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Кафедра ИУ5 «Системы обработки информации и управления»

Курс «Теория машинного обучения»

Отчет по лабораторной работе №2
«Обработка пропусков в данных, кодирование категориальных признаков, масштабирование данных»

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Москва, 2022 г.

Обработка пропусков в данных, кодирование категориальных признаков, масштабирование данных.

В чем состоит проблема?

- Если в данных есть пропуски, то большинство алгоритмов машинного обучения не будут с ними работать. Даже корреляционная матрица не будет строиться корректно.
- Большинство алгоритмов машинного обучения требуют явного перекодирования категориальных признаков в числовые. Даже если алгоритм не требует этого явно, такое перекодирование возможно стоит попробовать, чтобы повысить качество модели.
- Большинство алгоритмов показывает лучшее качество на масштабированных признаках, в особенности алгоритмы, использующие методы градиентного спуска.

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
sns.set(style="ticks")
```

Загрузка и первичный анализ данных

Используем данные о странах Country & Area Dataset

```
# Загружаем данные
data = pd.read_csv('country_and_area_data.csv', sep=",")
```

```
# размер набора данных
data.shape
```

```
(250, 10)
```

```
# типы колонок
data.dtypes
```

```
country _or_area                        object
iso_alpha3 _code                        object
m49_code                                 int64
region_1                                object
region_2                                object
continent                               object
population_rank                        float64
population                             float64
population_percentage_ of_the_world    float64
date                                    object
dtype: object
```

```
# проверим есть ли пропущенные значения
data.isnull().sum()
```

```
country _or_area                        0
iso_alpha3 _code                        1
m49_code                                0
region_1                                0
region_2                                7
continent                               0
population_rank                        60
population                             21
```

```
population_percentage_ of_the_world    23
date                                   22
dtype: int64
```

```
# Первые 5 строк датасета
data.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	country _or_area	iso_alpha3 _code	m49_code	region_1	region_2	continent	population_rank	population	population_percentage_ of_the_world	date
0	Afghanistan	AFG	4	Southern Asia	None	Asia	43.0	32890171.0	0.004140	1/07/2020
1	Åland Islands	ALA	248	Northern Europe	None	Europe	NaN	30344.0	0.000004	31/12/2021
2	Albania	ALB	8	Southern Europe	None	Europe	135.0	2829741.0	0.000356	1/01/2021
3	Algeria	DZA	12	Northern Africa	None	Africa	32.0	45400000.0	0.005710	1/01/2022
4	American Samoa	ASM	16	Polynesia	None	Oceania	NaN	49710.0	0.000006	1/04/2020

```
total_count = data.shape[0]
print('Всего строк: {}'.format(total_count))
```

```
Всего строк: 250
```

Обработка пропусков в данных

Простые стратегии - удаление или заполнение нулями

Удаление колонок, содержащих пустые значения `res = data.dropna(axis=1, how='any')`

Удаление строк, содержащих пустые значения `res = data.dropna(axis=0, how='any')`

[Документация]

Удаление может производиться для группы строк или колонок.

```
# Удаление колонок, содержащих пустые значения
data_with_drop_null_columns = data.dropna(axis=1, how='any')
(data.shape, data_with_drop_null_columns.shape)
```

```
((250, 10), (250, 4))
```

```
# Удаление строк, содержащих пустые значения
data_with_drop_null_rows = data.dropna(axis=0, how='any')
(data.shape, data_with_drop_null_rows.shape)
```

```
((250, 10), (185, 10))
```

```
data.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	country_or_area	iso_alpha3_code	m49_code	region_1	region_2	continent	population_rank	population	population_percentage_of_the_world	date
0	Afghanistan	AFG	4	Southern Asia	None	Asia	43.0	32890171.0	0.004140	1/07/2020
1	Åland Islands	ALA	248	Northern Europe	None	Europe	NaN	30344.0	0.000004	31/12/2021
2	Albania	ALB	8	Southern Europe	None	Europe	135.0	2829741.0	0.000356	1/01/2021
3	Algeria	DZA	12	Northern Africa	None	Africa	32.0	45400000.0	0.005710	1/01/2022
4	American Samoa	ASM	16	Polynesia	None	Oceania	NaN	49710.0	0.000006	1/04/2020

```
# Заполнение всех пропущенных значений нулями
# В данном случае это некорректно, так как нулями заполняются в том числе категориальные колонки
data_with_set_null_values_as_zero = data.fillna(0)
data_with_set_null_values_as_zero.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	country_or_area	iso_alpha3_code	m49_code	region_1	region_2	continent	population_rank	population	population_percentage_of_the_world	date
0	Afghanistan	AFG	4	Southern Asia	None	Asia	43.0	32890171.0	0.004140	1/07/2020
1	Åland Islands	ALA	248	Northern Europe	None	Europe	0.0	30344.0	0.000004	31/12/2021
2	Albania	ALB	8	Southern Europe	None	Europe	135.0	2829741.0	0.000356	1/01/2021
3	Algeria	DZA	12	Northern Africa	None	Africa	32.0	45400000.0	0.005710	1/01/2022
4	American Samoa	ASM	16	Polynesia	None	Oceania	0.0	49710.0	0.000006	1/04/2020

"Внедрение значений" - импьютация (imputation)

