РТ5-61Б, Забурунов Л. В.

Технологии Машинного Обучения

Рубежный Контроль №2

"Методы построения моделей машинного обучения"

Воспользуемся набором данных №5 (по варианту на семестр) из числа предложенных в задании. В соответствии с академической группой модели для обучения - дерево решений и градиентный бустинг.

1. Загрузка данных

In [27]:

```python
import numpy as np
import pandas as pd
import seaborn as sns

rk2_data = pd.read_csv("ML_Datasets/RK2/heart.csv")
```

In [28]:

```python
print(rk2_data.shape, rk2_data.info(), sep = "\n\n")
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count   Dtype
---  ------    --------------   -----
 0   age       303 non-null     int64
 1   sex       303 non-null     int64
 2   cp        303 non-null     int64
 3   trestbps  303 non-null     int64
 4   chol      303 non-null     int64
 5   fbs       303 non-null     int64
 6   restecg   303 non-null     int64
 7   thalach   303 non-null     int64
 8   exang     303 non-null     int64
 9   oldpeak   303 non-null     float64
 10  slope     303 non-null     int64
 11  ca        303 non-null     int64
 12  thal      303 non-null     int64
 13  target    303 non-null     int64
dtypes: float64(1), int64(13)
memory usage: 33.3 KB
(303, 14)

None
```
Пропуски в данных отсутствуют.

In [29]:

```python
for column in rk2_data.columns:
    print(column, ": ", rk2_data[column].unique())
```

```
age :  [63 37 41 56 57 44 52 54 48 49 64 58 50 66 43 69 59 42 61 40 71 51 65 53
 46 45 39 47 62 34 35 29 55 60 67 68 74 76 70 38 77]
sex :  [1 0]
cp :  [3 2 1 0]
trestbps :  [145 130 120 140 172 150 110 135 160 105 125 142 155 104 138 128 108 134
 122 115 118 100 124  94 112 102 152 101 132 148 178 129 180 136 126 106
 156 170 146 117 200 165 174 192 144 123 154 114 164]
chol :  [233 250 204 236 354 192 294 263 199 168 239 275 266 211 283 219 340 226
 247 234 243 302 212 175 417 197 198 177 273 213 304 232 269 360 308 245
 208 264 321 325 235 257 216 256 231 141 252 201 222 260 182 303 265 309
 186 203 183 220 209 258 227 261 221 205 240 318 298 564 277 214 248 255
 207 223 288 160 394 315 246 244 270 195 196 254 126 313 262 215 193 271
 268 267 210 295 306 178 242 180 228 149 278 253 342 157 286 229 284 224
 206 167 230 335 276 353 225 330 290 172 305 188 282 185 326 274 164 307
 249 341 407 217 174 281 289 322 299 300 293 184 409 259 200 327 237 218
 319 166 311 169 187 176 241 131]
fbs :  [1 0]
restecg :  [0 1 2]
thalach :  [150 187 172 178 163 148 153 173 162 174 160 139 171 144 158 114 151 161
 179 137 157 123 152 168 140 188 125 170 165 142 180 143 182 156 115 149
 146 175 186 185 159 130 190 132 147 154 202 166 164 184 122 169 138 111
 145 194 131 133 155 167 192 121  96 126 105 181 116 108 129 120 112 128
 109 113  99 177 141 136  97 127 103 124  88 195 106  95 117  71 118 134
  90]
exang :  [0 1]
oldpeak :  [2.3 3.5 1.4 0.8 0.6 0.4 1.3 0.  0.5 1.6 1.2 0.2 1.8 1.  2.6 1.5 3.  2.4
 0.1 1.9 4.2 1.1 2.  0.7 0.3 0.9 3.6 3.1 3.2 2.5 2.2 2.8 3.4 6.2 4.  5.6
 2.9 2.1 3.8 4.4]
slope :  [0 2 1]
ca :  [0 2 1 3 4]
thal :  [1 2 3 0]
target :  [1 0]
```

Требуется кодирование категориальных признаков и масштабирование данных

In [34]:

```python
rk2_data = pd.get_dummies(rk2_data, columns = ["restecg", "slope", "ca", "thal"])
```

In [36]:

```python
def MoveColumnToEnd(data, column_name):
    columns = data.columns.tolist()
    column = columns.pop(columns.index(column_name))
    columns.append(column)
    return columns
```

In [37]:

```python
columns = MoveColumnToEnd(rk2_data, "target")
rk2_data = rk2_data[columns]
```

In [45]:

```python
import matplotlib.pyplot as plt


def ShowColumnsDistribution(data):
    columns = data.columns.to_list()
    fig, ax = plt.subplots(len(columns), 1, figsize=(20, 5 * len(columns)))
    for i in range(len(columns)):
        sns.histplot(data[columns[i]], ax=ax[i], kde = True)
```

