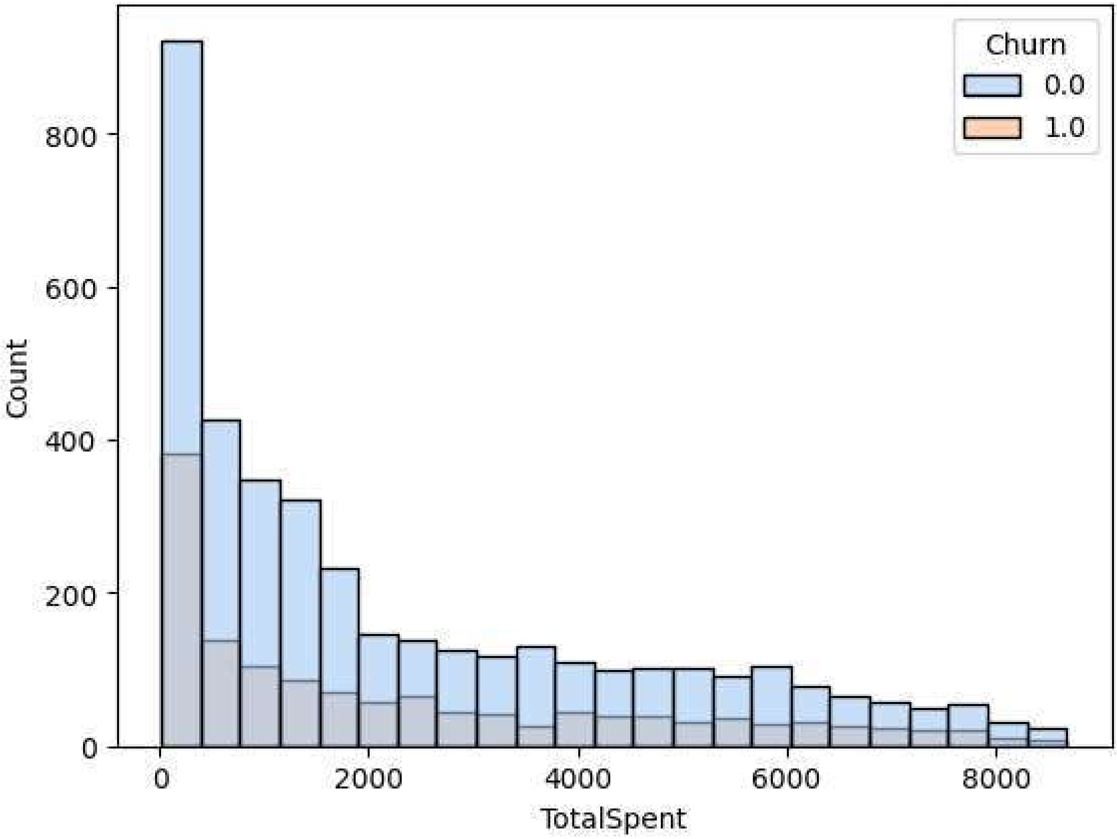
```
Column name: ClientPeriod
```



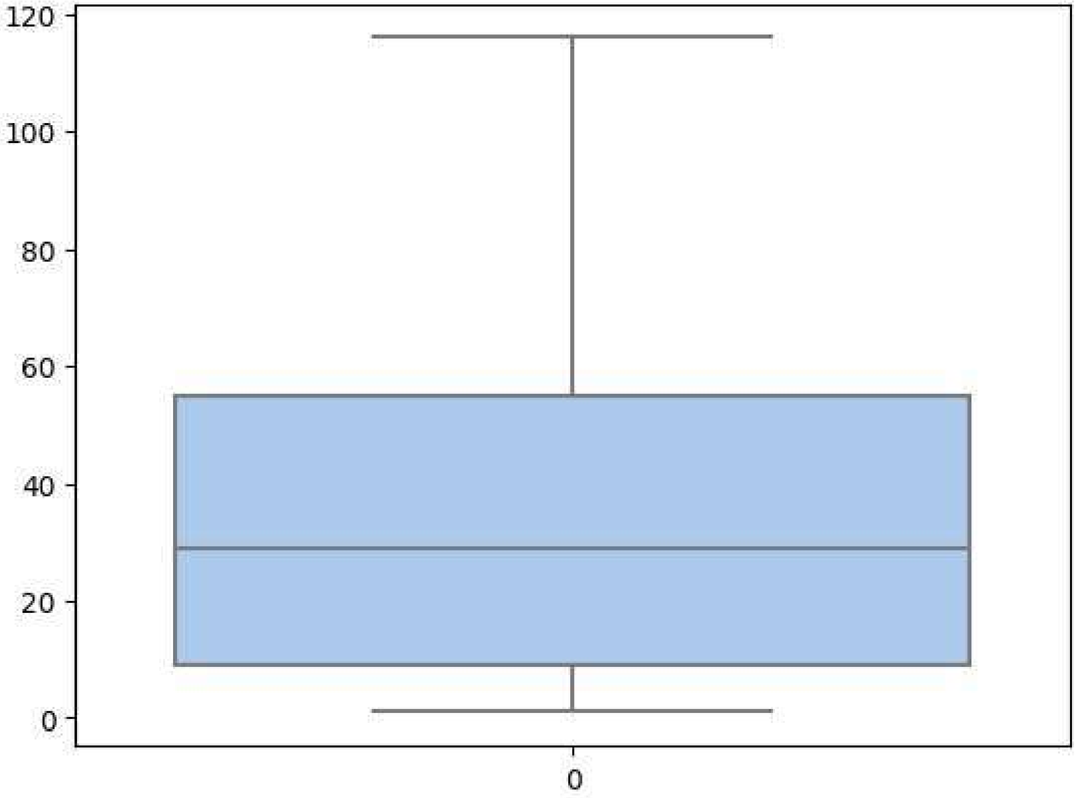
```
