```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler, StandardScaler,
RobustScaler
import scipy.stats as stats
import six
import sys
from sklearn.impute import SimpleImputer
sys.modules['sklearn.externals.six'] = six
import joblib
sys.modules['sklearn.externals.joblib'] = joblib
from mlxtend.feature_selection import ExhaustiveFeatureSelector as EFS
from sklearn.neighbors import KNeighborsRegressor
from sklearn.linear_model import Lasso
from sklearn.feature_selection import SelectFromModel
import warnings
warnings.filterwarnings('ignore')
```

```
!wget  https://raw.githubusercontent.com/azar-
s91/dataset/master/BankChurners.csv
data = pd.read_csv('BankChurners.csv', sep=",")
data.head()
```

```
--2023-05-02 10:40:26--
https://raw.githubusercontent.com/azar-s91/dataset/master/BankChurners
.csv
Resolving raw.githubusercontent.com (raw.githubusercontent.com)...
185.199.110.133, 185.199.108.133, 185.199.111.133, ...
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)|
185.199.110.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 1210878 (1.2M) [text/plain]
Saving to: ‘BankChurners.csv.1’

 BankChurners.csv.1    0%[                    ]       0  --.-KB/s
BankChurners.csv.1  100%[===================>]   1.15M  --.-KB/s    in
0.01s

2023-05-02 10:40:26 (106 MB/s) - ‘BankChurners.csv.1’ saved
[1210878/1210878]
```

	CLIENTNUM	Attrition_Flag	Customer_Age	Gender	Dependent_count
0	768805383	Existing Customer	45	M	3
1	818770008	Existing Customer	49	F	5

```
2  713982108  Existing Customer            51      M                3

3  769911858  Existing Customer            40      F                4

4  709106358  Existing Customer            40      M                3


  Education_Level Marital_Status Income_Category Card_Category  \
