```
In [1]:  from warnings import filterwarnings
         filterwarnings('ignore')
```

```
In [2]:  import numpy as np
         import pandas as pd
         import matplotlib.pyplot as plt
         import seaborn as sns
         from sklearn.preprocessing import scale
         from sklearn.model_selection import train_test_split, GridSearchCV, cross_val_score
         from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_score, classification_report, con
         from sklearn.metrics import roc_auc_score, roc_curve
         from sklearn.linear_model import LogisticRegression
         from sklearn.naive_bayes import GaussianNB
         from sklearn.neighbors import KNeighborsClassifier
         from sklearn.svm import SVC
         from sklearn.neural_network import MLPClassifier
         from sklearn import tree
         from sklearn.tree import DecisionTreeClassifier
         from sklearn.ensemble import RandomForestClassifier
         from sklearn.ensemble import GradientBoostingClassifier
         from xgboost import XGBClassifier
         from lightgbm import LGBMClassifier
         from catboost import CatBoostClassifier
         import os
```

```
In [3]:  df = pd.read_csv('cleaning_data.csv')
         df.head()
```

Out[3]:

	BataryaGucu	Bluetooth	MikroislemciHizi	CiftHat	OnKameraMP	4G	DahiliBellek	Kalinlik	Agirlik	CekirdekSayisi	ArkaKameraMP	Cozunu
0	1325	1	1.9	1	2.0	1	50	0.1	146	1	10	
1	1046	0	2.8	0	0.0	0	58	0.2	100	8	0	
2	843	1	1.3	0	1.0	1	16	0.9	119	7	4	
3	894	1	0.5	0	1.0	0	50	0.5	199	3	14	
4	936	1	1.0	1	1.0	1	18	0.2	153	3	18	

```
In [4]:  df.info()

         <class 'pandas.core.frame.DataFrame'>
         RangeIndex: 2000 entries, 0 to 1999
         Data columns (total 19 columns):
          #   Column             Non-Null Count  Dtype
         ---  ------             --------------  -----
          0   BataryaGucu        2000 non-null   int64
          1   Bluetooth          2000 non-null   int64
          2   MikroislemciHizi   2000 non-null   float64
          3   CiftHat            2000 non-null   int64
          4   OnKameraMP         2000 non-null   float64
          5   4G                 2000 non-null   int64
          6   DahiliBellek       2000 non-null   int64
          7   Kalinlik           2000 non-null   float64
          8   Agirlik            2000 non-null   int64
          9   CekirdekSayisi     2000 non-null   int64
          10  ArkaKameraMP       2000 non-null   int64
          11  CozunurlukYükseklik 2000 non-null  int64
          12  CozunurlukGenislik 2000 non-null   int64
          13  RAM                2000 non-null   float64
          14  BataryaOmru        2000 non-null   int64
          15  3G                 2000 non-null   int64
          16  Dokunmatik         2000 non-null   int64
          17  WiFi               2000 non-null   int64
          18  FiyatAraligi       2000 non-null   int64
         dtypes: float64(4), int64(15)
         memory usage: 297.0 KB
```

```
In [5]:  df.corr()
```

Out[5]:

	BataryaGucu	Bluetooth	MikroislemciHizi	CiftHat	OnKameraMP	4G	DahiliBellek	Kalinlik	Agirlik	Cekirde
BataryaGucu	1.000000	-0.011252	0.011482	0.041847	0.032192	-0.015665	-0.004004	0.034085	0.001844	-0
Bluetooth	-0.011252	1.000000	-0.021419	0.035198	-0.002186	0.013443	-0.041177	-0.004049	0.008605	-0
MikroislemciHizi	0.011482	-0.021419	1.000000	0.001315	-0.000246	0.043073	0.006545	-0.014364	0.012350	-0
CiftHat	0.041847	0.035198	0.001315	1.000000	0.028692	0.003187	0.015679	0.022142	0.008979	0
OnKameraMP	0.032192	-0.002186	-0.000246	0.028692	1.000000	0.017030	-0.028572	-0.001774	0.024632	-0
4G	-0.015665	0.013443	0.043073	0.003187	0.017030	1.000000	-0.008690	0.001823	0.016537	0
DahiliBellek	-0.004004	-0.041177	0.006545	0.015679	-0.028572	-0.008690	1.000000	0.006886	-0.034214	-0
Kalinlik	0.034085	-0.004049	-0.014364	0.022142	-0.001774	0.001823	0.006886	1.000000	0.021756	-0
Agirlik	0.001844	0.008605	0.012350	0.008979	0.024632	0.016537	-0.034214	0.021756	1.000000	-0
CekirdekSayisi	-0.029727	-0.036161	-0.005724	0.024658	-0.013685	0.029706	-0.028310	-0.003504	-0.018989	1
ArkaKameraMP	0.031441	0.009952	-0.005245	0.017143	0.644543	0.005598	-0.033273	0.026282	0.018844	-0
CozunurlukYükseklik	0.014901	0.006872	-0.014523	0.020875	-0.010676	0.019236	0.010441	0.025263	0.000939	-0
CozunurlukGenislik	-0.008402	0.041533	-0.009476	-0.014291	-0.005633	-0.007448	-0.008335	0.023566	0.000090	-0
RAM	0.001017	-0.025398	0.003289	-0.041740	0.013733	-0.006855	0.033154	-0.009837	-0.004101	0
BataryaOmru	0.052510	-0.013934	-0.011432	0.039404	-0.007037	0.046628	-0.002790	0.017003	0.006209	0
3G	-0.011522	-0.030236	0.046433	-0.014008	-0.002083	0.584246	0.009366	0.012065	-0.001551	0
Dokunmatik	0.010516	0.010061	-0.019756	-0.017117	0.014375	0.016758	0.026999	0.002638	0.014368	-0
WiFi	0.008343	-0.021863	0.024471	0.022740	-0.021473	-0.017620	-0.006993	0.028353	0.000409	0
FiyatAraligi	-0.123526	0.006261	0.004029	0.003131	-0.030718	-0.010295	-0.006767	0.007832	-0.015783	-0

Logistic Regression

Model

In [4]:
```python
x = df.drop(["FiyatAraligi"], axis=1)
y = df["FiyatAraligi"]
```

In [7]:
```python
x
```

Out[7]:

	BataryaGucu	Bluetooth	MikroislemciHizi	CiftHat	OnKameraMP	4G	DahiliBellek	Kalinlik	Agirlik	CekirdekSayisi	ArkaKameraMP	Coz
0	1325	1	1.9	1	2.0	1	50	0.1	146	1	10	
1	1046	0	2.8	0	0.0	0	58	0.2	100	8	0	
2	843	1	1.3	0	1.0	1	16	0.9	119	7	4	
3	894	1	0.5	0	1.0	0	50	0.5	199	3	14	
4	936	1	1.0	1	1.0	1	18	0.2	153	3	18	
...	...	...	...	...	...	...	...	...	...	...	...	
1995	689	1	2.9	0	3.0	0	7	0.8	147	2	6	
1996	1654	1	1.8	1	1.0	1	11	0.3	146	7	2	
1997	742	1	2.2	0	4.0	1	56	0.2	190	7	14	
1998	704	1	2.2	0	4.0	1	53	0.2	186	6	6	
1999	1872	1	0.5	1	5.0	0	26	0.5	172	4	10	

2000 rows × 18 columns

In [8]:
```python
y # we have 4 options at our dependent variable but logistic regression uses binary variables. Though we are go
```

Out[8]:
```
0       0
1       1
2       2
3       1
4       0
       ..
1995    3
1996    2
1997    1
1998    0
1999    0
Name: FiyatAraligi, Length: 2000, dtype: int64
```

In [9]:
```python
type(y)
```

```
Out[9]:   pandas.core.series.Series
```

```
In [5]:   x_train, x_test, y_train, y_test = train_test_split(x, y,
                                                             test_size=0.20,
                                                             random_state=42)
```

```
In [39]:  loj = LogisticRegression(solver="liblinear")
          loj_model = loj.fit(x_train, y_train)
          loj_model
```

```
Out[39]:  ▼          LogisticRegression
          LogisticRegression(solver='liblinear')
```

```
In [40]:  print(loj_model.intercept_)
          print(loj_model.coef_)

          [-4.67698256e-01 -1.06383753e+01 -2.38788595e-03  8.39182976e+00]
          [[-2.14649867e-04 -2.22428059e-02 -1.20152973e-01  6.68291579e-02
             2.09175358e-02  2.28252799e-01 -9.00934000e-03 -2.36655132e-01
            -1.24644139e-03  1.45234553e-02 -2.74953163e-02 -4.69641212e-05
            -3.42613796e-04  4.76842428e-04 -2.03194470e-02 -2.76141055e-01
             1.22628186e-01 -1.29971050e-02]
           [ 1.90124032e-03 -2.16865897e-01 -1.56704418e-01 -1.78779122e-01
            -4.93215676e-03 -6.70117319e-01 -1.92015626e-03 -7.39160984e-01
            -2.31428396e-02 -1.24006670e-01 -1.44501257e-02  1.49288926e-03
             8.95163215e-04  3.90767256e-03 -3.31756891e-02  4.28372993e-01
            -3.95328802e-01 -3.49392428e-02]
           [-1.42795020e-04 -3.96514764e-03 -1.66069095e-02 -9.60335627e-04
             7.41186525e-03 -3.95180275e-03  1.93454215e-03  7.58727299e-03
             1.17242704e-04 -4.23122294e-02  6.27290199e-03  1.02077503e-04
             3.18357945e-06 -5.57377000e-04  1.43959624e-03 -6.25027269e-04
            -7.97423721e-03  3.16247897e-03]
           [-2.99718158e-03  3.25548856e-01  4.50555516e-01 -6.03182181e-02
            -3.98500626e-02  2.41511796e-01  3.98290876e-03  9.71004846e-02
             1.65060807e-02  1.49414910e-01  3.17934044e-02 -2.13337939e-03
            -1.00824519e-03 -5.95217425e-03  3.82036677e-02  9.87738401e-02
             2.90215102e-01  3.75971400e-02]]
```

Prediction & Model Tuning

```
In [41]:  y_pred = loj_model.predict(x_test)
          confusion_matrix(y_test, y_pred)
```

```
Out[41]:  array([[ 53,  22,  22,   0],
                 [  0,  94,   0,   0],
                 [ 25,   0,  63,  12],
                 [  0,   0,   2, 107]], dtype=int64)
```

```
In [42]:  accuracy_score(y_test, y_pred)
```

```
Out[42]:  0.7925
```

```
In [43]:  print(classification_report(y_test, y_pred))

                        precision    recall  f1-score   support

                     0       0.68      0.55      0.61        97
                     1       0.81      1.00      0.90        94
                     2       0.72      0.63      0.67       100
                     3       0.90      0.98      0.94       109

              accuracy                           0.79       400
             macro avg       0.78      0.79      0.78       400
          weighted avg       0.78      0.79      0.78       400
```

```
In [17]:  loj_parameters = {'penalty' : ['l1', 'l2', 'elasticnet'],
                            'solver' : ['lbfgs', 'liblinear', 'newton-cg', 'newton-cholesky', 'sag', 'saga'],
                            'multi_class' : ['auto', 'ovr', 'multinominal']}
          loj_cv = GridSearchCV(loj, loj_parameters, cv=10)
          loj_cv.fit(x_train, y_train) # optimized model
```

```
Out[17]:  ▶          GridSearchCV
          ▶ estimator: LogisticRegression

              ▶ LogisticRegression
```

```
In [18]:  loj_cv.best_params_
```

```
Out[18]:  {'multi_class': 'auto', 'penalty': 'l2', 'solver': 'newton-cg'}
```

```
In [44]:  loj = LogisticRegression(multi_class = 'auto'
```

```
In [44]: loj = LogisticRegression(multi_class = 'auto',
                                   penalty = 'l2',
                                   solver = 'newton-cg')
         loj_tuned = loj.fit(x_train, y_train) # optimized model
```

```
In [45]: y_pred = loj_tuned.predict(x_test)
         accuracy_score(y_test, y_pred) # Our result is better than up to result but this model can was overfit. We will
```

Out[45]: 0.975

```
In [46]: print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.96      0.95      0.95        97
           1       0.97      0.99      0.98        94
           2       0.98      0.96      0.97       100
           3       0.99      1.00      1.00       109

    accuracy                           0.97       400
   macro avg       0.97      0.97      0.97       400
weighted avg       0.97      0.97      0.97       400
```

```
In [22]: # FPR, TPR and threshold value calculate for every class
         fpr = {}
         tpr = {}
         thresh = {}
         for i in range(4):
             fpr[i], tpr[i], thresh[i] = roc_curve(y_test, loj_tuned.predict_proba(x_test)[:,i], pos_label=i)

         # ROC curves draw
         plt.figure(figsize=(8,6))
         colors = ['red', 'blue', 'green', 'orange']
         for i in range(4):
             plt.plot(fpr[i], tpr[i], color=colors[i], lw=2,
                      label='Class {0} (AUC = {1:0.2f})'
                      ''.format(i+1, np.trapz(tpr[i],fpr[i])))

         plt.plot([0, 1], [0, 1], 'k--', lw=2)
         plt.xlim([-0.01, 1.0])
         plt.ylim([0.0, 1.01])
         plt.xlabel('False Positive Rate')
         plt.ylabel('True Positive Rate')
         plt.title('Receiver Operating Characteristic')
         plt.legend(loc="lower right")
         plt.show()
```
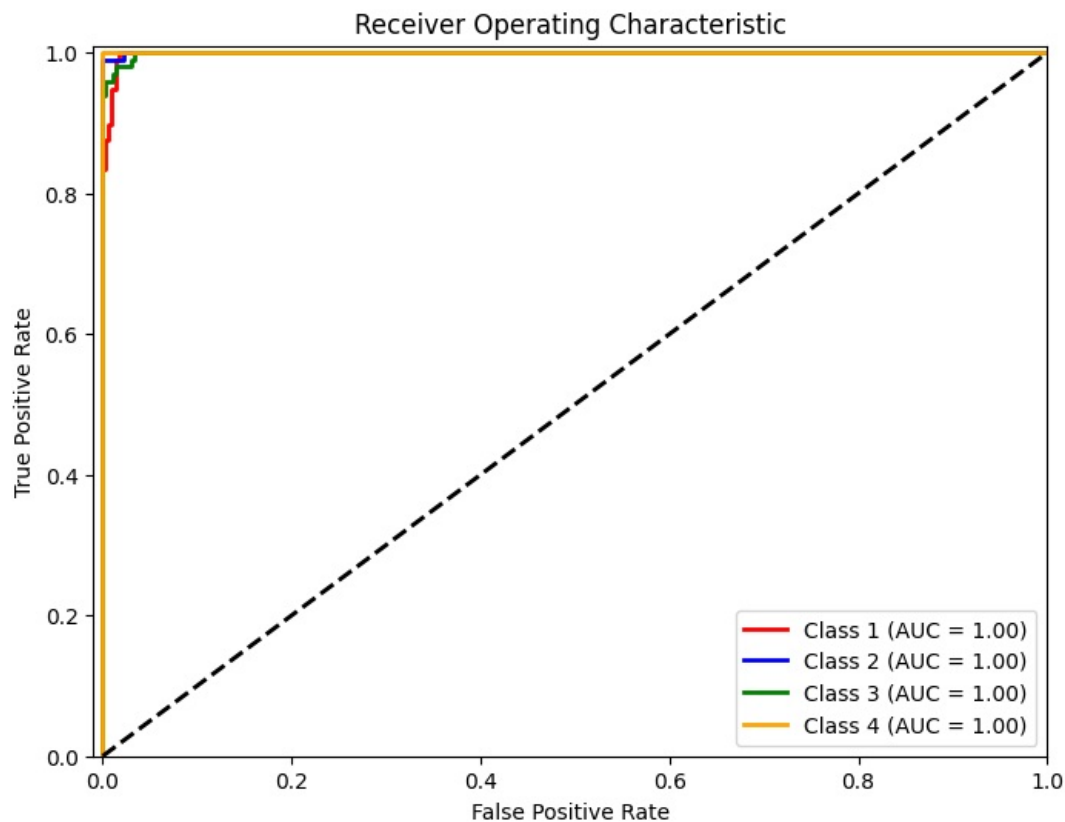

Naive Bayes

Model & Prediction

```
In [47]: nb = GaussianNB()
         nb_model = nb.fit(x_train, y_train)
         nb_model
```

Out[47]: ▾ GaussianNB

GaussianNB()

```
In [48]: nb_model.predict(x_test)[0:10]
```

Out[48]: array([0, 3, 1, 2, 0, 0, 1, 2, 1, 2], dtype=int64)

```
In [49]: y_pred = nb_model.predict(x_test)
         accuracy_score(y_test, y_pred)
```

Out[49]: 0.81

```
In [50]: cross_val_score(nb_model, x_test, y_test, cv=10).mean()
```

Out[50]: 0.8

```
In [51]: print(classification_report(y_test, y_pred))
```

```
               precision    recall  f1-score   support

           0       0.70      0.71      0.70        97
           1       0.88      0.86      0.87        94
           2       0.73      0.74      0.74       100
           3       0.93      0.92      0.92       109

    accuracy                           0.81       400
   macro avg       0.81      0.81      0.81       400
weighted avg       0.81      0.81      0.81       400
```

```
In [52]: # FPR, TPR and threshold value calculate for every class
         fpr = {}
         tpr = {}
         thresh = {}
         for i in range(4):
             fpr[i], tpr[i], thresh[i] = roc_curve(y_test, nb_model.predict_proba(x_test)[:,i], pos_label=i)

         # ROC curves draw
         plt.figure(figsize=(8,6))
         colors = ['red', 'blue', 'green', 'orange']
         for i in range(4):
             plt.plot(fpr[i], tpr[i], color=colors[i], lw=2,
                      label='Class {0} (AUC = {1:0.2f})'
                      ''.format(i+1, np.trapz(tpr[i],fpr[i])))

         plt.plot([0, 1], [0, 1], 'k--', lw=2)
         plt.xlim([-0.01, 1.0])
         plt.ylim([0.0, 1.01])
         plt.xlabel('False Positive Rate')
         plt.ylabel('True Positive Rate')
         plt.title('Receiver Operating Characteristic')
         plt.legend(loc="lower right")
         plt.show()
```

Receiver Operating Characteristic
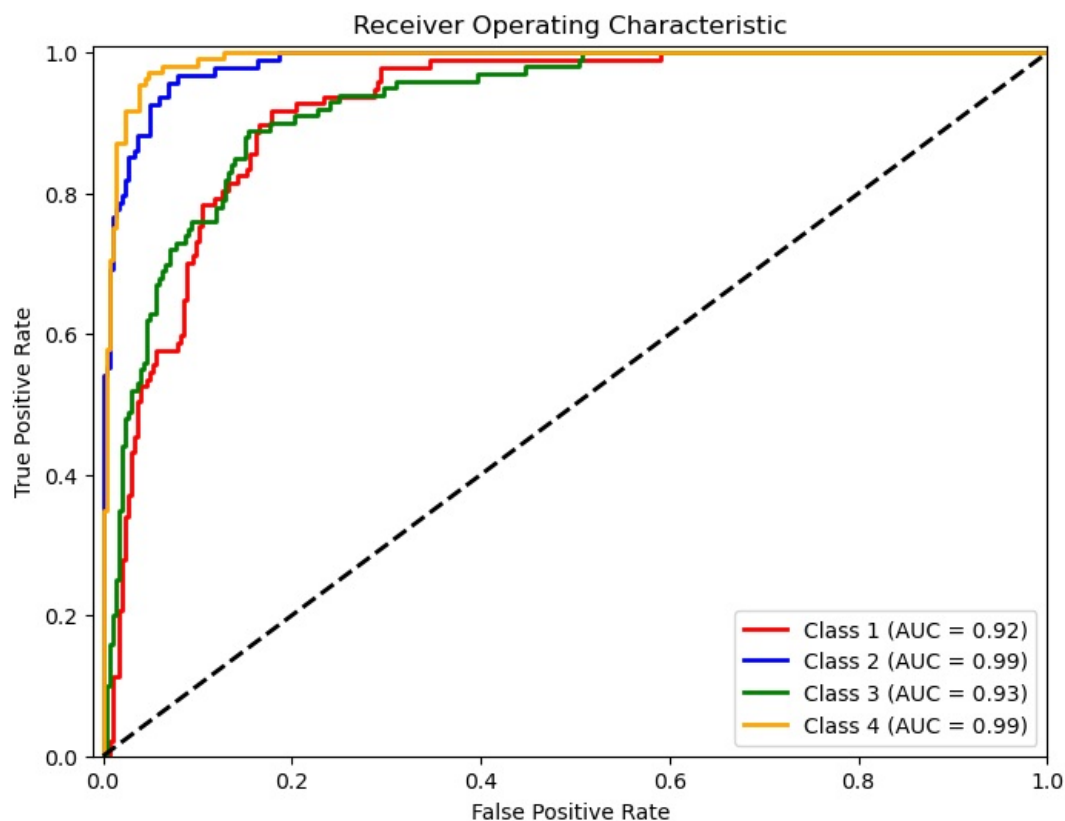
KNN

Model & Prediction

```
In [88]:  knn = KNeighborsClassifier()
          knn_model = knn.fit(x_train, y_train)
          knn_model
```

```
Out[88]:  ▼ KNeighborsClassifier

          KNeighborsClassifier()
```

```
In [89]:  y_pred = knn_model.predict(x_test)
          accuracy_score(y_test, y_pred)
```

```
Out[89]:  0.9275
```

```
In [13]:  print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.90      0.91      0.90        97
           1       0.95      0.94      0.94        94
           2       0.92      0.90      0.91       100
           3       0.95      0.96      0.95       109

    accuracy                           0.93       400
   macro avg       0.93      0.93      0.93       400
weighted avg       0.93      0.93      0.93       400
```

```
In [14]:  # FPR, TPR and threshold value calculate for every class
          fpr = {}
          tpr = {}
          thresh = {}
          for i in range(4):
              fpr[i], tpr[i], thresh[i] = roc_curve(y_test, knn_model.predict_proba(x_test)[:,i], pos_label=i)

          # ROC curves draw
          plt.figure(figsize=(8,6))
          colors = ['red', 'blue', 'green', 'orange']
          for i in range(4):
              plt.plot(fpr[i], tpr[i], color=colors[i], lw=2,
                       label='Class {0} (AUC = {1:0.2f})'
                       ''.format(i+1, np.trapz(tpr[i],fpr[i])))

          plt.plot([0, 1], [0, 1], 'k--', lw=2)
          plt.xlim([-0.01, 1.0])
```

```
plt.ylim([0.0, 1.01])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc="lower right")
plt.show()
```
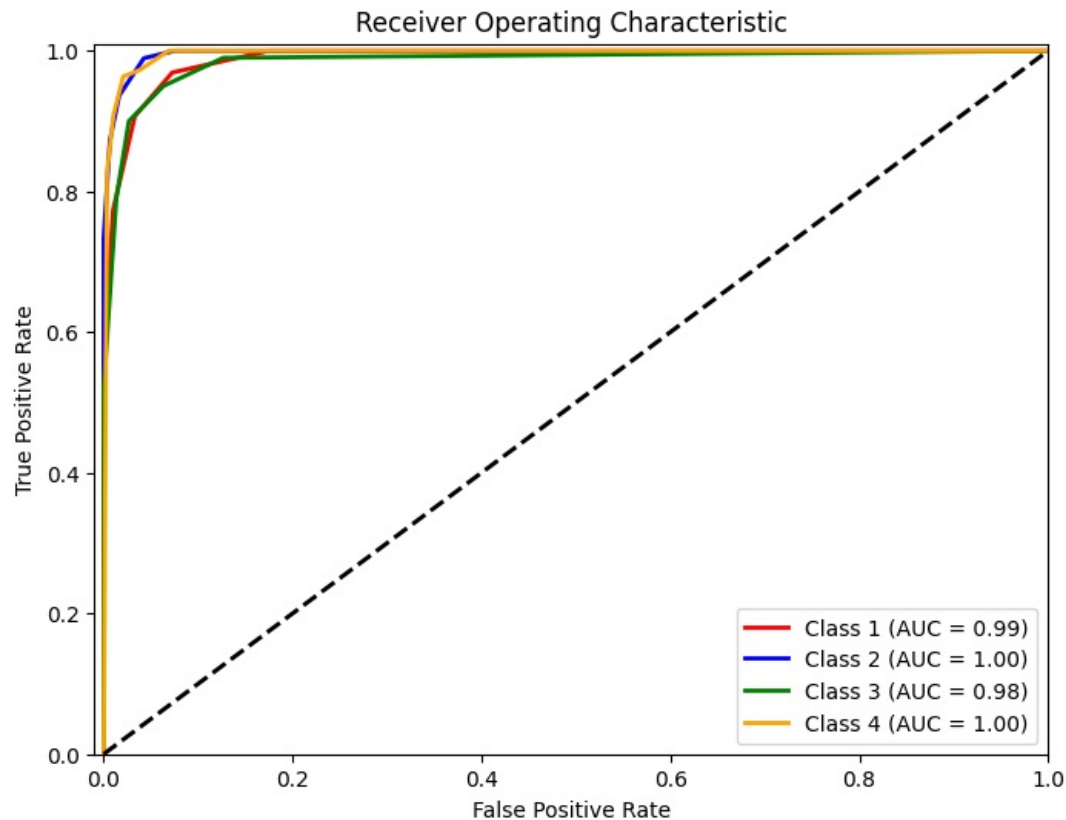