Column name: MonthlySpending
```



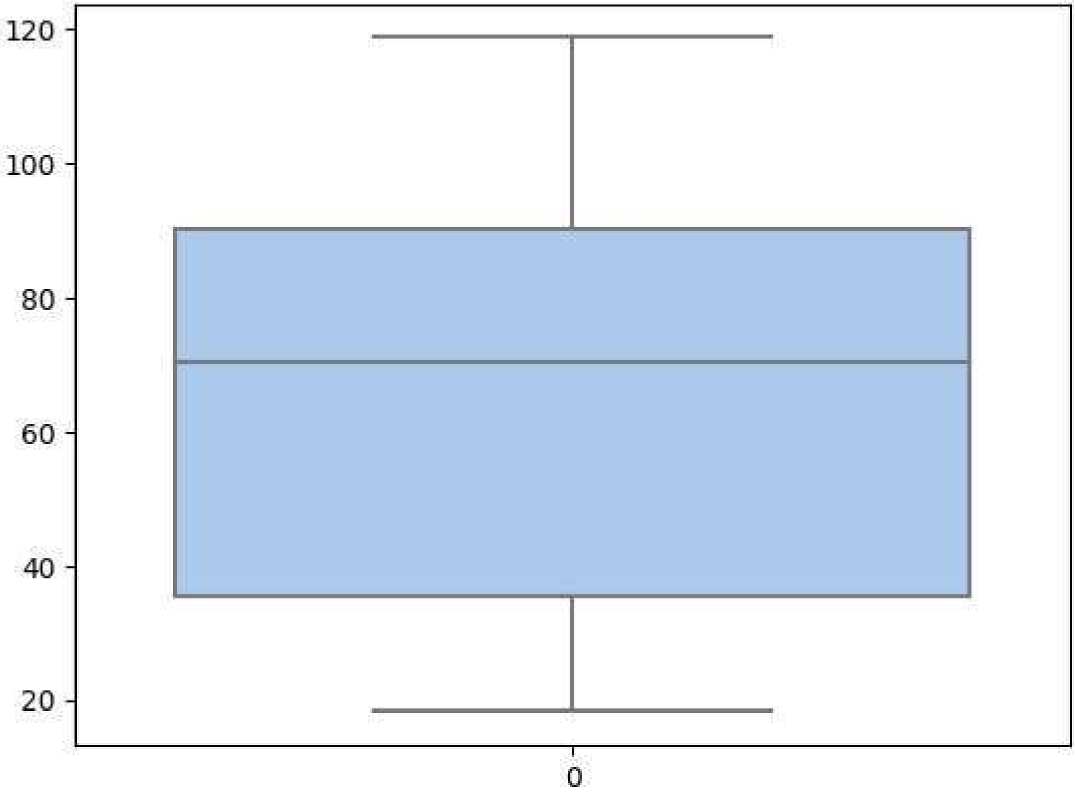
```
Column name: TotalSpent
```



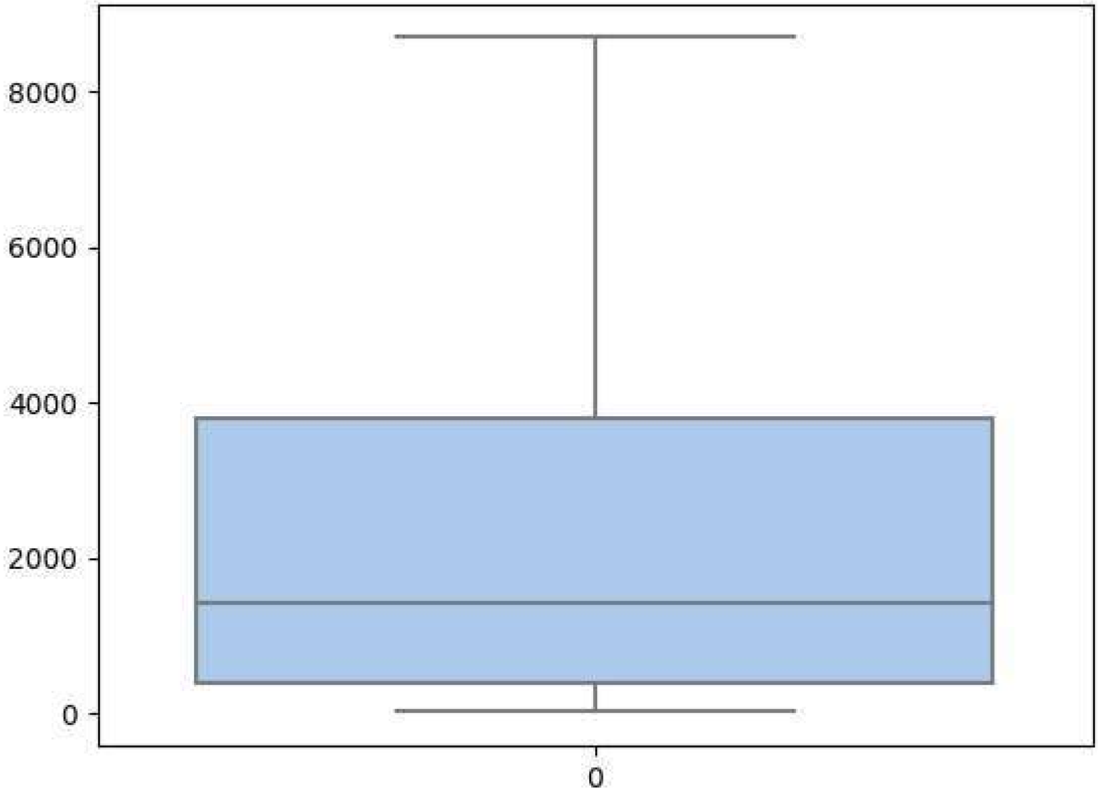
```
Column name: ClientPeriod
```



```
Column name: MonthlySpending
```



```
Column name: TotalSpent
```