0     High School        Married     $60K - $80K          Blue
1        Graduate         Single  Less than $40K          Blue
2        Graduate        Married    $80K - $120K          Blue
3     High School        Unknown  Less than $40K          Blue
4      Uneducated        Married     $60K - $80K          Blue

   Months_on_book  ...  Months_Inactive_12_mon  Contacts_Count_12_mon
\
0              39  ...                       1                      3

1              44  ...                       1                      2

2              36  ...                       1                      0

3              34  ...                       4                      1

4              21  ...                       1                      0


   Credit_Limit  Total_Revolving_Bal  Avg_Open_To_Buy
Total_Amt_Chng_Q4_Q1  \
0       12691.0                  777          11914.0
1.335
1        8256.0                  864           7392.0
1.541
2        3418.0                    0           3418.0
2.594
3        3313.0                 2517            796.0
1.405
4        4716.0                    0           4716.0
2.175

   Total_Trans_Amt  Total_Trans_Ct  Total_Ct_Chng_Q4_Q1
Avg_Utilization_Ratio
0             1144              42                1.625
0.061
1             1291              33                3.714
0.105
2             1887              20                2.333
0.000
3             1171              20                2.333
```

```
0.760
4              816              28                2.500
0.000

[5 rows x 21 columns]
```

Масштабирование признаков

```
data['Total_Trans_Ct'].describe()
```

```
count    10127.000000
mean        64.858695
std         23.472570
min         10.000000
25%         45.000000