Model Tuning

In [15]:
```
knn_params = {'n_neighbors': np.arange(1,100)}
knn_cv = GridSearchCV(knn, knn_params, cv=10)
knn_cv.fit(x_train, y_train)
```

Out[15]:
```
  ▸         GridSearchCV
  ▸ estimator: KNeighborsClassifier
        ▸ KNeighborsClassifier
```

In [16]:
```
knn_cv.best_params_
```

Out[16]:
```
{'n_neighbors': 15}
```

In [53]:
```
knn = KNeighborsClassifier(15)
knn_tuned = knn.fit(x_train, y_train) # optimized model
```

In [55]:
```
y_pred = knn_tuned.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[55]:
```
0.9225
```

SVM

Model & Prediction

In [56]:
```
svm_model_linear = SVC(kernel="linear").fit(x_train, y_train)
svm_model_linear
```

Out[56]:
```
  ▾         SVC
SVC(kernel='linear')
```

In [57]:
```
y_pred_linear = svm_model_linear.predict(x_test)
accuracy_score(y_test, y_pred_linear)
```

0.9825

let's do using rbp kernel

```
In [58]: svm_model_rbf = SVC(kernel="rbf").fit(x_train, y_train)
         svm_model_rbf
```

Out[58]: ▼ SVC

SVC()

```
In [59]: y_pred_rbf = svm_model_rbf.predict(x_test)
         accuracy_score(y_test, y_pred_rbf)
```

Out[59]: 0.9575

```
In [60]: print(classification_report(y_pred_linear, y_test)) # better than rbf kernel
```

```
              precision    recall  f1-score   support

           0       1.00      0.94      0.97       103
           1       0.98      1.00      0.99        92
           2       0.96      0.99      0.97        97
           3       0.99      1.00      1.00       108

    accuracy                           0.98       400
   macro avg       0.98      0.98      0.98       400
weighted avg       0.98      0.98      0.98       400
```
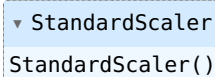
```
In [61]: print(classification_report(y_pred_rbf, y_test))
```

```
              precision    recall  f1-score   support

           0       0.95      0.94      0.94        98
           1       0.97      0.96      0.96        95
           2       0.92      0.98      0.95        94
           3       0.99      0.96      0.97       113

    accuracy                           0.96       400
   macro avg       0.96      0.96      0.96       400
weighted avg       0.96      0.96      0.96       400
```

Artificial Neureal Network

Model & Tahmin

```
In [26]: from sklearn.preprocessing import StandardScaler
         scaler = StandardScaler()
         scaler.fit(x_train)
```

Out[26]: ▼ StandardScaler

StandardScaler()

```
In [27]: x_train_scaled = scaler.transform(x_train)
         x_test_scaled = scaler.transform(x_test)
```

```
In [28]: x_train_scaled[0:5]
```

```
Out[28]: array([[-0.79776826,  1.02148066, -1.00800608, -0.96801137,  1.05214835,
                 -0.98142253, -0.21445191, -1.03316872,  0.31817032,  0.65243169,
                  1.02459764, -0.88223152, -0.83174836, -1.27555582, -0.56610356,
                 -0.56772709,  1.00375706, -0.98634324],
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                 -0.56772709, -0.996257  ,  1.01384584],
                [ 0.00334266, -0.97897106,  1.20688482,  1.03304572,  0.59800736,
                  1.01892912, -1.04271804,  1.04834643, -1.19701154, -0.21386765,
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                  0.36196376, -0.66479069,  0.51048558,  0.35932652, -1.30219922,
                 -0.56772709, -0.996257  , -0.98634324]])
```

```
In [29]:  x_test_scaled[0:5]
```

```
Out[29]:  array([[ 0.44564616, -0.97897106,  0.96078583,  1.03304572, -0.53734513,
                  -0.98142253, -1.48445998, -1.38008791, -0.31077309,  0.21928202,
                   0.19630529, -0.50060067, -1.06158294, -0.00785649,  1.45815949,
                  -0.56772709,  1.00375706, -0.98634324],
                 [-0.13882632, -0.97897106, -0.76190709,  1.03304572,  0.59800736,
                   1.01892912, -0.10401642,  1.74218482,  0.20381698, -0.21386765,
                   1.68723152,  0.21828536, -0.00434387, -1.22690408,  0.90608775,
                   1.76140969, -0.996257  , -0.98634324],
                 [-0.53374015,  1.02148066,  1.32993432, -0.96801137,  1.50628935,
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                   0.52762223, -0.67366582,  0.90809941,  0.86512112, -0.01403182,
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                 [-0.59466972, -0.97897106, -1.25410507, -0.96801137,  0.14386636,
                   1.01892912, -1.04271804, -0.33933033,  1.51888048,  0.21928202,
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                 [ 1.29866004, -0.97897106,  1.20688482,  1.03304572, -0.08320414,
                  -0.98142253, -1.48445998,  0.35450805, -1.19701154, -0.21386765,
                   1.02459764, -0.4406935 , -1.55802563,  0.51354339, -0.56610356,
                  -0.56772709, -0.996257  , -0.98634324]])
```

```
In [30]:  mlp_model = MLPClassifier().fit(x_train_scaled, y_train)
```

```
In [31]:  y_pred = mlp_model.predict(x_test_scaled)
          accuracy_score(y_test, y_pred) # Learning rate is looking very low. Though let's do optimization
```

```
Out[31]:  0.9075
```

Model Tuning

```
In [32]:  mlp_params = {"alpha": [0.1, 0.01, 0.02, 0.005, 0.0001, 0.00001],
                        "hidden_layer_sizes": [(10,10,10),
                                               (100,100,100),
                                               (100,100),
                                               (3,5),
                                               (5, 3)],
                        "solver" : ["lbfgs","adam","sgd"],
                        "activation": ["relu","logistic"]}
          mlp_model = MLPClassifier()
          mlp_cv_model = GridSearchCV(mlp_model, mlp_params,
                                      cv=10,
                                      n_jobs=-1,
                                      verbose=2)
          mlp_cv_model.fit(x_train, y_train)
```

```
          Fitting 10 folds for each of 180 candidates, totalling 1800 fits
```

```
Out[32]:  ▸       GridSearchCV
          ▸ estimator: MLPClassifier
               ▸ MLPClassifier
```

```
In [33]:  mlp_cv_model.best_params_
```

```
Out[33]:  {'activation': 'logistic',
           'alpha': 0.005,
           'hidden_layer_sizes': (100, 100),
           'solver': 'adam'}
```

```
In [34]:  mlp_tuned = MLPClassifier(activation= 'logistic',
                                    alpha= 0.005,
                                    hidden_layer_sizes= (100, 100),
                                    solver= 'adam')
          mlp_tuned.fit(x_train_scaled, y_train)
```

```
Out[34]:  ▾                      MLPClassifier
          MLPClassifier(activation='logistic', alpha=0.005, hidden_layer_sizes=(100, 100))
```

```
In [35]:  y_pred = mlp_tuned.predict(x_test_scaled)
          accuracy_score(y_test, y_pred)
```

```
Out[35]:  0.98
```

```
In [36]:  print(classification_report(y_pred, y_test))
```

	precision	recall	f1-score	support
0	0.99	0.96	0.97	100
1	0.98	0.99	0.98	93
2	0.97	0.98	0.97	99
3	0.98	0.99	0.99	108
accuracy			0.98	400
macro avg	0.98	0.98	0.98	400
weighted avg	0.98	0.98	0.98	400

In [37]:
```python
# FPR, TPR and threshold value calculate for every class
fpr = {}
tpr = {}
thresh = {}
for i in range(4):
    fpr[i], tpr[i], thresh[i] = roc_curve(y_test, mlp_tuned.predict_proba(x_test_scaled)[:,i], pos_label=i)

# ROC curves draw
plt.figure(figsize=(8,6))
colors = ['red', 'blue', 'green', 'orange']
for i in range(4):
    plt.plot(fpr[i], tpr[i], color=colors[i], lw=2,
             label='Class {0} (AUC = {1:0.2f})'
             ''.format(i+1, np.trapz(tpr[i],fpr[i])))

plt.plot([0, 1], [0, 1], 'k--', lw=2)
plt.xlim([-0.01, 1.0])
plt.ylim([0.0, 1.01])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc="lower right")
plt.show()
```
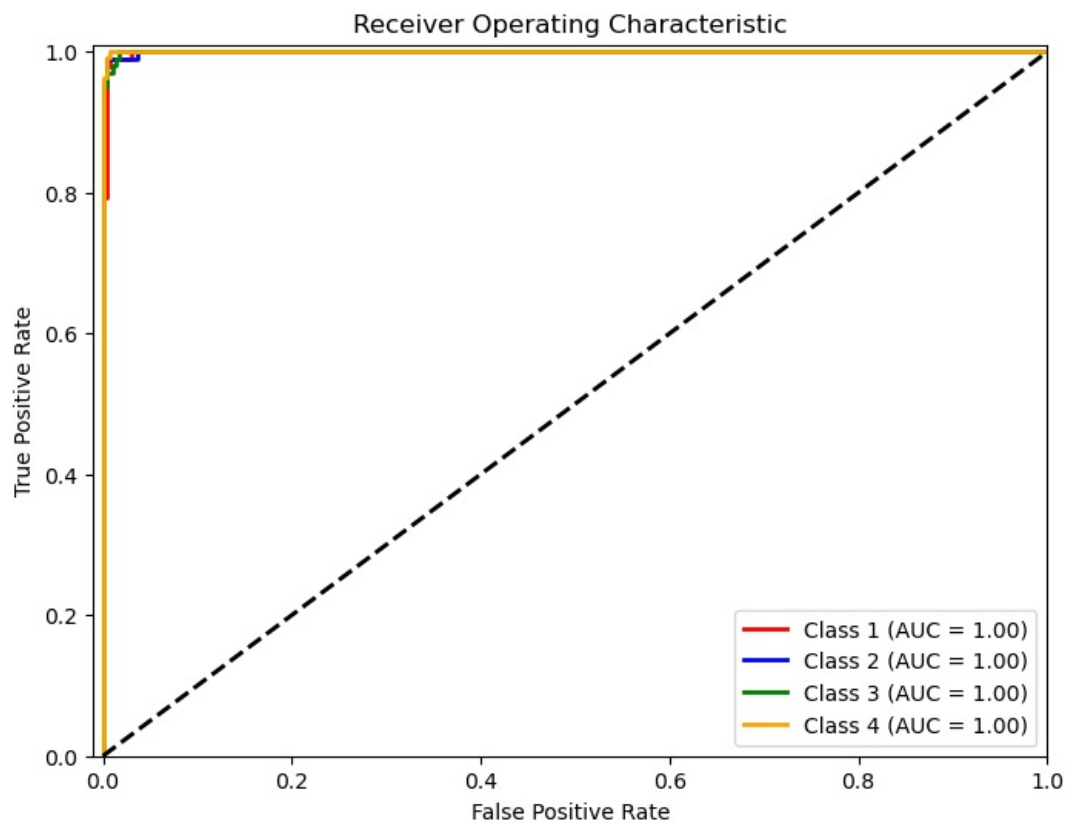

As we see after to optimize our success rate increased and it wasn't overfit

CART

Model & Prediction

In [73]:
```python
cart = DecisionTreeClassifier(max_depth=2)
cart_model = cart.fit(x_train, y_train)
```

In [74]:
```python
cart_model
```

```
Out[74]:  ▼        DecisionTreeClassifier
         DecisionTreeClassifier(max_depth=2)
```

```
In [75]:  y_pred = cart_model.predict(x_test)
          accuracy_score(y_test, y_pred)
```

```
Out[75]:  0.75
```

Model Tuning

```
In [35]:  cart_params = {'max_depth': range(1,10),
                        'min_samples_split': list(range(2,50))}
          cart = DecisionTreeClassifier()
          cart_cv = GridSearchCV(cart, cart_params,
                                 cv=10,
                                 n_jobs=-1,
                                 verbose=2)
          cart_cv_model = cart_cv.fit(x_train, y_train)
```

```
Fitting 10 folds for each of 432 candidates, totalling 4320 fits
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In [36]:
```python
cart_cv_model.best_params_
```

Out[36]: `{'max_depth': 8, 'min_samples_split': 21}`

In [62]:
```python
cart = DecisionTreeClassifier(max_depth = 8,
                              min_samples_split = 21)
cart_tuned = cart.fit(x_train, y_train)
```

In [63]:
```python
y_pred = cart_tuned.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[63]: `0.8575`

In [39]: `print(classification_report(y_pred, y_test))`

```
              precision    recall  f1-score   support

           0       0.82      0.77      0.80       104
           1       0.88      0.89      0.89        93
           2       0.80      0.83      0.82        96
           3       0.92      0.93      0.93       107

    accuracy                           0.86       400
   macro avg       0.86      0.86      0.86       400
weighted avg       0.86      0.86      0.86       400
```

In [40]:
```python
# FPR, TPR and threshold value calculate for every class
fpr = {}
tpr = {}
thresh = {}
for i in range(4):
    fpr[i], tpr[i], thresh[i] = roc_curve(y_test, cart_tuned.predict_proba(x_test)[:,i], pos_label=i)

# ROC curves draw
plt.figure(figsize=(8,6))
colors = ['red', 'blue', 'green', 'orange']
for i in range(4):
    plt.plot(fpr[i], tpr[i], color=colors[i], lw=2,
             label='Class {0} (AUC = {1:0.2f})'
             ''.format(i+1, np.trapz(tpr[i],fpr[i])))

plt.plot([0, 1], [0, 1], 'k--', lw=2)
plt.xlim([-0.01, 1.0])
plt.ylim([0.0, 1.01])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc="lower right")
plt.show()
```
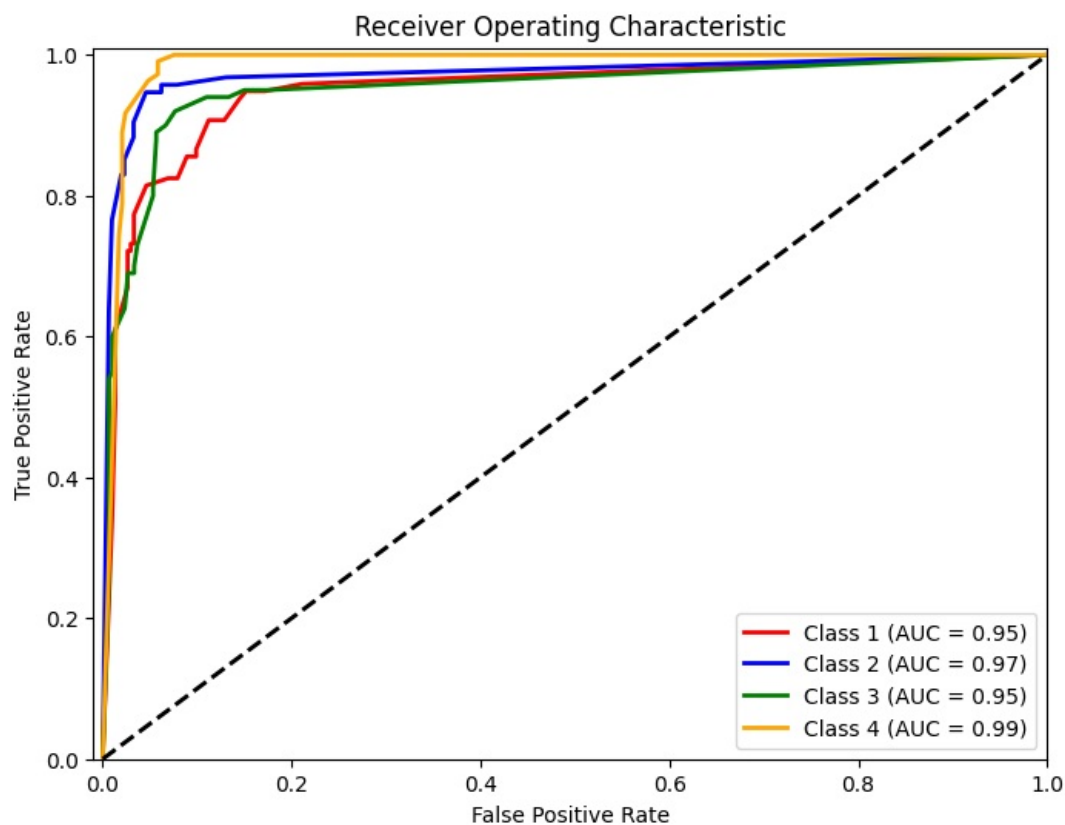

Random Forests

Model & Prediction

In [76]:
```python
rf = RandomForestClassifier()
rf_model = rf.fit(x_train, y_train)
```

In [77]:
```python
y_pred = rf_model.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[77]:
0.8775

Model Tuning

In [43]:
```python
rf_params = {"max_depth": [2,3,5,8,10],
             "max_features": [2,5,8],
             "n_estimators": [10,500,1000],
             "min_samples_split": [2,5,10]}
rf = RandomForestClassifier()
rf_cv = GridSearchCV(rf, rf_params,
                     cv=10,
                     n_jobs=-1,
                     verbose=2)
rf_cv_model = rf_cv.fit(x_train, y_train)
```

```
Fitting 10 folds for each of 135 candidates, totalling 1350 fits
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[CV] END max_depth=10, max_features=5, min_samples_split=2, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=2, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=2, n_estimators=1000; total time=   3.8s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.8s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.9s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=5, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
```

```
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.9s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=500; total time=   1.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.6s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.6s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.8s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.6s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.7s
[CV] END max_depth=10, max_features=5, min_samples_split=10, n_estimators=1000; total time=   3.7s
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[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.8s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=2, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.0s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.7s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.8s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.9s
[CV] END max_depth=10, max_features=8, min_samples_split=5, n_estimators=1000; total time=   4.6s
```

```
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=10; total time=   0.1s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.4s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=500; total time=   2.3s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.5s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.5s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.5s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.5s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.5s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.6s
[CV] END max_depth=10, max_features=8, min_samples_split=10, n_estimators=1000; total time=   4.6s
```

In [44]: `rf_cv_model.best_params_`

Out[44]:
```
{'max_depth': 10,
 'max_features': 8,
 'min_samples_split': 5,
 'n_estimators': 500}
```

In [64]:
```python
rf_tuned = RandomForestClassifier(max_depth = 10,
                                  max_features = 8,
                                  min_samples_split = 5,
                                  n_estimators = 500)
rf_tuned.fit(x_train, y_train)
```

Out[64]:
```
                        RandomForestClassifier
RandomForestClassifier(max_depth=10, max_features=8, min_samples_split=5,
                       n_estimators=500)
```

In [65]:
```python
y_pred = rf_tuned.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[65]: `0.9125`

In [48]:
```python
Importance = pd.DataFrame({"Importance": rf_tuned.feature_importances_*100},
                          index = x_train.columns)
Importance.sort_values(by = "Importance",
                       axis = 0,
                       ascending = True).plot(kind ="barh", color = "r")

plt.xlabel("Değişken Önem Düzeyleri")
```

Out[48]: `Text(0.5, 0, 'Değişken Önem Düzeyleri')`

As we see the most important variable is RAM variable on our dataset. Anyway we saw when we did correlation

Gradient Boosting Machines(GBM)

Model & Prediction

```
In [78]: gbm = GradientBoostingClassifier()
         gbm_model = gbm.fit(x_train, y_train)
```

```
In [79]: y_pred = gbm_model.predict(x_test)
         accuracy_score(y_test, y_pred)
```

```
Out[79]: 0.915
```

Model Tuning

```
In [8]: gbm_params = {"learning_rate" : [0.001, 0.01, 0.1],
                       "n_estimators": [100,500],
                       "max_depth": [3,5,10],
                       "min_samples_split": [2,5,10]}
        gbm_cv = GridSearchCV(gbm, gbm_params,
                              cv=10,
                              n_jobs=-1,
                              verbose=2)
        gbm_cv_model = gbm_cv.fit(x_train, y_train)
```

```
        Fitting 10 folds for each of 54 candidates, totalling 540 fits
```

```
In [66]: gbm = GradientBoostingClassifier(learning_rate = 0.1,
                                           max_depth = 5,
```

```
                                      min_samples_split = 2,
                                      n_estimators = 100)
gbm_tuned = gbm.fit(x_train, y_train)
```

In [67]:
```
y_pred = gbm_tuned.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[67]: 0.915

XGBoost

Model & Prediction

In [80]:
```
xgb_model = XGBClassifier().fit(x_train, y_train)
```

In [81]:
```
y_pred = xgb_model.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[81]: 0.93

Model Tuning

In [11]:
```
xgb_params = {
        'n_estimators': [100, 500, 1000],
        'subsample': [0.6, 0.8, 1.0],
        'max_depth': [3, 4, 5],
        'learning_rate': [0.1, 0.01, 0.05],
        'min_samples_split': [2, 5, 10]}
xgb = XGBClassifier()
xgb_cv = GridSearchCV(xgb, xgb_params,
                        cv = 10,
                        n_jobs = -1,
                        verbose = 2)
xgb_cv_model = xgb_cv.fit(x_train, y_train)
```

```
Fitting 10 folds for each of 243 candidates, totalling 2430 fits
[02:53:27] WARNING: C:\buildkite-agent\builds\buildkite-windows-cpu-autoscaling-group-i-07593ffd91cd9da33-1\xgb
oost\xgboost-ci-windows\src\learner.cc:767:
Parameters: { "min_samples_split" } are not used.
```

In [12]:
```
xgb_cv_model.best_params_
```

Out[12]:
```
{'learning_rate': 0.1,
 'max_depth': 4,
 'min_samples_split': 2,
 'n_estimators': 500,
 'subsample': 0.6}
```

In [68]:
```
xgb = XGBClassifier(learning_rate = 0.1,
                        max_depth = 4,
                        min_samples_split = 2,
                        n_estimators = 500,
                        subsample = 0.6)
xgb_tuned =  xgb.fit(x_train,y_train)
```

```
[03:23:21] WARNING: C:\buildkite-agent\builds\buildkite-windows-cpu-autoscaling-group-i-07593ffd91cd9da33-1\xgb
oost\xgboost-ci-windows\src\learner.cc:767:
Parameters: { "min_samples_split" } are not used.
```

In [69]:
```
y_pred = xgb_tuned.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[69]: 0.9275