Anomaly detection

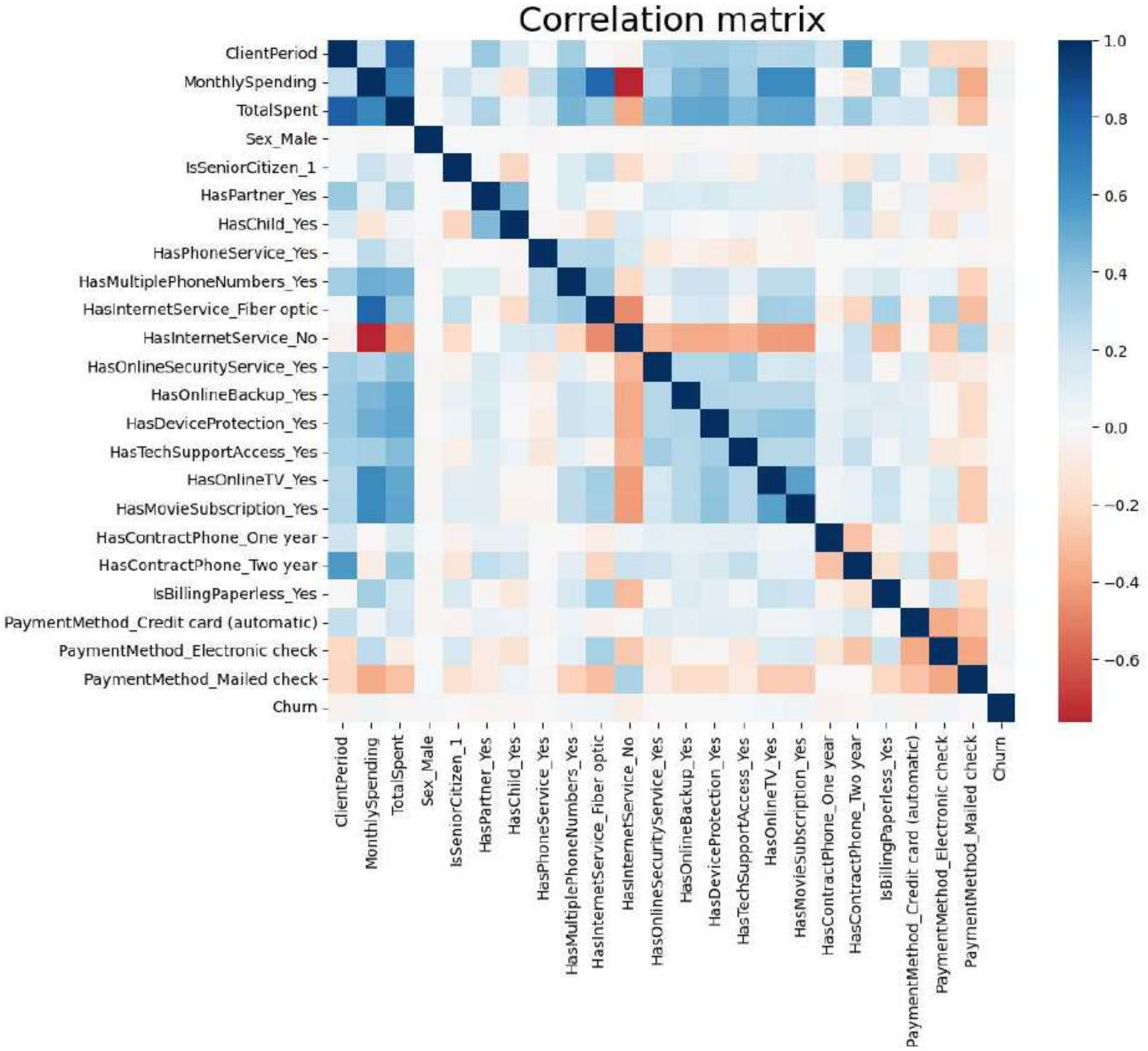
In [ ]:

```
# Correct anomaly data
upper_limit_ClientPeriod = 75
df_analysis['ClientPeriod'] = np.where(df_analysis['ClientPeriod'] > upper_limit_Cl
```

Correlation matrix

In [615…

```
# correlation = pd.concat([x_data,y_data], axis=1).corr()
correlation = df_analysis.corr()

plt.figure(figsize=(10, 8))
sns.heatmap(
    correlation,
    xticklabels=correlation.columns,
    yticklabels=correlation.columns,
    cmap="RdBu",
    center=0,
)

plt.title("Correlation matrix", fontsize=22)
plt.show()
```



Join preproc columns

In [616…

```
# Concatenate OHE columns + numeric columns
x_data = pd.concat([outflow_users_df[num_cols], df_cat_ohe_sklearn],axis=1)
x_data_testfile = pd.concat([test_outflow_users_df[num_cols], df_cat_ohe_sklearn_te

y_data = outflow_users_df[target_colname]

# show shape
print(x_data.shape, x_data_testfile.shape, y_data.shape)
x_data.head(3)
```

```
(5282, 23) (1761, 23) (5282,)
```

Out[616]:

	ClientPeriod	MonthlySpending	TotalSpent	Sex_Male	IsSeniorCitizen_1	HasPartner_Yes	HasCh
0	55.0	19.50	1026.35	1	0	1	
1	72.0	25.85	1872.20	1	0	1	
2	1.0	75.90	75.90	1	0	0	