50%         67.000000
75%         81.000000
max        139.000000
Name: Total_Trans_Ct, dtype: float64
```

```
minMaxScaler = MinMaxScaler()
data['Total_Trans_Ct_minmax'] =
minMaxScaler.fit_transform(data[['Total_Trans_Ct']])
data['Total_Trans_Ct_minmax'].describe()
```

```
count    10127.000000
mean         0.425261
std          0.181958
min          0.000000
25%          0.271318
50%          0.441860
75%          0.550388
max          1.000000
Name: Total_Trans_Ct_minmax, dtype: float64
```

```
standardScaler = StandardScaler()
data['Total_Trans_Ct_standard'] =
standardScaler.fit_transform(data[['Total_Trans_Ct']])
data['Total_Trans_Ct_standard'].describe()
```

```
count    1.012700e+04
mean    -2.245222e-16
std      1.000049e+00
min     -2.337256e+00
25%     -8.460801e-01
50%      9.123036e-02
75%      6.877007e-01
max      3.158792e+00
Name: Total_Trans_Ct_standard, dtype: float64
```

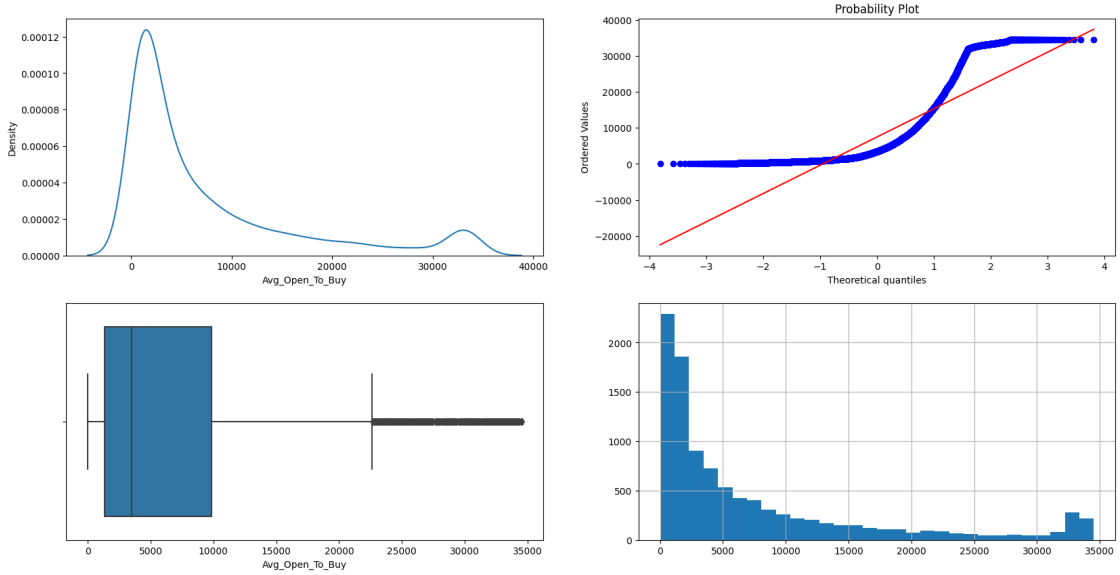
```
robustScaler = RobustScaler()
data['Total_Trans_Ct_robust'] =
```

```
robustScaler.fit_transform(data[['Total_Trans_Ct']])
data['Total_Trans_Ct_robust'].describe()
```

```
count    10127.000000
mean        -0.059481
std          0.652016
min         -1.583333
25%         -0.611111
50%          0.000000
75%          0.388889
max          2.000000
Name: Total_Trans_Ct_robust, dtype: float64
```

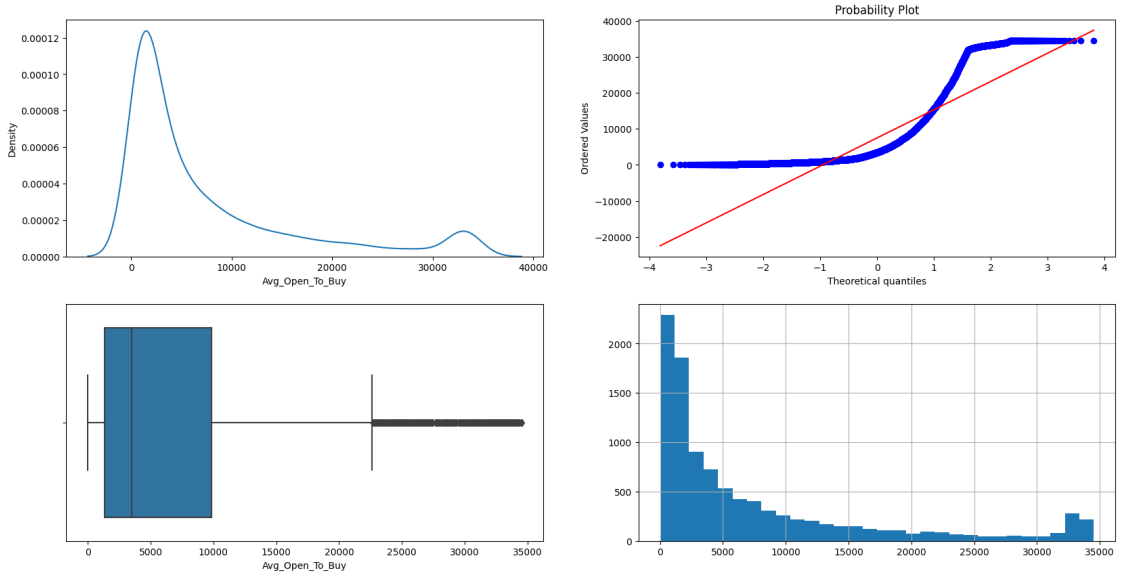
Обработка выбросов

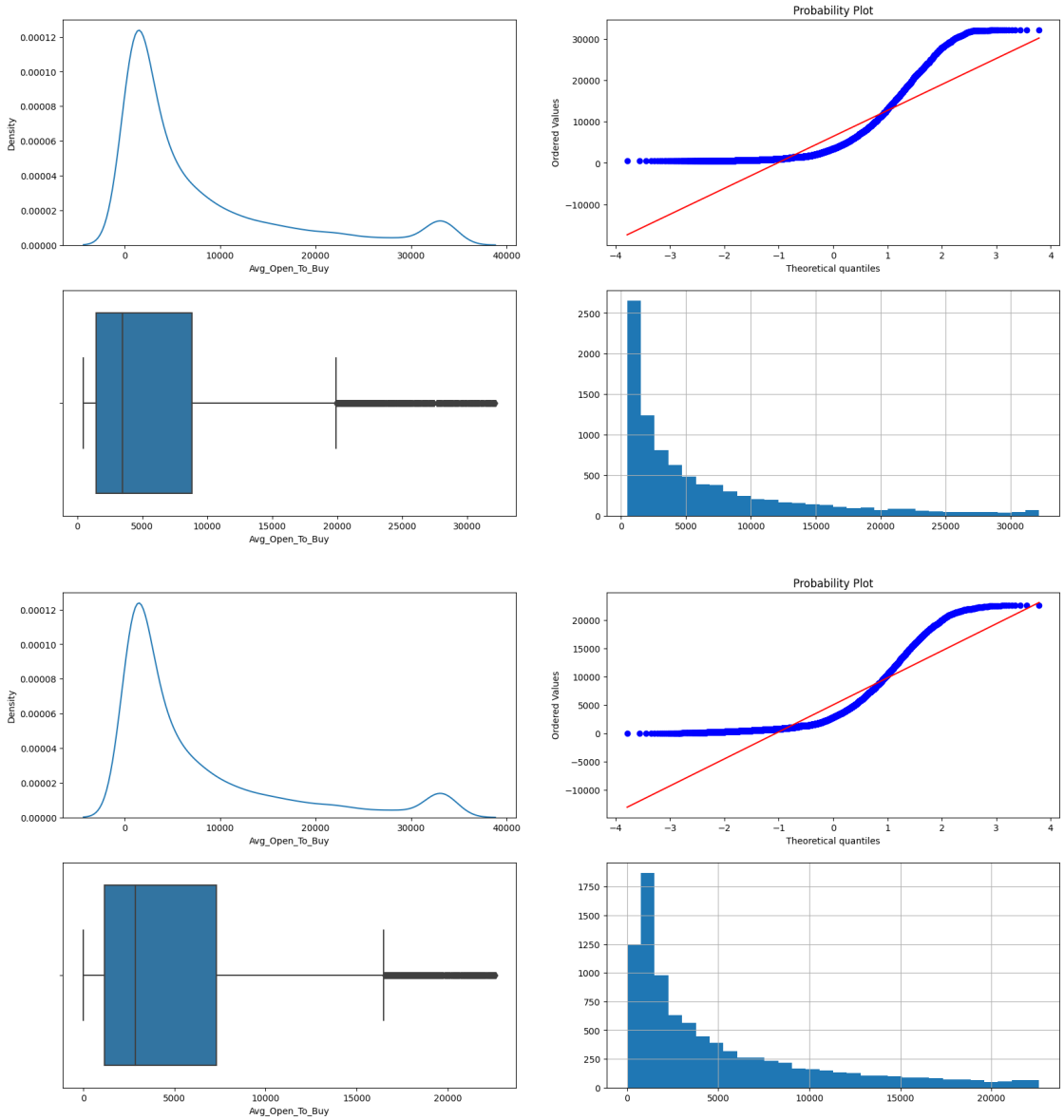
```
def diagnostic_plots(df, variable):
 fig, ax = plt.subplots(figsize=(20,10))
 plt.subplot(2, 2, 1)
 sns.kdeplot(data=data, x=variable)
 ## Q-Q plot
 plt.subplot(2, 2, 2)
 stats.probplot(df[variable], dist="norm", plot=plt)
 # ящик с усами
 plt.subplot(2, 2, 3)
 sns.boxplot(x=df[variable])
