

```
!pip install pandas_datareader
```

```
!pip install -U kaleido
```

Легенда

Вы - успешный специалист в области datascience и вас наняла риэлторская компания, размещающая объявления о продаже/аренде домов на популярном сайте для объявлений vatio.org. Вам требуется обучить модель, которая сможет предсказать популярность объявления - исходя из этих предсказаний аналитики риэлторской компании будут редактировать описания объявлений, выставляемых на этой платформе.

```
import pandas as pd
import numpy as np
import datetime as dt
import pandas_datareader.data as web
from sklearn.model_selection import train_test_split
```

```
houses_ads_df = pd.read_csv('houses_ads_popularity.csv')
houses_ads_df.head(5)
```

	Id	bathrooms	bedrooms	building_id \
0	57094	1.0	3	0
1	33389	1.0	1	9225efdfb57a50bf3ec17ebab082f94a
2	60458	1.0	0	320de7d3cc88e50a7fbbcfdele825d21
3	53048	1.0	2	ce6d18bf3238e668b2bf23f4110b7b67
4	592	1.0	3	fee4d465932160318364d9d48d272879

	created	description \
0	2016-05-19 18:06:27	A FABULOUS 3BR IN MIDTOWN WEST! PERFECT APAR...
1	2016-06-16 02:01:49	Renovated Kitchen and Bathroom!
2	2016-05-04 02:42:50	RARE AND BEST DEAL ON THE MARKET!!!! PERFECT S...
3	2016-05-12 05:57:56	Newly renovated flex 2 apartment offers the ne...
4	2016-06-16 06:06:15	LOW FEE apartments do not come around like thi...

	display_address \
0	HOW AMAZING IS THIS MIDTOWN WEST STEAL!! NO FE...
1	55 River Drive South
2	W 77 Street
3	John Street
4	West 16th Street

listing_id \	features	latitude
0 7039994	['Laundry In Unit', 'No Fee', 'Elevator']	40.7647
1 7166774	['Dogs Allowed', 'Cats Allowed', 'No Fee']	40.7275
2 6962716	['Elevator', 'Hardwood Floors']	40.7798
3 7002458	['Swimming Pool', 'Doorman', 'Elevator', 'Fitn...']	40.7081
4 7170465	['Laundry in Building', 'Laundry in Unit', 'Di...']	40.7416

	longitude	manager_id \
0	-73.9918	4bdc3d8c1aaa90d997ce2cb77680679b
1	-74.0322	e5808a5e6cc13988fe596704428d38d5
2	-73.9751	d69d4e111612dd12ef864031c1148543
3	-74.0065	e6472c7237327dd3903b3d6f6a94515a
4	-74.0025	6fba9b3a8327c607b8b043716efee684

	photos	price \
0	['https://photos.renthop.com/2/7039994_07be01b...']	4495
1	['https://photos.renthop.com/2/7166774_03cf63a...']	2570
2	['https://photos.renthop.com/2/6962716_ec7f56f...']	1795
3	['https://photos.renthop.com/2/7002458_93f4010...']	3400
4	['https://photos.renthop.com/2/7170465_9c3f173...']	5695

	street_address	TARGET
0	W 50 & AVE 10	medium
1	55 River Drive South	medium
2	22 W 77 Street	low
3	100 John Street	low
4	321 West 16th Street	low

#1 часть Feature engineering - необходимо заполнить пропуски в данных, обработать категориальные признаки и т.д.

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

Выполним обработку признаков, которая никак не приведет к утечке данных: заменим текстовые данные на информацию об их наличии, заменим массивы в ячейках на их длину, удалим признаки, которые не несут важной информации

Проверка столбцов на наличие в них пропусков

```
houses_ads_df.isna().any()
```

```
Id                False
bathrooms         False
bedrooms          False
building_id       False
created           False
description        True
display_address   True
features          False
latitude          False
listing_id        False
longitude         False
manager_id        False
photos            False
price             False
street_address    True
TARGET            False
dtype: bool
```

Пропуски в данных есть в столбцах description, display_address, street_address

Заменяем данные в столбцах description, display_address, street_address на 0, если в ячейке пропуск, на 1, если ячейка не пустая

```
houses_ads_df.loc[houses_ads_df["description"].isna(),
["is_there_description"]] = 0
houses_ads_df.loc[houses_ads_df["description"].isna()==False,
["is_there_description"]] = 1
houses_ads_df.loc[houses_ads_df["display_address"].isna(),
["is_there_display_address"]] = 0
houses_ads_df.loc[houses_ads_df["display_address"].isna()==False,
["is_there_display_address"]] = 1
houses_ads_df.loc[houses_ads_df["street_address"].isna(),
["is_there_street_address"]] = 0
houses_ads_df.loc[houses_ads_df["street_address"].isna()==False,
["is_there_street_address"]] = 1
houses_ads_df = houses_ads_df.drop(columns=["description",
"display_address", "street_address"])
```

Теперь пропусков в данных нет

Заменяем массивы в столбцах features и photos на их длину (количество признаков/фотографий)

```
houses_ads_df["number_of_features"] =
houses_ads_df['features'].apply(eval).apply(len)
houses_ads_df["number_of_photos"] =
houses_ads_df['photos'].apply(eval).apply(len)
houses_ads_df = houses_ads_df.drop(columns=["features", "photos"])
```

Удалим столбцы Id и listing_id, тк они не несут в себе дополнительной информации, а просто содержат уникальные числа для каждой строки

```
houses_ads_df = houses_ads_df.drop(columns=["Id", "listing_id"])
```

Закодируем категориальные признаки manager_id, building_id. Все правила кодировки выводятся по обучающей выборке, а затем применяются на тестовую, чтобы не допустить утечки данных из тестовой выборки

Разделим выборку на тестовую и обучающую

```
data_train, data_test = train_test_split(houses_ads_df, test_size=0.2, random_state=0)
```

```
X_train = data_train.drop(["TARGET"], axis=1)
```

```
X_test = data_test.drop(["TARGET"], axis=1)
```

```
y_train = data_train["TARGET"]
```

```
y_test = data_test["TARGET"]
```

Кодировем категориальные признаки по обучающей выборке

```
enc = OneHotEncoder(sparse=False, handle_unknown='ignore')
```

```
columns_to_one_hot = ["manager_id", "building_id"]
```

```
enc.fit(X_train.loc[:, columns_to_one_hot])
```

```
encoded_array = enc.transform(houses_ads_df.loc[:, columns_to_one_hot])
```

```
df_encoded = pd.DataFrame(encoded_array,
```

```
columns=enc.get_feature_names_out())
```

```
df_sklearn_encoded = pd.concat([houses_ads_df, df_encoded], axis=1)
```

```
df_sklearn_encoded.drop(labels=columns_to_one_hot, axis=1, inplace=True)
```

Закодируем TARGET: low - 1, medium - 2, high - 3

```
df_sklearn_encoded.loc[df_sklearn_encoded["TARGET"]=="low",  
["TARGET"]] = 1
```

```
df_sklearn_encoded.loc[df_sklearn_encoded["TARGET"]=="medium",  
["TARGET"]] = 2
```

```
df_sklearn_encoded.loc[df_sklearn_encoded["TARGET"]=="high",  
["TARGET"]] = 3
```

Переведем created в количество дней от создания до текущей даты, выведем месяц, день и час в отдельные признаки. Год везде одинаковый, # так что не будем его учитывать

```
df_sklearn_encoded["created"] =
```

```
df_sklearn_encoded["created"].apply(pd.to_datetime)
```

```
df_sklearn_encoded["month"] = df_sklearn_encoded["created"].dt.month
```

```
df_sklearn_encoded["day_in_month"] =
```

```

df_sklearn_encoded["created"].dt.day
df_sklearn_encoded["hour"] = df_sklearn_encoded["created"].dt.hour
now = dt.datetime.now()
df_sklearn_encoded["how_long_ago_created"] =
df_sklearn_encoded["created"].apply(lambda x: (now-x).days)
df_sklearn_encoded = df_sklearn_encoded.drop(columns=["created"])

```

Можно было бы закодировать координаты, через страну, но для такой большой выборке это занимает очень много времени
Нормализуем данные:

Нормализуем данные в столбцах, где значения могут быть отличны от 0 и 1, через MinMaxScaler

```

train_index = X_train.index
test_index = X_test.index

scaler = preprocessing.MinMaxScaler()

names = ['bathrooms', 'bedrooms', 'how_long_ago_created', 'hour',
'month', 'day_in_month', 'latitude', 'longitude', 'price',
'number_of_features', 'number_of_photos']
scaler.fit(df_sklearn_encoded.loc[train_index, names])
tmp = scaler.transform(df_sklearn_encoded.loc[:, names])

df_sklearn_encoded =
pd.concat([df_sklearn_encoded.drop(columns=names), pd.DataFrame(tmp,
columns=names)], axis=1)

```

Обновим тестовую и обучающую выборки

```

train_index = X_train.index
test_index = X_test.index

X_train_enc = df_sklearn_encoded.iloc[train_index, :].drop(["TARGET"],
axis=1)
X_test_enc = df_sklearn_encoded.iloc[test_index, :].drop(["TARGET"],
axis=1)
y_train_enc = df_sklearn_encoded.loc[train_index, ["TARGET"]]
y_test_enc = df_sklearn_encoded.loc[test_index, ["TARGET"]]

X_train_enc.sample(5)

```

	is_there_description	is_there_display_address	\
22940	1.0	1.0	
34034	1.0	1.0	
27303	1.0	1.0	
10950	1.0	1.0	
18439	1.0	1.0	

	is_there_street_address		
manager_id_0000abd7518b94c35a90d64b56fbf3e6	\		
22940	1.0		
0.0			
34034	1.0		
0.0			
27303	1.0		
0.0			
10950	1.0		
0.0			
18439	1.0		
0.0			
manager_id_001ce808ce1720e24a9510e014c69707	\		
22940	0.0		
34034	0.0		
27303	0.0		
10950	0.0		
18439	0.0		
manager_id_003fc4e9a70053082f131b1054966aaf	\		
22940	0.0		
34034	0.0		
27303	0.0		
10950	0.0		
18439	0.0		
manager_id_00607a02f6efd9c6c7c588826e471ee9	\		
22940	0.0		
34034	0.0		
27303	0.0		
10950	0.0		
18439	0.0		
manager_id_00995ff28d79127ed2dca8320e9e7d09	\		
22940	0.0		
34034	0.0		
27303	0.0		
10950	0.0		
18439	0.0		
manager_id_00a8d77892cab18fffaa22a751f1f8eb	\		
22940	0.0		
34034	0.0		
27303	0.0		
10950	0.0		
18439	0.0		
manager_id_00f0b3346ba8379b26b95be8a19d46b1	... bedrooms \		
22940	0.0	...	0.333333

34034	0.0	...	0.333333
27303	0.0	...	0.333333
10950	0.0	...	0.000000
18439	0.0	...	0.000000

	how_long_ago_created	hour	month	day_in_month	
latitude \					
22940	0.382022	0.130435	0.5	0.866667	0.914216
34034	0.786517	0.260870	0.0	0.666667	0.913458
27303	0.078652	0.130435	1.0	0.733333	0.913743
10950	0.988764	0.086957	0.0	0.066667	0.913153
18439	0.483146	0.043478	0.5	0.566667	0.913427

	longitude	price	number_of_features	number_of_photos
22940	0.020863	0.000781	0.111111	0.304348
34034	0.020343	0.001549	0.222222	0.195652
27303	0.020634	0.000736	0.194444	0.152174
10950	0.020324	0.000630	0.083333	0.108696
18439	0.020176	0.000480	0.083333	0.021739

[5 rows x 8616 columns]

Обработка признаков завершена

Вывод: удалены все признаки, из которых трудно вывести полезную информацию; все категориальные признаки закодированы так, чтобы их можно было использовать; все числовые признаки нормализованы

2 часть

EDA - необходимо исследовать данные в предлагаемом Вам датасете. К исследованию данных относится анализ распределения значений в признаках, проверка скоррелированности признаков и т.д.

```
import scipy.stats as st
from scipy.stats.stats import pearsonr
import plotly.express as px
import matplotlib.pyplot as plt
import plotly.graph_objects as go
import seaborn as sns
```

Проверка корреляции между некотегориальными признаками

```

names = ['bathrooms', 'bedrooms', 'how_long_ago_created', 'hour',
'month', 'day_in_month', 'latitude', 'longitude', 'price',
'number_of_features', 'number_of_photos']
no_correlation = []
correlation = []

for i in range(len(names)):
    for j in range(i+1, len(names)):
        print(f'Correlation test for {names[i]} and {names[j]}')
        corr, p = pearsonr(X_train_enc[names[i]], X_train_enc[names[j]])
        print("p-value for significance is: ", p)
        print("correlation is: ", corr)

        if p > 0.05:
            no_correlation.append([names[i], names[j]])
            print("No correlation\n")
        else:
            correlation.append([names[i], names[j]])
            print("Correlation\n")

print("Pairs of features without correlation: ", no_correlation)
print("Pairs of features with correlation: ", correlation)

```

Correlation test for bathrooms and bedrooms
p-value for significance is: 0.0
correlation is: 0.5341828360113188
Correlation

Correlation test for bathrooms and how_long_ago_created
p-value for significance is: 0.6381469877061254
correlation is: -0.0028290982536954994
No correlation

Correlation test for bathrooms and hour
p-value for significance is: 0.036520696559973004
correlation is: -0.012578706280078483
Correlation

Correlation test for bathrooms and month
p-value for significance is: 0.988181591608654
correlation is: -8.910803434796638e-05
No correlation

Correlation test for bathrooms and day_in_month
p-value for significance is: 0.08456351663903783
correlation is: 0.010375501903195996
No correlation

Correlation test for bathrooms and latitude
p-value for significance is: 6.325457450132603e-06

correlation is: -0.027156871713079067
Correlation

Correlation test for bathrooms and longitude
p-value for significance is: 3.450409626189413e-06
correlation is: 0.02791921453651551
Correlation

Correlation test for bathrooms and price
p-value for significance is: 6.790677919984652e-16
correlation is: 0.04854301877707854
Correlation

Correlation test for bathrooms and number_of_features
p-value for significance is: 0.0
correlation is: 0.2368668068365552
Correlation

Correlation test for bathrooms and number_of_photos
p-value for significance is: 5.556413150409792e-130
correlation is: 0.14514905421904947
Correlation

Correlation test for bedrooms and how_long_ago_created
p-value for significance is: 0.011006719451371196
correlation is: -0.015293790079875288
Correlation

Correlation test for bedrooms and hour
p-value for significance is: 1.726633614778396e-12
correlation is: 0.042420954382560785
Correlation

Correlation test for bedrooms and month
p-value for significance is: 0.025613595805941625
correlation is: 0.013426434376936957
Correlation

Correlation test for bedrooms and day_in_month
p-value for significance is: 0.28965557925750396
correlation is: 0.006369764278831952
No correlation

Correlation test for bedrooms and latitude
p-value for significance is: 0.0885165375011986
correlation is: -0.010246027893182076
No correlation

Correlation test for bedrooms and longitude

p-value for significance is: 0.04892244763414459
correlation is: 0.01184599108450814
Correlation

Correlation test for bedrooms and price
p-value for significance is: 1.0429453094152757e-10
correlation is: 0.038849940326606804
Correlation

Correlation test for bedrooms and number_of_features
p-value for significance is: 4.169044681736479e-108
correlation is: 0.132286175452079
Correlation

Correlation test for bedrooms and number_of_photos
p-value for significance is: 2.3487960779541143e-140
correlation is: 0.15085241525104037
Correlation

Correlation test for how_long_ago_created and hour
p-value for significance is: 1.32953369343189e-66
correlation is: -0.1034316566811645
Correlation

Correlation test for how_long_ago_created and month
p-value for significance is: 0.0
correlation is: -0.9474422781038772
Correlation

Correlation test for how_long_ago_created and day_in_month
p-value for significance is: 0.0
correlation is: -0.24412052800525352
Correlation

Correlation test for how_long_ago_created and latitude
p-value for significance is: 0.5362546964773863
correlation is: -0.0037205810634593313
No correlation

Correlation test for how_long_ago_created and longitude
p-value for significance is: 0.7799490609769351
correlation is: 0.0016806817327813697
No correlation

Correlation test for how_long_ago_created and price
p-value for significance is: 0.06444315886253421
correlation is: -0.011123190304671862
No correlation

Correlation test for how_long_ago_created and number_of_features
p-value for significance is: 0.10776971599735338
correlation is: 0.009674725983914698
No correlation

Correlation test for how_long_ago_created and number_of_photos
p-value for significance is: 0.10245488541325286
correlation is: -0.0098237115767794
No correlation