3 rows × 23 columns

Train/Test split

In [617…

```
# Train/Test split
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(x_data, y_data, test_size=0.1,

# show shape
print(x_data.shape, y_data.shape, x_train.shape, x_test.shape, y_train.shape, y_tes
x_train.head(3)
```

```
(5282, 23) (5282,) (4753, 23) (529, 23) (4753,) (529,)
```

Out[617]:

	ClientPeriod	MonthlySpending	TotalSpent	Sex_Male	IsSeniorCitizen_1	HasPartner_Yes	Ha
1106	2.0	76.5	162.45	1	0	0	
2095	27.0	79.5	2180.55	1	0	0	
4469	72.0	104.8	7470.10	1	0	1	

3 rows × 23 columns

Normalization Numeric columns

In [618…

```
from sklearn.preprocessing import StandardScaler
if len(num_cols) > 0:
    scaler = StandardScaler()
    # Fit on train data!
    scaler.fit(x_train[num_cols])
    x_train[num_cols] = scaler.transform(x_train[num_cols])
    x_test[num_cols] = scaler.transform(x_test[num_cols])

    scaler_all = StandardScaler()
    scaler_all.fit(x_data[num_cols])
    x_data_normalize = scaler_all.transform(x_data[num_cols])
    x_data_testfile_normalize = scaler_all.transform(x_data_testfile[num_cols])

    # show shape
    print(x_data.shape, y_data.shape, x_train.shape, x_test.shape, y_train.shape, y
```

```
(5282, 23) (5282,) (4753, 23) (529, 23) (4753,) (529,)
```

Create models

In [619…

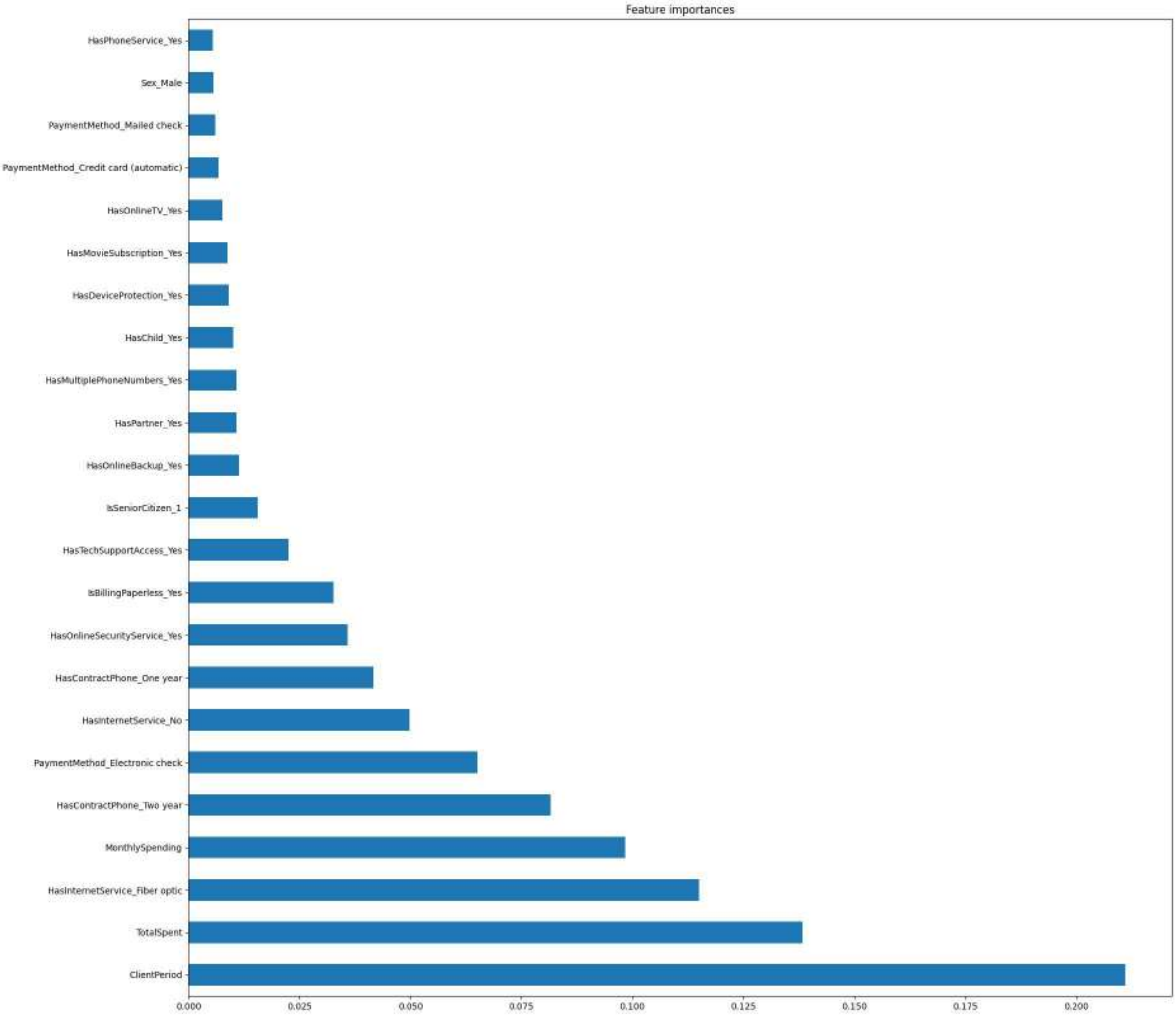
```
# Load models
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import cross_val_predict
import catboost
```