In [46]:

```python
from sklearn.preprocessing import MinMaxScaler


zScaler = MinMaxScaler()
columns = rk2_data.columns.to_list()
```
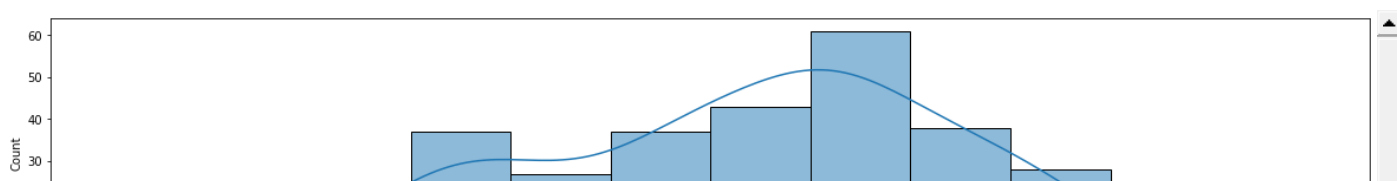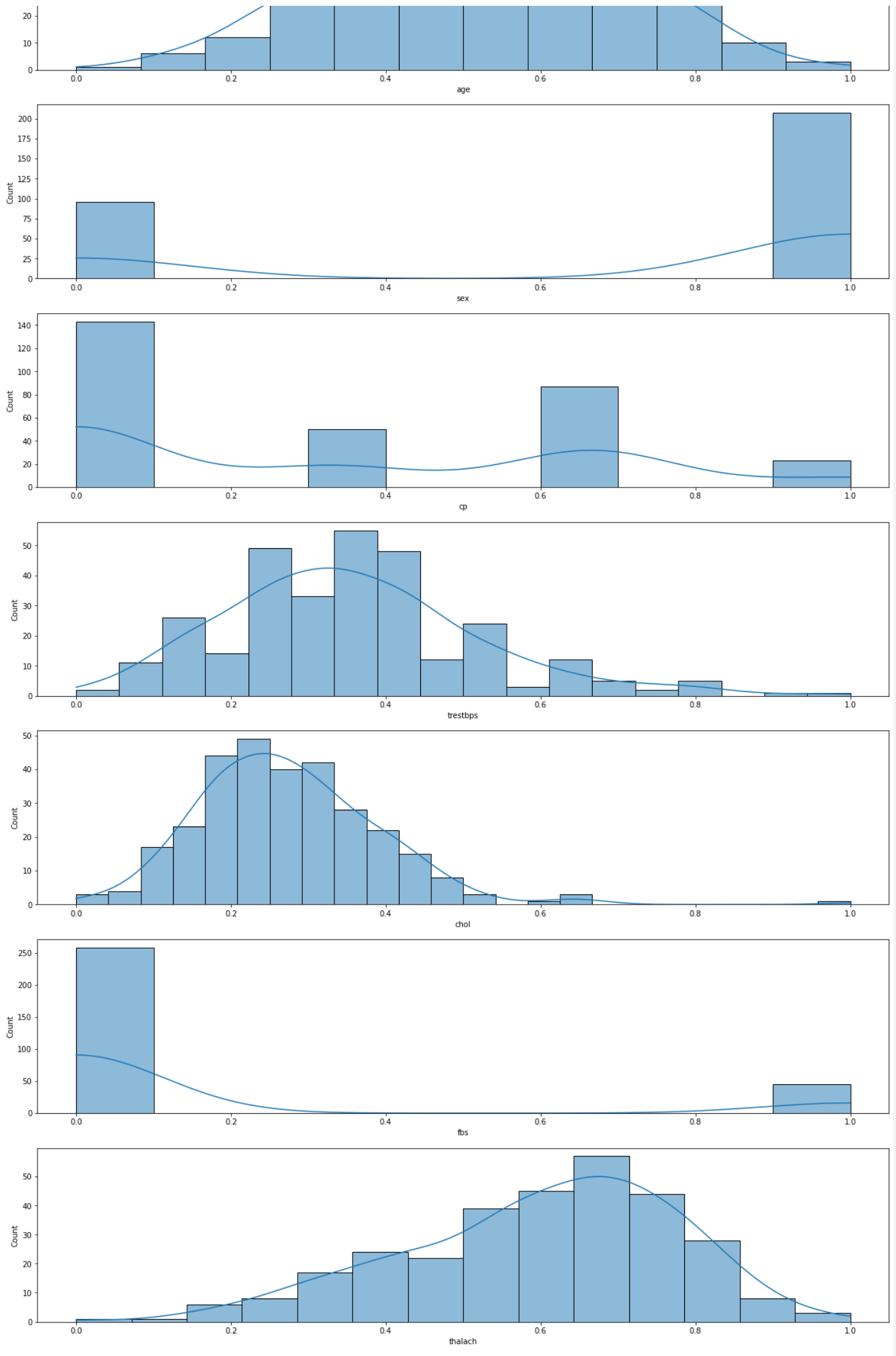
In [47]:

```python
for column in columns[:-1]:
    rk2_data[column] = zScaler.fit_transform(rk2_data[[column]])
```
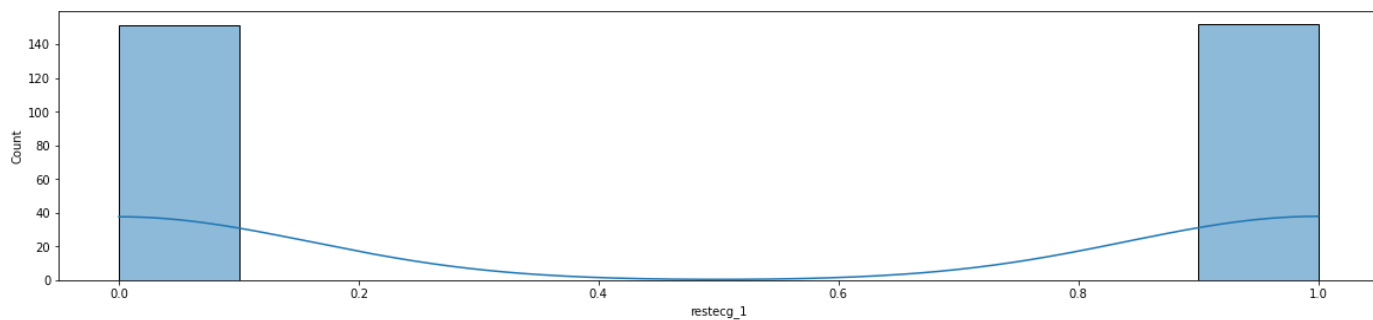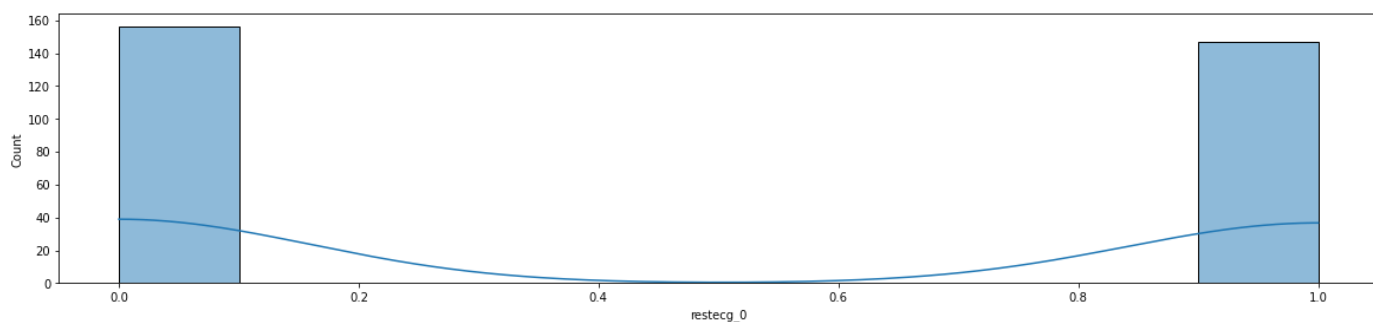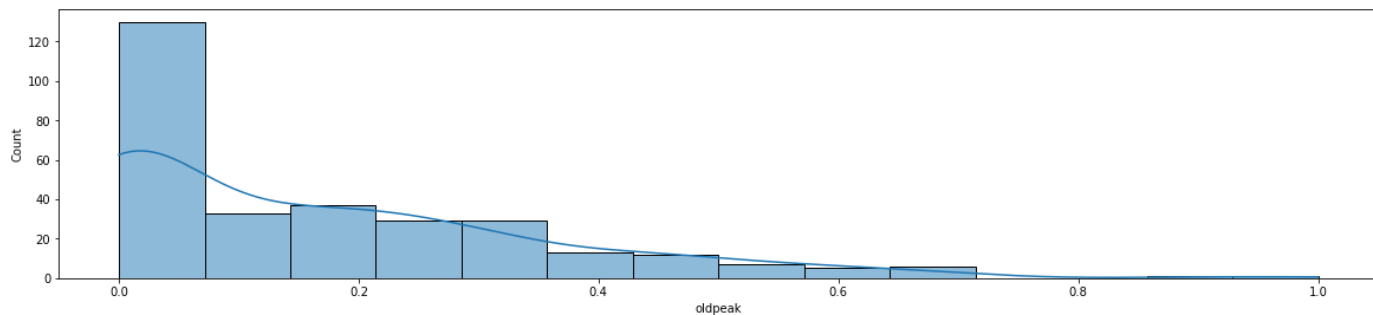
In [48]:

```python
ShowColumnsDistribution(rk2_data)
```
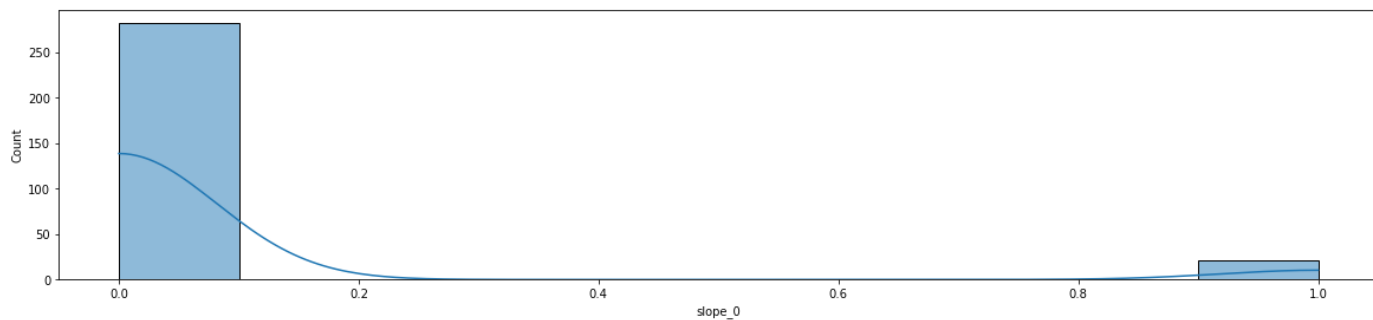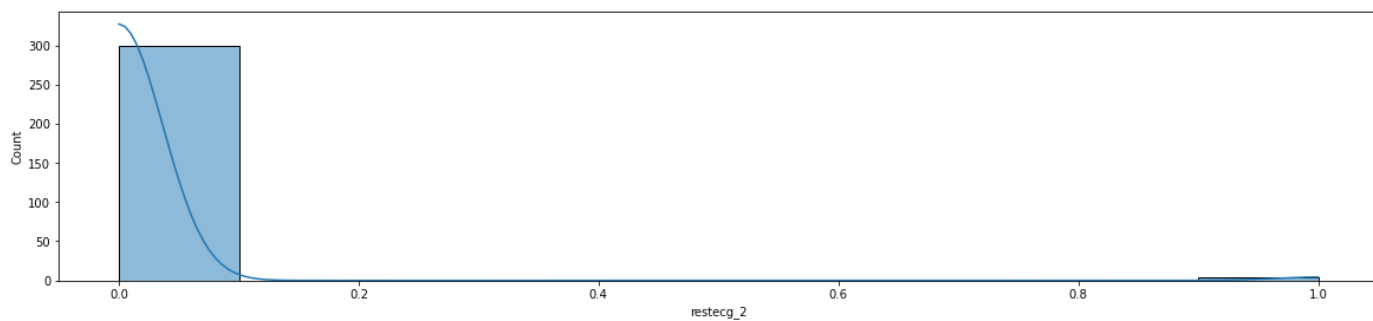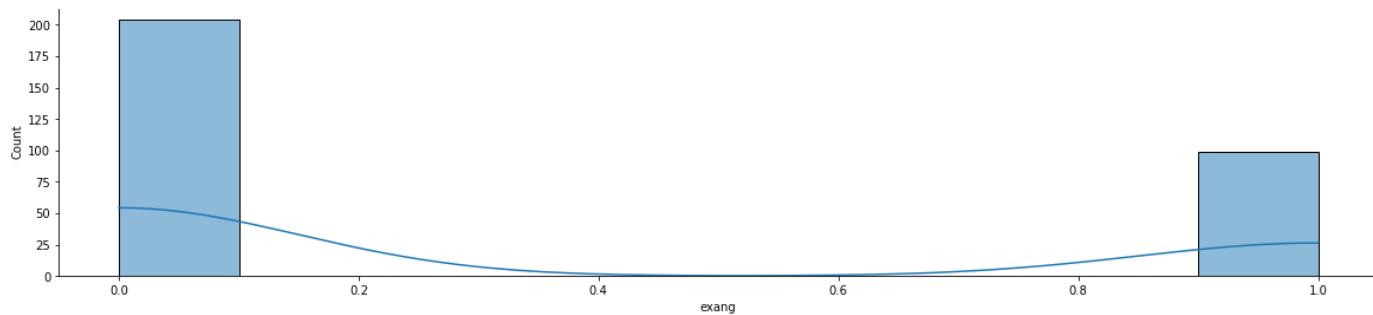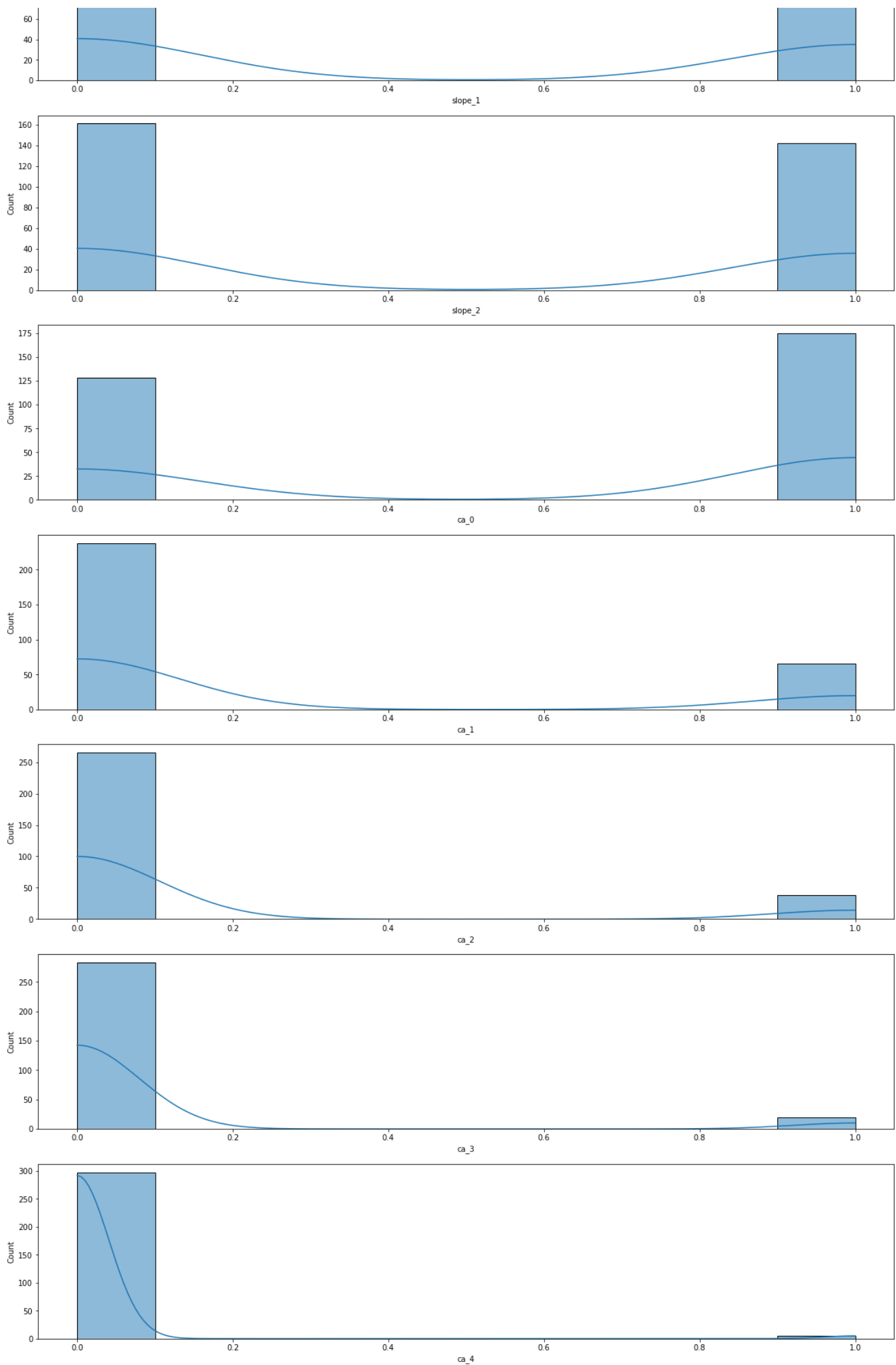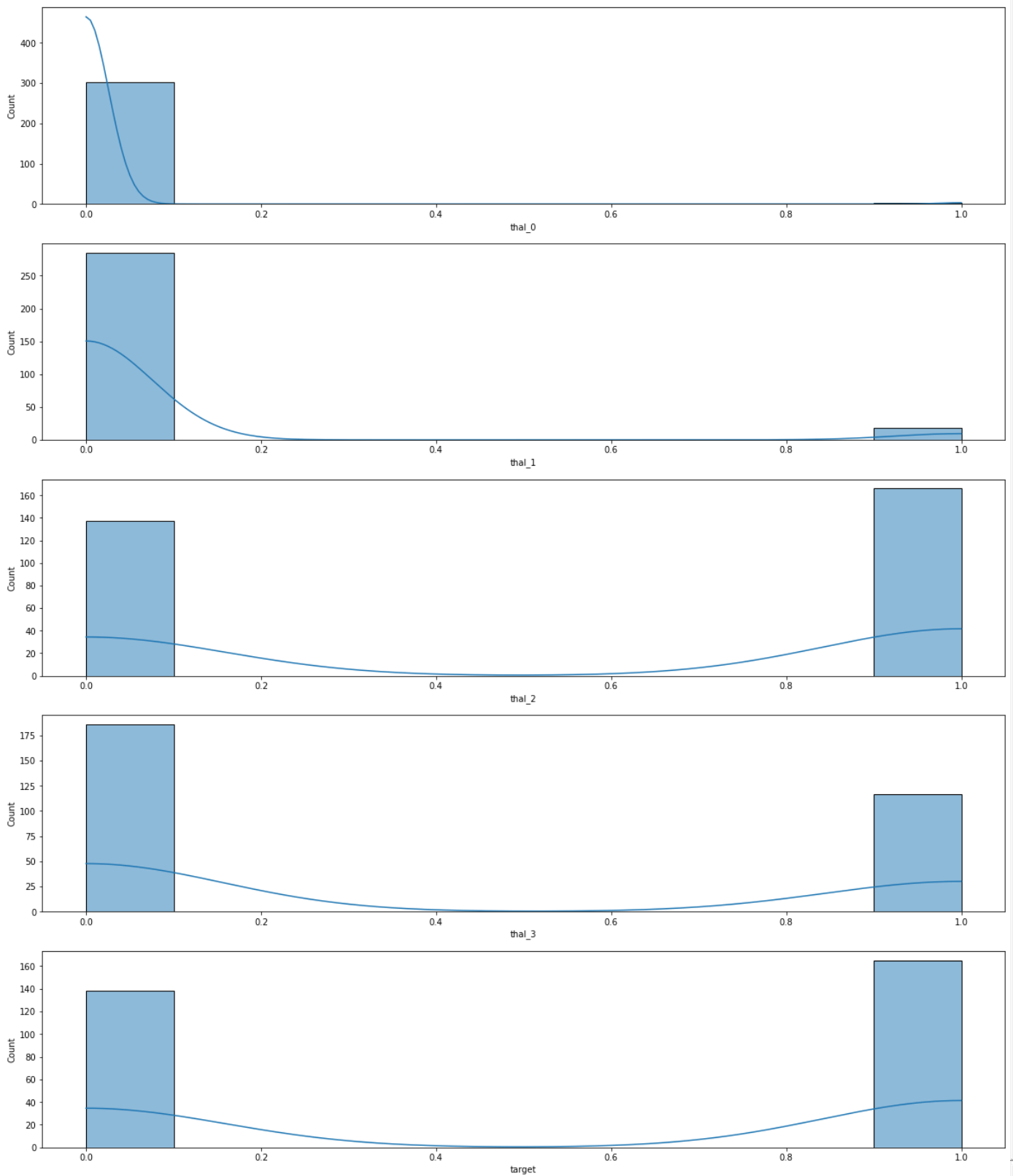
```
fig, ax = plt.subplots(figsize=(25, 25))
sns.set(font_scale = 2)
sns.heatmap(rk2_data.corr(), ax=ax, annot=True, fmt=".2f", linewidths=0.3, linecolor="black", vmin = -1, vmax
```