Обработка пропусков в числовых данных

```
data_with_null_column = data[data.isnull().sum()[data.isnull().sum()!=0].index]
data_with_null_column
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	iso_alpha3 _code	region_2	population_rank	population	population_percentage_ of_the_world	date
0	AFG	None	43.0	32890171.0	0.004140	1/07/2020
1	ALA	None	NaN	30344.0	0.000004	31/12/2021
2	ALB	None	135.0	2829741.0	0.000356	1/01/2021
3	DZA	None	32.0	45400000.0	0.005710	1/01/2022
4	ASM	None	NaN	49710.0	0.000006	1/04/2020
...	...	...	...	...	...	...
245	ESH	None	NaN	612000.0	0.000077	1/07/2021
246	YEM	None	48.0	30491000.0	0.003830	1/07/2021
247	ZMB	Sub-Saharan Africa	64.0	18400556.0	0.002310	1/07/2021
248	ZWE	Sub-Saharan Africa	72.0	15790716.0	0.001990	1/07/2021
249	TWN	Province of China	NaN	23375314.0	0.002940	31/12/2021

250 rows × 6 columns

```
# Выберем числовые колонки с пропущенными значениями
# Цикл по колонкам датасета
data_with_null_column = data[data.isnull().sum()[data.isnull().sum()!=0].index]
num_cols = []
#Выбираем только числовые столбцы
for col in data_with_null_column.columns:
    # Количество пустых значений
    dt = str(data_with_null_column[col].dtype)
    if (dt=='float64' or dt=='int64'):
        num_cols.append(col)
        temp_perc = round((data[col].isnull().sum() / data[col].count()) * 100.0, 2)
        print('Колонка {}. Тип данных {}. Количество пустых значений {}, {}%.'.format(col, dt, data[col].isnull().sum() ,
temp_perc))
```

```
Колонка population_rank. Тип данных float64. Количество пустых значений 60, 31.58%.
Колонка population. Тип данных float64. Количество пустых значений 21, 9.17%.
Колонка population_percentage_ of_the_world. Тип данных float64. Количество пустых значений 23, 10.13%.
```

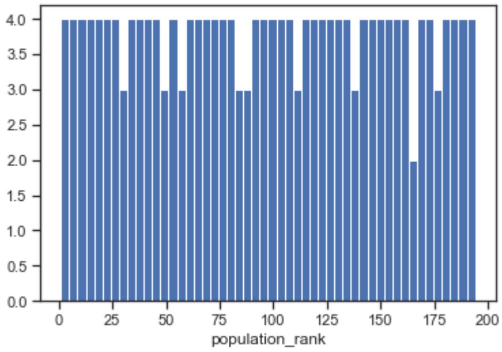
```
# Фильтр по колонкам с пропущенными значениями
data_num = data[num_cols]
data_num
```

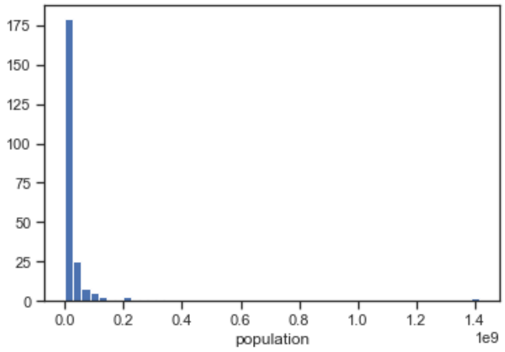
```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

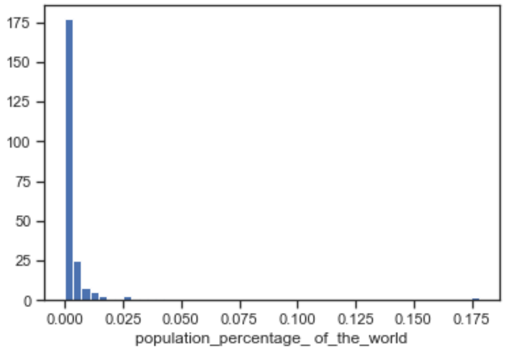
	population_rank	population	population_percentage_of_the_world
0	43.0	32890171.0	0.004140
1	NaN	30344.0	0.000004
2	135.0	2829741.0	0.000356
3	32.0	45400000.0	0.005710
4	NaN	49710.0	0.000006
...	...	...	...
245	NaN	612000.0	0.000077
246	48.0	30491000.0	0.003830
247	64.0	18400556.0	0.002310
248	72.0	15790716.0	0.001990
249	NaN	23375314.0	0.002940

250 rows × 3 columns

```
# Гистограмма по признакам
for col in data_num:
    plt.hist(data[col], 50)
    plt.xlabel(col)
    plt.show()
```







Будем использовать встроенные средства импьютации библиотеки scikit-learn - https://scikit-learn.org/stable/modules/impute.html

```
data_num_population = data_num[['population']]
data_num_population.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	population
0	32890171.0
1	30344.0
2	2829741.0
3	45400000.0
4	49710.0

```
from sklearn.impute import SimpleImputer
from sklearn.impute import MissingIndicator
```

```
# Фильтр для проверки заполнения пустых значений
indicator = MissingIndicator()
mask_missing_values_only = indicator.fit_transform(data_num_population)
mask_missing_values_only
```

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

С помощью класса SimpleImputer можно проводить импьютацию различными показателями центра распределения

```
strategies=['mean', 'median', 'most_frequent']
```

```
def test_num_impute(strategy_param):
    imp_num = SimpleImputer(strategy=strategy_param)
    data_num_imp = imp_num.fit_transform(data_num_population)
    return data_num_imp[mask_missing_values_only]
```

```
strategies[0], test_num_impute(strategies[0])
```

```
('mean',
 array([33971287.267869, 33971287.267869, 33971287.267869, 33971287.267869,
        33971287.267869, 33971287.267869, 33971287.267869, 33971287.267869,
        33971287.267869, 33971287.267869, 33971287.267869, 33971287.267869,
        33971287.267869, 33971287.267869, 33971287.267869, 33971287.267869,
        33971287.267869, 33971287.267869, 33971287.267869, 33971287.267869,
        33971287.267869]))
```

