Лабораторная работа №3

Подготовка обучающей и тестовой выборки, кросс-валидация и подбор гиперпараметров на примере метода ближайших соседей.

- Импорт необходимых библиотек, создание DataFraim'a

In [ ]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

df = pd.read_csv('data/WineQT.csv')
```

Анализ датасета

In [ ]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1143 entries, 0 to 1142
Data columns (total 13 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   fixed acidity         1143 non-null   float64
 1   volatile acidity      1143 non-null   float64
 2   citric acid           1143 non-null   float64
 3   residual sugar        1143 non-null   float64
 4   chlorides             1143 non-null   float64
 5   free sulfur dioxide   1143 non-null   float64
 6   total sulfur dioxide  1143 non-null   float64
 7   density               1143 non-null   float64
 8   pH                    1143 non-null   float64
 9   sulphates             1143 non-null   float64
 10  alcohol               1143 non-null   float64
 11  quality               1143 non-null   int64  
 12  Id                    1143 non-null   int64  
dtypes: float64(11), int64(2)
memory usage: 116.2 KB
```

- Датасет имеет 12 колонок и 1143 строк

In [ ]:

```
df.head()
```

Out[ ]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	al
0	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	
1	7.8	0.88	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	0.68	
2	7.8	0.76	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	0.65	
3	11.2	0.28	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	0.58	
4	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	

In [ ]:

```
import os
import sys
module_path = os.path.abspath(os.path.join('..'))
if module_path not in sys.path:
    sys.path.append(module_path)

from lab2.utils import get_df_info

get_df_info(df)
```

```
Столбец fixed acidity (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индек
с 0)

Столбец volatile acidity (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (и
ндекс 1)

Столбец citric acid (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс
2)

Столбец residual sugar (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (инде
кс 3)

Столбец chlorides (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 4)

Столбец free sulfur dioxide (тип float64) имеет 0 пропусков из 1143 значений, 0.0%
(индекс 5)

Столбец total sulfur dioxide (тип float64) имеет 0 пропусков из 1143 значений, 0.
0% (индекс 6)

Столбец density (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 7)

Столбец pH (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 8)

Столбец sulphates (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 9)

Столбец alcohol (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 10)

Столбец quality (тип int64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 11)

Столбец Id (тип int64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 12)
```