Correlation test for hour and month
p-value for significance is: 4.384168850520202e-56
correlation is: 0.09470361129745411
Correlation

Correlation test for hour and day_in_month
p-value for significance is: 0.7306029568265922
correlation is: -0.0020713254683326823
No correlation

Correlation test for hour and latitude
p-value for significance is: 4.528570210733573e-07
correlation is: -0.030343616725096695
Correlation

Correlation test for hour and longitude
p-value for significance is: 8.842829401051728e-05
correlation is: 0.02358001870405081
Correlation

Correlation test for hour and price
p-value for significance is: 0.6179529263590658
correlation is: -0.0030003172829221013
No correlation

Correlation test for hour and number_of_features
p-value for significance is: 0.020193923909995748
correlation is: -0.013972003057046666
Correlation

Correlation test for hour and number_of_photos
p-value for significance is: 8.174110912248722e-30
correlation is: 0.0681470331969914
Correlation

Correlation test for month and day_in_month
p-value for significance is: 4.8303980760566364e-39
correlation is: -0.07850836381988488
Correlation

Correlation test for month and latitude
p-value for significance is: 0.43380296035640614
correlation is: 0.004708421152649472
No correlation

Correlation test for month and longitude
p-value for significance is: 0.6097801244409562
correlation is: -0.0030703007747858303
No correlation

Correlation test for month and price
p-value for significance is: 0.14731049075303934
correlation is: 0.008717084672876244
No correlation

Correlation test for month and number_of_features
p-value for significance is: 0.2629010031274719
correlation is: -0.006734801182735468
No correlation

Correlation test for month and number_of_photos
p-value for significance is: 0.074776796783938
correlation is: 0.01071855118636267
No correlation

Correlation test for day_in_month and latitude
p-value for significance is: 0.8298685250922566
correlation is: -0.0012925818208786319
No correlation

Correlation test for day_in_month and longitude
p-value for significance is: 0.6132303343838945
correlation is: 0.0030407065682610886
No correlation

Correlation test for day_in_month and price
p-value for significance is: 0.15428315681158553
correlation is: 0.008569513474112202
No correlation

Correlation test for day_in_month and number_of_features
p-value for significance is: 0.23963177072635947
correlation is: -0.007073752251229184
No correlation

Correlation test for day_in_month and number_of_photos
p-value for significance is: 0.4698978271146666
correlation is: -0.004347155600123393

No correlation

Correlation test for latitude and longitude
p-value for significance is: 0.0
correlation is: -0.9923768384056837
Correlation

Correlation test for latitude and price
p-value for significance is: 0.8085134683804117
correlation is: -0.0014578554008608468
No correlation

Correlation test for latitude and number_of_features
p-value for significance is: 0.7586101403980992
correlation is: -0.0018486441954251916
No correlation

Correlation test for latitude and number_of_photos
p-value for significance is: 0.40502467571461626
correlation is: -0.005009080040461404
No correlation

Correlation test for longitude and price
p-value for significance is: 0.9011555834650767
correlation is: 0.000747152923324335
No correlation

Correlation test for longitude and number_of_features
p-value for significance is: 0.3333725731290565
correlation is: -0.00581914110385766
No correlation

Correlation test for longitude and number_of_photos
p-value for significance is: 0.7213914236678294
correlation is: 0.002145174637983932
No correlation

Correlation test for price and number_of_features
p-value for significance is: 0.003864527663574653
correlation is: 0.017377960116563288
Correlation

Correlation test for price and number_of_photos
p-value for significance is: 0.6734536283928726
correlation is: -0.0025350652473338526
No correlation

Correlation test for number_of_features and number_of_photos
p-value for significance is: 5.10257246950655e-158

correlation is: 0.1600768249369157
Correlation

Pairs of features without correlation: [['bathrooms', 'how_long_ago_created'], ['bathrooms', 'month'], ['bathrooms', 'day_in_month'], ['bedrooms', 'day_in_month'], ['bedrooms', 'latitude'], ['how_long_ago_created', 'latitude'], ['how_long_ago_created', 'longitude'], ['how_long_ago_created', 'price'], ['how_long_ago_created', 'number_of_features'], ['how_long_ago_created', 'number_of_photos'], ['hour', 'day_in_month'], ['hour', 'price'], ['month', 'latitude'], ['month', 'longitude'], ['month', 'price'], ['month', 'number_of_features'], ['month', 'number_of_photos'], ['day_in_month', 'latitude'], ['day_in_month', 'longitude'], ['day_in_month', 'price'], ['day_in_month', 'number_of_features'], ['day_in_month', 'number_of_photos'], ['latitude', 'price'], ['latitude', 'number_of_features'], ['latitude', 'number_of_photos'], ['longitude', 'price'], ['longitude', 'number_of_features'], ['longitude', 'number_of_photos'], ['price', 'number_of_photos']]

Pairs of features with correlation: [['bathrooms', 'bedrooms'], ['bathrooms', 'hour'], ['bathrooms', 'latitude'], ['bathrooms', 'longitude'], ['bathrooms', 'price'], ['bathrooms', 'number_of_features'], ['bathrooms', 'number_of_photos'], ['bedrooms', 'how_long_ago_created'], ['bedrooms', 'hour'], ['bedrooms', 'month'], ['bedrooms', 'longitude'], ['bedrooms', 'price'], ['bedrooms', 'number_of_features'], ['bedrooms', 'number_of_photos'], ['how_long_ago_created', 'hour'], ['how_long_ago_created', 'month'], ['how_long_ago_created', 'day_in_month'], ['hour', 'month'], ['hour', 'latitude'], ['hour', 'longitude'], ['hour', 'number_of_features'], ['hour', 'number_of_photos'], ['month', 'day_in_month'], ['latitude', 'longitude'], ['price', 'number_of_features'], ['number_of_features', 'number_of_photos']]

Построение диаграммы размаха зависимости количества спален от количества ванных

```
fig = go.Figure()
fig.add_trace(go.Box(y=X_train_enc['bathrooms'].tolist(), name="Number of bathrooms", boxpoints='all'))
fig.add_trace(go.Box(y=X_train_enc['bedrooms'].tolist(), name="Number of bedrooms", boxpoints='all'))
fig.show('png')
```

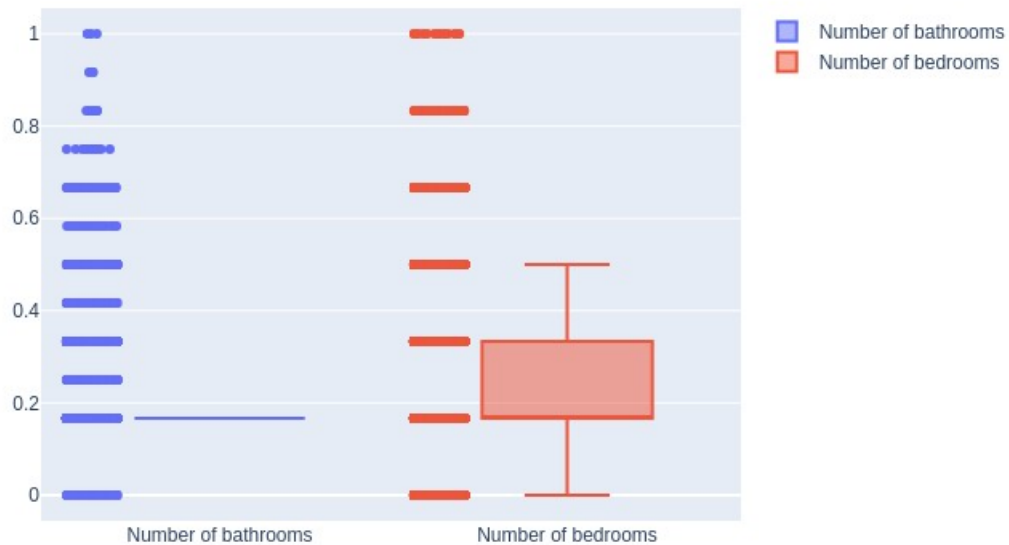
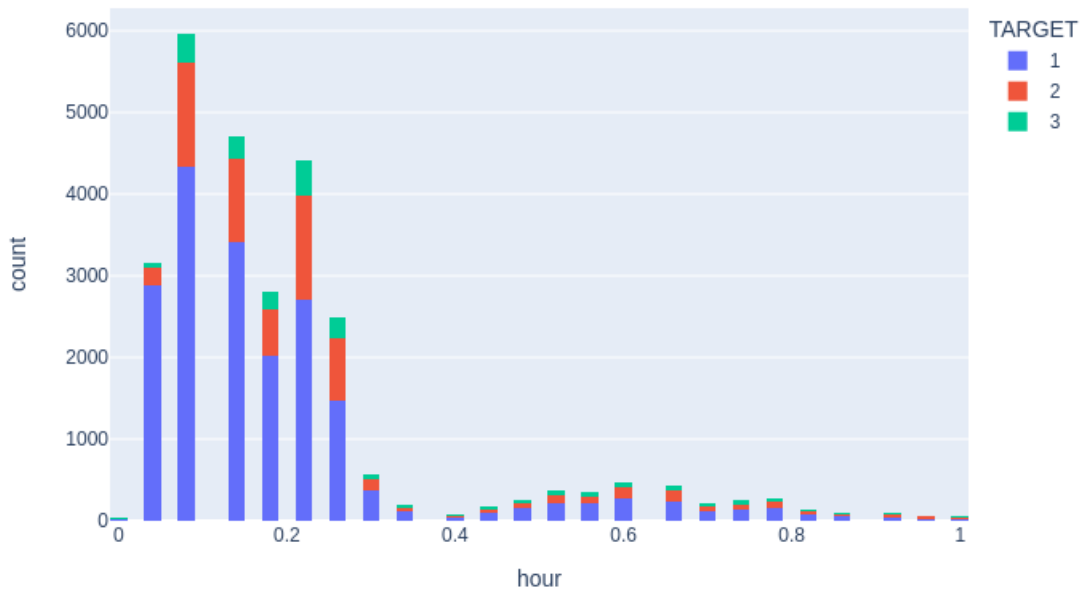