`<AxesSubplot:>`
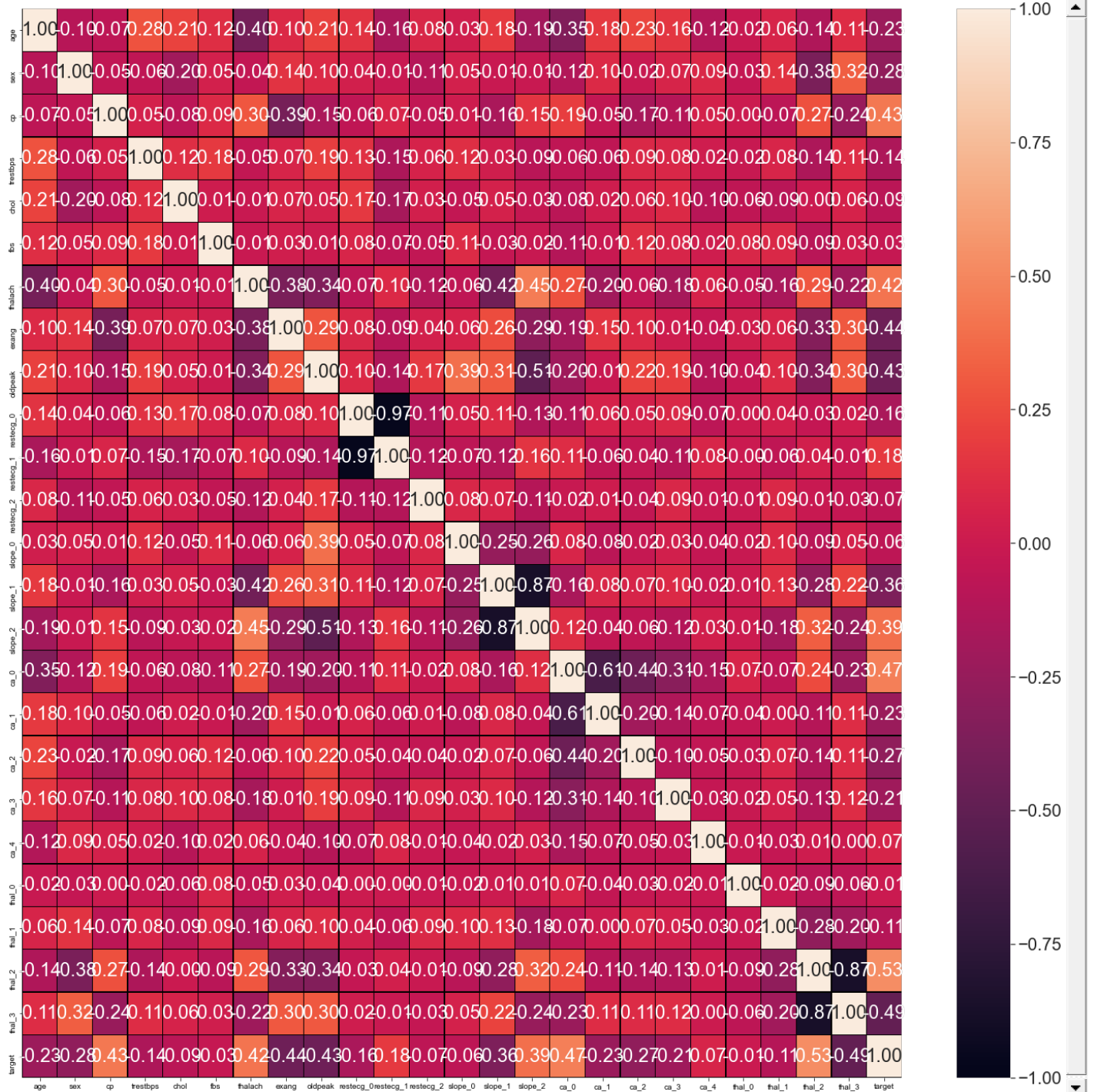
В целом линейных зависимостей (в особенности с целевым признаком) крайне мало, поэтому с учётом количества колонок рассчитываем на недообучение модели из-за малого объёма данных.

```python
from sklearn.model_selection import train_test_split
```

```python
rk2_x_train, rk2_x_test, rk2_y_train, rk2_y_test = train_test_split(rk2_data[columns[:-1]], rk2_data[columns[
```

2. Обучение дерева решений

```python
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import balanced_accuracy_score, f1_score, precision_score, recall_score, roc_auc_score,
```

```python
tree = DecisionTreeClassifier(max_depth = 5, random_state = 6)
tree.fit(rk2_x_train, rk2_y_train)
tree_prediction = tree.predict(rk2_x_test)
```

Будем смотреть на долю ошибок *False Positive* (**Precision**) и *False Negative* (**Recall**), а также на показатель **ROC AUC**

```
plot_confusion_matrix(tree, rk2_x_test, rk2_y_test)
```

```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x23193ca10d0>
```

```
precision_score(rk2_y_test, tree_prediction)
```

```
0.7435897435897436
```

```
recall_score(rk2_y_test, tree_prediction)
```

```
0.725
```

```
roc_auc_score(rk2_y_test, tree_prediction)
```

```
0.7236111111111111
```