 # ящик с усами
 plt.subplot(2, 2, 4)
 df[variable].hist(bins=30)
 plt.show()

diagnostic_plots(data, 'Avg_Open_To_Buy')
```




```
outlierBoundaryType = {
 'SIGMA': 1,
```

```
 'QUANTILE': 2,
 'IRQ': 3
}

def get_outlier_boundaries(df, col, outlier_boundary_type):
 if outlier_boundary_type == outlierBoundaryType['SIGMA']:
  K1 = 3
  lower_boundary = df[col].mean() - (K1 * df[col].std())
  upper_boundary = df[col].mean() + (K1 * df[col].std())
 elif outlier_boundary_type == outlierBoundaryType['QUANTILE']:
  lower_boundary = df[col].quantile(0.05)
  upper_boundary = df[col].quantile(0.95)
 elif outlier_boundary_type == outlierBoundaryType['IRQ']:
  K2 = 1.5
  IQR = df[col].quantile(0.75) - df[col].quantile(0.25)
  lower_boundary = df[col].quantile(0.25) - (K2 * IQR)
  upper_boundary = df[col].quantile(0.75) + (K2 * IQR)
 else:
  return 0, 0
 return lower_boundary, upper_boundary

for key, value in outlierBoundaryType.items():
 col = 'Avg_Open_To_Buy'
 lower_boundary, upper_boundary = get_outlier_boundaries(data, col,
value)
 outliers_temp = np.where(data[col] > upper_boundary, True,
np.where(data[col] < lower_boundary, True, False))
 data_trimmed = data.loc[~(outliers_temp), ]
 diagnostic_plots(data_trimmed, col)
```





Обработка нестандартного признака

```
!wget https://raw.githubusercontent.com/GAMES-
UChile/mogptk/master/examples/data/AirQualityUCI.csv
data2 = pd.read_csv('AirQualityUCI.csv', sep=';', encoding='utf-8')
data2 = data2.dropna(subset=['T'])
data2 = data2.dropna(axis='columns')
data2.head()
```

```
--2023-05-02 10:50:47--  https://raw.githubusercontent.com/GAMES-
UChile/mogptk/master/examples/data/AirQualityUCI.csv
Resolving raw.githubusercontent.com (raw.githubusercontent.com)...