Диаграмма размаха показывает, что признаки схожи не так сильно

*# Построим гистограмму, отображающую зависимость популярности предложения от часа публикации (признаки нормированные, поэтому чем выше
цифра TARGET, тем популярнее предложение, часы распределены от 0 до 1)*

```
fig = px.histogram(pd.concat([X_train_enc["hour"], y_train_enc],
axis=1), x="hour", color="TARGET", title="Зависимость часа публикации
от популярности предложения")
fig.show('png')
```

Зависимость часа публикации от популярности предложения



Возможно наличие информации о месяце, дне и часе создания предложения избыточна, это показывает корреляция с признаком давности создания. Удалим их

Удаляем лишние признаки

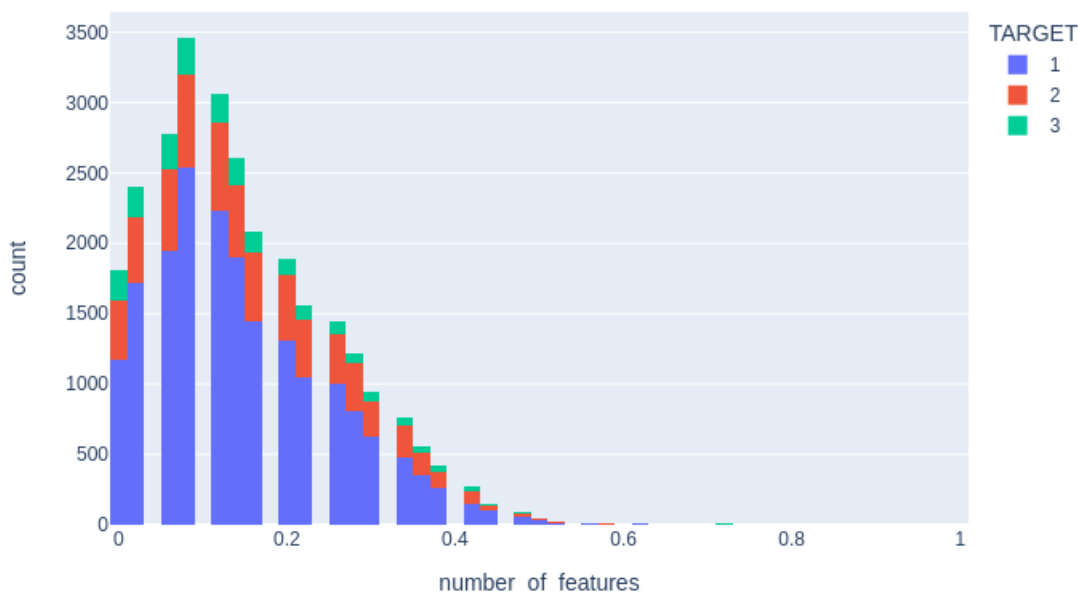
```
X_train_enc = X_train_enc.drop(columns=['hour', 'month',  
                                         'day_in_month'])  
X_test_enc = X_test_enc.drop(columns=['hour', 'month',  
                                       'day_in_month'])
```

Построим гистограмму, отображающую зависимость популярности предложения от количества фишек (признаки нормированные, поэтому чем выше

цифра TARGET, тем популярнее предложение, количество фишек распределено от 0 до 1)

```
fig = px.histogram(pd.concat([X_train_enc["number_of_features"],  
                              y_train_enc], axis=1), x="number_of_features", color="TARGET",  
                  title="Зависимость количества фишек от популярности просмотра")  
fig.show('png')
```


Зависимость количества фишек от популярности просмотра



```
X_train = X_train_enc  
X_test = X_test_enc  
#y_train = y_train_enc.astype('int')  
#y_test = y_test_enc.astype('int')
```

Вывод: среди признаков есть скоррелированные, но складывается ощущение, что по большей части среди них нет каузации. Некоторые признаки удалили, но оставим большую часть

3 часть

Выбор целевой метрики - необходимо выбрать метрику качества, которую вы будете оптимизировать. Для выбранной метрики необходимо написать пояснение. В этом задании нет единственного правильного ответа, однако за откровенно неадекватный выбор или слабую аргументацию будут снижаться баллы.

У нас стоит задача классификации, поэтому будем рассматривать метрики: *f1*, *accusacy* и *confusion matrix*. Наиболее наглядная и при этом учитывающая наибольшее количество параметров - *f1*

Вывод: попробуем оптимизировать метрику *f1*

4 часть

Проведение экспериментов - необходимо попробовать разные модели, изученные в рамках курса и оптимизировать ими выбранную вами целевую метрику. Решение, состоящее только из grid-search по гиперпараметрам Catboost, получает 0 баллов.

```
!pip install catboost
```

```
from sklearn.metrics import accuracy_score, f1_score, confusion_matrix
from catboost import CatBoostClassifier
from sklearn.metrics import classification_report
```

```
from sklearn.svm import LinearSVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.linear_model import LinearRegression, LogisticRegression
from sklearn.dummy import DummyClassifier
from sklearn.ensemble import BaggingClassifier,
RandomForestClassifier, StackingClassifier, GradientBoostingClassifier
from sklearn.ensemble import AdaBoostClassifier, ExtraTreesClassifier
```

```
catboosting = CatBoostClassifier(metric_period=50, random_state=42)
catboosting.fit(X_train, y_train)
y_pred = catboosting.predict(X_test)
```

```
print(classification_report(list(y_test.values), y_pred, digits=4))
```

Learning rate set to 0.093721

0:	learn: 1.0300384	total: 210ms	remaining: 3m 29s
50:	learn: 0.6388351	total: 6.74s	remaining: 2m 5s
100:	learn: 0.6160417	total: 13.6s	remaining: 2m 1s
150:	learn: 0.6012226	total: 19.4s	remaining: 1m 48s
200:	learn: 0.5917134	total: 26.1s	remaining: 1m 43s
250:	learn: 0.5852582	total: 29.8s	remaining: 1m 28s
300:	learn: 0.5803347	total: 32.6s	remaining: 1m 15s
350:	learn: 0.5762092	total: 35.4s	remaining: 1m 5s
400:	learn: 0.5726150	total: 38.3s	remaining: 57.2s
450:	learn: 0.5698205	total: 41.1s	remaining: 50s
500:	learn: 0.5668755	total: 43.9s	remaining: 43.7s
550:	learn: 0.5644459	total: 46.7s	remaining: 38s
600:	learn: 0.5614100	total: 49.5s	remaining: 32.9s
650:	learn: 0.5592704	total: 52.3s	remaining: 28.1s
700:	learn: 0.5569495	total: 55.2s	remaining: 23.5s
750:	learn: 0.5549180	total: 58s	remaining: 19.2s
800:	learn: 0.5530397	total: 1m	remaining: 15.1s
850:	learn: 0.5513240	total: 1m 3s	remaining: 11.2s
900:	learn: 0.5497617	total: 1m 9s	remaining: 7.59s
950:	learn: 0.5477667	total: 1m 14s	remaining: 3.83s
999:	learn: 0.5458989	total: 1m 19s	remaining: 0us

	precision	recall	f1-score	support
--	-----------	--------	----------	---------

high	0.6379	0.2094	0.3153	530
low	0.7776	0.9488	0.8547	4769
medium	0.5158	0.2936	0.3742	1611
accuracy			0.7394	6910
macro avg	0.6438	0.4840	0.5148	6910
weighted avg	0.7059	0.7394	0.7013	6910