CatBoost

Model & Prediction

In [82]:
```
cat_model = CatBoostClassifier().fit(x_train, y_train)
```

```
Learning rate set to 0.081046
0:      learn: 1.2717028      total: 5.67ms   remaining: 5.66s
1:      learn: 1.1833891      total: 10.8ms   remaining: 5.37s
2:      learn: 1.1151186      total: 16ms     remaining: 5.32s
3:      learn: 1.0376020      total: 23.3ms   remaining: 5.8s
4:      learn: 0.9682810      total: 28.5ms   remaining: 5.68s
```

```
5:      learn: 0.9271879      total: 34.4ms    remaining: 5.7s
6:      learn: 0.8798053      total: 38.6ms    remaining: 5.48s
7:      learn: 0.8353139      total: 42.7ms    remaining: 5.3s
8:      learn: 0.7937513      total: 47.2ms    remaining: 5.19s
9:      learn: 0.7511193      total: 51.2ms    remaining: 5.07s
10:     learn: 0.7263842      total: 55.1ms    remaining: 4.95s
11:     learn: 0.6942446      total: 59ms      remaining: 4.86s
12:     learn: 0.6686105      total: 62.6ms    remaining: 4.75s
13:     learn: 0.6370311      total: 66.3ms    remaining: 4.67s
14:     learn: 0.6115176      total: 70.3ms    remaining: 4.62s
15:     learn: 0.5906100      total: 74.1ms    remaining: 4.56s
16:     learn: 0.5677915      total: 77.9ms    remaining: 4.5s
17:     learn: 0.5468161      total: 82ms      remaining: 4.47s
18:     learn: 0.5359260      total: 85.9ms    remaining: 4.43s
19:     learn: 0.5202595      total: 91ms      remaining: 4.46s
20:     learn: 0.5038326      total: 94.8ms    remaining: 4.42s
21:     learn: 0.4874713      total: 98.6ms    remaining: 4.38s
22:     learn: 0.4762413      total: 102ms     remaining: 4.35s
23:     learn: 0.4629430      total: 106ms     remaining: 4.32s
24:     learn: 0.4517652      total: 110ms     remaining: 4.29s
25:     learn: 0.4423234      total: 114ms     remaining: 4.26s
26:     learn: 0.4337366      total: 118ms     remaining: 4.27s
27:     learn: 0.4231196      total: 122ms     remaining: 4.24s
28:     learn: 0.4117561      total: 126ms     remaining: 4.23s
29:     learn: 0.4018168      total: 131ms     remaining: 4.22s
30:     learn: 0.3919916      total: 135ms     remaining: 4.21s
31:     learn: 0.3835022      total: 139ms     remaining: 4.19s
32:     learn: 0.3763968      total: 143ms     remaining: 4.18s
33:     learn: 0.3718074      total: 147ms     remaining: 4.17s
34:     learn: 0.3630852      total: 151ms     remaining: 4.16s
35:     learn: 0.3570718      total: 155ms     remaining: 4.14s
36:     learn: 0.3477973      total: 158ms     remaining: 4.12s
37:     learn: 0.3438388      total: 163ms     remaining: 4.11s
38:     learn: 0.3398750      total: 166ms     remaining: 4.1s
39:     learn: 0.3364118      total: 170ms     remaining: 4.08s
40:     learn: 0.3314051      total: 174ms     remaining: 4.06s
41:     learn: 0.3277496      total: 178ms     remaining: 4.06s
42:     learn: 0.3246369      total: 182ms     remaining: 4.05s
43:     learn: 0.3193332      total: 186ms     remaining: 4.05s
44:     learn: 0.3155783      total: 192ms     remaining: 4.07s
45:     learn: 0.3127380      total: 196ms     remaining: 4.06s
46:     learn: 0.3090766      total: 201ms     remaining: 4.07s
47:     learn: 0.3060279      total: 208ms     remaining: 4.12s
48:     learn: 0.3022312      total: 212ms     remaining: 4.12s
49:     learn: 0.2967522      total: 217ms     remaining: 4.13s
50:     learn: 0.2946694      total: 222ms     remaining: 4.13s
51:     learn: 0.2913679      total: 226ms     remaining: 4.12s
52:     learn: 0.2865557      total: 234ms     remaining: 4.17s
53:     learn: 0.2825314      total: 240ms     remaining: 4.2s
54:     learn: 0.2783217      total: 245ms     remaining: 4.21s
55:     learn: 0.2761865      total: 250ms     remaining: 4.21s
56:     learn: 0.2728544      total: 257ms     remaining: 4.25s
57:     learn: 0.2698671      total: 262ms     remaining: 4.25s
58:     learn: 0.2674704      total: 267ms     remaining: 4.26s
59:     learn: 0.2653935      total: 273ms     remaining: 4.28s
60:     learn: 0.2619215      total: 278ms     remaining: 4.28s
61:     learn: 0.2580365      total: 284ms     remaining: 4.3s
62:     learn: 0.2567747      total: 291ms     remaining: 4.32s
63:     learn: 0.2545168      total: 296ms     remaining: 4.32s
64:     learn: 0.2530320      total: 301ms     remaining: 4.32s
65:     learn: 0.2505556      total: 307ms     remaining: 4.34s
66:     learn: 0.2473474      total: 313ms     remaining: 4.35s
67:     learn: 0.2451151      total: 319ms     remaining: 4.37s
68:     learn: 0.2425302      total: 325ms     remaining: 4.38s
69:     learn: 0.2397799      total: 331ms     remaining: 4.4s
70:     learn: 0.2379619      total: 339ms     remaining: 4.43s
71:     learn: 0.2365799      total: 345ms     remaining: 4.45s
72:     learn: 0.2331767      total: 353ms     remaining: 4.49s
73:     learn: 0.2315117      total: 360ms     remaining: 4.51s
74:     learn: 0.2293287      total: 367ms     remaining: 4.53s
75:     learn: 0.2281428      total: 373ms     remaining: 4.54s
76:     learn: 0.2270126      total: 380ms     remaining: 4.56s
77:     learn: 0.2247497      total: 387ms     remaining: 4.57s
78:     learn: 0.2229260      total: 395ms     remaining: 4.6s
79:     learn: 0.2201835      total: 404ms     remaining: 4.64s
80:     learn: 0.2190042      total: 410ms     remaining: 4.66s
81:     learn: 0.2168943      total: 418ms     remaining: 4.68s
82:     learn: 0.2139148      total: 423ms     remaining: 4.67s
83:     learn: 0.2123306      total: 427ms     remaining: 4.66s
84:     learn: 0.2098447      total: 433ms     remaining: 4.66s
85:     learn: 0.2091172      total: 441ms     remaining: 4.69s
86:     learn: 0.2058625      total: 449ms     remaining: 4.72s
87:     learn: 0.2053902      total: 454ms     remaining: 4.7s
88:     learn: 0.2029889      total: 458ms     remaining: 4.69s
89:     learn: 0.2014844      total: 464ms     remaining: 4.69s
90:     learn: 0.1997856      total: 468ms     remaining: 4.67s
91:     learn: 0.1984586      total: 471ms     remaining: 4.65s
92:     learn: 0.1960737      total: 475ms     remaining: 4.64s
93:     learn: 0.1942660      total: 482ms     remaining: 4.64s
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94:     learn: 0.1929161     total: 486ms     remaining: 4.63s
95:     learn: 0.1911708     total: 490ms     remaining: 4.61s
96:     learn: 0.1902074     total: 497ms     remaining: 4.63s
97:     learn: 0.1884600     total: 501ms     remaining: 4.61s
98:     learn: 0.1861981     total: 506ms     remaining: 4.6s
99:     learn: 0.1849892     total: 510ms     remaining: 4.59s
100:    learn: 0.1835635     total: 517ms     remaining: 4.6s
101:    learn: 0.1822115     total: 522ms     remaining: 4.59s
102:    learn: 0.1805335     total: 526ms     remaining: 4.58s
103:    learn: 0.1798795     total: 533ms     remaining: 4.59s
104:    learn: 0.1790386     total: 537ms     remaining: 4.57s
105:    learn: 0.1774465     total: 541ms     remaining: 4.56s
106:    learn: 0.1764200     total: 545ms     remaining: 4.55s
107:    learn: 0.1754278     total: 552ms     remaining: 4.56s
108:    learn: 0.1744442     total: 558ms     remaining: 4.56s
109:    learn: 0.1735904     total: 565ms     remaining: 4.57s
110:    learn: 0.1726062     total: 569ms     remaining: 4.56s
111:    learn: 0.1706629     total: 575ms     remaining: 4.56s
112:    learn: 0.1692244     total: 582ms     remaining: 4.57s
113:    learn: 0.1682710     total: 585ms     remaining: 4.55s
114:    learn: 0.1676993     total: 589ms     remaining: 4.54s
115:    learn: 0.1667727     total: 595ms     remaining: 4.53s
116:    learn: 0.1659054     total: 598ms     remaining: 4.52s
117:    learn: 0.1646372     total: 602ms     remaining: 4.5s
118:    learn: 0.1634150     total: 605ms     remaining: 4.48s
119:    learn: 0.1617735     total: 611ms     remaining: 4.48s
120:    learn: 0.1611335     total: 615ms     remaining: 4.46s
121:    learn: 0.1607142     total: 618ms     remaining: 4.45s
122:    learn: 0.1597713     total: 623ms     remaining: 4.44s
123:    learn: 0.1583032     total: 627ms     remaining: 4.43s
124:    learn: 0.1572222     total: 631ms     remaining: 4.42s
125:    learn: 0.1560870     total: 638ms     remaining: 4.43s
126:    learn: 0.1553035     total: 643ms     remaining: 4.42s
127:    learn: 0.1550364     total: 646ms     remaining: 4.4s
128:    learn: 0.1539692     total: 650ms     remaining: 4.39s
129:    learn: 0.1526549     total: 655ms     remaining: 4.38s
130:    learn: 0.1516819     total: 660ms     remaining: 4.38s
131:    learn: 0.1508098     total: 664ms     remaining: 4.36s
132:    learn: 0.1496971     total: 667ms     remaining: 4.35s
133:    learn: 0.1486553     total: 673ms     remaining: 4.35s
134:    learn: 0.1482532     total: 677ms     remaining: 4.33s
135:    learn: 0.1475403     total: 680ms     remaining: 4.32s
136:    learn: 0.1465857     total: 684ms     remaining: 4.31s
137:    learn: 0.1450133     total: 690ms     remaining: 4.31s
138:    learn: 0.1436576     total: 694ms     remaining: 4.29s
139:    learn: 0.1433413     total: 697ms     remaining: 4.28s
140:    learn: 0.1419578     total: 701ms     remaining: 4.27s
141:    learn: 0.1412495     total: 706ms     remaining: 4.26s
142:    learn: 0.1397887     total: 709ms     remaining: 4.25s
143:    learn: 0.1389578     total: 713ms     remaining: 4.24s
144:    learn: 0.1381841     total: 718ms     remaining: 4.23s
145:    learn: 0.1376186     total: 721ms     remaining: 4.22s
146:    learn: 0.1366782     total: 725ms     remaining: 4.21s
147:    learn: 0.1361739     total: 728ms     remaining: 4.19s
148:    learn: 0.1355746     total: 732ms     remaining: 4.18s
149:    learn: 0.1350867     total: 737ms     remaining: 4.17s
150:    learn: 0.1343685     total: 740ms     remaining: 4.16s
151:    learn: 0.1336928     total: 744ms     remaining: 4.15s
152:    learn: 0.1330006     total: 749ms     remaining: 4.14s
153:    learn: 0.1323118     total: 753ms     remaining: 4.13s
154:    learn: 0.1314684     total: 756ms     remaining: 4.12s
155:    learn: 0.1306512     total: 760ms     remaining: 4.11s
156:    learn: 0.1304375     total: 764ms     remaining: 4.1s
157:    learn: 0.1296586     total: 768ms     remaining: 4.09s
158:    learn: 0.1289533     total: 771ms     remaining: 4.08s
159:    learn: 0.1286117     total: 775ms     remaining: 4.07s
160:    learn: 0.1281296     total: 778ms     remaining: 4.06s
161:    learn: 0.1273084     total: 783ms     remaining: 4.05s
162:    learn: 0.1265437     total: 786ms     remaining: 4.04s
163:    learn: 0.1258828     total: 789ms     remaining: 4.02s
164:    learn: 0.1248544     total: 793ms     remaining: 4.01s
165:    learn: 0.1242879     total: 798ms     remaining: 4.01s
166:    learn: 0.1238815     total: 801ms     remaining: 4s
167:    learn: 0.1234804     total: 805ms     remaining: 3.98s
168:    learn: 0.1223782     total: 808ms     remaining: 3.97s
169:    learn: 0.1218170     total: 814ms     remaining: 3.98s
170:    learn: 0.1213518     total: 818ms     remaining: 3.96s
171:    learn: 0.1202675     total: 821ms     remaining: 3.95s
172:    learn: 0.1198894     total: 825ms     remaining: 3.94s
173:    learn: 0.1189230     total: 830ms     remaining: 3.94s
174:    learn: 0.1186202     total: 834ms     remaining: 3.93s
175:    learn: 0.1178995     total: 838ms     remaining: 3.92s
176:    learn: 0.1176920     total: 841ms     remaining: 3.91s
177:    learn: 0.1170213     total: 847ms     remaining: 3.91s
178:    learn: 0.1165422     total: 850ms     remaining: 3.9s
179:    learn: 0.1159154     total: 853ms     remaining: 3.89s
180:    learn: 0.1152075     total: 857ms     remaining: 3.88s
181:    learn: 0.1148459     total: 864ms     remaining: 3.88s
182:    learn: 0.1137684     total: 868ms     remaining: 3.87s
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183:     learn: 0.1134186      total: 871ms    remaining: 3.86s
184:     learn: 0.1127520      total: 878ms    remaining: 3.87s
185:     learn: 0.1121780      total: 882ms    remaining: 3.86s
186:     learn: 0.1115317      total: 885ms    remaining: 3.85s
187:     learn: 0.1110334      total: 889ms    remaining: 3.84s
188:     learn: 0.1102634      total: 895ms    remaining: 3.84s
189:     learn: 0.1100678      total: 898ms    remaining: 3.83s
190:     learn: 0.1097478      total: 903ms    remaining: 3.82s
191:     learn: 0.1092108      total: 906ms    remaining: 3.81s
192:     learn: 0.1086512      total: 912ms    remaining: 3.81s
193:     learn: 0.1079181      total: 915ms    remaining: 3.8s
194:     learn: 0.1076076      total: 918ms    remaining: 3.79s
195:     learn: 0.1071329      total: 922ms    remaining: 3.78s
196:     learn: 0.1066362      total: 927ms    remaining: 3.78s
197:     learn: 0.1064403      total: 930ms    remaining: 3.77s
198:     learn: 0.1060233      total: 934ms    remaining: 3.76s
199:     learn: 0.1054765      total: 937ms    remaining: 3.75s
200:     learn: 0.1050564      total: 943ms    remaining: 3.75s
201:     learn: 0.1047403      total: 946ms    remaining: 3.74s
202:     learn: 0.1043094      total: 949ms    remaining: 3.73s
203:     learn: 0.1041559      total: 953ms    remaining: 3.72s
204:     learn: 0.1038236      total: 958ms    remaining: 3.71s
205:     learn: 0.1034109      total: 962ms    remaining: 3.71s
206:     learn: 0.1031200      total: 966ms    remaining: 3.7s
207:     learn: 0.1026077      total: 970ms    remaining: 3.69s
208:     learn: 0.1020673      total: 976ms    remaining: 3.69s
209:     learn: 0.1018493      total: 980ms    remaining: 3.69s
210:     learn: 0.1013113      total: 985ms    remaining: 3.68s
211:     learn: 0.1010428      total: 992ms    remaining: 3.69s
212:     learn: 0.1004899      total: 996ms    remaining: 3.68s
213:     learn: 0.1001241      total: 999ms    remaining: 3.67s
214:     learn: 0.0997176      total: 1.01s    remaining: 3.67s
215:     learn: 0.0993054      total: 1.01s    remaining: 3.67s
216:     learn: 0.0990284      total: 1.01s    remaining: 3.66s
217:     learn: 0.0986864      total: 1.02s    remaining: 3.65s
218:     learn: 0.0981005      total: 1.02s    remaining: 3.64s
219:     learn: 0.0978665      total: 1.02s    remaining: 3.64s
220:     learn: 0.0973460      total: 1.03s    remaining: 3.63s
221:     learn: 0.0968130      total: 1.03s    remaining: 3.62s
222:     learn: 0.0964517      total: 1.04s    remaining: 3.62s
223:     learn: 0.0959080      total: 1.04s    remaining: 3.61s
224:     learn: 0.0955058      total: 1.04s    remaining: 3.6s
225:     learn: 0.0950454      total: 1.05s    remaining: 3.59s
226:     learn: 0.0947959      total: 1.05s    remaining: 3.59s
227:     learn: 0.0944620      total: 1.06s    remaining: 3.58s
228:     learn: 0.0940267      total: 1.06s    remaining: 3.57s
229:     learn: 0.0936580      total: 1.06s    remaining: 3.57s
230:     learn: 0.0931979      total: 1.07s    remaining: 3.56s
231:     learn: 0.0930331      total: 1.07s    remaining: 3.55s
232:     learn: 0.0928653      total: 1.08s    remaining: 3.54s
233:     learn: 0.0924074      total: 1.08s    remaining: 3.54s
234:     learn: 0.0920642      total: 1.08s    remaining: 3.53s
235:     learn: 0.0917315      total: 1.09s    remaining: 3.53s
236:     learn: 0.0913729      total: 1.09s    remaining: 3.52s
237:     learn: 0.0911011      total: 1.1s     remaining: 3.52s
238:     learn: 0.0906809      total: 1.1s     remaining: 3.51s
239:     learn: 0.0901226      total: 1.11s    remaining: 3.51s
240:     learn: 0.0899046      total: 1.11s    remaining: 3.5s
241:     learn: 0.0896562      total: 1.12s    remaining: 3.5s
242:     learn: 0.0888880      total: 1.12s    remaining: 3.49s
243:     learn: 0.0885402      total: 1.12s    remaining: 3.48s
244:     learn: 0.0883556      total: 1.13s    remaining: 3.48s
245:     learn: 0.0879051      total: 1.13s    remaining: 3.48s
246:     learn: 0.0877062      total: 1.14s    remaining: 3.47s
247:     learn: 0.0874015      total: 1.14s    remaining: 3.46s
248:     learn: 0.0872807      total: 1.15s    remaining: 3.46s
249:     learn: 0.0867934      total: 1.15s    remaining: 3.46s
250:     learn: 0.0864720      total: 1.16s    remaining: 3.45s
251:     learn: 0.0859585      total: 1.16s    remaining: 3.45s
252:     learn: 0.0857256      total: 1.17s    remaining: 3.45s
253:     learn: 0.0854997      total: 1.17s    remaining: 3.45s
254:     learn: 0.0851370      total: 1.18s    remaining: 3.45s
255:     learn: 0.0848627      total: 1.18s    remaining: 3.44s
256:     learn: 0.0845201      total: 1.19s    remaining: 3.44s
257:     learn: 0.0842352      total: 1.2s     remaining: 3.44s
258:     learn: 0.0840931      total: 1.2s     remaining: 3.43s
259:     learn: 0.0837543      total: 1.2s     remaining: 3.42s
260:     learn: 0.0834474      total: 1.21s    remaining: 3.42s
261:     learn: 0.0830299      total: 1.21s    remaining: 3.42s
262:     learn: 0.0827711      total: 1.22s    remaining: 3.41s
263:     learn: 0.0824819      total: 1.22s    remaining: 3.4s
264:     learn: 0.0821756      total: 1.23s    remaining: 3.4s
265:     learn: 0.0817282      total: 1.23s    remaining: 3.4s
266:     learn: 0.0815027      total: 1.24s    remaining: 3.39s
267:     learn: 0.0812483      total: 1.24s    remaining: 3.38s
268:     learn: 0.0810272      total: 1.25s    remaining: 3.39s
269:     learn: 0.0807855      total: 1.25s    remaining: 3.38s
270:     learn: 0.0805173      total: 1.25s    remaining: 3.37s
271:     learn: 0.0800233      total: 1.26s    remaining: 3.38s
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272:    learn: 0.0797333    total: 1.27s    remaining: 3.37s
273:    learn: 0.0792043    total: 1.27s    remaining: 3.36s
274:    learn: 0.0791158    total: 1.28s    remaining: 3.37s
275:    learn: 0.0789004    total: 1.28s    remaining: 3.36s
276:    learn: 0.0787020    total: 1.28s    remaining: 3.35s
277:    learn: 0.0784383    total: 1.29s    remaining: 3.36s
278:    learn: 0.0783316    total: 1.3s     remaining: 3.35s
279:    learn: 0.0780954    total: 1.3s     remaining: 3.35s
280:    learn: 0.0778444    total: 1.31s    remaining: 3.35s
281:    learn: 0.0777231    total: 1.31s    remaining: 3.35s
282:    learn: 0.0771985    total: 1.32s    remaining: 3.34s
283:    learn: 0.0770071    total: 1.33s    remaining: 3.34s
284:    learn: 0.0767632    total: 1.33s    remaining: 3.34s
285:    learn: 0.0764563    total: 1.33s    remaining: 3.33s
286:    learn: 0.0763107    total: 1.34s    remaining: 3.33s
287:    learn: 0.0758238    total: 1.34s    remaining: 3.33s
288:    learn: 0.0755996    total: 1.35s    remaining: 3.32s
289:    learn: 0.0753409    total: 1.36s    remaining: 3.32s
290:    learn: 0.0751111    total: 1.36s    remaining: 3.32s
291:    learn: 0.0747060    total: 1.36s    remaining: 3.31s
292:    learn: 0.0742441    total: 1.37s    remaining: 3.31s
293:    learn: 0.0740392    total: 1.38s    remaining: 3.31s
294:    learn: 0.0738012    total: 1.38s    remaining: 3.3s
295:    learn: 0.0736580    total: 1.39s    remaining: 3.31s
296:    learn: 0.0734682    total: 1.39s    remaining: 3.3s
297:    learn: 0.0733021    total: 1.4s     remaining: 3.29s
298:    learn: 0.0730383    total: 1.41s    remaining: 3.3s
299:    learn: 0.0727812    total: 1.41s    remaining: 3.29s
300:    learn: 0.0724846    total: 1.42s    remaining: 3.3s
301:    learn: 0.0722212    total: 1.42s    remaining: 3.29s
302:    learn: 0.0720950    total: 1.43s    remaining: 3.29s
303:    learn: 0.0719152    total: 1.44s    remaining: 3.29s
304:    learn: 0.0716130    total: 1.44s    remaining: 3.28s
305:    learn: 0.0713946    total: 1.44s    remaining: 3.27s
306:    learn: 0.0712338    total: 1.45s    remaining: 3.27s
307:    learn: 0.0709582    total: 1.46s    remaining: 3.27s
308:    learn: 0.0707637    total: 1.46s    remaining: 3.26s
309:    learn: 0.0705713    total: 1.47s    remaining: 3.26s
310:    learn: 0.0704183    total: 1.47s    remaining: 3.26s
311:    learn: 0.0701358    total: 1.47s    remaining: 3.25s
312:    learn: 0.0698944    total: 1.48s    remaining: 3.24s
313:    learn: 0.0697336    total: 1.48s    remaining: 3.24s
314:    learn: 0.0694459    total: 1.49s    remaining: 3.23s
315:    learn: 0.0690810    total: 1.49s    remaining: 3.23s
316:    learn: 0.0687983    total: 1.5s     remaining: 3.23s
317:    learn: 0.0685956    total: 1.5s     remaining: 3.22s
318:    learn: 0.0684598    total: 1.5s     remaining: 3.21s
319:    learn: 0.0683595    total: 1.51s    remaining: 3.21s
320:    learn: 0.0681744    total: 1.51s    remaining: 3.2s
321:    learn: 0.0679967    total: 1.52s    remaining: 3.2s
322:    learn: 0.0677958    total: 1.52s    remaining: 3.19s
323:    learn: 0.0676527    total: 1.53s    remaining: 3.19s
324:    learn: 0.0675654    total: 1.53s    remaining: 3.18s
325:    learn: 0.0674219    total: 1.54s    remaining: 3.18s
326:    learn: 0.0671411    total: 1.54s    remaining: 3.17s
327:    learn: 0.0669731    total: 1.55s    remaining: 3.17s
328:    learn: 0.0668252    total: 1.55s    remaining: 3.16s
329:    learn: 0.0664867    total: 1.55s    remaining: 3.15s
330:    learn: 0.0662759    total: 1.56s    remaining: 3.15s
331:    learn: 0.0660049    total: 1.56s    remaining: 3.15s
332:    learn: 0.0658044    total: 1.57s    remaining: 3.14s
333:    learn: 0.0655181    total: 1.57s    remaining: 3.13s
334:    learn: 0.0652947    total: 1.58s    remaining: 3.13s
335:    learn: 0.0651168    total: 1.58s    remaining: 3.12s
336:    learn: 0.0649990    total: 1.58s    remaining: 3.12s
337:    learn: 0.0647168    total: 1.59s    remaining: 3.11s
338:    learn: 0.0646670    total: 1.59s    remaining: 3.11s
339:    learn: 0.0644502    total: 1.6s     remaining: 3.1s
340:    learn: 0.0643212    total: 1.6s     remaining: 3.09s
341:    learn: 0.0640964    total: 1.6s     remaining: 3.09s
342:    learn: 0.0639497    total: 1.61s    remaining: 3.09s
343:    learn: 0.0636645    total: 1.61s    remaining: 3.08s
344:    learn: 0.0635142    total: 1.62s    remaining: 3.07s
345:    learn: 0.0633244    total: 1.62s    remaining: 3.07s
346:    learn: 0.0630372    total: 1.63s    remaining: 3.06s
347:    learn: 0.0629630    total: 1.63s    remaining: 3.06s
348:    learn: 0.0628631    total: 1.64s    remaining: 3.05s
349:    learn: 0.0626656    total: 1.64s    remaining: 3.05s
350:    learn: 0.0624849    total: 1.65s    remaining: 3.05s
351:    learn: 0.0622891    total: 1.65s    remaining: 3.04s
352:    learn: 0.0621762    total: 1.66s    remaining: 3.04s
353:    learn: 0.0620096    total: 1.66s    remaining: 3.03s
354:    learn: 0.0619171    total: 1.67s    remaining: 3.02s
355:    learn: 0.0617328    total: 1.67s    remaining: 3.02s
356:    learn: 0.0616484    total: 1.68s    remaining: 3.02s
357:    learn: 0.0615245    total: 1.68s    remaining: 3.01s
358:    learn: 0.0613479    total: 1.68s    remaining: 3.01s
359:    learn: 0.0611046    total: 1.69s    remaining: 3s
360:    learn: 0.0609209    total: 1.69s    remaining: 3s
```