Показатели в целом удовлетворительные, однако очевидным образом сказывается катастрофически малый объём набора данных.
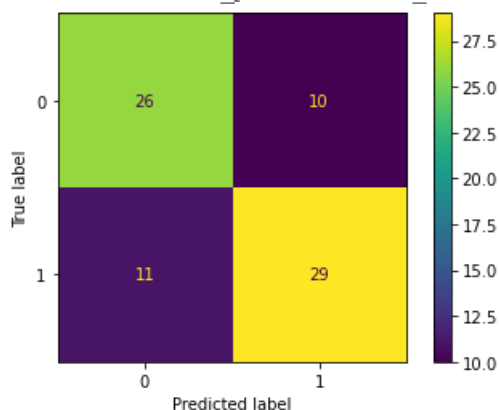
3. Обучение модели градиентного бустинга

```
from catboost import CatBoostClassifier
```

```
cb = CatBoostClassifier(random_seed = 6)
cb.fit(rk2_x_train, rk2_y_train)
cb_prediction = tree.predict(rk2_x_test)
```

```
Learning rate set to 0.00547
0: learn: 0.6888646 total: 155ms remaining: 2m 34s
1: learn: 0.6841253 total: 157ms remaining: 1m 18s
2: learn: 0.6794309 total: 160ms remaining: 53.2s
3: learn: 0.6744901 total: 163ms remaining: 40.5s
4: learn: 0.6708695 total: 165ms remaining: 32.9s
5: learn: 0.6657667 total: 168ms remaining: 27.8s
6: learn: 0.6614075 total: 180ms remaining: 25.5s
7: learn: 0.6572223 total: 183ms remaining: 22.6s
8: learn: 0.6525637 total: 194ms remaining: 21.4s
9: learn: 0.6487621 total: 210ms remaining: 20.8s
10: learn: 0.6451055 total: 212ms remaining: 19.1s
11: learn: 0.6402508 total: 215ms remaining: 17.7s
12: learn: 0.6376855 total: 216ms remaining: 16.4s
13: learn: 0.6328529 total: 219ms remaining: 15.4s
14: learn: 0.6298895 total: 221ms remaining: 14.5s
15: learn: 0.6254514 total: 224ms remaining: 13.8s
16: learn: 0.6211357 total: 238ms remaining: 13.8s
17: learn: 0.6172575 total: 240ms remaining: 13.1s
18: learn: 0.6146426 total: 243ms remaining: 12.5s
19: learn: 0.6106139 total: 245ms remaining: 12s
20: learn: 0.6079081 total: 247ms remaining: 11.5s
21: learn: 0.6038872 total: 249ms remaining: 11.1s
22: learn: 0.5995565 total: 268ms remaining: 11.4s
23: learn: 0.5973037 total: 270ms remaining: 11s
24: learn: 0.5945113 total: 283ms remaining: 11s
25: learn: 0.5916681 total: 285ms remaining: 10.7s
26: learn: 0.5871266 total: 288ms remaining: 10.4s
27: learn: 0.5829796 total: 291ms remaining: 10.1s
28: learn: 0.5796557 total: 293ms remaining: 9.81s
29: learn: 0.5759299 total: 296ms remaining: 9.56s
```

```
30: learn: 0.5722075 total: 298ms remaining: 9.32s
31: learn: 0.5685810 total: 301ms remaining: 9.1s
32: learn: 0.5651115 total: 303ms remaining: 8.89s
33: learn: 0.5611845 total: 306ms remaining: 8.69s
34: learn: 0.5586480 total: 309ms remaining: 8.51s
35: learn: 0.5549929 total: 311ms remaining: 8.33s
36: learn: 0.5515668 total: 313ms remaining: 8.14s
37: learn: 0.5479617 total: 315ms remaining: 7.96s
38: learn: 0.5446157 total: 316ms remaining: 7.8s
39: learn: 0.5410555 total: 318ms remaining: 7.64s
40: learn: 0.5375049 total: 326ms remaining: 7.63s
41: learn: 0.5341505 total: 342ms remaining: 7.79s
42: learn: 0.5306406 total: 344ms remaining: 7.65s
43: learn: 0.5279320 total: 345ms remaining: 7.5s
44: learn: 0.5245761 total: 347ms remaining: 7.36s
45: learn: 0.5225590 total: 348ms remaining: 7.23s
46: learn: 0.5194364 total: 357ms remaining: 7.23s
47: learn: 0.5161399 total: 358ms remaining: 7.11s
48: learn: 0.5144987 total: 360ms remaining: 6.99s
49: learn: 0.5119120 total: 362ms remaining: 6.88s
50: learn: 0.5093994 total: 364ms remaining: 6.77s
51: learn: 0.5073648 total: 370ms remaining: 6.75s
52: learn: 0.5048608 total: 372ms remaining: 6.65s
53: learn: 0.5019000 total: 374ms remaining: 6.55s
54: learn: 0.4999392 total: 386ms remaining: 6.62s
55: learn: 0.4975085 total: 387ms remaining: 6.53s
56: learn: 0.4946039 total: 389ms remaining: 6.43s
57: learn: 0.4922362 total: 391ms remaining: 6.34s
58: learn: 0.4892972 total: 392ms remaining: 6.25s
59: learn: 0.4872866 total: 394ms remaining: 6.17s
60: learn: 0.4855584 total: 400ms remaining: 6.15s
61: learn: 0.4832663 total: 415ms remaining: 6.28s
62: learn: 0.4801622 total: 431ms remaining: 6.41s
63: learn: 0.4776258 total: 433ms remaining: 6.34s
64: learn: 0.4751590 total: 436ms remaining: 6.27s
65: learn: 0.4728286 total: 439ms remaining: 6.21s
66: learn: 0.4708008 total: 441ms remaining: 6.14s
67: learn: 0.4684943 total: 444ms remaining: 6.08s
68: learn: 0.4658164 total: 446ms remaining: 6.02s
69: learn: 0.4636261 total: 449ms remaining: 5.96s
70: learn: 0.4617873 total: 452ms remaining: 5.91s
71: learn: 0.4589849 total: 454ms remaining: 5.85s
72: learn: 0.4570799 total: 458ms remaining: 5.82s
73: learn: 0.4544728 total: 460ms remaining: 5.75s
74: learn: 0.4523672 total: 462ms remaining: 5.69s
75: learn: 0.4508176 total: 463ms remaining: 5.63s
76: learn: 0.4485706 total: 465ms remaining: 5.57s
77: learn: 0.4466729 total: 467ms remaining: 5.52s
78: learn: 0.4442026 total: 468ms remaining: 5.46s
79: learn: 0.4422229 total: 472ms remaining: 5.43s
80: learn: 0.4400619 total: 489ms remaining: 5.54s
81: learn: 0.4378678 total: 490ms remaining: 5.49s
82: learn: 0.4360144 total: 492ms remaining: 5.43s
83: learn: 0.4339450 total: 494ms remaining: 5.38s
84: learn: 0.4315778 total: 495ms remaining: 5.33s
85: learn: 0.4294147 total: 503ms remaining: 5.34s
86: learn: 0.4275919 total: 517ms remaining: 5.43s
87: learn: 0.4260777 total: 549ms remaining: 5.69s
88: learn: 0.4248401 total: 551ms remaining: 5.64s
89: learn: 0.4229251 total: 554ms remaining: 5.6s
90: learn: 0.4210058 total: 556ms remaining: 5.56s
91: learn: 0.4196785 total: 559ms remaining: 5.52s
92: learn: 0.4181639 total: 562ms remaining: 5.48s
93: learn: 0.4166692 total: 564ms remaining: 5.44s
94: learn: 0.4145676 total: 567ms remaining: 5.4s
95: learn: 0.4129131 total: 569ms remaining: 5.36s
96: learn: 0.4109451 total: 572ms remaining: 5.32s
97: learn: 0.4092651 total: 575ms remaining: 5.29s
98: learn: 0.4075184 total: 577ms remaining: 5.25s
99: learn: 0.4055949 total: 580ms remaining: 5.22s
100: learn: 0.4033997 total: 591ms remaining: 5.26s
101: learn: 0.4012633 total: 594ms remaining: 5.22s
102: learn: 0.3996595 total: 596ms remaining: 5.19s
103: learn: 0.3979938 total: 605ms remaining: 5.21s
104: learn: 0.3970822 total: 607ms remaining: 5.17s
105: learn: 0.3958252 total: 609ms remaining: 5.14s
106: learn: 0.3937881 total: 612ms remaining: 5.11s
```

```
107: learn: 0.3922971 total: 614ms remaining: 5.07s
108: learn: 0.3905009 total: 617ms remaining: 5.04s
109: learn: 0.3895438 total: 620ms remaining: 5.01s
110: learn: 0.3878676 total: 622ms remaining: 4.98s
111: learn: 0.3864267 total: 634ms remaining: 5.02s
112: learn: 0.3852074 total: 648ms remaining: 5.09s
113: learn: 0.3835888 total: 664ms remaining: 5.16s
114: learn: 0.3819575 total: 667ms remaining: 5.13s
115: learn: 0.3805860 total: 669ms remaining: 5.1s
116: learn: 0.3793423 total: 672ms remaining: 5.07s
117: learn: 0.3777554 total: 674ms remaining: 5.04s
118: learn: 0.3763097 total: 679ms remaining: 5.02s
119: learn: 0.3751944 total: 681ms remaining: 5s
120: learn: 0.3736991 total: 694ms remaining: 5.04s
121: learn: 0.3722878 total: 697ms remaining: 5.01s
122: learn: 0.3711786 total: 700ms remaining: 4.99s
123: learn: 0.3703069 total: 708ms remaining: 5s
124: learn: 0.3689998 total: 725ms remaining: 5.07s
125: learn: 0.3678362 total: 740ms remaining: 5.13s
126: learn: 0.3668695 total: 743ms remaining: 5.11s
127: learn: 0.3652150 total: 745ms remaining: 5.08s
128: learn: 0.3634025 total: 754ms remaining: 5.09s
129: learn: 0.3626268 total: 770ms remaining: 5.15s
130: learn: 0.3614756 total: 773ms remaining: 5.13s
131: learn: 0.3600327 total: 775ms remaining: 5.1s
132: learn: 0.3583964 total: 778ms remaining: 5.07s
133: learn: 0.3569134 total: 780ms remaining: 5.04s
134: learn: 0.3557337 total: 783ms remaining: 5.01s
135: learn: 0.3542699 total: 799ms remaining: 5.08s
136: learn: 0.3532005 total: 802ms remaining: 5.05s
137: learn: 0.3524781 total: 805ms remaining: 5.03s
138: learn: 0.3511214 total: 807ms remaining: 5s
139: learn: 0.3498638 total: 810ms remaining: 4.97s
140: learn: 0.3487041 total: 813ms remaining: 4.95s
141: learn: 0.3471589 total: 815ms remaining: 4.93s
142: learn: 0.3460661 total: 818ms remaining: 4.9s
143: learn: 0.3448743 total: 828ms remaining: 4.92s
144: learn: 0.3436375 total: 831ms remaining: 4.9s
145: learn: 0.3422676 total: 834ms remaining: 4.88s
146: learn: 0.3411872 total: 843ms remaining: 4.89s
147: learn: 0.3399777 total: 846ms remaining: 4.87s
148: learn: 0.3388042 total: 848ms remaining: 4.84s
149: learn: 0.3377851 total: 857ms remaining: 4.85s
150: learn: 0.3363248 total: 859ms remaining: 4.83s
151: learn: 0.3347559 total: 862ms remaining: 4.81s
152: learn: 0.3335414 total: 872ms remaining: 4.83s
153: learn: 0.3327523 total: 887ms remaining: 4.87s
154: learn: 0.3316337 total: 890ms remaining: 4.85s
155: learn: 0.3302606 total: 893ms remaining: 4.83s
156: learn: 0.3294434 total: 895ms remaining: 4.81s
157: learn: 0.3283040 total: 901ms remaining: 4.8s
158: learn: 0.3280792 total: 902ms remaining: 4.77s
159: learn: 0.3269144 total: 906ms remaining: 4.75s
160: learn: 0.3258060 total: 908ms remaining: 4.73s
161: learn: 0.3246605 total: 910ms remaining: 4.71s
162: learn: 0.3234930 total: 912ms remaining: 4.68s
163: learn: 0.3226457 total: 914ms remaining: 4.66s
164: learn: 0.3213475 total: 916ms remaining: 4.64s
165: learn: 0.3201285 total: 918ms remaining: 4.61s
166: learn: 0.3193573 total: 920ms remaining: 4.59s
167: learn: 0.3182892 total: 922ms remaining: 4.57s
168: learn: 0.3173274 total: 924ms remaining: 4.54s
169: learn: 0.3162406 total: 943ms remaining: 4.6s
170: learn: 0.3155965 total: 975ms remaining: 4.73s
171: learn: 0.3150709 total: 990ms remaining: 4.76s
172: learn: 0.3143065 total: 1.01s remaining: 4.81s
173: learn: 0.3132109 total: 1.02s remaining: 4.84s
174: learn: 0.3124941 total: 1.02s remaining: 4.82s
175: learn: 0.3111362 total: 1.02s remaining: 4.8s
176: learn: 0.3101630 total: 1.03s remaining: 4.78s
177: learn: 0.3091748 total: 1.03s remaining: 4.78s
178: learn: 0.3080298 total: 1.04s remaining: 4.76s
179: learn: 0.3071844 total: 1.04s remaining: 4.74s
180: learn: 0.3061256 total: 1.05s remaining: 4.74s
181: learn: 0.3052798 total: 1.06s remaining: 4.78s
182: learn: 0.3048523 total: 1.06s remaining: 4.75s
183: learn: 0.3036143 total: 1.07s remaining: 4.73s
```

```
184: learn: 0.3026898 total: 1.08s remaining: 4.75s
185: learn: 0.3018467 total: 1.08s remaining: 4.73s
186: learn: 0.3008251 total: 1.08s remaining: 4.71s
187: learn: 0.3000593 total: 1.09s remaining: 4.71s
188: learn: 0.2989356 total: 1.11s remaining: 4.75s
189: learn: 0.2983302 total: 1.11s remaining: 4.73s
190: learn: 0.2976581 total: 1.12s remaining: 4.75s
191: learn: 0.2969675 total: 1.14s remaining: 4.78s
192: learn: 0.2962201 total: 1.15s remaining: 4.82s
193: learn: 0.2955009 total: 1.15s remaining: 4.8s
194: learn: 0.2945761 total: 1.16s remaining: 4.78s
195: learn: 0.2939642 total: 1.16s remaining: 4.76s
196: learn: 0.2929670 total: 1.16s remaining: 4.74s
197: learn: 0.2923799 total: 1.17s remaining: 4.72s
198: learn: 0.2918708 total: 1.17s remaining: 4.7s
199: learn: 0.2910667 total: 1.18s remaining: 4.73s
200: learn: 0.2902461 total: 1.19s remaining: 4.71s
201: learn: 0.2891717 total: 1.19s remaining: 4.69s
202: learn: 0.2882066 total: 1.19s remaining: 4.67s
203: learn: 0.2875501 total: 1.19s remaining: 4.66s
204: learn: 0.2866587 total: 1.2s remaining: 4.64s
205: learn: 0.2858825 total: 1.2s remaining: 4.62s
206: learn: 0.2852388 total: 1.2s remaining: 4.6s
207: learn: 0.2843341 total: 1.2s remaining: 4.58s
208: learn: 0.2836931 total: 1.21s remaining: 4.56s
209: learn: 0.2828147 total: 1.21s remaining: 4.55s
210: learn: 0.2820582 total: 1.21s remaining: 4.53s
211: learn: 0.2809760 total: 1.21s remaining: 4.51s
212: learn: 0.2800379 total: 1.22s remaining: 4.52s
213: learn: 0.2794205 total: 1.23s remaining: 4.5s
214: learn: 0.2785943 total: 1.23s remaining: 4.48s
215: learn: 0.2778971 total: 1.23s remaining: 4.46s
216: learn: 0.2770610 total: 1.23s remaining: 4.44s
217: learn: 0.2761178 total: 1.23s remaining: 4.42s
218: learn: 0.2750994 total: 1.24s remaining: 4.4s
219: learn: 0.2743448 total: 1.24s remaining: 4.38s
220: learn: 0.2735066 total: 1.25s remaining: 4.42s
221: learn: 0.2725481 total: 1.25s remaining: 4.4s
222: learn: 0.2718579 total: 1.26s remaining: 4.38s
223: learn: 0.2711351 total: 1.27s remaining: 4.39s
224: learn: 0.2702300 total: 1.27s remaining: 4.37s
225: learn: 0.2694619 total: 1.27s remaining: 4.36s
226: learn: 0.2685756 total: 1.27s remaining: 4.34s
227: learn: 0.2677160 total: 1.27s remaining: 4.32s
228: learn: 0.2671308 total: 1.28s remaining: 4.3s
229: learn: 0.2664703 total: 1.28s remaining: 4.28s
230: learn: 0.2656404 total: 1.28s remaining: 4.26s
231: learn: 0.2649451 total: 1.28s remaining: 4.24s
232: learn: 0.2642455 total: 1.28s remaining: 4.23s
233: learn: 0.2632920 total: 1.29s remaining: 4.24s
234: learn: 0.2623719 total: 1.3s remaining: 4.22s
235: learn: 0.2614807 total: 1.3s remaining: 4.21s
236: learn: 0.2608173 total: 1.3s remaining: 4.19s
237: learn: 0.2602292 total: 1.31s remaining: 4.2s
238: learn: 0.2594378 total: 1.31s remaining: 4.18s
239: learn: 0.2585498 total: 1.31s remaining: 4.16s
240: learn: 0.2577198 total: 1.33s remaining: 4.18s
241: learn: 0.2572097 total: 1.33s remaining: 4.16s
242: learn: 0.2566032 total: 1.34s remaining: 4.18s
243: learn: 0.2560340 total: 1.34s remaining: 4.16s
244: learn: 0.2555359 total: 1.34s remaining: 4.14s
245: learn: 0.2551252 total: 1.35s remaining: 4.13s
246: learn: 0.2544288 total: 1.35s remaining: 4.13s
247: learn: 0.2537716 total: 1.37s remaining: 4.16s
248: learn: 0.2530771 total: 1.37s remaining: 4.14s
249: learn: 0.2525142 total: 1.37s remaining: 4.12s
250: learn: 0.2519426 total: 1.38s remaining: 4.11s
251: learn: 0.2514972 total: 1.38s remaining: 4.09s
252: learn: 0.2507490 total: 1.38s remaining: 4.07s
253: learn: 0.2500621 total: 1.38s remaining: 4.06s
254: learn: 0.2494006 total: 1.38s remaining: 4.04s
255: learn: 0.2487060 total: 1.38s remaining: 4.02s
256: learn: 0.2480009 total: 1.39s remaining: 4.01s
257: learn: 0.2474913 total: 1.39s remaining: 3.99s
258: learn: 0.2468807 total: 1.39s remaining: 3.98s
259: learn: 0.2464421 total: 1.39s remaining: 3.96s
260: learn: 0.2458941 total: 1.39s remaining: 3.95s
```