Search feature importances

In [620…

```
rf_importances = RandomForestClassifier(max_depth=7, n_estimators=200, n_jobs=-1)
rf_importances.fit(x_train, y_train)

predict_rf_importances = rf_importances.predict_proba(x_test)[:, 1]

print(roc_auc_score(y_test, predict_rf_importances))
feat_importances = pd.Series(rf_importances.feature_importances_, index=x_train.co
feat_importances.nlargest(x_train.shape[0]).plot(kind='barh', title="Feature import
plt.show()
```

```
0.8626560320469259
```



In [621…

```
# Choice important features
important_features = ["ClientPeriod", "TotalSpent", "MonthlySpending", "HasInternet
# Check score
rf_importances = RandomForestClassifier(max_depth=7, n_estimators=200, n_jobs=-1)
rf_importances.fit(x_train[important_features], y_train)
predict_rf_importances = rf_importances.predict_proba(x_test[important_features])[

logreg = LogisticRegression()
logreg.fit(x_train[important_features], y_train)
predict_logreg_importances = logreg.predict_proba(x_test[important_features])[:, 1]

print(f"ROC-AUC RandomForest: {roc_auc_score(y_test, predict_rf_importances)}, ROC-
```

```
ROC-AUC RandomForest: 0.862405665438678, ROC-AUC LogisticRegression: 0.84496941950
71354
```

In [622…

```
# Remove duplicates for rows without non important features
# delete duplicates in data from train_file
# 1. delete full duplicates
x_data_important = pd.concat([x_data[important_features], y_data],axis=1)
x_data_important = x_data_important.drop_duplicates()

# 2. delete equivalent features with other targets!
mask_duplicate_rows = x_data_important.drop(target_colname, axis=1).duplicated()
x_data_important = x_data_important[~mask_duplicate_rows].reset_index()
```

```
# select y_data, x_data
y_data = x_data_important[target_colname]
x_data_important = x_data_important[important_features]

# testfile data select only important features
x_data_important_testfile = x_data_testfile[important_features]


# Train/Test split
x_train, x_test, y_train, y_test = train_test_split(x_data_important, y_data, test_

x_data_important.shape, y_data.shape, x_train.shape, x_test.shape, y_train.shape, y
```

Out[622]:

```
((5230, 14), (5230,), (4707, 14), (523, 14), (4707,), (523,))
```

Models analysis

In [623…

```
# Selection of hyperparameter C
from sklearn.linear_model import LogisticRegressionCV
hparameter_C = [100, 10, 1, 0.1, 0.01, 0.001]
log_reg_cv = LogisticRegressionCV(Cs=hparameter_C, scoring='roc_auc', refit=True, r
log_reg_cv.fit(x_train, y_train)

# get score roc_auc:
auc_score_v1 = log_reg_cv.score(x_test, y_test)
predict_log_reg_cv = log_reg_cv.predict_proba(x_test)[:,1]
auc_score_v2 = roc_auc_score(y_test, predict_log_reg_cv)

print(f"ROC AUC Score. calc score v1:{auc_score_v1}, calc score v2: {auc_score_v2},
print(f"Best C parameters from ({hparameter_C}): {log_reg_cv.C_}")
```

```
ROC AUC Score. calc score v1:0.8602977667493796, calc score v2: 0.860297766749379
6, v1==v2: True
Best C parameters from ([100, 10, 1, 0.1, 0.01, 0.001]): [1.]
```