185.199.108.133, 185.199.109.133, 185.199.110.133, ...
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)|
185.199.108.133|:443... connected.
```

```
HTTP request sent, awaiting response... 200 OK
Length: 785065 (767K) [text/plain]
Saving to: ‘AirQualityUCI.csv.13’

 AirQualityUCI.csv.1   0%[                    ]       0  --.-KB/s
AirQualityUCI.csv.1 100%[===================>] 766.67K  --.-KB/s    in
0.007s

2023-05-02 10:50:47 (113 MB/s) - ‘AirQualityUCI.csv.13’ saved
[785065/785065]


         Date      Time  CO(GT)  PT08.S1(CO)  NMHC(GT)  C6H6(GT)  \
0  10/03/2004  18.00.00     2.6       1360.0     150.0      11.9
1  10/03/2004  19.00.00     2.0       1292.0     112.0       9.4
2  10/03/2004  20.00.00     2.2       1402.0      88.0       9.0
3  10/03/2004  21.00.00     2.2       1376.0      80.0       9.2
4  10/03/2004  22.00.00     1.6       1272.0      51.0       6.5

   PT08.S2(NMHC)  NOx(GT)  PT08.S3(NOx)  NO2(GT)  PT08.S4(NO2)
PT08.S5(O3)  \
0         1046.0    166.0        1056.0    113.0        1692.0
1268.0
1          955.0    103.0        1174.0     92.0        1559.0
972.0
2          939.0    131.0        1140.0    114.0        1555.0
1074.0
3          948.0    172.0        1092.0    122.0        1584.0
1203.0
4          836.0    131.0        1205.0    116.0        1490.0
1110.0

      T    RH      AH
0  13.6  48.9  0.7578
1  13.3  47.7  0.7255
2  11.9  54.0  0.7502
3  11.0  60.0  0.7867
4  11.2  59.6  0.7888
```

```
imputer = SimpleImputer(strategy="mean")
data2[['CO(GT)']] = imputer.fit_transform(data2[['CO(GT)']])
data2[['NOx(GT)']] = imputer.fit_transform(data2[['NOx(GT)']])
data2[['NO2(GT)']] = imputer.fit_transform(data2[['NO2(GT)']])
data2 = data2.drop(columns=['NMHC(GT)'])
data2.head()
```

```
         Date      Time  CO(GT)  PT08.S1(CO)  C6H6(GT)  PT08.S2(NMHC)
\
0  10/03/2004  18.00.00     2.6       1360.0      11.9         1046.0
```

```
1  10/03/2004  19.00.00     2.0       1292.0       9.4          955.0