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361:    learn: 0.0607411      total: 1.7s      remaining: 2.99s
362:    learn: 0.0605887      total: 1.71s     remaining: 2.99s
363:    learn: 0.0603464      total: 1.71s     remaining: 2.99s
364:    learn: 0.0601768      total: 1.71s     remaining: 2.98s
365:    learn: 0.0599936      total: 1.72s     remaining: 2.98s
366:    learn: 0.0598824      total: 1.72s     remaining: 2.97s
367:    learn: 0.0597540      total: 1.73s     remaining: 2.97s
368:    learn: 0.0596257      total: 1.73s     remaining: 2.96s
369:    learn: 0.0594817      total: 1.74s     remaining: 2.96s
370:    learn: 0.0593703      total: 1.74s     remaining: 2.95s
371:    learn: 0.0592919      total: 1.75s     remaining: 2.95s
372:    learn: 0.0591427      total: 1.75s     remaining: 2.95s
373:    learn: 0.0589475      total: 1.76s     remaining: 2.94s
374:    learn: 0.0587734      total: 1.76s     remaining: 2.94s
375:    learn: 0.0586748      total: 1.77s     remaining: 2.94s
376:    learn: 0.0584181      total: 1.77s     remaining: 2.93s
377:    learn: 0.0583233      total: 1.78s     remaining: 2.93s
378:    learn: 0.0582116      total: 1.78s     remaining: 2.92s
379:    learn: 0.0581088      total: 1.79s     remaining: 2.92s
380:    learn: 0.0578922      total: 1.79s     remaining: 2.91s
381:    learn: 0.0576076      total: 1.8s      remaining: 2.91s
382:    learn: 0.0574485      total: 1.8s      remaining: 2.9s
383:    learn: 0.0573236      total: 1.81s     remaining: 2.9s
384:    learn: 0.0570832      total: 1.81s     remaining: 2.89s
385:    learn: 0.0568475      total: 1.82s     remaining: 2.89s
386:    learn: 0.0566872      total: 1.82s     remaining: 2.89s
387:    learn: 0.0565525      total: 1.83s     remaining: 2.88s
388:    learn: 0.0563975      total: 1.83s     remaining: 2.88s
389:    learn: 0.0562772      total: 1.83s     remaining: 2.87s
390:    learn: 0.0561691      total: 1.84s     remaining: 2.87s
391:    learn: 0.0559919      total: 1.84s     remaining: 2.86s
392:    learn: 0.0558375      total: 1.85s     remaining: 2.86s
393:    learn: 0.0556668      total: 1.85s     remaining: 2.85s
394:    learn: 0.0555261      total: 1.86s     remaining: 2.85s
395:    learn: 0.0554364      total: 1.86s     remaining: 2.84s
396:    learn: 0.0551839      total: 1.86s     remaining: 2.83s
397:    learn: 0.0550234      total: 1.87s     remaining: 2.83s
398:    learn: 0.0549007      total: 1.87s     remaining: 2.82s
399:    learn: 0.0547278      total: 1.88s     remaining: 2.81s
400:    learn: 0.0546119      total: 1.88s     remaining: 2.81s
401:    learn: 0.0545443      total: 1.88s     remaining: 2.8s
402:    learn: 0.0542863      total: 1.89s     remaining: 2.8s
403:    learn: 0.0541858      total: 1.89s     remaining: 2.79s
404:    learn: 0.0540504      total: 1.9s      remaining: 2.79s
405:    learn: 0.0538713      total: 1.9s      remaining: 2.78s
406:    learn: 0.0537831      total: 1.9s      remaining: 2.77s
407:    learn: 0.0536579      total: 1.91s     remaining: 2.77s
408:    learn: 0.0534779      total: 1.91s     remaining: 2.76s
409:    learn: 0.0533003      total: 1.92s     remaining: 2.76s
410:    learn: 0.0531412      total: 1.92s     remaining: 2.75s
411:    learn: 0.0530187      total: 1.92s     remaining: 2.75s
412:    learn: 0.0527988      total: 1.93s     remaining: 2.74s
413:    learn: 0.0525911      total: 1.93s     remaining: 2.73s
414:    learn: 0.0523675      total: 1.94s     remaining: 2.73s
415:    learn: 0.0522304      total: 1.94s     remaining: 2.72s
416:    learn: 0.0520928      total: 1.94s     remaining: 2.72s
417:    learn: 0.0519005      total: 1.95s     remaining: 2.71s
418:    learn: 0.0517320      total: 1.95s     remaining: 2.71s
419:    learn: 0.0516205      total: 1.96s     remaining: 2.7s
420:    learn: 0.0514924      total: 1.96s     remaining: 2.69s
421:    learn: 0.0513940      total: 1.96s     remaining: 2.69s
422:    learn: 0.0512332      total: 1.97s     remaining: 2.68s
423:    learn: 0.0510575      total: 1.97s     remaining: 2.68s
424:    learn: 0.0509307      total: 1.97s     remaining: 2.67s
425:    learn: 0.0507797      total: 1.98s     remaining: 2.67s
426:    learn: 0.0506878      total: 1.98s     remaining: 2.66s
427:    learn: 0.0504984      total: 1.99s     remaining: 2.65s
428:    learn: 0.0503606      total: 1.99s     remaining: 2.65s
429:    learn: 0.0502526      total: 1.99s     remaining: 2.64s
430:    learn: 0.0501522      total: 2s        remaining: 2.64s
431:    learn: 0.0500270      total: 2s        remaining: 2.63s
432:    learn: 0.0499285      total: 2s        remaining: 2.63s
433:    learn: 0.0497749      total: 2.01s     remaining: 2.62s
434:    learn: 0.0496367      total: 2.01s     remaining: 2.61s
435:    learn: 0.0495681      total: 2.02s     remaining: 2.61s
436:    learn: 0.0494548      total: 2.02s     remaining: 2.6s
437:    learn: 0.0493257      total: 2.02s     remaining: 2.6s
438:    learn: 0.0492221      total: 2.03s     remaining: 2.59s
439:    learn: 0.0491348      total: 2.03s     remaining: 2.59s
440:    learn: 0.0489926      total: 2.04s     remaining: 2.58s
441:    learn: 0.0488062      total: 2.04s     remaining: 2.58s
442:    learn: 0.0486618      total: 2.04s     remaining: 2.57s
443:    learn: 0.0485102      total: 2.05s     remaining: 2.57s
444:    learn: 0.0483782      total: 2.06s     remaining: 2.56s
445:    learn: 0.0482397      total: 2.06s     remaining: 2.56s
446:    learn: 0.0481267      total: 2.06s     remaining: 2.55s
447:    learn: 0.0479065      total: 2.07s     remaining: 2.55s
448:    learn: 0.0477265      total: 2.08s     remaining: 2.55s
449:    learn: 0.0476225      total: 2.08s     remaining: 2.54s
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450:    learn: 0.0475018    total: 2.08s    remaining: 2.54s
451:    learn: 0.0474088    total: 2.09s    remaining: 2.54s
452:    learn: 0.0473139    total: 2.1s     remaining: 2.53s
453:    learn: 0.0472178    total: 2.1s     remaining: 2.53s
454:    learn: 0.0470890    total: 2.11s    remaining: 2.52s
455:    learn: 0.0470075    total: 2.11s    remaining: 2.52s
456:    learn: 0.0468664    total: 2.12s    remaining: 2.52s
457:    learn: 0.0468162    total: 2.12s    remaining: 2.51s
458:    learn: 0.0467190    total: 2.13s    remaining: 2.51s
459:    learn: 0.0465838    total: 2.13s    remaining: 2.51s
460:    learn: 0.0464579    total: 2.14s    remaining: 2.5s
461:    learn: 0.0463299    total: 2.14s    remaining: 2.5s
462:    learn: 0.0462407    total: 2.15s    remaining: 2.49s
463:    learn: 0.0461478    total: 2.15s    remaining: 2.49s
464:    learn: 0.0460679    total: 2.16s    remaining: 2.48s
465:    learn: 0.0459570    total: 2.16s    remaining: 2.48s
466:    learn: 0.0458341    total: 2.17s    remaining: 2.48s
467:    learn: 0.0457845    total: 2.17s    remaining: 2.47s
468:    learn: 0.0457027    total: 2.18s    remaining: 2.47s
469:    learn: 0.0456310    total: 2.19s    remaining: 2.46s
470:    learn: 0.0455793    total: 2.19s    remaining: 2.46s
471:    learn: 0.0454713    total: 2.19s    remaining: 2.45s
472:    learn: 0.0453410    total: 2.2s     remaining: 2.45s
473:    learn: 0.0451401    total: 2.21s    remaining: 2.45s
474:    learn: 0.0450046    total: 2.21s    remaining: 2.44s
475:    learn: 0.0449096    total: 2.22s    remaining: 2.44s
476:    learn: 0.0448365    total: 2.22s    remaining: 2.44s
477:    learn: 0.0447778    total: 2.23s    remaining: 2.43s
478:    learn: 0.0446625    total: 2.23s    remaining: 2.43s
479:    learn: 0.0445841    total: 2.24s    remaining: 2.42s
480:    learn: 0.0445260    total: 2.24s    remaining: 2.42s
481:    learn: 0.0443803    total: 2.25s    remaining: 2.42s
482:    learn: 0.0442838    total: 2.25s    remaining: 2.41s
483:    learn: 0.0441873    total: 2.25s    remaining: 2.4s
484:    learn: 0.0441229    total: 2.26s    remaining: 2.4s
485:    learn: 0.0439902    total: 2.26s    remaining: 2.4s
486:    learn: 0.0439230    total: 2.27s    remaining: 2.39s
487:    learn: 0.0438423    total: 2.27s    remaining: 2.38s
488:    learn: 0.0437339    total: 2.28s    remaining: 2.38s
489:    learn: 0.0436222    total: 2.28s    remaining: 2.37s
490:    learn: 0.0435628    total: 2.29s    remaining: 2.37s
491:    learn: 0.0435257    total: 2.29s    remaining: 2.36s
492:    learn: 0.0433653    total: 2.29s    remaining: 2.36s
493:    learn: 0.0432342    total: 2.3s     remaining: 2.35s
494:    learn: 0.0431222    total: 2.3s     remaining: 2.35s
495:    learn: 0.0430213    total: 2.31s    remaining: 2.34s
496:    learn: 0.0429440    total: 2.31s    remaining: 2.34s
497:    learn: 0.0428578    total: 2.31s    remaining: 2.33s
498:    learn: 0.0427807    total: 2.32s    remaining: 2.33s
499:    learn: 0.0427051    total: 2.32s    remaining: 2.32s
500:    learn: 0.0425893    total: 2.33s    remaining: 2.32s
501:    learn: 0.0424644    total: 2.33s    remaining: 2.31s
502:    learn: 0.0423089    total: 2.33s    remaining: 2.31s
503:    learn: 0.0422214    total: 2.34s    remaining: 2.3s
504:    learn: 0.0420928    total: 2.34s    remaining: 2.3s
505:    learn: 0.0419563    total: 2.35s    remaining: 2.29s
506:    learn: 0.0418263    total: 2.35s    remaining: 2.29s
507:    learn: 0.0416749    total: 2.35s    remaining: 2.28s
508:    learn: 0.0415737    total: 2.36s    remaining: 2.28s
509:    learn: 0.0414214    total: 2.36s    remaining: 2.27s
510:    learn: 0.0413216    total: 2.37s    remaining: 2.27s
511:    learn: 0.0412358    total: 2.37s    remaining: 2.26s
512:    learn: 0.0411181    total: 2.38s    remaining: 2.25s
513:    learn: 0.0410714    total: 2.38s    remaining: 2.25s
514:    learn: 0.0410260    total: 2.38s    remaining: 2.24s
515:    learn: 0.0409312    total: 2.39s    remaining: 2.24s
516:    learn: 0.0409008    total: 2.39s    remaining: 2.23s
517:    learn: 0.0408687    total: 2.4s     remaining: 2.23s
518:    learn: 0.0408248    total: 2.4s     remaining: 2.22s
519:    learn: 0.0406726    total: 2.4s     remaining: 2.22s
520:    learn: 0.0406154    total: 2.41s    remaining: 2.21s
521:    learn: 0.0405059    total: 2.41s    remaining: 2.21s
522:    learn: 0.0404144    total: 2.42s    remaining: 2.2s
523:    learn: 0.0403184    total: 2.42s    remaining: 2.2s
524:    learn: 0.0401183    total: 2.43s    remaining: 2.19s
525:    learn: 0.0400436    total: 2.43s    remaining: 2.19s
526:    learn: 0.0399963    total: 2.43s    remaining: 2.18s
527:    learn: 0.0399269    total: 2.44s    remaining: 2.18s
528:    learn: 0.0398269    total: 2.44s    remaining: 2.18s
529:    learn: 0.0397507    total: 2.45s    remaining: 2.17s
530:    learn: 0.0396397    total: 2.45s    remaining: 2.16s
531:    learn: 0.0394991    total: 2.46s    remaining: 2.16s
532:    learn: 0.0393883    total: 2.46s    remaining: 2.15s
533:    learn: 0.0392777    total: 2.46s    remaining: 2.15s
534:    learn: 0.0392284    total: 2.47s    remaining: 2.15s
535:    learn: 0.0391007    total: 2.47s    remaining: 2.14s
536:    learn: 0.0389954    total: 2.48s    remaining: 2.13s
537:    learn: 0.0389230    total: 2.48s    remaining: 2.13s
538:    learn: 0.0388040    total: 2.49s    remaining: 2.13s
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539:    learn: 0.0386879    total: 2.49s    remaining: 2.12s
540:    learn: 0.0386306    total: 2.49s    remaining: 2.12s
541:    learn: 0.0385654    total: 2.5s     remaining: 2.11s
542:    learn: 0.0384619    total: 2.5s     remaining: 2.11s
543:    learn: 0.0383373    total: 2.51s    remaining: 2.1s
544:    learn: 0.0382659    total: 2.51s    remaining: 2.1s
545:    learn: 0.0381789    total: 2.52s    remaining: 2.09s
546:    learn: 0.0380670    total: 2.52s    remaining: 2.09s
547:    learn: 0.0380047    total: 2.52s    remaining: 2.08s
548:    learn: 0.0378677    total: 2.53s    remaining: 2.08s
549:    learn: 0.0378191    total: 2.54s    remaining: 2.07s
550:    learn: 0.0377250    total: 2.54s    remaining: 2.07s
551:    learn: 0.0376561    total: 2.54s    remaining: 2.06s
552:    learn: 0.0375793    total: 2.55s    remaining: 2.06s
553:    learn: 0.0374910    total: 2.55s    remaining: 2.05s
554:    learn: 0.0374380    total: 2.56s    remaining: 2.05s
555:    learn: 0.0373507    total: 2.56s    remaining: 2.04s
556:    learn: 0.0372330    total: 2.57s    remaining: 2.04s
557:    learn: 0.0371479    total: 2.57s    remaining: 2.04s
558:    learn: 0.0371135    total: 2.57s    remaining: 2.03s
559:    learn: 0.0370540    total: 2.58s    remaining: 2.03s
560:    learn: 0.0369706    total: 2.58s    remaining: 2.02s
561:    learn: 0.0369367    total: 2.59s    remaining: 2.02s
562:    learn: 0.0368826    total: 2.59s    remaining: 2.01s
563:    learn: 0.0368140    total: 2.6s     remaining: 2.01s
564:    learn: 0.0367514    total: 2.6s     remaining: 2s
565:    learn: 0.0366429    total: 2.61s    remaining: 2s
566:    learn: 0.0365326    total: 2.61s    remaining: 1.99s
567:    learn: 0.0364655    total: 2.62s    remaining: 1.99s
568:    learn: 0.0363794    total: 2.62s    remaining: 1.98s
569:    learn: 0.0363257    total: 2.62s    remaining: 1.98s
570:    learn: 0.0362359    total: 2.63s    remaining: 1.98s
571:    learn: 0.0361826    total: 2.63s    remaining: 1.97s
572:    learn: 0.0361131    total: 2.64s    remaining: 1.96s
573:    learn: 0.0360430    total: 2.64s    remaining: 1.96s
574:    learn: 0.0359905    total: 2.65s    remaining: 1.96s
575:    learn: 0.0359371    total: 2.65s    remaining: 1.95s
576:    learn: 0.0358479    total: 2.65s    remaining: 1.95s
577:    learn: 0.0357780    total: 2.66s    remaining: 1.94s
578:    learn: 0.0356761    total: 2.66s    remaining: 1.94s
579:    learn: 0.0356239    total: 2.67s    remaining: 1.93s
580:    learn: 0.0355091    total: 2.67s    remaining: 1.92s
581:    learn: 0.0354275    total: 2.67s    remaining: 1.92s
582:    learn: 0.0353137    total: 2.68s    remaining: 1.92s
583:    learn: 0.0352355    total: 2.68s    remaining: 1.91s
584:    learn: 0.0351887    total: 2.68s    remaining: 1.9s
585:    learn: 0.0351073    total: 2.69s    remaining: 1.9s
586:    learn: 0.0350387    total: 2.69s    remaining: 1.9s
587:    learn: 0.0349246    total: 2.7s     remaining: 1.89s
588:    learn: 0.0348927    total: 2.7s     remaining: 1.88s
589:    learn: 0.0348360    total: 2.71s    remaining: 1.88s
590:    learn: 0.0347381    total: 2.71s    remaining: 1.88s
591:    learn: 0.0346575    total: 2.71s    remaining: 1.87s
592:    learn: 0.0345695    total: 2.72s    remaining: 1.86s
593:    learn: 0.0345336    total: 2.72s    remaining: 1.86s
594:    learn: 0.0344625    total: 2.73s    remaining: 1.86s
595:    learn: 0.0343760    total: 2.73s    remaining: 1.85s
596:    learn: 0.0343443    total: 2.73s    remaining: 1.85s
597:    learn: 0.0342939    total: 2.74s    remaining: 1.84s
598:    learn: 0.0342061    total: 2.74s    remaining: 1.84s
599:    learn: 0.0341176    total: 2.75s    remaining: 1.83s
600:    learn: 0.0340791    total: 2.75s    remaining: 1.83s
601:    learn: 0.0339879    total: 2.76s    remaining: 1.82s
602:    learn: 0.0338787    total: 2.76s    remaining: 1.82s
603:    learn: 0.0338089    total: 2.77s    remaining: 1.81s
604:    learn: 0.0337139    total: 2.77s    remaining: 1.81s
605:    learn: 0.0336352    total: 2.78s    remaining: 1.81s
606:    learn: 0.0335478    total: 2.78s    remaining: 1.8s
607:    learn: 0.0334929    total: 2.79s    remaining: 1.8s
608:    learn: 0.0334194    total: 2.79s    remaining: 1.79s
609:    learn: 0.0333835    total: 2.8s     remaining: 1.79s
610:    learn: 0.0333464    total: 2.8s     remaining: 1.78s
611:    learn: 0.0333105    total: 2.81s    remaining: 1.78s
612:    learn: 0.0332495    total: 2.81s    remaining: 1.77s
613:    learn: 0.0331900    total: 2.82s    remaining: 1.77s
614:    learn: 0.0331513    total: 2.82s    remaining: 1.77s
615:    learn: 0.0330919    total: 2.83s    remaining: 1.76s
616:    learn: 0.0330059    total: 2.83s    remaining: 1.76s
617:    learn: 0.0329768    total: 2.84s    remaining: 1.75s
618:    learn: 0.0329398    total: 2.85s    remaining: 1.75s
619:    learn: 0.0328872    total: 2.85s    remaining: 1.75s
620:    learn: 0.0328064    total: 2.85s    remaining: 1.74s
621:    learn: 0.0327233    total: 2.86s    remaining: 1.74s
622:    learn: 0.0326406    total: 2.87s    remaining: 1.73s
623:    learn: 0.0325289    total: 2.87s    remaining: 1.73s
624:    learn: 0.0324363    total: 2.87s    remaining: 1.72s
625:    learn: 0.0323781    total: 2.88s    remaining: 1.72s
626:    learn: 0.0323511    total: 2.88s    remaining: 1.71s
627:    learn: 0.0322594    total: 2.88s    remaining: 1.71s
```

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628:	learn: 0.0322316	total: 2.89s	remaining: 1.7s
629:	learn: 0.0321654	total: 2.89s	remaining: 1.7s
630:	learn: 0.0320346	total: 2.9s	remaining: 1.69s
631:	learn: 0.0319071	total: 2.9s	remaining: 1.69s
632:	learn: 0.0318566	total: 2.91s	remaining: 1.68s
633:	learn: 0.0318176	total: 2.91s	remaining: 1.68s
634:	learn: 0.0317369	total: 2.91s	remaining: 1.67s
635:	learn: 0.0317030	total: 2.92s	remaining: 1.67s
636:	learn: 0.0316564	total: 2.92s	remaining: 1.67s
637:	learn: 0.0315754	total: 2.93s	remaining: 1.66s
638:	learn: 0.0315054	total: 2.93s	remaining: 1.66s
639:	learn: 0.0314754	total: 2.94s	remaining: 1.65s
640:	learn: 0.0314144	total: 2.94s	remaining: 1.65s
641:	learn: 0.0313672	total: 2.94s	remaining: 1.64s
642:	learn: 0.0313181	total: 2.95s	remaining: 1.64s
643:	learn: 0.0312473	total: 2.95s	remaining: 1.63s
644:	learn: 0.0311951	total: 2.96s	remaining: 1.63s
645:	learn: 0.0311342	total: 2.96s	remaining: 1.62s
646:	learn: 0.0310806	total: 2.96s	remaining: 1.62s
647:	learn: 0.0310189	total: 2.97s	remaining: 1.61s
648:	learn: 0.0309918	total: 2.97s	remaining: 1.61s
649:	learn: 0.0309346	total: 2.98s	remaining: 1.6s
650:	learn: 0.0308916	total: 2.98s	remaining: 1.6s
651:	learn: 0.0308602	total: 2.99s	remaining: 1.59s
652:	learn: 0.0308061	total: 2.99s	remaining: 1.59s
653:	learn: 0.0307175	total: 3s	remaining: 1.58s
654:	learn: 0.0306840	total: 3s	remaining: 1.58s
655:	learn: 0.0306214	total: 3s	remaining: 1.57s
656:	learn: 0.0305990	total: 3.01s	remaining: 1.57s
657:	learn: 0.0305734	total: 3.01s	remaining: 1.56s
658:	learn: 0.0305402	total: 3.02s	remaining: 1.56s
659:	learn: 0.0304786	total: 3.02s	remaining: 1.55s
660:	learn: 0.0304541	total: 3.02s	remaining: 1.55s
661:	learn: 0.0303739	total: 3.03s	remaining: 1.55s
662:	learn: 0.0303088	total: 3.03s	remaining: 1.54s
663:	learn: 0.0302756	total: 3.04s	remaining: 1.54s
664:	learn: 0.0301880	total: 3.04s	remaining: 1.53s
665:	learn: 0.0301563	total: 3.05s	remaining: 1.53s
666:	learn: 0.0301162	total: 3.05s	remaining: 1.52s
667:	learn: 0.0300133	total: 3.06s	remaining: 1.52s
668:	learn: 0.0299410	total: 3.06s	remaining: 1.51s
669:	learn: 0.0298950	total: 3.06s	remaining: 1.51s
670:	learn: 0.0298229	total: 3.07s	remaining: 1.5s
671:	learn: 0.0297702	total: 3.08s	remaining: 1.5s
672:	learn: 0.0297104	total: 3.08s	remaining: 1.5s
673:	learn: 0.0296533	total: 3.08s	remaining: 1.49s
674:	learn: 0.0295624	total: 3.09s	remaining: 1.49s
675:	learn: 0.0295441	total: 3.09s	remaining: 1.48s
676:	learn: 0.0294828	total: 3.1s	remaining: 1.48s
677:	learn: 0.0294206	total: 3.1s	remaining: 1.47s
678:	learn: 0.0293971	total: 3.11s	remaining: 1.47s
679:	learn: 0.0293520	total: 3.11s	remaining: 1.46s
680:	learn: 0.0293220	total: 3.12s	remaining: 1.46s
681:	learn: 0.0292723	total: 3.12s	remaining: 1.46s
682:	learn: 0.0292069	total: 3.13s	remaining: 1.45s
683:	learn: 0.0290865	total: 3.13s	remaining: 1.45s
684:	learn: 0.0290403	total: 3.14s	remaining: 1.44s
685:	learn: 0.0289953	total: 3.14s	remaining: 1.44s
686:	learn: 0.0289561	total: 3.15s	remaining: 1.43s
687:	learn: 0.0288851	total: 3.15s	remaining: 1.43s
688:	learn: 0.0288099	total: 3.16s	remaining: 1.42s
689:	learn: 0.0287547	total: 3.16s	remaining: 1.42s
690:	learn: 0.0287124	total: 3.16s	remaining: 1.42s
691:	learn: 0.0286427	total: 3.17s	remaining: 1.41s
692:	learn: 0.0286155	total: 3.17s	remaining: 1.41s
693:	learn: 0.0285594	total: 3.18s	remaining: 1.4s
694:	learn: 0.0285065	total: 3.19s	remaining: 1.4s
695:	learn: 0.0284812	total: 3.19s	remaining: 1.39s
696:	learn: 0.0284261	total: 3.19s	remaining: 1.39s
697:	learn: 0.0283686	total: 3.2s	remaining: 1.39s
698:	learn: 0.0282986	total: 3.21s	remaining: 1.38s
699:	learn: 0.0282618	total: 3.21s	remaining: 1.38s
700:	learn: 0.0282095	total: 3.21s	remaining: 1.37s
701:	learn: 0.0281765	total: 3.22s	remaining: 1.37s
702:	learn: 0.0281309	total: 3.22s	remaining: 1.36s
703:	learn: 0.0280914	total: 3.23s	remaining: 1.36s
704:	learn: 0.0280445	total: 3.23s	remaining: 1.35s
705:	learn: 0.0280117	total: 3.24s	remaining: 1.35s
706:	learn: 0.0279687	total: 3.24s	remaining: 1.34s
707:	learn: 0.0279048	total: 3.25s	remaining: 1.34s
708:	learn: 0.0278637	total: 3.25s	remaining: 1.34s
709:	learn: 0.0278240	total: 3.26s	remaining: 1.33s
710:	learn: 0.0277714	total: 3.27s	remaining: 1.33s
711:	learn: 0.0277312	total: 3.27s	remaining: 1.32s
712:	learn: 0.0276587	total: 3.27s	remaining: 1.32s
713:	learn: 0.0276095	total: 3.28s	remaining: 1.31s
714:	learn: 0.0275430	total: 3.28s	remaining: 1.31s
715:	learn: 0.0274816	total: 3.29s	remaining: 1.3s
716:	learn: 0.0274392	total: 3.29s	remaining: 1.3s
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717:    learn: 0.0274085    total: 3.29s    remaining: 1.29s
718:    learn: 0.0273734    total: 3.3s     remaining: 1.29s
719:    learn: 0.0272716    total: 3.3s     remaining: 1.28s
720:    learn: 0.0272017    total: 3.31s    remaining: 1.28s
721:    learn: 0.0271738    total: 3.31s    remaining: 1.27s
722:    learn: 0.0271320    total: 3.31s    remaining: 1.27s
723:    learn: 0.0271118    total: 3.32s    remaining: 1.26s
724:    learn: 0.0270686    total: 3.32s    remaining: 1.26s
725:    learn: 0.0270131    total: 3.33s    remaining: 1.25s
726:    learn: 0.0269504    total: 3.33s    remaining: 1.25s
727:    learn: 0.0268919    total: 3.33s    remaining: 1.25s
728:    learn: 0.0268517    total: 3.34s    remaining: 1.24s
729:    learn: 0.0268003    total: 3.34s    remaining: 1.24s
730:    learn: 0.0267529    total: 3.35s    remaining: 1.23s
731:    learn: 0.0267231    total: 3.35s    remaining: 1.23s
732:    learn: 0.0266954    total: 3.35s    remaining: 1.22s
733:    learn: 0.0266586    total: 3.36s    remaining: 1.22s
734:    learn: 0.0266357    total: 3.37s    remaining: 1.21s
735:    learn: 0.0265857    total: 3.37s    remaining: 1.21s
736:    learn: 0.0265367    total: 3.37s    remaining: 1.2s
737:    learn: 0.0264988    total: 3.38s    remaining: 1.2s
738:    learn: 0.0264529    total: 3.38s    remaining: 1.19s
739:    learn: 0.0264062    total: 3.38s    remaining: 1.19s
740:    learn: 0.0263795    total: 3.39s    remaining: 1.18s
741:    learn: 0.0263258    total: 3.4s     remaining: 1.18s
742:    learn: 0.0262370    total: 3.4s     remaining: 1.18s
743:    learn: 0.0262183    total: 3.4s     remaining: 1.17s
744:    learn: 0.0261960    total: 3.41s    remaining: 1.17s
745:    learn: 0.0261372    total: 3.41s    remaining: 1.16s
746:    learn: 0.0261093    total: 3.42s    remaining: 1.16s
747:    learn: 0.0260315    total: 3.42s    remaining: 1.15s
748:    learn: 0.0259861    total: 3.42s    remaining: 1.15s
749:    learn: 0.0259461    total: 3.43s    remaining: 1.14s
750:    learn: 0.0258764    total: 3.43s    remaining: 1.14s
751:    learn: 0.0258510    total: 3.44s    remaining: 1.13s
752:    learn: 0.0258113    total: 3.44s    remaining: 1.13s
753:    learn: 0.0257773    total: 3.45s    remaining: 1.12s
754:    learn: 0.0257414    total: 3.45s    remaining: 1.12s
755:    learn: 0.0257018    total: 3.46s    remaining: 1.11s
756:    learn: 0.0256641    total: 3.46s    remaining: 1.11s
757:    learn: 0.0256194    total: 3.46s    remaining: 1.1s
758:    learn: 0.0255812    total: 3.47s    remaining: 1.1s
759:    learn: 0.0255262    total: 3.47s    remaining: 1.1s
760:    learn: 0.0254754    total: 3.48s    remaining: 1.09s
761:    learn: 0.0254391    total: 3.48s    remaining: 1.09s
762:    learn: 0.0253936    total: 3.48s    remaining: 1.08s
763:    learn: 0.0253288    total: 3.49s    remaining: 1.08s
764:    learn: 0.0252544    total: 3.49s    remaining: 1.07s
765:    learn: 0.0252194    total: 3.5s     remaining: 1.07s
766:    learn: 0.0251845    total: 3.5s     remaining: 1.06s
767:    learn: 0.0251501    total: 3.51s    remaining: 1.06s
768:    learn: 0.0251330    total: 3.51s    remaining: 1.05s
769:    learn: 0.0250820    total: 3.52s    remaining: 1.05s
770:    learn: 0.0250543    total: 3.52s    remaining: 1.05s
771:    learn: 0.0250293    total: 3.52s    remaining: 1.04s
772:    learn: 0.0250016    total: 3.53s    remaining: 1.04s
773:    learn: 0.0249196    total: 3.54s    remaining: 1.03s
774:    learn: 0.0248868    total: 3.54s    remaining: 1.03s
775:    learn: 0.0248660    total: 3.54s    remaining: 1.02s
776:    learn: 0.0248344    total: 3.55s    remaining: 1.02s
777:    learn: 0.0247753    total: 3.55s    remaining: 1.01s
778:    learn: 0.0247432    total: 3.56s    remaining: 1.01s
779:    learn: 0.0247358    total: 3.56s    remaining: 1s
780:    learn: 0.0246938    total: 3.57s    remaining: 1s
781:    learn: 0.0246373    total: 3.57s    remaining: 995ms
782:    learn: 0.0245967    total: 3.57s    remaining: 991ms
783:    learn: 0.0245401    total: 3.58s    remaining: 986ms
784:    learn: 0.0245131    total: 3.58s    remaining: 981ms
785:    learn: 0.0244912    total: 3.59s    remaining: 977ms
786:    learn: 0.0244628    total: 3.59s    remaining: 972ms
787:    learn: 0.0244076    total: 3.59s    remaining: 967ms
788:    learn: 0.0243883    total: 3.6s     remaining: 963ms
789:    learn: 0.0243336    total: 3.6s     remaining: 958ms
790:    learn: 0.0242890    total: 3.61s    remaining: 953ms
791:    learn: 0.0242542    total: 3.61s    remaining: 948ms
792:    learn: 0.0242118    total: 3.62s    remaining: 944ms
793:    learn: 0.0241875    total: 3.62s    remaining: 939ms
794:    learn: 0.0241464    total: 3.62s    remaining: 934ms
795:    learn: 0.0241145    total: 3.63s    remaining: 930ms
796:    learn: 0.0240757    total: 3.63s    remaining: 925ms
797:    learn: 0.0240476    total: 3.63s    remaining: 920ms
798:    learn: 0.0240070    total: 3.64s    remaining: 916ms
799:    learn: 0.0239691    total: 3.64s    remaining: 911ms
800:    learn: 0.0239285    total: 3.65s    remaining: 907ms
801:    learn: 0.0238936    total: 3.65s    remaining: 902ms
802:    learn: 0.0238313    total: 3.66s    remaining: 898ms
803:    learn: 0.0238120    total: 3.66s    remaining: 893ms
804:    learn: 0.0237811    total: 3.67s    remaining: 889ms
805:    learn: 0.0237516    total: 3.67s    remaining: 884ms
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806:    learn: 0.0237321    total: 3.68s    remaining: 880ms
807:    learn: 0.0236875    total: 3.68s    remaining: 875ms
808:    learn: 0.0236688    total: 3.69s    remaining: 870ms
809:    learn: 0.0236293    total: 3.69s    remaining: 866ms
810:    learn: 0.0235863    total: 3.69s    remaining: 861ms
811:    learn: 0.0235655    total: 3.7s     remaining: 857ms
812:    learn: 0.0235514    total: 3.7s     remaining: 852ms
813:    learn: 0.0235195    total: 3.71s    remaining: 848ms
814:    learn: 0.0234684    total: 3.72s    remaining: 844ms
815:    learn: 0.0234277    total: 3.72s    remaining: 839ms
816:    learn: 0.0233961    total: 3.73s    remaining: 835ms
817:    learn: 0.0233335    total: 3.73s    remaining: 830ms
818:    learn: 0.0233021    total: 3.74s    remaining: 826ms
819:    learn: 0.0232816    total: 3.74s    remaining: 821ms
820:    learn: 0.0232385    total: 3.75s    remaining: 817ms
821:    learn: 0.0232002    total: 3.75s    remaining: 812ms
822:    learn: 0.0231661    total: 3.75s    remaining: 808ms
823:    learn: 0.0231152    total: 3.76s    remaining: 803ms
824:    learn: 0.0230738    total: 3.76s    remaining: 799ms
825:    learn: 0.0230399    total: 3.77s    remaining: 794ms
826:    learn: 0.0230139    total: 3.77s    remaining: 790ms
827:    learn: 0.0229581    total: 3.78s    remaining: 785ms
828:    learn: 0.0229277    total: 3.79s    remaining: 781ms
829:    learn: 0.0229021    total: 3.79s    remaining: 776ms
830:    learn: 0.0228657    total: 3.79s    remaining: 772ms
831:    learn: 0.0227940    total: 3.8s     remaining: 767ms
832:    learn: 0.0227503    total: 3.8s     remaining: 762ms
833:    learn: 0.0227117    total: 3.8s     remaining: 757ms
834:    learn: 0.0226893    total: 3.81s    remaining: 753ms
835:    learn: 0.0226577    total: 3.81s    remaining: 748ms
836:    learn: 0.0226351    total: 3.82s    remaining: 743ms
837:    learn: 0.0226038    total: 3.82s    remaining: 739ms
838:    learn: 0.0225831    total: 3.82s    remaining: 734ms
839:    learn: 0.0225510    total: 3.83s    remaining: 729ms
840:    learn: 0.0225268    total: 3.83s    remaining: 724ms
841:    learn: 0.0224848    total: 3.83s    remaining: 719ms
842:    learn: 0.0224174    total: 3.84s    remaining: 715ms
843:    learn: 0.0223726    total: 3.84s    remaining: 710ms
844:    learn: 0.0223412    total: 3.84s    remaining: 705ms
845:    learn: 0.0223057    total: 3.85s    remaining: 700ms
846:    learn: 0.0222861    total: 3.85s    remaining: 696ms
847:    learn: 0.0222478    total: 3.85s    remaining: 691ms
848:    learn: 0.0222217    total: 3.86s    remaining: 686ms
849:    learn: 0.0221899    total: 3.86s    remaining: 682ms
850:    learn: 0.0221535    total: 3.87s    remaining: 677ms
851:    learn: 0.0221289    total: 3.87s    remaining: 672ms
852:    learn: 0.0221004    total: 3.87s    remaining: 668ms
853:    learn: 0.0220796    total: 3.88s    remaining: 664ms
854:    learn: 0.0220332    total: 3.88s    remaining: 659ms
855:    learn: 0.0220258    total: 3.89s    remaining: 654ms
856:    learn: 0.0220048    total: 3.89s    remaining: 650ms
857:    learn: 0.0219698    total: 3.9s     remaining: 645ms
858:    learn: 0.0219368    total: 3.9s     remaining: 640ms
859:    learn: 0.0219220    total: 3.9s     remaining: 636ms
860:    learn: 0.0218885    total: 3.91s    remaining: 631ms
861:    learn: 0.0218386    total: 3.91s    remaining: 626ms
862:    learn: 0.0218023    total: 3.92s    remaining: 622ms
863:    learn: 0.0217760    total: 3.92s    remaining: 617ms
864:    learn: 0.0217428    total: 3.92s    remaining: 613ms
865:    learn: 0.0217055    total: 3.93s    remaining: 608ms
866:    learn: 0.0216816    total: 3.93s    remaining: 603ms
867:    learn: 0.0216555    total: 3.94s    remaining: 599ms
868:    learn: 0.0216410    total: 3.94s    remaining: 594ms
869:    learn: 0.0216092    total: 3.94s    remaining: 589ms
870:    learn: 0.0215784    total: 3.95s    remaining: 585ms
871:    learn: 0.0215682    total: 3.95s    remaining: 580ms
872:    learn: 0.0215223    total: 3.96s    remaining: 576ms
873:    learn: 0.0214963    total: 3.96s    remaining: 571ms
874:    learn: 0.0214816    total: 3.96s    remaining: 566ms
875:    learn: 0.0214391    total: 3.97s    remaining: 562ms
876:    learn: 0.0214141    total: 3.97s    remaining: 557ms
877:    learn: 0.0213758    total: 3.98s    remaining: 553ms
878:    learn: 0.0213533    total: 3.98s    remaining: 548ms
879:    learn: 0.0213282    total: 3.98s    remaining: 543ms
880:    learn: 0.0212796    total: 3.99s    remaining: 539ms
881:    learn: 0.0212645    total: 3.99s    remaining: 534ms
882:    learn: 0.0212167    total: 3.99s    remaining: 529ms
883:    learn: 0.0211518    total: 4s       remaining: 525ms
884:    learn: 0.0211366    total: 4s       remaining: 520ms
885:    learn: 0.0211090    total: 4.01s    remaining: 516ms
886:    learn: 0.0210816    total: 4.01s    remaining: 511ms
887:    learn: 0.0210668    total: 4.02s    remaining: 507ms
888:    learn: 0.0210400    total: 4.02s    remaining: 502ms
889:    learn: 0.0210203    total: 4.02s    remaining: 497ms
890:    learn: 0.0210042    total: 4.03s    remaining: 493ms
891:    learn: 0.0209710    total: 4.03s    remaining: 488ms
892:    learn: 0.0209296    total: 4.04s    remaining: 484ms
893:    learn: 0.0208960    total: 4.04s    remaining: 479ms
894:    learn: 0.0208699    total: 4.05s    remaining: 475ms
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895:    learn: 0.0208222    total: 4.05s    remaining: 470ms
896:    learn: 0.0207694    total: 4.06s    remaining: 466ms
897:    learn: 0.0207377    total: 4.06s    remaining: 461ms
898:    learn: 0.0207056    total: 4.06s    remaining: 457ms
899:    learn: 0.0206805    total: 4.07s    remaining: 452ms
900:    learn: 0.0206519    total: 4.07s    remaining: 448ms
901:    learn: 0.0206118    total: 4.08s    remaining: 443ms
902:    learn: 0.0205899    total: 4.08s    remaining: 439ms
903:    learn: 0.0205454    total: 4.09s    remaining: 434ms
904:    learn: 0.0205109    total: 4.09s    remaining: 429ms
905:    learn: 0.0204868    total: 4.09s    remaining: 425ms
906:    learn: 0.0204630    total: 4.1s     remaining: 420ms
907:    learn: 0.0204344    total: 4.1s     remaining: 416ms
908:    learn: 0.0203998    total: 4.11s    remaining: 411ms
909:    learn: 0.0203779    total: 4.11s    remaining: 407ms
910:    learn: 0.0203580    total: 4.12s    remaining: 402ms
911:    learn: 0.0203341    total: 4.12s    remaining: 398ms
912:    learn: 0.0202945    total: 4.13s    remaining: 394ms
913:    learn: 0.0202341    total: 4.13s    remaining: 389ms
914:    learn: 0.0201936    total: 4.14s    remaining: 385ms
915:    learn: 0.0201596    total: 4.15s    remaining: 380ms
916:    learn: 0.0201110    total: 4.15s    remaining: 376ms
917:    learn: 0.0200977    total: 4.16s    remaining: 372ms
918:    learn: 0.0200747    total: 4.17s    remaining: 367ms
919:    learn: 0.0200428    total: 4.17s    remaining: 363ms
920:    learn: 0.0200252    total: 4.18s    remaining: 359ms
921:    learn: 0.0199882    total: 4.19s    remaining: 354ms
922:    learn: 0.0199592    total: 4.2s     remaining: 350ms
923:    learn: 0.0199315    total: 4.2s     remaining: 346ms
924:    learn: 0.0198954    total: 4.21s    remaining: 341ms
925:    learn: 0.0198760    total: 4.22s    remaining: 337ms
926:    learn: 0.0198434    total: 4.22s    remaining: 333ms
927:    learn: 0.0198250    total: 4.23s    remaining: 328ms
928:    learn: 0.0198081    total: 4.24s    remaining: 324ms
929:    learn: 0.0197946    total: 4.25s    remaining: 320ms
930:    learn: 0.0197560    total: 4.26s    remaining: 315ms
931:    learn: 0.0197299    total: 4.26s    remaining: 311ms
932:    learn: 0.0197069    total: 4.27s    remaining: 307ms
933:    learn: 0.0196579    total: 4.28s    remaining: 302ms
934:    learn: 0.0196444    total: 4.28s    remaining: 298ms
935:    learn: 0.0196061    total: 4.29s    remaining: 293ms
936:    learn: 0.0195799    total: 4.29s    remaining: 289ms
937:    learn: 0.0195547    total: 4.3s     remaining: 284ms
938:    learn: 0.0195330    total: 4.3s     remaining: 280ms
939:    learn: 0.0194593    total: 4.31s    remaining: 275ms
940:    learn: 0.0194281    total: 4.31s    remaining: 271ms
941:    learn: 0.0194054    total: 4.32s    remaining: 266ms
942:    learn: 0.0193791    total: 4.32s    remaining: 261ms
943:    learn: 0.0193603    total: 4.33s    remaining: 257ms
944:    learn: 0.0193085    total: 4.33s    remaining: 252ms
945:    learn: 0.0192623    total: 4.34s    remaining: 248ms
946:    learn: 0.0192336    total: 4.34s    remaining: 243ms
947:    learn: 0.0192049    total: 4.35s    remaining: 238ms
948:    learn: 0.0191854    total: 4.35s    remaining: 234ms
949:    learn: 0.0191475    total: 4.36s    remaining: 229ms
950:    learn: 0.0191080    total: 4.36s    remaining: 225ms
951:    learn: 0.0190848    total: 4.36s    remaining: 220ms
952:    learn: 0.0190757    total: 4.37s    remaining: 216ms
953:    learn: 0.0190577    total: 4.37s    remaining: 211ms
954:    learn: 0.0190396    total: 4.38s    remaining: 206ms
955:    learn: 0.0190106    total: 4.38s    remaining: 202ms
956:    learn: 0.0189963    total: 4.39s    remaining: 197ms
957:    learn: 0.0189349    total: 4.39s    remaining: 193ms
958:    learn: 0.0189151    total: 4.4s     remaining: 188ms
959:    learn: 0.0188846    total: 4.4s     remaining: 183ms
960:    learn: 0.0188510    total: 4.41s    remaining: 179ms
961:    learn: 0.0188206    total: 4.41s    remaining: 174ms
962:    learn: 0.0187986    total: 4.42s    remaining: 170ms
963:    learn: 0.0187729    total: 4.42s    remaining: 165ms
964:    learn: 0.0187516    total: 4.42s    remaining: 160ms
965:    learn: 0.0187177    total: 4.43s    remaining: 156ms
966:    learn: 0.0186825    total: 4.43s    remaining: 151ms
967:    learn: 0.0186691    total: 4.44s    remaining: 147ms
968:    learn: 0.0186466    total: 4.44s    remaining: 142ms
969:    learn: 0.0186285    total: 4.44s    remaining: 137ms
970:    learn: 0.0186103    total: 4.45s    remaining: 133ms
971:    learn: 0.0185859    total: 4.45s    remaining: 128ms
972:    learn: 0.0185602    total: 4.46s    remaining: 124ms
973:    learn: 0.0185415    total: 4.46s    remaining: 119ms
974:    learn: 0.0185027    total: 4.47s    remaining: 115ms
975:    learn: 0.0184852    total: 4.47s    remaining: 110ms
976:    learn: 0.0184517    total: 4.47s    remaining: 105ms
977:    learn: 0.0184214    total: 4.48s    remaining: 101ms
978:    learn: 0.0184077    total: 4.48s    remaining: 96.2ms
979:    learn: 0.0183859    total: 4.49s    remaining: 91.6ms
980:    learn: 0.0183615    total: 4.49s    remaining: 87ms
981:    learn: 0.0183490    total: 4.5s     remaining: 82.5ms
982:    learn: 0.0183254    total: 4.5s     remaining: 77.9ms
983:    learn: 0.0183100    total: 4.5s     remaining: 73.3ms
```

```
984:    learn: 0.0182787    total: 4.51s    remaining: 68.7ms
985:    learn: 0.0182645    total: 4.51s    remaining: 64.1ms
986:    learn: 0.0182489    total: 4.52s    remaining: 59.5ms
987:    learn: 0.0182303    total: 4.52s    remaining: 54.9ms
988:    learn: 0.0182142    total: 4.53s    remaining: 50.4ms
989:    learn: 0.0181772    total: 4.53s    remaining: 45.8ms
990:    learn: 0.0181534    total: 4.54s    remaining: 41.2ms
991:    learn: 0.0181047    total: 4.54s    remaining: 36.6ms
992:    learn: 0.0180819    total: 4.54s    remaining: 32ms
993:    learn: 0.0180633    total: 4.55s    remaining: 27.5ms
994:    learn: 0.0180240    total: 4.55s    remaining: 22.9ms
995:    learn: 0.0180068    total: 4.56s    remaining: 18.3ms
996:    learn: 0.0179672    total: 4.56s    remaining: 13.7ms
997:    learn: 0.0179526    total: 4.57s    remaining: 9.15ms
998:    learn: 0.0179209    total: 4.57s    remaining: 4.58ms
999:    learn: 0.0178871    total: 4.58s    remaining: 0us
```