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261: learn: 0.2455131 total: 1.4s remaining: 3.94s
262: learn: 0.2448020 total: 1.4s remaining: 3.93s
263: learn: 0.2440961 total: 1.4s remaining: 3.91s
264: learn: 0.2433821 total: 1.4s remaining: 3.9s
265: learn: 0.2427055 total: 1.41s remaining: 3.88s
266: learn: 0.2421721 total: 1.41s remaining: 3.87s
267: learn: 0.2414986 total: 1.41s remaining: 3.85s
268: learn: 0.2409023 total: 1.41s remaining: 3.84s
269: learn: 0.2402697 total: 1.41s remaining: 3.82s
270: learn: 0.2396409 total: 1.44s remaining: 3.88s
271: learn: 0.2393521 total: 1.46s remaining: 3.9s
272: learn: 0.2390779 total: 1.46s remaining: 3.89s
273: learn: 0.2385949 total: 1.46s remaining: 3.88s
274: learn: 0.2381010 total: 1.47s remaining: 3.86s
275: learn: 0.2376267 total: 1.47s remaining: 3.85s
276: learn: 0.2371087 total: 1.47s remaining: 3.84s
277: learn: 0.2367187 total: 1.47s remaining: 3.83s
278: learn: 0.2360190 total: 1.48s remaining: 3.81s
279: learn: 0.2353147 total: 1.48s remaining: 3.8s
280: learn: 0.2347209 total: 1.49s remaining: 3.81s
281: learn: 0.2341700 total: 1.49s remaining: 3.8s
282: learn: 0.2336005 total: 1.5s remaining: 3.81s
283: learn: 0.2327998 total: 1.51s remaining: 3.8s
284: learn: 0.2321134 total: 1.51s remaining: 3.79s
285: learn: 0.2313814 total: 1.51s remaining: 3.77s
286: learn: 0.2307907 total: 1.52s remaining: 3.77s
287: learn: 0.2303410 total: 1.53s remaining: 3.79s
288: learn: 0.2296068 total: 1.54s remaining: 3.78s
289: learn: 0.2292061 total: 1.55s remaining: 3.79s
290: learn: 0.2285338 total: 1.56s remaining: 3.81s
291: learn: 0.2282066 total: 1.56s remaining: 3.79s
292: learn: 0.2278309 total: 1.57s remaining: 3.78s
293: learn: 0.2272472 total: 1.57s remaining: 3.77s
294: learn: 0.2267563 total: 1.58s remaining: 3.77s
295: learn: 0.2261674 total: 1.58s remaining: 3.76s
296: learn: 0.2258753 total: 1.58s remaining: 3.75s
297: learn: 0.2253914 total: 1.59s remaining: 3.74s
298: learn: 0.2248686 total: 1.59s remaining: 3.72s
299: learn: 0.2244408 total: 1.59s remaining: 3.71s
300: learn: 0.2239142 total: 1.59s remaining: 3.7s
301: learn: 0.2234512 total: 1.6s remaining: 3.69s
302: learn: 0.2227931 total: 1.6s remaining: 3.68s
303: learn: 0.2224314 total: 1.6s remaining: 3.67s
304: learn: 0.2217432 total: 1.6s remaining: 3.66s
305: learn: 0.2213618 total: 1.62s remaining: 3.68s
306: learn: 0.2207828 total: 1.62s remaining: 3.67s
307: learn: 0.2201699 total: 1.64s remaining: 3.67s
308: learn: 0.2196012 total: 1.64s remaining: 3.66s
309: learn: 0.2190345 total: 1.65s remaining: 3.67s
310: learn: 0.2185309 total: 1.65s remaining: 3.66s
311: learn: 0.2179583 total: 1.66s remaining: 3.65s
312: learn: 0.2173680 total: 1.67s remaining: 3.65s
313: learn: 0.2168128 total: 1.68s remaining: 3.67s
314: learn: 0.2161800 total: 1.68s remaining: 3.66s
315: learn: 0.2155696 total: 1.7s remaining: 3.67s
316: learn: 0.2153411 total: 1.7s remaining: 3.66s
317: learn: 0.2149732 total: 1.7s remaining: 3.65s
318: learn: 0.2146285 total: 1.71s remaining: 3.65s
319: learn: 0.2140961 total: 1.71s remaining: 3.64s
320: learn: 0.2136051 total: 1.73s remaining: 3.65s
321: learn: 0.2130642 total: 1.74s remaining: 3.67s
322: learn: 0.2125622 total: 1.74s remaining: 3.66s
323: learn: 0.2119692 total: 1.75s remaining: 3.64s
324: learn: 0.2116797 total: 1.75s remaining: 3.63s
325: learn: 0.2111853 total: 1.75s remaining: 3.62s
326: learn: 0.2108498 total: 1.75s remaining: 3.61s
327: learn: 0.2106649 total: 1.77s remaining: 3.63s
328: learn: 0.2101287 total: 1.79s remaining: 3.64s
329: learn: 0.2099477 total: 1.8s remaining: 3.66s
330: learn: 0.2094671 total: 1.8s remaining: 3.65s
331: learn: 0.2090782 total: 1.81s remaining: 3.64s
332: learn: 0.2087186 total: 1.82s remaining: 3.64s
333: learn: 0.2082720 total: 1.83s remaining: 3.65s
334: learn: 0.2076473 total: 1.83s remaining: 3.64s
335: learn: 0.2071865 total: 1.84s remaining: 3.63s
336: learn: 0.2067050 total: 1.84s remaining: 3.62s
337: learn: 0.2064919 total: 1.84s remaining: 3.61s
```

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338:	learn: 0.2060672	total: 1.85s	remaining: 3.6s
339:	learn: 0.2057119	total: 1.85s	remaining: 3.59s
340:	learn: 0.2053542	total: 1.86s	remaining: 3.6s
341:	learn: 0.2049349	total: 1.86s	remaining: 3.58s
342:	learn: 0.2044188	total: 1.88s	remaining: 3.59s
343:	learn: 0.2041798	total: 1.88s	remaining: 3.58s
344:	learn: 0.2037598	total: 1.89s	remaining: 3.59s
345:	learn: 0.2033624	total: 1.89s	remaining: 3.58s
346:	learn: 0.2026727	total: 1.9s	remaining: 3.57s
347:	learn: 0.2022688	total: 1.9s	remaining: 3.56s
348:	learn: 0.2017553	total: 1.9s	remaining: 3.55s
349:	learn: 0.2012069	total: 1.9s	remaining: 3.54s
350:	learn: 0.2006705	total: 1.91s	remaining: 3.53s
351:	learn: 0.2003209	total: 1.92s	remaining: 3.54s
352:	learn: 0.1999425	total: 1.92s	remaining: 3.53s
353:	learn: 0.1998487	total: 1.94s	remaining: 3.53s
354:	learn: 0.1994505	total: 1.94s	remaining: 3.52s
355:	learn: 0.1991507	total: 1.94s	remaining: 3.51s
356:	learn: 0.1987637	total: 1.94s	remaining: 3.5s
357:	learn: 0.1984542	total: 1.95s	remaining: 3.5s
358:	learn: 0.1980046	total: 1.95s	remaining: 3.49s
359:	learn: 0.1978061	total: 1.96s	remaining: 3.48s
360:	learn: 0.1973109	total: 1.96s	remaining: 3.47s
361:	learn: 0.1968702	total: 1.96s	remaining: 3.46s
362:	learn: 0.1965398	total: 1.97s	remaining: 3.45s
363:	learn: 0.1962352	total: 1.97s	remaining: 3.44s
364:	learn: 0.1960415	total: 1.97s	remaining: 3.43s
365:	learn: 0.1954809	total: 1.98s	remaining: 3.43s
366:	learn: 0.1950410	total: 2s	remaining: 3.44s
367:	learn: 0.1945756	total: 2.01s	remaining: 3.46s
368:	learn: 0.1940087	total: 2.01s	remaining: 3.44s
369:	learn: 0.1934202	total: 2.02s	remaining: 3.43s
370:	learn: 0.1929106	total: 2.02s	remaining: 3.42s
371:	learn: 0.1925121	total: 2.03s	remaining: 3.42s
372:	learn: 0.1922408	total: 2.04s	remaining: 3.43s
373:	learn: 0.1918566	total: 2.04s	remaining: 3.42s
374:	learn: 0.1913916	total: 2.05s	remaining: 3.41s
375:	learn: 0.1912119	total: 2.06s	remaining: 3.41s
376:	learn: 0.1907911	total: 2.07s	remaining: 3.43s
377:	learn: 0.1903402	total: 2.08s	remaining: 3.42s
378:	learn: 0.1900420	total: 2.08s	remaining: 3.4s
379:	learn: 0.1897729	total: 2.09s	remaining: 3.41s
380:	learn: 0.1894480	total: 2.09s	remaining: 3.4s
381:	learn: 0.1891934	total: 2.09s	remaining: 3.39s
382:	learn: 0.1890370	total: 2.1s	remaining: 3.39s
383:	learn: 0.1887407	total: 2.12s	remaining: 3.4s
384:	learn: 0.1885308	total: 2.12s	remaining: 3.39s
385:	learn: 0.1881633	total: 2.12s	remaining: 3.38s
386:	learn: 0.1878301	total: 2.13s	remaining: 3.37s
387:	learn: 0.1875925	total: 2.13s	remaining: 3.36s
388:	learn: 0.1873024	total: 2.13s	remaining: 3.35s
389:	learn: 0.1872034	total: 2.13s	remaining: 3.34s
390:	learn: 0.1868751	total: 2.14s	remaining: 3.33s
391:	learn: 0.1865655	total: 2.14s	remaining: 3.32s
392:	learn: 0.1862363	total: 2.14s	remaining: 3.31s
393:	learn: 0.1861657	total: 2.15s	remaining: 3.3s
394:	learn: 0.1857669	total: 2.15s	remaining: 3.29s
395:	learn: 0.1854657	total: 2.15s	remaining: 3.28s
396:	learn: 0.1851786	total: 2.15s	remaining: 3.27s
397:	learn: 0.1848857	total: 2.15s	remaining: 3.26s
398:	learn: 0.1845225	total: 2.16s	remaining: 3.25s
399:	learn: 0.1842814	total: 2.16s	remaining: 3.24s
400:	learn: 0.1841090	total: 2.16s	remaining: 3.23s
401:	learn: 0.1837805	total: 2.16s	remaining: 3.21s
402:	learn: 0.1835428	total: 2.16s	remaining: 3.21s
403:	learn: 0.1832833	total: 2.17s	remaining: 3.21s
404:	learn: 0.1829562	total: 2.18s	remaining: 3.2s
405:	learn: 0.1826366	total: 2.18s	remaining: 3.19s
406:	learn: 0.1822966	total: 2.18s	remaining: 3.18s
407:	learn: 0.1820004	total: 2.18s	remaining: 3.17s
408:	learn: 0.1815328	total: 2.18s	remaining: 3.16s
409:	learn: 0.1815136	total: 2.19s	remaining: 3.15s
410:	learn: 0.1810717	total: 2.19s	remaining: 3.14s
411:	learn: 0.1807126	total: 2.19s	remaining: 3.13s
412:	learn: 0.1805226	total: 2.21s	remaining: 3.13s
413:	learn: 0.1802180	total: 2.21s	remaining: 3.12s
414:	learn: 0.1799892	total: 2.21s	remaining: 3.11s
```