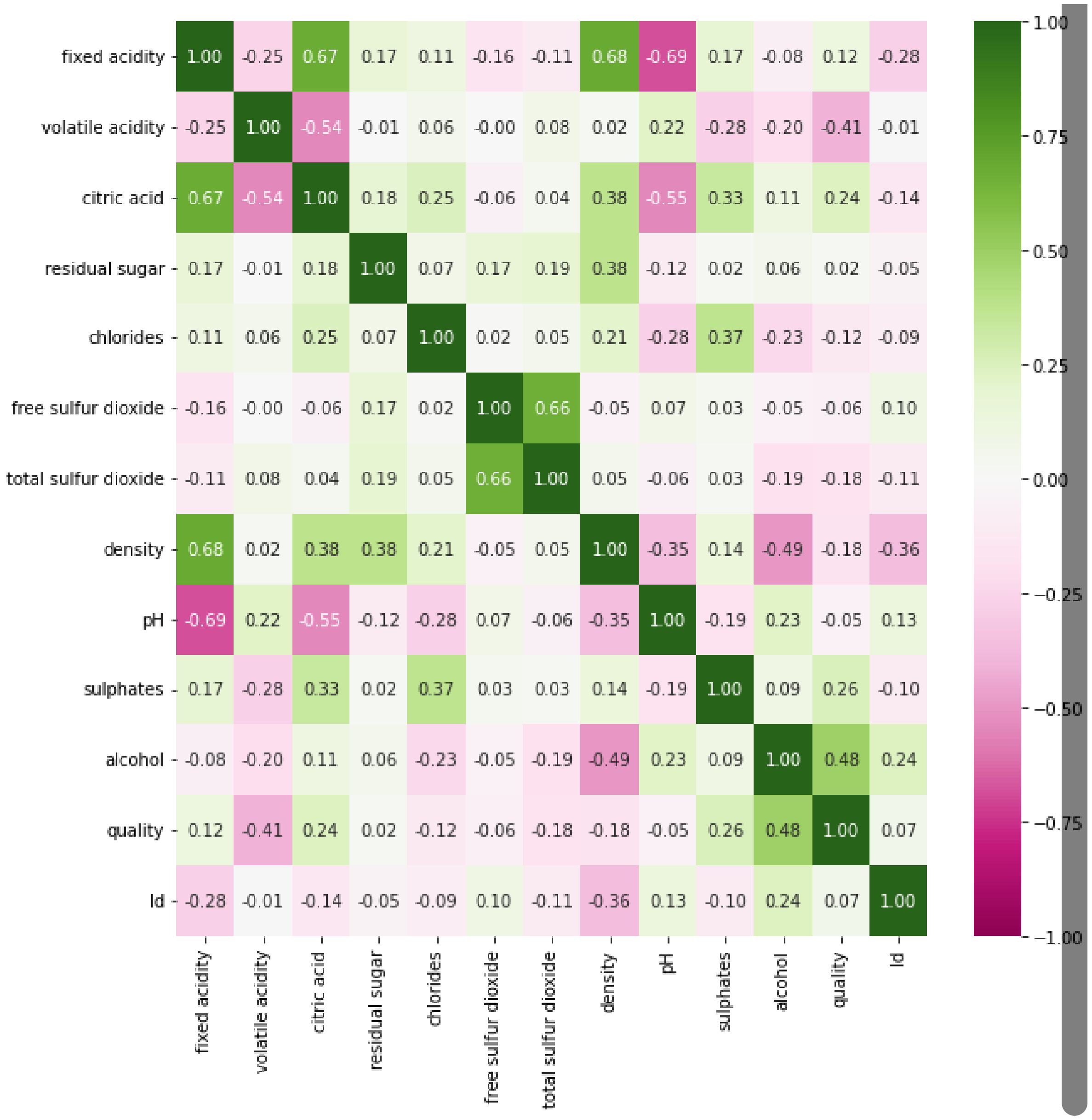
- Во всех столбцах нет пропусков

In [ ]:

```
fig, ax = plt.subplots(1, 1, sharex="col", sharey="row", figsize=(10, 10))
sns.heatmap(df.corr(), annot=True, cmap="PiYG", fmt=".2f", vmin=-1, vmax=1)
```

Out[ ]:

```
<AxesSubplot:>
```



> Выберем параметры "quality" и "fixed acidity" как целевые

- Произведём отбор доп. параметров

In [ ]:
```
nparray = df.to_numpy()

taken_cols = [0, 1, 2, 7, 8, 9, 10, 11]
taken_cols_cl = [1, 2, 9, 10, 11]
```

In [ ]:
```
nparray_sliced = nparray.take(taken_cols, 1)

nparray_cl = nparray.take(taken_cols_cl, 1)

df_sliced = pd.DataFrame(nparray_sliced, columns=df.columns.take(taken_cols)
df_cl = pd.DataFrame(nparray_cl, columns=df.columns.take(taken_cols_cl))

df_sliced.head()
```

Out[ ]:

	fixed acidity	volatile acidity	citric acid	density	pH	sulphates	alcohol	quality
0	7.4	0.70	0.00	0.9978	3.51	0.56	9.4	5.0
1	7.8	0.88	0.00	0.9968	3.20	0.68	9.8	5.0
2	7.8	0.76	0.04	0.9970	3.26	0.65	9.8	5.0
3	11.2	0.28	0.56	0.9980	3.16	0.58	9.8	6.0
4	7.4	0.70	0.00	0.9978	3.51	0.56	9.4	5.0

In [ ]:

```
df_sliced.describe()
```

Out[ ]:

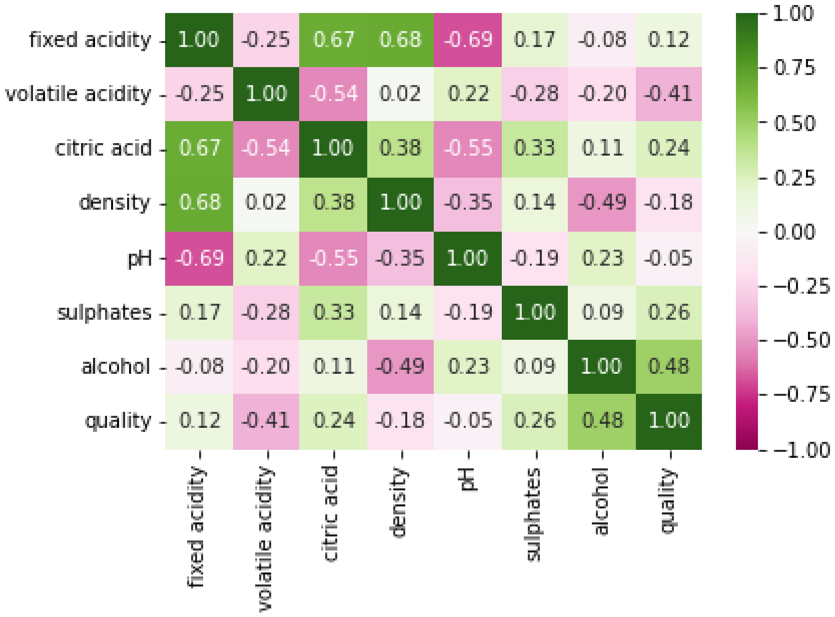
	fixed acidity	volatile acidity	citric acid	density	pH	sulphates	
count	1143.000000	1143.000000	1143.000000	1143.000000	1143.000000	1143.000000	1143
mean	8.311111	0.531339	0.268364	0.996730	3.311015	0.657708	1
std	1.747595	0.179633	0.196686	0.001925	0.156664	0.170399	
min	4.600000	0.120000	0.000000	0.990070	2.740000	0.330000	8
25%	7.100000	0.392500	0.090000	0.995570	3.205000	0.550000	9
50%	7.900000	0.520000	0.250000	0.996680	3.310000	0.620000	10
75%	9.100000	0.640000	0.420000	0.997845	3.400000	0.730000	1
max	15.900000	1.580000	1.000000	1.003690	4.010000	2.000000	14

