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ФАКУЛЬТЕТ Информатика и системы управления и искусственный интеллект
КАФЕДРА Системы обработки информации и управления

Лабораторная работа № 3

По курсу

«Методы машинного обучения»

На тему:

«Обработка признаков (часть 2)»

Подготовил:

Студент группы

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Проверил:

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- **Цель лабораторной работы:** изучение продвинутых способов предварительной обработки данных для дальнейшего формирования моделей.

Задание

- Выбрать один или несколько наборов данных (датасетов) для решения следующих задач. Каждая задача может быть решена на отдельном датасете, или несколько задач могут быть решены на одном датасете. Просьба не использовать датасет, на котором данная задача решалась в лекции.
- Для выбранного датасета (датасетов) на основе материалов лекций решить следующие задачи:
 - масштабирование признаков (не менее чем тремя способами);
 - обработку выбросов для числовых признаков (по одному способу для удаления выбросов и для замены выбросов);
 - обработку по крайней мере одного нестандартного признака (который не является числовым или категориальным);
 - отбор признаков:
 - один метод из группы методов фильтрации (filter methods);
 - один метод из группы методов обертывания (wrapper methods);
 - один метод из группы методов вложений (embedded methods).

Подключение библиотек

```
In [8]: import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns
from sklearn.datasets import _california_housing
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import RobustScaler
from sklearn.preprocessing import MaxAbsScaler
```

Ход работы

Загрузка и предобработка данных

```
In [15]: california_ds = _california_housing.fetch_california_housing()
data = pd.DataFrame(california_ds.data,
                    columns=california_ds.feature_names)
data['Y'] = california_ds.target
data.shape
```

```
Out[15]: (20640, 9)
```

```
In [16]: data.head()
```

Out[16]:

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup	Latitude	Longitude
0	8.3252	41.0	6.984127	1.023810	322.0	2.555556	37.88	-122.23
1	8.3014	21.0	6.238137	0.971880	2401.0	2.109842	37.86	-122.22
2	7.2574	52.0	8.288136	1.073446	496.0	2.802260	37.85	-122.24
3	5.6431	52.0	5.817352	1.073059	558.0	2.547945	37.85	-122.25
4	3.8462	52.0	6.281853	1.081081	565.0	2.181467	37.85	-122.25

In [17]: `data.describe()`

Out[17]:

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup
count	20640.000000	20640.000000	20640.000000	20640.000000	20640.000000	20640.000000
mean	3.870671	28.639486	5.429000	1.096675	1425.476744	3.070655
std	1.899822	12.585558	2.474173	0.473911	1132.462122	10.386050
min	0.499900	1.000000	0.846154	0.333333	3.000000	0.692308
25%	2.563400	18.000000	4.440716	1.006079	787.000000	2.429741
50%	3.534800	29.000000	5.229129	1.048780	1166.000000	2.818116
75%	4.743250	37.000000	6.052381	1.099526	1725.000000	3.282261
max	15.000100	52.000000	141.909091	34.066667	35682.000000	1243.333333

In [18]: `# DataFrame не содержащий целевой признак`
`X_ALL = data.drop('Y', axis=1)`

In [19]: `# Функция для восстановления датафрейма`
`# на основе масштабированных данных`
`def arr_to_df(arr_scaled):`
 `res = pd.DataFrame(arr_scaled, columns=X_ALL.columns)`
 `return res`

In [20]: `# Разделим выборку на обучающую и тестовую`
`X_train, X_test, y_train, y_test = train_test_split(X_ALL, data['Y'],`
 `test_size=0.2,`
 `random_state=1)`
`# Преобразуем массивы в DataFrame`
`X_train_df = arr_to_df(X_train)`
`X_test_df = arr_to_df(X_test)`
`X_train_df.shape, X_test_df.shape`

Out[20]: ((16512, 8), (4128, 8))

Масштабирование признаков

(не менее чем тремя способами);

- **Масштабирование** - это изменение диапазона измерения признака с целью улучшения качества построения модели.

Масштабирование данных на основе Z-оценки

$$x' = \frac{x - \mu(x)}{\sigma(x)}$$

где x - признак, $\mu(x) = \text{mean}(x)$ - среднее значение, $\sigma(x) = \text{std}(x)$ - среднеквадратичное отклонение.

Особенности метода:

- Среднее значение приводится к 0.
- Среднеквадратичное отклонение приводится к 1.
- Форма исходного распределения сохраняется.
- Максимальные и минимальные значения могут варьироваться.
- Выбросы сохраняются.

```
In [21]: # Обучаем StandardScaler на всей выборке и масштабируем
cs11 = StandardScaler()
data_cs11_scaled_temp = cs11.fit_transform(X_ALL)
# формируем DataFrame на основе массива
data_cs11_scaled = arr_to_df(data_cs11_scaled_temp)
data_cs11_scaled
```

```
Out[21]:
```

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup	Latitude	Longitude
0	2.344766	0.982143	0.628559	-0.153758	-0.974429	-0.049597	1.052548	-122.529963
1	2.332238	-0.607019	0.327041	-0.263336	0.861439	-0.092512	1.043185	-122.501714
2	1.782699	1.856182	1.155620	-0.049016	-0.820777	-0.025843	1.038503	-122.501714
3	0.932968	1.856182	0.156966	-0.049833	-0.766028	-0.050329	1.038503	-122.501714
4	-0.012881	1.856182	0.344711	-0.032906	-0.759847	-0.085616	1.038503	-122.501714
...
20635	-1.216128	-0.289187	-0.155023	0.077354	-0.512592	-0.049110	1.801647	-0.000000
20636	-0.691593	-0.845393	0.276881	0.462365	-0.944405	0.005021	1.806329	-0.000000
20637	-1.142593	-0.924851	-0.090318	0.049414	-0.369537	-0.071735	1.778237	-0.000000
20638	-1.054583	-0.845393	-0.040211	0.158778	-0.604429	-0.091225	1.778237	-0.000000
20639	-0.780129	-1.004309	-0.070443	0.138403	-0.033977	-0.043682	1.750146	-0.000000

20640 rows × 8 columns

```
In [22]: data_cs11_scaled.describe()
```

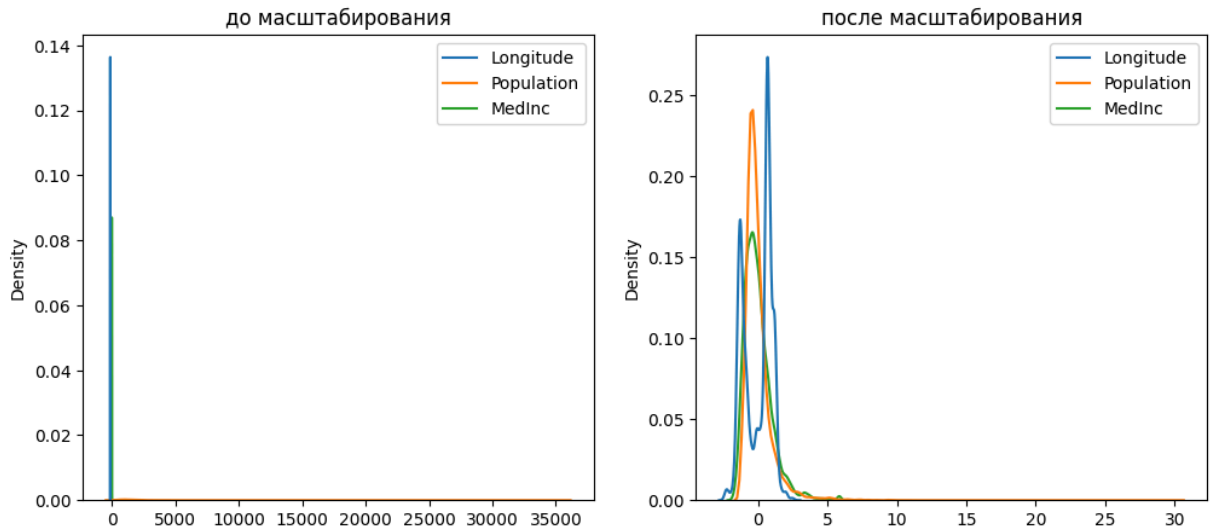
```
Out[22]:
```

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup
count	2.064000e+04	2.064000e+04	2.064000e+04	2.064000e+04	2.064000e+04	2.064000e+04
mean	6.609700e-17	5.508083e-18	6.609700e-17	-1.060306e-16	-1.101617e-17	3.442550e-17
std	1.000024e+00	1.000024e+00	1.000024e+00	1.000024e+00	1.000024e+00	1.000024e+00
min	-1.774299e+00	-2.196180e+00	-1.852319e+00	-1.610768e+00	-1.256123e+00	-2.290000e+00
25%	-6.881186e-01	-8.453931e-01	-3.994496e-01	-1.911716e-01	-5.638089e-01	-6.171000e-01
50%	-1.767951e-01	2.864572e-02	-8.078489e-02	-1.010650e-01	-2.291318e-01	-2.431000e-01
75%	4.593063e-01	6.643103e-01	2.519615e-01	6.015869e-03	2.644949e-01	2.037450e-01
max	5.858286e+00	1.856182e+00	5.516324e+01	6.957171e+01	3.025033e+01	1.194190e+01

```
In [23]: # Построение плотности распределения
def draw_kde(col_list, df1, df2, label1, label2):
    fig, (ax1, ax2) = plt.subplots(
        ncols=2, figsize=(12, 5))
    # первый график
    ax1.set_title(label1)
    sns.kdeplot(data=df1[col_list], ax=ax1)
    # второй график
    ax2.set_title(label2)
```

```
sns.kdeplot(data=df2[col_list], ax=ax2)
plt.show()
```

In [25]: `draw_kde(['Longitude', 'Population', 'MedInc'], data, data_cs11_scaled, 'до масштаб`



```
In [26]: # Обучаем StandardScaler на обучающей выборке
# и масштабируем обучающую и тестовую выборки
cs12 = StandardScaler()
cs12.fit(X_train)
data_cs12_scaled_train_temp = cs12.transform(X_train)
data_cs12_scaled_test_temp = cs12.transform(X_test)
# формируем DataFrame на основе массива
data_cs12_scaled_train = arr_to_df(data_cs12_scaled_train_temp)
data_cs12_scaled_test = arr_to_df(data_cs12_scaled_test_temp)
```

In [27]: `data_cs12_scaled_train.describe()`

Out[27]:

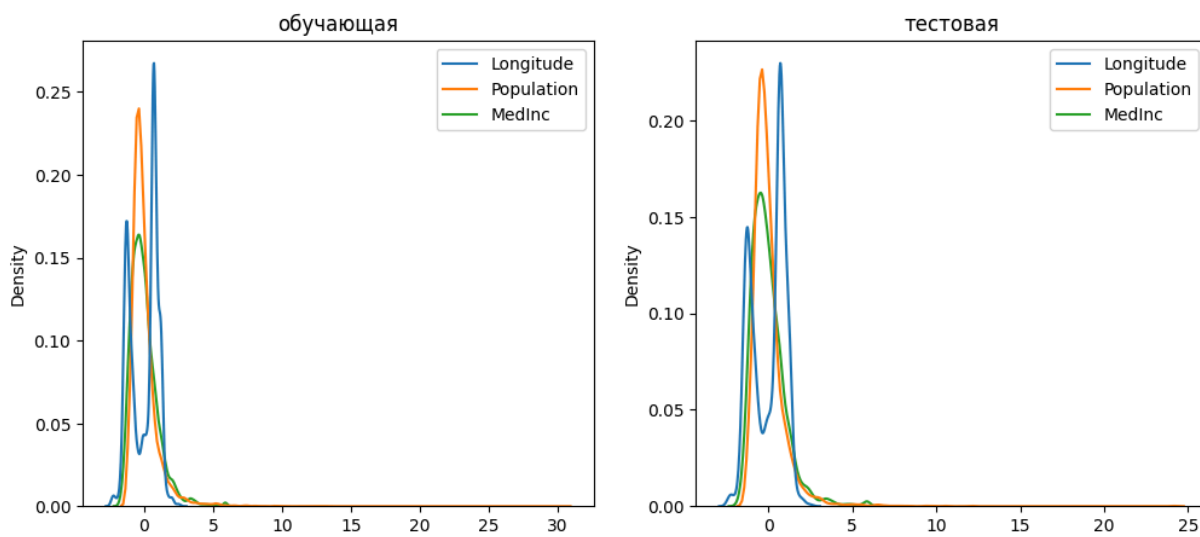
	MedInc	HouseAge	AveRooms	AveBedrms	Population	Ave
count	1.651200e+04	1.651200e+04	1.651200e+04	1.651200e+04	1.651200e+04	1.65120
mean	-1.663183e-16	5.239134e-17	1.912768e-16	2.119321e-16	2.280691e-17	1.18337
std	1.000030e+00	1.000030e+00	1.000030e+00	1.000030e+00	1.000030e+00	1.00003
min	-1.784934e+00	-2.193326e+00	-1.758064e+00	-1.510898e+00	-1.265666e+00	-2.022
25%	-6.894428e-01	-8.425832e-01	-3.830692e-01	-1.840409e-01	-5.688744e-01	-5.757
50%	-1.753078e-01	3.142707e-02	-8.210226e-02	-1.001681e-01	-2.324925e-01	-2.427
75%	4.619818e-01	6.670709e-01	2.359401e-01	-4.655013e-05	2.649611e-01	1.54231
max	5.880939e+00	1.858903e+00	5.221361e+01	6.500353e+01	3.048505e+01	1.06944

In [28]: `data_cs12_scaled_test.describe()`

Out[28]:

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup	L
count	4128.000000	4128.000000	4128.000000	4128.000000	4128.000000	4128.000000	4128
mean	-0.014481	0.013911	-0.023175	-0.028812	0.000977	-0.010484	-0
std	1.021662	0.999880	0.692871	0.604269	1.038310	0.100045	0
min	-1.784934	-2.113871	-1.521001	-1.428741	-1.258546	-0.207179	-1
25%	-0.712242	-0.842583	-0.381876	-0.186036	-0.564647	-0.056193	-0
50%	-0.198860	0.031427	-0.076683	-0.101062	-0.220479	-0.021970	-0
75%	0.451514	0.667071	0.224293	-0.000800	0.271190	0.019040	0
max	5.880939	1.858903	17.369108	18.082473	24.152526	4.165286	2

In [29]: *# распределения для обучающей и тестовой выборки немного отличаются*
draw_kde(['Longitude', 'Population', 'MedInc'], data_cs12_scaled_train, data_cs12_s



Масштабирование "Mean Normalisation"

$$x' = \frac{x - \mu(x)}{\max(x) - \min(x)}$$

где x - признак, $\mu(x) = \text{mean}(x)$ - среднее значение.