2  10/03/2004  20.00.00     2.2       1402.0       9.0          939.0

3  10/03/2004  21.00.00     2.2       1376.0       9.2          948.0

4  10/03/2004  22.00.00     1.6       1272.0       6.5          836.0


   NOx(GT)  PT08.S3(NOx)  NO2(GT)  PT08.S4(NO2)  PT08.S5(O3)     T
RH  \
0    166.0        1056.0    113.0        1692.0       1268.0  13.6
48.9
1    103.0        1174.0     92.0        1559.0        972.0  13.3
47.7
2    131.0        1140.0    114.0        1555.0       1074.0  11.9
54.0
3    172.0        1092.0    122.0        1584.0       1203.0  11.0
60.0
4    131.0        1205.0    116.0        1490.0       1110.0  11.2
59.6

       AH
0  0.7578
1  0.7255
2  0.7502
3  0.7867
4  0.7888
```

```
time_hour = []
for item in data2['Time']:
 time_hour.append(int(item.split('.')[0]))
day = []
month = []
year = []
for item in data2['Date']:
 day.append(int(item.split('/')[0]))
 month.append(int(item.split('/')[1]))
 year.append(int(item.split('/')[2]))
data2.insert(1, 'Day', day, allow_duplicates=False)
data2.insert(2, 'Month', month, allow_duplicates=False)
data2.insert(3, 'Year', year, allow_duplicates=False)

data2.insert(5, 'Time(Hours)', time_hour, allow_duplicates=False)
data2 = data2.drop(columns='Date')
data2 = data2.drop(columns='Time')
data2.head()
```

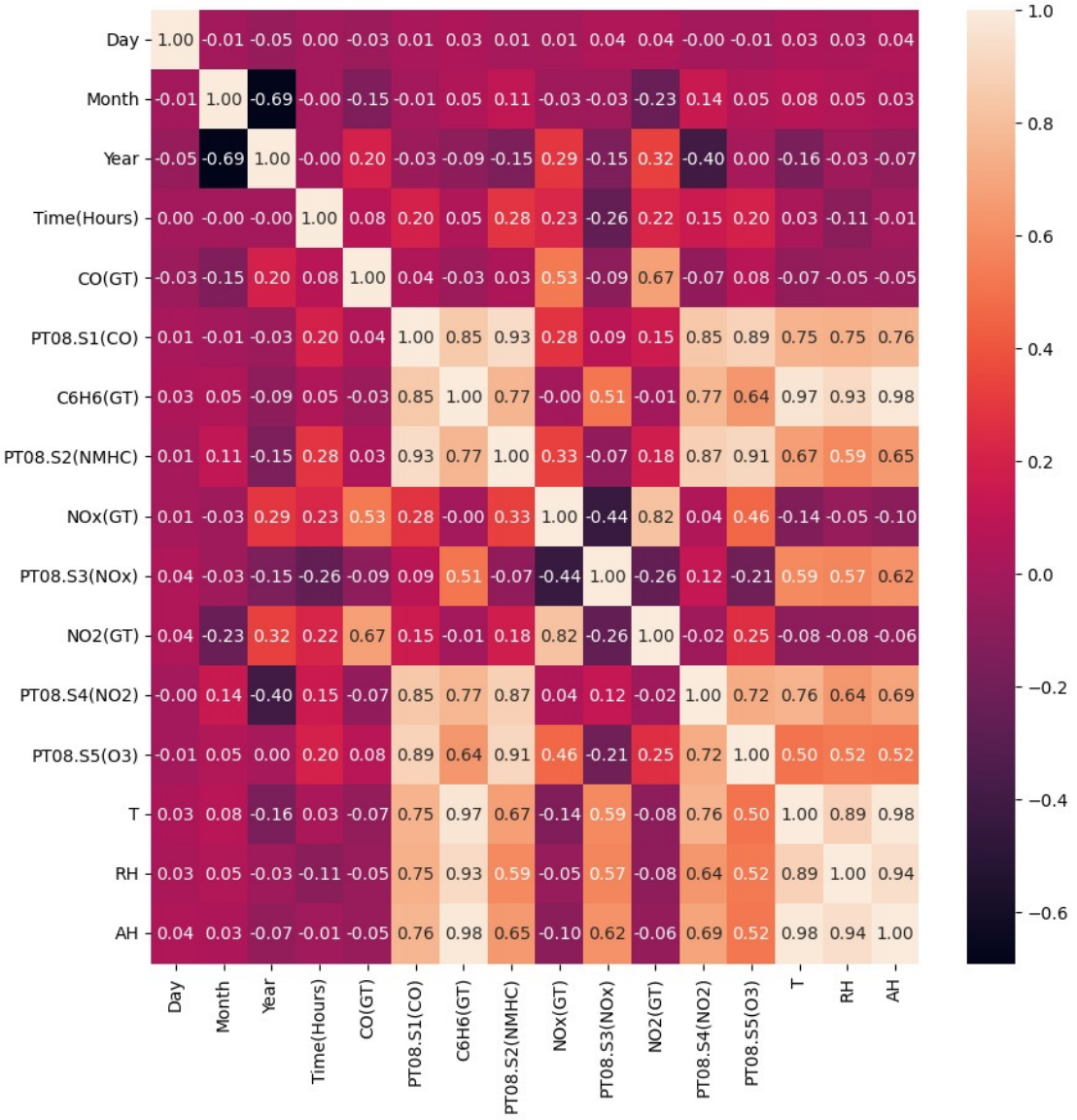
```
   Day  Month  Year  Time(Hours)  CO(GT)  PT08.S1(CO)  C6H6(GT)  \
0   10      3  2004           18     2.6       1360.0      11.9
```

```
1   10      3  2004           19     2.0       1292.0       9.4
2   10      3  2004           20     2.2       1402.0       9.0
3   10      3  2004           21     2.2       1376.0       9.2
4   10      3  2004           22     1.6       1272.0       6.5

   PT08.S2(NMHC)  NOx(GT)  PT08.S3(NOx)  NO2(GT)  PT08.S4(NO2)
PT08.S5(O3)  \
0         1046.0    166.0        1056.0    113.0        1692.0
1268.0
1          955.0    103.0        1174.0     92.0        1559.0