In [ ]:

```
sns.heatmap(df_sliced.corr(), annot=True, cmap="PiYG", fmt=".2f", vmin=-1, v
```

Out[ ]:

```
<AxesSubplot:>
```



	fixed acidity	volatile acidity	citric acid	density	pH	sulphates	alcohol	quality
fixed acidity	1.00	-0.25	0.67	0.68	-0.69	0.17	-0.08	0.12
volatile acidity	-0.25	1.00	-0.54	0.02	0.22	-0.28	-0.20	-0.41
citric acid	0.67	-0.54	1.00	0.38	-0.55	0.33	0.11	0.24
density	0.68	0.02	0.38	1.00	-0.35	0.14	-0.49	-0.18
pH	-0.69	0.22	-0.55	-0.35	1.00	-0.19	0.23	-0.05
sulphates	0.17	-0.28	0.33	0.14	-0.19	1.00	0.09	0.26
alcohol	-0.08	-0.20	0.11	-0.49	0.23	0.09	1.00	0.48
quality	0.12	-0.41	0.24	-0.18	-0.05	0.26	0.48	1.00

In [ ]:

```
get_df_info(df_sliced)
```

```
Столбец fixed acidity (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индек
с 0)

Столбец volatile acidity (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (и
ндекс 1)

Столбец citric acid (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс
2)

Столбец density (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 3)

Столбец pH (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 4)

Столбец sulphates (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 5)

Столбец alcohol (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 6)

Столбец quality (тип float64) имеет 0 пропусков из 1143 значений, 0.0% (индекс 7)
```

In [ ]:

```python
from sklearn.preprocessing import MinMaxScaler

sc = MinMaxScaler()

# данные для регрессии
df_sliced_scaled = df_sliced.copy()

# данные для классификации
df_scaled_cl = df_cl.copy()

columns_for_scaling = df_sliced.columns

for i in columns_for_scaling:
    df_sliced_scaled[[i]] = sc.fit_transform(df_sliced[[i]])

for i in df_cl.columns:
    if i != 'quality':
      df_scaled_cl[[i]] = sc.fit_transform(df_cl[[i]])


df_sliced_scaled.describe()
```

Out[ ]:

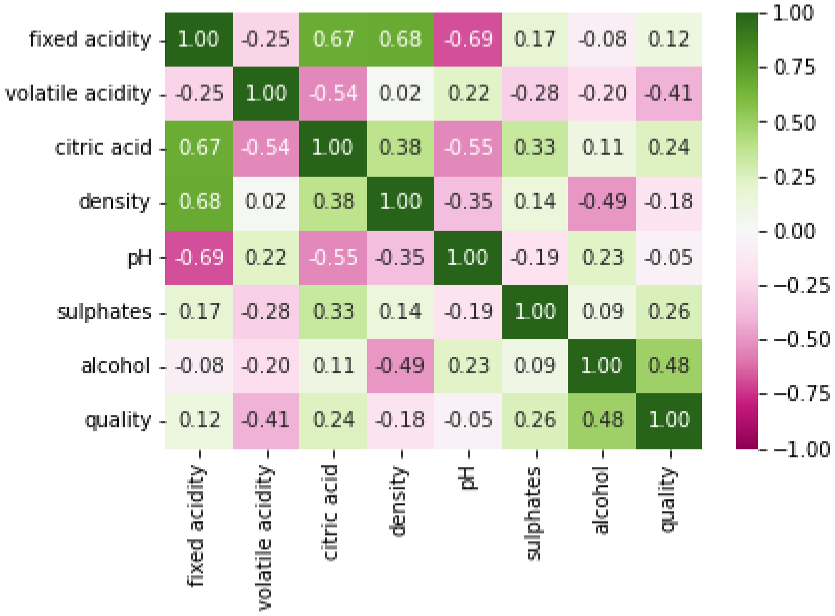
	fixed acidity	volatile acidity	citric acid	density	pH	sulphates
count	1143.000000	1143.000000	1143.000000	1143.000000	1143.000000	1143.000000
mean	0.328417	0.281739	0.268364	0.489017	0.449618	0.196232
std	0.154654	0.123036	0.196686	0.141341	0.123358	0.102035
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.221239	0.186644	0.090000	0.403818	0.366142	0.131737
50%	0.292035	0.273973	0.250000	0.485316	0.448819	0.173653
75%	0.398230	0.356164	0.420000	0.570852	0.519685	0.239521
max	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

In [ ]:

```python
sns.heatmap(df_sliced_scaled.corr(), annot=True, cmap="PiYG", fmt=".2f", vmi
```

Out[ ]:

```
<AxesSubplot:>
```



Метод kNN

In [ ]:

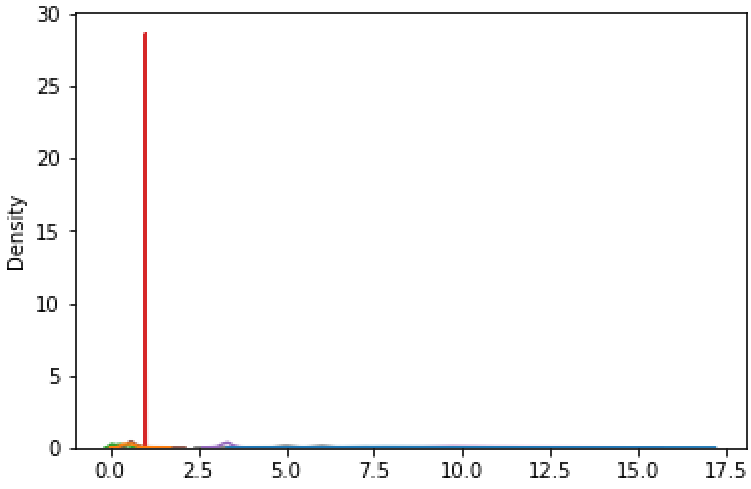
```
data_unscaled = df_sliced
data_scaled = df_sliced_scaled
```

In [ ]:

```
sns.kdeplot(data = data_unscaled, legend = False)
```

Out[ ]:

```
<AxesSubplot:ylabel='Density'>
```

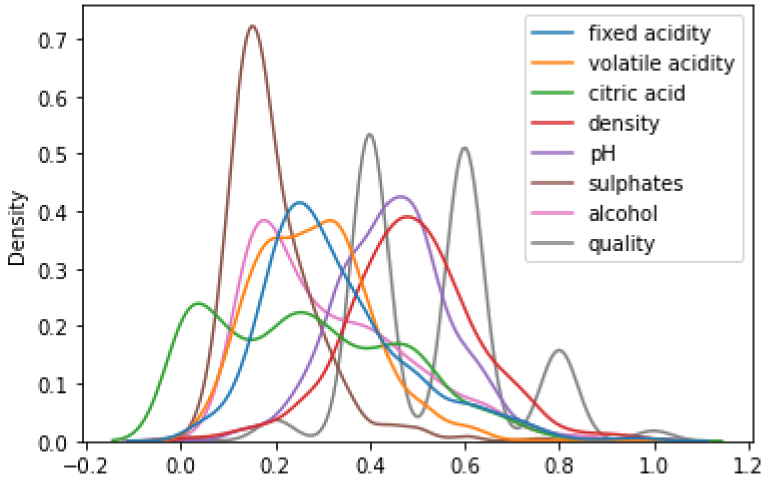


In [ ]:

```
sns.kdeplot(data = data_scaled)
```

Out[ ]:

```
<AxesSubplot:ylabel='Density'>
```



Регрессия

In [ ]:

```
from sklearn.model_selection import train_test_split


# Для определённости будем всегда подставлять в random_state одно значение
RANDOM_STATE_GLOBAL = 1
# Указываем, где целевой признак, а где - набор данных

y_column = "fixed acidity"
# y_column = "quality"
x_columns = data_unscaled.columns.tolist()
x_columns.pop(x_columns.index(y_column))


data_unscaled_x_train, data_unscaled_x_test, data_unscaled_y_train, data_uns




data_scaled_x_train, data_scaled_x_test, data_scaled_y_train, data_scaled_y_
```

Получение произвольной модели

In [ ]:

```
from sklearn.neighbors import KNeighborsRegressor


random_param = 15

knn_unscaled = KNeighborsRegressor(n_neighbors = random_param)
knn_scaled = KNeighborsRegressor(n_neighbors = random_param)

knn_unscaled.fit(data_unscaled_x_train, data_unscaled_y_train)
knn_scaled.fit(data_scaled_x_train, data_scaled_y_train)

knn_unscaled_prediction = knn_unscaled.predict(data_unscaled_x_test)
knn_scaled_prediction = knn_scaled.predict(data_scaled_x_test)
```

In [ ]:

```
from sklearn.metrics import mean_absolute_error, mean_squared_error, median_
from sklearn.model_selection import ShuffleSplit, cross_val_score, cross_val


def print_regression_metrics(y_test, y_predicted):
    abs_err = mean_absolute_error(y_test, y_predicted)
    med_abs_err = median_absolute_error(y_test, y_predicted)
    mean_sq_err = mean_squared_error(y_test, y_predicted, squared=False)
    r2 = r2_score(y_test, y_predicted)

    return f"-Средняя абсолютная ошибка = {abs_err};\
          \n-Медианная абсолютная ошибка = {med_abs_err};\
          \n-Среднеквадратичная ошибка = {mean_sq_err};\
          \n-Коэффициент детерминации = {r2}."
```

In [ ]:

```
unscaled_results = print_regression_metrics(data_unscaled_y_test, knn_unscal
print("Для немасштабированных данных:\n" + unscaled_results)
```

```
Для немасштабированных данных:
-Средняя абсолютная ошибка = 0.9337117903930132;
-Медианная абсолютная ошибка = 0.6733333333333347;
-Среднеквадратичная ошибка = 1.3030409698256435;
-Коэффициент детерминации = 0.48034335910257353.
```

In [ ]:

```
scaled_results = print_regression_metrics(data_scaled_y_test, knn_scaled_pre
print("Для масштабированных данных:\n" + scaled_results)
```

```
Для масштабированных данных:
-Средняя абсолютная ошибка = 0.051172856204351365;
-Медианная абсолютная ошибка = 0.040117994100294985;
-Среднеквадратичная ошибка = 0.06825895007051318;
-Коэффициент детерминации = 0.8179140507244748.
```