```
strategies[1], test_num_impute(strategies[1])
```

```
('median',
 array([5550066., 5550066., 5550066., 5550066., 5550066., 5550066.,
        5550066., 5550066., 5550066., 5550066., 5550066., 5550066.,
        5550066., 5550066., 5550066., 5550066., 5550066., 5550066.,
        5550066., 5550066., 5550066.]))
```

```
strategies[2], test_num_impute(strategies[2])
```

```
('most_frequent',
 array([30., 30., 30., 30., 30., 30., 30., 30., 30., 30., 30., 30., 30.,
        30., 30., 30., 30., 30., 30., 30., 30.]))
```

```
# Более сложная функция, которая позволяет задавать колонку и вид импьютации
def test_num_impute_col(dataset, column, strategy_param):
    temp_data = dataset[[column]]

    indicator = MissingIndicator()
    mask_missing_values_only = indicator.fit_transform(temp_data)

    imp_num = SimpleImputer(strategy=strategy_param)
    data_num_imp = imp_num.fit_transform(temp_data)

    filled_data = data_num_imp[mask_missing_values_only]

    return column, strategy_param, filled_data.size, filled_data[0], filled_data[filled_data.size-1]
```

```
data[['population_percentage_ of_the_world']].describe()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	population_percentage_ of_the_world
count	227.000000
mean	0.004309
std	0.017309

	population_percentage_ of_the_world
min	0.000000
25%	0.000052
50%	0.000708
75%	0.002745
max	0.178000

```
test_num_impute_col(data, 'population_percentage_ of_the_world', strategies[0])
```

```
('population_percentage_ of_the_world',
 'mean',
 23,
 0.004309447577092511,
 0.004309447577092511)
```

```
test_num_impute_col(data, 'population_percentage_ of_the_world', strategies[1])
```

```
('population_percentage_ of_the_world', 'median', 23, 0.000708, 0.000708)
```

```
test_num_impute_col(data, 'population_percentage_ of_the_world', strategies[2])
```

```
('population_percentage_ of_the_world', 'most_frequent', 23, 0.0, 0.0)
```

Обработка пропусков в категориальных данных

```
# Выберем категориальные колонки с пропущенными значениями
# Цикл по колонкам датасета
cat_cols = []
for col in data.columns:
    # Количество пустых значений
    temp_null_count = data[data[col].isnull()].shape[0]
    dt = str(data[col].dtype)
    if temp_null_count>0 and (dt=='object'):
        cat_cols.append(col)
        temp_perc = round((temp_null_count / total_count) * 100.0, 2)
        print('Колонка {}. Тип данных {}. Количество пустых значений {}, {}%.'.format(col, dt, temp_null_count, temp_perc))
```

```
Колонка iso_alpha3 _code. Тип данных object. Количество пустых значений 1, 0.4%.
Колонка region_2. Тип данных object. Количество пустых значений 7, 2.8%.
Колонка date. Тип данных object. Количество пустых значений 22, 8.8%.
```

Класс SimpleImputer можно использовать для категориальных признаков со стратегиями "most_frequent" или "constant".

```
cat_temp_data = data[['region_2']]
cat_temp_data.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	region_2
0	None
1	None
2	None
3	None
4	None

```
cat_temp_data['region_2'].unique()
```

```
array(['None', 'Sub-Saharan Africa', 'Latin America and the Caribbean',
       nan, 'Special Administrative Region of China', 'Channel Islands',
       'Province of China'], dtype=object)
```

```
cat_temp_data[cat_temp_data['region_2'].isnull()].shape
```

```
(7, 1)
```

```
# Импьютация наиболее частыми значениями
imp2 = SimpleImputer(missing_values=np.nan, strategy='most_frequent')
data_imp2 = imp2.fit_transform(cat_temp_data)
data_imp2
```

```
array([['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
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       ['None'],
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       ['Latin America and the Caribbean'],
       ['None'],
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       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['None'],
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       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
```

```
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Special Administrative Region of China'],
        ['Special Administrative Region of China'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Channel Islands'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
```

```
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Channel Islands'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
```

```
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Channel Islands'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['Province of China']], dtype=object)
```

```
# Пустые значения отсутствуют
np.unique(data_imp2)
```

```
array(['Channel Islands', 'Latin America and the Caribbean', 'None',
       'Province of China', 'Special Administrative Region of China',
       'Sub-Saharan Africa'], dtype=object)
```

```
# Импьютация константой
imp3 = SimpleImputer(missing_values=np.nan, strategy='constant', fill_value='None')
data_imp3 = imp3.fit_transform(cat_temp_data)
data_imp3
```

```
array([['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Special Administrative Region of China'],
       ['Special Administrative Region of China'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['Sub-Saharan Africa'],
```

```
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Channel Islands'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Channel Islands'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
```

```
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Channel Islands'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
        ['None'],
        ['None'],
        ['Sub-Saharan Africa'],
        ['Sub-Saharan Africa'],
        ['Latin America and the Caribbean'],
        ['Sub-Saharan Africa'],
        ['None'],
        ['None'],
        ['None'],
        ['None'],
        ['Latin America and the Caribbean'],
        ['None'],
```

```
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['Latin America and the Caribbean'],
       ['None'],
       ['None'],
       ['None'],
       ['None'],
       ['Sub-Saharan Africa'],
       ['Sub-Saharan Africa'],
       ['Province of China']], dtype=object)
```

```
np.unique(data_imp3)
```

```
array(['Channel Islands', 'Latin America and the Caribbean', 'None',
       'Province of China', 'Special Administrative Region of China',
       'Sub-Saharan Africa'], dtype=object)
```

```
data_imp3[data_imp3=='nan'].size
```

```
0
```

Преобразование категориальных признаков в числовые

```
cat_enc = pd.DataFrame({'c1':data_imp2.T[0]})
cat_enc
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	c1

	c1
0	None
1	None
2	None
3	None
4	None
...	...
245	None
246	None
247	Sub-Saharan Africa
248	Sub-Saharan Africa
249	Province of China

250 rows × 1 columns

Кодирование категорий целочисленными значениями (label encoding)

В этом случае уникальные значения категориального признака кодируются целыми числами.