In [83]:
```python
y_pred = cat_model.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[83]:
```
0.9425
```

Model Tuning

In [21]:
```python
cat_params = {'iterations': [200,500],
              'learning_rate': [0.01,0.05, 0.1],
              'depth': [3,5,8]}
cat = CatBoostClassifier()
cat_cv = GridSearchCV(cat, cat_params,
                      cv=5,
                      n_jobs = -1,
                      verbose = 2)
cat_cv_model = cat_cv.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 18 candidates, totalling 90 fits
0:     learn: 1.3210651    total: 3.48ms    remaining: 1.74s
1:     learn: 1.2613843    total: 6.96ms    remaining: 1.73s
2:     learn: 1.2088009    total: 9.78ms    remaining: 1.62s
3:     learn: 1.1658894    total: 12.4ms    remaining: 1.53s
4:     learn: 1.1252462    total: 15ms      remaining: 1.48s
5:     learn: 1.0957008    total: 17.4ms    remaining: 1.43s
6:     learn: 1.0655415    total: 19.5ms    remaining: 1.37s
7:     learn: 1.0363936    total: 21.6ms    remaining: 1.33s
8:     learn: 1.0106390    total: 23.6ms    remaining: 1.29s
9:     learn: 0.9784369    total: 25.9ms    remaining: 1.27s
10:    learn: 0.9528020    total: 28.2ms    remaining: 1.25s
11:    learn: 0.9315465    total: 30.3ms    remaining: 1.23s
12:    learn: 0.9084348    total: 32.7ms    remaining: 1.22s
13:    learn: 0.8872876    total: 34.9ms    remaining: 1.21s
14:    learn: 0.8642760    total: 37.1ms    remaining: 1.2s
15:    learn: 0.8456024    total: 38.9ms    remaining: 1.18s
16:    learn: 0.8258013    total: 40.9ms    remaining: 1.16s
17:    learn: 0.8045096    total: 43.4ms    remaining: 1.16s
18:    learn: 0.7885936    total: 45.3ms    remaining: 1.15s
19:    learn: 0.7744609    total: 47.3ms    remaining: 1.13s
20:    learn: 0.7598776    total: 49.5ms    remaining: 1.13s
21:    learn: 0.7494610    total: 51.5ms    remaining: 1.12s
22:    learn: 0.7330622    total: 53.5ms    remaining: 1.11s
23:    learn: 0.7185213    total: 55.8ms    remaining: 1.11s
24:    learn: 0.7065307    total: 58.4ms    remaining: 1.11s
25:    learn: 0.6942748    total: 60.6ms    remaining: 1.1s
26:    learn: 0.6849825    total: 63.1ms    remaining: 1.1s
27:    learn: 0.6733485    total: 65.4ms    remaining: 1.1s
28:    learn: 0.6618658    total: 67.6ms    remaining: 1.1s
29:    learn: 0.6517091    total: 69.9ms    remaining: 1.09s
30:    learn: 0.6438311    total: 72.1ms    remaining: 1.09s
31:    learn: 0.6345434    total: 74.5ms    remaining: 1.09s
32:    learn: 0.6265974    total: 76.7ms    remaining: 1.08s
33:    learn: 0.6176994    total: 79.2ms    remaining: 1.08s
34:    learn: 0.6107301    total: 81.6ms    remaining: 1.08s
35:    learn: 0.6026589    total: 84.1ms    remaining: 1.08s
36:    learn: 0.5956419    total: 86.4ms    remaining: 1.08s
37:    learn: 0.5913461    total: 88.7ms    remaining: 1.08s
38:    learn: 0.5870731    total: 91.2ms    remaining: 1.08s
39:    learn: 0.5784643    total: 93.5ms    remaining: 1.07s
40:    learn: 0.5738319    total: 95.8ms    remaining: 1.07s
41:    learn: 0.5673390    total: 98.3ms    remaining: 1.07s
42:    learn: 0.5658154    total: 101ms     remaining: 1.07s
43:    learn: 0.5588086    total: 103ms     remaining: 1.07s
44:    learn: 0.5518758    total: 106ms     remaining: 1.07s
45:    learn: 0.5460820    total: 108ms     remaining: 1.06s
46:    learn: 0.5404973    total: 110ms     remaining: 1.06s
47:    learn: 0.5370412    total: 112ms     remaining: 1.06s
48:    learn: 0.5296249    total: 115ms     remaining: 1.05s
49:    learn: 0.5244972    total: 116ms     remaining: 1.05s
50:    learn: 0.5182349    total: 118ms     remaining: 1.04s
51:    learn: 0.5112527    total: 120ms     remaining: 1.03s
```