In [ ]:

```
def print_dictionary(dict):
    for k, v in dict.items():
        print(f"\n{k} -> {v}")
```

In [ ]:

```
scoring_strategies = ["neg_root_mean_squared_error", "r2"]

# Кросс-валидация по стратегии ShuffleSplit
data_unscaled_cv_scores = cross_validate(KNeighborsRegressor(n_neighbors = r
data_scaled_cv_scores = cross_validate(KNeighborsRegressor(n_neighbors = ran

print("Кросс-валидация для немасштабированных данных:")
print_dictionary(data_unscaled_cv_scores)

print("\n\nКросс-валидация для масштабированных данных:")
print_dictionary(data_scaled_cv_scores)
```

```
Кросс-валидация для немасштабированных данных:

fit_time -> [0.0017159  0.00124884 0.00118494 0.00121403 0.0011611  0.001118
9
 0.00119114 0.00114894]

score_time -> [0.00501513 0.0045681  0.00432324 0.00438309 0.00410485 0.0042
7008
 0.00557685 0.00444508]

test_neg_root_mean_squared_error -> [-1.39626202 -1.44587844 -1.51642493 -1.
45415924 -1.50586796 -1.49622013
 -1.52830483 -1.53428592]

test_r2 -> [0.32751969 0.28905716 0.25992897 0.28830724 0.26166938 0.2676702
1
 0.26171954 0.24662078]


Кросс-валидация для масштабированных данных:

fit_time -> [0.00538015 0.00123692 0.00229192 0.00117826 0.00129008 0.001317
26
 0.00119901 0.00118589]

score_time -> [0.00632381 0.00658107 0.00545812 0.00599289 0.00599074 0.0060
4892
 0.00583196 0.005759  ]

test_neg_root_mean_squared_error -> [-0.07748939 -0.07989178 -0.08442376 -0.
07777424 -0.08516609 -0.08251339
 -0.08758429 -0.08454686]

test_r2 -> [0.73552351 0.72283898 0.70710107 0.74004567 0.69844439 0.7156053
3
 0.69039303 0.70788568]
```

Получение оптимальной модели

In [ ]:

```
from sklearn.model_selection import GridSearchCV, RandomizedSearchCV, KFold

tested_parametres = {"n_neighbors" : np.array(range(1, 41, 1))}
```

In [ ]:

```
%%time
# Кросс-валидация по стратегии KFold
randomized_grid_search = RandomizedSearchCV(KNeighborsRegressor(),
                                            tested_parametres,
                                            n_iter = 40,
                                            random_state = RANDOM_STATE_GLOB
                                            cv = KFold(shuffle = True, randc
                                            scoring = "neg_root_mean_squared

randomized_grid_search.fit(data_unscaled[x_columns], data_unscaled[y_column]
```

```
CPU times: user 721 ms, sys: 4.43 ms, total: 725 ms
Wall time: 724 ms
```

Out[ ]:

```
RandomizedSearchCV(cv=KFold(n_splits=5, random_state=1, shuffle=True),
                   estimator=KNeighborsRegressor(), n_iter=40,
                   param_distributions={'n_neighbors': array([ 1,  2,  3,
4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17,
       18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34,
       35, 36, 37, 38, 39, 40])},
                   random_state=1, scoring='neg_root_mean_squared_error')
```

```
In [ ]: randomized_best_param = randomized_grid_search.best_params_.get("n_neighbors
        print(randomized_best_param, randomized_grid_search.best_score_)
```

```
7 -1.1681855323422545
```

```
In [ ]: # Ищем решение вокруг полученного значения с радиусом 10
        # Тоже перебираю так много из-за проблем с масштабированными данными
        gs_parametres = {"n_neighbors" : np.array(range(randomized_best_param - 3, r

        # Прогоняем все решения в окрестности
        grid_search = GridSearchCV(KNeighborsRegressor(), gs_parametres, scoring = "
        # Обучаем оптимальную модель
        grid_search.fit(data_unscaled[x_columns], data_unscaled[y_column])
```

```
Out[ ]: GridSearchCV(cv=KFold(n_splits=5, random_state=1, shuffle=True),
                     estimator=KNeighborsRegressor(),
                     param_grid={'n_neighbors': array([ 4,  5,  6,  7,  8,  9, 1
        0])},
                     scoring='neg_root_mean_squared_error')
```

```
In [ ]: # Итоговые "наилучшие" параметр и показатель RMSE:
        best_param = grid_search.best_params_.get("n_neighbors")
        print(best_param, grid_search.best_score_)
```

```
7 -1.1681855323422545
```

```
In [ ]: # Обучаем оптимальную модель
        cv_found_knn_unscaled = KNeighborsRegressor(n_neighbors = best_param)
        cv_found_knn_unscaled.fit(data_unscaled_x_train, data_unscaled_y_train)
        cv_found_knn_unscaled_prediction = cv_found_knn_unscaled.predict(data_unscal

        cv_unscaled_results = print_regression_metrics(data_unscaled_y_test, cv_foun
```

```
In [ ]: def print_results(random, optimum):
            print("Немасштабированные данные\n")
            print("Случайная модель:\n" + random)
            print('------------------------------------------')
            print("Оптимальная модель:\n" + optimum)
```

```
In [ ]: print_results(unscaled_results, cv_unscaled_results)
```

```
Немасштабированные данные

Случайная модель:
-Средняя абсолютная ошибка = 0.9337117903930132;
-Медианная абсолютная ошибка = 0.6733333333333347;
-Среднеквадратичная ошибка = 1.3030409698256435;
-Коэффициент детерминации = 0.48034335910257353.
------------------------------------------
Оптимальная модель:
-Средняя абсолютная ошибка = 0.8537741734248284;
-Медианная абсолютная ошибка = 0.5857142857142845;
-Среднеквадратичная ошибка = 1.2386117898073419;
-Коэффициент детерминации = 0.5304619856518069.
```

```
In [ ]: # Точно также прогоняем: тот же диапазон возможных значений К, тот же ключ генерато
        #                        та же стратегия кросс-валидации, та же метрика.
        randomized_grid_search = RandomizedSearchCV(KNeighborsRegressor(),
                                                    tested_parametres,
                                                    n_iter = 40,
                                                    random_state = RANDOM_STATE_GLOB
                                                    cv = KFold(shuffle = True, rando
                                                    scoring = "neg_root_mean_squared
        # Теперь работаем с масштабированными данными
        randomized_grid_search.fit(data_scaled[x_columns], data_scaled[y_column])
```

```
# Найденное рабочее значение
randomized_best_param = randomized_grid_search.best_params_.get("n_neighbors
print(randomized_best_param, randomized_grid_search.best_score_)

# Ищем оптимальное значение гиперпараметра
gs_parametres = {"n_neighbors" : np.array(range(randomized_best_param - 3, r
grid_search = GridSearchCV(KNeighborsRegressor(), gs_parametres, scoring = "
grid_search.fit(data_scaled[x_columns], data_scaled[y_column])

# Найденное оптимальное значение
best_param = grid_search.best_params_.get("n_neighbors")
print(best_param, grid_search.best_score_)

# Обучаем оптимальную модель
cv_found_knn_scaled = KNeighborsRegressor(n_neighbors = best_param)
cv_found_knn_scaled.fit(data_scaled_x_train, data_scaled_y_train)
cv_found_knn_scaled_prediction = cv_found_knn_scaled.predict(data_scaled_x_t

cv_scaled_results = print_regression_metrics(data_scaled_y_test, cv_found_kn
```

```
5 -0.06991970951644243
5 -0.06991970951644243
```