В scikit-learn для такого кодирования используется два класса :

- LabelEncoder - который ориентирован на применение к одному признаку. Этот класс прежде всего предназначен для кодирования целевого признака, но может быть также использован для последовательного кодирования отдельных нецелевых признаков.
- OrdinalEncoder - который ориентирован на применение к матрице объект-признак, то есть для кодирования матрицы нецелевых признаков.

Использование LabelEncoder

```
from sklearn.preprocessing import LabelEncoder
```

```
cat_enc['c1'].unique()
```

```
array(['None', 'Sub-Saharan Africa', 'Latin America and the Caribbean',
       'Special Administrative Region of China', 'Channel Islands',
       'Province of China'], dtype=object)
```

```
le = LabelEncoder()
cat_enc_le = le.fit_transform(cat_enc['c1'])
```

```
# Наименования категорий в соответствии с порядковыми номерами

# Свойство называется classes, потому что предполагается что мы решаем
# задачу классификации и каждое значение категории соответствует
# какому-либо классу целевого признака

le.classes_
```

```
array(['Channel Islands', 'Latin America and the Caribbean', 'None',
       'Province of China', 'Special Administrative Region of China',
       'Sub-Saharan Africa'], dtype=object)
```

```
cat_enc_le
```

```
array([2, 2, 2, 2, 2, 2, 5, 1, 2, 1, 1, 2, 1, 2, 2, 2, 1, 2, 2, 1, 2, 2,
       1, 5, 2, 2, 1, 1, 2, 5, 1, 1, 5, 1, 2, 2, 5, 5, 5, 2, 5, 2, 1, 5,
       5, 1, 2, 4, 4, 2, 2, 1, 5, 5, 2, 1, 5, 2, 1, 1, 2, 2, 2, 5, 2, 5,
       1, 1, 1, 2, 1, 5, 5, 2, 5, 5, 1, 2, 2, 2, 2, 1, 2, 5, 5, 5, 2, 2,
       5, 2, 2, 2, 1, 1, 2, 1, 0, 5, 5, 1, 1, 2, 2, 1, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 1, 2, 0, 2, 2, 5, 2, 2, 2, 2, 2, 2, 5, 5, 2, 2, 2, 2,
       5, 5, 2, 2, 5, 2, 2, 1, 5, 5, 5, 1, 2, 2, 2, 2, 1, 2, 5, 2, 5, 2,
       2, 2, 2, 2, 1, 5, 5, 2, 2, 2, 2, 2, 2, 2, 2, 1, 2, 1, 1, 2, 2, 2,
       2, 1, 2, 2, 2, 5, 2, 2, 5, 1, 5, 1, 1, 1, 2, 1, 2, 2, 5, 0, 2, 5,
       2, 5, 5, 2, 1, 2, 2, 2, 5, 5, 1, 5, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2,
       2, 2, 5, 2, 2, 1, 2, 2, 2, 1, 2, 5, 2, 2, 2, 5, 2, 2, 1, 1, 2, 2,
       1, 2, 2, 2, 2, 5, 5, 3])
```

```
np.unique(cat_enc_le)
```

```
array([0, 1, 2, 3, 4, 5])
```

```
# В этом примере видно, что перед кодированием
# уникальные значения признака сортируются в лексикографическом порядке
le.inverse_transform([0, 1, 2, 3])
```

```
array(['Channel Islands', 'Latin America and the Caribbean', 'None',
       'Province of China'], dtype=object)
```

Использование OrdinalEncoder

```
from sklearn.preprocessing import OrdinalEncoder
```

```
data_oe = data[data.dtypes[data.dtypes=='object'].index]
data_oe.head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	country _or_area	iso_alpha3 _code	region_1	region_2	continent	date
0	Afghanistan	AFG	Southern Asia	None	Asia	1/07/2020
1	Åland Islands	ALA	Northern Europe	None	Europe	31/12/2021
2	Albania	ALB	Southern Europe	None	Europe	1/01/2021
3	Algeria	DZA	Northern Africa	None	Africa	1/01/2022
4	American Samoa	ASM	Polynesia	None	Oceania	1/04/2020

```
imp4 = SimpleImputer(missing_values=np.nan, strategy='constant', fill_value='NA')
data_oe_filled = imp4.fit_transform(data_oe)
data_oe_filled
```

```
array([['Afghanistan', 'AFG', 'Southern Asia', 'None', 'Asia',
        '1/07/2020'],
```

```
       ['Åland Islands', 'ALA', 'Northern Europe', 'None', 'Europe',
        '31/12/2021'],
       ['Albania', 'ALB', 'Southern Europe', 'None', 'Europe',
        '1/01/2021'],
       ...,
       ['Zambia', 'ZMB', 'Eastern Africa', 'Sub-Saharan Africa',
        'Africa', '1/07/2021'],
       ['Zimbabwe', 'ZWE', 'Eastern Africa', 'Sub-Saharan Africa',
        'Africa', '1/07/2021'],
       ['Taiwan', 'TWN', 'Eastern Asia', 'Province of China', 'Asia',
        '31/12/2021']], dtype=object)
```

```
oe = OrdinalEncoder()
cat_enc_oe = oe.fit_transform(data_oe_filled)
cat_enc_oe
```

```
array([[  0.,   1.,  18.,   3.,   2.,  10.],
       [249.,   4.,  13.,   3.,   3.,  38.],
       [  1.,   5.,  19.,   3.,   3.,   1.],
       ...,
       [247., 248.,   5.,   6.,   0.,  11.],
       [248., 249.,   5.,   6.,   0.,  11.],
       [218., 229.,   6.,   4.,   2.,  38.]])
```