```
52:    learn: 0.5064300    total: 122ms    remaining: 1.02s
53:    learn: 0.5021630    total: 124ms    remaining: 1.02s
54:    learn: 0.4964337    total: 126ms    remaining: 1.02s
55:    learn: 0.4934815    total: 128ms    remaining: 1.01s
56:    learn: 0.4923312    total: 130ms    remaining: 1.01s
57:    learn: 0.4871356    total: 133ms    remaining: 1.01s
58:    learn: 0.4846832    total: 135ms    remaining: 1.01s
59:    learn: 0.4812210    total: 137ms    remaining: 1.01s
60:    learn: 0.4799209    total: 140ms    remaining: 1s
61:    learn: 0.4743603    total: 142ms    remaining: 1s
62:    learn: 0.4733464    total: 144ms    remaining: 1s
63:    learn: 0.4685406    total: 147ms    remaining: 999ms
64:    learn: 0.4650241    total: 149ms    remaining: 998ms
65:    learn: 0.4601138    total: 151ms    remaining: 994ms
66:    learn: 0.4559336    total: 153ms    remaining: 987ms
67:    learn: 0.4521011    total: 155ms    remaining: 984ms
68:    learn: 0.4482509    total: 157ms    remaining: 982ms
69:    learn: 0.4447805    total: 159ms    remaining: 979ms
70:    learn: 0.4412071    total: 162ms    remaining: 980ms
71:    learn: 0.4380611    total: 164ms    remaining: 977ms
72:    learn: 0.4354827    total: 167ms    remaining: 979ms
73:    learn: 0.4319237    total: 170ms    remaining: 976ms
74:    learn: 0.4280377    total: 172ms    remaining: 973ms
75:    learn: 0.4267384    total: 174ms    remaining: 971ms
76:    learn: 0.4223317    total: 176ms    remaining: 969ms
77:    learn: 0.4186762    total: 179ms    remaining: 966ms
78:    learn: 0.4158168    total: 181ms    remaining: 964ms
79:    learn: 0.4116457    total: 183ms    remaining: 961ms
80:    learn: 0.4099362    total: 185ms    remaining: 957ms
81:    learn: 0.4074805    total: 187ms    remaining: 952ms
82:    learn: 0.4052843    total: 188ms    remaining: 944ms
83:    learn: 0.4030971    total: 189ms    remaining: 936ms
84:    learn: 0.4008780    total: 190ms    remaining: 928ms
85:    learn: 0.3997459    total: 191ms    remaining: 920ms
86:    learn: 0.3971253    total: 192ms    remaining: 912ms
87:    learn: 0.3958294    total: 193ms    remaining: 905ms
88:    learn: 0.3947792    total: 194ms    remaining: 897ms
89:    learn: 0.3910472    total: 195ms    remaining: 890ms
90:    learn: 0.3886695    total: 198ms    remaining: 889ms
91:    learn: 0.3872147    total: 200ms    remaining: 886ms
92:    learn: 0.3864823    total: 201ms    remaining: 882ms
93:    learn: 0.3847119    total: 203ms    remaining: 878ms
94:    learn: 0.3829277    total: 206ms    remaining: 877ms
95:    learn: 0.3815210    total: 208ms    remaining: 874ms
96:    learn: 0.3793530    total: 209ms    remaining: 869ms
97:    learn: 0.3780227    total: 211ms    remaining: 865ms
98:    learn: 0.3762159    total: 213ms    remaining: 861ms
99:    learn: 0.3739799    total: 215ms    remaining: 858ms
100:   learn: 0.3715207    total: 217ms    remaining: 856ms
101:   learn: 0.3696601    total: 218ms    remaining: 852ms
102:   learn: 0.3690073    total: 222ms    remaining: 856ms
103:   learn: 0.3673820    total: 224ms    remaining: 853ms
104:   learn: 0.3666611    total: 226ms    remaining: 850ms
105:   learn: 0.3652307    total: 227ms    remaining: 844ms
106:   learn: 0.3633233    total: 229ms    remaining: 842ms
107:   learn: 0.3625943    total: 231ms    remaining: 839ms
108:   learn: 0.3612391    total: 233ms    remaining: 835ms
109:   learn: 0.3598078    total: 234ms    remaining: 830ms
110:   learn: 0.3567952    total: 235ms    remaining: 825ms
111:   learn: 0.3558667    total: 236ms    remaining: 819ms
112:   learn: 0.3545059    total: 238ms    remaining: 814ms
113:   learn: 0.3519369    total: 239ms    remaining: 808ms
114:   learn: 0.3508636    total: 240ms    remaining: 803ms
115:   learn: 0.3489125    total: 241ms    remaining: 797ms
116:   learn: 0.3474051    total: 242ms    remaining: 792ms
117:   learn: 0.3456095    total: 245ms    remaining: 794ms
118:   learn: 0.3436230    total: 247ms    remaining: 789ms
119:   learn: 0.3422197    total: 248ms    remaining: 784ms
120:   learn: 0.3402030    total: 249ms    remaining: 779ms
121:   learn: 0.3390662    total: 250ms    remaining: 774ms
122:   learn: 0.3382987    total: 251ms    remaining: 769ms
123:   learn: 0.3378405    total: 252ms    remaining: 764ms
124:   learn: 0.3362017    total: 253ms    remaining: 759ms
125:   learn: 0.3353997    total: 254ms    remaining: 754ms
126:   learn: 0.3346457    total: 255ms    remaining: 749ms
127:   learn: 0.3331454    total: 256ms    remaining: 745ms
128:   learn: 0.3323007    total: 257ms    remaining: 740ms
129:   learn: 0.3309408    total: 259ms    remaining: 736ms
130:   learn: 0.3290050    total: 261ms    remaining: 735ms
131:   learn: 0.3272301    total: 262ms    remaining: 732ms
132:   learn: 0.3264202    total: 264ms    remaining: 728ms
133:   learn: 0.3260324    total: 265ms    remaining: 724ms
134:   learn: 0.3241394    total: 266ms    remaining: 719ms
135:   learn: 0.3229779    total: 267ms    remaining: 715ms
136:   learn: 0.3214411    total: 268ms    remaining: 711ms
137:   learn: 0.3211015    total: 269ms    remaining: 706ms
138:   learn: 0.3189641    total: 270ms    remaining: 702ms
139:   learn: 0.3173286    total: 272ms    remaining: 698ms
140:   learn: 0.3169722    total: 273ms    remaining: 694ms
```

```
141:    learn: 0.3158052        total: 274ms    remaining: 690ms
142:    learn: 0.3148739        total: 275ms    remaining: 687ms
143:    learn: 0.3132286        total: 277ms    remaining: 685ms
144:    learn: 0.3125743        total: 278ms    remaining: 682ms
145:    learn: 0.3124381        total: 280ms    remaining: 678ms
146:    learn: 0.3115057        total: 281ms    remaining: 675ms
147:    learn: 0.3098365        total: 283ms    remaining: 672ms
148:    learn: 0.3082801        total: 284ms    remaining: 669ms
149:    learn: 0.3071553        total: 285ms    remaining: 666ms
150:    learn: 0.3049346        total: 286ms    remaining: 662ms
151:    learn: 0.3042607        total: 288ms    remaining: 658ms
152:    learn: 0.3034181        total: 289ms    remaining: 655ms
153:    learn: 0.3021525        total: 290ms    remaining: 651ms
154:    learn: 0.3015522        total: 292ms    remaining: 650ms
155:    learn: 0.3014578        total: 293ms    remaining: 647ms
156:    learn: 0.2998253        total: 295ms    remaining: 644ms
157:    learn: 0.2987631        total: 296ms    remaining: 640ms
158:    learn: 0.2974780        total: 297ms    remaining: 637ms
159:    learn: 0.2965097        total: 298ms    remaining: 633ms
160:    learn: 0.2959727        total: 299ms    remaining: 630ms
161:    learn: 0.2946289        total: 300ms    remaining: 626ms
162:    learn: 0.2935701        total: 301ms    remaining: 623ms
163:    learn: 0.2924825        total: 302ms    remaining: 619ms
164:    learn: 0.2918879        total: 303ms    remaining: 616ms
165:    learn: 0.2906477        total: 304ms    remaining: 613ms
166:    learn: 0.2896425        total: 306ms    remaining: 609ms
167:    learn: 0.2889283        total: 307ms    remaining: 607ms
168:    learn: 0.2881842        total: 309ms    remaining: 605ms
169:    learn: 0.2872788        total: 310ms    remaining: 602ms
170:    learn: 0.2869147        total: 311ms    remaining: 599ms
171:    learn: 0.2857760        total: 312ms    remaining: 596ms
172:    learn: 0.2842250        total: 313ms    remaining: 592ms
173:    learn: 0.2828891        total: 315ms    remaining: 589ms
174:    learn: 0.2814904        total: 316ms    remaining: 586ms
175:    learn: 0.2809901        total: 317ms    remaining: 583ms
176:    learn: 0.2807382        total: 318ms    remaining: 580ms
177:    learn: 0.2804443        total: 319ms    remaining: 577ms
178:    learn: 0.2795263        total: 320ms    remaining: 574ms
179:    learn: 0.2783916        total: 321ms    remaining: 571ms
180:    learn: 0.2776987        total: 323ms    remaining: 569ms
181:    learn: 0.2769965        total: 324ms    remaining: 567ms
182:    learn: 0.2762558        total: 326ms    remaining: 565ms
183:    learn: 0.2756746        total: 327ms    remaining: 562ms
184:    learn: 0.2748243        total: 328ms    remaining: 559ms
185:    learn: 0.2736299        total: 330ms    remaining: 556ms
186:    learn: 0.2727997        total: 331ms    remaining: 554ms
187:    learn: 0.2722299        total: 332ms    remaining: 551ms
188:    learn: 0.2716904        total: 333ms    remaining: 548ms
189:    learn: 0.2714092        total: 334ms    remaining: 545ms
190:    learn: 0.2705472        total: 335ms    remaining: 542ms
191:    learn: 0.2700435        total: 336ms    remaining: 540ms
192:    learn: 0.2691573        total: 338ms    remaining: 537ms
193:    learn: 0.2684360        total: 340ms    remaining: 536ms
194:    learn: 0.2681012        total: 341ms    remaining: 533ms
195:    learn: 0.2679548        total: 342ms    remaining: 531ms
196:    learn: 0.2670651        total: 343ms    remaining: 528ms
197:    learn: 0.2667586        total: 344ms    remaining: 525ms
198:    learn: 0.2658871        total: 345ms    remaining: 523ms
199:    learn: 0.2649154        total: 347ms    remaining: 520ms
200:    learn: 0.2635807        total: 348ms    remaining: 517ms
201:    learn: 0.2626310        total: 349ms    remaining: 515ms
202:    learn: 0.2622961        total: 350ms    remaining: 512ms
203:    learn: 0.2616688        total: 352ms    remaining: 510ms
204:    learn: 0.2606020        total: 353ms    remaining: 508ms
205:    learn: 0.2601926        total: 356ms    remaining: 508ms
206:    learn: 0.2593079        total: 357ms    remaining: 506ms
207:    learn: 0.2582663        total: 358ms    remaining: 503ms
208:    learn: 0.2570459        total: 360ms    remaining: 501ms
209:    learn: 0.2568319        total: 361ms    remaining: 498ms
210:    learn: 0.2561383        total: 362ms    remaining: 495ms
211:    learn: 0.2553577        total: 363ms    remaining: 493ms
212:    learn: 0.2544871        total: 364ms    remaining: 490ms
213:    learn: 0.2533137        total: 365ms    remaining: 488ms
214:    learn: 0.2524541        total: 366ms    remaining: 485ms
215:    learn: 0.2522559        total: 367ms    remaining: 483ms
216:    learn: 0.2518124        total: 368ms    remaining: 481ms
217:    learn: 0.2512226        total: 370ms    remaining: 479ms
218:    learn: 0.2509632        total: 372ms    remaining: 477ms
219:    learn: 0.2500786        total: 373ms    remaining: 475ms
220:    learn: 0.2493668        total: 375ms    remaining: 473ms
221:    learn: 0.2484252        total: 376ms    remaining: 471ms
222:    learn: 0.2482757        total: 377ms    remaining: 468ms
223:    learn: 0.2476902        total: 378ms    remaining: 466ms
224:    learn: 0.2466863        total: 379ms    remaining: 463ms
225:    learn: 0.2464783        total: 380ms    remaining: 461ms
226:    learn: 0.2459354        total: 381ms    remaining: 459ms
227:    learn: 0.2453567        total: 382ms    remaining: 456ms
228:    learn: 0.2446004        total: 383ms    remaining: 454ms
229:    learn: 0.2439275        total: 385ms    remaining: 452ms
```

```
230:	learn: 0.2433805	total: 387ms	remaining: 450ms
231:	learn: 0.2432260	total: 388ms	remaining: 448ms
232:	learn: 0.2426405	total: 389ms	remaining: 446ms
233:	learn: 0.2418350	total: 390ms	remaining: 444ms
234:	learn: 0.2407784	total: 392ms	remaining: 442ms
235:	learn: 0.2403636	total: 393ms	remaining: 439ms
236:	learn: 0.2400407	total: 394ms	remaining: 437ms
237:	learn: 0.2399377	total: 395ms	remaining: 435ms
238:	learn: 0.2395624	total: 396ms	remaining: 433ms
239:	learn: 0.2391364	total: 397ms	remaining: 431ms
240:	learn: 0.2381516	total: 399ms	remaining: 428ms
241:	learn: 0.2374997	total: 400ms	remaining: 426ms
242:	learn: 0.2366962	total: 403ms	remaining: 426ms
243:	learn: 0.2358804	total: 405ms	remaining: 425ms
244:	learn: 0.2353731	total: 406ms	remaining: 423ms
245:	learn: 0.2346824	total: 409ms	remaining: 422ms
246:	learn: 0.2340018	total: 412ms	remaining: 422ms
247:	learn: 0.2334474	total: 415ms	remaining: 421ms
248:	learn: 0.2327982	total: 417ms	remaining: 421ms
249:	learn: 0.2324127	total: 419ms	remaining: 419ms
250:	learn: 0.2321929	total: 421ms	remaining: 418ms
251:	learn: 0.2315817	total: 424ms	remaining: 417ms
252:	learn: 0.2311017	total: 426ms	remaining: 416ms
253:	learn: 0.2308177	total: 429ms	remaining: 415ms
254:	learn: 0.2299518	total: 431ms	remaining: 415ms
255:	learn: 0.2295334	total: 434ms	remaining: 414ms
256:	learn: 0.2288408	total: 436ms	remaining: 413ms
257:	learn: 0.2277278	total: 438ms	remaining: 411ms
258:	learn: 0.2275563	total: 441ms	remaining: 410ms
259:	learn: 0.2269617	total: 443ms	remaining: 409ms
260:	learn: 0.2266912	total: 445ms	remaining: 407ms
261:	learn: 0.2258958	total: 446ms	remaining: 405ms
262:	learn: 0.2250745	total: 448ms	remaining: 404ms
263:	learn: 0.2248777	total: 451ms	remaining: 403ms
264:	learn: 0.2241243	total: 454ms	remaining: 403ms
265:	learn: 0.2234348	total: 456ms	remaining: 401ms
266:	learn: 0.2226115	total: 457ms	remaining: 399ms
267:	learn: 0.2219551	total: 459ms	remaining: 397ms
268:	learn: 0.2215492	total: 461ms	remaining: 396ms
269:	learn: 0.2212617	total: 462ms	remaining: 394ms
270:	learn: 0.2210748	total: 465ms	remaining: 393ms
271:	learn: 0.2208873	total: 468ms	remaining: 392ms
272:	learn: 0.2206083	total: 470ms	remaining: 391ms
273:	learn: 0.2201642	total: 472ms	remaining: 389ms
274:	learn: 0.2193864	total: 473ms	remaining: 387ms
275:	learn: 0.2186670	total: 475ms	remaining: 385ms
276:	learn: 0.2185844	total: 476ms	remaining: 383ms
277:	learn: 0.2180152	total: 477ms	remaining: 381ms
278:	learn: 0.2176870	total: 480ms	remaining: 380ms
279:	learn: 0.2175650	total: 481ms	remaining: 378ms
280:	learn: 0.2173658	total: 482ms	remaining: 376ms
281:	learn: 0.2168903	total: 484ms	remaining: 374ms
282:	learn: 0.2167815	total: 485ms	remaining: 372ms
283:	learn: 0.2166001	total: 486ms	remaining: 370ms
284:	learn: 0.2161882	total: 488ms	remaining: 368ms
285:	learn: 0.2160388	total: 489ms	remaining: 366ms
286:	learn: 0.2156082	total: 490ms	remaining: 363ms
287:	learn: 0.2149456	total: 491ms	remaining: 361ms
288:	learn: 0.2147529	total: 492ms	remaining: 359ms
289:	learn: 0.2143638	total: 494ms	remaining: 358ms
290:	learn: 0.2142195	total: 496ms	remaining: 356ms
291:	learn: 0.2140345	total: 498ms	remaining: 354ms
292:	learn: 0.2134837	total: 499ms	remaining: 352ms
293:	learn: 0.2131221	total: 500ms	remaining: 350ms
294:	learn: 0.2128319	total: 501ms	remaining: 348ms
295:	learn: 0.2127408	total: 502ms	remaining: 346ms
296:	learn: 0.2123279	total: 503ms	remaining: 344ms
297:	learn: 0.2122647	total: 504ms	remaining: 342ms
298:	learn: 0.2115901	total: 506ms	remaining: 340ms
299:	learn: 0.2112150	total: 507ms	remaining: 338ms
300:	learn: 0.2108557	total: 508ms	remaining: 336ms
301:	learn: 0.2107243	total: 510ms	remaining: 335ms
302:	learn: 0.2102569	total: 511ms	remaining: 333ms
303:	learn: 0.2100633	total: 513ms	remaining: 331ms
304:	learn: 0.2099769	total: 514ms	remaining: 328ms
305:	learn: 0.2093057	total: 515ms	remaining: 326ms
306:	learn: 0.2088209	total: 516ms	remaining: 324ms
307:	learn: 0.2084186	total: 517ms	remaining: 322ms
308:	learn: 0.2080124	total: 518ms	remaining: 320ms
309:	learn: 0.2076718	total: 519ms	remaining: 318ms
310:	learn: 0.2075625	total: 520ms	remaining: 316ms
311:	learn: 0.2068982	total: 522ms	remaining: 314ms
312:	learn: 0.2063015	total: 523ms	remaining: 312ms
313:	learn: 0.2061209	total: 525ms	remaining: 311ms
314:	learn: 0.2055175	total: 527ms	remaining: 310ms
315:	learn: 0.2053088	total: 529ms	remaining: 308ms
316:	learn: 0.2049388	total: 530ms	remaining: 306ms
317:	learn: 0.2045913	total: 531ms	remaining: 304ms
318:	learn: 0.2041915	total: 533ms	remaining: 302ms
```

```
319:    learn: 0.2039349    total: 534ms    remaining: 300ms
320:    learn: 0.2036380    total: 535ms    remaining: 299ms
321:    learn: 0.2032117    total: 537ms    remaining: 297ms
322:    learn: 0.2030053    total: 538ms    remaining: 295ms
323:    learn: 0.2029338    total: 539ms    remaining: 293ms
324:    learn: 0.2024864    total: 540ms    remaining: 291ms
325:    learn: 0.2019629    total: 542ms    remaining: 290ms
326:    learn: 0.2016067    total: 544ms    remaining: 288ms
327:    learn: 0.2013976    total: 545ms    remaining: 286ms
328:    learn: 0.2010651    total: 546ms    remaining: 284ms
329:    learn: 0.2006636    total: 548ms    remaining: 282ms
330:    learn: 0.2003499    total: 549ms    remaining: 280ms
331:    learn: 0.2002749    total: 550ms    remaining: 278ms
332:    learn: 0.1999822    total: 551ms    remaining: 276ms
333:    learn: 0.1996499    total: 552ms    remaining: 275ms
334:    learn: 0.1994917    total: 554ms    remaining: 273ms
335:    learn: 0.1991152    total: 555ms    remaining: 271ms
336:    learn: 0.1988865    total: 557ms    remaining: 269ms
337:    learn: 0.1985612    total: 558ms    remaining: 268ms
338:    learn: 0.1979157    total: 560ms    remaining: 266ms
339:    learn: 0.1974938    total: 561ms    remaining: 264ms
340:    learn: 0.1969468    total: 563ms    remaining: 262ms
341:    learn: 0.1966136    total: 564ms    remaining: 261ms
342:    learn: 0.1961162    total: 566ms    remaining: 259ms
343:    learn: 0.1958825    total: 567ms    remaining: 257ms
344:    learn: 0.1953951    total: 568ms    remaining: 255ms
345:    learn: 0.1949623    total: 569ms    remaining: 253ms
346:    learn: 0.1946392    total: 570ms    remaining: 251ms
347:    learn: 0.1942749    total: 572ms    remaining: 250ms
348:    learn: 0.1941493    total: 574ms    remaining: 248ms
349:    learn: 0.1938356    total: 575ms    remaining: 246ms
350:    learn: 0.1932578    total: 576ms    remaining: 245ms
351:    learn: 0.1931376    total: 577ms    remaining: 243ms
352:    learn: 0.1928578    total: 579ms    remaining: 241ms
353:    learn: 0.1925204    total: 580ms    remaining: 239ms
354:    learn: 0.1923450    total: 581ms    remaining: 237ms
355:    learn: 0.1922093    total: 582ms    remaining: 235ms
356:    learn: 0.1918354    total: 583ms    remaining: 234ms
357:    learn: 0.1917173    total: 585ms    remaining: 232ms
358:    learn: 0.1916321    total: 586ms    remaining: 230ms
359:    learn: 0.1910993    total: 588ms    remaining: 229ms
360:    learn: 0.1909486    total: 589ms    remaining: 227ms
361:    learn: 0.1907566    total: 591ms    remaining: 225ms
362:    learn: 0.1904625    total: 592ms    remaining: 223ms
363:    learn: 0.1900501    total: 593ms    remaining: 222ms
364:    learn: 0.1896202    total: 594ms    remaining: 220ms
365:    learn: 0.1894650    total: 595ms    remaining: 218ms
366:    learn: 0.1888791    total: 597ms    remaining: 216ms
367:    learn: 0.1887649    total: 598ms    remaining: 215ms
368:    learn: 0.1882510    total: 599ms    remaining: 213ms
369:    learn: 0.1878843    total: 600ms    remaining: 211ms
370:    learn: 0.1877554    total: 602ms    remaining: 209ms
371:    learn: 0.1872687    total: 605ms    remaining: 208ms
372:    learn: 0.1868264    total: 606ms    remaining: 206ms
373:    learn: 0.1864776    total: 609ms    remaining: 205ms
374:    learn: 0.1862952    total: 611ms    remaining: 204ms
375:    learn: 0.1858533    total: 612ms    remaining: 202ms
376:    learn: 0.1856069    total: 613ms    remaining: 200ms
377:    learn: 0.1851048    total: 615ms    remaining: 198ms
378:    learn: 0.1846264    total: 617ms    remaining: 197ms
379:    learn: 0.1842510    total: 620ms    remaining: 196ms
380:    learn: 0.1839288    total: 623ms    remaining: 195ms
381:    learn: 0.1837933    total: 626ms    remaining: 193ms
382:    learn: 0.1835428    total: 628ms    remaining: 192ms
383:    learn: 0.1832866    total: 630ms    remaining: 190ms
384:    learn: 0.1830660    total: 631ms    remaining: 188ms
385:    learn: 0.1825602    total: 632ms    remaining: 187ms
386:    learn: 0.1822742    total: 635ms    remaining: 185ms
387:    learn: 0.1821821    total: 637ms    remaining: 184ms
388:    learn: 0.1818541    total: 639ms    remaining: 182ms
389:    learn: 0.1816666    total: 641ms    remaining: 181ms
390:    learn: 0.1814358    total: 643ms    remaining: 179ms
391:    learn: 0.1812888    total: 645ms    remaining: 178ms
392:    learn: 0.1807179    total: 647ms    remaining: 176ms
393:    learn: 0.1805072    total: 649ms    remaining: 175ms
394:    learn: 0.1802893    total: 651ms    remaining: 173ms
395:    learn: 0.1801247    total: 652ms    remaining: 171ms
396:    learn: 0.1797678    total: 654ms    remaining: 170ms
397:    learn: 0.1794976    total: 655ms    remaining: 168ms
398:    learn: 0.1790361    total: 656ms    remaining: 166ms
399:    learn: 0.1787674    total: 658ms    remaining: 164ms
400:    learn: 0.1787225    total: 659ms    remaining: 163ms
401:    learn: 0.1781359    total: 660ms    remaining: 161ms
402:    learn: 0.1777932    total: 661ms    remaining: 159ms
403:    learn: 0.1774277    total: 662ms    remaining: 157ms
404:    learn: 0.1769658    total: 664ms    remaining: 156ms
405:    learn: 0.1765731    total: 666ms    remaining: 154ms
406:    learn: 0.1765445    total: 668ms    remaining: 153ms
407:    learn: 0.1761315    total: 670ms    remaining: 151ms
```