In [ ]:

```
print_results(scaled_results, cv_scaled_results)
```

```
Немасштабированные данные

Случайная модель:
-Средняя абсолютная ошибка = 0.05117285620435136 5;
-Медианная абсолютная ошибка = 0.040117994100294985;
-Среднеквадратичная ошибка = 0.06825895007051318;
-Коэффициент детерминации = 0.8179140507244748.
------------------------------------------
Оптимальная модель:
-Средняя абсолютная ошибка = 0.048019476755419885;
-Медианная абсолютная ошибка = 0.033628318584070865;
-Среднеквадратичная ошибка = 0.06460724870773447;
-Коэффициент детерминации = 0.8368753018768951.
```

> Как видно, подбор гиперпараметра K поспособствовал улучшению качества модели как для масштабированных данных, так для немасштабированных

Классификация

- Воспользуемся методом kNN также для решения задачи классификации для параметра "quality"

In [ ]:

```
# Для определённости будем всегда подставлять в random_state одно значение
RANDOM_STATE_GLOBAL = 1
# Указываем, где целевой признак, а где - набор данных

data_scaled = df_scaled_cl.copy()
data_unscaled = df_cl.copy()
y_column = "quality"
x_columns = data_unscaled.columns.tolist()
x_columns.pop(x_columns.index(y_column))


data_unscaled_x_train, data_unscaled_x_test, data_unscaled_y_train, data_uns
```

```
data_scaled_x_train, data_scaled_x_test, data_scaled_y_train, data_scaled_y_
```

Получение произвольной модели

In [ ]:

```
from sklearn.neighbors import KNeighborsClassifier


random_param = 15

knn_unscaled = KNeighborsClassifier(n_neighbors = random_param)
knn_scaled = KNeighborsClassifier(n_neighbors = random_param)

knn_unscaled.fit(data_unscaled_x_train, data_unscaled_y_train)
knn_scaled.fit(data_scaled_x_train, data_scaled_y_train)

knn_unscaled_prediction = knn_unscaled.predict(data_unscaled_x_test)
knn_scaled_prediction = knn_scaled.predict(data_scaled_x_test)
```

- Создадим метод, для вывода методов оценки модели

In [ ]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score, recall_score, f1_score

def print_classification_metrics(y_test, y_predicted):
    acc_score = accuracy_score(y_test, y_predicted)
    prec_score = precision_score(y_test, y_predicted, average='weighted')
    rec_score = recall_score(y_test, y_predicted, average='weighted')
    f1 = f1_score(y_test, y_predicted, average='weighted')

    return f"-Accuracy = {acc_score};\
          \n-Precision= {prec_score};\
          \n-Recall = {rec_score};\
          \n-f1 = {f1}."
```

In [ ]:

```
unscaled_results = print_classification_metrics(data_unscaled_y_test, knn_un
print("Для немасштабированных данных:\n" + unscaled_results)
```