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415: learn: 0.1798310 total: 2.21s remaining: 3.1s
416: learn: 0.1796299 total: 2.21s remaining: 3.09s
417: learn: 0.1793580 total: 2.21s remaining: 3.08s
418: learn: 0.1791330 total: 2.21s remaining: 3.07s
419: learn: 0.1789082 total: 2.22s remaining: 3.06s
420: learn: 0.1784160 total: 2.22s remaining: 3.05s
421: learn: 0.1781616 total: 2.22s remaining: 3.04s
422: learn: 0.1777913 total: 2.22s remaining: 3.03s
423: learn: 0.1774367 total: 2.23s remaining: 3.03s
424: learn: 0.1772563 total: 2.23s remaining: 3.02s
425: learn: 0.1767529 total: 2.24s remaining: 3.01s
426: learn: 0.1762989 total: 2.24s remaining: 3s
427: learn: 0.1759054 total: 2.24s remaining: 2.99s
428: learn: 0.1755432 total: 2.24s remaining: 2.98s
429: learn: 0.1752061 total: 2.24s remaining: 2.97s
430: learn: 0.1748871 total: 2.24s remaining: 2.96s
431: learn: 0.1745216 total: 2.25s remaining: 2.95s
432: learn: 0.1741888 total: 2.25s remaining: 2.94s
433: learn: 0.1739105 total: 2.25s remaining: 2.93s
434: learn: 0.1735464 total: 2.26s remaining: 2.94s
435: learn: 0.1731510 total: 2.28s remaining: 2.95s
436: learn: 0.1729498 total: 2.29s remaining: 2.96s
437: learn: 0.1726977 total: 2.3s remaining: 2.95s
438: learn: 0.1723137 total: 2.3s remaining: 2.94s
439: learn: 0.1719810 total: 2.3s remaining: 2.93s
440: learn: 0.1715581 total: 2.3s remaining: 2.92s
441: learn: 0.1712841 total: 2.3s remaining: 2.91s
442: learn: 0.1710462 total: 2.31s remaining: 2.9s
443: learn: 0.1707052 total: 2.31s remaining: 2.89s
444: learn: 0.1704342 total: 2.31s remaining: 2.88s
445: learn: 0.1700751 total: 2.31s remaining: 2.87s
446: learn: 0.1698048 total: 2.31s remaining: 2.86s
447: learn: 0.1694823 total: 2.32s remaining: 2.86s
448: learn: 0.1692414 total: 2.33s remaining: 2.85s
449: learn: 0.1689229 total: 2.33s remaining: 2.84s
450: learn: 0.1685308 total: 2.34s remaining: 2.85s
451: learn: 0.1681607 total: 2.34s remaining: 2.84s
452: learn: 0.1678037 total: 2.34s remaining: 2.83s
453: learn: 0.1675758 total: 2.34s remaining: 2.82s
454: learn: 0.1672479 total: 2.35s remaining: 2.82s
455: learn: 0.1669239 total: 2.37s remaining: 2.82s
456: learn: 0.1666380 total: 2.38s remaining: 2.83s
457: learn: 0.1665531 total: 2.38s remaining: 2.82s
458: learn: 0.1662289 total: 2.39s remaining: 2.81s
459: learn: 0.1658190 total: 2.39s remaining: 2.8s
460: learn: 0.1656189 total: 2.4s remaining: 2.8s
461: learn: 0.1654419 total: 2.4s remaining: 2.79s
462: learn: 0.1652218 total: 2.4s remaining: 2.79s
463: learn: 0.1650191 total: 2.4s remaining: 2.78s
464: learn: 0.1645709 total: 2.41s remaining: 2.77s
465: learn: 0.1643409 total: 2.41s remaining: 2.76s
466: learn: 0.1639642 total: 2.43s remaining: 2.77s
467: learn: 0.1636044 total: 2.43s remaining: 2.76s
468: learn: 0.1633145 total: 2.44s remaining: 2.77s
469: learn: 0.1631587 total: 2.44s remaining: 2.76s
470: learn: 0.1629920 total: 2.46s remaining: 2.76s
471: learn: 0.1628070 total: 2.46s remaining: 2.75s
472: learn: 0.1626284 total: 2.47s remaining: 2.76s
473: learn: 0.1624071 total: 2.48s remaining: 2.75s
474: learn: 0.1621269 total: 2.48s remaining: 2.74s
475: learn: 0.1620395 total: 2.48s remaining: 2.73s
476: learn: 0.1617750 total: 2.49s remaining: 2.73s
477: learn: 0.1616094 total: 2.5s remaining: 2.73s
478: learn: 0.1614199 total: 2.52s remaining: 2.74s
479: learn: 0.1610153 total: 2.53s remaining: 2.74s
480: learn: 0.1608100 total: 2.55s remaining: 2.75s
481: learn: 0.1605883 total: 2.56s remaining: 2.75s
482: learn: 0.1603577 total: 2.58s remaining: 2.76s
483: learn: 0.1600964 total: 2.58s remaining: 2.75s
484: learn: 0.1596603 total: 2.58s remaining: 2.74s
485: learn: 0.1592941 total: 2.58s remaining: 2.73s
486: learn: 0.1590544 total: 2.59s remaining: 2.73s
487: learn: 0.1587609 total: 2.59s remaining: 2.72s
488: learn: 0.1584930 total: 2.61s remaining: 2.73s
489: learn: 0.1580927 total: 2.61s remaining: 2.72s
490: learn: 0.1578840 total: 2.61s remaining: 2.71s
491: learn: 0.1576102 total: 2.62s remaining: 2.7s
```

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492: learn: 0.1575270 total: 2.62s remaining: 2.7s
493: learn: 0.1573694 total: 2.62s remaining: 2.69s
494: learn: 0.1570900 total: 2.63s remaining: 2.68s
495: learn: 0.1568133 total: 2.64s remaining: 2.68s
496: learn: 0.1565616 total: 2.65s remaining: 2.69s
497: learn: 0.1562193 total: 2.65s remaining: 2.68s
498: learn: 0.1559279 total: 2.67s remaining: 2.68s
499: learn: 0.1557538 total: 2.68s remaining: 2.68s
500: learn: 0.1554740 total: 2.69s remaining: 2.67s
501: learn: 0.1552780 total: 2.7s remaining: 2.68s
502: learn: 0.1550581 total: 2.71s remaining: 2.68s
503: learn: 0.1548184 total: 2.73s remaining: 2.69s
504: learn: 0.1545479 total: 2.73s remaining: 2.68s
505: learn: 0.1541865 total: 2.75s remaining: 2.68s
506: learn: 0.1538905 total: 2.75s remaining: 2.67s
507: learn: 0.1537422 total: 2.75s remaining: 2.66s
508: learn: 0.1534966 total: 2.75s remaining: 2.65s
509: learn: 0.1531872 total: 2.76s remaining: 2.65s
510: learn: 0.1529701 total: 2.76s remaining: 2.64s
511: learn: 0.1528191 total: 2.76s remaining: 2.63s
512: learn: 0.1525704 total: 2.77s remaining: 2.63s
513: learn: 0.1524917 total: 2.77s remaining: 2.62s
514: learn: 0.1524379 total: 2.77s remaining: 2.61s
515: learn: 0.1521981 total: 2.78s remaining: 2.6s
516: learn: 0.1518488 total: 2.79s remaining: 2.6s
517: learn: 0.1515936 total: 2.79s remaining: 2.6s
518: learn: 0.1514004 total: 2.79s remaining: 2.59s
519: learn: 0.1511936 total: 2.8s remaining: 2.59s
520: learn: 0.1510175 total: 2.8s remaining: 2.58s
521: learn: 0.1508608 total: 2.81s remaining: 2.57s
522: learn: 0.1506144 total: 2.82s remaining: 2.57s
523: learn: 0.1504424 total: 2.83s remaining: 2.57s
524: learn: 0.1501757 total: 2.83s remaining: 2.56s
525: learn: 0.1500005 total: 2.84s remaining: 2.56s
526: learn: 0.1497868 total: 2.84s remaining: 2.55s
527: learn: 0.1496170 total: 2.84s remaining: 2.54s
528: learn: 0.1492922 total: 2.84s remaining: 2.53s
529: learn: 0.1490430 total: 2.85s remaining: 2.52s
530: learn: 0.1488404 total: 2.85s remaining: 2.52s
531: learn: 0.1487527 total: 2.85s remaining: 2.51s
532: learn: 0.1484247 total: 2.86s remaining: 2.51s
533: learn: 0.1482827 total: 2.86s remaining: 2.5s
534: learn: 0.1479833 total: 2.87s remaining: 2.49s
535: learn: 0.1477147 total: 2.87s remaining: 2.48s
536: learn: 0.1475727 total: 2.88s remaining: 2.48s
537: learn: 0.1472707 total: 2.89s remaining: 2.48s
538: learn: 0.1469898 total: 2.91s remaining: 2.49s
539: learn: 0.1469012 total: 2.92s remaining: 2.49s
540: learn: 0.1466536 total: 2.93s remaining: 2.48s
541: learn: 0.1464412 total: 2.94s remaining: 2.48s
542: learn: 0.1461472 total: 2.94s remaining: 2.48s
543: learn: 0.1458816 total: 2.94s remaining: 2.47s
544: learn: 0.1456686 total: 2.95s remaining: 2.47s
545: learn: 0.1455733 total: 2.96s remaining: 2.46s
546: learn: 0.1454427 total: 2.96s remaining: 2.45s
547: learn: 0.1452549 total: 2.97s remaining: 2.45s
548: learn: 0.1449846 total: 2.97s remaining: 2.44s
549: learn: 0.1447443 total: 2.98s remaining: 2.44s
550: learn: 0.1444562 total: 3s remaining: 2.44s
551: learn: 0.1442562 total: 3s remaining: 2.44s
552: learn: 0.1440083 total: 3.01s remaining: 2.44s
553: learn: 0.1437983 total: 3.03s remaining: 2.44s
554: learn: 0.1436521 total: 3.04s remaining: 2.44s
555: learn: 0.1434172 total: 3.04s remaining: 2.43s
556: learn: 0.1430921 total: 3.05s remaining: 2.42s
557: learn: 0.1429362 total: 3.06s remaining: 2.42s
558: learn: 0.1427443 total: 3.07s remaining: 2.42s
559: learn: 0.1424927 total: 3.08s remaining: 2.42s
560: learn: 0.1422024 total: 3.08s remaining: 2.41s
561: learn: 0.1420063 total: 3.08s remaining: 2.4s
562: learn: 0.1418890 total: 3.09s remaining: 2.4s
563: learn: 0.1417115 total: 3.09s remaining: 2.39s
564: learn: 0.1414982 total: 3.09s remaining: 2.38s
565: learn: 0.1413506 total: 3.1s remaining: 2.37s
566: learn: 0.1412939 total: 3.1s remaining: 2.36s
567: learn: 0.1411668 total: 3.1s remaining: 2.36s
568: learn: 0.1409302 total: 3.1s remaining: 2.35s
```