```
408:    learn: 0.1759312    total: 671ms    remaining: 149ms
409:    learn: 0.1756009    total: 672ms    remaining: 148ms
410:    learn: 0.1754754    total: 673ms    remaining: 146ms
411:    learn: 0.1751560    total: 675ms    remaining: 144ms
412:    learn: 0.1750231    total: 676ms    remaining: 142ms
413:    learn: 0.1749221    total: 677ms    remaining: 141ms
414:    learn: 0.1748716    total: 679ms    remaining: 139ms
415:    learn: 0.1745959    total: 681ms    remaining: 137ms
416:    learn: 0.1744202    total: 682ms    remaining: 136ms
417:    learn: 0.1743585    total: 684ms    remaining: 134ms
418:    learn: 0.1741706    total: 685ms    remaining: 132ms
419:    learn: 0.1740952    total: 686ms    remaining: 131ms
420:    learn: 0.1735581    total: 687ms    remaining: 129ms
421:    learn: 0.1734511    total: 688ms    remaining: 127ms
422:    learn: 0.1732066    total: 689ms    remaining: 126ms
423:    learn: 0.1731434    total: 691ms    remaining: 124ms
424:    learn: 0.1729493    total: 692ms    remaining: 122ms
425:    learn: 0.1728802    total: 693ms    remaining: 120ms
426:    learn: 0.1725026    total: 694ms    remaining: 119ms
427:    learn: 0.1722333    total: 697ms    remaining: 117ms
428:    learn: 0.1718248    total: 699ms    remaining: 116ms
429:    learn: 0.1714004    total: 700ms    remaining: 114ms
430:    learn: 0.1710243    total: 701ms    remaining: 112ms
431:    learn: 0.1707870    total: 703ms    remaining: 111ms
432:    learn: 0.1704622    total: 704ms    remaining: 109ms
433:    learn: 0.1701154    total: 705ms    remaining: 107ms
434:    learn: 0.1698438    total: 706ms    remaining: 106ms
435:    learn: 0.1696099    total: 707ms    remaining: 104ms
436:    learn: 0.1695698    total: 709ms    remaining: 102ms
437:    learn: 0.1694544    total: 710ms    remaining: 100ms
438:    learn: 0.1691441    total: 712ms    remaining: 98.9ms
439:    learn: 0.1690164    total: 714ms    remaining: 97.3ms
440:    learn: 0.1687206    total: 715ms    remaining: 95.7ms
441:    learn: 0.1684613    total: 716ms    remaining: 94ms
442:    learn: 0.1682735    total: 718ms    remaining: 92.3ms
443:    learn: 0.1682218    total: 719ms    remaining: 90.7ms
444:    learn: 0.1677963    total: 720ms    remaining: 89ms
445:    learn: 0.1677530    total: 721ms    remaining: 87.3ms
446:    learn: 0.1676913    total: 723ms    remaining: 85.7ms
447:    learn: 0.1675338    total: 724ms    remaining: 84ms
448:    learn: 0.1674538    total: 725ms    remaining: 82.4ms
449:    learn: 0.1673750    total: 727ms    remaining: 80.7ms
450:    learn: 0.1671042    total: 729ms    remaining: 79.2ms
451:    learn: 0.1670058    total: 730ms    remaining: 77.5ms
452:    learn: 0.1666066    total: 731ms    remaining: 75.9ms
453:    learn: 0.1664194    total: 733ms    remaining: 74.2ms
454:    learn: 0.1662461    total: 734ms    remaining: 72.6ms
455:    learn: 0.1660763    total: 736ms    remaining: 71ms
456:    learn: 0.1658964    total: 737ms    remaining: 69.3ms
457:    learn: 0.1656535    total: 738ms    remaining: 67.7ms
458:    learn: 0.1655003    total: 740ms    remaining: 66.1ms
459:    learn: 0.1653476    total: 741ms    remaining: 64.4ms
460:    learn: 0.1652021    total: 742ms    remaining: 62.8ms
461:    learn: 0.1645402    total: 744ms    remaining: 61.2ms
462:    learn: 0.1644567    total: 745ms    remaining: 59.6ms
463:    learn: 0.1642713    total: 747ms    remaining: 57.9ms
464:    learn: 0.1640530    total: 748ms    remaining: 56.3ms
465:    learn: 0.1637208    total: 749ms    remaining: 54.7ms
466:    learn: 0.1635703    total: 750ms    remaining: 53ms
467:    learn: 0.1634750    total: 751ms    remaining: 51.4ms
468:    learn: 0.1632163    total: 753ms    remaining: 49.8ms
469:    learn: 0.1630559    total: 754ms    remaining: 48.1ms
470:    learn: 0.1629327    total: 755ms    remaining: 46.5ms
471:    learn: 0.1628623    total: 756ms    remaining: 44.9ms
472:    learn: 0.1628331    total: 757ms    remaining: 43.2ms
473:    learn: 0.1626020    total: 760ms    remaining: 41.7ms
474:    learn: 0.1625264    total: 761ms    remaining: 40.1ms
475:    learn: 0.1623817    total: 763ms    remaining: 38.5ms
476:    learn: 0.1623027    total: 764ms    remaining: 36.8ms
477:    learn: 0.1621926    total: 765ms    remaining: 35.2ms
478:    learn: 0.1618631    total: 766ms    remaining: 33.6ms
479:    learn: 0.1616972    total: 767ms    remaining: 32ms
480:    learn: 0.1616376    total: 769ms    remaining: 30.4ms
481:    learn: 0.1615947    total: 770ms    remaining: 28.7ms
482:    learn: 0.1612696    total: 771ms    remaining: 27.1ms
483:    learn: 0.1609891    total: 772ms    remaining: 25.5ms
484:    learn: 0.1608418    total: 773ms    remaining: 23.9ms
485:    learn: 0.1605867    total: 775ms    remaining: 22.3ms
486:    learn: 0.1602867    total: 777ms    remaining: 20.7ms
487:    learn: 0.1599936    total: 778ms    remaining: 19.1ms
488:    learn: 0.1596746    total: 779ms    remaining: 17.5ms
489:    learn: 0.1596137    total: 781ms    remaining: 15.9ms
490:    learn: 0.1593599    total: 782ms    remaining: 14.3ms
491:    learn: 0.1592449    total: 783ms    remaining: 12.7ms
492:    learn: 0.1591946    total: 784ms    remaining: 11.1ms
493:    learn: 0.1591193    total: 786ms    remaining: 9.54ms
494:    learn: 0.1587012    total: 787ms    remaining: 7.95ms
495:    learn: 0.1585541    total: 788ms    remaining: 6.35ms
496:    learn: 0.1583058    total: 789ms    remaining: 4.76ms
```

```
497:     learn: 0.1581542      total: 792ms    remaining: 3.18ms
498:     learn: 0.1579877      total: 793ms    remaining: 1.59ms
499:     learn: 0.1579240      total: 794ms    remaining: 0us
```

In [22]: `cat_cv_model.best_params_`

Out[22]: `{'depth': 3, 'iterations': 500, 'learning_rate': 0.05}`

In [70]:
```python
cat = CatBoostClassifier(depth = 3,
                         iterations = 500,
                         learning_rate = 0.05)
cat_tuned = cat.fit(x_train, y_train)
```
```
0:      learn: 1.3210651      total: 2.2ms    remaining: 1.1s
1:      learn: 1.2613843      total: 4ms      remaining: 995ms
2:      learn: 1.2088009      total: 5.41ms   remaining: 897ms
3:      learn: 1.1658894      total: 6.9ms    remaining: 856ms
4:      learn: 1.1252462      total: 8.57ms   remaining: 848ms
5:      learn: 1.0957008      total: 10.2ms   remaining: 843ms
6:      learn: 1.0655415      total: 12.2ms   remaining: 858ms
7:      learn: 1.0363936      total: 13.5ms   remaining: 828ms
8:      learn: 1.0106390      total: 17.2ms   remaining: 937ms
9:      learn: 0.9784369      total: 18.4ms   remaining: 904ms
10:     learn: 0.9528020      total: 19.6ms   remaining: 872ms
11:     learn: 0.9315465      total: 20.7ms   remaining: 840ms
12:     learn: 0.9084348      total: 21.8ms   remaining: 818ms
13:     learn: 0.8872876      total: 23.8ms   remaining: 826ms
14:     learn: 0.8642760      total: 25.2ms   remaining: 815ms
15:     learn: 0.8456024      total: 26.6ms   remaining: 803ms
16:     learn: 0.8258013      total: 27.9ms   remaining: 792ms
17:     learn: 0.8045096      total: 30.1ms   remaining: 807ms
18:     learn: 0.7885936      total: 31.5ms   remaining: 798ms
19:     learn: 0.7744609      total: 32.7ms   remaining: 784ms
20:     learn: 0.7598776      total: 33.9ms   remaining: 773ms
21:     learn: 0.7494610      total: 35.2ms   remaining: 764ms
22:     learn: 0.7330622      total: 36.3ms   remaining: 752ms
23:     learn: 0.7185213      total: 37.7ms   remaining: 749ms
24:     learn: 0.7065307      total: 39.1ms   remaining: 742ms
25:     learn: 0.6942748      total: 40.3ms   remaining: 735ms
26:     learn: 0.6849825      total: 41.4ms   remaining: 726ms
27:     learn: 0.6733485      total: 42.6ms   remaining: 717ms
28:     learn: 0.6618658      total: 43.7ms   remaining: 710ms
29:     learn: 0.6517091      total: 44.9ms   remaining: 704ms
30:     learn: 0.6438311      total: 46.1ms   remaining: 698ms
31:     learn: 0.6345434      total: 47.3ms   remaining: 692ms
32:     learn: 0.6265974      total: 48.5ms   remaining: 687ms
33:     learn: 0.6176994      total: 49.7ms   remaining: 681ms
34:     learn: 0.6107301      total: 50.9ms   remaining: 677ms
35:     learn: 0.6026589      total: 52.1ms   remaining: 671ms
36:     learn: 0.5956419      total: 53.4ms   remaining: 668ms
37:     learn: 0.5913461      total: 54.4ms   remaining: 661ms
38:     learn: 0.5870731      total: 55.5ms   remaining: 656ms
39:     learn: 0.5784643      total: 56.7ms   remaining: 652ms
40:     learn: 0.5738319      total: 57.9ms   remaining: 648ms
41:     learn: 0.5673390      total: 59ms     remaining: 643ms
42:     learn: 0.5658154      total: 60.3ms   remaining: 641ms
43:     learn: 0.5588086      total: 61.4ms   remaining: 636ms
44:     learn: 0.5518758      total: 62.6ms   remaining: 633ms
45:     learn: 0.5460820      total: 63.9ms   remaining: 631ms
46:     learn: 0.5404973      total: 65.1ms   remaining: 628ms
47:     learn: 0.5370412      total: 66.4ms   remaining: 625ms
48:     learn: 0.5296249      total: 67.5ms   remaining: 621ms
49:     learn: 0.5244972      total: 68.7ms   remaining: 618ms
50:     learn: 0.5182349      total: 70.1ms   remaining: 617ms
51:     learn: 0.5112527      total: 71.5ms   remaining: 616ms
52:     learn: 0.5064300      total: 73ms     remaining: 615ms
53:     learn: 0.5021630      total: 74.6ms   remaining: 616ms
54:     learn: 0.4964337      total: 75.9ms   remaining: 614ms
55:     learn: 0.4934815      total: 77.2ms   remaining: 612ms
56:     learn: 0.4923312      total: 78.4ms   remaining: 609ms
57:     learn: 0.4871356      total: 79.7ms   remaining: 607ms
58:     learn: 0.4846832      total: 80.9ms   remaining: 605ms
59:     learn: 0.4812210      total: 82ms     remaining: 601ms
60:     learn: 0.4799209      total: 82.9ms   remaining: 597ms
61:     learn: 0.4743603      total: 84ms     remaining: 594ms
62:     learn: 0.4733464      total: 85.2ms   remaining: 591ms
63:     learn: 0.4685406      total: 86.4ms   remaining: 588ms
64:     learn: 0.4650241      total: 87.5ms   remaining: 585ms
65:     learn: 0.4601138      total: 88.6ms   remaining: 582ms
66:     learn: 0.4559336      total: 89.8ms   remaining: 580ms
67:     learn: 0.4521011      total: 91ms     remaining: 578ms
68:     learn: 0.4482509      total: 92.1ms   remaining: 575ms
69:     learn: 0.4447805      total: 93.3ms   remaining: 573ms
70:     learn: 0.4412071      total: 94.5ms   remaining: 571ms
71:     learn: 0.4380611      total: 95.8ms   remaining: 569ms
72:     learn: 0.4354827      total: 96.8ms   remaining: 566ms
73:     learn: 0.4319237      total: 97.9ms   remaining: 564ms
74:     learn: 0.4280377      total: 99ms     remaining: 561ms
```