Особенности метода:

- Среднее значение приводится к 0.
- Среднеквадратичное отклонение может варьироваться.
- Форма исходного распределения может изменяться.
- Максимальные и минимальные значения в диапазоне [-1;1].
- Выбросы сохраняются.

```
In [30]: class MeanNormalisation:

    def fit(self, param_df):
        self.means = X_train.mean(axis=0)
        maxs = X_train.max(axis=0)
        mins = X_train.min(axis=0)
        self.ranges = maxs - mins

    def transform(self, param_df):
        param_df_scaled = (param_df - self.means) / self.ranges
        return param_df_scaled

    def fit_transform(self, param_df):
        self.fit(param_df)
        return self.transform(param_df)
```

```
In [31]: sc21 = MeanNormalisation()
data_cs21_scaled = sc21.fit_transform(X_ALL)
data_cs21_scaled.describe()
```

```
Out[31]:
```

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup
count	20640.000000	20640.000000	20640.000000	20640.000000	20640.000000	20640.000000
mean	-0.000378	0.000687	-0.000086	-0.000087	0.000006	-0.000020
std	0.131020	0.246776	0.017539	0.014049	0.031740	0.008358
min	-0.232842	-0.541264	-0.032574	-0.022715	-0.039863	-0.001934
25%	-0.090533	-0.207931	-0.007092	-0.002772	-0.017889	-0.000535
50%	-0.023541	0.007756	-0.001503	-0.001506	-0.007266	-0.000223
75%	0.059799	0.164618	0.004333	-0.000002	0.008401	0.000151
max	0.767158	0.458736	0.967426	0.977285	0.960137	0.998113

```
In [32]: cs22 = MeanNormalisation()
cs22.fit(X_train)
data_cs22_scaled_train = cs22.transform(X_train)
data_cs22_scaled_test = cs22.transform(X_test)
```

```
In [33]: data_cs22_scaled_train.describe()
```


Out[33]:

	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccu
count	1.651200e+04	1.651200e+04	1.651200e+04	1.651200e+04	1.651200e+04	1.651200e+04
mean	-2.183869e-17	1.328610e-17	3.477852e-18	3.187050e-18	7.732295e-19	1.197665e-2
std	1.304522e-01	2.467852e-01	1.852880e-02	1.503479e-02	3.149631e-02	9.333299e-0
min	-2.328416e-01	-5.412641e-01	-3.257383e-02	-2.271534e-02	-3.986258e-02	-1.887174e-0
25%	-8.993664e-02	-2.079308e-01	-7.097596e-03	-2.766932e-03	-1.791690e-02	-5.373388e-0
50%	-2.286860e-02	7.755500e-03	-1.521210e-03	-1.505960e-03	-7.322435e-03	-2.265616e-0
75%	6.026474e-02	1.646182e-01	4.371553e-03	-6.998501e-07	8.345045e-03	1.439448e-0
max	7.671584e-01	4.587359e-01	9.674262e-01	9.772847e-01	9.601374e-01	9.981128e-0

In [34]:

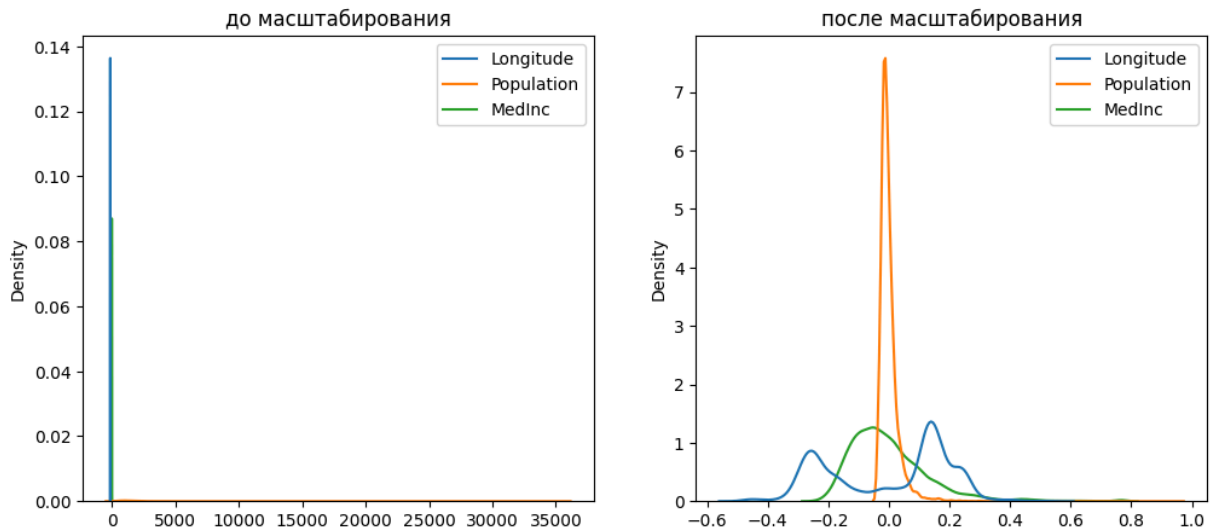
data_cs22_scaled_test.describe()

Out[34]:

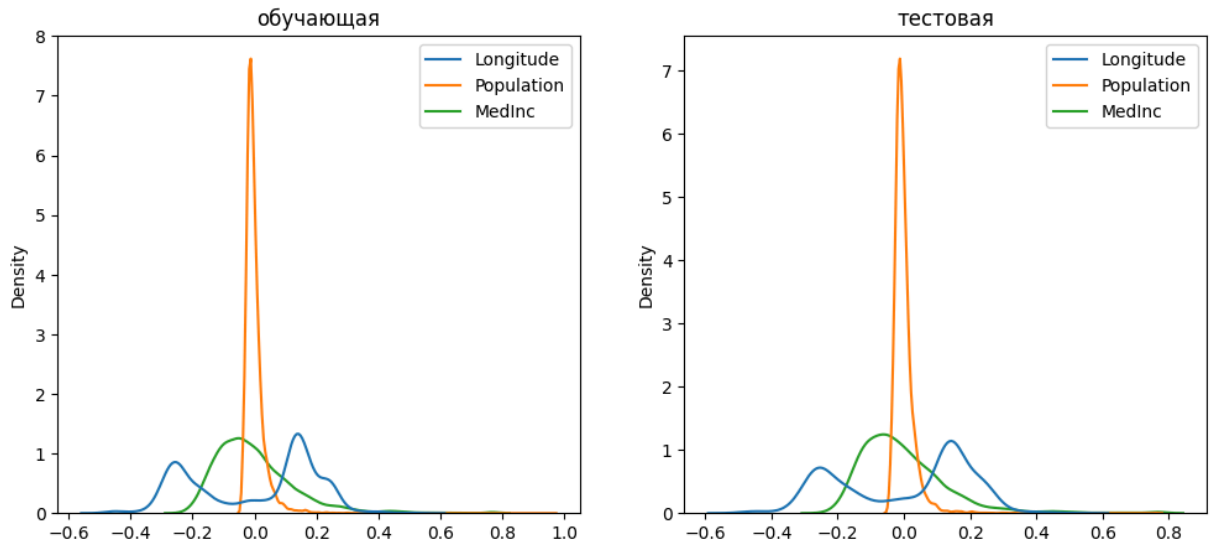
	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup	L
count	4128.000000	4128.000000	4128.000000	4128.000000	4128.000000	4128.000000	4128
mean	-0.001889	0.003433	-0.000429	-0.000433	0.000031	-0.000098	-0
std	0.133274	0.246748	0.012838	0.009085	0.032702	0.000934	0
min	-0.232842	-0.521656	-0.028181	-0.021480	-0.039638	-0.001934	-0
25%	-0.092911	-0.207931	-0.007075	-0.002797	-0.017784	-0.000524	-0
50%	-0.025941	0.007756	-0.001421	-0.001519	-0.006944	-0.000205	-0
75%	0.058899	0.164618	0.004156	-0.000012	0.008541	0.000178	0
max	0.767158	0.458736	0.321819	0.271858	0.760692	0.038875	0

In [35]:

draw_kde(['Longitude', 'Population', 'MedInc'], data, data_cs21_scaled, 'до масштаб



In [36]: `draw_kde(['Longitude', 'Population', 'MedInc'], data_cs22_scaled_train, data_cs22_s`



MinMax-масштабирование

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Особенности метода:

- Среднее значение может варьироваться.
- Среднеквадратичное отклонение может варьироваться.
- Форма исходного распределения может изменяться.
- Максимальные и минимальные значения в диапазоне [0;1].
- Выбросы сохраняются.

In [37]: `# Обучаем StandardScaler на всей выборке и масштабируем
cs31 = MinMaxScaler()
data_cs31_scaled_temp = cs31.fit_transform(X_ALL)
формируем DataFrame на основе массива`

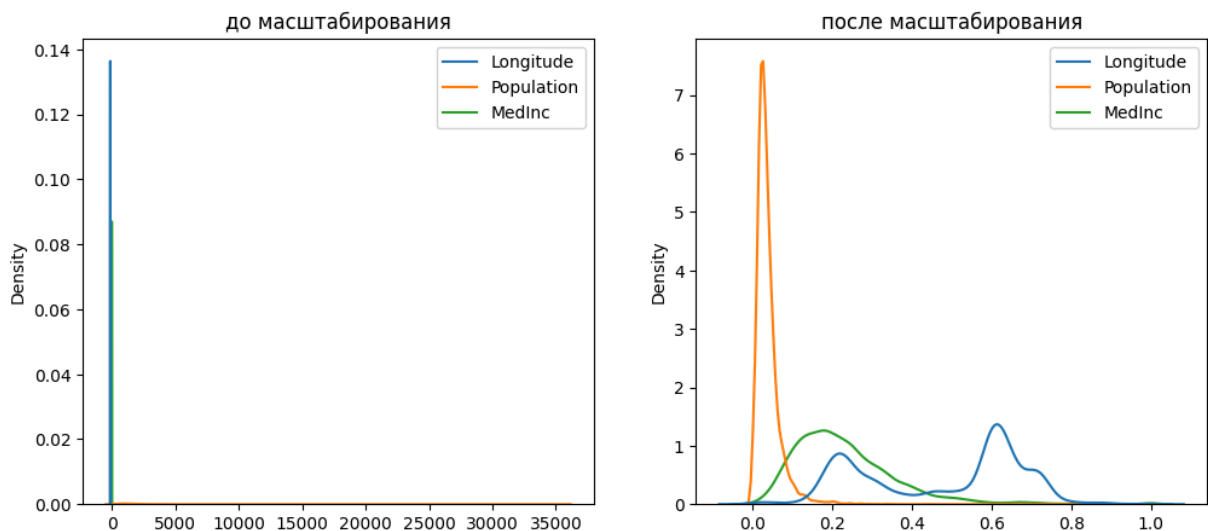
```
data_cs31_scaled = arr_to_df(data_cs31_scaled_temp)
data_cs31_scaled.describe()
```

Out[37]:

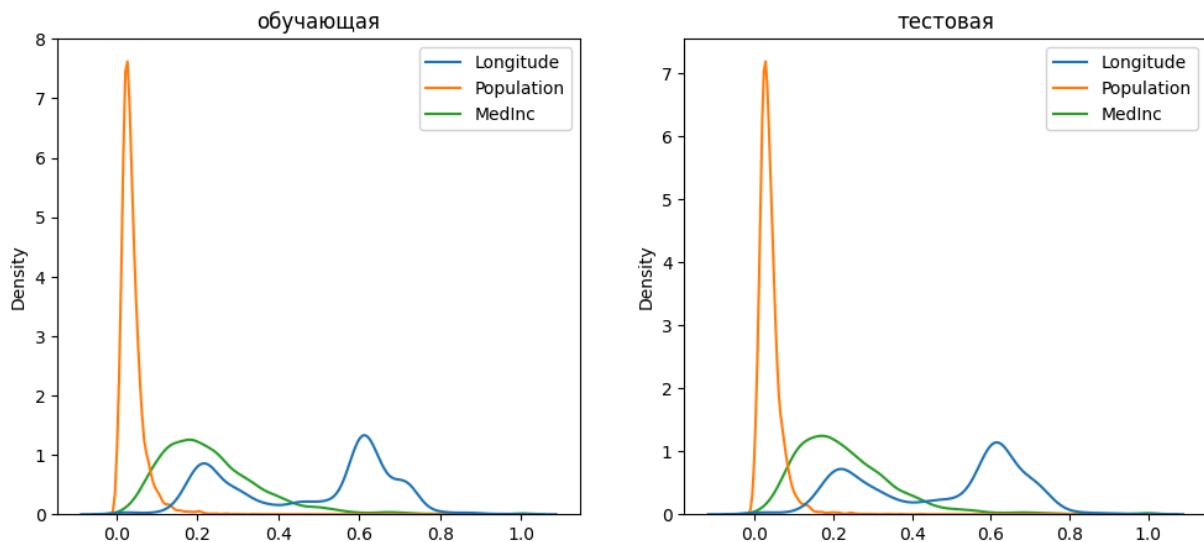
	MedInc	HouseAge	AveRooms	AveBedrms	Population	AveOccup
count	20640.000000	20640.000000	20640.000000	20640.000000	20640.000000	20640.000000
mean	0.232464	0.541951	0.032488	0.022629	0.039869	0.001914
std	0.131020	0.246776	0.017539	0.014049	0.031740	0.008358
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.142308	0.333333	0.025482	0.019943	0.021974	0.001398
50%	0.209301	0.549020	0.031071	0.021209	0.032596	0.001711
75%	0.292641	0.705882	0.036907	0.022713	0.048264	0.002084
max	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

```
In [38]: cs32 = MinMaxScaler()
cs32.fit(X_train)
data_cs32_scaled_train_temp = cs32.transform(X_train)
data_cs32_scaled_test_temp = cs32.transform(X_test)
# формируем DataFrame на основе массива
data_cs32_scaled_train = arr_to_df(data_cs32_scaled_train_temp)
data_cs32_scaled_test = arr_to_df(data_cs32_scaled_test_temp)
```

```
In [39]: draw_kde(['Longitude', 'Population', 'MedInc'], data, data_cs31_scaled, 'до масштаб
```



```
In [40]: draw_kde(['Longitude', 'Population', 'MedInc'], data_cs32_scaled_train, data_cs32_s
```



Обработка выбросов для числовых признаков

(по одному способу для удаления выбросов и для замены выбросов);

Почему необходимо устранять выбросы? Выбросы негативно влияют на построение модели.

Причины появления выбросов:

- Ошибки в измерениях, например, часть значений признака "расстояние" была измерена не в километрах, а в метрах.
- Технические ошибки форматирования данных.

Основные задачи обработки выбросов:

- Обнаружение выбросов.
- Устранение (удаление или замена) выбросов (в зависимости от требований задачи).