```
Для немасштабированных данных:
-Accuracy = 0.5807860262008734;
-Precision= 0.5412787344483809;
-Recall = 0.5807860262008734;
-f1 = 0.5579432160980076.
```

```
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision
is ill-defined and being set to 0.0 in labels with no predicted samples. Use
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [ ]:

```
scaled_results = print_classification_metrics(data_scaled_y_test, knn_scaled
print("Для масштабированных данных:\n" + scaled_results)
```

```
Для масштабированных данных:
-Accuracy = 0.5895196506550219;
-Precision= 0.5693327204474067;
-Recall = 0.5895196506550219;
-f1 = 0.5735453609940674.
```

```
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Precision
is ill-defined and being set to 0.0 in labels with no predicted samples. Use
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

> Точность классификации получилась не очень высокой

Получение оптимальной модели

In [ ]:

```
from sklearn.model_selection import GridSearchCV, RandomizedSearchCV, KFold

tested_parametres = {"n_neighbors" : np.array(range(1, 51, 1))}
```

In [ ]:

```
%%time
# Кросс-валидация по стратегии KFold
randomized_grid_search = RandomizedSearchCV(KNeighborsClassifier(),
                                            tested_parametres,
                                            n_iter = 50,
                                            random_state = RANDOM_STATE_GLOB
                                            cv = KFold(shuffle = True, rando
                                            scoring = "balanced_accuracy")


randomized_grid_search.fit(data_unscaled[x_columns], data_unscaled[y_column]
```

```
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1987: UserWarning: y_pred contains clas
ses not in y_true
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/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1987: UserWarning: y_pred contains clas
ses not in y_true
  warnings.warn("y_pred contains classes not in y_true")
```

```
CPU times: user 1.66 s, sys: 9.21 ms, total: 1.67 s
Wall time: 1.67 s
```

Out[ ]:

```
RandomizedSearchCV(cv=KFold(n_splits=5, random_state=1, shuffle=True),
                   estimator=KNeighborsClassifier(), n_iter=50,
                   param_distributions={'n_neighbors': array([ 1,  2,  3,
4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17,
       18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34,
       35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50])},
                   random_state=1, scoring='balanced_accuracy')
```

In [ ]:

```
randomized_best_param = randomized_grid_search.best_params_.get("n_neighbors
print(randomized_best_param, randomized_grid_search.best_score_)
```

```
1 0.38085391319132766
```

In [ ]:

```
gs_parametres = {"n_neighbors": np.array(
    range(randomized_best_param - 3, randomized_best_param + 4))}

grid_search = GridSearchCV(KNeighborsClassifier(), gs_parametres, scoring='b
    shuffle=True, random_state=RANDOM_STATE_GLOBAL))
```

```
grid_search.fit(data_unscaled[x_columns], data_unscaled[y_column])
```

```
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1987: UserWarning: y_pred contains clas
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  warnings.warn("y_pred contains classes not in y_true")
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/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/model_selection/_validation.py:372: FitFailedWarning:
15 fits failed out of a total of 35.
The score on these train-test partitions for these parameters will be set to
nan.
If these failures are not expected, you can try to debug them by setting err
or_score='raise'.

Below are more details about the failures:
----------------------------------------------------------------------------
----
5 fits failed with the following error:
Traceback (most recent call last):
  File "/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-
packages/sklearn/model_selection/_validation.py", line 680, in _fit_and_scor
e
    estimator.fit(X_train, y_train, **fit_params)
  File "/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-
packages/sklearn/neighbors/_classification.py", line 198, in fit
    return self._fit(X, y)
  File "/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-
packages/sklearn/neighbors/_base.py", line 569, in _fit
    raise ValueError("Expected n_neighbors > 0. Got %d" % self.n_neighbors)
ValueError: Expected n_neighbors > 0. Got -2

----------------------------------------------------------------------------
----
5 fits failed with the following error:
Traceback (most recent call last):
  File "/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-
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packages/sklearn/neighbors/_base.py", line 569, in _fit
    raise ValueError("Expected n_neighbors > 0. Got %d" % self.n_neighbors)
ValueError: Expected n_neighbors > 0. Got -1

----------------------------------------------------------------------------
----
5 fits failed with the following error:
Traceback (most recent call last):
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    raise ValueError("Expected n_neighbors > 0. Got %d" % self.n_neighbors)
ValueError: Expected n_neighbors > 0. Got 0

  warnings.warn(some_fits_failed_message, FitFailedWarning)
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/model_selection/_search.py:969: UserWarning: One or more of the te
st scores are non-finite: [        nan        nan        nan 0.38085391 0.307
76432 0.30401159
 0.28841833]
  warnings.warn(
```

Out[ ]:

```
GridSearchCV(cv=KFold(n_splits=5, random_state=1, shuffle=True),
             estimator=KNeighborsClassifier(),
             param_grid={'n_neighbors': array([-2, -1,  0,  1,  2,  3,
4])},
             scoring='balanced_accuracy')
```

In [ ]:

```
# Итоговые "наилучшие" параметр и показатель RMSE:
best_param = grid_search.best_params_.get("n_neighbors")
print(best_param, grid_search.best_score_)
```

```
1 0.38085391319132766
```

In [ ]:

```
cv_found_knn_unscaled = KNeighborsClassifier(n_neighbors = best_param)
cv_found_knn_unscaled.fit(data_unscaled_x_train, data_unscaled_y_train)
cv_found_knn_unscaled_prediction = cv_found_knn_unscaled.predict(data_unscal

cv_unscaled_results = print_classification_metrics(data_unscaled_y_test, cv_
```

```
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Recall is
ill-defined and being set to 0.0 in labels with no true samples. Use `zero_d
ivision` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [ ]:

```
print_results(unscaled_results, cv_unscaled_results)
```

```
Немасштабированные данные

Случайная модель:
-Accuracy = 0.5807860262008734;
-Precision= 0.5412787344483809;
-Recall = 0.5807860262008734;
-f1 = 0.5579432160980076.
------------------------------------------
Оптимальная модель:
-Accuracy = 0.62882096069869;
-Precision= 0.627083626801897;
-Recall = 0.62882096069869;
-f1 = 0.6253016146073963.
```

In [ ]:

```
randomized_grid_search = RandomizedSearchCV(KNeighborsClassifier(),
                                            tested_parametres,
                                            n_iter=50,
                                            random_state=RANDOM_STATE_GLOBAL
                                            cv=KFold(
                                                shuffle=True, random_state=R
                                            scoring='balanced_accuracy')

randomized_grid_search.fit(data_scaled[x_columns], data_scaled[y_column])

randomized_best_param = randomized_grid_search.best_params_.get("n_neighbors
print(randomized_best_param, randomized_grid_search.best_score_)
gs_parametres = {"n_neighbors": np.array(
    range(randomized_best_param - 3, randomized_best_param + 4))}
grid_search = GridSearchCV(KNeighborsClassifier(), gs_parametres, scoring='b
    shuffle=True, random_state=RANDOM_STATE_GLOBAL))
grid_search.fit(data_scaled[x_columns], data_scaled[y_column])

best_param = grid_search.best_params_.get("n_neighbors")
print(best_param, grid_search.best_score_)

cv_found_knn_scaled = KNeighborsClassifier(n_neighbors=best_param)
cv_found_knn_scaled.fit(data_scaled_x_train, data_scaled_y_train)
cv_found_knn_scaled_prediction = cv_found_knn_scaled.predict(
    data_scaled_x_test)

cv_scaled_results = print_classification_metrics(
    data_scaled_y_test, cv_found_knn_scaled_prediction)
```

```
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  warnings.warn("y_pred contains classes not in y_true")
```

```
1 0.4107454755371836
1 0.4107454755371836
```

```
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ValueError: Expected n_neighbors > 0. Got -2

----------------------------------------------------------------------------
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ValueError: Expected n_neighbors > 0. Got -1

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/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/model_selection/_search.py:969: UserWarning: One or more of the te
st scores are non-finite: [        nan        nan        nan 0.41074548 0.299
98324 0.30676351
 0.30669648]
  warnings.warn(
/Users/feelsbadmans/Univer/bmstu-6-sem-tmo/.venv/lib/python3.8/site-package
s/sklearn/metrics/_classification.py:1318: UndefinedMetricWarning: Recall is
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ivision` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [ ]:

```
print_results(scaled_results, cv_scaled_results)
```

```
Немасштабированные данные

Случайная модель:
-Accuracy = 0.5895196506550219;
-Precision= 0.5693327204474067;
-Recall = 0.5895196506550219;
-f1 = 0.5735453609940674.
------------------------------------------
Оптимальная модель:
-Accuracy = 0.611353711790393;
-Precision= 0.6290764417233151;
-Recall = 0.611353711790393;
-f1 = 0.6176357435350698.
```

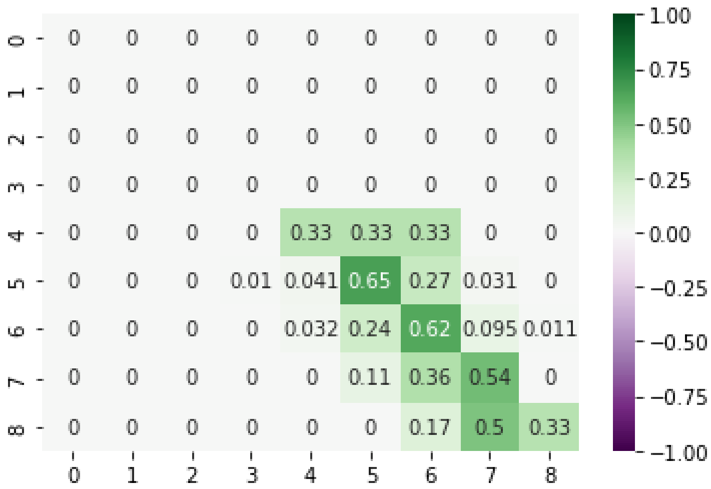
In [ ]:

```
cm = confusion_matrix(data_scaled_y_test, cv_found_knn_scaled_prediction, la

sns.heatmap(cm, annot=True, cmap=plt.cm.PRGn, vmin=-1, vmax=1)
```

Out[ ]:

```
<AxesSubplot:>
```



> С помощью подбора гиперпараметра удалось немного повысить качество модели