```
75:     learn: 0.4267384     total: 100ms     remaining: 559ms
76:     learn: 0.4223317     total: 101ms     remaining: 556ms
77:     learn: 0.4186762     total: 102ms     remaining: 554ms
78:     learn: 0.4158168     total: 103ms     remaining: 551ms
79:     learn: 0.4116457     total: 105ms     remaining: 549ms
80:     learn: 0.4099362     total: 106ms     remaining: 547ms
81:     learn: 0.4074805     total: 107ms     remaining: 545ms
82:     learn: 0.4052843     total: 108ms     remaining: 543ms
83:     learn: 0.4030971     total: 109ms     remaining: 540ms
84:     learn: 0.4008780     total: 110ms     remaining: 538ms
85:     learn: 0.3997459     total: 111ms     remaining: 536ms
86:     learn: 0.3971253     total: 112ms     remaining: 534ms
87:     learn: 0.3958294     total: 114ms     remaining: 533ms
88:     learn: 0.3947792     total: 115ms     remaining: 531ms
89:     learn: 0.3910472     total: 116ms     remaining: 530ms
90:     learn: 0.3886695     total: 117ms     remaining: 527ms
91:     learn: 0.3872147     total: 118ms     remaining: 525ms
92:     learn: 0.3864823     total: 120ms     remaining: 524ms
93:     learn: 0.3847119     total: 121ms     remaining: 523ms
94:     learn: 0.3829277     total: 122ms     remaining: 521ms
95:     learn: 0.3815210     total: 123ms     remaining: 519ms
96:     learn: 0.3793530     total: 125ms     remaining: 517ms
97:     learn: 0.3780227     total: 126ms     remaining: 515ms
98:     learn: 0.3762159     total: 127ms     remaining: 514ms
99:     learn: 0.3739799     total: 128ms     remaining: 513ms
100:    learn: 0.3715207     total: 130ms     remaining: 512ms
101:    learn: 0.3696601     total: 131ms     remaining: 510ms
102:    learn: 0.3690073     total: 132ms     remaining: 509ms
103:    learn: 0.3673820     total: 133ms     remaining: 507ms
104:    learn: 0.3666611     total: 134ms     remaining: 505ms
105:    learn: 0.3652307     total: 135ms     remaining: 503ms
106:    learn: 0.3633233     total: 137ms     remaining: 501ms
107:    learn: 0.3625943     total: 138ms     remaining: 499ms
108:    learn: 0.3612391     total: 139ms     remaining: 497ms
109:    learn: 0.3598078     total: 140ms     remaining: 496ms
110:    learn: 0.3567952     total: 141ms     remaining: 494ms
111:    learn: 0.3558667     total: 142ms     remaining: 492ms
112:    learn: 0.3545059     total: 143ms     remaining: 491ms
113:    learn: 0.3519369     total: 144ms     remaining: 489ms
114:    learn: 0.3508636     total: 145ms     remaining: 487ms
115:    learn: 0.3489125     total: 147ms     remaining: 485ms
116:    learn: 0.3474051     total: 148ms     remaining: 483ms
117:    learn: 0.3456095     total: 149ms     remaining: 482ms
118:    learn: 0.3436230     total: 150ms     remaining: 480ms
119:    learn: 0.3422197     total: 151ms     remaining: 479ms
120:    learn: 0.3402030     total: 152ms     remaining: 477ms
121:    learn: 0.3390662     total: 153ms     remaining: 475ms
122:    learn: 0.3382987     total: 155ms     remaining: 474ms
123:    learn: 0.3378405     total: 156ms     remaining: 472ms
124:    learn: 0.3362017     total: 157ms     remaining: 470ms
125:    learn: 0.3353997     total: 158ms     remaining: 468ms
126:    learn: 0.3346457     total: 159ms     remaining: 466ms
127:    learn: 0.3331454     total: 160ms     remaining: 464ms
128:    learn: 0.3323007     total: 161ms     remaining: 463ms
129:    learn: 0.3309408     total: 162ms     remaining: 461ms
130:    learn: 0.3290050     total: 163ms     remaining: 460ms
131:    learn: 0.3272301     total: 164ms     remaining: 458ms
132:    learn: 0.3264202     total: 166ms     remaining: 457ms
133:    learn: 0.3260324     total: 167ms     remaining: 455ms
134:    learn: 0.3241394     total: 168ms     remaining: 454ms
135:    learn: 0.3229779     total: 169ms     remaining: 452ms
136:    learn: 0.3214411     total: 170ms     remaining: 450ms
137:    learn: 0.3211015     total: 171ms     remaining: 448ms
138:    learn: 0.3189641     total: 172ms     remaining: 447ms
139:    learn: 0.3173286     total: 173ms     remaining: 445ms
140:    learn: 0.3169722     total: 174ms     remaining: 443ms
141:    learn: 0.3158052     total: 175ms     remaining: 442ms
142:    learn: 0.3148739     total: 176ms     remaining: 440ms
143:    learn: 0.3132286     total: 178ms     remaining: 439ms
144:    learn: 0.3125743     total: 179ms     remaining: 437ms
145:    learn: 0.3124381     total: 180ms     remaining: 436ms
146:    learn: 0.3115057     total: 181ms     remaining: 434ms
147:    learn: 0.3098365     total: 183ms     remaining: 435ms
148:    learn: 0.3082801     total: 184ms     remaining: 433ms
149:    learn: 0.3071553     total: 185ms     remaining: 432ms
150:    learn: 0.3049346     total: 186ms     remaining: 430ms
151:    learn: 0.3042607     total: 187ms     remaining: 429ms
152:    learn: 0.3034181     total: 188ms     remaining: 427ms
153:    learn: 0.3021525     total: 189ms     remaining: 426ms
154:    learn: 0.3015522     total: 190ms     remaining: 424ms
155:    learn: 0.3014578     total: 192ms     remaining: 422ms
156:    learn: 0.2998253     total: 193ms     remaining: 421ms
157:    learn: 0.2987631     total: 194ms     remaining: 419ms
158:    learn: 0.2974780     total: 195ms     remaining: 418ms
159:    learn: 0.2965097     total: 196ms     remaining: 417ms
160:    learn: 0.2959727     total: 198ms     remaining: 417ms
161:    learn: 0.2946289     total: 199ms     remaining: 416ms
162:    learn: 0.2935701     total: 201ms     remaining: 415ms
163:    learn: 0.2924825     total: 202ms     remaining: 413ms
```

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164:    learn: 0.2918879    total: 203ms    remaining: 412ms
165:    learn: 0.2906477    total: 204ms    remaining: 410ms
166:    learn: 0.2896425    total: 205ms    remaining: 409ms
167:    learn: 0.2889283    total: 206ms    remaining: 408ms
168:    learn: 0.2881842    total: 208ms    remaining: 407ms
169:    learn: 0.2872788    total: 209ms    remaining: 406ms
170:    learn: 0.2869147    total: 210ms    remaining: 404ms
171:    learn: 0.2857760    total: 211ms    remaining: 403ms
172:    learn: 0.2842250    total: 213ms    remaining: 402ms
173:    learn: 0.2828891    total: 214ms    remaining: 401ms
174:    learn: 0.2814904    total: 215ms    remaining: 400ms
175:    learn: 0.2809901    total: 217ms    remaining: 399ms
176:    learn: 0.2807382    total: 218ms    remaining: 398ms
177:    learn: 0.2804443    total: 219ms    remaining: 397ms
178:    learn: 0.2795263    total: 221ms    remaining: 396ms
179:    learn: 0.2783916    total: 222ms    remaining: 395ms
180:    learn: 0.2776987    total: 223ms    remaining: 394ms
181:    learn: 0.2769965    total: 225ms    remaining: 393ms
182:    learn: 0.2762558    total: 226ms    remaining: 392ms
183:    learn: 0.2756746    total: 228ms    remaining: 391ms
184:    learn: 0.2748243    total: 230ms    remaining: 391ms
185:    learn: 0.2736299    total: 231ms    remaining: 389ms
186:    learn: 0.2727997    total: 232ms    remaining: 388ms
187:    learn: 0.2722299    total: 233ms    remaining: 386ms
188:    learn: 0.2716904    total: 234ms    remaining: 385ms
189:    learn: 0.2714092    total: 235ms    remaining: 383ms
190:    learn: 0.2705472    total: 236ms    remaining: 382ms
191:    learn: 0.2700435    total: 237ms    remaining: 380ms
192:    learn: 0.2691573    total: 238ms    remaining: 379ms
193:    learn: 0.2684360    total: 239ms    remaining: 378ms
194:    learn: 0.2681012    total: 240ms    remaining: 376ms
195:    learn: 0.2679548    total: 242ms    remaining: 375ms
196:    learn: 0.2670651    total: 243ms    remaining: 374ms
197:    learn: 0.2667586    total: 245ms    remaining: 374ms
198:    learn: 0.2658871    total: 247ms    remaining: 373ms
199:    learn: 0.2649154    total: 248ms    remaining: 372ms
200:    learn: 0.2635807    total: 249ms    remaining: 370ms
201:    learn: 0.2626310    total: 250ms    remaining: 369ms
202:    learn: 0.2622961    total: 251ms    remaining: 367ms
203:    learn: 0.2616688    total: 252ms    remaining: 366ms
204:    learn: 0.2606020    total: 253ms    remaining: 365ms
205:    learn: 0.2601926    total: 255ms    remaining: 363ms
206:    learn: 0.2593079    total: 256ms    remaining: 362ms
207:    learn: 0.2582663    total: 257ms    remaining: 360ms
208:    learn: 0.2570459    total: 259ms    remaining: 360ms
209:    learn: 0.2568319    total: 260ms    remaining: 359ms
210:    learn: 0.2561383    total: 261ms    remaining: 358ms
211:    learn: 0.2553577    total: 262ms    remaining: 356ms
212:    learn: 0.2544871    total: 263ms    remaining: 355ms
213:    learn: 0.2533137    total: 264ms    remaining: 353ms
214:    learn: 0.2524541    total: 265ms    remaining: 352ms
215:    learn: 0.2522559    total: 267ms    remaining: 350ms
216:    learn: 0.2518124    total: 268ms    remaining: 349ms
217:    learn: 0.2512226    total: 269ms    remaining: 348ms
218:    learn: 0.2509632    total: 270ms    remaining: 346ms
219:    learn: 0.2500786    total: 271ms    remaining: 345ms
220:    learn: 0.2493668    total: 272ms    remaining: 344ms
221:    learn: 0.2484252    total: 274ms    remaining: 343ms
222:    learn: 0.2482757    total: 275ms    remaining: 342ms
223:    learn: 0.2476902    total: 276ms    remaining: 340ms
224:    learn: 0.2466863    total: 277ms    remaining: 339ms
225:    learn: 0.2464783    total: 278ms    remaining: 337ms
226:    learn: 0.2459354    total: 279ms    remaining: 336ms
227:    learn: 0.2453567    total: 281ms    remaining: 335ms
228:    learn: 0.2446004    total: 282ms    remaining: 333ms
229:    learn: 0.2439275    total: 283ms    remaining: 332ms
230:    learn: 0.2433805    total: 284ms    remaining: 330ms
231:    learn: 0.2432260    total: 285ms    remaining: 329ms
232:    learn: 0.2426405    total: 286ms    remaining: 327ms
233:    learn: 0.2418350    total: 287ms    remaining: 326ms
234:    learn: 0.2407784    total: 288ms    remaining: 325ms
235:    learn: 0.2403636    total: 290ms    remaining: 324ms
236:    learn: 0.2400407    total: 291ms    remaining: 323ms
237:    learn: 0.2399377    total: 292ms    remaining: 322ms
238:    learn: 0.2395624    total: 294ms    remaining: 321ms
239:    learn: 0.2391364    total: 295ms    remaining: 319ms
240:    learn: 0.2381516    total: 296ms    remaining: 318ms
241:    learn: 0.2374997    total: 297ms    remaining: 316ms
242:    learn: 0.2366962    total: 298ms    remaining: 315ms
243:    learn: 0.2358804    total: 299ms    remaining: 314ms
244:    learn: 0.2353731    total: 300ms    remaining: 312ms
245:    learn: 0.2346824    total: 301ms    remaining: 311ms
246:    learn: 0.2340018    total: 302ms    remaining: 310ms
247:    learn: 0.2334474    total: 303ms    remaining: 308ms
248:    learn: 0.2327982    total: 305ms    remaining: 308ms
249:    learn: 0.2324127    total: 307ms    remaining: 307ms
250:    learn: 0.2321929    total: 308ms    remaining: 305ms
251:    learn: 0.2315817    total: 309ms    remaining: 304ms
252:    learn: 0.2311017    total: 310ms    remaining: 302ms
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253:    learn: 0.2308177    total: 311ms    remaining: 301ms
254:    learn: 0.2299518    total: 312ms    remaining: 300ms
255:    learn: 0.2295334    total: 313ms    remaining: 298ms
256:    learn: 0.2288408    total: 314ms    remaining: 297ms
257:    learn: 0.2277278    total: 315ms    remaining: 296ms
258:    learn: 0.2275563    total: 317ms    remaining: 295ms
259:    learn: 0.2269617    total: 318ms    remaining: 293ms
260:    learn: 0.2266912    total: 319ms    remaining: 292ms
261:    learn: 0.2258958    total: 320ms    remaining: 291ms
262:    learn: 0.2250745    total: 322ms    remaining: 290ms
263:    learn: 0.2248777    total: 323ms    remaining: 289ms
264:    learn: 0.2241243    total: 324ms    remaining: 287ms
265:    learn: 0.2234348    total: 325ms    remaining: 286ms
266:    learn: 0.2226115    total: 326ms    remaining: 285ms
267:    learn: 0.2219551    total: 327ms    remaining: 283ms
268:    learn: 0.2215492    total: 328ms    remaining: 282ms
269:    learn: 0.2212617    total: 329ms    remaining: 281ms
270:    learn: 0.2210748    total: 330ms    remaining: 279ms
271:    learn: 0.2208873    total: 332ms    remaining: 278ms
272:    learn: 0.2206083    total: 333ms    remaining: 277ms
273:    learn: 0.2201642    total: 334ms    remaining: 275ms
274:    learn: 0.2193864    total: 335ms    remaining: 274ms
275:    learn: 0.2186670    total: 337ms    remaining: 274ms
276:    learn: 0.2185844    total: 338ms    remaining: 272ms
277:    learn: 0.2180152    total: 339ms    remaining: 271ms
278:    learn: 0.2176870    total: 340ms    remaining: 269ms
279:    learn: 0.2175650    total: 341ms    remaining: 268ms
280:    learn: 0.2173658    total: 342ms    remaining: 267ms
281:    learn: 0.2168903    total: 343ms    remaining: 265ms
282:    learn: 0.2167815    total: 344ms    remaining: 264ms
283:    learn: 0.2166001    total: 346ms    remaining: 263ms
284:    learn: 0.2161882    total: 347ms    remaining: 262ms
285:    learn: 0.2160388    total: 348ms    remaining: 260ms
286:    learn: 0.2156082    total: 349ms    remaining: 259ms
287:    learn: 0.2149456    total: 351ms    remaining: 258ms
288:    learn: 0.2147529    total: 352ms    remaining: 257ms
289:    learn: 0.2143638    total: 353ms    remaining: 256ms
290:    learn: 0.2142195    total: 354ms    remaining: 254ms
291:    learn: 0.2140345    total: 355ms    remaining: 253ms
292:    learn: 0.2134837    total: 356ms    remaining: 252ms
293:    learn: 0.2131221    total: 358ms    remaining: 251ms
294:    learn: 0.2128319    total: 359ms    remaining: 249ms
295:    learn: 0.2127408    total: 360ms    remaining: 248ms
296:    learn: 0.2123279    total: 361ms    remaining: 247ms
297:    learn: 0.2122647    total: 362ms    remaining: 245ms
298:    learn: 0.2115901    total: 363ms    remaining: 244ms
299:    learn: 0.2112150    total: 364ms    remaining: 243ms
300:    learn: 0.2108557    total: 365ms    remaining: 241ms
301:    learn: 0.2107243    total: 367ms    remaining: 240ms
302:    learn: 0.2102569    total: 368ms    remaining: 239ms
303:    learn: 0.2100633    total: 369ms    remaining: 238ms
304:    learn: 0.2099769    total: 370ms    remaining: 237ms
305:    learn: 0.2093057    total: 371ms    remaining: 235ms
306:    learn: 0.2088209    total: 372ms    remaining: 234ms
307:    learn: 0.2084186    total: 374ms    remaining: 233ms
308:    learn: 0.2080124    total: 375ms    remaining: 232ms
309:    learn: 0.2076718    total: 376ms    remaining: 230ms
310:    learn: 0.2075625    total: 377ms    remaining: 229ms
311:    learn: 0.2068982    total: 378ms    remaining: 228ms
312:    learn: 0.2063015    total: 379ms    remaining: 227ms
313:    learn: 0.2061209    total: 380ms    remaining: 225ms
314:    learn: 0.2055175    total: 382ms    remaining: 224ms
315:    learn: 0.2053088    total: 383ms    remaining: 223ms
316:    learn: 0.2049388    total: 385ms    remaining: 222ms
317:    learn: 0.2045913    total: 386ms    remaining: 221ms
318:    learn: 0.2041915    total: 388ms    remaining: 220ms
319:    learn: 0.2039349    total: 389ms    remaining: 219ms
320:    learn: 0.2036380    total: 390ms    remaining: 217ms
321:    learn: 0.2032117    total: 391ms    remaining: 216ms
322:    learn: 0.2030053    total: 392ms    remaining: 215ms
323:    learn: 0.2029338    total: 393ms    remaining: 214ms
324:    learn: 0.2024864    total: 395ms    remaining: 213ms
325:    learn: 0.2019629    total: 396ms    remaining: 211ms
326:    learn: 0.2016067    total: 397ms    remaining: 210ms
327:    learn: 0.2013976    total: 400ms    remaining: 209ms
328:    learn: 0.2010651    total: 401ms    remaining: 208ms
329:    learn: 0.2006636    total: 402ms    remaining: 207ms
330:    learn: 0.2003499    total: 403ms    remaining: 206ms
331:    learn: 0.2002749    total: 404ms    remaining: 205ms
332:    learn: 0.1999822    total: 406ms    remaining: 203ms
333:    learn: 0.1996499    total: 407ms    remaining: 202ms
334:    learn: 0.1994917    total: 408ms    remaining: 201ms
335:    learn: 0.1991152    total: 409ms    remaining: 200ms
336:    learn: 0.1988865    total: 411ms    remaining: 199ms
337:    learn: 0.1985612    total: 412ms    remaining: 197ms
338:    learn: 0.1979157    total: 414ms    remaining: 196ms
339:    learn: 0.1974938    total: 416ms    remaining: 196ms
340:    learn: 0.1969468    total: 417ms    remaining: 195ms
341:    learn: 0.1966136    total: 418ms    remaining: 193ms
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342:    learn: 0.1961162    total: 420ms    remaining: 192ms
343:    learn: 0.1958825    total: 421ms    remaining: 191ms
344:    learn: 0.1953951    total: 422ms    remaining: 190ms
345:    learn: 0.1949623    total: 423ms    remaining: 188ms
346:    learn: 0.1946392    total: 425ms    remaining: 187ms
347:    learn: 0.1942749    total: 426ms    remaining: 186ms
348:    learn: 0.1941493    total: 427ms    remaining: 185ms
349:    learn: 0.1938356    total: 429ms    remaining: 184ms
350:    learn: 0.1932578    total: 431ms    remaining: 183ms
351:    learn: 0.1931376    total: 432ms    remaining: 182ms
352:    learn: 0.1928578    total: 433ms    remaining: 180ms
353:    learn: 0.1925204    total: 434ms    remaining: 179ms
354:    learn: 0.1923450    total: 435ms    remaining: 178ms
355:    learn: 0.1922093    total: 437ms    remaining: 177ms
356:    learn: 0.1918354    total: 438ms    remaining: 175ms
357:    learn: 0.1917173    total: 439ms    remaining: 174ms
358:    learn: 0.1916321    total: 440ms    remaining: 173ms
359:    learn: 0.1910993    total: 442ms    remaining: 172ms
360:    learn: 0.1909486    total: 443ms    remaining: 171ms
361:    learn: 0.1907566    total: 445ms    remaining: 169ms
362:    learn: 0.1904625    total: 447ms    remaining: 169ms
363:    learn: 0.1900501    total: 448ms    remaining: 167ms
364:    learn: 0.1896202    total: 449ms    remaining: 166ms
365:    learn: 0.1894650    total: 450ms    remaining: 165ms
366:    learn: 0.1888791    total: 451ms    remaining: 164ms
367:    learn: 0.1887649    total: 453ms    remaining: 162ms
368:    learn: 0.1882510    total: 454ms    remaining: 161ms
369:    learn: 0.1878843    total: 455ms    remaining: 160ms
370:    learn: 0.1877554    total: 456ms    remaining: 159ms
371:    learn: 0.1872687    total: 458ms    remaining: 157ms
372:    learn: 0.1868264    total: 459ms    remaining: 156ms
373:    learn: 0.1864776    total: 460ms    remaining: 155ms
374:    learn: 0.1862952    total: 463ms    remaining: 154ms
375:    learn: 0.1858533    total: 464ms    remaining: 153ms
376:    learn: 0.1856069    total: 465ms    remaining: 152ms
377:    learn: 0.1851048    total: 466ms    remaining: 151ms
378:    learn: 0.1846264    total: 468ms    remaining: 149ms
379:    learn: 0.1842510    total: 469ms    remaining: 148ms
380:    learn: 0.1839288    total: 470ms    remaining: 147ms
381:    learn: 0.1837933    total: 472ms    remaining: 146ms
382:    learn: 0.1835428    total: 473ms    remaining: 144ms
383:    learn: 0.1832866    total: 474ms    remaining: 143ms
384:    learn: 0.1830660    total: 475ms    remaining: 142ms
385:    learn: 0.1825602    total: 477ms    remaining: 141ms
386:    learn: 0.1822742    total: 478ms    remaining: 140ms
387:    learn: 0.1821821    total: 479ms    remaining: 138ms
388:    learn: 0.1818541    total: 481ms    remaining: 137ms
389:    learn: 0.1816666    total: 482ms    remaining: 136ms
390:    learn: 0.1814358    total: 483ms    remaining: 135ms
391:    learn: 0.1812888    total: 485ms    remaining: 134ms
392:    learn: 0.1807179    total: 486ms    remaining: 132ms
393:    learn: 0.1805072    total: 487ms    remaining: 131ms
394:    learn: 0.1802893    total: 488ms    remaining: 130ms
395:    learn: 0.1801247    total: 489ms    remaining: 129ms
396:    learn: 0.1797678    total: 491ms    remaining: 127ms
397:    learn: 0.1794976    total: 492ms    remaining: 126ms
398:    learn: 0.1790361    total: 494ms    remaining: 125ms
399:    learn: 0.1787674    total: 495ms    remaining: 124ms
400:    learn: 0.1787225    total: 496ms    remaining: 123ms
401:    learn: 0.1781359    total: 498ms    remaining: 121ms
402:    learn: 0.1777932    total: 499ms    remaining: 120ms
403:    learn: 0.1774277    total: 500ms    remaining: 119ms
404:    learn: 0.1769658    total: 501ms    remaining: 118ms
405:    learn: 0.1765731    total: 503ms    remaining: 116ms
406:    learn: 0.1765445    total: 504ms    remaining: 115ms
407:    learn: 0.1761315    total: 505ms    remaining: 114ms
408:    learn: 0.1759312    total: 506ms    remaining: 113ms
409:    learn: 0.1756009    total: 509ms    remaining: 112ms
410:    learn: 0.1754754    total: 510ms    remaining: 110ms
411:    learn: 0.1751560    total: 511ms    remaining: 109ms
412:    learn: 0.1750231    total: 513ms    remaining: 108ms
413:    learn: 0.1749221    total: 514ms    remaining: 107ms
414:    learn: 0.1748716    total: 515ms    remaining: 105ms
415:    learn: 0.1745959    total: 516ms    remaining: 104ms
416:    learn: 0.1744202    total: 517ms    remaining: 103ms
417:    learn: 0.1743585    total: 519ms    remaining: 102ms
418:    learn: 0.1741706    total: 520ms    remaining: 100ms
419:    learn: 0.1740952    total: 521ms    remaining: 99.2ms
420:    learn: 0.1735581    total: 522ms    remaining: 98ms
421:    learn: 0.1734511    total: 525ms    remaining: 97ms
422:    learn: 0.1732066    total: 526ms    remaining: 95.7ms
423:    learn: 0.1731434    total: 527ms    remaining: 94.5ms
424:    learn: 0.1729493    total: 528ms    remaining: 93.2ms
425:    learn: 0.1728802    total: 530ms    remaining: 92ms
426:    learn: 0.1725026    total: 531ms    remaining: 90.7ms
427:    learn: 0.1722333    total: 532ms    remaining: 89.5ms
428:    learn: 0.1718248    total: 533ms    remaining: 88.3ms
429:    learn: 0.1714004    total: 535ms    remaining: 87ms
430:    learn: 0.1710243    total: 536ms    remaining: 85.8ms
```

```
431:     learn: 0.1707870     total: 537ms     remaining: 84.6ms
432:     learn: 0.1704622     total: 540ms     remaining: 83.6ms
433:     learn: 0.1701154     total: 541ms     remaining: 82.3ms
434:     learn: 0.1698438     total: 543ms     remaining: 81.1ms
435:     learn: 0.1696099     total: 544ms     remaining: 79.8ms
436:     learn: 0.1695698     total: 545ms     remaining: 78.6ms
437:     learn: 0.1694544     total: 546ms     remaining: 77.3ms
438:     learn: 0.1691441     total: 547ms     remaining: 76ms
439:     learn: 0.1690164     total: 548ms     remaining: 74.8ms
440:     learn: 0.1687206     total: 550ms     remaining: 73.5ms
441:     learn: 0.1684613     total: 551ms     remaining: 72.3ms
442:     learn: 0.1682735     total: 552ms     remaining: 71ms
443:     learn: 0.1682218     total: 554ms     remaining: 69.9ms
444:     learn: 0.1677963     total: 556ms     remaining: 68.7ms
445:     learn: 0.1677530     total: 557ms     remaining: 67.5ms
446:     learn: 0.1676913     total: 558ms     remaining: 66.2ms
447:     learn: 0.1675338     total: 559ms     remaining: 64.9ms
448:     learn: 0.1674538     total: 561ms     remaining: 63.7ms
449:     learn: 0.1673750     total: 562ms     remaining: 62.4ms
450:     learn: 0.1671042     total: 563ms     remaining: 61.2ms
451:     learn: 0.1670058     total: 564ms     remaining: 59.9ms
452:     learn: 0.1666066     total: 565ms     remaining: 58.7ms
453:     learn: 0.1664194     total: 567ms     remaining: 57.4ms
454:     learn: 0.1662461     total: 568ms     remaining: 56.2ms
455:     learn: 0.1660763     total: 570ms     remaining: 55ms
456:     learn: 0.1658964     total: 572ms     remaining: 53.8ms
457:     learn: 0.1656535     total: 573ms     remaining: 52.5ms
458:     learn: 0.1655003     total: 574ms     remaining: 51.3ms
459:     learn: 0.1653476     total: 575ms     remaining: 50ms
460:     learn: 0.1652021     total: 576ms     remaining: 48.7ms
461:     learn: 0.1645402     total: 578ms     remaining: 47.5ms
462:     learn: 0.1644567     total: 579ms     remaining: 46.3ms
463:     learn: 0.1642713     total: 580ms     remaining: 45ms
464:     learn: 0.1640530     total: 581ms     remaining: 43.8ms
465:     learn: 0.1637208     total: 583ms     remaining: 42.5ms
466:     learn: 0.1635703     total: 584ms     remaining: 41.3ms
467:     learn: 0.1634750     total: 587ms     remaining: 40.1ms
468:     learn: 0.1632163     total: 588ms     remaining: 38.9ms
469:     learn: 0.1630559     total: 589ms     remaining: 37.6ms
470:     learn: 0.1629327     total: 591ms     remaining: 36.4ms
471:     learn: 0.1628623     total: 592ms     remaining: 35.1ms
472:     learn: 0.1628331     total: 593ms     remaining: 33.8ms
473:     learn: 0.1626020     total: 594ms     remaining: 32.6ms
474:     learn: 0.1625264     total: 595ms     remaining: 31.3ms
475:     learn: 0.1623817     total: 596ms     remaining: 30ms
476:     learn: 0.1623027     total: 597ms     remaining: 28.8ms
477:     learn: 0.1621926     total: 598ms     remaining: 27.5ms
478:     learn: 0.1618631     total: 600ms     remaining: 26.3ms
479:     learn: 0.1616972     total: 602ms     remaining: 25.1ms
480:     learn: 0.1616376     total: 603ms     remaining: 23.8ms
481:     learn: 0.1615947     total: 604ms     remaining: 22.5ms
482:     learn: 0.1612696     total: 605ms     remaining: 21.3ms
483:     learn: 0.1609891     total: 606ms     remaining: 20ms
484:     learn: 0.1608418     total: 608ms     remaining: 18.8ms
485:     learn: 0.1605867     total: 609ms     remaining: 17.5ms
486:     learn: 0.1602867     total: 610ms     remaining: 16.3ms
487:     learn: 0.1599936     total: 611ms     remaining: 15ms
488:     learn: 0.1596746     total: 613ms     remaining: 13.8ms
489:     learn: 0.1596137     total: 614ms     remaining: 12.5ms
490:     learn: 0.1593599     total: 616ms     remaining: 11.3ms
491:     learn: 0.1592449     total: 618ms     remaining: 10ms
492:     learn: 0.1591946     total: 619ms     remaining: 8.78ms
493:     learn: 0.1591193     total: 620ms     remaining: 7.53ms
494:     learn: 0.1587012     total: 621ms     remaining: 6.27ms
495:     learn: 0.1585541     total: 622ms     remaining: 5.02ms
496:     learn: 0.1583058     total: 623ms     remaining: 3.76ms
497:     learn: 0.1581542     total: 624ms     remaining: 2.51ms
498:     learn: 0.1579877     total: 625ms     remaining: 1.25ms
499:     learn: 0.1579240     total: 626ms     remaining: 0us
```

In [71]:
```python
y_pred = cat_tuned.predict(x_test)
accuracy_score(y_test, y_pred)
```

Out[71]:
```
0.935
```

Compare of All Models

In [92]:
```python
models = [
    loj_tuned,
    nb_model,
    knn_model,
    svm_model_linear,
    mlp_tuned,
    cart_tuned,
    rf_tuned,
    gbm_tuned,
```

```
        xgb_tuned,
        cat_tuned
]

for model in models:
    names = model.__class__.__name__
    y_pred = model.predict(x_test)
    accuracy = accuracy_score(y_test, y_pred)
    print("-"*28)
    print(names + ":" )
    print("Accuracy: {:.4%}".format(accuracy))
```

```
----------------------------
LogisticRegression:
Accuracy: 97.5000%
----------------------------
GaussianNB:
Accuracy: 81.0000%
----------------------------
KNeighborsClassifier:
Accuracy: 92.7500%
----------------------------
SVC:
Accuracy: 98.2500%
----------------------------
MLPClassifier:
Accuracy: 23.5000%
----------------------------
DecisionTreeClassifier:
Accuracy: 85.7500%
----------------------------
RandomForestClassifier:
Accuracy: 91.2500%
----------------------------
GradientBoostingClassifier:
Accuracy: 91.5000%
----------------------------
XGBClassifier:
Accuracy: 92.7500%
----------------------------
CatBoostClassifier:
Accuracy: 93.5000%
```

In [93]:
```
result = []
results = pd.DataFrame(columns= ["Models","Accuracy"])

for model in models:
    names = model.__class__.__name__
    y_pred = model.predict(x_test)
    accuracy = accuracy_score(y_test, y_pred)
    result = pd.DataFrame([[names, accuracy*100]], columns= ["Models","Accuracy"])
    results = results.append(result)

sns.barplot(x= 'Accuracy', y = 'Models', data=results, color="r")
plt.xlabel('Accuracy %')
plt.title('Accuracy Rate of Models');
```


Accuracy Rate of Models
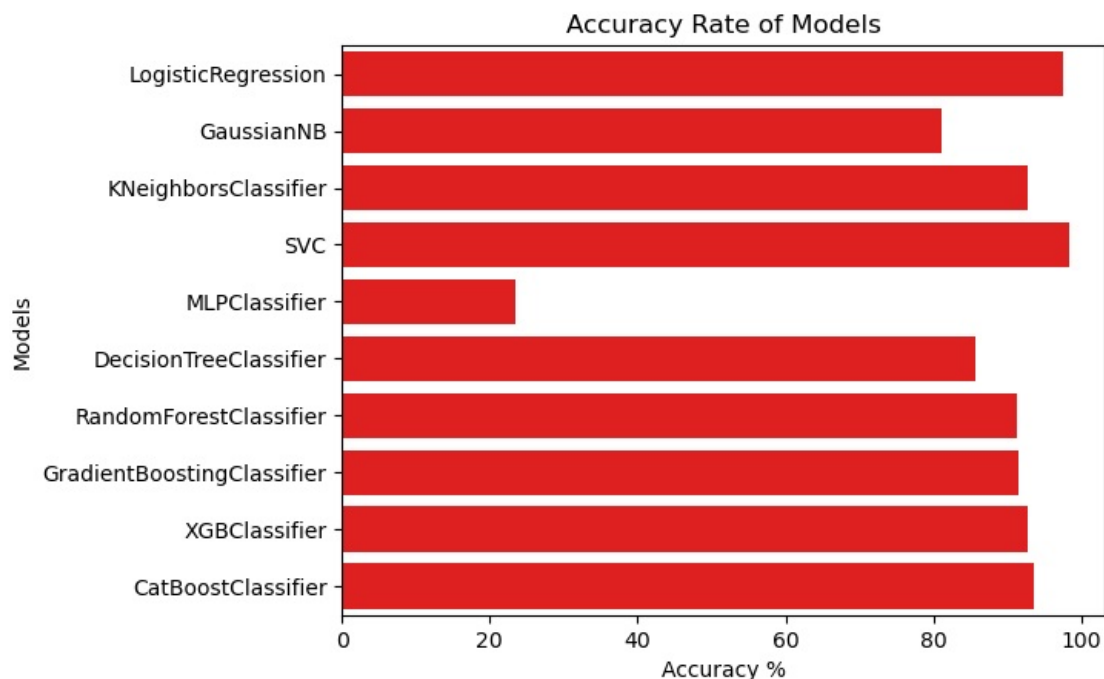
As we see it seems the most successfull algorithm is SVC.