Функция для вывода результатов классификации

```
def class_function(classifier, X_train, y_train, X_test, y_test):
    model = classifier
    model.fit(X_train, list(y_train.values))
    y_pred_train, y_pred_test = model.predict(X_train),
    model.predict(X_test)

    print(f"--Classifier: {classifier}--")
    print(f'f1_score: {f1_score(y_test, y_pred_test, average =
"weighted")}')
    print(f'accuracy_score: {accuracy_score(y_test, y_pred_test)}')
    print(f'confusion_matrix:\n{confusion_matrix(list(y_test.values),
y_pred_test)}\n')
```

Посмотрим на результаты стандартных классификаторов

Линейные опорные вектора

```
class_function(LinearSVC(), X_train, y_train, X_test, y_test)
```

Дерево

```
class_function(DecisionTreeClassifier(), X_train, y_train, X_test,
y_test)
```

```
--Classifier: LinearSVC()--
f1_score: 0.6776476587040606
accuracy_score: 0.702315484804631
confusion_matrix:
[[ 99 230 201]
 [ 55 4233 481]
 [ 111 979 521]]
```

```
--Classifier: DecisionTreeClassifier()--
f1_score: 0.6866555976963833
accuracy_score: 0.6931982633863966
confusion_matrix:
[[ 170 150 210]
 [ 105 3993 671]
 [ 153 831 627]]
```

Посмотрим на результаты ансамблевых классификаторов

Бэггинг по дереву

```
class_function(BaggingClassifier(DecisionTreeClassifier(random_state = 42), random_state = 42), X_train, y_train, X_test, y_test)
```

--Classifier:

```
BaggingClassifier(base_estimator=DecisionTreeClassifier(random_state=42), random_state=42) --
```

f1_score: 0.7009206152498779

accuracy_score: 0.7240231548480464

confusion_matrix:

```
[[ 159  171  200]
 [   50 4318  401]
 [  117  968 526]]
```

Бэггинг по лесу

```
class_function(BaggingClassifier(RandomForestClassifier(random_state = 42), random_state = 42), X_train, y_train, X_test, y_test)
```

--Classifier:

```
BaggingClassifier(base_estimator=RandomForestClassifier(random_state=42), random_state=42) --
```

f1_score: 0.6758674024181268

accuracy_score: 0.7260492040520984

confusion_matrix:

```
[[  95  277  158]
 [   7 4564  198]
 [  54 1199  358]]
```

Градиентный бустинг

```
class_function(GradientBoostingClassifier(random_state = 42), X_train, y_train, X_test, y_test)
```

--Classifier: GradientBoostingClassifier(random_state=42) --

f1_score: 0.6714214327595435

accuracy_score: 0.7264833574529667

confusion_matrix:

```
[[  95  272  163]
 [  13 4604  152]
 [  41 1249  321]]
```

Стэкинг по [tree, svc] и tree

```
class_function(StackingClassifier([("tree", DecisionTreeClassifier(random_state = 42)), ("svc", LinearSVC(random_state = 42))],
```

```

                                final_estimator =
DecisionTreeClassifier(random_state = 42)), X_train, y_train, X_test,
y_test)

# Стэкинг по [tree, svc] и svc
class_function(StackingClassifier([("tree",
DecisionTreeClassifier(random_state = 42)), ("svc",
LinearSVC(random_state = 42))],
                                final_estimator =
LinearSVC(random_state = 42)), X_train, y_train, X_test, y_test)

--Classifier: StackingClassifier(estimators=[('tree',
DecisionTreeClassifier(random_state=42)),
('svc', LinearSVC(random_state=42))],

final_estimator=DecisionTreeClassifier(random_state=42))--
f1_score: 0.6316685588849311
accuracy_score: 0.6327062228654124
confusion_matrix:
[[ 132  202  196]
 [ 216 3717  836]
 [ 202  886  523]]

--Classifier: StackingClassifier(estimators=[('tree',
DecisionTreeClassifier(random_state=42)),
('svc', LinearSVC(random_state=42))],
                                final_estimator=LinearSVC(random_state=42))--
f1_score: 0.6708508916438938
accuracy_score: 0.7206946454413893
confusion_matrix:
[[  39  238  253]
 [   5 4522  242]
 [  23 1169  419]]

# Адаптивный бустинг
class_function(AdaBoostClassifier(LogisticRegression(random_state =
42)), X_train, y_train, X_test, y_test)

--Classifier:
AdaBoostClassifier(base_estimator=LogisticRegression(random_state=42))
--
f1_score: 0.5636388689285963
accuracy_score: 0.6901591895803184
confusion_matrix:
[[   0  530   0]
 [   0 4769   0]

```

```
[ 0 1611 0]]
```

Лучший результат был на бэггинге по дереву, попробуем улучшить результат, подобрав гиперпараметры

```
def bagging(parameter_bagging: str, values_bagging: list, X_train,
X_test, y_train, y_test):
    for value in values_bagging:
        for max_depth in range(10, 21, 2):
            model =
BaggingClassifier(DecisionTreeClassifier(max_depth=max_depth),
**{parameter_bagging: value})
            model.fit(X_train, y_train)
            y_pred_train, y_pred_test = model.predict(X_train),
model.predict(X_test)
            print(f"--{parameter_bagging}: {value}; max_depth:
{max_depth}--")
            print(f'f1_score: {f1_score(y_test, y_pred_test, average =
"weighted")}\n')

#print("----n_estimators----")
#bagging('n_estimators', np.arange(2, 21, 2), X_train, X_test,
y_train, y_test)
```

Пришлось проверять гиперпараметры в другом ноутбуке, тк здесь слишком много нагрузки, результат такой:

--n_estimators: 12; max_depth: 14-- f1_score: 0.6987556841675473	--n_estimators: 12; max_depth: 16-- f1_score: 0.6967780244706351
--n_estimators: 12; max_depth: 18-- f1_score: 0.7026120022051031	--n_estimators: 12; max_depth: 20-- f1_score: 0.7036524394036862
--n_estimators: 14; max_depth: 10-- f1_score: 0.6843362857281587	--n_estimators: 14; max_depth: 12-- f1_score: 0.6961780083412348
--n_estimators: 14; max_depth: 14-- f1_score: 0.6956944234568435	--n_estimators: 14; max_depth: 16-- f1_score: 0.7015843386603091
--n_estimators: 18; max_depth: 10-- f1_score: 0.6853809610499172	--n_estimators: 14; max_depth: 18-- f1_score: 0.6973809959194539
--n_estimators: 18; max_depth: 12-- f1_score: 0.6893918901629047	--n_estimators: 14; max_depth: 20-- f1_score: 0.6999735166178899
--n_estimators: 18; max_depth: 14-- f1_score: 0.6970471516797716	--n_estimators: 16; max_depth: 10-- f1_score: 0.6847206391739867
--n_estimators: 18; max_depth: 16-- f1_score: 0.7027151579568715	--n_estimators: 16; max_depth: 12-- f1_score: 0.6891168410370199
--n_estimators: 18; max_depth: 18-- f1_score: 0.6943758009865177	--n_estimators: 16; max_depth: 14-- f1_score: 0.6999424627241819
--n_estimators: 18; max_depth: 20-- f1_score: 0.7018360500471578	--n_estimators: 16; max_depth: 16-- f1_score: 0.6977095481074984
--n_estimators: 20; max_depth: 10-- f1_score: 0.6878193698032778	--n_estimators: 16; max_depth: 18-- f1_score: 0.7000536898687079
--n_estimators: 20; max_depth: 12-- f1_score: 0.694378168597844	--n_estimators: 16; max_depth: 20-- f1_score: 0.7043634743708439

```

----n_estimators----
--n_estimators: 2; max_depth: 10--
f1_score: 0.6885961971224538

--n_estimators: 2; max_depth: 12--
f1_score: 0.6860881093111483

--n_estimators: 6; max_depth: 20--
f1_score: 0.6925325795447147

--n_estimators: 2; max_depth: 14--
f1_score: 0.6796817221631246

--n_estimators: 8; max_depth: 10--
f1_score: 0.6844529005113982

--n_estimators: 2; max_depth: 16--
f1_score: 0.6906661556581654

--n_estimators: 8; max_depth: 12--
f1_score: 0.6882364022472119

--n_estimators: 2; max_depth: 18--
f1_score: 0.684605439016107

--n_estimators: 8; max_depth: 14--
f1_score: 0.6957759086509608

--n_estimators: 2; max_depth: 20--
f1_score: 0.6759439512088219

--n_estimators: 8; max_depth: 16--
f1_score: 0.6971062991386511

--n_estimators: 4; max_depth: 10--
f1_score: 0.6801396651740357

--n_estimators: 8; max_depth: 18--
f1_score: 0.6986275387917675

--n_estimators: 4; max_depth: 12--
f1_score: 0.6905115654974953

--n_estimators: 8; max_depth: 20--
f1_score: 0.7018139692292109

--n_estimators: 4; max_depth: 14--
f1_score: 0.6943293299832424

--n_estimators: 10; max_depth: 10--
f1_score: 0.681818268941309

--n_estimators: 4; max_depth: 16--
f1_score: 0.6930618462246925

--n_estimators: 10; max_depth: 12--
f1_score: 0.6882168696256807

--n_estimators: 4; max_depth: 18--
f1_score: 0.6908203957474119

--n_estimators: 10; max_depth: 14--
f1_score: 0.6953637524352904

--n_estimators: 4; max_depth: 20--
f1_score: 0.6942092967434447

--n_estimators: 10; max_depth: 16--
f1_score: 0.6968902778373174

--n_estimators: 6; max_depth: 10--
f1_score: 0.6787706768001275

--n_estimators: 10; max_depth: 18--
f1_score: 0.6964920364453141

--n_estimators: 6; max_depth: 12--
f1_score: 0.6885626689601974

--n_estimators: 10; max_depth: 20--
f1_score: 0.7016347387480902

--n_estimators: 6; max_depth: 14--
f1_score: 0.6938743701625688

--n_estimators: 12; max_depth: 10--
f1_score: 0.683869378564854

--n_estimators: 6; max_depth: 16--
f1_score: 0.6932371129815452

--n_estimators: 12; max_depth: 12--
f1_score: 0.6906283236627916

--n_estimators: 6; max_depth: 18--
f1_score: 0.6969721677651256

```

Лучший результат при n_estimators: 16; max_depth: 20

Изначальный результат

```

model = BaggingClassifier(DecisionTreeClassifier(random_state = 42),
random_state = 42)
model.fit(X_train, list(y_train.values))
y_pred_train, y_pred_test = model.predict(X_train),
model.predict(X_test)

```



```

print(f"--Classifier:
{BaggingClassifier(DecisionTreeClassifier(random_state = 42),
random_state = 42)}--")
print(f'f1_score: {f1_score(y_test, y_pred_test, average =
"weighted")}')
print(f'accuracy_score: {accuracy_score(y_test, y_pred_test)}')
print(f'confusion_matrix:\n{confusion_matrix(list(y_test.values),
y_pred_test)}\n')

--Classifier:
BaggingClassifier(base_estimator=DecisionTreeClassifier(random_state=4
2),
                    random_state=42)--
f1_score: 0.7009206152498779
accuracy_score: 0.7240231548480464
confusion_matrix:
[[ 159  171  200]
 [   50 4318  401]
 [  117  968  526]]

```

*# Бэггинг по дереву с учетом гиперпараметров (n_estimators: 16;
max_depth: 20). Делаем не через функцию, чтобы сохранить предсказание*

```

model = BaggingClassifier(DecisionTreeClassifier(random_state = 42,
max_depth=20), random_state = 42, n_estimators=16)
model.fit(X_train, list(y_train.values))
y_pred_train, y_pred_test = model.predict(X_train),
model.predict(X_test)

print(f"--Classifier:
{BaggingClassifier(DecisionTreeClassifier(random_state = 42,
max_depth=18), random_state = 42, n_estimators=16)}--")
print(f'f1_score: {f1_score(y_test, y_pred_test, average =
"weighted")}')
print(f'accuracy_score: {accuracy_score(y_test, y_pred_test)}')
print(f'confusion_matrix:\n{confusion_matrix(list(y_test.values),
y_pred_test)}\n')

--Classifier:
BaggingClassifier(base_estimator=DecisionTreeClassifier(max_depth=18,
                    random_state=42),
                    n_estimators=16, random_state=42)--
f1_score: 0.697651096370905
accuracy_score: 0.7244573082489146
confusion_matrix:
[[ 133  175  222]
 [   30 4359  380]]

```

```
[ 95 1002 514]]
```

Результат получился хуже, чем исходный, возьмем второй по качеству набор гиперпараметров

Бэггинг по дереву с учетом гиперпараметров (n_estimators: 18; max_depth: 20). Делаем не через функцию, чтобы сохранить предсказание

```
model = BaggingClassifier(DecisionTreeClassifier(random_state = 42,
max_depth=20), random_state = 42, n_estimators=18)
model.fit(X_train, list(y_train.values))
y_pred_train, y_pred_test = model.predict(X_train),
model.predict(X_test)
```

```
print(f"--Classifier:
{BaggingClassifier(DecisionTreeClassifier(random_state = 42,
max_depth=18), random_state = 42, n_estimators=16)}--")
print(f'f1_score: {f1_score(y_test, y_pred_test, average =
"weighted")}')
print(f'accuracy_score: {accuracy_score(y_test, y_pred_test)}')
print(f'confusion_matrix:\n{confusion_matrix(list(y_test.values),
y_pred_test)}\n')

--Classifier:
BaggingClassifier(base_estimator=DecisionTreeClassifier(max_depth=18,

random_state=42),
                  n_estimators=16, random_state=42)--
f1_score: 0.7012123748155945
accuracy_score: 0.7277858176555716
confusion_matrix:
[[ 132  174  224]
 [  31 4369  369]
 [  91  992  528]]
```

Получилось немного улучшить результат. Можно перебрать еще несколько гиперпараметров, но это очень долго, поэтому попробуем посмотреть на примеры, где модель дала неправильный ответ

Вывод: *лучшего результата удалось достичь, используя бэггинг по дереву, перебрав несколько гиперпараметров*

#5 часть Анализ ошибок модели - необходимо взять несколько примеров из тестовой части датасета, на которых модель дала неправильный ответ, и попытаться проанализировать их, найти закономерности, полученные выводы проверить на других примерах.

Создадим датафрейм, состоящий только из элементов, на которых была ошибка

```
not_equal = pd.DataFrame(y_pred_test != y_test)
not_equal = not_equal[not_equal==True].dropna()
error = X_test.loc[not_equal.index, :]
error.sample(5)
```

	is_there_description	is_there_display_address \
18	1.0	1.0
28991	1.0	1.0
3351	1.0	1.0
26880	1.0	1.0
31752	1.0	1.0

	is_there_street_address
manager_id_0000abd7518b94c35a90d64b56fbf3e6 \	
18	1.0
0.0	
28991	1.0
0.0	
3351	1.0
0.0	
26880	1.0
0.0	
31752	1.0
0.0	

	manager_id_001ce808ce1720e24a9510e014c69707 \
18	0.0
28991	0.0
3351	0.0
26880	0.0
31752	0.0

	manager_id_003fc4e9a70053082f131b1054966aaf \
18	0.0
28991	0.0
3351	0.0
26880	0.0
31752	0.0

	manager_id_00607a02f6efd9c6c7c588826e471ee9 \
18	0.0
28991	0.0
3351	0.0
26880	0.0
31752	0.0

	manager_id_00995ff28d79127ed2dca8320e9e7d09 \
--	---

18	0.0
28991	0.0
3351	0.0
26880	0.0
31752	0.0

	manager_id_00a8d77892cab18fffaa22a751f1f8eb \
18	0.0
28991	0.0
3351	0.0
26880	0.0
31752	0.0

	manager_id_00f0b3346ba8379b26b95be8a19d46b1 ... \
18	0.0 ...
28991	0.0 ...
3351	0.0 ...
26880	0.0 ...
31752	0.0 ...

	building_id_fff0a02ad82421c226c6d6765a0dde57 \
18	0.0
28991	0.0
3351	0.0
26880	0.0
31752	0.0

	building_id_fff5915444b98b72a44a9456901f083c	bathrooms
bedrooms \		
18	0.0	0.166667
0.000000		
28991	0.0	0.166667
0.166667		
3351	0.0	0.166667
0.333333		
26880	0.0	0.166667
0.166667		
31752	0.0	0.166667
0.333333		

	how_long_ago_created	latitude	longitude	price \
18	0.157303	0.914276	0.020748	0.000424
28991	0.696629	0.913628	0.020515	0.000679
3351	0.393258	0.913808	0.020196	0.000725
26880	0.707865	0.913418	0.020442	0.000546
31752	0.438202	0.913187	0.020358	0.000747

	number_of_features	number_of_photos
18	0.111111	0.130435
28991	0.166667	0.086957

3351	0.361111	0.173913
26880	0.194444	0.086957
31752	0.277778	0.239130

[5 rows x 8613 columns]

Посмотрим каждый десятый признак датафрейма ошибок

```
columns = error.columns
for i in range(0, 8613, 10):
    print(f'{columns[i]}: {error.iloc[:, i].unique()}')
```

```
is_there_description: [1. 0.]
manager_id_01074bb974b125b65fa1b11a64c65135: [0.]
manager_id_01f1fadb85be52e12ffe3456b571fe5e: [0.]
manager_id_0319c8009f00e29f3d434c1dd1d25e74: [0. 1.]
manager_id_03fea70f5551838fed4d6fe32859efab: [0.]
manager_id_0492625ca98a35bd7d75849f6b4944ae: [0.]
manager_id_0577b9cf7d26e41800d814cb70b2bbf0: [0.]
manager_id_067687be0b9efedec0af4f163d2487dc: [0.]
manager_id_07c511151921e268b260a2bc96399704: [0.]
manager_id_08e9bc53025e9420adb4f038b43166c1: [0.]
manager_id_09703fead6059562ab26a3522f738f87: [0.]
manager_id_0a2670d4936ba82672ca782d8137e7ae: [0.]
manager_id_0ab238985a49334440f05fe80a5a565c: [0.]
manager_id_0b8a0fb573c92be71bc4e077aec9a570: [0. 1.]
manager_id_0c8cc24d93c15cc2b7505f4c153b4906: [0.]
manager_id_0d16d096ef1256ba3fdd6df87f8e98fe: [0.]
manager_id_0db6148efb87ded68e91c2960511439e: [0.]
manager_id_0e53b32a013810c4b3d86299425a658c: [0.]
manager_id_0f08ff6ab816344dc6686bdc305038ec: [0. 1.]
manager_id_1014a43e89b749c41b1385d09539b94d: [0.]
manager_id_10be73296059f9d33a723f0bdc27bc97: [0.]
manager_id_119d9b577a2506cd7348d01fd5d0830b: [0. 1.]
manager_id_124e0088638a99447f90170bc6ac33a2: [0. 1.]
manager_id_136fd7686946505e6fc2ce468dc50ae2: [0.]
manager_id_14524a21e07c6c45fcc0ad0f32d78c75: [0.]
manager_id_15145db0ac7db7f3d304e17a5cb075d3: [0.]
manager_id_15d3873fc00222877aab72c3fb2c0a60: [0.]
manager_id_1673af5c310a091971eda275dccc4508: [0. 1.]
manager_id_17746fc88a31d4c65d9d0c5bdf8078fc: [0.]
manager_id_1807014bb678c7e5f2844be6929b651a: [0.]
manager_id_18f688fa3d5006feb48785f2810f41b1: [0.]
manager_id_19ba5c5d3452211c835a3c4e76bd6774: [0. 1.]
manager_id_1a3e7d72bd7d5e84620930eedb35083a: [0.]
manager_id_1b06d3b9766e101dc15533df16848c3d: [0.]
manager_id_1badf2eefe8228387979149413ec071b: [0.]
manager_id_1ce456323441ffd6a3b29a98cd5fc7fe: [0.]
manager_id_1d6178a624091026d2bf761991d71ef7: [0.]
manager_id_1e163e62e27b7ac04b0129dfe7d35631: [0.]
```

manager_id_1f5630fb3e0dc7d307fa82a6b63a03a1: [0. 1.]
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Создадим датафрейм, состоящий только из элементов, на которых ошибки не было

```

index = X_test.index.tolist()
for ind in not_equal.index.tolist():
    index.remove(ind)
correct = X_test.loc[index, :]

# Посмотрим каждый десятый признак датафрейма без ошибок

columns = correct.columns
for i in range(0, 8613, 10):
    print(f'{columns[i]}: {correct.iloc[:, i].unique()}')

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0.00059154	0.00081404	0.00050557	0.00093275	0.00066838	0.00074032
0.00063364	0.00094656	0.00177062	0.001392	0.00095324	0.00061404
0.00040758	0.00029065	0.00081849	0.00107017	0.00077128	0.00090201
0.00052339	0.0008764	0.00078509	0.00048664	0.00084745	0.00078486
0.00076727	0.00276395	0.00344213	0.0005078	0.00166037	0.0002784
0.00128175	0.00085858	0.00087596	0.00152674	0.00045657	0.00037974
0.0006637	0.001196	0.00054566	0.000745	0.01112595	0.00118153
0.00150447	0.00059021	0.00119266	0.0004911	0.00124834	0.00090112
0.0009421	0.00095413	0.00141093	0.00062918	0.00305237	0.00076927
0.00061114	0.00137774	0.00255125	0.00128955	0.00105346	0.0010891
0.00097662	0.00052673	0.00181204	0.00069533	0.00136861	0.00102562
0.00212808	0.00065791	0.00333077	0.00050045	0.00064923	0.00111582
0.00068598	0.00112585	0.00114144	0.00036303	0.00137084	0.0014499
0.00121382	0.00090313	0.00105792	0.00079065	0.00115369	0.00088575
0.00087573	0.00090647	0.00117039	0.00110914	0.00081159	0.00089199
0.00039644	0.00070112	0.00141427	0.00120914	0.00077952	0.00080825
0.00091315	0.00152117	0.00109645	0.0003686	0.00040424	0.00095881
0.00084856	0.00103008	0.00046326	0.00355349	0.00088486	0.00054655
0.00069934	0.00062696	0.00097217	0.0005323	0.00111471	0.00047462
0.00321941	0.00137975	0.00065368	0.00079734	0.00103565	0.00068887
0.00077105	0.00142652	0.0006931	0.00056014	0.00127618	0.0008862
0.00056682	0.00130514	0.00074388	0.00299669	0.00097573	0.0009107
0.00060023	0.00049444	0.00104789	0.00027394	0.00260693	0.00049666
0.0060034	0.00190536	0.00081961	0.00059778	0.00210581	0.00130402
0.00141538	0.0013597	0.00062027	0.0009087	0.00059689	0.00160469
0.00156906	0.00083186	0.00036749	0.00059577	0.0006303	0.00044655
0.00101783	0.00107462	0.00199445	0.00042985	0.00037417	0.00159311
0.00115925	0.00077395	0.00061025	0.00060223	0.00149445	0.00075524
0.00083854	0.00132206	0.0008303	0.00041092	0.0003519	0.00032962
0.00042205	0.00052139	0.00182897	0.00091983	0.00099734	0.00127841
0.00025724	0.00141516	0.00116928	0.00112451	0.00074745	0.00074166
0.00111605	0.00041871	0.001794	0.00065747	0.00081582	0.00079422
0.00248889	0.00106905	0.0007862	0.00143209	0.00100335	0.00136972
0.00043319	0.00136616	0.00065145	0.00047439	0.00068553	0.00054121
0.00029622	0.00265147	0.00053007	0.00234412	0.00178844	0.00444437
0.00123609	0.00109801	0.00096437	0.00098665	0.00157129	0.00107573
0.00094767	0.00045747	0.00169935	0.00256239	0.00039065	0.00081471
0.00151115	0.00067239	0.00070179	0.00062807	0.00077506	0.00076393
0.00089845	0.00052829	0.00122941	0.00141739	0.00249112	0.00086682
0.00072607	0.00048553	0.00084433	0.00108464	0.0009548	0.00143543
0.00050023	0.00161472	0.00282965	0.00081538	0.00067818	0.00057996

0.0010568	0.0009666	0.00185971	0.0005862	0.00133743	0.00169044
0.00174835	0.0003764	0.00058687	0.00071827	0.00125391	0.00163699
0.000747	0.00119155	0.00054455	0.00052562	0.00079511	0.00092094
0.00131961	0.00095079	0.00110335	0.00082629	0.00026838	0.00026281
0.00115146	0.00077595	0.00316373	0.00052205	0.00071493	0.00097284
0.00044098	0.00126571	0.00072473	0.00052272	0.00070045	0.00069444
0.00307286	0.00310694	0.0010646	0.0008274	0.0004176	0.00201561
0.00056883	0.00070246	0.00158242	0.00078954	0.00072027	0.00111248
0.00073007	0.00059644	0.00053586	0.00096794	0.00089088	0.00079622
0.00069266	0.00533524	0.00095101	0.00087863	0.00057907	0.00075992
0.00081226	0.00074076	0.00081382	0.00071248	0.00243989	0.00134745
0.00088063	0.00057573	0.00034722	0.00051025	0.00133298	0.00093475
0.00139756	0.00052228	0.00197218	0.00030735	0.00136304	0.00069823
0.00127061	0.00122607	0.00129734	0.00076615	0.00305126	0.00246105
0.00069377	0.00048887	0.00589204	0.00071716	0.00058508	0.00555796
0.00025613	0.00466708	0.00174946	0.00071159	0.00098553	0.0016381
0.00166683	0.00030067	0.00091649	0.00227285	0.00218376	0.00238421
0.00086771	0.00332965	0.00128509	0.00070713	0.00058352	0.00091515
0.00098932	0.00095257	0.00103453	0.00139623	0.00092807	0.00148777
0.0008519	0.00041225	0.00422053	0.00103475	0.00127885	0.00221695
0.00094099	0.00127774	0.00064032	0.00140425	0.00066192	0.00099132
0.00057618	0.00059667	0.00105124	0.00067261	0.00075502	0.00102317
0.00246216	0.00148108	0.00310805	0.0007225	0.00115257	0.01291216
0.00090424	0.0005911	0.00051003	0.00114433	0.00288533	0.00105881
0.00105146	0.0003274	0.0011891	0.00070936	0.00059332	0.00172719
0.00042473	0.0011568	0.00042539	0.0007078	0.00109689	0.0006392
0.00068508	0.00124456	0.00064143	0.00057595	0.0004686	0.00055858
0.00057417	0.00130959	0.00103609	0.00023497	0.00070513	0.00071938
0.00052361	0.00158977	0.0007303	0.00128153	0.00147329	0.00063809
0.00088197	0.0036203	0.00064255	0.00232853	0.00047528	0.00021247
0.00030847	0.00128554	0.00071782	0.00035635	0.00100424	0.00043519
0.00048998	0.00088598	0.00129289	0.00055123	0.00166483	0.00014477
0.00073319	0.00120714	0.00114856	0.00093097	0.00038865	0.00085413
0.00108687	0.00169378	0.00100246	0.00193655	0.00073453	0.00082495
0.00190425	0.00222719	0.00071137	0.00034744	0.00144033	0.00032294
0.0008107	0.00081137	0.0003931	0.00081627	0.00109244	0.00064477
0.00131694	0.00068152	0.0008205	0.00037395	0.00080736	0.00041426
0.00047261	0.00270715	0.00054344	0.00070825	0.00845331	0.00081716
0.00127507	0.00064678	0.00143609	0.0007617	0.00132407	0.00081114
0.00090758	0.00087952	0.00034076	0.00065479	0.00080179	0.00066259
0.00064321	0.00073431	0.000696	0.00151561	0.00086861	0.00124277
0.00127908	0.00068375	0.00092985	0.00249223	0.00121159	0.00133142
0.00141805	0.00193877	0.00171605	0.00156104	0.00113921	0.0016136
0.00060468	0.00109467	0.00160915	0.00118041	0.00121471	0.00062139
0.00034611	0.00031849	0.00075569	0.00072762	0.00088241	0.00081604
0.00106349	0.00073386	0.0028174	0.0010323	0.00113698	0.00373166
0.00082072	0.00028954	0.00107685	0.00047328	0.00062384	0.00073943
0.00070379	0.00667156	0.00128732	0.00286306	0.00121271	0.00182741
0.00132117	0.00107239	0.00132473	0.00055524	0.0004441	0.00031515
0.00057974	0.00134968	0.0012773	0.0007107	0.00062562	0.00052985

```

0.00399893 0.00039978 0.00067595 0.00045435 0.00057551 0.00060914
0.0007156 0.00065101 0.00056571 0.0013401 0.00063965 0.00067662
0.00038263 0.00075168 0.00114678 0.00072161 0.00411029 0.00087217
0.00057128 0.00131516 0.00150113 0.00103431 0.00095034 0.00028508
0.00099867 0.001245 0.00109132 0.002039 0.00100669 0.00074633
0.00032383 0.00128286 0.001147 0.00152941 0.00823059 0.00176951
0.00079399 0.00145057 0.00066103 0.00109177 0.00068909 0.00150336
0.00083564 0.00107796 0.00120113 0.00149177 0.00067039 0.00066593
0.00084967 0.00050201 0.00103899 0.00085547 0.00080201 0.00092317
0.00062361 0.00126616 0.00041292 0.00186082 0.00295771 0.00116705
0.00042873 0.00076059 0.00058241 0.00076571 0.00097997 0.00115079
0.00090892 0.00099556 0.00159244 0.00213588 0.00145881 0.00082852
0.00142897 0.00078152 0.0004098 0.00063141 0.0011332 0.00084633
0.00062451 0.00093431 0.000617044 0.0017038 0.00057796 0.00070134
0.00077618 0.00159935 0.00087128 0.00076103 0.00102451 0.00087195
0.00090491 0.00112362 0.00142117 0.00132496 0.00025167 0.00042139
0.00248443 0.00087462 0.00136527 0.00068464 0.00065079 0.00039377
0.00051782 0.00058107 0.0001833 0.00087083 0.0026615 0.00170492
0.00443323 0.00105458 0.00084299 0.00105391 0.00064878 0.0007205
0.00165926 0.00164367 0.00089355 0.00103119 0.00086237 0.00130179
0.00086727 0.00171939 0.01001235 0.00090736 0.00054433 0.00070958
0.00067707 0.00066905 0.00126505 0.00222608 0.0020724 0.00075613
0.00189423 0.00097885 0.00060401 0.00059221 0.00059355 0.00055568
0.00119244 0.00466597 0.00333055 0.0018283 0.00133921 0.00140981
0.00053898 0.00112785 0.00124545 0.00094544 0.00106415 0.00068709
0.0007127 0.00178287 0.00097774 0.00306351 0.00143587 0.00131627
0.0005127 0.00172608 0.00151226 0.00088687 0.00079644 0.00098999
0.00074901 0.00075056 0.00068642 0.00089645 0.00115836 0.00061805
0.00220604 0.00097974 0.00106014 0.00062606 0.0005196 0.00110692
0.00112429 0.00095435 0.00107908 0.00183922 0.00153899 0.00102005]

```

По выборке из 860 признаков видно, что среди элементов, где было ошибочное предсказание гораздо больше нулевых признаков

Посмотрим еще какие результаты наиболее вероятно предсказываются неправильно

Количество различных значений в тестовой выборке

```

y_test.value_counts()

low      4769
medium   1611
high      530
Name: TARGET, dtype: int64

```

Количество различных значений среди ошибочных предсказаний

```

y_test[not_equal.index].value_counts()

```

```
medium    1083
low        400
high       398
Name: TARGET, dtype: int64
```

Количество различных значений среди правильных предсказаний

```
y_test[correct.index].value_counts()
```

```
low        4369
medium      528
high        132
Name: TARGET, dtype: int64
```

Количество различных значений во всей базе данных

```
y_test.append(y_train).value_counts()
```

```
low        23999
medium      7860
high        2687
Name: TARGET, dtype: int64
```

Объявлений с низким уровнем популярности больше всего в тестовой выборке и на них меньше всего ошибок. Объявления средней и высокой популярности в большинстве случаев были предсказаны неправильно

Вывод: У модели есть проблемы с определением объявлений со средним и высоким уровнем популярности, но низкую популярность определяет достаточно хорошо. Также ошибки могут возникать в элементах, где встречается большая разреженность признаков (многие признаки равны нулю)