```
# Уникальные значения 1 признака
np.unique(cat_enc_oe[:, 0])
```

```
array([  0.,   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.,  51.,  52.,  53.,  54.,
        55.,  56.,  57.,  58.,  59.,  60.,  61.,  62.,  63.,  64.,  65.,
        66.,  67.,  68.,  69.,  70.,  71.,  72.,  73.,  74.,  75.,  76.,
        77.,  78.,  79.,  80.,  81.,  82.,  83.,  84.,  85.,  86.,  87.,
        88.,  89.,  90.,  91.,  92.,  93.,  94.,  95.,  96.,  97.,  98.,
        99., 100., 101., 102., 103., 104., 105., 106., 107., 108., 109.,
       110., 111., 112., 113., 114., 115., 116., 117., 118., 119., 120.,
       121., 122., 123., 124., 125., 126., 127., 128., 129., 130., 131.,
       132., 133., 134., 135., 136., 137., 138., 139., 140., 141., 142.,
       143., 144., 145., 146., 147., 148., 149., 150., 151., 152., 153.,
       154., 155., 156., 157., 158., 159., 160., 161., 162., 163., 164.,
       165., 166., 167., 168., 169., 170., 171., 172., 173., 174., 175.,
       176., 177., 178., 179., 180., 181., 182., 183., 184., 185., 186.,
       187., 188., 189., 190., 191., 192., 193., 194., 195., 196., 197.,
       198., 199., 200., 201., 202., 203., 204., 205., 206., 207., 208.,
       209., 210., 211., 212., 213., 214., 215., 216., 217., 218., 219.,
       220., 221., 222., 223., 224., 225., 226., 227., 228., 229., 230.,
       231., 232., 233., 234., 235., 236., 237., 238., 239., 240., 241.,
       242., 243., 244., 245., 246., 247., 248., 249.])
```

```
# Уникальные значения 2 признака
np.unique(cat_enc_oe[:, 1])
```

```
array([  0.,   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.,  51.,  52.,  53.,  54.,
        55.,  56.,  57.,  58.,  59.,  60.,  61.,  62.,  63.,  64.,  65.,
        66.,  67.,  68.,  69.,  70.,  71.,  72.,  73.,  74.,  75.,  76.,
        77.,  78.,  79.,  80.,  81.,  82.,  83.,  84.,  85.,  86.,  87.,
        88.,  89.,  90.,  91.,  92.,  93.,  94.,  95.,  96.,  97.,  98.,
```

```
        99., 100., 101., 102., 103., 104., 105., 106., 107., 108., 109.,
       110., 111., 112., 113., 114., 115., 116., 117., 118., 119., 120.,
       121., 122., 123., 124., 125., 126., 127., 128., 129., 130., 131.,
       132., 133., 134., 135., 136., 137., 138., 139., 140., 141., 142.,
       143., 144., 145., 146., 147., 148., 149., 150., 151., 152., 153.,
       154., 155., 156., 157., 158., 159., 160., 161., 162., 163., 164.,
       165., 166., 167., 168., 169., 170., 171., 172., 173., 174., 175.,
       176., 177., 178., 179., 180., 181., 182., 183., 184., 185., 186.,
       187., 188., 189., 190., 191., 192., 193., 194., 195., 196., 197.,
       198., 199., 200., 201., 202., 203., 204., 205., 206., 207., 208.,
       209., 210., 211., 212., 213., 214., 215., 216., 217., 218., 219.,
       220., 221., 222., 223., 224., 225., 226., 227., 228., 229., 230.,
       231., 232., 233., 234., 235., 236., 237., 238., 239., 240., 241.,
       242., 243., 244., 245., 246., 247., 248., 249.])
```

```
# Уникальные значения 3 признака
np.unique(cat_enc_oe[:, 2])
```

```
array([ 0.,  1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.,  9., 10., 11., 12.,
       13., 14., 15., 16., 17., 18., 19., 20., 21., 22.])
```

```
# Наименования категорий в соответствии с порядковыми номерами
oe.categories_
```