972.0
2          939.0    131.0        1140.0    114.0        1555.0
1074.0
3          948.0    172.0        1092.0    122.0        1584.0
1203.0
4          836.0    131.0        1205.0    116.0        1490.0
1110.0

      T    RH      AH
0  13.6  48.9  0.7578
1  13.3  47.7  0.7255
2  11.9  54.0  0.7502
3  11.0  60.0  0.7867
4  11.2  59.6  0.7888
```

Отбор признаков по корреляции

```
fig, ax = plt.subplots(figsize=(10,10))
sns.heatmap(data2.corr(method='pearson'), annot=True, fmt='.2f')
```

```
<Axes: >
```




```
for row in data2.corr():
 if data2.corr()[row]['AH'] >= 0.8:
  print(row, data2.corr()[row]['AH'])
```

```
C6H6(GT) 0.984555069291292
T 0.9810012182689022
RH 0.9439949303397153
AH 1.0
```

Отбор признаков методом обёртывания

```
knn = KNeighborsRegressor()
efs1 = EFS(knn,
 min_features=2,
 max_features=4,
 scoring='r2',
```

```
 print_progress=True,
 cv=5)
efs1 = efs1.fit(data2.drop(columns=['AH']), data2['AH'])
print('Best accuracy score: %.2f' % efs1.best_score_)
print('Best subset (indices):', efs1.best_idx_)
print('Best subset (corresponding names):', efs1.best_feature_names_)
```

```
Features: 1925/1925
```

```
Best accuracy score: 1.00
Best subset (indices): (13, 14)
Best subset (corresponding names): ('T', 'RH')
```

Отбор признаков методом вложений

```
e_lr1 = Lasso()
e_lr1.fit(data2.drop(columns=['AH']), data2['AH'])
# Коэффициенты регрессии
e_lr1.coef_
```

```
array([-0.00000000e+00, -0.00000000e+00, -0.00000000e+00,
0.00000000e+00,
        6.87431144e-05,  8.68174290e-04,  7.26479761e-01, -
1.53372531e-02,
       -4.03944079e-03,  3.86105204e-04,  6.33796911e-03, -
5.37266566e-03,
        5.74973019e-04,  2.36172795e-01,  8.19589105e-02])
```

```
sel_e_lr1 = SelectFromModel(e_lr1)
sel_e_lr1.fit(data2.drop(columns=['AH']), data2['AH'])
sel_e_lr1.get_support()
```

```
array([False, False, False, False,  True,  True,  True,  True,  True,
        True,  True,  True,  True,  True,  True])
```