In [624…

```
# Select the best parameters for RandomForestClassifier
from sklearn.model_selection import GridSearchCV
# set parameters
param_grid = {
    "max_depth": np.arange(3, 10, 3),
    "n_estimators": np.arange(200, 400, 50),
    "min_samples_split": np.arange(2, 6, 2),
    "bootstrap": [True, False],
}
# create and fit GridSearchCV model
rfc=RandomForestClassifier(n_estimators=200, random_state=42, criterion="entropy")
model = GridSearchCV(rfc, param_grid, cv=5, scoring='roc_auc', refit=True, n_jobs=-
model.fit(x_train, y_train)

# Show best parameters
print("Best ROC-AUC metric:", model.best_score_)
print("Best estimator's parameters:", model.best_params_)
```

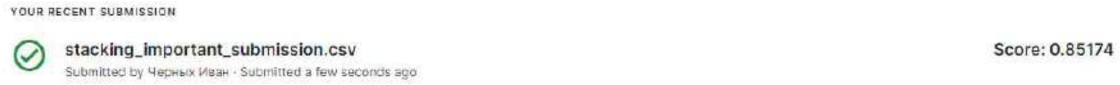
```
Fitting 5 folds for each of 48 candidates, totalling 240 fits
Best ROC-AUC metric: 0.8435295790339079
Best estimator's parameters: {'bootstrap': True, 'max_depth': 6, 'min_samples_spli
t': 2, 'n_estimators': 300}
```

Stacking

In [625…

```
catboost_model = catboost.CatBoostClassifier(n_estimators=200, silent=True, eval_me
rand_forest_3 = RandomForestClassifier(max_depth=3, n_estimators=200, bootstrap=Tru
rand_forest_7 = RandomForestClassifier(max_depth=7, n_estimators=200, bootstrap=Tru
rand_forest_10 = RandomForestClassifier(max_depth=10, n_estimators=200, bootstrap=T
# rand_forest_3 = RandomForestClassifier(max_depth=3, n_estimators=200, 'bootstrap
# rand_forest_7 = RandomForestClassifier(max_depth=7, n_estimators=200, n_jobs=-1)
# rand_forest_10 = RandomForestClassifier(max_depth=10, n_estimators=200, n_jobs=-1

models = [
    catboost_model,
    rand_forest_3,
    rand_forest_7,
    rand_forest_10,
    ]

train_features_model_predicts = np.zeros(x_data_important.shape[0])[...,None]
test_features_model_predicts = np.zeros(x_data_important_testfile.shape[0])[...,Nor

for model in models:
    print(f"model: {model}")
    model.fit(x_data_important, y_data)
    cv_predict = cross_val_predict(model, x_data_important, y_data, cv=5, method="p

    predict_test = model.predict_proba(x_data_important_testfile)
    train_features_model_predicts = np.concatenate((train_features_model_predicts,
    test_features_model_predicts = np.concatenate((test_features_model_predicts, pr

train_features_model_predicts = train_features_model_predicts[:,1:]
test_features_model_predicts = test_features_model_predicts[:,1:]

stacking_model = LogisticRegression(penalty='l2', C=1, max_iter=30)
stacking_model.fit(train_features_model_predicts, y_data)

predict_stacking_model_proba = stacking_model.predict_proba(test_features_model_pre

# Write submission
predict_df = pd.DataFrame(predict_stacking_model_proba)
predict_df = pd.concat([pd.DataFrame(predict_df.index.values), predict_df], axis=1)
predict_df.to_csv(PATH_DATASET + "stacking_important_submission.csv", sep=",", inde
```

```
model: <catboost.core.CatBoostClassifier object at 0x00000297989E66C8>
model: RandomForestClassifier(criterion='entropy', max_depth=3, n_estimators=200,
                       n_jobs=-1)
model: RandomForestClassifier(criterion='entropy', max_depth=7, n_estimators=200,
                       n_jobs=-1)
model: RandomForestClassifier(criterion='entropy', max_depth=10, n_estimators=200,
                       n_jobs=-1)
```



YOUR RECENT SUBMISSION

stacking_important_submission.csv

Submitted by Черных Иван · Submitted a few seconds ago

Score: 0.85174