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569: learn: 0.1407631 total: 3.1s remaining: 2.34s
570: learn: 0.1404992 total: 3.1s remaining: 2.33s
571: learn: 0.1403705 total: 3.11s remaining: 2.32s
572: learn: 0.1400939 total: 3.11s remaining: 2.32s
573: learn: 0.1399011 total: 3.12s remaining: 2.31s
574: learn: 0.1395830 total: 3.12s remaining: 2.3s
575: learn: 0.1392610 total: 3.12s remaining: 2.3s
576: learn: 0.1390618 total: 3.12s remaining: 2.29s
577: learn: 0.1388807 total: 3.12s remaining: 2.28s
578: learn: 0.1387099 total: 3.13s remaining: 2.27s
579: learn: 0.1385441 total: 3.13s remaining: 2.26s
580: learn: 0.1383834 total: 3.13s remaining: 2.26s
581: learn: 0.1381288 total: 3.14s remaining: 2.26s
582: learn: 0.1379208 total: 3.15s remaining: 2.25s
583: learn: 0.1377783 total: 3.16s remaining: 2.25s
584: learn: 0.1376382 total: 3.17s remaining: 2.25s
585: learn: 0.1374515 total: 3.18s remaining: 2.24s
586: learn: 0.1372061 total: 3.18s remaining: 2.23s
587: learn: 0.1368675 total: 3.18s remaining: 2.23s
588: learn: 0.1366274 total: 3.18s remaining: 2.22s
589: learn: 0.1364223 total: 3.18s remaining: 2.21s
590: learn: 0.1361558 total: 3.18s remaining: 2.2s
591: learn: 0.1358448 total: 3.19s remaining: 2.2s
592: learn: 0.1356753 total: 3.19s remaining: 2.19s
593: learn: 0.1353834 total: 3.19s remaining: 2.18s
594: learn: 0.1351423 total: 3.19s remaining: 2.17s
595: learn: 0.1349756 total: 3.19s remaining: 2.17s
596: learn: 0.1347610 total: 3.2s remaining: 2.16s
597: learn: 0.1344757 total: 3.2s remaining: 2.15s
598: learn: 0.1343467 total: 3.2s remaining: 2.14s
599: learn: 0.1341521 total: 3.2s remaining: 2.14s
600: learn: 0.1340017 total: 3.21s remaining: 2.13s
601: learn: 0.1338290 total: 3.21s remaining: 2.12s
602: learn: 0.1337151 total: 3.21s remaining: 2.11s
603: learn: 0.1335279 total: 3.21s remaining: 2.1s
604: learn: 0.1333950 total: 3.21s remaining: 2.1s
605: learn: 0.1331945 total: 3.22s remaining: 2.09s
606: learn: 0.1329806 total: 3.23s remaining: 2.09s
607: learn: 0.1327326 total: 3.23s remaining: 2.08s
608: learn: 0.1325353 total: 3.25s remaining: 2.08s
609: learn: 0.1323797 total: 3.25s remaining: 2.08s
610: learn: 0.1321970 total: 3.26s remaining: 2.08s
611: learn: 0.1318798 total: 3.27s remaining: 2.07s
612: learn: 0.1316607 total: 3.27s remaining: 2.06s
613: learn: 0.1315416 total: 3.27s remaining: 2.06s
614: learn: 0.1313000 total: 3.27s remaining: 2.05s
615: learn: 0.1311540 total: 3.28s remaining: 2.04s
616: learn: 0.1308344 total: 3.28s remaining: 2.04s
617: learn: 0.1305890 total: 3.28s remaining: 2.03s
618: learn: 0.1303363 total: 3.29s remaining: 2.02s
619: learn: 0.1302431 total: 3.29s remaining: 2.01s
620: learn: 0.1300723 total: 3.29s remaining: 2.01s
621: learn: 0.1299876 total: 3.29s remaining: 2s
622: learn: 0.1297745 total: 3.29s remaining: 1.99s
623: learn: 0.1295824 total: 3.31s remaining: 1.99s
624: learn: 0.1293627 total: 3.31s remaining: 1.98s
625: learn: 0.1291973 total: 3.32s remaining: 1.98s
626: learn: 0.1290279 total: 3.32s remaining: 1.98s
627: learn: 0.1288924 total: 3.32s remaining: 1.97s
628: learn: 0.1286317 total: 3.33s remaining: 1.97s
629: learn: 0.1285787 total: 3.34s remaining: 1.96s
630: learn: 0.1284415 total: 3.34s remaining: 1.95s
631: learn: 0.1282343 total: 3.34s remaining: 1.94s
632: learn: 0.1280612 total: 3.34s remaining: 1.94s
633: learn: 0.1279147 total: 3.34s remaining: 1.93s
634: learn: 0.1276518 total: 3.35s remaining: 1.92s
635: learn: 0.1274697 total: 3.35s remaining: 1.92s
636: learn: 0.1271936 total: 3.35s remaining: 1.91s
637: learn: 0.1269355 total: 3.36s remaining: 1.91s
638: learn: 0.1267258 total: 3.37s remaining: 1.9s
639: learn: 0.1265696 total: 3.37s remaining: 1.89s
640: learn: 0.1263628 total: 3.37s remaining: 1.89s
641: learn: 0.1261229 total: 3.38s remaining: 1.88s
642: learn: 0.1258481 total: 3.38s remaining: 1.88s
643: learn: 0.1255403 total: 3.38s remaining: 1.87s
644: learn: 0.1253636 total: 3.39s remaining: 1.87s
645: learn: 0.1252231 total: 3.4s remaining: 1.86s
```

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646: learn: 0.1249901 total: 3.4s remaining: 1.85s
647: learn: 0.1248544 total: 3.4s remaining: 1.85s
648: learn: 0.1245622 total: 3.41s remaining: 1.84s
649: learn: 0.1243624 total: 3.41s remaining: 1.83s
650: learn: 0.1241670 total: 3.42s remaining: 1.83s
651: learn: 0.1240070 total: 3.44s remaining: 1.83s
652: learn: 0.1238309 total: 3.44s remaining: 1.83s
653: learn: 0.1236796 total: 3.44s remaining: 1.82s
654: learn: 0.1235821 total: 3.44s remaining: 1.81s
655: learn: 0.1234876 total: 3.45s remaining: 1.81s
656: learn: 0.1233552 total: 3.47s remaining: 1.81s
657: learn: 0.1231306 total: 3.47s remaining: 1.8s
658: learn: 0.1229195 total: 3.47s remaining: 1.8s
659: learn: 0.1227602 total: 3.48s remaining: 1.79s
660: learn: 0.1225676 total: 3.48s remaining: 1.78s
661: learn: 0.1223672 total: 3.48s remaining: 1.78s
662: learn: 0.1222618 total: 3.49s remaining: 1.77s
663: learn: 0.1221478 total: 3.49s remaining: 1.77s
664: learn: 0.1219224 total: 3.5s remaining: 1.76s
665: learn: 0.1216924 total: 3.51s remaining: 1.76s
666: learn: 0.1215572 total: 3.52s remaining: 1.75s
667: learn: 0.1213452 total: 3.52s remaining: 1.75s
668: learn: 0.1211723 total: 3.53s remaining: 1.75s
669: learn: 0.1209530 total: 3.53s remaining: 1.74s
670: learn: 0.1207445 total: 3.54s remaining: 1.74s
671: learn: 0.1206185 total: 3.54s remaining: 1.73s
672: learn: 0.1205688 total: 3.56s remaining: 1.73s
673: learn: 0.1203860 total: 3.56s remaining: 1.72s
674: learn: 0.1202195 total: 3.57s remaining: 1.72s
675: learn: 0.1201285 total: 3.59s remaining: 1.72s
676: learn: 0.1199977 total: 3.6s remaining: 1.72s
677: learn: 0.1198664 total: 3.62s remaining: 1.72s
678: learn: 0.1196759 total: 3.62s remaining: 1.71s
679: learn: 0.1194787 total: 3.62s remaining: 1.7s
680: learn: 0.1192495 total: 3.63s remaining: 1.7s
681: learn: 0.1191394 total: 3.63s remaining: 1.69s
682: learn: 0.1190073 total: 3.65s remaining: 1.69s
683: learn: 0.1188606 total: 3.65s remaining: 1.69s
684: learn: 0.1187069 total: 3.65s remaining: 1.68s
685: learn: 0.1185372 total: 3.65s remaining: 1.67s
686: learn: 0.1183119 total: 3.66s remaining: 1.67s
687: learn: 0.1181830 total: 3.66s remaining: 1.66s
688: learn: 0.1179803 total: 3.66s remaining: 1.65s
689: learn: 0.1177671 total: 3.67s remaining: 1.65s
690: learn: 0.1176239 total: 3.67s remaining: 1.64s
691: learn: 0.1175035 total: 3.67s remaining: 1.64s
692: learn: 0.1172764 total: 3.68s remaining: 1.63s
693: learn: 0.1171253 total: 3.69s remaining: 1.63s
694: learn: 0.1168919 total: 3.71s remaining: 1.63s
695: learn: 0.1167582 total: 3.71s remaining: 1.62s
696: learn: 0.1165076 total: 3.72s remaining: 1.62s
697: learn: 0.1163612 total: 3.72s remaining: 1.61s
698: learn: 0.1162196 total: 3.73s remaining: 1.61s
699: learn: 0.1160414 total: 3.74s remaining: 1.6s
700: learn: 0.1158486 total: 3.74s remaining: 1.59s
701: learn: 0.1158067 total: 3.74s remaining: 1.59s
702: learn: 0.1157243 total: 3.75s remaining: 1.58s
703: learn: 0.1155459 total: 3.75s remaining: 1.58s
704: learn: 0.1153505 total: 3.75s remaining: 1.57s
705: learn: 0.1152101 total: 3.76s remaining: 1.57s
706: learn: 0.1150762 total: 3.78s remaining: 1.57s
707: learn: 0.1149149 total: 3.79s remaining: 1.56s
708: learn: 0.1147579 total: 3.81s remaining: 1.56s
709: learn: 0.1146365 total: 3.81s remaining: 1.56s
710: learn: 0.1144544 total: 3.81s remaining: 1.55s
711: learn: 0.1143353 total: 3.83s remaining: 1.55s
712: learn: 0.1141579 total: 3.83s remaining: 1.54s
713: learn: 0.1140995 total: 3.83s remaining: 1.53s
714: learn: 0.1139940 total: 3.84s remaining: 1.53s
715: learn: 0.1137905 total: 3.84s remaining: 1.52s
716: learn: 0.1136698 total: 3.85s remaining: 1.52s
717: learn: 0.1135294 total: 3.86s remaining: 1.51s
718: learn: 0.1135168 total: 3.87s remaining: 1.51s
719: learn: 0.1133485 total: 3.88s remaining: 1.51s
720: learn: 0.1132027 total: 3.89s remaining: 1.5s
721: learn: 0.1130973 total: 3.92s remaining: 1.51s
722: learn: 0.1129409 total: 3.93s remaining: 1.5s
```

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723: learn: 0.1128771 total: 3.94s remaining: 1.5s
724: learn: 0.1127127 total: 3.95s remaining: 1.5s
725: learn: 0.1125528 total: 3.95s remaining: 1.49s
726: learn: 0.1123635 total: 3.95s remaining: 1.48s
727: learn: 0.1122947 total: 3.96s remaining: 1.48s
728: learn: 0.1121683 total: 3.96s remaining: 1.47s
729: learn: 0.1120924 total: 3.96s remaining: 1.47s
730: learn: 0.1119046 total: 3.97s remaining: 1.46s
731: learn: 0.1118059 total: 3.97s remaining: 1.45s
732: learn: 0.1115956 total: 3.98s remaining: 1.45s
733: learn: 0.1113769 total: 3.98s remaining: 1.44s
734: learn: 0.1111403 total: 3.98s remaining: 1.44s
735: learn: 0.1110170 total: 3.98s remaining: 1.43s
736: learn: 0.1107997 total: 3.99s remaining: 1.42s
737: learn: 0.1107079 total: 4s remaining: 1.42s
738: learn: 0.1105460 total: 4s remaining: 1.41s
739: learn: 0.1103738 total: 4.02s remaining: 1.41s
740: learn: 0.1101810 total: 4.04s remaining: 1.41s
741: learn: 0.1100096 total: 4.04s remaining: 1.4s
742: learn: 0.1098515 total: 4.04s remaining: 1.4s
743: learn: 0.1096947 total: 4.04s remaining: 1.39s
744: learn: 0.1095156 total: 4.04s remaining: 1.38s
745: learn: 0.1094258 total: 4.05s remaining: 1.38s
746: learn: 0.1093015 total: 4.05s remaining: 1.37s
747: learn: 0.1091448 total: 4.05s remaining: 1.36s
748: learn: 0.1090467 total: 4.05s remaining: 1.36s
749: learn: 0.1088853 total: 4.06s remaining: 1.35s
750: learn: 0.1086798 total: 4.06s remaining: 1.35s
751: learn: 0.1085211 total: 4.06s remaining: 1.34s
752: learn: 0.1083366 total: 4.08s remaining: 1.34s
753: learn: 0.1081777 total: 4.08s remaining: 1.33s
754: learn: 0.1080490 total: 4.08s remaining: 1.32s
755: learn: 0.1078260 total: 4.08s remaining: 1.32s
756: learn: 0.1076521 total: 4.08s remaining: 1.31s
757: learn: 0.1075671 total: 4.08s remaining: 1.3s
758: learn: 0.1074490 total: 4.09s remaining: 1.3s
759: learn: 0.1073404 total: 4.09s remaining: 1.29s
760: learn: 0.1071553 total: 4.09s remaining: 1.28s
761: learn: 0.1070489 total: 4.09s remaining: 1.28s
762: learn: 0.1069511 total: 4.11s remaining: 1.27s
763: learn: 0.1068249 total: 4.12s remaining: 1.27s
764: learn: 0.1066615 total: 4.12s remaining: 1.27s
765: learn: 0.1064545 total: 4.12s remaining: 1.26s
766: learn: 0.1062845 total: 4.13s remaining: 1.25s
767: learn: 0.1061997 total: 4.13s remaining: 1.25s
768: learn: 0.1060807 total: 4.13s remaining: 1.24s
769: learn: 0.1059060 total: 4.13s remaining: 1.23s
770: learn: 0.1057222 total: 4.13s remaining: 1.23s
771: learn: 0.1055569 total: 4.14s remaining: 1.22s
772: learn: 0.1054013 total: 4.14s remaining: 1.22s
773: learn: 0.1051982 total: 4.14s remaining: 1.21s
774: learn: 0.1051051 total: 4.15s remaining: 1.2s
775: learn: 0.1049460 total: 4.15s remaining: 1.2s
776: learn: 0.1047571 total: 4.15s remaining: 1.19s
777: learn: 0.1045553 total: 4.15s remaining: 1.19s
778: learn: 0.1043641 total: 4.16s remaining: 1.18s
779: learn: 0.1042972 total: 4.17s remaining: 1.18s
780: learn: 0.1041851 total: 4.17s remaining: 1.17s
781: learn: 0.1040637 total: 4.17s remaining: 1.16s
782: learn: 0.1039333 total: 4.17s remaining: 1.16s
783: learn: 0.1038147 total: 4.18s remaining: 1.15s
784: learn: 0.1036245 total: 4.18s remaining: 1.14s
785: learn: 0.1034213 total: 4.19s remaining: 1.14s
786: learn: 0.1033434 total: 4.2s remaining: 1.14s
787: learn: 0.1031664 total: 4.2s remaining: 1.13s
788: learn: 0.1030664 total: 4.2s remaining: 1.12s
789: learn: 0.1028876 total: 4.2s remaining: 1.12s
790: learn: 0.1027678 total: 4.21s remaining: 1.11s
791: learn: 0.1026747 total: 4.22s remaining: 1.11s
792: learn: 0.1026055 total: 4.24s remaining: 1.11s
793: learn: 0.1025671 total: 4.24s remaining: 1.1s
794: learn: 0.1024721 total: 4.24s remaining: 1.09s
795: learn: 0.1022896 total: 4.25s remaining: 1.09s
796: learn: 0.1021212 total: 4.25s remaining: 1.08s
797: learn: 0.1020190 total: 4.25s remaining: 1.07s
798: learn: 0.1018448 total: 4.25s remaining: 1.07s
799: learn: 0.1017538 total: 4.25s remaining: 1.06s
```

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799: learn: 0.1017000 total: 4.25s remaining: 1.06s
800: learn: 0.1016190 total: 4.26s remaining: 1.06s
801: learn: 0.1015887 total: 4.27s remaining: 1.05s
802: learn: 0.1015025 total: 4.27s remaining: 1.05s
803: learn: 0.1014035 total: 4.27s remaining: 1.04s
804: learn: 0.1011752 total: 4.27s remaining: 1.03s
805: learn: 0.1010238 total: 4.28s remaining: 1.03s
806: learn: 0.1009571 total: 4.29s remaining: 1.02s
807: learn: 0.1008675 total: 4.29s remaining: 1.02s
808: learn: 0.1007005 total: 4.29s remaining: 1.01s
809: learn: 0.1005370 total: 4.29s remaining: 1.01s
810: learn: 0.1003644 total: 4.29s remaining: 1s
811: learn: 0.1002651 total: 4.29s remaining: 995ms
812: learn: 0.1000536 total: 4.3s remaining: 989ms
813: learn: 0.0999087 total: 4.3s remaining: 982ms
814: learn: 0.0997164 total: 4.31s remaining: 979ms
815: learn: 0.0995609 total: 4.33s remaining: 976ms
816: learn: 0.0994546 total: 4.34s remaining: 973ms
817: learn: 0.0993184 total: 4.34s remaining: 967ms
818: learn: 0.0991988 total: 4.36s remaining: 963ms
819: learn: 0.0990343 total: 4.39s remaining: 963ms
820: learn: 0.0989713 total: 4.39s remaining: 957ms
821: learn: 0.0988448 total: 4.39s remaining: 951ms
822: learn: 0.0987461 total: 4.4s remaining: 947ms
823: learn: 0.0985744 total: 4.4s remaining: 941ms
824: learn: 0.0985078 total: 4.42s remaining: 937ms
825: learn: 0.0983352 total: 4.42s remaining: 931ms
826: learn: 0.0981871 total: 4.42s remaining: 925ms
827: learn: 0.0980877 total: 4.42s remaining: 919ms
828: learn: 0.0979914 total: 4.42s remaining: 913ms
829: learn: 0.0978648 total: 4.43s remaining: 907ms
830: learn: 0.0977661 total: 4.43s remaining: 902ms
831: learn: 0.0976735 total: 4.43s remaining: 896ms
832: learn: 0.0975169 total: 4.45s remaining: 892ms
833: learn: 0.0973287 total: 4.45s remaining: 886ms
834: learn: 0.0971836 total: 4.45s remaining: 880ms
835: learn: 0.0970057 total: 4.46s remaining: 875ms
836: learn: 0.0969271 total: 4.48s remaining: 872ms
837: learn: 0.0967800 total: 4.48s remaining: 866ms
838: learn: 0.0966255 total: 4.48s remaining: 860ms
839: learn: 0.0964616 total: 4.48s remaining: 854ms
840: learn: 0.0963738 total: 4.49s remaining: 848ms
841: learn: 0.0962771 total: 4.49s remaining: 843ms
842: learn: 0.0961304 total: 4.49s remaining: 837ms
843: learn: 0.0959183 total: 4.51s remaining: 833ms
844: learn: 0.0958317 total: 4.52s remaining: 830ms
845: learn: 0.0957480 total: 4.55s remaining: 829ms
846: learn: 0.0956131 total: 4.56s remaining: 823ms
847: learn: 0.0954644 total: 4.56s remaining: 817ms
848: learn: 0.0953710 total: 4.56s remaining: 811ms
849: learn: 0.0952623 total: 4.57s remaining: 806ms
850: learn: 0.0952120 total: 4.58s remaining: 803ms
851: learn: 0.0950574 total: 4.59s remaining: 797ms
852: learn: 0.0949571 total: 4.6s remaining: 793ms
853: learn: 0.0948253 total: 4.63s remaining: 792ms
854: learn: 0.0946775 total: 4.63s remaining: 786ms
855: learn: 0.0946171 total: 4.63s remaining: 780ms
856: learn: 0.0945484 total: 4.64s remaining: 775ms
857: learn: 0.0944506 total: 4.65s remaining: 769ms
858: learn: 0.0942738 total: 4.66s remaining: 765ms
859: learn: 0.0941459 total: 4.68s remaining: 761ms
860: learn: 0.0939278 total: 4.68s remaining: 755ms
861: learn: 0.0938410 total: 4.68s remaining: 749ms
862: learn: 0.0936871 total: 4.68s remaining: 743ms
863: learn: 0.0936173 total: 4.69s remaining: 738ms
864: learn: 0.0935430 total: 4.7s remaining: 734ms
865: learn: 0.0934404 total: 4.71s remaining: 728ms
866: learn: 0.0933957 total: 4.71s remaining: 722ms
867: learn: 0.0933068 total: 4.71s remaining: 716ms
868: learn: 0.0932183 total: 4.71s remaining: 710ms
869: learn: 0.0931671 total: 4.72s remaining: 705ms
870: learn: 0.0930865 total: 4.72s remaining: 699ms
871: learn: 0.0929673 total: 4.72s remaining: 693ms
872: learn: 0.0928288 total: 4.72s remaining: 687ms
873: learn: 0.0926919 total: 4.76s remaining: 687ms
874: learn: 0.0925457 total: 4.77s remaining: 681ms
875: learn: 0.0924244 total: 4.78s remaining: 677ms
876: learn: 0.0922964 total: 4.79s remaining: 673ms
```