Подгрузка библиотек и просмотр датасета

```
In [42]: import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import scipy.stats as stats
from sklearn.svm import SVR
from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.ensemble import GradientBoostingRegressor
from sklearn.metrics import mean_squared_error
```

```
from sklearn.model_selection import train_test_split
from IPython.display import Image
%matplotlib inline
sns.set(style="ticks")
```

```
In [44]: x_col_list = ['Longitude', 'Population', 'MedInc']
```

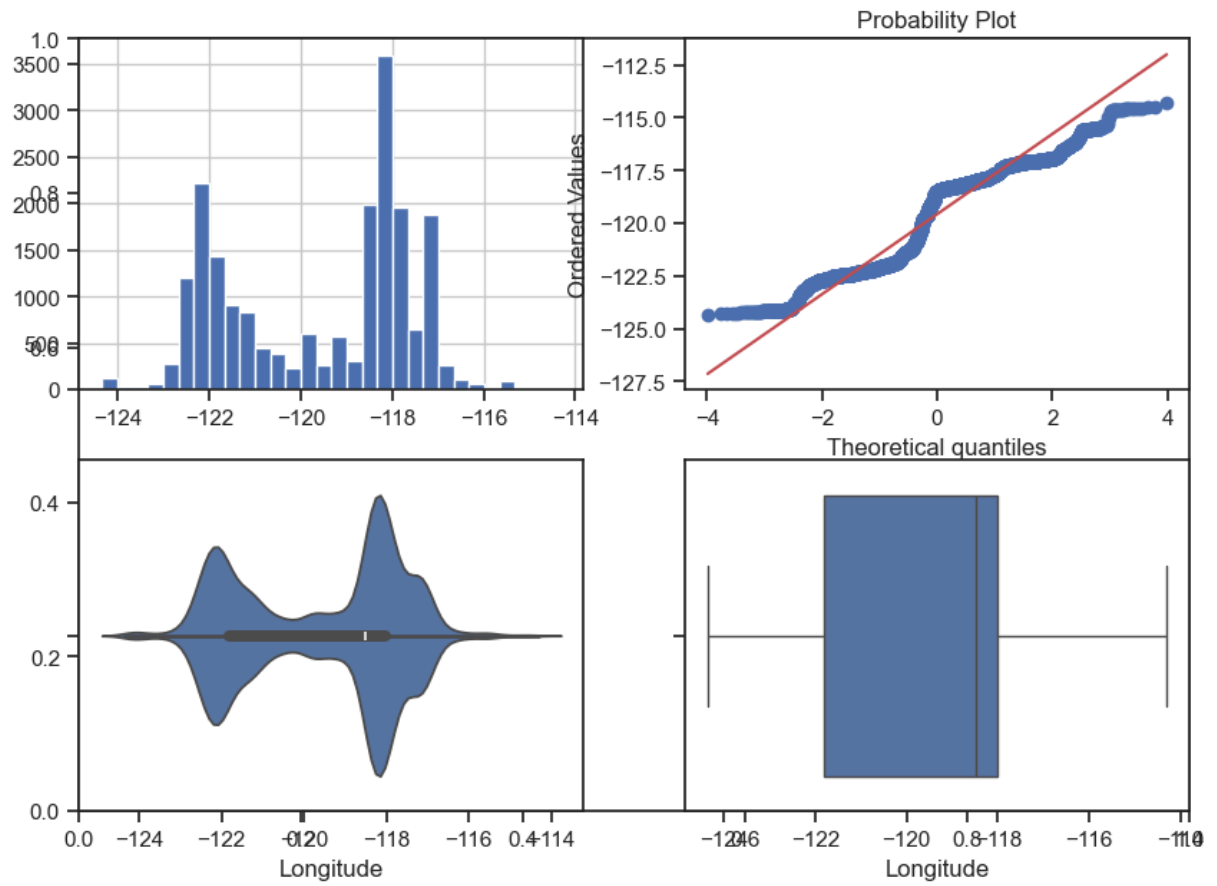
```
In [46]: data = pd.DataFrame(california_ds.data,
                             columns=california_ds.feature_names)[x_col_list]
data['Y'] = california_ds.target
data.shape
```

```
Out[46]: (20640, 4)
```

```
In [47]: def diagnostic_plots(df, variable, title):
    fig, ax = plt.subplots(figsize=(10,7))
    # гистограмма
    plt.subplot(2, 2, 1)
    df[variable].hist(bins=30)
    ## 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.violinplot(x=df[variable])
    # ящик с усами
    plt.subplot(2, 2, 4)
    sns.boxplot(x=df[variable])
    fig.suptitle(title)
    plt.show()
```

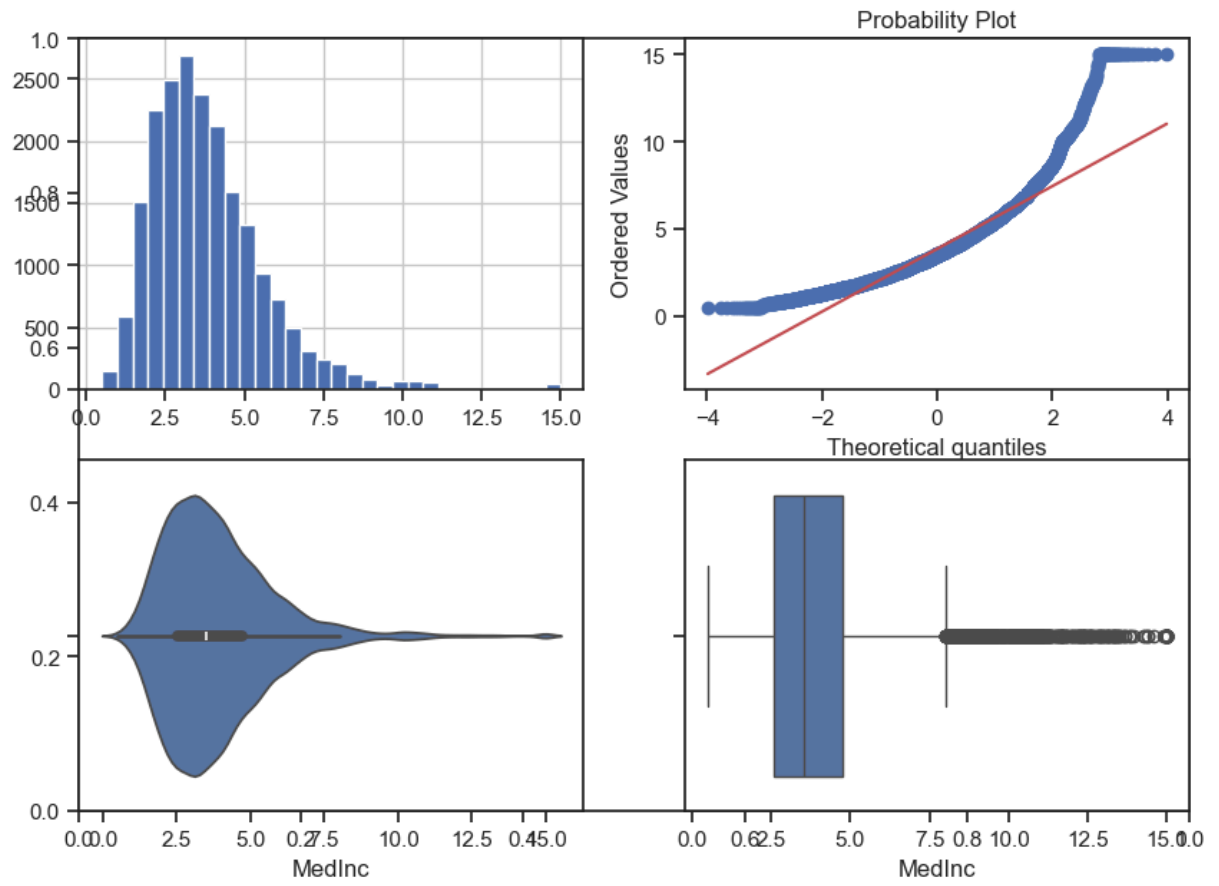
```
In [48]: diagnostic_plots(data, 'Longitude', 'Longitude - original')
```

Longitude - original



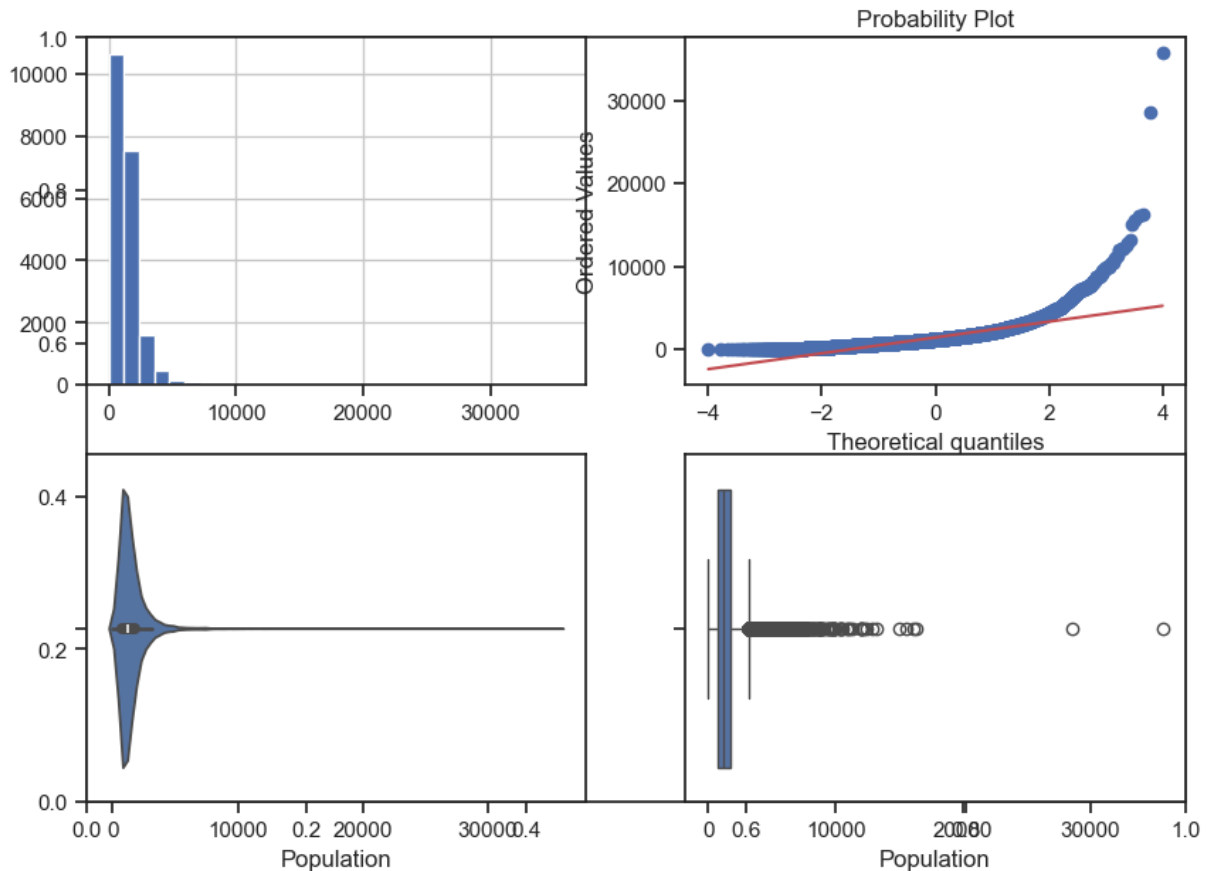
```
In [50]: diagnostic_plots(data, 'MedInc', 'MedInc - original')
```

MedInc - original



```
In [49]: diagnostic_plots(data, 'Population', 'Population - original')
```

Population - original



```
In [53]: # Тип вычисления верхней и нижней границы выбросов
from enum import Enum
class OutlierBoundaryType(Enum):
    SIGMA = 1
    QUANTILE = 2
    IRQ = 3

# Функция вычисления верхней и нижней границы выбросов
def get_outlier_boundaries(df, col, outlier_boundary_type: OutlierBoundaryType):
    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:
        raise NameError('Unknown Outlier Boundary Type')
```



```
return lower_boundary, upper_boundary
```

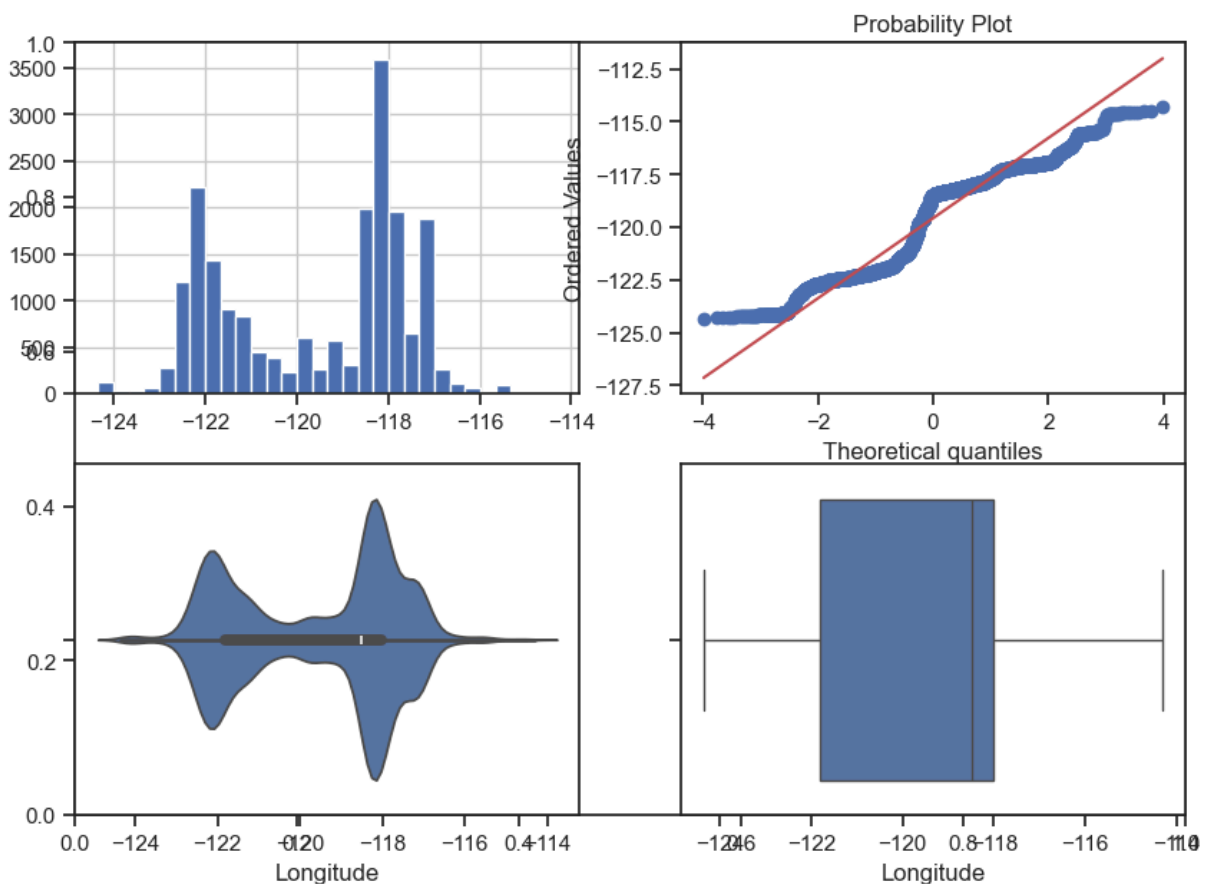
Для удаления выбросов

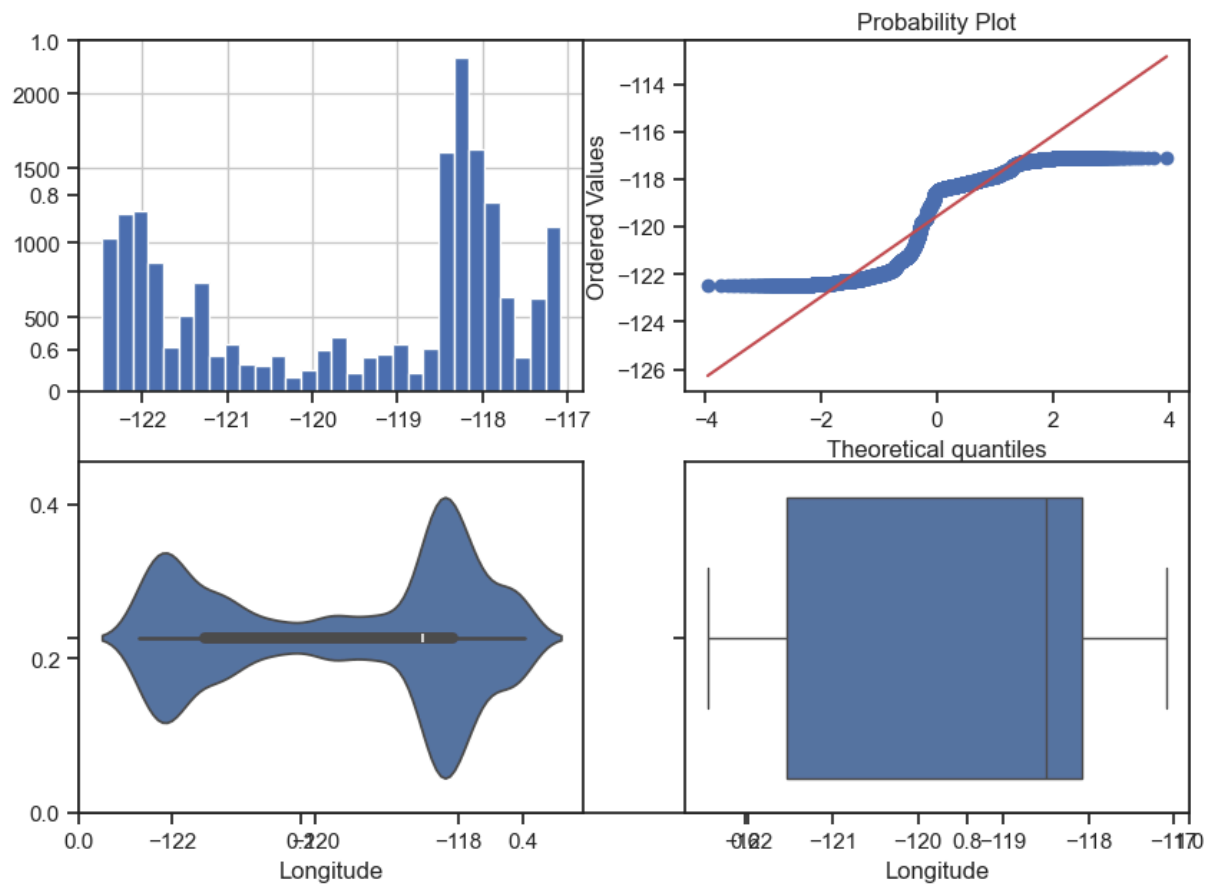
```
In [51]: data.shape
```

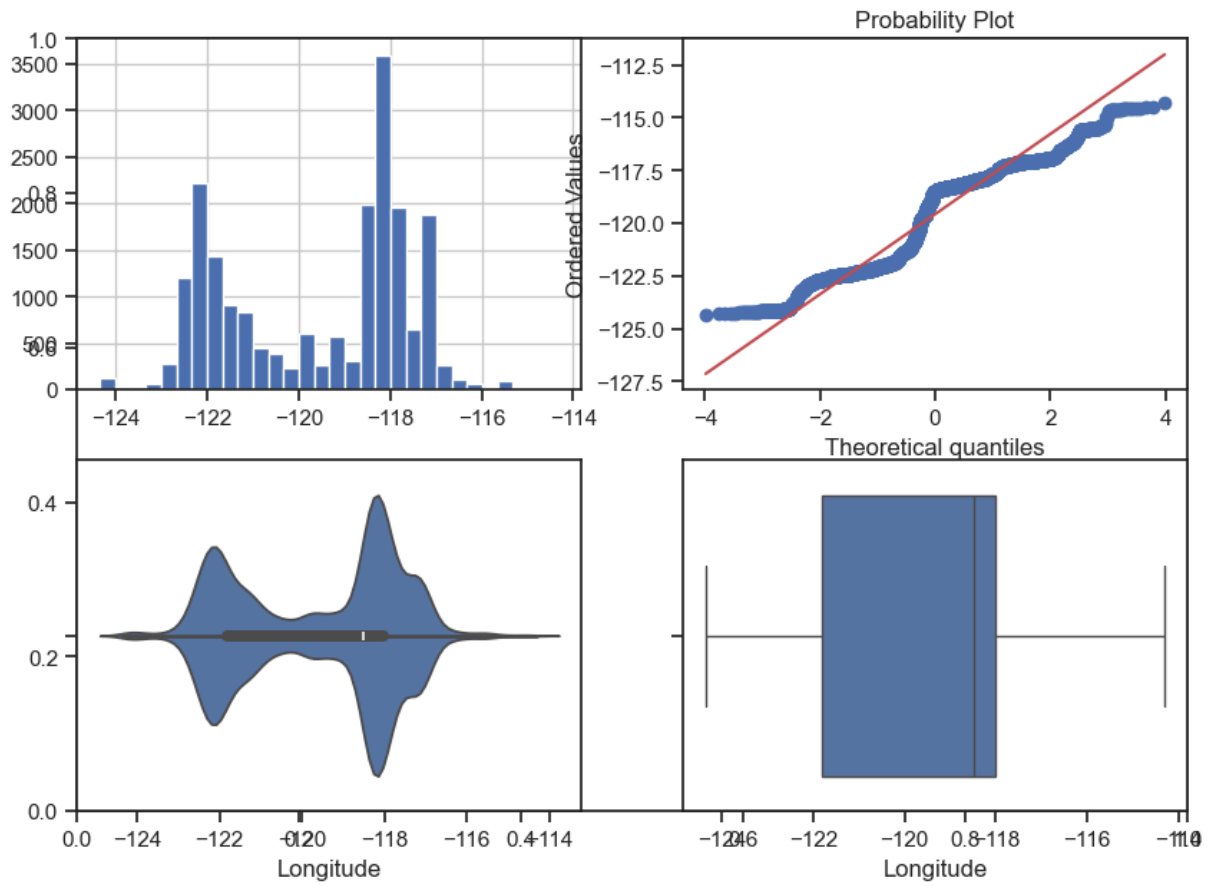
```
Out[51]: (20640, 4)
```

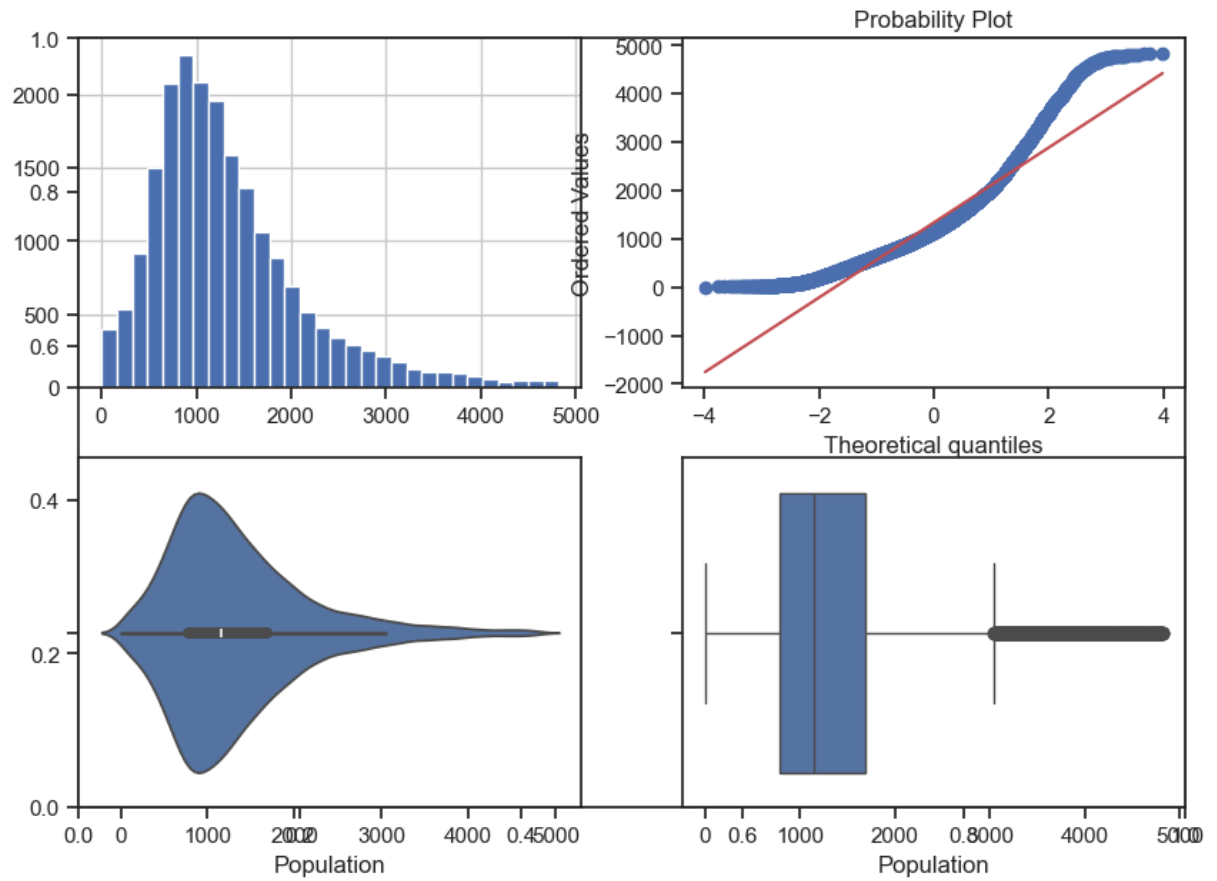
```
In [54]: for col in x_col_list:
          for obt in OutlierBoundaryType:
              # Вычисление верхней и нижней границы
              lower_boundary, upper_boundary = get_outlier_boundaries(data, col, obt)
              # Флаги для удаления выбросов
              outliers_temp = np.where(data[col] > upper_boundary, True,
                                       np.where(data[col] < lower_boundary, True, False))
              # Удаление данных на основе флага
              data_trimmed = data.loc[~(outliers_temp), ]
              title = 'Поле-{}, метод-{}, строк-{}'.format(col, obt, data_trimmed.shape[0])
              diagnostic_plots(data_trimmed, col, title)
```

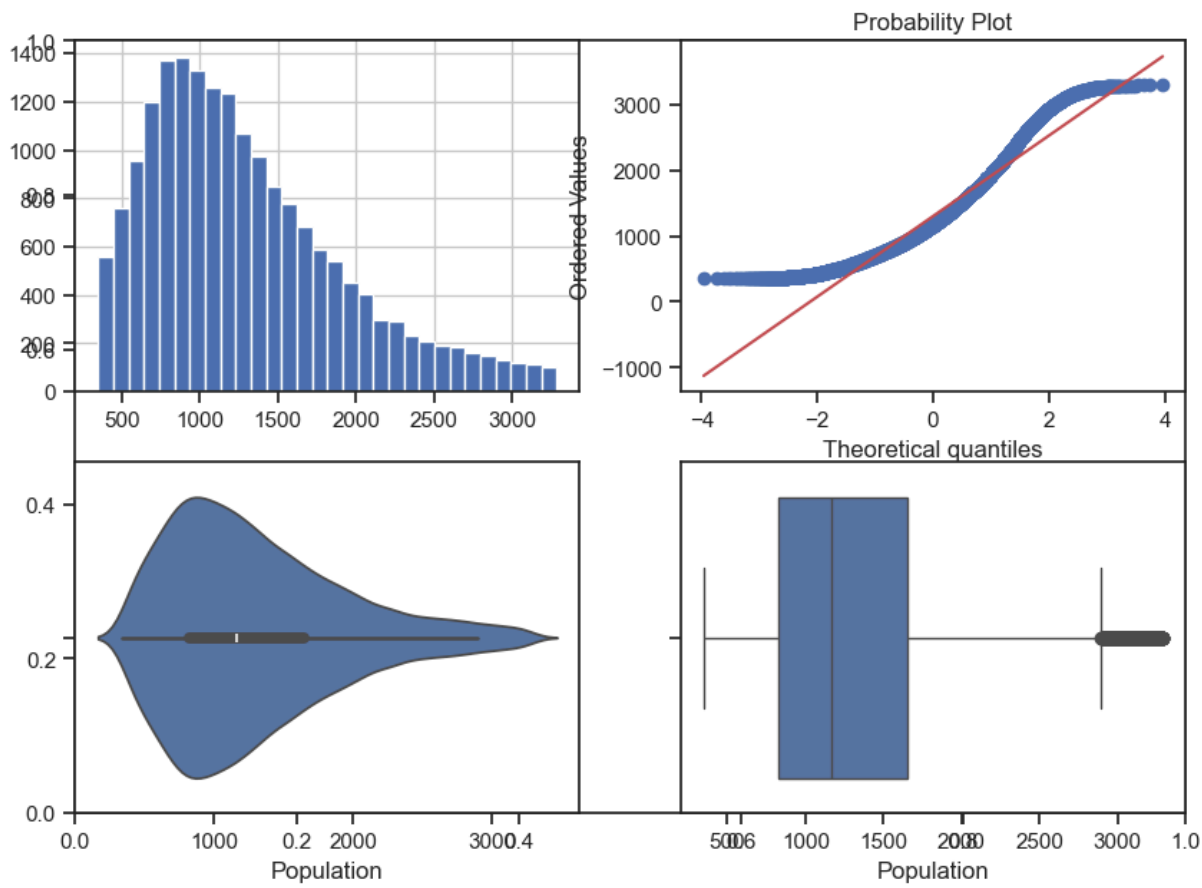
Поле-Longitude, метод-OutlierBoundaryType.SIGMA, строк-20640

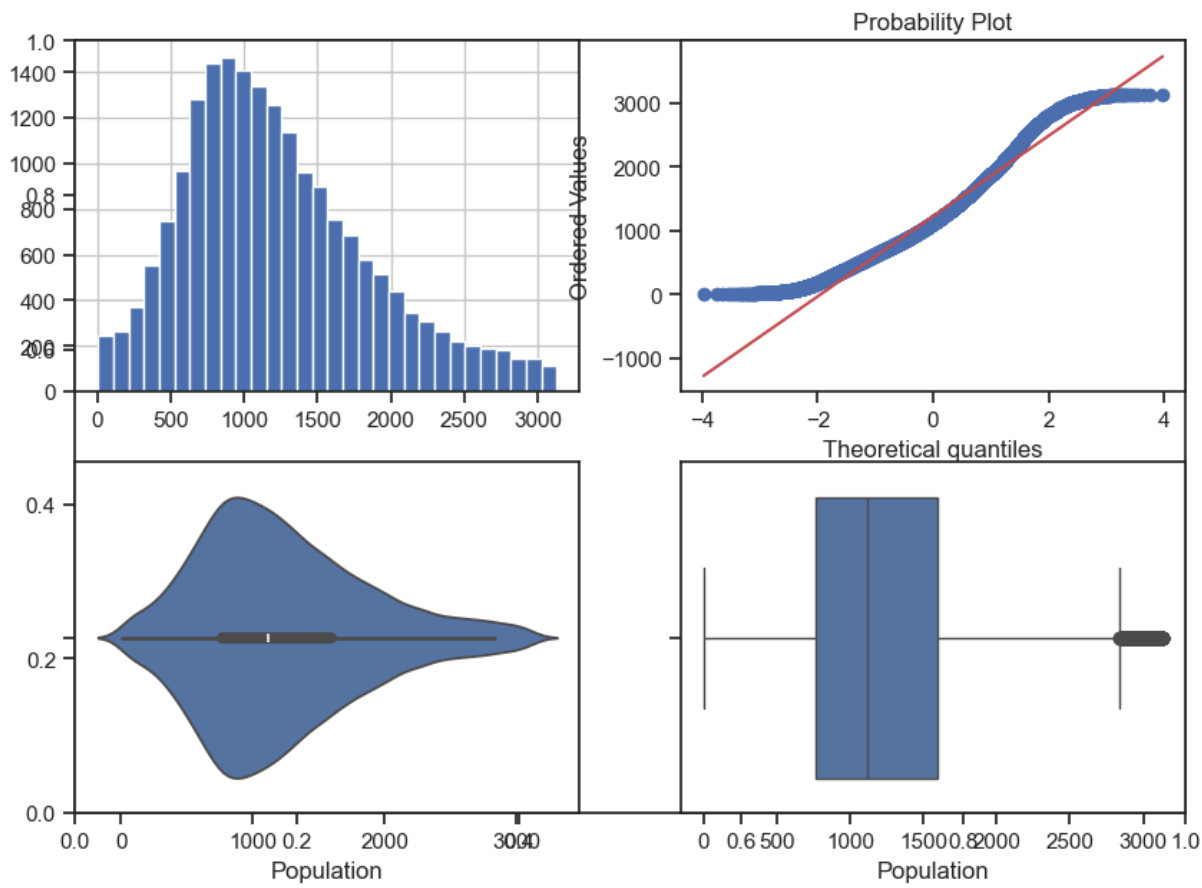


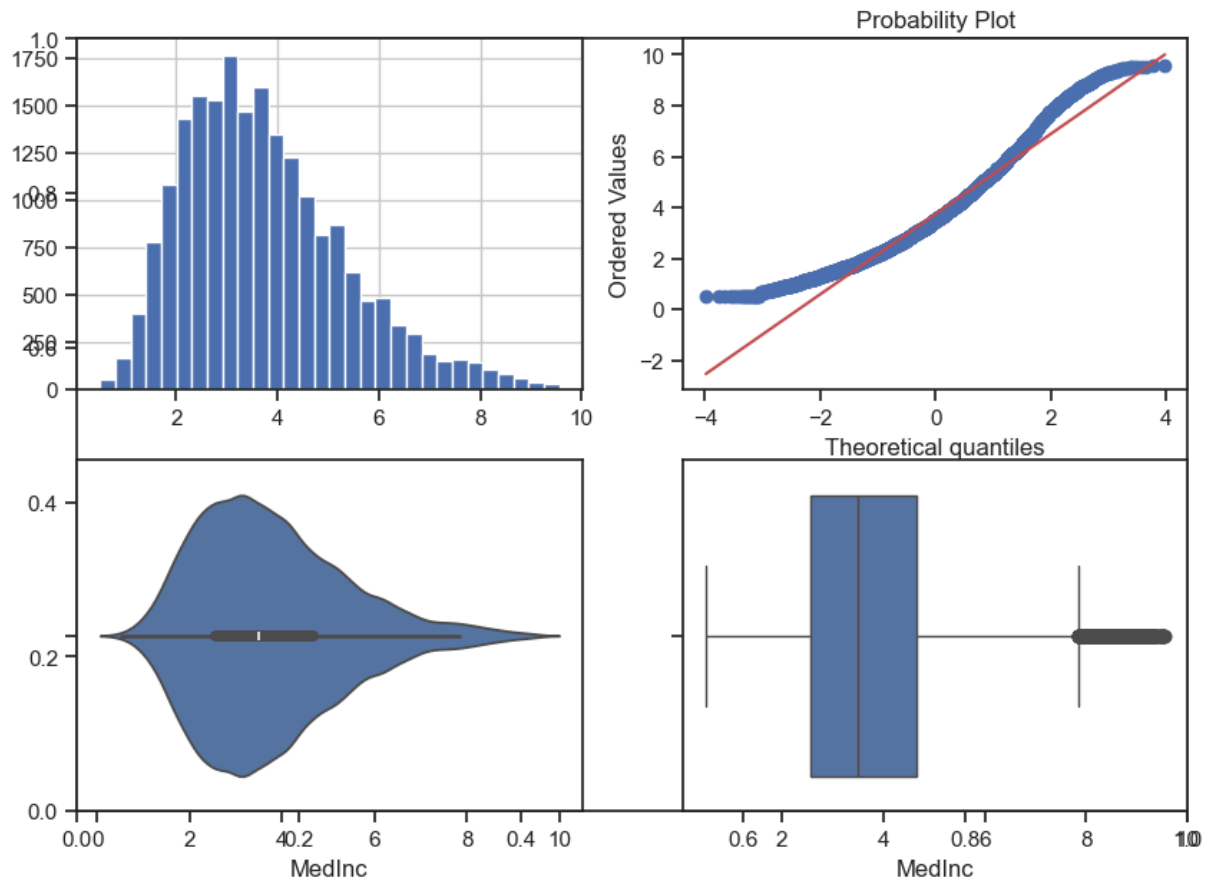


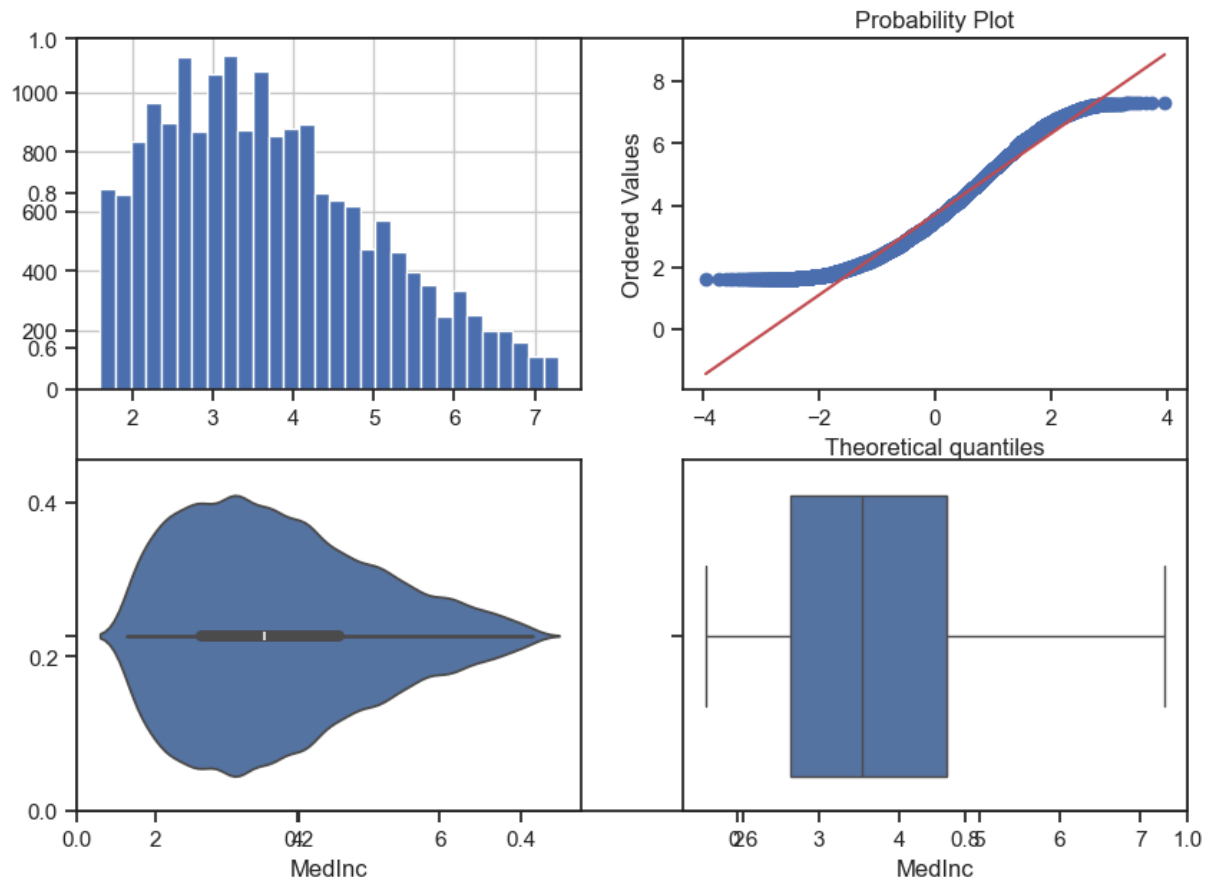


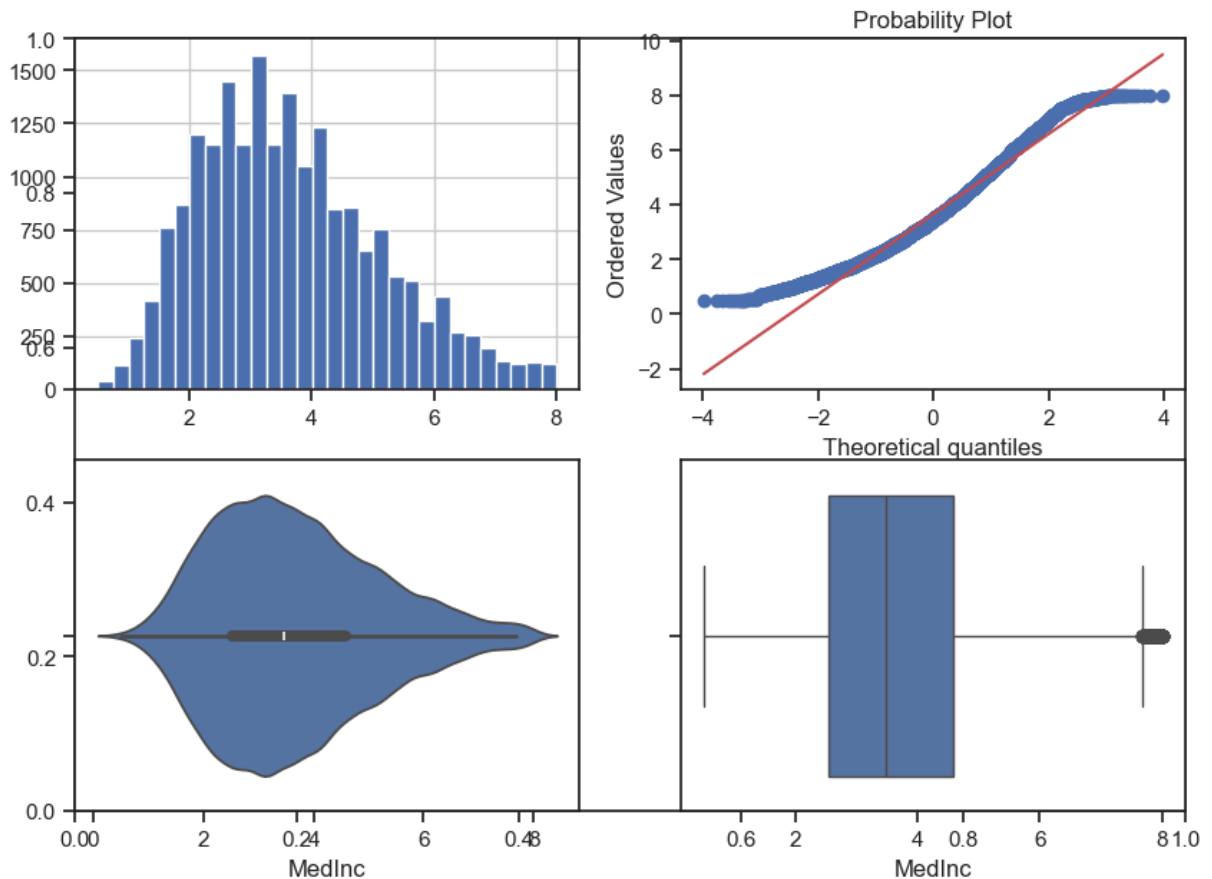










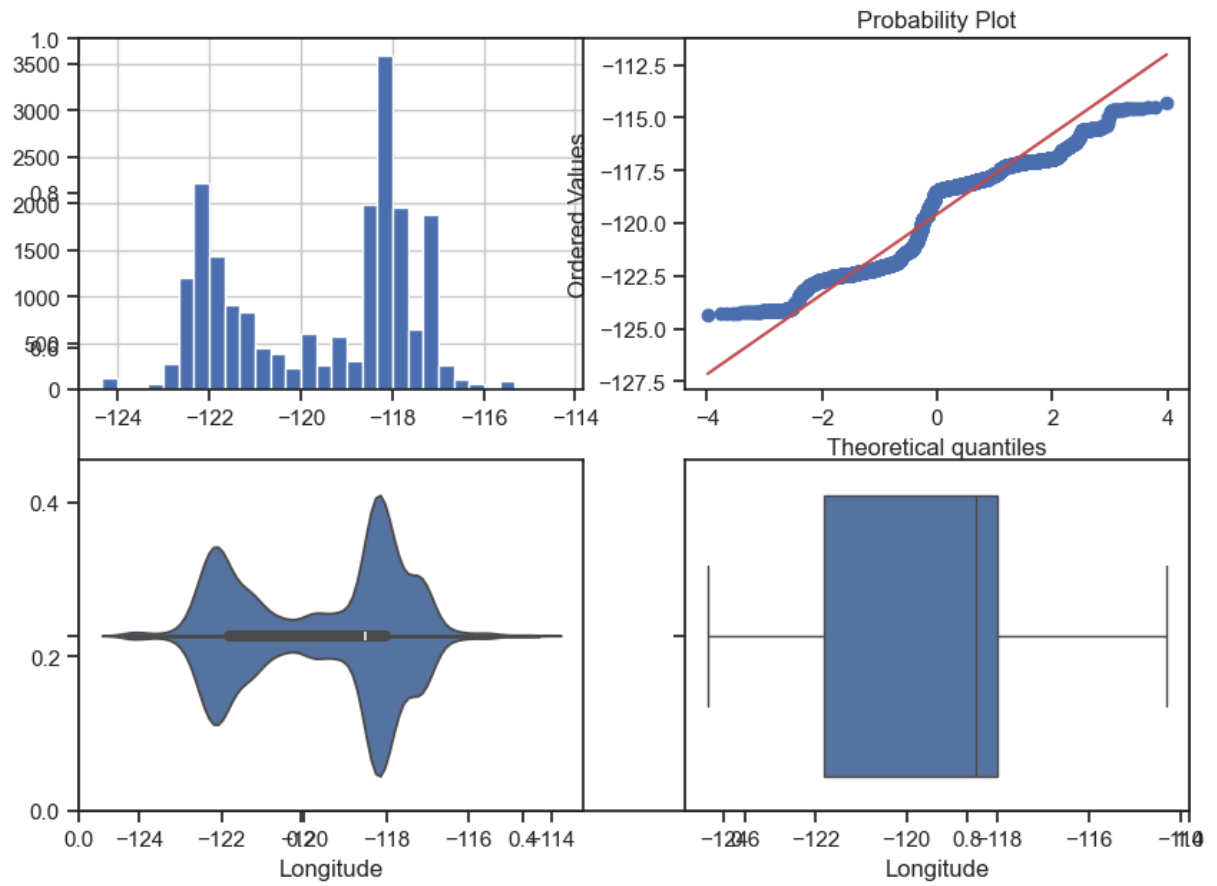


Для замены выбросов

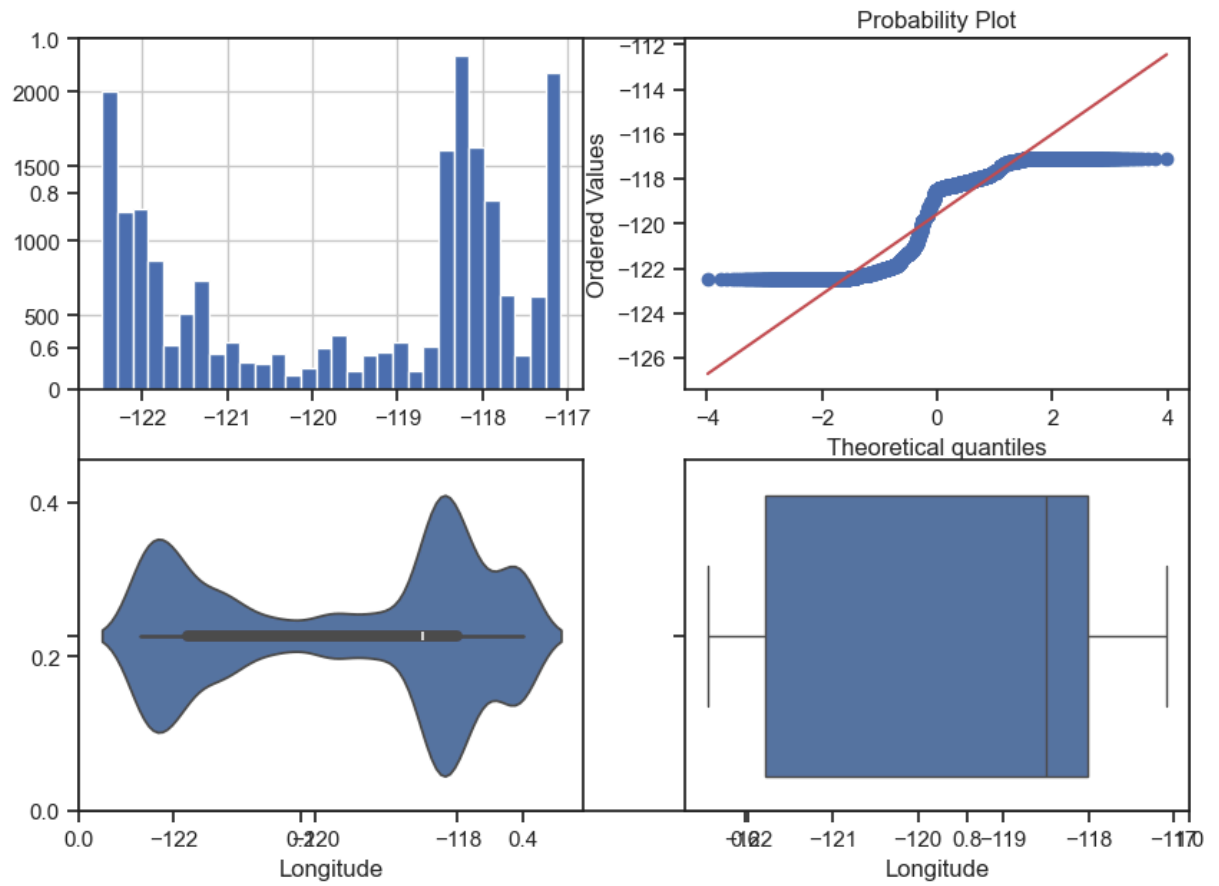
Для замены используем найденные верхнюю и нижнюю границы.

```
In [55]: for col in x_col_list:
          for obt in OutlierBoundaryType:
              # Вычисление верхней и нижней границы
              lower_boundary, upper_boundary = get_outlier_boundaries(data, col, obt)
              # Изменение данных
              data[col] = np.where(data[col] > upper_boundary, upper_boundary,
                                   np.where(data[col] < lower_boundary, lower_boundary,
                                             data[col]))
              title = 'Поле-{}, метод-{}'.format(col, obt)
              diagnostic_plots(data, col, title)
```

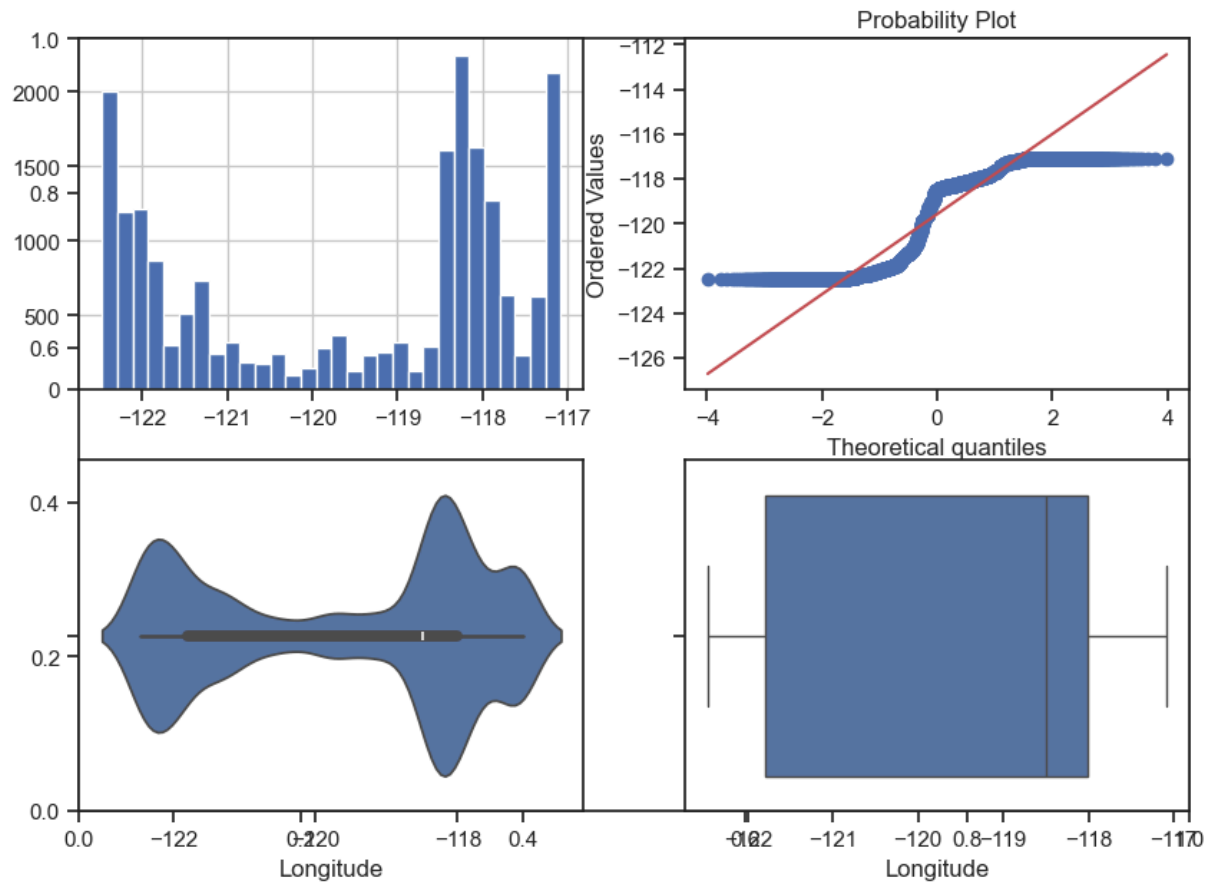
Поле-Longitude, метод-OutlierBoundaryType.SIGMA



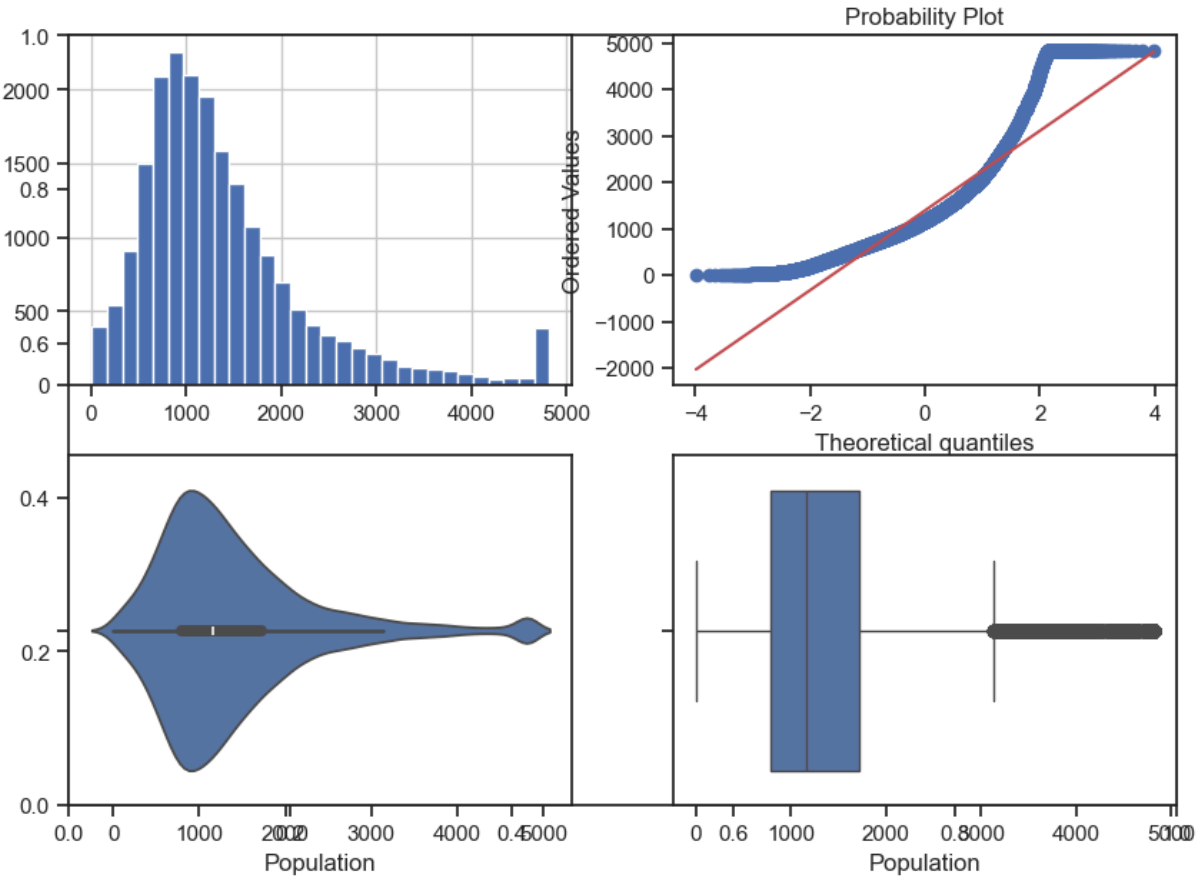
Поле-Longitude, метод-OutlierBoundaryType.QUANTILE



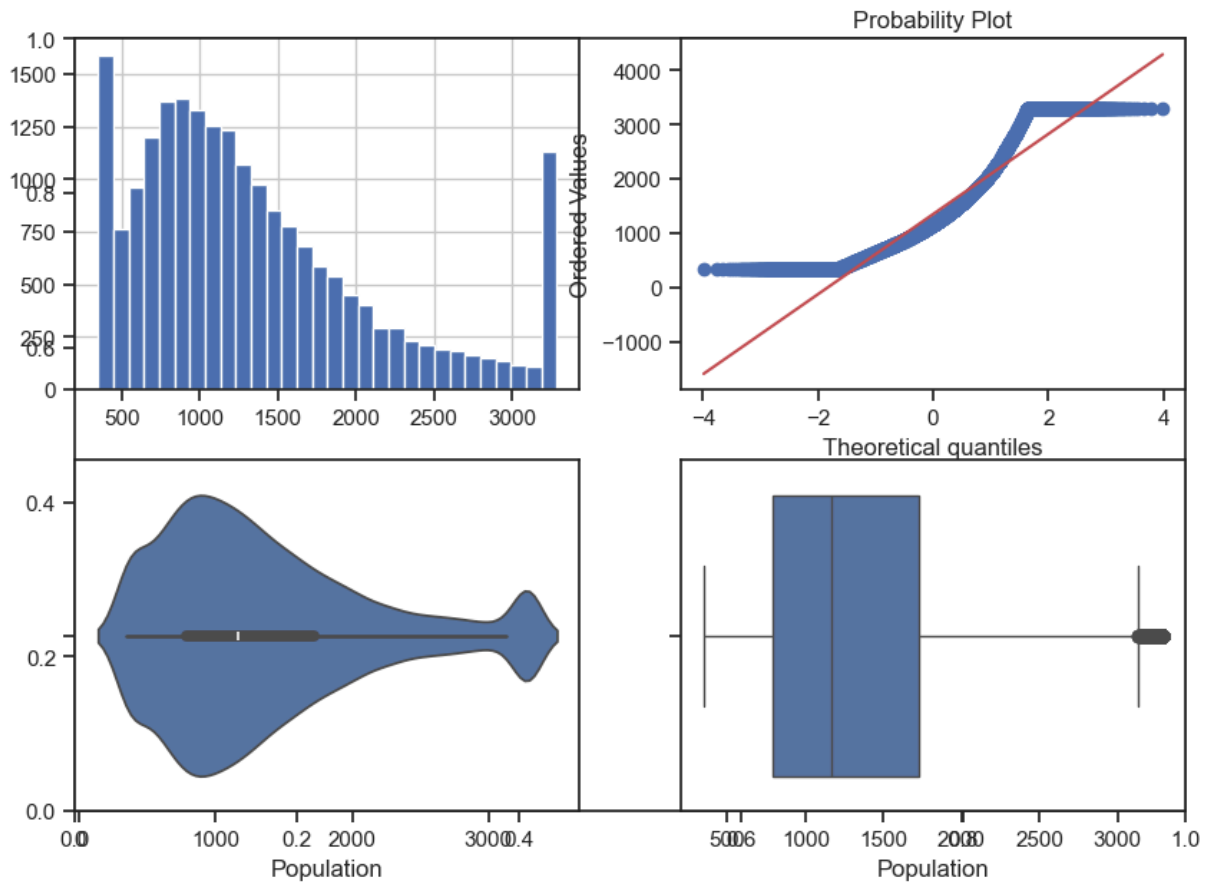
Поле-Longitude, метод-OutlierBoundaryType.IRQ



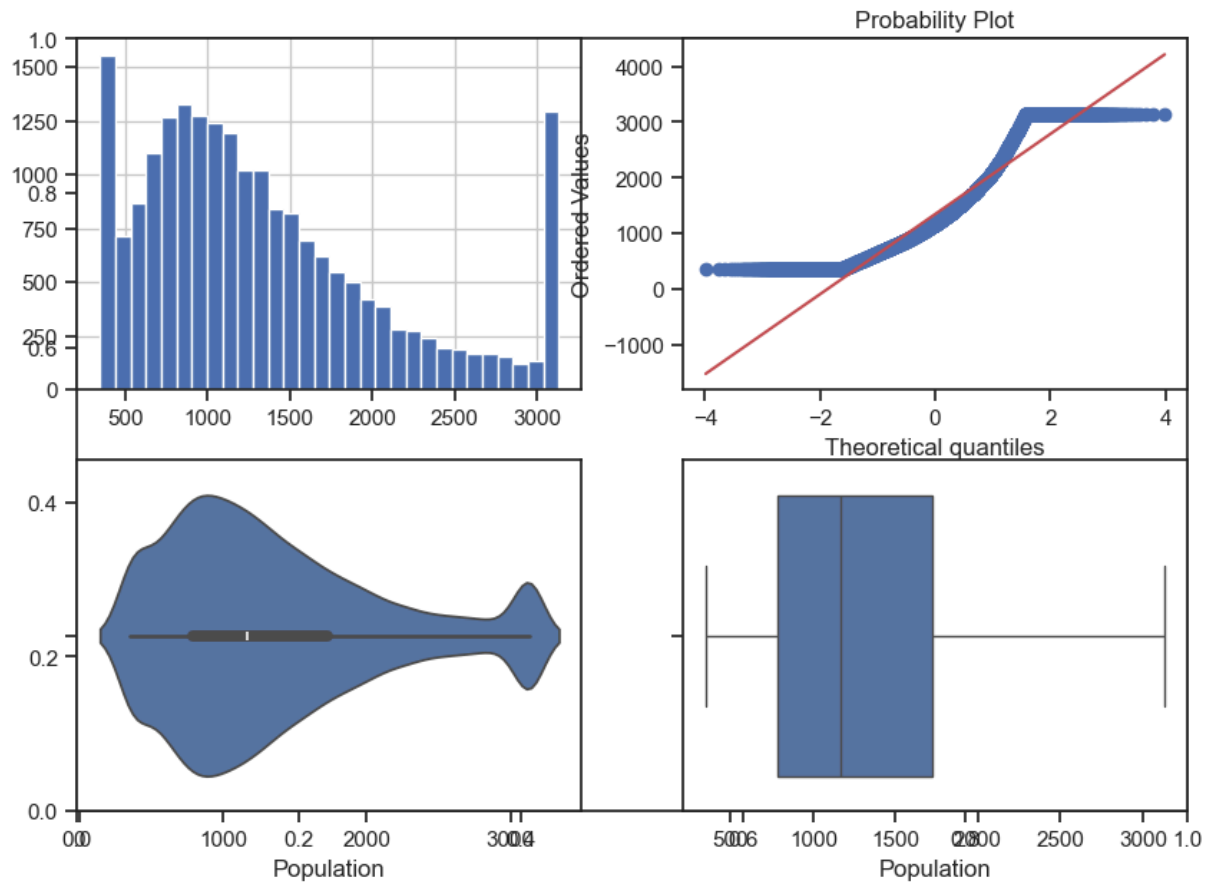
Поле-Population, метод-OutlierBoundaryType.SIGMA



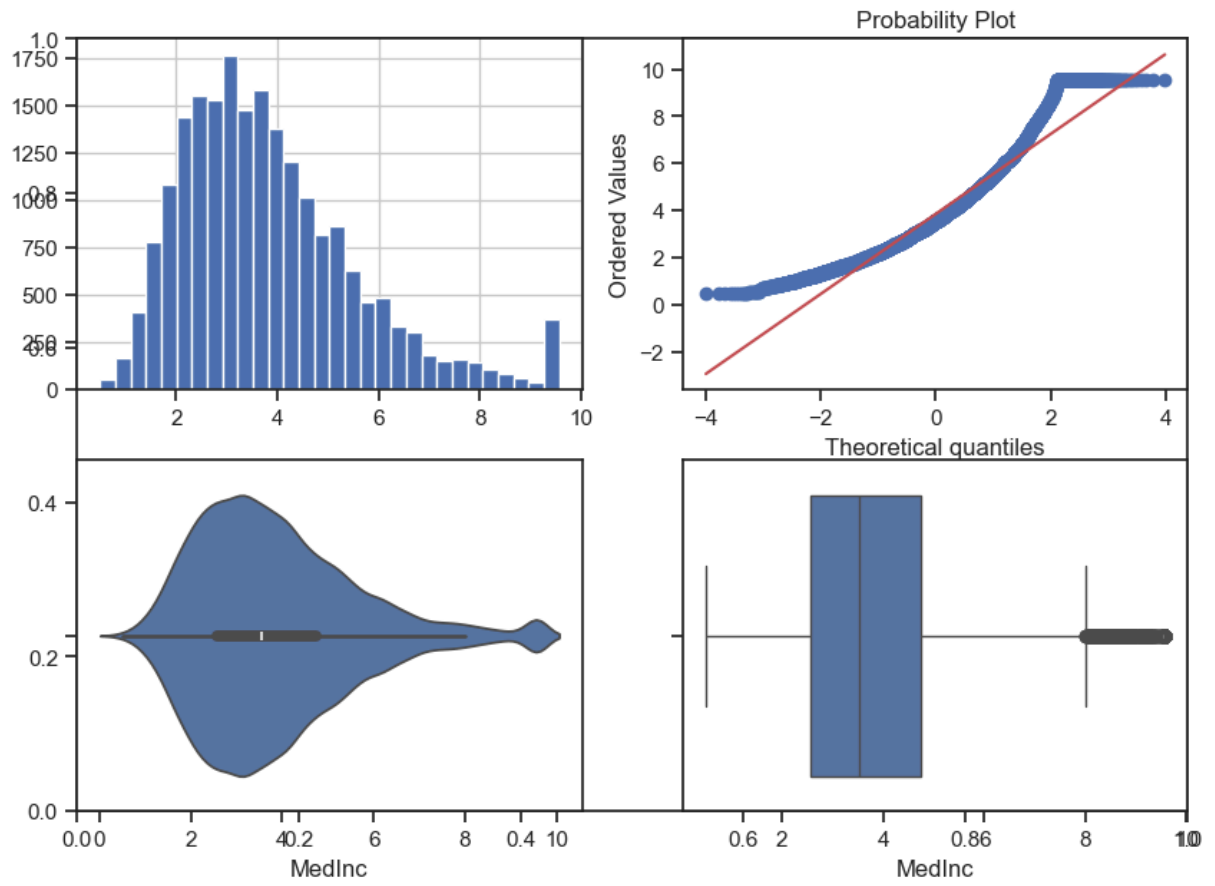
Поле-Population, метод-OutlierBoundaryType.QUANTILE



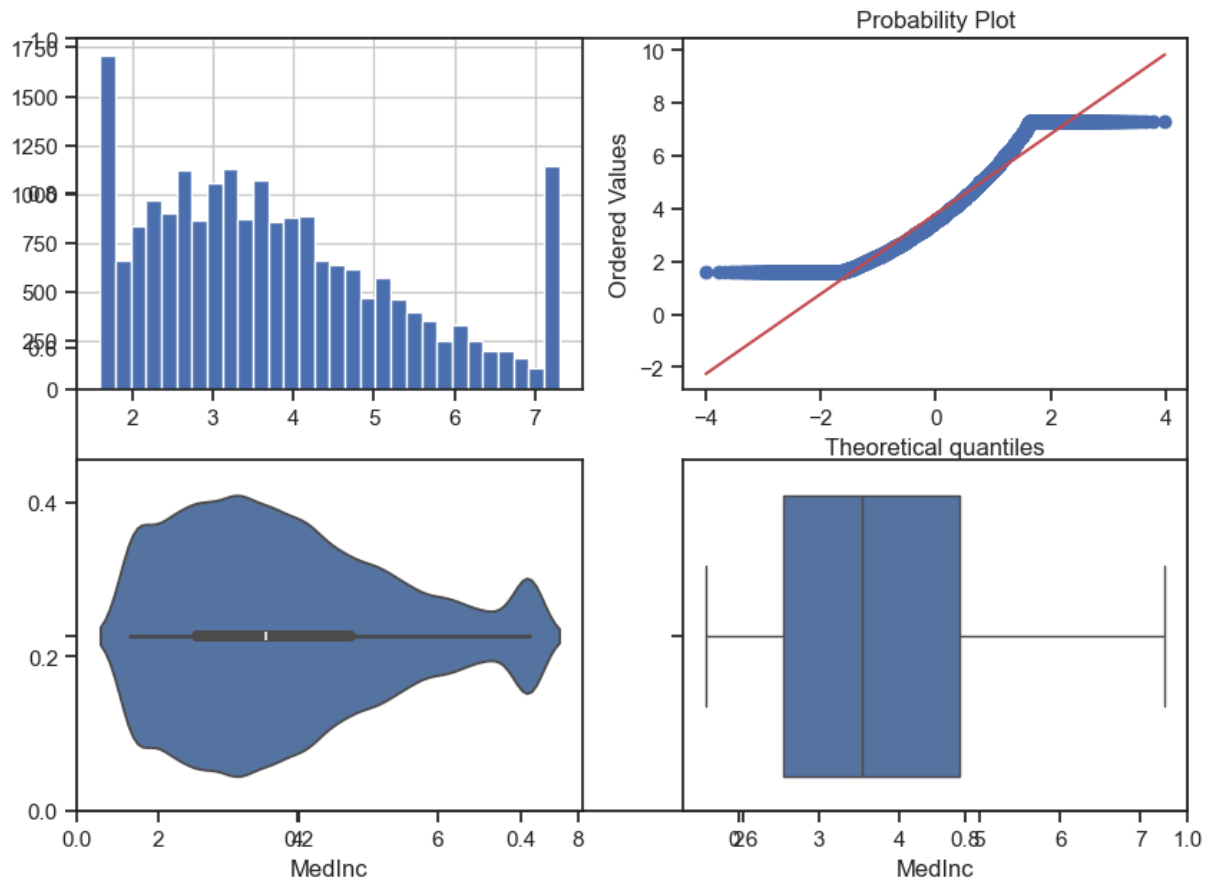
Поле-Population, метод-OutlierBoundaryType.IRQ



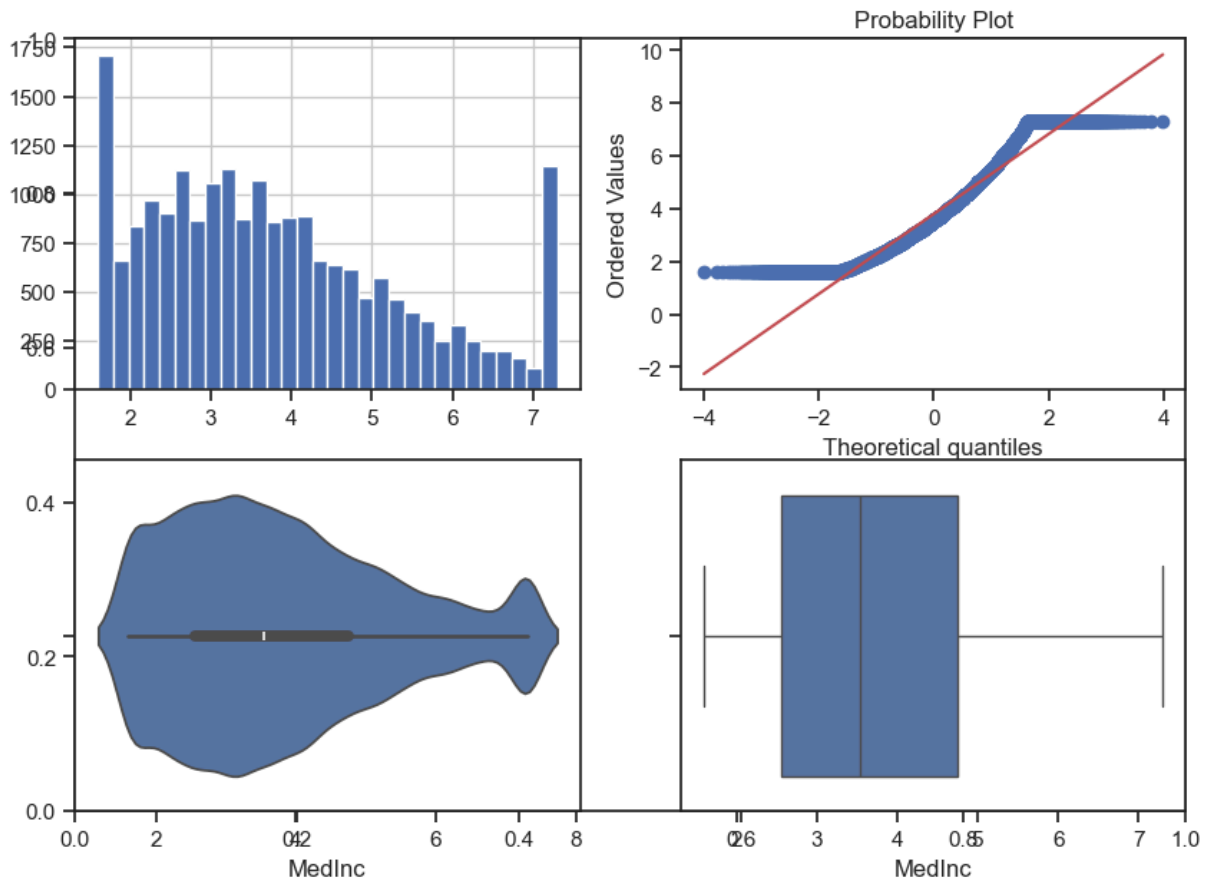
Поле-MedInc, метод-OutlierBoundaryType.SIGMA



Поле-MedInc, метод-OutlierBoundaryType.QUANTILE



Поле-MedInc, метод-OutlierBoundaryType.IRQ



Обработка нестандартного признака

(который не является числовым или категориальным);

Подгрузим датасет, который содержит временной тип

```
In [61]: # Импорт датасета
data = pd.read_csv('datasets/messages.csv')

# Вывод первых 5 строк
data.head(5)
```

```
Out[61]:
```

	date	msg
0	2013-12-15 00:50:00	ищу на сегодня мужика 37
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *.о 067.16.34.576
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше

```
In [66]: # Сконвертируем дату и время в нужный формат
data['dt'] = data.apply(lambda x: pd.to_datetime(x['date'], format='%Y-%m-%d %H:%M:
```

```
In [67]: data.head()
```

```
Out[67]:
```

	date	msg	dt
0	2013-12-15 00:50:00	ищу на сегодня мужика 37	2013-12-15 00:50:00
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826	2014-04-29 23:40:00
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *.о 067.16.34.576	2012-12-30 00:21:00
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...	2014-11-28 00:31:00
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше	2013-10-26 23:11:00

```
In [68]: data.dtypes
```

```
Out[68]: date          object
msg          object
dt          datetime64[ns]
dtype: object
```

```
In [70]: # День
data['day'] = data['dt'].dt.day
# Месяц
data['month'] = data['dt'].dt.month
# Год
data['year'] = data['dt'].dt.year
# Часы
data['hour'] = data['dt'].dt.hour
#Минуты
data['minute'] = data['dt'].dt.minute
#Секунды
data['second'] = data['dt'].dt.second
#Неделя года
data['week'] = data['dt'].dt.isocalendar().week
#Квартал
data['quarter'] = data['dt'].dt.quarter
#День недели
data['dayofweek'] = data['dt'].dt.dayofweek
#Выходной день
data['day_name'] = data['dt'].dt.day_name()
data['is_holiday'] = data.apply(lambda x: 1 if x['dt'].dayofweek in [5,6] else 0, a
```

```
In [71]: data.head()
```

Out[71]:	date	msg	dt	day	month	year	hour	minute	second	week	quarter
0	2013-12-15 00:50:00	ищу на сегодня мужика 37	2013-12-15 00:50:00	15	12	2013	0	50	0	50	
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826	2014-04-29 23:40:00	29	4	2014	23	40	0	18	
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *о 067.16.34.576	2012-12-30 00:21:00	30	12	2012	0	21	0	52	
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...	2014-11-28 00:31:00	28	11	2014	0	31	0	48	
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше	2013-10-26 23:11:00	26	10	2013	23	11	0	43	

```
In [72]: # Создадим масштабируемые признаки для дальнейших экспериментов
dt_features = ['year', 'day', 'month', 'hour', 'minute', 'second', 'week', 'quarter']
dt_features_scaled = []
for f in dt_features:
    f_new = str(f + '_scaled')
    dt_features_scaled.append(f_new)
    data[f_new] = MinMaxScaler().fit_transform(data[[f]])
dt_features_scaled
```

```
Out[72]: ['year_scaled',
'day_scaled',
'month_scaled',
'hour_scaled',
'minute_scaled',
'second_scaled',
'week_scaled',
'quarter_scaled',
'dayofweek_scaled']
```

```
In [73]: data.head()
```

Out[73]:

	date	msg	dt	day	month	year	hour	minute	second	week	...	is
0	2013-12-15 00:50:00	ищу на сегодня мужика 37	2013-12-15 00:50:00	15	12	2013	0	50	0	50	...	
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826	2014-04-29 23:40:00	29	4	2014	23	40	0	18	...	
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *о 067.16.34.576	2012-12-30 00:21:00	30	12	2012	0	21	0	52	...	
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...	2014-11-28 00:31:00	28	11	2014	0	31	0	48	...	
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше	2013-10-26 23:11:00	26	10	2013	23	11	0	43	...	

5 rows × 23 columns

In [75]:

```
import datetime

# Разница между датами
data['now'] = datetime.datetime.today()
data['diff'] = data['now'] - data['dt']
data.dtypes
```

```
Out[75]: date                object
        msg                object
        dt                datetime64[ns]
        day                int32
        month              int32
        year               int32
        hour               int32
        minute             int32
        second             int32
        week               UInt32
        quarter            int32
        dayofweek          int32
        day_name           object
        is_holiday         int64
        year_scaled        float64
        day_scaled         float64
        month_scaled       float64
        hour_scaled        float64
        minute_scaled      float64
        second_scaled      float64
        week_scaled        float64
        quarter_scaled     float64
        dayofweek_scaled   float64
        now                datetime64[us]
        diff               timedelta64[ns]
        dtype: object
```

```
In [76]: data.head()
```

Out[76]:

	date	msg	dt	day	month	year	hour	minute	second	week	...	d
0	2013-12-15 00:50:00	ищу на сегодня мужика 37	2013-12-15 00:50:00	15	12	2013	0	50	0	50	...	
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826	2014-04-29 23:40:00	29	4	2014	23	40	0	18	...	
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *о 067.16.34.576	2012-12-30 00:21:00	30	12	2012	0	21	0	52	...	
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...	2014-11-28 00:31:00	28	11	2014	0	31	0	48	...	
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше	2013-10-26 23:11:00	26	10	2013	23	11	0	43	...	

5 rows × 25 columns

In [77]:

```
# Чтобы получить разницу между датами в заданных единицах
# (минутах, днях и т.д.) нужно разделить timedelta64 на длительность
data['diff_days']=data['diff']/np.timedelta64(1,'D')
data.dtypes
```

```
Out[77]: date                object
        msg                object
        dt                datetime64[ns]
        day                int32
        month              int32
        year               int32
        hour               int32
        minute             int32
        second             int32
        week               UInt32
        quarter            int32
        dayofweek          int32
        day_name           object
        is_holiday         int64
        year_scaled        float64
        day_scaled         float64
        month_scaled       float64
        hour_scaled        float64
        minute_scaled      float64
        second_scaled      float64
        week_scaled        float64
        quarter_scaled     float64
        dayofweek_scaled   float64
        now                datetime64[us]
        diff               timedelta64[ns]
        diff_days          float64
        dtype: object
```

```
In [78]: data.head()
```


Out[78]:

	date	msg	dt	day	month	year	hour	minute	second	week	...	n
0	2013-12-15 00:50:00	ищу на сегодня мужика 37	2013-12-15 00:50:00	15	12	2013	0	50	0	50	...	
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826	2014-04-29 23:40:00	29	4	2014	23	40	0	18	...	
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *о 067.16.34.576	2012-12-30 00:21:00	30	12	2012	0	21	0	52	...	
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...	2014-11-28 00:31:00	28	11	2014	0	31	0	48	...	
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше	2013-10-26 23:11:00	26	10	2013	23	11	0	43	...	

5 rows × 26 columns

Отображение на круг

```
In [79]: def round_code(v, T, cos_flag = True):
x = 2*np.pi*v/T
if cos_flag:
return np.cos(x)
else:
return np.sin(x)
```

```
In [80]: # Определим периоды для признаков
for f in data:
print(f, data[f].min(), data[f].max())
```

```

date 2012-01-01 02:58:00 2017-01-18 00:11:00
msg ПАРЕНЬ ИЩЕТ ДЕВУШКУ ДЛЯ СЕР ОТНОШЕНИЯ МОЖНО РЕБЕНКОМ 0637914986 зап я уволен в
запас я дембель я дома. Ура! постав майданова
dt 2012-01-01 02:58:00 2017-01-18 00:11:00
day 1 31
month 1 12
year 2012 2017
hour 0 23
minute 0 59
second 0 0
week 1 53
quarter 1 4
dayofweek 0 6
day_name Friday Wednesday
is_holiday 0 1
year_scaled 0.0 1.0
day_scaled 0.0 0.9999999999999999
month_scaled 0.0 0.9999999999999999
hour_scaled 0.0 1.0
minute_scaled 0.0 1.0
second_scaled 0.0 0.0
week_scaled 0.0 1.0000000000000002
quarter_scaled 0.0 1.0
dayofweek_scaled 0.0 1.0
now 2024-05-16 16:35:11.224954 2024-05-16 16:35:11.224954
diff 2675 days 16:24:11.224954 4519 days 13:37:11.224954
diff_days 2675.683463251782 4519.56749102956

```

```

In [81]: # периоды для признаков
dt_features_periods = [0, 31, 12, 24, 60, 60, 52, 4, 7]

```

```

In [84]: dt_features_round = ['year_round']

```

```

In [85]: %%time
# Построим отображение признаков на круг, год пропускаем
for f,p in zip(dt_features[1:], dt_features_periods[1:]):
    f_cos = str(f + '_cos')
    f_sin = str(f + '_sin')
    data[f_cos] = data.apply(lambda x: round_code(x[f], p), axis=1)
    data[f_sin] = data.apply(lambda x: round_code(x[f], p, False), axis=1)
    dt_features_round.append(f_cos)
    dt_features_round.append(f_sin)
dt_features_round

```

```

CPU times: total: 156 ms
Wall time: 133 ms

```

```
Out[85]: ['year_round',
          'day_cos',
          'day_sin',
          'month_cos',
          'month_sin',
          'hour_cos',
          'hour_sin',
          'minute_cos',
          'minute_sin',
          'second_cos',
          'second_sin',
          'week_cos',
          'week_sin',
          'quarter_cos',
          'quarter_sin',
          'dayofweek_cos',
          'dayofweek_sin']
```

```
In [86]: data.head()
```

Out[86]:	date	msg	dt	day	month	year	hour	minute	second	week	...	n
0	2013-12-15 00:50:00	ищу на сегодня мужика 37	2013-12-15 00:50:00	15	12	2013	0	50	0	50	...	
1	2014-04-29 23:40:00	ПАРЕНЬ БИ ИЩЕТ ДРУГА СЕЙЧАС!! СМС ММС 0955532826	2014-04-29 23:40:00	29	4	2014	23	40	0	18	...	
2	2012-12-30 00:21:00	Днепр.м 43 позн.с д/ж *.o 067.16.34.576	2012-12-30 00:21:00	30	12	2012	0	21	0	52	...	
3	2014-11-28 00:31:00	КИЕВ ИЩУ Д/Ж ДО 45 МНЕ СЕЙЧАС СКУЧНО 093 629 9...	2014-11-28 00:31:00	28	11	2014	0	31	0	48	...	
4	2013-10-26 23:11:00	Зая я тебя никогда не обижу люблю тебя!) Даше	2013-10-26 23:11:00	26	10	2013	23	11	0	43	...	

5 rows × 42 columns

Отбор признаков:

```
In [88]: import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import scipy.stats as stats
from sklearn.svm import SVR
from sklearn.svm import LinearSVC
from sklearn.feature_selection import SelectFromModel
from sklearn.linear_model import Lasso
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.neighbors import KNeighborsRegressor
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.ensemble import GradientBoostingRegressor
from sklearn.metrics import mean_squared_error
from sklearn.model_selection import train_test_split
from sklearn.feature_selection import VarianceThreshold
from sklearn.feature_selection import mutual_info_classif, mutual_info_regression
from sklearn.feature_selection import SelectKBest, SelectPercentile
from IPython.display import Image
%matplotlib inline
sns.set(style="ticks")
```

```
In [89]: california_ds = _california_housing.fetch_california_housing()
data = pd.DataFrame(california_ds.data,
                    columns=california_ds.feature_names)
data['Y'] = california_ds.target
data.shape
```

Out[89]: (20640, 9)

Метод из группы методов фильтрации (filter methods)

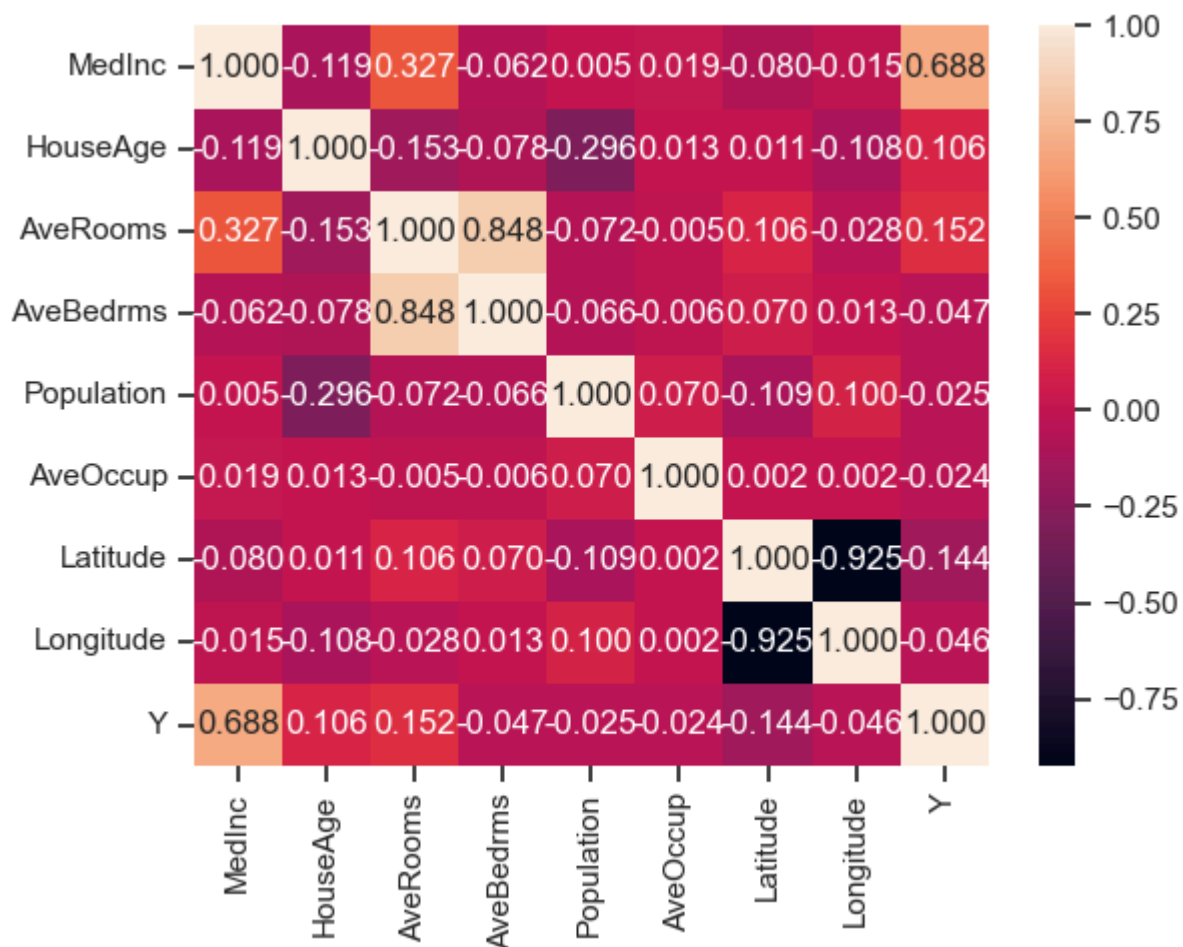
- Методы выбирают наиболее "подходящие" признаки без использования моделей машинного обучения на основе статистических характеристик выборки (корреляция и т.д.)
- Наименее затратны с точки зрения вычислительных ресурсов.
- Могут уступать другим методам по качеству отбора признаков, потому что не учитывают зависимости между признаками.
- Хорошо подходят для начальной фильтрации признаков.

Методы, основанные на корреляции

- Желательно, чтобы признаки хорошо коррелировали с целевым признаком.
- Важно, чтобы признаки не коррелировали между собой.

```
In [96]: sns.heatmap(data.corr(), annot=True, fmt='.3f')
```

Out[96]: <Axes: >



```
In [97]: # Формирование DataFrame с сильными корреляциями
```

```
def make_corr_df(df):  
    cr = data.corr()  
    cr = cr.abs().unstack()  
    cr = cr.sort_values(ascending=False)  
    cr = cr[cr >= 0.8]  
    cr = cr[cr < 1]  
    cr = pd.DataFrame(cr).reset_index()  
    cr.columns = ['f1', 'f2', 'corr']  
    return cr
```

```
In [98]: make_corr_df(data)
```

```
Out[98]:
```

	f1	f2	corr
0	Longitude	Latitude	0.924664
1	Latitude	Longitude	0.924664
2	AveRooms	AveBedrms	0.847621
3	AveBedrms	AveRooms	0.847621

```
In [99]: # Обнаружение групп коррелирующих признаков
def corr_groups(cr):
    grouped_feature_list = []
    correlated_groups = []

    for feature in cr['f1'].unique():
        if feature not in grouped_feature_list:
            # находим коррелирующие признаки
            correlated_block = cr[cr['f1'] == feature]
            cur_dups = list(correlated_block['f2'].unique()) + [feature]
            grouped_feature_list = grouped_feature_list + cur_dups
            correlated_groups.append(cur_dups)

    return correlated_groups
```

```
In [100... # Группы коррелирующих признаков
corr_groups(make_corr_df(data))
```

```
Out[100... [['Latitude', 'Longitude'], ['AveBedrms', 'AveRooms']]
```

Метод из группы методов обертывания (wrapper methods)

- Используют модели машинного обучения для отбора признаков.
- Формируют подмножества признаков.
- Для каждого подмножества признаков строится отдельная модель машинного обучения.
- Для конкретной модели машинного обучения (на которой производится оценка) чаще всего генерируют оптимальный набор признаков. (Но этот набор не обобщается на все модели.)
- Очень затратны с точки зрения вычислительных ресурсов.
- Могут приводить к переобучению моделей (особенно в случае маленьких выборок).

Алгоритмы полного перебора

- Осуществляют перебор всех комбинаций из 1, 2, ... N признаков.
- Для каждой комбинации строится модель и оценивается метрика качества.
- Выбирается лучшая модель на основе метрики.

- По сравнению с предыдущими двумя подходами, данный подход наиболее требователен к ресурсам.

Для решения задачи используется класс `ExhaustiveFeatureSelector` из библиотеки `MLxtend`.

Параметры `min_features` и `max_features` используются для задания диапазона количества перебираемых признаков.

```
In [123... from mlxtend.feature_selection import ExhaustiveFeatureSelector as EFS
from sklearn.datasets import load_diabetes

knn = KNeighborsClassifier(n_neighbors=3)

In [129... efs1 = EFS(knn,
              min_features=2,
              max_features=4,
              scoring='accuracy',
              print_progress=True,
              cv=5)

diabets = load_diabetes()
diabets_x = diabets.data
diabets_y = diabets.target
diabets_feature_names = diabets['feature_names']
diabets_x_df = pd.DataFrame(data=diabets['data'], columns=diabets['feature_names'])

efs1 = efs1.fit(diabets_x, diabets_y)

print('Best accuracy score: %.2f' % efs1.best_score_)
print('Best subset (indices):', efs1.best_idx_)
print('Best subset (corresponding names):', efs1.best_feature_names_)
```

[illegible]

[illegible]

[illegible]

```
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[illegible]


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  warnings.warn(
Features: 375/375
Best accuracy score: 0.02
Best subset (indices): (0, 1, 4, 6)
Best subset (corresponding names): ('0', '1', '4', '6')

```

Метод из группы методов вложений (embedded methods)

- Являются гибридом фильтрации и обертывания.
- Осуществляют отбор признаков на основе оценки важности признаков в процессе конструирования модели.
- По сравнению с методами обертывания, менее затратны с точки зрения вычислительных ресурсов.

Использование линейных моделей

In [131...

```

# Используем L1-регуляризацию
e_lr1 = LogisticRegression(C=1000, solver='liblinear', penalty='l1', max_iter=500,
e_lr1.fit(diabets_x, diabets_y)
# Коэффициенты регрессии
e_lr1.coef_

```

```
c:\Users\NKliukin\Code\bmstu\mmo_2_2024\venv\Lib\site-packages\sklearn\svm\_base.py:
1237: ConvergenceWarning: Liblinear failed to converge, increase the number of itera
tions.
```

```
warnings.warn(
```

```
Out[131... array([[ 3.59674720e+00, -4.57841723e+01, -3.60920124e-01, ...,
        -4.55458434e+01,  2.70474898e+01, -1.31482645e+01],
        [ 9.87769163e+01, -7.27638225e+01, -1.13728539e+00, ...,
        -4.65985286e+02, -1.91943796e+02,  0.00000000e+00],
        [ 5.91685466e+01, -6.39101830e+01, -1.61273486e+02, ...,
        0.00000000e+00, -3.49347601e+01, -4.89011437e+01],
        ...,
        [ 5.40540965e+01,  4.12790995e+01,  2.03521201e+02, ...,
        0.00000000e+00,  0.00000000e+00,  1.09520878e+02],
        [ 0.00000000e+00,  0.00000000e+00,  4.99210349e+01, ...,
        1.00619378e+02, -3.43526050e+01,  0.00000000e+00],
        [-3.28855574e+00, -4.74442541e+01,  1.16773221e+02, ...,
        0.00000000e+00,  0.00000000e+00,  0.00000000e+00]])
```

```
In [132... # Все 4 признака являются "хорошими"
sel_e_lr1 = SelectFromModel(e_lr1)
sel_e_lr1.fit(diabets_x, diabets_y)
sel_e_lr1.get_support()
```

```
c:\Users\NKliukin\Code\bmstu\mmo_2_2024\venv\Lib\site-packages\sklearn\svm\_base.py:
1237: ConvergenceWarning: Liblinear failed to converge, increase the number of itera
tions.
```

```
warnings.warn(
```

```
Out[132... array([ True,  True,  True,  True,  True,  True,  True,  True,  True,
        True])
```