```
[array(['Afghanistan', 'Albania', 'Algeria', 'American Samoa', 'Andorra',
        'Angola', 'Anguilla', 'Antarctica', 'Antigua and Barbuda',
        'Argentina', 'Armenia', 'Aruba', 'Australia', 'Austria',
        'Azerbaijan', 'Bahamas', 'Bahrain', 'Bangladesh', 'Barbados',
        'Belarus', 'Belgium', 'Belize', 'Benin', 'Bermuda', 'Bhutan',
        'Bolivia', 'Bonaire, Sint Eustatius and Saba',
        'Bosnia and Herzegovina', 'Botswana', 'Bouvet Island', 'Brazil',
        'British Indian Ocean Territory', 'British Virgin Islands',
        'Brunei Darussalam', 'Bulgaria', 'Burkina Faso', 'Burundi',
        'Cabo Verde', 'Cambodia', 'Cameroon', 'Canada', 'Cayman Islands',
        'Central African Republic', 'Chad', 'Chile', 'China',
        'Christmas Island', 'Cocos (Keeling) Islands', 'Colombia',
        'Comoros', 'Congo', 'Cook Islands', 'Costa Rica', 'Croatia',
        'Cuba', 'Curaçao', 'Cyprus', 'Czechia', 'Côte d’Ivoire',
        'Democratic Republic of the Congo', 'Denmark', 'Djibouti',
        'Dominica', 'Dominican Republic', 'Ecuador', 'Egypt',
        'El Salvador', 'Equatorial Guinea', 'Eritrea', 'Estonia',
        'Eswatini', 'Ethiopia', 'Falkland Islands', 'Faroe Islands',
        'Fiji', 'Finland', 'France', 'French Guiana', 'French Polynesia',
        'French Southern Territories', 'Gabon', 'Gambia', 'Georgia',
        'Germany', 'Ghana', 'Gibraltar', 'Greece', 'Greenland', 'Grenada',
        'Guadeloupe', 'Guam', 'Guatemala', 'Guernsey', 'Guinea',
        'Guinea-Bissau', 'Guyana', 'Haiti',
        'Heard Island and McDonald Islands', 'Holy See', 'Honduras',
        'Hong Kong', 'Hungary', 'Iceland', 'India', 'Indonesia', 'Iran',
        'Iraq', 'Ireland', 'Isle of Man', 'Israel', 'Italy', 'Jamaica',
        'Japan', 'Jersey', 'Jordan', 'Kazakhstan', 'Kenya', 'Kiribati',
        'Kuwait', 'Kyrgyzstan', 'Laos', 'Latvia', 'Lebanon', 'Lesotho',
        'Liberia', 'Libya', 'Liechtenstein', 'Lithuania', 'Luxembourg',
        'Macao', 'Madagascar', 'Malawi', 'Malaysia', 'Maldives', 'Mali',
        'Malta', 'Marshall Islands', 'Martinique', 'Mauritania',
        'Mauritius', 'Mayotte', 'Mexico', 'Micronesia', 'Moldova',
        'Monaco', 'Mongolia', 'Montenegro', 'Montserrat', 'Morocco',
        'Mozambique', 'Myanmar', 'Namibia', 'Nauru', 'Nepal',
        'Netherlands', 'New Caledonia', 'New Zealand', 'Nicaragua',
        'Niger', 'Nigeria', 'Niue', 'Norfolk Island', 'North Korea',
        'North Macedonia', 'Northern Mariana Islands', 'Norway', 'Oman',
        'Pakistan', 'Palau', 'Palestine', 'Panama', 'Papua New Guinea',
        'Paraguay', 'Peru', 'Philippines', 'Pitcairn', 'Poland',
        'Portugal', 'Puerto Rico', 'Qatar', 'Romania', 'Russia', 'Rwanda',
        'Réunion', 'Saint Barthélemy', 'Saint Helena',
        'Saint Kitts and Nevis', 'Saint Lucia',
        'Saint Martin (French Part)', 'Saint Pierre and Miquelon',
```

```
        'Saint Vincent and the Grenadines', 'Samoa', 'San Marino',
        'Sao Tome and Principe', 'Sark', 'Saudi Arabia', 'Senegal',
        'Serbia', 'Seychelles', 'Sierra Leone', 'Singapore',
        'Sint Maarten (Dutch part)', 'Slovakia', 'Slovenia',
        'Solomon Islands', 'Somalia', 'South Africa',
        'South Georgia and the South Sandwich Islands', 'South Korea',
        'South Sudan', 'Spain', 'Sri Lanka', 'Sudan', 'Suriname',
        'Svalbard and Jan Mayen Islands', 'Sweden', 'Switzerland', 'Syria',
        'Taiwan', 'Tajikistan', 'Tanzania', 'Thailand', 'Timor-Leste',
        'Togo', 'Tokelau', 'Tonga', 'Trinidad and Tobago', 'Tunisia',
        'Turkey', 'Turkmenistan', 'Turks and Caicos Islands', 'Tuvalu',
        'Uganda', 'Ukraine', 'United Arab Emirates', 'United Kingdom',
        'United States', 'United States Minor Outlying Islands',
        'United States Virgin Islands', 'Uruguay', 'Uzbekistan', 'Vanuatu',
        'Venezuela', 'Vietnam', 'Wallis and Futuna Islands',
        'Western Sahara', 'Yemen', 'Zambia', 'Zimbabwe', 'Åland Islands'],
       dtype=object),
 array(['ABW', 'AFG', 'AGO', 'AIA', 'ALA', 'ALB', 'AND', 'ARE', 'ARG',
        'ARM', 'ASM', 'ATA', 'ATF', 'ATG', 'AUS', 'AUT', 'AZE', 'BDI',
        'BEL', 'BEN', 'BES', 'BFA', 'BGD', 'BGR', 'BHR', 'BHS', 'BIH',
        'BLM', 'BLR', 'BLZ', 'BMU', 'BOL', 'BRA', 'BRB', 'BRN', 'BTN',
        'BVT', 'BWA', 'CAF', 'CAN', 'CCK', 'CHE', 'CHL', 'CHN', 'CIV',
        'CMR', 'COD', 'COG', 'COK', 'COL', 'COM', 'CPV', 'CRI', 'CUB',
        'CUW', 'CXR', 'CYM', 'CYP', 'CZE', 'DEU', 'DJI', 'DMA', 'DNK',
        'DOM', 'DZA', 'ECU', 'EGY', 'ERI', 'ESH', 'ESP', 'EST', 'ETH',
        'FIN', 'FJI', 'FLK', 'FRA', 'FRO', 'FSM', 'GAB', 'GBR', 'GEO',
        'GGY', 'GHA', 'GIB', 'GIN', 'GLP', 'GMB', 'GNB', 'GNQ', 'GRC',
        'GRD', 'GRL', 'GTM', 'GUF', 'GUM', 'GUY', 'HKG', 'HMD', 'HND',
        'HRV', 'HTI', 'HUN', 'IDN', 'IMN', 'IND', 'IOT', 'IRL', 'IRN',
        'IRQ', 'ISL', 'ISR', 'ITA', 'JAM', 'JEY', 'JOR', 'JPN', 'KAZ',
        'KEN', 'KGZ', 'KHM', 'KIR', 'KNA', 'KOR', 'KWT', 'LAO', 'LBN',
        'LBR', 'LBY', 'LCA', 'LIE', 'LKA', 'LSO', 'LTU', 'LUX', 'LVA',
        'MAC', 'MAF', 'MAR', 'MCO', 'MDA', 'MDG', 'MDV', 'MEX', 'MHL',
        'MKD', 'MLI', 'MLT', 'MMR', 'MNE', 'MNG', 'MNP', 'MOZ', 'MRT',
        'MSR', 'MTQ', 'MUS', 'MWI', 'MYS', 'MYT', 'NA', 'NAM', 'NCL',
        'NER', 'NFK', 'NGA', 'NIC', 'NIU', 'NLD', 'NOR', 'NPL', 'NRU',
        'NZL', 'OMN', 'PAK', 'PAN', 'PCN', 'PER', 'PHL', 'PLW', 'PNG',
        'POL', 'PRI', 'PRK', 'PRT', 'PRY', 'PSE', 'PYF', 'QAT', 'REU',
        'ROU', 'RUS', 'RWA', 'SAU', 'SDN', 'SEN', 'SGP', 'SGS', 'SHN',
        'SJM', 'SLB', 'SLE', 'SLV', 'SMR', 'SOM', 'SPM', 'SRB', 'SSD',
        'STP', 'SUR', 'SVK', 'SVN', 'SWE', 'SWZ', 'SXM', 'SYC', 'SYR',
        'TCA', 'TCD', 'TGO', 'THA', 'TJK', 'TKL', 'TKM', 'TLS', 'TON',
        'TTO', 'TUN', 'TUR', 'TUV', 'TWN', 'TZA', 'UGA', 'UKR', 'UMI',
        'URY', 'USA', 'UZB', 'VAT', 'VCT', 'VEN', 'VGB', 'VIR', 'VNM',
        'VUT', 'WLF', 'WSM', 'YEM', 'ZAF', 'ZMB', 'ZWE'], dtype=object),
 array(['Antarctica', 'Australia and New Zealand', 'Caribbean',
        'Central America', 'Central Asia', 'Eastern Africa',
        'Eastern Asia', 'Eastern Europe', 'Melanesia', 'Micronesia',
        'Middle Africa', 'Northern Africa', 'Northern America',
        'Northern Europe', 'Polynesia', 'South America',
        'South-eastern Asia', 'Southern Africa', 'Southern Asia',
        'Southern Europe', 'Western Africa', 'Western Asia',
        'Western Europe'], dtype=object),
 array(['Channel Islands', 'Latin America and the Caribbean', 'NA', 'None',
        'Province of China', 'Special Administrative Region of China',
        'Sub-Saharan Africa'], dtype=object),
 array(['Africa', 'Antarctica', 'Asia', 'Europe', 'North America',
        'Oceania', 'South America'], dtype=object),
 array(['1/01/2019', '1/01/2021', '1/01/2022', '1/02/2022', '1/03/2022',
        '1/04/2020', '1/04/2021', '1/04/2022', '1/07/2018', '1/07/2019',
        '1/07/2020', '1/07/2021', '1/10/2021', '1/11/2021', '1/12/2021',
        '11/11/2021', '15/12/2017', '17/03/2020', '18/05/2022',
        '22/03/2021', '23/05/2022', '27/06/2021', '28/02/2022',
        '3/03/2019', '30/03/2022', '30/05/2021', '30/05/2022',
        '30/06/2020', '30/06/2021', '30/09/2020', '30/09/2021',
        '31/03/2021', '31/03/2022', '31/07/2019', '31/08/2019',
        '31/08/2021', '31/12/2019', '31/12/2020', '31/12/2021',
        '7/09/2021', 'NA'], dtype=object)]
```

```
# Обратное преобразование
oe.inverse_transform(cat_enc_oe)
```

```
array([['Afghanistan', 'AFG', 'Southern Asia', 'None', 'Asia',
        '1/07/2020'],
       ['Åland Islands', 'ALA', 'Northern Europe', 'None', 'Europe',
        '31/12/2021'],
       ['Albania', 'ALB', 'Southern Europe', 'None', 'Europe',
        '1/01/2021'],
       ...,
       ['Zambia', 'ZMB', 'Eastern Africa', 'Sub-Saharan Africa',
        'Africa', '1/07/2021'],
       ['Zimbabwe', 'ZWE', 'Eastern Africa', 'Sub-Saharan Africa',
        'Africa', '1/07/2021'],
       ['Taiwan', 'TWN', 'Eastern Asia', 'Province of China', 'Asia',
        '31/12/2021']], dtype=object)
```

Кодирование шкал порядка

Библиотека scikit-learn не предоставляет готового решения для кодирования шкал порядка, но можно воспользоваться функцией map для отдельных объектов Series.

```
# пример шкалы порядка 'small' < 'medium' < 'large'
sizes = ['small', 'medium', 'large', 'small', 'medium', 'large', 'small', 'medium', 'large']
```

```
pd_sizes = pd.DataFrame(data={'sizes':sizes})
pd_sizes
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	sizes
0	small
1	medium
2	large
3	small
4	medium
5	large
6	small
7	medium
8	large

```
pd_sizes['sizes_codes'] = pd_sizes['sizes'].map({'small':1, 'medium':2, 'large':3})
pd_sizes
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	sizes	sizes_codes

	sizes	sizes_codes
0	small	1
1	medium	2
2	large	3
3	small	1
4	medium	2
5	large	3
6	small	1
7	medium	2
8	large	3

```
pd_sizes['sizes_decoded'] = pd_sizes['sizes_codes'].map({1:'small', 2:'medium', 3:'large'})
pd_sizes
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	sizes	sizes_codes	sizes_decoded
0	small	1	small
1	medium	2	medium
2	large	3	large
3	small	1	small
4	medium	2	medium
5	large	3	large
6	small	1	small
7	medium	2	medium
8	large	3	large

Кодирование категорий наборами бинарных значений - one-hot encoding

В этом случае каждое уникальное значение признака становится новым отдельным признаком.

```
from sklearn.preprocessing import OneHotEncoder
```

```
ohe = OneHotEncoder()
cat_enc_ohe = ohe.fit_transform(cat_enc[['c1']])
```

```
cat_enc.shape
```

```
(250, 1)
```

```
cat_enc_ohe.shape
```

```
(250, 6)
```

```
cat_enc_ohe
```

```
<250x6 sparse matrix of type '<class 'numpy.float64'>'
    with 250 stored elements in Compressed Sparse Row format>
```

```
cat_enc_ohe.todense()[0:10]
```

```
matrix([[0., 0., 1., 0., 0., 0.],
        [0., 0., 1., 0., 0., 0.],
        [0., 0., 1., 0., 0., 0.],
        [0., 0., 1., 0., 0., 0.],
        [0., 0., 1., 0., 0., 0.],
        [0., 0., 1., 0., 0., 0.],
        [0., 0., 0., 0., 0., 1.],
        [0., 1., 0., 0., 0., 0.],
        [0., 0., 1., 0., 0., 0.],
        [0., 1., 0., 0., 0., 0.]])
```

```
cat_enc.head(10)
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	c1
0	None
1	None
2	None
3	None
4	None
5	None
6	Sub-Saharan Africa
7	Latin America and the Caribbean
8	None
9	Latin America and the Caribbean

Pandas get_dummies - быстрый вариант one-hot кодирования

```
pd.get_dummies(cat_enc).head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}
```

```
.dataframe thead th {
    text-align: right;
}
```

	c1_Channel Islands	c1_Latin America and the Caribbean	c1_None	c1_Province of China	c1_Special Administrative Region of China	c1_Sub-Saharan Africa
0	0	0	1	0	0	0
1	0	0	1	0	0	0
2	0	0	1	0	0	0
3	0	0	1	0	0	0
4	0	0	1	0	0	0

```
pd.get_dummies(cat_temp_data, dummy_na=True).head()
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	region_2_Channel Islands	region_2_Latin America and the Caribbean	region_2_None	region_2_Province of China	region_2_Special Administrative Region of China	region_2_Sub-Saharan Africa	region_2_nan
0	0	0	1	0	0	0	0
1	0	0	1	0	0	0	0
2	0	0	1	0	0	0	0
3	0	0	1	0	0	0	0
4	0	0	1	0	0	0	0

Масштабирование данных

Термины "масштабирование" и "нормализация" часто используются как синонимы, но это неверно. Масштабирование предполагает изменение диапазона измерения величины, а нормализация - изменение распределения этой величины. В этом разделе рассматривается только масштабирование.

Если признаки лежат в различных диапазонах, то необходимо их нормализовать. Как правило, применяют два подхода:

- MinMax масштабирование: $$ x_{новый} = \frac{x_{старый} - min(X)}{max(X)-min(X)} $$

В этом случае значения лежат в диапазоне от 0 до 1.

- Масштабирование данных на основе Z-оценки: $$ x_{новый} = \frac{x_{старый} - AVG(X) }{\sigma(X)} $$

В этом случае большинство значений попадает в диапазон от -3 до 3.

где X - матрица объект-признак, $AVG(X)$ - среднее значение, σ - среднеквадратичное отклонение.

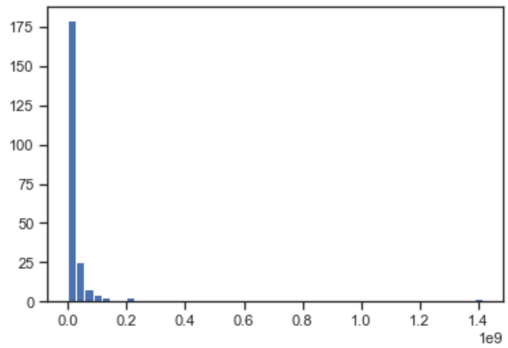
```
from sklearn.preprocessing import MinMaxScaler, StandardScaler, Normalizer
```

MinMax масштабирование

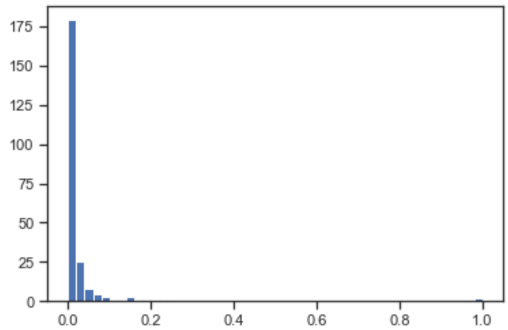
```
sc1 = MinMaxScaler()
sc1_data = sc1.fit_transform(data[['population']])
```

```
plt.hist(data['population'], 50)
plt.show()
```

```
D:\anaconda\lib\site-packages\numpy\lib\histograms.py:839: RuntimeWarning: invalid value encountered in greater_equal
  keep = (tmp_a >= first_edge)
D:\anaconda\lib\site-packages\numpy\lib\histograms.py:840: RuntimeWarning: invalid value encountered in less_equal
  keep &= (tmp_a <= last_edge)
```




```
plt.hist(sc1_data, 50)
plt.show()
```



Масштабирование данных на основе Z-оценки - StandardScaler

```
sc2 = StandardScaler()
sc2_data = sc2.fit_transform(data[['population']])
```

```
plt.hist(sc2_data, 50)
plt.show()
```

```
D:\anaconda\lib\site-packages\numpy\lib\histograms.py:839: RuntimeWarning: invalid value encountered in greater_equal
  keep = (tmp_a >= first_edge)
D:\anaconda\lib\site-packages\numpy\lib\histograms.py:840: RuntimeWarning: invalid value encountered in less_equal
  keep &= (tmp_a <= last_edge)
```