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876: learn: 0.0922904 total: 4.79s remaining: 678ms
877: learn: 0.0921544 total: 4.83s remaining: 671ms
878: learn: 0.0919926 total: 4.83s remaining: 665ms
879: learn: 0.0919051 total: 4.83s remaining: 659ms
880: learn: 0.0917729 total: 4.83s remaining: 653ms
881: learn: 0.0916696 total: 4.83s remaining: 647ms
882: learn: 0.0915554 total: 4.84s remaining: 641ms
883: learn: 0.0915029 total: 4.84s remaining: 635ms
884: learn: 0.0913927 total: 4.86s remaining: 631ms
885: learn: 0.0912070 total: 4.86s remaining: 625ms
886: learn: 0.0911281 total: 4.86s remaining: 619ms
887: learn: 0.0909478 total: 4.86s remaining: 613ms
888: learn: 0.0908515 total: 4.86s remaining: 607ms
889: learn: 0.0908029 total: 4.87s remaining: 601ms
890: learn: 0.0907034 total: 4.87s remaining: 596ms
891: learn: 0.0905308 total: 4.9s remaining: 593ms
892: learn: 0.0904760 total: 4.91s remaining: 589ms
893: learn: 0.0904032 total: 4.93s remaining: 584ms
894: learn: 0.0902857 total: 4.95s remaining: 580ms
895: learn: 0.0901509 total: 4.96s remaining: 576ms
896: learn: 0.0900605 total: 4.96s remaining: 570ms
897: learn: 0.0900101 total: 4.96s remaining: 564ms
898: learn: 0.0898672 total: 4.97s remaining: 558ms
899: learn: 0.0897538 total: 4.97s remaining: 553ms
900: learn: 0.0896511 total: 4.97s remaining: 547ms
901: learn: 0.0894851 total: 4.99s remaining: 542ms
902: learn: 0.0893825 total: 4.99s remaining: 536ms
903: learn: 0.0893263 total: 4.99s remaining: 530ms
904: learn: 0.0891968 total: 5s remaining: 525ms
905: learn: 0.0891489 total: 5s remaining: 519ms
906: learn: 0.0890668 total: 5s remaining: 513ms
907: learn: 0.0889948 total: 5s remaining: 507ms
908: learn: 0.0889057 total: 5.01s remaining: 501ms
909: learn: 0.0887762 total: 5.01s remaining: 496ms
910: learn: 0.0886408 total: 5.01s remaining: 490ms
911: learn: 0.0884507 total: 5.01s remaining: 484ms
912: learn: 0.0883679 total: 5.02s remaining: 478ms
913: learn: 0.0882371 total: 5.02s remaining: 472ms
914: learn: 0.0881351 total: 5.02s remaining: 466ms
915: learn: 0.0879839 total: 5.02s remaining: 461ms
916: learn: 0.0878724 total: 5.02s remaining: 455ms
917: learn: 0.0877662 total: 5.03s remaining: 449ms
918: learn: 0.0876390 total: 5.03s remaining: 443ms
919: learn: 0.0875978 total: 5.03s remaining: 437ms
920: learn: 0.0875106 total: 5.03s remaining: 432ms
921: learn: 0.0874321 total: 5.03s remaining: 426ms
922: learn: 0.0873315 total: 5.03s remaining: 420ms
923: learn: 0.0871969 total: 5.04s remaining: 415ms
924: learn: 0.0870935 total: 5.06s remaining: 410ms
925: learn: 0.0869929 total: 5.06s remaining: 405ms
926: learn: 0.0869431 total: 5.06s remaining: 399ms
927: learn: 0.0868290 total: 5.07s remaining: 393ms
928: learn: 0.0867179 total: 5.07s remaining: 388ms
929: learn: 0.0865688 total: 5.08s remaining: 382ms
930: learn: 0.0864074 total: 5.08s remaining: 376ms
931: learn: 0.0863129 total: 5.08s remaining: 371ms
932: learn: 0.0862222 total: 5.08s remaining: 365ms
933: learn: 0.0861398 total: 5.08s remaining: 359ms
934: learn: 0.0859814 total: 5.08s remaining: 353ms
935: learn: 0.0858410 total: 5.09s remaining: 348ms
936: learn: 0.0856772 total: 5.09s remaining: 342ms
937: learn: 0.0855729 total: 5.09s remaining: 336ms
938: learn: 0.0854776 total: 5.09s remaining: 331ms
939: learn: 0.0853096 total: 5.09s remaining: 325ms
940: learn: 0.0852191 total: 5.09s remaining: 319ms
941: learn: 0.0851559 total: 5.1s remaining: 314ms
942: learn: 0.0850230 total: 5.1s remaining: 309ms
943: learn: 0.0849096 total: 5.11s remaining: 303ms
944: learn: 0.0847913 total: 5.11s remaining: 297ms
945: learn: 0.0846993 total: 5.11s remaining: 292ms
946: learn: 0.0846092 total: 5.12s remaining: 287ms
947: learn: 0.0845580 total: 5.12s remaining: 281ms
948: learn: 0.0844054 total: 5.13s remaining: 276ms
949: learn: 0.0842676 total: 5.15s remaining: 271ms
950: learn: 0.0841846 total: 5.17s remaining: 266ms
951: learn: 0.0840727 total: 5.17s remaining: 261ms
952: learn: 0.0839626 total: 5.17s remaining: 255ms
953: learn: 0.0838457 total: 5.18s remaining: 250ms
```

```
953: learn: 0.0838457 total: 5.18s remaining: 250ms
954: learn: 0.0837581 total: 5.18s remaining: 244ms
955: learn: 0.0836852 total: 5.18s remaining: 239ms
956: learn: 0.0836027 total: 5.19s remaining: 233ms
957: learn: 0.0835519 total: 5.19s remaining: 228ms
958: learn: 0.0834229 total: 5.19s remaining: 222ms
959: learn: 0.0833449 total: 5.19s remaining: 216ms
960: learn: 0.0832574 total: 5.2s remaining: 211ms
961: learn: 0.0832042 total: 5.2s remaining: 205ms
962: learn: 0.0831396 total: 5.2s remaining: 200ms
963: learn: 0.0830530 total: 5.2s remaining: 194ms
964: learn: 0.0829945 total: 5.2s remaining: 189ms
965: learn: 0.0829143 total: 5.21s remaining: 183ms
966: learn: 0.0828136 total: 5.21s remaining: 178ms
967: learn: 0.0827496 total: 5.22s remaining: 173ms
968: learn: 0.0826252 total: 5.22s remaining: 167ms
969: learn: 0.0825274 total: 5.24s remaining: 162ms
970: learn: 0.0824057 total: 5.24s remaining: 156ms
971: learn: 0.0823000 total: 5.25s remaining: 151ms
972: learn: 0.0821992 total: 5.25s remaining: 146ms
973: learn: 0.0820637 total: 5.26s remaining: 140ms
974: learn: 0.0819668 total: 5.26s remaining: 135ms
975: learn: 0.0818374 total: 5.26s remaining: 129ms
976: learn: 0.0816907 total: 5.27s remaining: 124ms
977: learn: 0.0815546 total: 5.27s remaining: 119ms
978: learn: 0.0814672 total: 5.27s remaining: 113ms
979: learn: 0.0813612 total: 5.28s remaining: 108ms
980: learn: 0.0812039 total: 5.28s remaining: 102ms
981: learn: 0.0811539 total: 5.29s remaining: 96.9ms
982: learn: 0.0810504 total: 5.29s remaining: 91.5ms
983: learn: 0.0809345 total: 5.29s remaining: 86ms
984: learn: 0.0807957 total: 5.3s remaining: 80.7ms
985: learn: 0.0806758 total: 5.31s remaining: 75.4ms
986: learn: 0.0805435 total: 5.31s remaining: 70ms
987: learn: 0.0804733 total: 5.33s remaining: 64.7ms
988: learn: 0.0803433 total: 5.34s remaining: 59.4ms
989: learn: 0.0802877 total: 5.35s remaining: 54ms
990: learn: 0.0801482 total: 5.36s remaining: 48.7ms
991: learn: 0.0801037 total: 5.36s remaining: 43.2ms
992: learn: 0.0799900 total: 5.37s remaining: 37.8ms
993: learn: 0.0798310 total: 5.37s remaining: 32.4ms
994: learn: 0.0797642 total: 5.37s remaining: 27ms
995: learn: 0.0796332 total: 5.38s remaining: 21.6ms
996: learn: 0.0795671 total: 5.39s remaining: 16.2ms
997: learn: 0.0794397 total: 5.39s remaining: 10.8ms
998: learn: 0.0793606 total: 5.39s remaining: 5.4ms
999: learn: 0.0793315 total: 5.4s remaining: 0us
```

In [80]:

```
precision_score(rk2_y_test, cb_prediction)
```

Out[80]:

```
0.7435897435897436
```

In [81]:

```
recall_score(rk2_y_test, cb_prediction)
```

Out[81]:

```
0.725
```

In [82]:

```
roc_auc_score(rk2_y_test, cb_prediction)
```

Out[82]:

```
0.7236111111111111
```

Видим, что градиентный бустинг не дал никакого прироста. Проблему считаем той же - малый объём данных.

In [ ]: