ML TERM ASSIGNMENT

Dataset taken : Car Evaluation Data Set

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Course Code and Name: 2CS501 MACHINE LEARNING

Importing the libraries

- **Only basic libraries imported here**

In [77]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

Importing the dataset

- **Dataset information:**
  - **The dataset presented here is a multivariate dataset having 6 attributes. There are total 1728 instances in the dataset which can be splitted into training and testing data on user's own discretion.**
  - **The dataset has no missing values and the data type of attributes given in the dataset is categorical.**
  - **There are total 7 columns in the dataset where first six columns are of attributes namely:**
    1. **Buying**
    2. **Maintenance**
    3. **Doors**
    4. **Persons**
    5. **Lug_Boot**
    6. **Safety**
  - **Here, we are tasked to classify the acceptability of the car on the basis of above mentioned attributes. The car is tasked to be classified into four classes namely:**
    1. **Unacc**
    2. **Acc**
    3. **Good**
    4. **Vgood**
- **Reading the dataset from csv file:**
  - **Firstly, we read the csv file using standard function of pandas library i.e. read_csv. We read this file into dataframe named data.**
  - **Next we set the column names manually as the dataset does not have the column names in csv.**
  - **Proceeding ahead, we convert all the string values of dataset into suitable integer values as the ML classification algorithms cannot deal with the string data. This task was accomplished by mapping all the string values to integral values.**

In [78]:

```
dataset = pd.read_csv('car.csv', names=['buying','maint','doors','persons','lug boot','safety','class'])
```

Explanatory Data Analysis

- **Available Columns :**

In [79]:

```
list(dataset.columns)
```

Out[79]:

```
['buying', 'maint', 'doors', 'persons', 'lug boot', 'safety', 'class']
```

- **Printing first 5 rows of dataset :**

In [80]:

```
dataset.head()
```

Out[80]:

	buying	maint	doors	persons	lug boot	safety	class
0	vhigh	vhigh	2	2	small	low	unacc
1	vhigh	vhigh	2	2	small	med	unacc
2	vhigh	vhigh	2	2	small	high	unacc
3	vhigh	vhigh	2	2	med	low	unacc
4	vhigh	vhigh	2	2	med	med	unacc

- **Getting information of dataset and checking of null values if any**

In [81]:

```
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1728 entries, 0 to 1727
Data columns (total 7 columns):
 #   Column    Non-Null Count  Dtype 
---  ------    --------------  ----- 
 0   buying    1728 non-null   object
 1   maint     1728 non-null   object
 2   doors     1728 non-null   object
 3   persons   1728 non-null   object
 4   lug boot  1728 non-null   object
 5   safety    1728 non-null   object
 6   class     1728 non-null   object
dtypes: object(7)
memory usage: 94.6+ KB
```

- **As all the columns are categorical, checking for unique values :**

In [82]:

```
for i in dataset.columns:
  print(dataset[i].unique(),"\t",dataset[i].nunique())
```

```
['vhigh' 'high' 'med' 'low']    4
['vhigh' 'high' 'med' 'low']    4
['2' '3' '4' '5more']    4
```

```
['2' '4' 'more']   3
['small' 'med' 'big']   3
['low' 'med' 'high']   3
['unacc' 'acc' 'vgood' 'good']   4
```

- **Checking how unique categories are distributed among the columns :**

> **All of the columns except 'class' are distributed equally among the data, as shown in the below output.**

In [83]:

```
for i in dataset.columns:
  print(dataset[i].value_counts())
  print()
```

```
low      432
high     432
med      432
vhigh    432
Name: buying, dtype: int64

low      432
high     432
med      432
vhigh    432
Name: maint, dtype: int64

3        432
4        432
5more    432
2        432
Name: doors, dtype: int64

4       576
more    576
2       576
Name: persons, dtype: int64

med      576
small    576
big      576
Name: lug boot, dtype: int64

low     576
high    576
med     576
Name: safety, dtype: int64

unacc    1210
acc       384
good       69
vgood      65
Name: class, dtype: int64
```

Graphs :

- **The graph below shows the number of unique values in each column.**

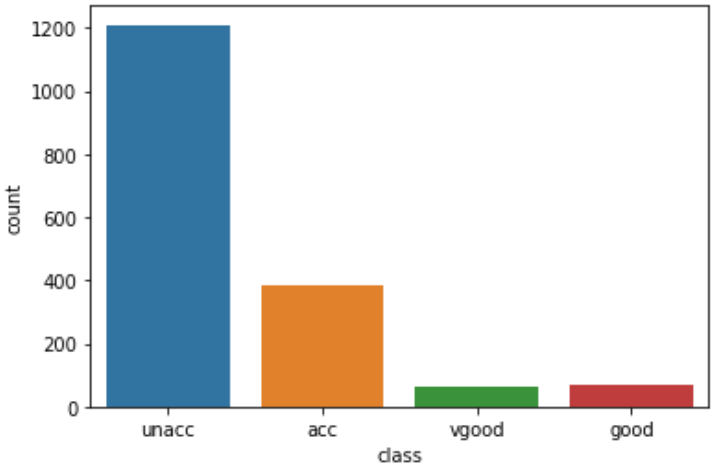
> **The graph shows that the result 'class' is unbalanced due to higher values of 'unacc'. As a result, there is a difficulty with an unbalanced multiclass classification.**

In [84]:

```
sns.countplot(x = dataset['class'])
```

Out[84]:

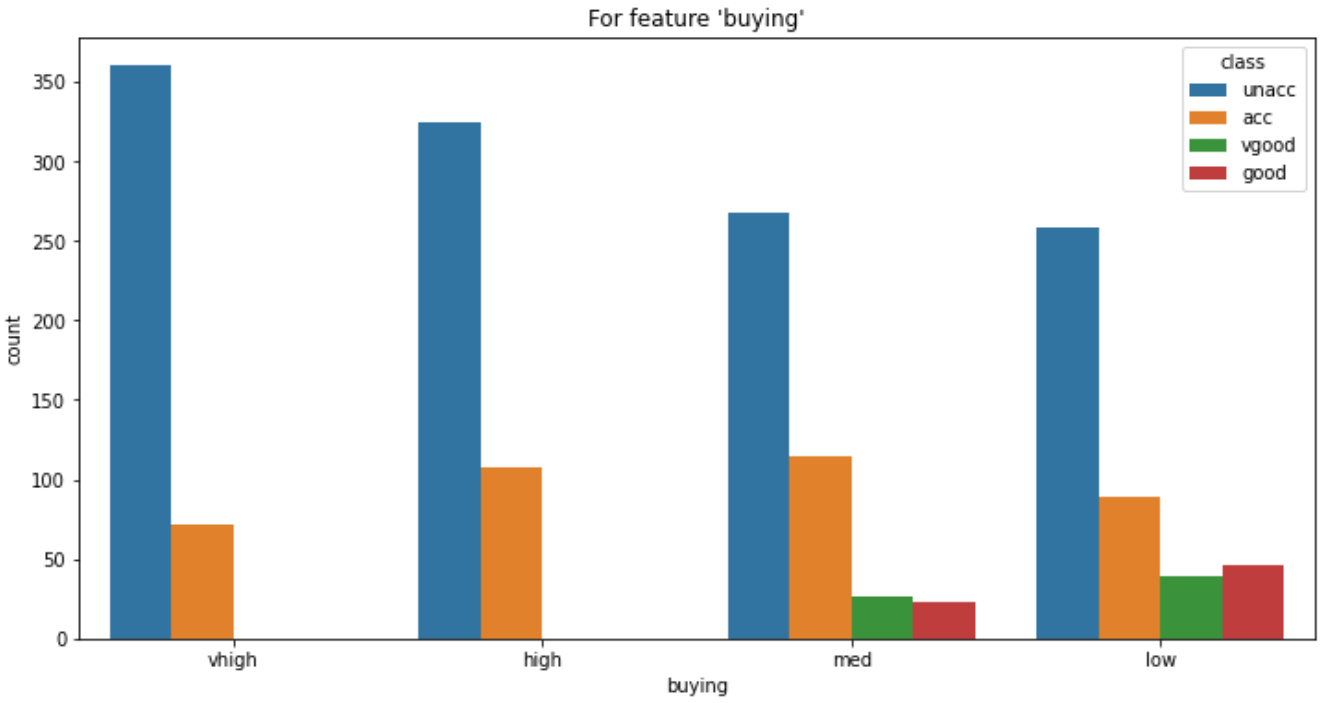
```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff31ec8cf90>
```

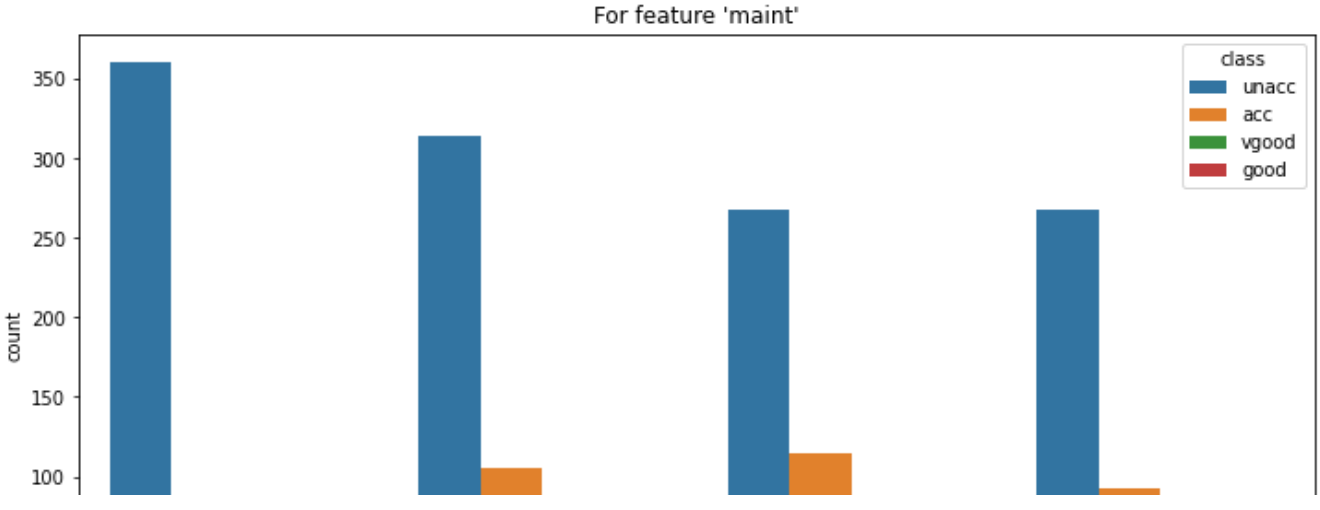


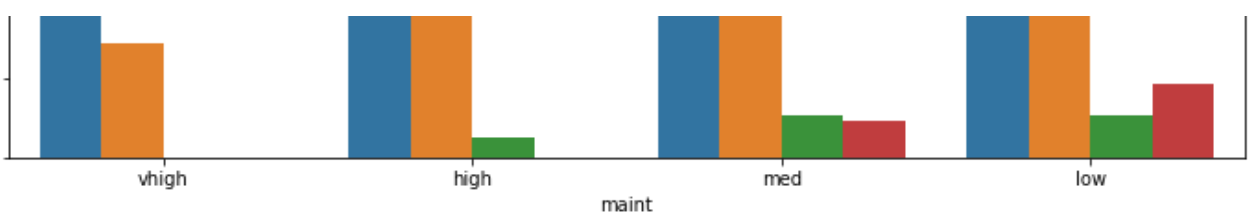
- **For each feature in our data, We looked at how the 'class' is distributed.**

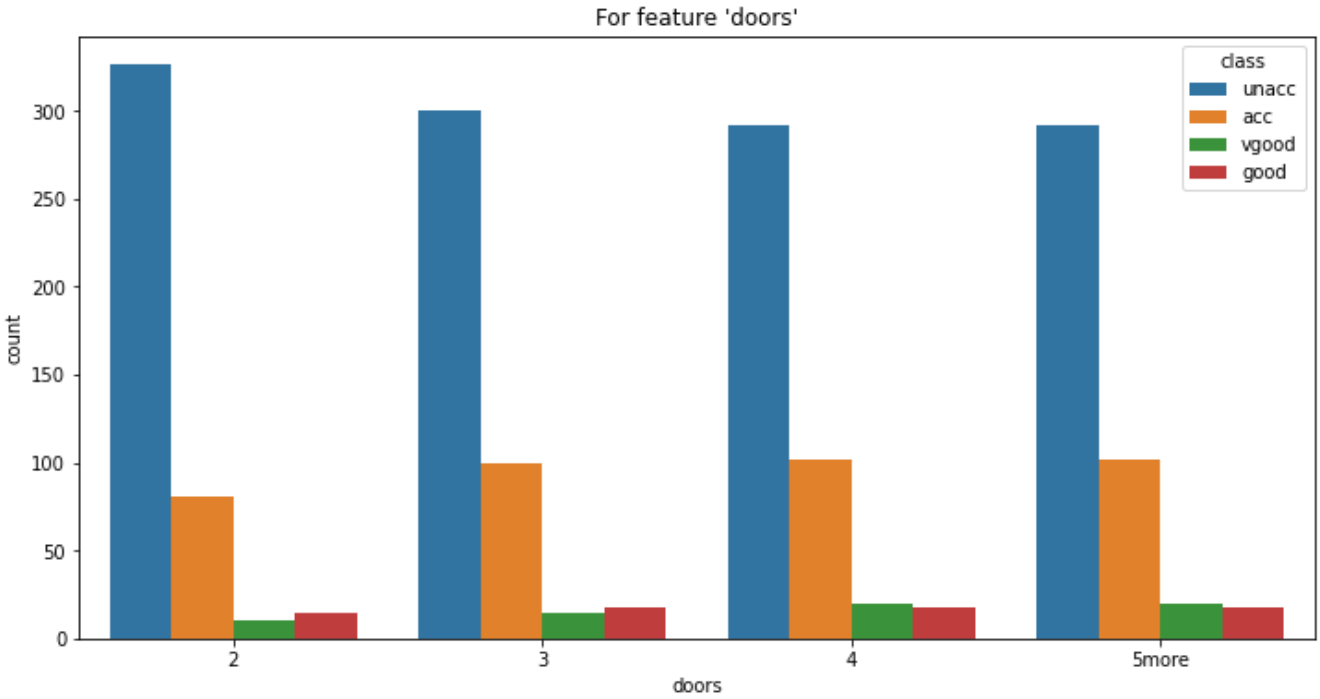
In [85]:

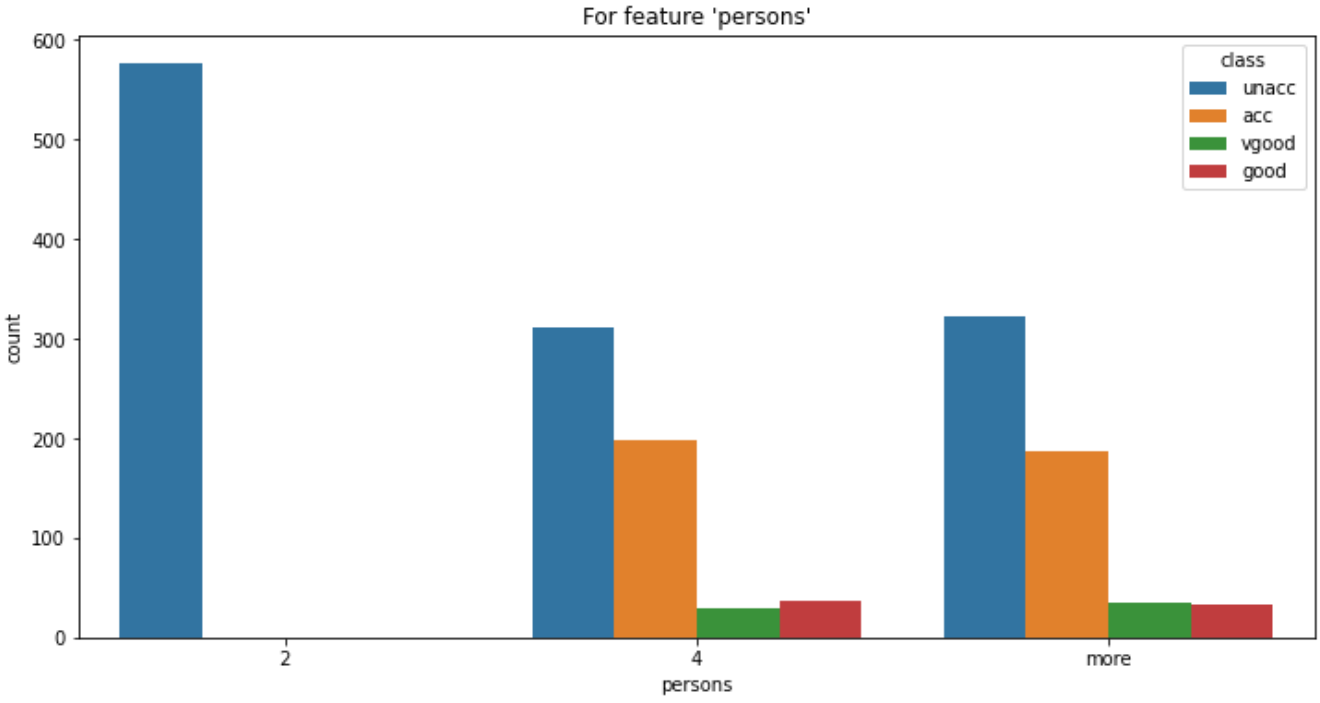
```
for i in dataset.columns[:-1]:
    plt.figure(figsize=(12,6))
    plt.title("For feature '%s'"%i)
    sns.countplot(x = dataset[i],hue=dataset['class'])
```

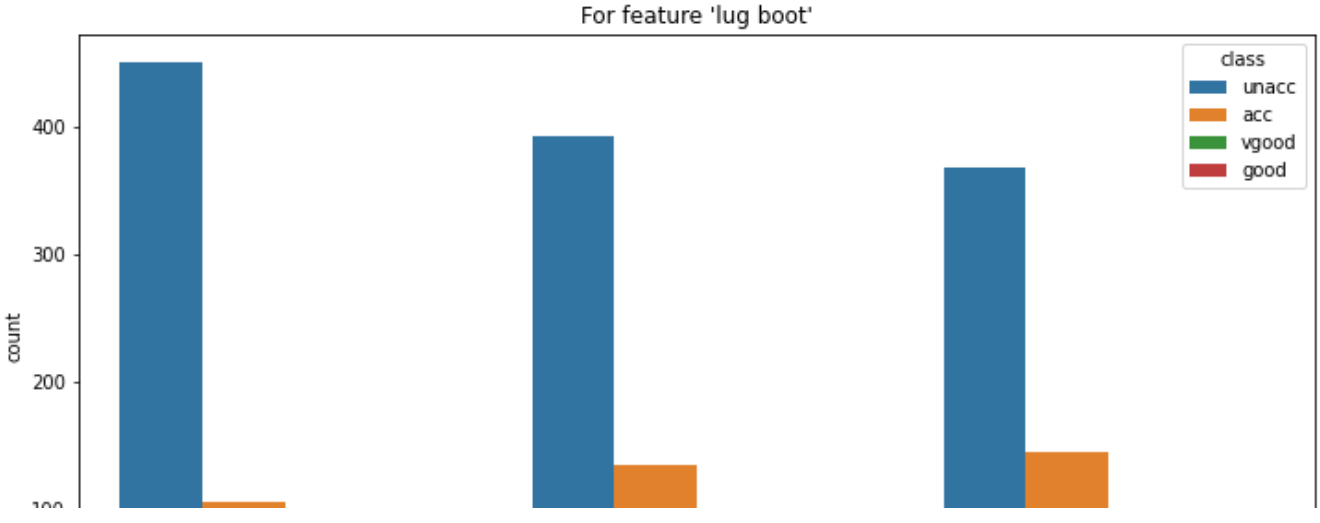


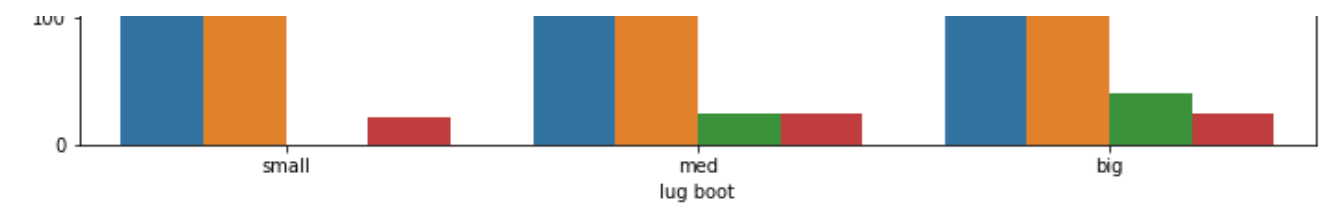


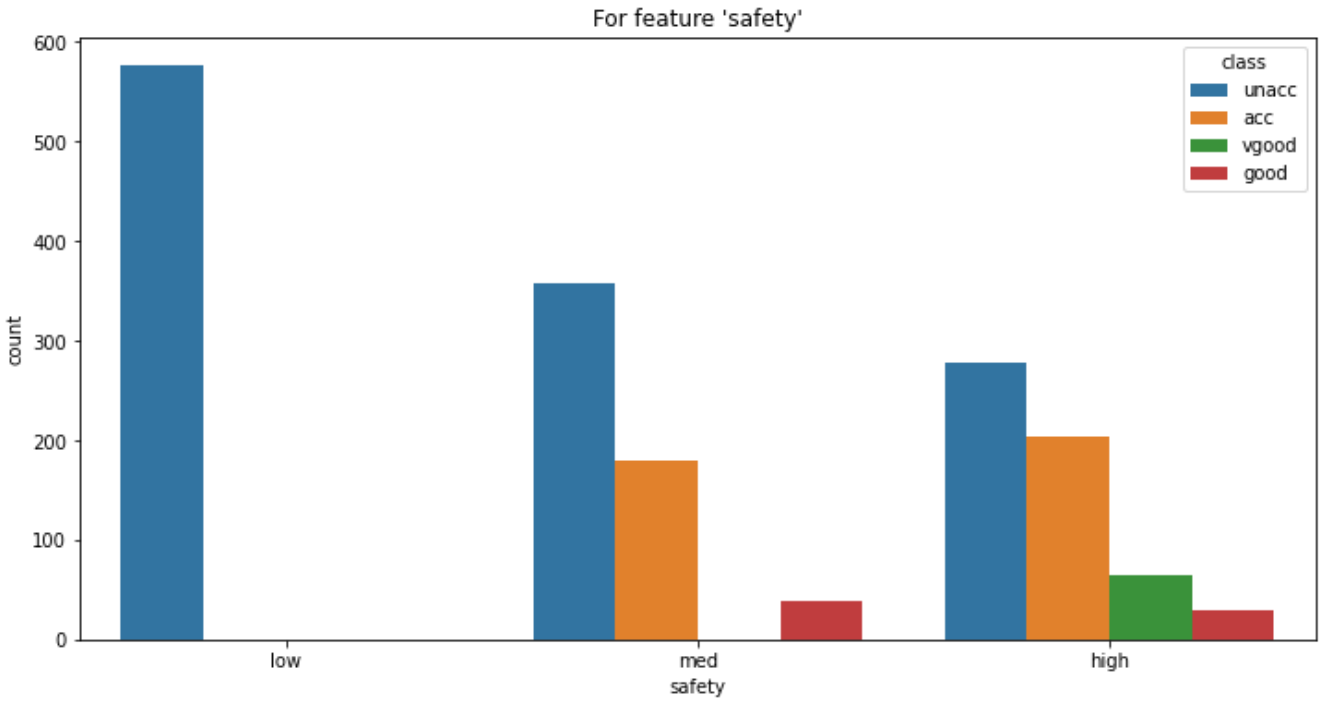

50
0
vhigh
high
med
low
maint


For feature 'doors'
class
unacc
acc
vgood
good
300
250
200
150
100
50
0
count
2
3
4
5more
doors


For feature 'persons'
class
unacc
acc
vgood
good
600
500
400
300
200
100
0
count
2
4
more
persons


For feature 'lug boot'
class
unacc
acc
vgood
good
400
300
200
count





Encoding categorical data

- **We transformed string categories to integers because scikit-learn algorithms don't usually operate with string values.**

In [86]:

```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
dataset.columns = ['Buying','Maintenance','Doors','Persons','Lug_Boot','Safety','Acceptab
ility']
dataset['Buying'] = dataset['Buying'].map({'vhigh':3,'high':2,'med':1,'low':0})
dataset['Maintenance'] = dataset['Maintenance'].map({'vhigh':3,'high':2,'med':1,'low':0}
)
dataset['Lug_Boot'] = dataset['Lug_Boot'].map({'big':2,'med':1,'small':0})
dataset['Safety'] = dataset['Safety'].map({'high':2,'med':1,'low':0})
dataset['Acceptability'] = dataset['Acceptability'].map({'unacc':0,'acc':1,'good':2, 'vg
ood':3})
dataset['Doors'] = dataset['Doors'].map({'2':2, '3':3, '4':4, '5more':5})
dataset['Persons'] = dataset['Persons'].map({'2':2, '4':4, 'more':5})

dataset
```

Out[86]:

	Buying	Maintenance	Doors	Persons	Lug_Boot	Safety	Acceptability
0	3	3	2	2	0	0	0
1	3	3	2	2	0	1	0
2	3	3	2	2	0	2	0
3	3	3	2	2	1	0	0
4	3	3	2	2	1	1	0
...	...	...	...	...	...	...	...
1723	0	0	5	5	1	1	2

	Buying	Maintenance	Doors	Persons	Lug_Boot	Safety	Acceptability
1724	0	0	5	5	1	2	3
1725	0	0	5	5	2	0	0
1726	0	0	5	5	2	1	2
1727	0	0	5	5	2	2	3

1728 rows × 7 columns

- **Splitting dataset into independent variable `X` and dependent variable `y` :**

In [87]:

```
X = dataset.iloc[:,:-1].values
y = dataset.iloc[:,-1].values
```

- **Independent variable `X` :**

In [88]:

```
dataset.iloc[:,:-1]
```

Out[88]:

	Buying	Maintenance	Doors	Persons	Lug_Boot	Safety
0	3	3	2	2	0	0
1	3	3	2	2	0	1
2	3	3	2	2	0	2
3	3	3	2	2	1	0
4	3	3	2	2	1	1
...	...	...	...	...	...	...
1723	0	0	5	5	1	1
1724	0	0	5	5	1	2
1725	0	0	5	5	2	0
1726	0	0	5	5	2	1
1727	0	0	5	5	2	2

1728 rows × 6 columns

- **Dependent variable `y` :**

In [89]:

```
dataset.iloc[:,-1]
```

Out[89]:

```
0       0
1       0
2       0
3       0
4       0
       ..
1723    2
1724    3
1725    0
1726    2
1727    3
Name: Acceptability, Length: 1728, dtype: int64
```

Splitting the dataset into the training set and testing set

- **Now we split the entire dataset into training and testing data. The ratio in which we want to split is stored in the split variable and then we make use of train_test_split function to do the required splitting quickly.**

In [90]:

```
from sklearn.model_selection import train_test_split

split = 0.2
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=split, random_state=
0)
```

Feature Scaling *(Preprocessing the data)*

- **Further we preprocess the training input data as well as testing input data by making use of StandardScaler. This helps us in standardizing features by removing the mean and scaling to unit variance.**

- **As multinomial bayes doesn't accept negative values, this section is for Multinomial bayes input.**

In [91]:

```
from sklearn.preprocessing import MinMaxScaler

scaler_minMax = MinMaxScaler()
X_train_mm = scaler_minMax.fit_transform(X_train)
X_test_mm = scaler_minMax.transform(X_test)
```

- **For other models :**

In [92]:

```
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

Classification of dataset along with analysis of different models

1. Logistic Regression

- **This section creates a logistic regression classifier. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**
- **Now the most important thing which is to be observed here is that as it is multi class classification, we use the one vs rest strategy. This is done by setting the value of multi_class as 'ovr' in LogisticRegression. The reason we need to this tweaks is that Logistic Regression does not natively support multi class classification and just supports binary classification.**
- **In order to perform multi class classification with help of such native binary classifiers, we need to make use of schemes such as one vs rest etc.**

In [93]:

```
from sklearn.linear_model import LogisticRegression
 clf_lr = LogisticRegression(multi_class = 'ovr', random_state=0)
 clf_lr.fit(X_train, y_train)    # fitting the training data into model
```

Out[93]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='ovr', n_jobs=None, penalty='l2', random_state=0,
                   solver='lbfgs', tol=0.0001, verbose=0, warm_start=False)
```

In [94]:

```
y_pred_lr = clf_lr.predict(X_test)  # making the predictions on the basis of trained mode
l
```

2. K-Nearest Neighbor (K-NN)

- **This section creates a K nearest neighbors classifier and choose the best parameters for our classifier with the help of GridSearchCV. Then the fine tuned classifier i.e. clf_gs is used for the training of our data. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**

In [95]:

```
from sklearn.neighbors import KNeighborsClassifier
clf_knn = KNeighborsClassifier(n_neighbors = 5, metric = 'minkowski', p = 2)
clf_knn.fit(X_train, y_train)
```

Out[95]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

In [96]:

```
y_pred_knn = clf_knn.predict(X_test)
```

- **with Grid Search :**

In [97]:

```
from sklearn.model_selection import GridSearchCV

hyperparams = {
                'n_neighbors' : [1, 5, 10, 25, 50, 100, 500, 900],
                'weights' : ['uniform', 'distance']
              }
gs_knn = GridSearchCV(KNeighborsClassifier(), hyperparams, cv=5)
gs_knn.fit(X_train, y_train)
```

Out[97]:

```
GridSearchCV(cv=5, error_score=nan,
             estimator=KNeighborsClassifier(algorithm='auto', leaf_size=30,
                                            metric='minkowski',
                                            metric_params=None, n_jobs=None,
                                            n_neighbors=5, p=2,
                                            weights='uniform'),
             iid='deprecated', n_jobs=None,
             param_grid={'n_neighbors': [1, 5, 10, 25, 50, 100, 500, 900],
                         'weights': ['uniform', 'distance']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=0)
```

- **Printing The best Accuracy achieved through various combinations :**

In [98]:

```
print(f"Best Accuracy achieved : {gs_knn.best_score_*100:.2f}%")
```

```
Best Accuracy achieved : 95.95%
```

- **Priting the best parameters through which highest accuracy is achieved :**

In [99]:

```
print(f"Best parameters achieved : {gs_knn.best_params_}")
```

```
Best parameters achieved : {'n_neighbors': 5, 'weights': 'distance'}
```

In [100]:

```
y_pred_knnGS = gs_knn.predict(X_test)
```

3. Support Vector Machine (SVM)

- **This section creates a support vector classifier. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**
- **Now the most important thing which is to be observed here is that as it is multi class classification, we use the one vs rest strategy. This is done by setting the value of decision_function_shape as 'ovr' in SVC. The reason we need to this tweaks is that Support Vector Classifiers does not natively support multi class classification and just supports binary classification.**
- **In order to perform multi class classification with help of such native binary classifiers, we need to make use of schemes such as one vs rest etc.**

In [101]:

```
from sklearn.svm import SVC
```

a. Linear :

In [102]:

```
clf_svc = SVC(kernel='linear', decision_function_shape='ovr', random_state=0)
clf_svc.fit(X_train, y_train)
```

Out[102]:

```
SVC(C=1.0, break_ties=False, cache_size=200, class_weight=None, coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma='scale', kernel='linear',
    max_iter=-1, probability=False, random_state=0, shrinking=True, tol=0.001,
    verbose=False)
```

In [103]:

```
y_pred_svc = clf_svc.predict(X_test)
```

b. Kernel SVM

In [104]:

```
clf_kernelSVC = SVC(kernel='rbf', random_state=0)
clf_kernelSVC.fit(X_train, y_train)
```

Out[104]:

```
SVC(C=1.0, break_ties=False, cache_size=200, class_weight=None, coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma='scale', kernel='rbf',
    max_iter=-1, probability=False, random_state=0, shrinking=True, tol=0.001,
    verbose=False)
```

In [105]:

```
y_pred_kernelSVC = clf_kernelSVC.predict(X_test)
```

4. Naïve Bayes

In [106]:

```
from sklearn.naive_bayes import GaussianNB, BernoulliNB, MultinomialNB
```

4.1 Gaussian Naïve Bayes

- **This function creates a gaussian naive bayes classifier. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**

In [107]:

```
clf_nbGB = GaussianNB()
clf_nbGB.fit(X_train, y_train)
```

Out[107]:

```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [108]:

```
y_pred_nbGB = clf_nbGB.predict(X_test)
```

4.2 Bernoulli Naïve Bayes

- **This function creates a bernoulli naive bayes classifier. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**

In [109]:

```
clf_nbBNB = BernoulliNB()
clf_nbBNB.fit(X_train, y_train)
```

Out[109]:

```
BernoulliNB(alpha=1.0, binarize=0.0, class_prior=None, fit_prior=True)
```

In [110]:

```
y_pred_nbBNB = clf_nbBNB.predict(X_test)
```

4.3 Multinomial Naïve Bayes

- **This section creates a multinomial naive bayes classifier. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**
- **Here one another interesting thing to be noticed is that inputs of training and testing data are passed explicitly unlike others. The reason behind it is that multinomial naive bayes model cannot work with negative values. And as we get negative values after standard scaling, we can't pass the training and testing data stored in global variables. Instead we will treat the data with min max scaling so that it is positive and then we will pass it to multinomial naive bayes classifier.**

In [111]:

```
clf_nbMNB = MultinomialNB()
clf_nbMNB.fit(X_train_mm, y_train)
```

Out[111]:

```
MultinomialNB(alpha=1.0, class_prior=None, fit_prior=True)
```

In [112]:

```
y_pred_nbMNB = clf_nbMNB.predict(X_test)
```

5. Decision Tree

- **This section creates a decision tree classifier and choose the best parameters for our classifier with the help of GridSearchCV. Then the fine tuned classifier i.e. clf_gs is used for the training of our data. Once the model is fit into training data, then it is used for testing purposes i.e. predictions are made on the input of testing data and analysis of the result is carried out.**
- **In decision tree, taking a step further, decision trees itself are visualised to get a clear picture of the classification.**

In [113]:

```
from sklearn.tree import DecisionTreeClassifier
```

- **with Gini :**

In [114]:

```
clf_dtGINI = DecisionTreeClassifier(criterion='gini',  random_state=0)
clf_dtGINI.fit(X_train, y_train)
```

Out[114]:

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None, criterion='gini',
                       max_depth=None, max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort='deprecated',
                       random_state=0, splitter='best')
```

In [115]:

```
y_pred_dtGINI = clf_dtGINI.predict(X_test)
```

- **with Entropy :**

In [116]:

```
clf_dtENTROPY = DecisionTreeClassifier(criterion='entropy',  random_state=0)
clf_dtENTROPY.fit(X_train, y_train)
```

Out[116]:

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None, criterion='entropy',
                       max_depth=None, max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort='deprecated',
                       random_state=0, splitter='best')
```

In [117]:

```
y_pred_dtENTROPY = clf_dtENTROPY.predict(X_test)
```

- **with Grid Search :**

In [118]:

```
from sklearn.model_selection import GridSearchCV

hyperparams = {
               'max_depth' : np.linspace(5, 100,num=20).tolist(),     # before : [1, 5,
```

```
10, 25, 50, 100]; after : [5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.
0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0, 90.0, 95.0, 100.0];
                'criterion': ['gini', 'entropy'],
              }
gs_dt = GridSearchCV(estimator=DecisionTreeClassifier(),
                           param_grid=hyperparams,
                           scoring='accuracy',
                           cv=10,
                           )
gs_dt.fit(X_train, y_train)
```

Out[118]:

```
GridSearchCV(cv=10, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None,
                                              criterion='gini', max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=None,
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': [5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0,
                                       40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0,
                                       75.0, 80.0, 85.0, 90.0, 95.0, 100.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='accuracy', verbose=0)
```

- **Printing The best Accuracy achieved through various combinations :**

In [119]:

```
print(f"Best Accuracy achieved : {gs_dt.best_score_*100:.2f}%")
```

```
Best Accuracy achieved : 98.41%
```

- **Priting the best parameters through which highest accuracy is achieved :**

In [120]:

```
print(f"Best parameters achieved : {gs_dt.best_params_}")
criteria, depth = gs_dt.best_params_['criterion'], gs_dt.best_params_['max_depth']
```

```
Best parameters achieved : {'criterion': 'entropy', 'max_depth': 50.0}
```

In [121]:

```
clf_dt = DecisionTreeClassifier(criterion=criteria, max_depth=depth)
clf_dt.fit(X_train, y_train)
y_pred_dtGS = clf_dt.predict(X_test)
```

- **Visualisation :**
  - **This section helps in visualising the decision tree by taking the respective classifier as input.**

In [122]:

```
from sklearn import tree

fig = plt.figure(figsize=(25,20))
tree.plot_tree(clf_dt, feature_names=list(dataset.iloc[:,:-1].columns), class_names=['Un
acc','Acc','Good','Vgood'], filled=True)
```

Out[122]:

```
out[122]:
```

```
[Text(845.848880597015, 1041.9, 'Safety <= -0.602\nentropy = 1.203\nsamples = 1382\nvalue
= [970, 305, 52, 55]\nclass = Unacc'),
 Text(825.0279850746268, 951.3000000000001, 'entropy = 0.0\nsamples = 470\nvalue = [470,
0, 0, 0]\nclass = Unacc'),
 Text(866.669776119403, 951.3000000000001, 'Persons <= -0.529\nentropy = 1.484\nsamples =
912\nvalue = [500, 305, 52, 55]\nclass = Unacc'),
 Text(845.848880597015, 860.7, 'entropy = 0.0\nsamples = 308\nvalue = [308, 0, 0, 0]\ncla
ss = Unacc'),
 Text(887.4906716417911, 860.7, 'Buying <= -0.005\nentropy = 1.643\nsamples = 604\nvalue
= [192, 305, 52, 55]\nclass = Acc'),
 Text(567.3694029850747, 770.1, 'Maintenance <= 0.023\nentropy = 1.737\nsamples = 297\nva
lue = [34, 156, 52, 55]\nclass = Acc'),
 Text(281.0820895522388, 679.5, 'Safety <= 0.615\nentropy = 1.796\nsamples = 153\nvalue =
[8, 48, 52, 45]\nclass = Good'),
 Text(114.51492537313433, 588.9, 'Lug_Boot <= -0.612\nentropy = 1.235\nsamples = 74\nvalu
e = [4, 40, 30, 0]\nclass = Acc'),
 Text(62.462686567164184, 498.29999999999995, 'Doors <= -0.907\nentropy = 0.567\nsamples
= 30\nvalue = [4, 26, 0, 0]\nclass = Acc'),
 Text(41.64179104477612, 407.69999999999993, 'Persons <= 0.67\nentropy = 1.0\nsamples = 8
\nvalue = [4, 4, 0, 0]\nclass = Unacc'),
 Text(20.82089552238806, 317.1, 'entropy = 0.0\nsamples = 4\nvalue = [0, 4, 0, 0]\nclass
= Acc'),
 Text(62.462686567164184, 317.1, 'entropy = 0.0\nsamples = 4\nvalue = [4, 0, 0, 0]\nclass
= Unacc'),
 Text(83.28358208955224, 407.69999999999993, 'entropy = 0.0\nsamples = 22\nvalue = [0, 22
, 0, 0]\nclass = Acc'),
 Text(166.56716417910448, 498.29999999999995, 'Buying <= -0.898\nentropy = 0.902\nsamples
= 44\nvalue = [0, 14, 30, 0]\nclass = Good'),
 Text(124.92537313432837, 407.69999999999993, 'Persons <= 0.67\nentropy = 0.559\nsamples
= 23\nvalue = [0, 3, 20, 0]\nclass = Good'),
 Text(104.1044776119403, 317.1, 'Doors <= -0.013\nentropy = 0.845\nsamples = 11\nvalue =
[0, 3, 8, 0]\nclass = Good'),
 Text(83.28358208955224, 226.5, 'Lug_Boot <= 0.616\nentropy = 1.0\nsamples = 6\nvalue = [
0, 3, 3, 0]\nclass = Acc'),
 Text(62.462686567164184, 135.89999999999998, 'entropy = 0.0\nsamples = 3\nvalue = [0, 3,
0, 0]\nclass = Acc'),
 Text(104.1044776119403, 135.89999999999998, 'entropy = 0.0\nsamples = 3\nvalue = [0, 0,
3, 0]\nclass = Good'),
 Text(124.92537313432837, 226.5, 'entropy = 0.0\nsamples = 5\nvalue = [0, 0, 5, 0]\nclass
= Good'),
 Text(145.7462686567164, 317.1, 'entropy = 0.0\nsamples = 12\nvalue = [0, 0, 12, 0]\nclas
s = Good'),
 Text(208.2089552238806, 407.69999999999993, 'Maintenance <= -0.871\nentropy = 0.998\nsam
ples = 21\nvalue = [0, 11, 10, 0]\nclass = Acc'),
 Text(187.38805970149255, 317.1, 'Doors <= -0.907\nentropy = 0.65\nsamples = 12\nvalue =
[0, 2, 10, 0]\nclass = Good'),
 Text(166.56716417910448, 226.5, 'Lug_Boot <= 0.616\nentropy = 0.918\nsamples = 3\nvalue
= [0, 2, 1, 0]\nclass = Acc'),
 Text(145.7462686567164, 135.89999999999998, 'entropy = 0.0\nsamples = 2\nvalue = [0, 2,
0, 0]\nclass = Acc'),
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1, 0]\nclass = Good'),
 Text(208.2089552238806, 226.5, 'entropy = 0.0\nsamples = 9\nvalue = [0, 0, 9, 0]\nclass
= Good'),
 Text(229.02985074626866, 317.1, 'entropy = 0.0\nsamples = 9\nvalue = [0, 9, 0, 0]\nclass
= Acc'),
 Text(447.64925373134326, 588.9, 'Lug_Boot <= -0.612\nentropy = 1.529\nsamples = 79\nvalu
e = [4, 8, 22, 45]\nclass = Vgood'),
 Text(333.13432835820896, 498.29999999999995, 'Doors <= -0.907\nentropy = 1.311\nsamples
= 27\nvalue = [4, 6, 17, 0]\nclass = Good'),
 Text(291.4925373134328, 407.69999999999993, 'Persons <= 0.67\nentropy = 1.406\nsamples =
8\nvalue = [4, 1, 3, 0]\nclass = Unacc'),
 Text(270.6716417910448, 317.1, 'Buying <= -0.898\nentropy = 0.811\nsamples = 4\nvalue =
[0, 1, 3, 0]\nclass = Good'),
 Text(249.85074626865674, 226.5, 'entropy = 0.0\nsamples = 2\nvalue = [0, 0, 2, 0]\nclass
= Good'),
 Text(291.4925373134328, 226.5, 'Maintenance <= -0.871\nentropy = 1.0\nsamples = 2\nvalue
= [0, 1, 1, 0]\nclass = Acc'),
 Text(270.6716417910448, 135.89999999999998, 'entropy = 0.0\nsamples = 1\nvalue = [0, 0,
1, 0]\nclass = Good'),
 Text(312.3134328358209, 135.89999999999998, 'entropy = 0.0\nsamples = 1\nvalue = [0, 1,
```

0, 0]\nclass = Acc'),
 Text(312.3134328358209, 317.1, 'entropy = 0.0\nsamples = 4\nvalue = [4, 0, 0, 0]\nclass = Unacc'),
 Text(374.7761194029851, 407.69999999999993, 'Buying <= -0.898\nentropy = 0.831\nsamples = 19\nvalue = [0, 5, 14, 0]\nclass = Good'),
 Text(353.95522388059703, 317.1, 'entropy = 0.0\nsamples = 9\nvalue = [0, 0, 9, 0]\nclass = Good'),
 Text(395.5970149253731, 317.1, 'Maintenance <= -0.871\nentropy = 1.0\nsamples = 10\nvalue = [0, 5, 5, 0]\nclass = Acc'),
 Text(374.7761194029851, 226.5, 'entropy = 0.0\nsamples = 5\nvalue = [0, 0, 5, 0]\nclass = Good'),
 Text(416.4179104477612, 226.5, 'entropy = 0.0\nsamples = 5\nvalue = [0, 5, 0, 0]\nclass = Acc'),
 Text(562.1641791044776, 498.29999999999995, 'Lug_Boot <= 0.616\nentropy = 0.686\nsamples = 52\nvalue = [0, 2, 5, 45]\nclass = Vgood'),
 Text(541.3432835820896, 407.69999999999993, 'Doors <= -0.907\nentropy = 1.123\nsamples = 24\nvalue = [0, 2, 5, 17]\nclass = Vgood'),
 Text(478.8805970149254, 317.1, 'Buying <= -0.898\nentropy = 0.971\nsamples = 5\nvalue = [0, 2, 3, 0]\nclass = Good'),
 Text(458.05970149253733, 226.5, 'entropy = 0.0\nsamples = 2\nvalue = [0, 0, 2, 0]\nclass = Good'),
 Text(499.70149253731347, 226.5, 'Maintenance <= -0.871\nentropy = 0.918\nsamples = 3\nvalue = [0, 2, 1, 0]\nclass = Acc'),
 Text(478.8805970149254, 135.89999999999998, 'entropy = 0.0\nsamples = 1\nvalue = [0, 0, 1, 0]\nclass = Good'),
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 Text(562.1641791044776, 135.89999999999998, 'entropy = 0.0\nsamples = 2\nvalue = [0, 0, 2, 0]\nclass = Good'),
 Text(603.8059701492538, 135.89999999999998, 'entropy = 0.0\nsamples = 4\nvalue = [0, 0, 0, 4]\nclass = Vgood'),
 Text(624.6268656716418, 226.5, 'entropy = 0.0\nsamples = 13\nvalue = [0, 0, 0, 13]\nclass = Vgood'),
 Text(582.9850746268656, 407.69999999999993, 'entropy = 0.0\nsamples = 28\nvalue = [0, 0, 0, 28]\nclass = Vgood'),
 Text(853.6567164179105, 679.5, 'Lug_Boot <= -0.612\nentropy = 1.024\nsamples = 144\nvalue = [26, 108, 0, 10]\nclass = Acc'),
 Text(770.3731343283582, 588.9, 'Safety <= 0.615\nentropy = 0.999\nsamples = 46\nvalue = [22, 24, 0, 0]\nclass = Acc'),
 Text(728.7313432835821, 498.29999999999995, 'Buying <= -0.898\nentropy = 0.738\nsamples = 24\nvalue = [19, 5, 0, 0]\nclass = Unacc'),
 Text(707.9104477611941, 407.69999999999993, 'Maintenance <= 0.917\nentropy = 1.0\nsamples = 10\nvalue = [5, 5, 0, 0]\nclass = Unacc'),
 Text(687.0895522388059, 317.1, 'Doors <= -0.907\nentropy = 0.65\nsamples = 6\nvalue = [1, 5, 0, 0]\nclass = Acc'),
 Text(666.2686567164179, 226.5, 'Persons <= 0.67\nentropy = 1.0\nsamples = 2\nvalue = [1, 1, 0, 0]\nclass = Unacc'),
 Text(645.4477611940299, 135.89999999999998, 'entropy = 0.0\nsamples = 1\nvalue = [0, 1, 0, 0]\nclass = Acc'),
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 Text(812.0149253731344, 498.29999999999995, 'Doors <= -0.907\nentropy = 0.575\nsamples = 22\nvalue = [3, 19, 0, 0]\nclass = Acc'),
 Text(791.1940298507462, 407.69999999999993, 'Persons <= 0.67\nentropy = 1.0\nsamples = 6\nvalue = [3, 3, 0, 0]\nclass = Unacc'),
 Text(770.3731343283582, 317.1, 'entropy = 0.0\nsamples = 3\nvalue = [0, 3, 0, 0]\nclass = Acc'),
 Text(812.0149253731344, 317.1, 'entropy = 0.0\nsamples = 3\nvalue = [3, 0, 0, 0]\nclass = Unacc'),
 Text(832.8358208955224, 407.69999999999993, 'entropy = 0.0\nsamples = 16\nvalue = [0, 16, 0, 0]\nclass = Acc'),
 Text(936.9402985074627, 588.9, 'Safety <= 0.615\nentropy = 0.715\nsamples = 98\nvalue =

[4, 84, 0, 10]\nclass = Acc'),
 Text(895.2985074626865, 498.29999999999995, 'Doors <= -0.013\nentropy = 0.408\nsamples = 49\nvalue = [4, 45, 0, 0]\nclass = Acc'),
 Text(874.4776119402985, 407.69999999999993, 'Lug_Boot <= 0.616\nentropy = 0.684\nsamples = 22\nvalue = [4, 18, 0, 0]\nclass = Acc'),
 Text(853.6567164179105, 317.1, 'Buying <= -0.898\nentropy = 0.991\nsamples = 9\nvalue = [4, 5, 0, 0]\nclass = Acc'),
 Text(832.8358208955224, 226.5, 'Maintenance <= 0.917\nentropy = 0.65\nsamples = 6\nvalue = [1, 5, 0, 0]\nclass = Acc'),
 Text(812.0149253731344, 135.89999999999998, 'entropy = 0.0\nsamples = 4\nvalue = [0, 4, 0, 0]\nclass = Acc'),
 Text(853.6567164179105, 135.89999999999998, 'Persons <= 0.67\nentropy = 1.0\nsamples = 2\nvalue = [1, 1, 0, 0]\nclass = Unacc'),
 Text(832.8358208955224, 45.299999999999955, 'entropy = 0.0\nsamples = 1\nvalue = [1, 0, 0, 0]\nclass = Unacc'),
 Text(874.4776119402985, 45.299999999999955, 'entropy = 0.0\nsamples = 1\nvalue = [0, 1, 0, 0]\nclass = Acc'),
 Text(874.4776119402985, 226.5, 'entropy = 0.0\nsamples = 3\nvalue = [3, 0, 0, 0]\nclass = Unacc'),
 Text(895.2985074626865, 317.1, 'entropy = 0.0\nsamples = 13\nvalue = [0, 13, 0, 0]\nclass = Acc'),
 Text(916.1194029850747, 407.69999999999993, 'entropy = 0.0\nsamples = 27\nvalue = [0, 27, 0, 0]\nclass = Acc'),
 Text(978.5820895522388, 498.29999999999995, 'Buying <= -0.898\nentropy = 0.73\nsamples = 49\nvalue = [0, 39, 0, 10]\nclass = Acc'),
 Text(957.7611940298508, 407.69999999999993, 'Maintenance <= 0.917\nentropy = 0.98\nsamples = 24\nvalue = [0, 14, 0, 10]\nclass = Acc'),
 Text(936.9402985074627, 317.1, 'Lug_Boot <= 0.616\nentropy = 0.779\nsamples = 13\nvalue = [0, 3, 0, 10]\nclass = Vgood'),
 Text(916.1194029850747, 226.5, 'Doors <= -0.013\nentropy = 1.0\nsamples = 6\nvalue = [0, 3, 0, 3]\nclass = Acc'),
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 Text(957.7611940298508, 226.5, 'entropy = 0.0\nsamples = 7\nvalue = [0, 0, 0, 7]\nclass = Vgood'),
 Text(978.5820895522388, 317.1, 'entropy = 0.0\nsamples = 11\nvalue = [0, 11, 0, 0]\nclass = Acc'),
 Text(999.4029850746269, 407.69999999999993, 'entropy = 0.0\nsamples = 25\nvalue = [0, 25, 0, 0]\nclass = Acc'),
 Text(1207.6119402985075, 770.1, 'Maintenance <= 0.917\nentropy = 0.999\nsamples = 307\nvalue = [158, 149, 0, 0]\nclass = Unacc'),
 Text(1186.7910447761194, 679.5, 'Lug_Boot <= -0.612\nentropy = 0.95\nsamples = 236\nvalue = [87, 149, 0, 0]\nclass = Acc'),
 Text(1061.865671641791, 588.9, 'Safety <= 0.615\nentropy = 0.923\nsamples = 77\nvalue = [51, 26, 0, 0]\nclass = Unacc'),
 Text(1041.044776119403, 498.29999999999995, 'entropy = 0.0\nsamples = 39\nvalue = [39, 0, 0, 0]\nclass = Unacc'),
 Text(1082.6865671641792, 498.29999999999995, 'Doors <= -0.907\nentropy = 0.9\nsamples = 38\nvalue = [12, 26, 0, 0]\nclass = Acc'),
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 Text(1020.223880597015, 317.1, 'Buying <= 0.889\nentropy = 0.722\nsamples = 5\nvalue = [1, 4, 0, 0]\nclass = Acc'),
 Text(999.4029850746269, 226.5, 'entropy = 0.0\nsamples = 3\nvalue = [0, 3, 0, 0]\nclass = Acc'),
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 Text(1020.223880597015, 135.89999999999998, 'entropy = 0.0\nsamples = 1\nvalue = [0, 1, 0, 0]\nclass = Acc'),
 Text(1061.865671641791, 135.89999999999998, 'entropy = 0.0\nsamples = 1\nvalue = [1, 0, 0, 0]\nclass = Unacc'),
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 Text(1124.3283582089553, 407.69999999999993, 'Maintenance <= 0.023\nentropy = 0.691\nsamples = 27\nvalue = [5, 22, 0, 0]\nclass = Acc'),
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 Text(1145.1492537313434, 317.1, 'Buying <= 0.889\nentropy = 1.0\nsamples = 10\nvalue = [5, 5, 0, 0]\nclass = Unacc'),
 Text(1124.3283582089553, 226.5, 'entropy = 0.0\nsamples = 5\nvalue = [0, 5, 0, 0]\nclass

= Acc'),
 Text(1165.9701492537313, 226.5, 'entropy = 0.0\nsamples = 5\nvalue = [5, 0, 0, 0]\nclass = Unacc'),
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 Text(1270.0746268656717, 498.29999999999995, 'Doors <= -0.013\nentropy = 0.437\nsamples = 111\nvalue = [10, 101, 0, 0]\nclass = Acc'),
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 Text(1228.4328358208954, 317.1, 'Safety <= 0.615\nentropy = 0.94\nsamples = 28\nvalue = [10, 18, 0, 0]\nclass = Acc'),
 Text(1207.6119402985075, 226.5, 'Persons <= 0.67\nentropy = 0.863\nsamples = 14\nvalue = [10, 4, 0, 0]\nclass = Unacc'),
 Text(1186.7910447761194, 135.89999999999998, 'entropy = 0.0\nsamples = 7\nvalue = [7, 0, 0, 0]\nclass = Unacc'),
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 Text(1207.6119402985075, 45.299999999999955, 'entropy = 0.0\nsamples = 3\nvalue = [3, 0, 0, 0]\nclass = Unacc'),
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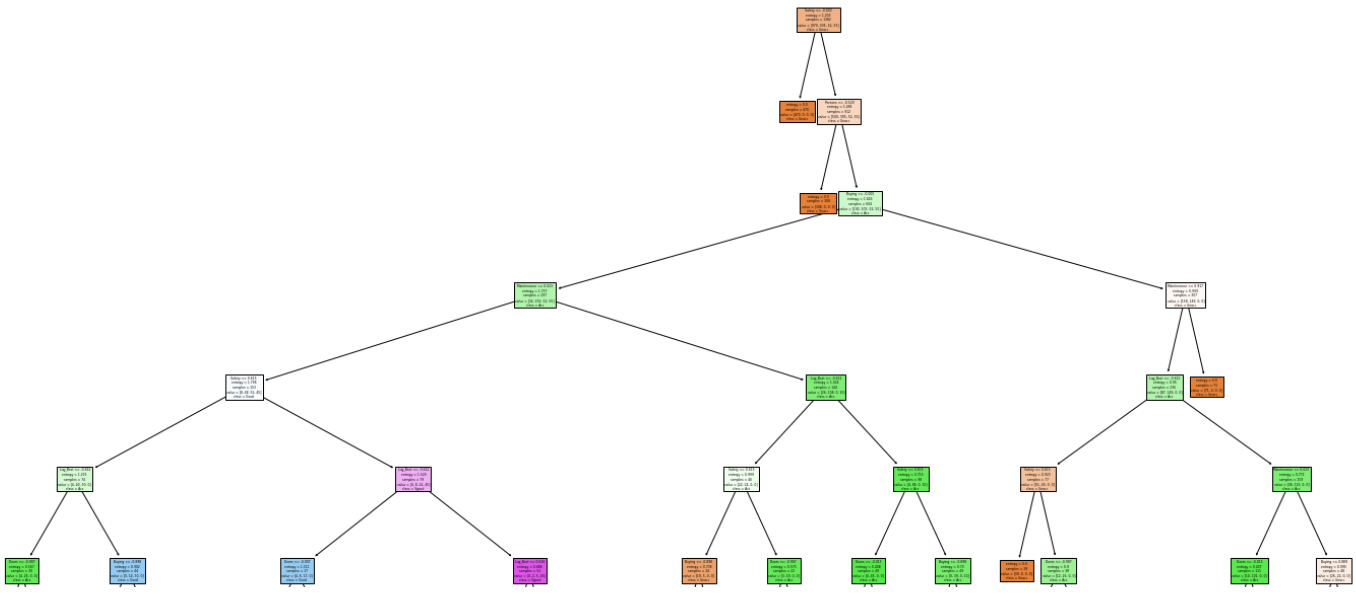
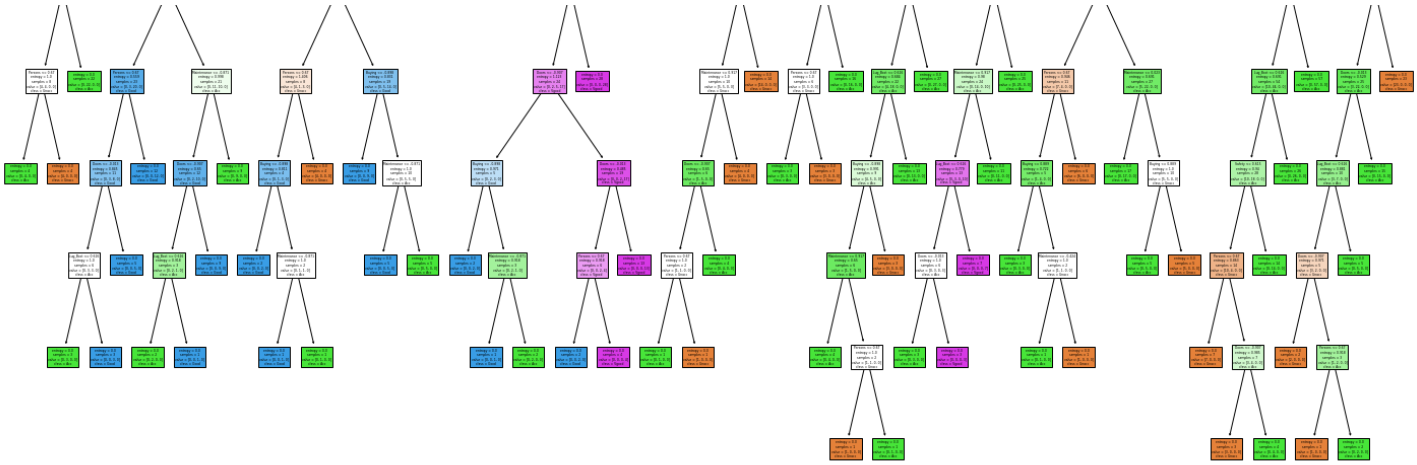
 Text(1249.2537313432836, 226.5, 'entropy = 0.0\nsamples = 14\nvalue = [0, 14, 0, 0]\nclass = Acc'),
 Text(1270.0746268656717, 317.1, 'entropy = 0.0\nsamples = 26\nvalue = [0, 26, 0, 0]\nclass = Acc'),
 Text(1290.8955223880598, 407.69999999999993, 'entropy = 0.0\nsamples = 57\nvalue = [0, 57, 0, 0]\nclass = Acc'),
 Text(1353.358208955224, 498.29999999999995, 'Buying <= 0.889\nentropy = 0.995\nsamples = 48\nvalue = [26, 22, 0, 0]\nclass = Unacc'),
 Text(1332.5373134328358, 407.69999999999993, 'Doors <= -0.013\nentropy = 0.529\nsamples = 25\nvalue = [3, 22, 0, 0]\nclass = Acc'),
 Text(1311.7164179104477, 317.1, 'Lug_Boot <= 0.616\nentropy = 0.881\nsamples = 10\nvalue = [3, 7, 0, 0]\nclass = Acc'),
 Text(1290.8955223880598, 226.5, 'Doors <= -0.907\nentropy = 0.971\nsamples = 5\nvalue = [3, 2, 0, 0]\nclass = Unacc'),
 Text(1270.0746268656717, 135.89999999999998, 'entropy = 0.0\nsamples = 2\nvalue = [2, 0, 0, 0]\nclass = Unacc'),
 Text(1311.7164179104477, 135.89999999999998, 'Persons <= 0.67\nentropy = 0.918\nsamples = 3\nvalue = [1, 2, 0, 0]\nclass = Acc'),
 Text(1290.8955223880598, 45.299999999999955, 'entropy = 0.0\nsamples = 1\nvalue = [1, 0, 0, 0]\nclass = Unacc'),
 Text(1332.5373134328358, 45.299999999999955, 'entropy = 0.0\nsamples = 2\nvalue = [0, 2, 0, 0]\nclass = Acc'),
 Text(1332.5373134328358, 226.5, 'entropy = 0.0\nsamples = 5\nvalue = [0, 5, 0, 0]\nclass = Acc'),
 Text(1353.358208955224, 317.1, 'entropy = 0.0\nsamples = 15\nvalue = [0, 15, 0, 0]\nclass = Acc'),
 Text(1374.1791044776119, 407.69999999999993, 'entropy = 0.0\nsamples = 23\nvalue = [23, 0, 0, 0]\nclass = Unacc'),
 Text(1228.4328358208954, 679.5, 'entropy = 0.0\nsamples = 71\nvalue = [71, 0, 0, 0]\nclass = Unacc')]





6. Random Forest Classifier

In [123]:

```
from sklearn.ensemble import RandomForestClassifier
```

- **with Gini**

In [124]:

```
clf_rfcGINI = RandomForestClassifier(n_estimators = 10, criterion = 'gini', random_state
= 0, n_jobs=-1)
clf_rfcGINI.fit(X_train, y_train)
```

Out[124]:

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=None, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=10, n_jobs=-1,
                       oob_score=False, random_state=0, verbose=0,
                       warm_start=False)
```

In [125]:

```
y_pred_rfcGINI = clf_rfcGINI.predict(X_test)
```

- **with Entropy**

In [126]:

```
clf_rfcENTROPY = RandomForestClassifier(n_estimators = 10, criterion = 'entropy', random
_state = 0, n_jobs=-1)
clf_rfcENTROPY.fit(X_train, y_train)
```

Out[126]:

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='entropy', max_depth=None, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=10, n_jobs=-1,
                       oob_score=False, random_state=0, verbose=0,
                       warm_start=False)
```

In [127]:

```
y_pred_rfcENTROPY = clf_rfcENTROPY.predict(X_test)
```

- **with Grid Search :**

In [128]:

```
from sklearn.model_selection import GridSearchCV, learning_curve

hyperparams = {
                'max_depth' : np.linspace(10, 100,num=10).tolist(),    # [10.0, 20.0, 30
.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0]
                'criterion': ['gini', 'entropy'],
              }
gs_rfc = GridSearchCV(estimator=DecisionTreeClassifier(),
                          param_grid=hyperparams,
                          scoring='accuracy',
                          cv=10,
                          )
gs_rfc.fit(X_train, y_train)
```

Out[128]:

```
GridSearchCV(cv=10, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None,
                                              criterion='gini', max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.0,
                                              presort='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=None,
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': [10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0,
                                       80.0, 90.0, 100.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='accuracy', verbose=0)
```

- **Printing The best Accuracy achieved through various combinations :**

In [129]:

```
print(f"Best Accuracy achieved : {gs_rfc.best_score_*100:.2f}%")
```

```
Best Accuracy achieved : 98.34%
```

- **Priting the best parameters through which highest accuracy is achieved :**

In [130]:

```
print(f"Best parameters achieved : {gs_rfc.best_params_}")
```

```
Best parameters achieved : {'criterion': 'gini', 'max_depth': 80.0}
```

In [131]:

```
y_pred_rfcGS = gs_rfc.predict(X_test)
```

7. Multi Layer Perceptron

- **This section creates a Multi-layer Perceptron. Once the model is fit into training data, then score of the classifier is calculated. Score returns the mean accuracy on the given test data and labels.**
- **In MLP, default values of various important parameters are as below:**

1. **Hidden Layer Size - (100,)**
2. **Activation function - relu**
3. **Initial Learning rate - 0.001**
4. **Learning rate - constant**
5. **Alpha (L2 regularisation parameter) - 0.0001**
6. **Maximum number of iterations - 200**

- **We can change these hyperparameters manually for obtaining the best score. But that would be troublesome. Instead we can make use of GridSearchCV here as well. We even tried to add it in our program, but it couldn't complete it's execution (possibly due to expensive computation it would require for testing all permutations and combinations with different possible hyperparamters). Hence due to this reason and also due to already getting very high score, we chose to remove the GridSearchCV from the implementation of MLP.**

In [132]:

```
from sklearn.neural_network import MLPClassifier
clf_mlp = MLPClassifier(max_iter=10000)
clf_mlp.fit(X_train, y_train)
y_pred_mlp = clf_mlp.predict(X_test)
mlp_accuracy = clf_mlp.score(X_test,y_test)
```

In [133]:

```
print(f'Accuracy achieved: {mlp_accuracy*100:.2f}%')
```

```
Accuracy achieved: 99.71%
```

Extra models :

- **#### Extreme Gradient Boosting *(XGBoost)***

In [134]:

```
pip install -U xgboost
```

```
Requirement already satisfied: xgboost in /usr/local/lib/python3.7/dist-packages (1.5.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.7/dist-packages (from xgbo
ost) (1.4.1)
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-packages (from xgbo
ost) (1.19.5)
```

- **Training XGBoost model on training set**

In [135]:

```
from xgboost import XGBClassifier
clf_xgb = XGBClassifier(use_label_encoder =False, eval_metric = 'mlogloss')
clf_xgb.fit(X_train, y_train)
```

Out[135]:

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, enable_categorical=False,
              eval_metric='mlogloss', gamma=0, gpu_id=-1, importance_type=None,
              interaction_constraints='', learning_rate=0.300000012,
              max_delta_step=0, max_depth=6, min_child_weight=1, missing=nan,
              monotone_constraints='()', n_estimators=100, n_jobs=2,
              num_parallel_tree=1, objective='multi:softprob', predictor='auto',
              random_state=0, reg_alpha=0, reg_lambda=1, scale_pos_weight=None,
              subsample=1, tree_method='exact', use_label_encoder=False,
              validate_parameters=1, ...)
```

- **Confusion matrix and Accuracy Score :**

In [136]:

```
from sklearn.metrics import confusion_matrix, accuracy_score
y_pred_xgb = clf_xgb.predict(X_test)
cm_xgb = confusion_matrix(y_test, y_pred_xgb)
print(cm_xgb)
accuracy_score(y_test, y_pred_xgb)
```

```
[[239   1   0   0]
 [  0  76   3   0]
 [  0   0  17   0]
 [  0   1   0   9]]
```

Out[136]:

```
0.9855491329479769
```

- **K-Fold Cross Validation :**

In [137]:

```
from sklearn.model_selection import cross_val_score
accuracies_xgb = cross_val_score(estimator = clf_xgb, X = X_train, y = y_train, cv = 10)
print(f"Accuracy: {accuracies_xgb.mean()*100:.2f} %")
print(f"Standard Deviation: {accuracies_xgb.std()*100:.2f} %")
```

```
Accuracy: 98.99 %
Standard Deviation: 0.93 %
```

- **#### CatBoost**

In [138]:

```
pip install -U catboost
```

```
Requirement already satisfied: catboost in /usr/local/lib/python3.7/dist-packages (1.0.3)
Requirement already satisfied: pandas>=0.24.0 in /usr/local/lib/python3.7/dist-packages (
from catboost) (1.1.5)
Requirement already satisfied: numpy>=1.16.0 in /usr/local/lib/python3.7/dist-packages (f
rom catboost) (1.19.5)
Requirement already satisfied: graphviz in /usr/local/lib/python3.7/dist-packages (from c
atboost) (0.10.1)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.7/dist-packages (from
catboost) (3.2.2)
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from catboo
st) (1.15.0)
Requirement already satisfied: plotly in /usr/local/lib/python3.7/dist-packages (from cat
boost) (4.4.1)
Requirement already satisfied: scipy in /usr/local/lib/python3.7/dist-packages (from catb
oost) (1.4.1)
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.7/dist-packages (fr
om pandas>=0.24.0->catboost) (2018.9)
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.7/dist-pa
ckages (from pandas>=0.24.0->catboost) (2.8.2)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.7/dist-package
s (from matplotlib->catboost) (1.3.2)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.7/dist-packages (fr
om matplotlib->catboost) (0.11.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/local/lib
/python3.7/dist-packages (from matplotlib->catboost) (2.4.7)
Requirement already satisfied: retrying>=1.3.3 in /usr/local/lib/python3.7/dist-packages
(from plotly->catboost) (1.3.3)
```

- **Training CatBoost model on training set**

In [139]:

```
from catboost import CatBoostClassifier
```

```
clf_cb = CatBoostClassifier()
clf_cb.fit(dataset.iloc[:,:-1].values, dataset.iloc[:,-1].values)
```

```
Learning rate set to 0.081365
0: learn: 1.2424803 total: 1.37ms remaining: 1.37s
1: learn: 1.1428147 total: 2.69ms remaining: 1.34s
2: learn: 1.0433181 total: 3.82ms remaining: 1.27s
3: learn: 0.9678411 total: 5.09ms remaining: 1.27s
4: learn: 0.8882661 total: 6.36ms remaining: 1.26s
5: learn: 0.8250270 total: 7.64ms remaining: 1.26s
6: learn: 0.7754668 total: 8.88ms remaining: 1.26s
7: learn: 0.7327375 total: 9.81ms remaining: 1.22s
8: learn: 0.6832526 total: 11.1ms remaining: 1.22s
9: learn: 0.6501498 total: 12.3ms remaining: 1.22s
10: learn: 0.6113986 total: 13.6ms remaining: 1.22s
11: learn: 0.5774126 total: 14.8ms remaining: 1.22s
12: learn: 0.5483033 total: 16.1ms remaining: 1.22s
13: learn: 0.5182601 total: 17.3ms remaining: 1.22s
14: learn: 0.4932282 total: 18.6ms remaining: 1.22s
15: learn: 0.4684922 total: 19.8ms remaining: 1.22s
16: learn: 0.4479845 total: 21ms remaining: 1.22s
17: learn: 0.4298701 total: 22.3ms remaining: 1.21s
18: learn: 0.4106868 total: 23.5ms remaining: 1.21s
19: learn: 0.3946085 total: 26ms remaining: 1.27s
20: learn: 0.3782956 total: 27.2ms remaining: 1.27s
21: learn: 0.3653097 total: 28.5ms remaining: 1.27s
22: learn: 0.3509999 total: 29.8ms remaining: 1.26s
23: learn: 0.3407737 total: 31ms remaining: 1.26s
24: learn: 0.3288464 total: 32.2ms remaining: 1.26s
25: learn: 0.3173380 total: 33.5ms remaining: 1.25s
26: learn: 0.3087779 total: 34.7ms remaining: 1.25s
27: learn: 0.3001371 total: 35.9ms remaining: 1.25s
28: learn: 0.2924391 total: 37.2ms remaining: 1.24s
29: learn: 0.2836376 total: 38.5ms remaining: 1.25s
30: learn: 0.2751695 total: 39.8ms remaining: 1.24s
31: learn: 0.2671855 total: 41ms remaining: 1.24s
32: learn: 0.2612425 total: 42.2ms remaining: 1.24s
33: learn: 0.2536447 total: 43.5ms remaining: 1.24s
34: learn: 0.2472872 total: 44.7ms remaining: 1.23s
35: learn: 0.2417508 total: 45.9ms remaining: 1.23s
36: learn: 0.2366335 total: 47.1ms remaining: 1.23s
37: learn: 0.2318036 total: 48.4ms remaining: 1.22s
38: learn: 0.2259309 total: 49.6ms remaining: 1.22s
39: learn: 0.2215062 total: 50.9ms remaining: 1.22s
40: learn: 0.2158634 total: 52.1ms remaining: 1.22s
41: learn: 0.2123173 total: 53.3ms remaining: 1.22s
42: learn: 0.2070181 total: 54.5ms remaining: 1.21s
43: learn: 0.2027030 total: 55.8ms remaining: 1.21s
44: learn: 0.1983778 total: 57.1ms remaining: 1.21s
45: learn: 0.1948317 total: 58.4ms remaining: 1.21s
46: learn: 0.1906196 total: 59.6ms remaining: 1.21s
47: learn: 0.1866392 total: 60.8ms remaining: 1.21s
48: learn: 0.1831423 total: 62ms remaining: 1.2s
49: learn: 0.1800603 total: 63.3ms remaining: 1.2s
50: learn: 0.1782231 total: 64.1ms remaining: 1.19s
51: learn: 0.1756270 total: 65.4ms remaining: 1.19s
52: learn: 0.1726167 total: 66.6ms remaining: 1.19s
53: learn: 0.1694958 total: 67.8ms remaining: 1.19s
54: learn: 0.1669885 total: 69.1ms remaining: 1.19s
55: learn: 0.1644802 total: 70.3ms remaining: 1.18s
56: learn: 0.1614615 total: 71.5ms remaining: 1.18s
57: learn: 0.1586206 total: 72.9ms remaining: 1.18s
58: learn: 0.1564393 total: 74.1ms remaining: 1.18s
59: learn: 0.1538896 total: 75.3ms remaining: 1.18s
60: learn: 0.1516820 total: 76.5ms remaining: 1.18s
61: learn: 0.1500092 total: 77.8ms remaining: 1.18s
62: learn: 0.1478807 total: 79ms remaining: 1.18s
63: learn: 0.1460924 total: 80.2ms remaining: 1.17s
64: learn: 0.1440037 total: 81.5ms remaining: 1.17s
65: learn: 0.1411653 total: 82.7ms remaining: 1.17s
66: learn: 0.1391314 total: 84ms remaining: 1.17s
67: learn: 0.1368513 total: 85.2ms remaining: 1.17s
```

```
68: learn: 0.1349675 total: 86.4ms remaining: 1.17s
69: learn: 0.1334988 total: 87.7ms remaining: 1.16s
70: learn: 0.1320055 total: 88.9ms remaining: 1.16s
71: learn: 0.1300496 total: 90.2ms remaining: 1.16s
72: learn: 0.1278539 total: 91.4ms remaining: 1.16s
73: learn: 0.1263726 total: 92.7ms remaining: 1.16s
74: learn: 0.1245558 total: 93.9ms remaining: 1.16s
75: learn: 0.1229572 total: 95.1ms remaining: 1.16s
76: learn: 0.1210023 total: 96.4ms remaining: 1.16s
77: learn: 0.1195958 total: 97.6ms remaining: 1.15s
78: learn: 0.1178213 total: 98.9ms remaining: 1.15s
79: learn: 0.1167384 total: 99.8ms remaining: 1.15s
80: learn: 0.1155450 total: 101ms remaining: 1.15s
81: learn: 0.1143040 total: 104ms remaining: 1.16s
82: learn: 0.1131452 total: 105ms remaining: 1.16s
83: learn: 0.1118929 total: 107ms remaining: 1.16s
84: learn: 0.1104255 total: 110ms remaining: 1.18s
85: learn: 0.1094126 total: 111ms remaining: 1.18s
86: learn: 0.1080206 total: 112ms remaining: 1.18s
87: learn: 0.1069868 total: 114ms remaining: 1.18s
88: learn: 0.1057104 total: 115ms remaining: 1.18s
89: learn: 0.1047744 total: 116ms remaining: 1.18s
90: learn: 0.1035556 total: 117ms remaining: 1.17s
91: learn: 0.1020613 total: 119ms remaining: 1.17s
92: learn: 0.1009552 total: 120ms remaining: 1.17s
93: learn: 0.0998322 total: 121ms remaining: 1.17s
94: learn: 0.0986589 total: 122ms remaining: 1.17s
95: learn: 0.0975412 total: 124ms remaining: 1.16s
96: learn: 0.0965911 total: 125ms remaining: 1.16s
97: learn: 0.0956407 total: 126ms remaining: 1.16s
98: learn: 0.0946876 total: 127ms remaining: 1.16s
99: learn: 0.0937722 total: 129ms remaining: 1.16s
100: learn: 0.0928623 total: 130ms remaining: 1.16s
101: learn: 0.0916519 total: 131ms remaining: 1.15s
102: learn: 0.0904459 total: 132ms remaining: 1.15s
103: learn: 0.0897657 total: 133ms remaining: 1.15s
104: learn: 0.0885731 total: 135ms remaining: 1.15s
105: learn: 0.0874799 total: 136ms remaining: 1.15s
106: learn: 0.0866889 total: 137ms remaining: 1.15s
107: learn: 0.0855392 total: 139ms remaining: 1.14s
108: learn: 0.0845318 total: 140ms remaining: 1.14s
109: learn: 0.0837876 total: 141ms remaining: 1.14s
110: learn: 0.0832099 total: 142ms remaining: 1.14s
111: learn: 0.0822065 total: 143ms remaining: 1.14s
112: learn: 0.0816565 total: 145ms remaining: 1.13s
113: learn: 0.0807306 total: 146ms remaining: 1.13s
114: learn: 0.0797970 total: 147ms remaining: 1.13s
115: learn: 0.0790331 total: 148ms remaining: 1.13s
116: learn: 0.0784883 total: 149ms remaining: 1.13s
117: learn: 0.0774443 total: 151ms remaining: 1.13s
118: learn: 0.0766131 total: 152ms remaining: 1.13s
119: learn: 0.0756309 total: 153ms remaining: 1.12s
120: learn: 0.0748502 total: 154ms remaining: 1.12s
121: learn: 0.0743297 total: 156ms remaining: 1.12s
122: learn: 0.0735704 total: 157ms remaining: 1.12s
123: learn: 0.0729883 total: 158ms remaining: 1.12s
124: learn: 0.0722600 total: 160ms remaining: 1.12s
125: learn: 0.0716866 total: 161ms remaining: 1.11s
126: learn: 0.0710229 total: 162ms remaining: 1.11s
127: learn: 0.0705123 total: 163ms remaining: 1.11s
128: learn: 0.0697864 total: 165ms remaining: 1.11s
129: learn: 0.0692059 total: 166ms remaining: 1.11s
130: learn: 0.0687731 total: 167ms remaining: 1.11s
131: learn: 0.0680955 total: 168ms remaining: 1.11s
132: learn: 0.0676565 total: 169ms remaining: 1.1s
133: learn: 0.0672467 total: 171ms remaining: 1.1s
134: learn: 0.0666060 total: 172ms remaining: 1.1s
135: learn: 0.0656435 total: 173ms remaining: 1.1s
136: learn: 0.0651756 total: 174ms remaining: 1.1s
137: learn: 0.0646381 total: 176ms remaining: 1.1s
138: learn: 0.0639797 total: 177ms remaining: 1.1s
139: learn: 0.0633618 total: 178ms remaining: 1.09s
```

```
140: learn: 0.0629323 total: 179ms remaining: 1.09s
141: learn: 0.0625131 total: 181ms remaining: 1.09s
142: learn: 0.0618117 total: 182ms remaining: 1.09s
143: learn: 0.0613929 total: 183ms remaining: 1.09s
144: learn: 0.0610136 total: 185ms remaining: 1.09s
145: learn: 0.0607081 total: 188ms remaining: 1.1s
146: learn: 0.0602679 total: 190ms remaining: 1.1s
147: learn: 0.0597637 total: 191ms remaining: 1.1s
148: learn: 0.0592026 total: 193ms remaining: 1.1s
149: learn: 0.0586286 total: 194ms remaining: 1.1s
150: learn: 0.0581378 total: 195ms remaining: 1.1s
151: learn: 0.0576010 total: 196ms remaining: 1.09s
152: learn: 0.0571656 total: 198ms remaining: 1.09s
153: learn: 0.0567206 total: 199ms remaining: 1.09s
154: learn: 0.0561697 total: 200ms remaining: 1.09s
155: learn: 0.0557815 total: 201ms remaining: 1.09s
156: learn: 0.0554366 total: 203ms remaining: 1.09s
157: learn: 0.0550556 total: 204ms remaining: 1.08s
158: learn: 0.0547122 total: 205ms remaining: 1.08s
159: learn: 0.0544000 total: 206ms remaining: 1.08s
160: learn: 0.0541359 total: 207ms remaining: 1.08s
161: learn: 0.0537545 total: 209ms remaining: 1.08s
162: learn: 0.0531852 total: 210ms remaining: 1.08s
163: learn: 0.0528092 total: 211ms remaining: 1.07s
164: learn: 0.0524368 total: 212ms remaining: 1.07s
165: learn: 0.0519767 total: 214ms remaining: 1.07s
166: learn: 0.0515609 total: 215ms remaining: 1.07s
167: learn: 0.0512389 total: 216ms remaining: 1.07s
168: learn: 0.0507777 total: 217ms remaining: 1.07s
169: learn: 0.0505415 total: 218ms remaining: 1.07s
170: learn: 0.0502962 total: 220ms remaining: 1.06s
171: learn: 0.0498544 total: 221ms remaining: 1.06s
172: learn: 0.0494461 total: 222ms remaining: 1.06s
173: learn: 0.0491721 total: 223ms remaining: 1.06s
174: learn: 0.0487406 total: 225ms remaining: 1.06s
175: learn: 0.0484246 total: 226ms remaining: 1.06s
176: learn: 0.0480677 total: 227ms remaining: 1.06s
177: learn: 0.0477892 total: 228ms remaining: 1.05s
178: learn: 0.0473673 total: 230ms remaining: 1.05s
179: learn: 0.0468644 total: 231ms remaining: 1.05s
180: learn: 0.0464974 total: 232ms remaining: 1.05s
181: learn: 0.0461338 total: 233ms remaining: 1.05s
182: learn: 0.0457960 total: 234ms remaining: 1.05s
183: learn: 0.0455363 total: 236ms remaining: 1.04s
184: learn: 0.0452869 total: 237ms remaining: 1.04s
185: learn: 0.0449177 total: 238ms remaining: 1.04s
186: learn: 0.0446143 total: 239ms remaining: 1.04s
187: learn: 0.0444020 total: 240ms remaining: 1.04s
188: learn: 0.0438913 total: 242ms remaining: 1.04s
189: learn: 0.0436954 total: 243ms remaining: 1.03s
190: learn: 0.0434343 total: 244ms remaining: 1.03s
191: learn: 0.0432218 total: 245ms remaining: 1.03s
192: learn: 0.0429823 total: 246ms remaining: 1.03s
193: learn: 0.0426923 total: 248ms remaining: 1.03s
194: learn: 0.0424750 total: 249ms remaining: 1.03s
195: learn: 0.0423019 total: 251ms remaining: 1.03s
196: learn: 0.0420156 total: 252ms remaining: 1.03s
197: learn: 0.0415577 total: 253ms remaining: 1.03s
198: learn: 0.0412667 total: 259ms remaining: 1.04s
199: learn: 0.0408233 total: 260ms remaining: 1.04s
200: learn: 0.0404185 total: 261ms remaining: 1.04s
201: learn: 0.0402624 total: 262ms remaining: 1.04s
202: learn: 0.0399925 total: 263ms remaining: 1.03s
203: learn: 0.0395901 total: 265ms remaining: 1.03s
204: learn: 0.0392163 total: 266ms remaining: 1.03s
205: learn: 0.0390657 total: 267ms remaining: 1.03s
206: learn: 0.0388502 total: 268ms remaining: 1.03s
207: learn: 0.0386762 total: 269ms remaining: 1.02s
208: learn: 0.0384391 total: 270ms remaining: 1.02s
209: learn: 0.0381836 total: 272ms remaining: 1.02s
210: learn: 0.0379736 total: 273ms remaining: 1.02s
211: learn: 0.0376836 total: 274ms remaining: 1.02s
```

```
212: learn: 0.0373524 total: 275ms remaining: 1.02s
213: learn: 0.0371874 total: 276ms remaining: 1.01s
214: learn: 0.0369988 total: 277ms remaining: 1.01s
215: learn: 0.0367977 total: 279ms remaining: 1.01s
216: learn: 0.0366638 total: 280ms remaining: 1.01s
217: learn: 0.0364904 total: 281ms remaining: 1.01s
218: learn: 0.0361969 total: 282ms remaining: 1s
219: learn: 0.0360558 total: 283ms remaining: 1s
220: learn: 0.0358465 total: 284ms remaining: 1s
221: learn: 0.0356442 total: 286ms remaining: 1s
222: learn: 0.0353411 total: 287ms remaining: 999ms
223: learn: 0.0351118 total: 288ms remaining: 998ms
224: learn: 0.0349061 total: 289ms remaining: 996ms
225: learn: 0.0347516 total: 291ms remaining: 995ms
226: learn: 0.0345390 total: 292ms remaining: 993ms
227: learn: 0.0344269 total: 296ms remaining: 1s
228: learn: 0.0342401 total: 297ms remaining: 1000ms
229: learn: 0.0340650 total: 298ms remaining: 998ms
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633: learn: 0.0091894 total: 833ms remaining: 481ms
634: learn: 0.0091731 total: 834ms remaining: 480ms
635: learn: 0.0091595 total: 836ms remaining: 478ms
636: learn: 0.0091449 total: 837ms remaining: 477ms
637: learn: 0.0091154 total: 838ms remaining: 476ms
638: learn: 0.0091018 total: 839ms remaining: 474ms
639: learn: 0.0090836 total: 841ms remaining: 473ms
640: learn: 0.0090702 total: 842ms remaining: 471ms
641: learn: 0.0090507 total: 843ms remaining: 470ms
642: learn: 0.0090246 total: 844ms remaining: 469ms
643: learn: 0.0090071 total: 845ms remaining: 467ms
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644: learn: 0.0089824 total: 847ms remaining: 466ms
645: learn: 0.0089664 total: 848ms remaining: 465ms
646: learn: 0.0089559 total: 849ms remaining: 463ms
647: learn: 0.0089273 total: 850ms remaining: 462ms
648: learn: 0.0089178 total: 851ms remaining: 460ms
649: learn: 0.0089056 total: 853ms remaining: 459ms
650: learn: 0.0088948 total: 854ms remaining: 458ms
651: learn: 0.0088721 total: 855ms remaining: 456ms
652: learn: 0.0088491 total: 856ms remaining: 455ms
653: learn: 0.0088335 total: 858ms remaining: 454ms
654: learn: 0.0088044 total: 859ms remaining: 452ms
655: learn: 0.0087770 total: 860ms remaining: 451ms
656: learn: 0.0087569 total: 861ms remaining: 450ms
657: learn: 0.0087435 total: 862ms remaining: 448ms
658: learn: 0.0087312 total: 864ms remaining: 447ms
659: learn: 0.0087198 total: 865ms remaining: 446ms
660: learn: 0.0087003 total: 866ms remaining: 444ms
661: learn: 0.0086907 total: 867ms remaining: 443ms
662: learn: 0.0086799 total: 869ms remaining: 442ms
663: learn: 0.0086643 total: 870ms remaining: 440ms
664: learn: 0.0086468 total: 871ms remaining: 439ms
665: learn: 0.0086277 total: 872ms remaining: 437ms
666: learn: 0.0086152 total: 873ms remaining: 436ms
667: learn: 0.0086027 total: 875ms remaining: 435ms
668: learn: 0.0085803 total: 876ms remaining: 433ms
669: learn: 0.0085585 total: 877ms remaining: 432ms
670: learn: 0.0085452 total: 878ms remaining: 431ms
671: learn: 0.0085270 total: 880ms remaining: 429ms
672: learn: 0.0085046 total: 881ms remaining: 428ms
673: learn: 0.0084828 total: 882ms remaining: 427ms
674: learn: 0.0084740 total: 883ms remaining: 425ms
675: learn: 0.0084519 total: 884ms remaining: 424ms
676: learn: 0.0084194 total: 886ms remaining: 423ms
677: learn: 0.0084078 total: 887ms remaining: 421ms
678: learn: 0.0083965 total: 888ms remaining: 420ms
679: learn: 0.0083760 total: 889ms remaining: 419ms
680: learn: 0.0083616 total: 891ms remaining: 417ms
681: learn: 0.0083522 total: 892ms remaining: 416ms
682: learn: 0.0083413 total: 893ms remaining: 415ms
683: learn: 0.0083329 total: 895ms remaining: 414ms
684: learn: 0.0083087 total: 898ms remaining: 413ms
685: learn: 0.0082959 total: 901ms remaining: 412ms
686: learn: 0.0082789 total: 903ms remaining: 411ms
687: learn: 0.0082621 total: 904ms remaining: 410ms
688: learn: 0.0082486 total: 905ms remaining: 408ms
689: learn: 0.0082404 total: 906ms remaining: 407ms
690: learn: 0.0082226 total: 907ms remaining: 406ms
691: learn: 0.0082122 total: 908ms remaining: 404ms
692: learn: 0.0081948 total: 910ms remaining: 403ms
693: learn: 0.0081787 total: 912ms remaining: 402ms
694: learn: 0.0081609 total: 916ms remaining: 402ms
695: learn: 0.0081471 total: 918ms remaining: 401ms
696: learn: 0.0081323 total: 919ms remaining: 400ms
697: learn: 0.0081197 total: 920ms remaining: 398ms
698: learn: 0.0081063 total: 921ms remaining: 397ms
699: learn: 0.0080971 total: 923ms remaining: 395ms
700: learn: 0.0080868 total: 924ms remaining: 394ms
701: learn: 0.0080787 total: 925ms remaining: 393ms
702: learn: 0.0080615 total: 926ms remaining: 391ms
703: learn: 0.0080489 total: 928ms remaining: 390ms
704: learn: 0.0080318 total: 929ms remaining: 389ms
705: learn: 0.0080112 total: 930ms remaining: 387ms
706: learn: 0.0079992 total: 931ms remaining: 386ms
707: learn: 0.0079906 total: 932ms remaining: 385ms
708: learn: 0.0079742 total: 934ms remaining: 383ms
709: learn: 0.0079622 total: 935ms remaining: 382ms
710: learn: 0.0079490 total: 936ms remaining: 380ms
711: learn: 0.0079365 total: 937ms remaining: 379ms
712: learn: 0.0079245 total: 938ms remaining: 378ms
713: learn: 0.0079125 total: 940ms remaining: 376ms
714: learn: 0.0079024 total: 941ms remaining: 375ms
715: learn: 0.0078903 total: 942ms remaining: 374ms
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716: learn: 0.0078746 total: 943ms remaining: 372ms
717: learn: 0.0078676 total: 945ms remaining: 371ms
718: learn: 0.0078590 total: 946ms remaining: 370ms
719: learn: 0.0078471 total: 947ms remaining: 368ms
720: learn: 0.0078368 total: 949ms remaining: 367ms
721: learn: 0.0078267 total: 950ms remaining: 366ms
722: learn: 0.0078104 total: 951ms remaining: 365ms
723: learn: 0.0077988 total: 953ms remaining: 363ms
724: learn: 0.0077881 total: 954ms remaining: 362ms
725: learn: 0.0077764 total: 956ms remaining: 361ms
726: learn: 0.0077647 total: 957ms remaining: 359ms
727: learn: 0.0077490 total: 958ms remaining: 358ms
728: learn: 0.0077315 total: 960ms remaining: 357ms
729: learn: 0.0077205 total: 961ms remaining: 355ms
730: learn: 0.0077085 total: 962ms remaining: 354ms
731: learn: 0.0076898 total: 963ms remaining: 353ms
732: learn: 0.0076718 total: 965ms remaining: 351ms
733: learn: 0.0076473 total: 966ms remaining: 350ms
734: learn: 0.0076236 total: 967ms remaining: 349ms
735: learn: 0.0076087 total: 969ms remaining: 347ms
736: learn: 0.0075981 total: 970ms remaining: 346ms
737: learn: 0.0075883 total: 971ms remaining: 345ms
738: learn: 0.0075794 total: 972ms remaining: 343ms
739: learn: 0.0075641 total: 974ms remaining: 342ms
740: learn: 0.0075484 total: 975ms remaining: 341ms
741: learn: 0.0075402 total: 976ms remaining: 339ms
742: learn: 0.0075272 total: 977ms remaining: 338ms
743: learn: 0.0075108 total: 979ms remaining: 337ms
744: learn: 0.0074926 total: 980ms remaining: 335ms
745: learn: 0.0074793 total: 981ms remaining: 334ms
746: learn: 0.0074730 total: 982ms remaining: 333ms
747: learn: 0.0074608 total: 983ms remaining: 331ms
748: learn: 0.0074539 total: 985ms remaining: 330ms
749: learn: 0.0074454 total: 986ms remaining: 329ms
750: learn: 0.0074238 total: 987ms remaining: 327ms
751: learn: 0.0074122 total: 988ms remaining: 326ms
752: learn: 0.0073998 total: 990ms remaining: 325ms
753: learn: 0.0073856 total: 991ms remaining: 323ms
754: learn: 0.0073673 total: 992ms remaining: 322ms
755: learn: 0.0073515 total: 993ms remaining: 321ms
756: learn: 0.0073388 total: 995ms remaining: 319ms
757: learn: 0.0073262 total: 996ms remaining: 318ms
758: learn: 0.0073139 total: 997ms remaining: 317ms
759: learn: 0.0073036 total: 998ms remaining: 315ms
760: learn: 0.0072923 total: 999ms remaining: 314ms
761: learn: 0.0072769 total: 1s remaining: 313ms
762: learn: 0.0072562 total: 1s remaining: 311ms
763: learn: 0.0072362 total: 1s remaining: 310ms
764: learn: 0.0072263 total: 1s remaining: 309ms
765: learn: 0.0072069 total: 1s remaining: 307ms
766: learn: 0.0071985 total: 1.01s remaining: 306ms
767: learn: 0.0071837 total: 1.01s remaining: 304ms
768: learn: 0.0071705 total: 1.01s remaining: 303ms
769: learn: 0.0071582 total: 1.01s remaining: 302ms
770: learn: 0.0071393 total: 1.01s remaining: 301ms
771: learn: 0.0071202 total: 1.01s remaining: 299ms
772: learn: 0.0071084 total: 1.01s remaining: 298ms
773: learn: 0.0071009 total: 1.01s remaining: 297ms
774: learn: 0.0070863 total: 1.02s remaining: 295ms
775: learn: 0.0070762 total: 1.02s remaining: 294ms
776: learn: 0.0070579 total: 1.02s remaining: 293ms
777: learn: 0.0070390 total: 1.02s remaining: 291ms
778: learn: 0.0070287 total: 1.02s remaining: 290ms
779: learn: 0.0070163 total: 1.02s remaining: 289ms
780: learn: 0.0070066 total: 1.02s remaining: 287ms
781: learn: 0.0069966 total: 1.02s remaining: 286ms
782: learn: 0.0069896 total: 1.03s remaining: 285ms
783: learn: 0.0069828 total: 1.03s remaining: 283ms
784: learn: 0.0069731 total: 1.03s remaining: 282ms
785: learn: 0.0069659 total: 1.03s remaining: 281ms
786: learn: 0.0069603 total: 1.03s remaining: 279ms
787: learn: 0.0069448 total: 1.03s remaining: 278ms
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788: learn: 0.0069382 total: 1.03s remaining: 277ms
789: learn: 0.0069316 total: 1.03s remaining: 275ms
790: learn: 0.0069225 total: 1.04s remaining: 274ms
791: learn: 0.0069042 total: 1.04s remaining: 273ms
792: learn: 0.0068966 total: 1.04s remaining: 271ms
793: learn: 0.0068874 total: 1.04s remaining: 270ms
794: learn: 0.0068722 total: 1.04s remaining: 269ms
795: learn: 0.0068629 total: 1.04s remaining: 267ms
796: learn: 0.0068498 total: 1.04s remaining: 266ms
797: learn: 0.0068389 total: 1.04s remaining: 265ms
798: learn: 0.0068311 total: 1.05s remaining: 263ms
799: learn: 0.0068219 total: 1.05s remaining: 262ms
800: learn: 0.0068150 total: 1.05s remaining: 261ms
801: learn: 0.0068075 total: 1.05s remaining: 259ms
802: learn: 0.0067985 total: 1.05s remaining: 258ms
803: learn: 0.0067865 total: 1.05s remaining: 257ms
804: learn: 0.0067738 total: 1.05s remaining: 255ms
805: learn: 0.0067604 total: 1.05s remaining: 254ms
806: learn: 0.0067485 total: 1.06s remaining: 253ms
807: learn: 0.0067384 total: 1.06s remaining: 251ms
808: learn: 0.0067321 total: 1.06s remaining: 250ms
809: learn: 0.0067207 total: 1.06s remaining: 249ms
810: learn: 0.0067071 total: 1.06s remaining: 247ms
811: learn: 0.0066959 total: 1.06s remaining: 246ms
812: learn: 0.0066825 total: 1.06s remaining: 245ms
813: learn: 0.0066741 total: 1.06s remaining: 244ms
814: learn: 0.0066623 total: 1.07s remaining: 243ms
815: learn: 0.0066495 total: 1.07s remaining: 241ms
816: learn: 0.0066406 total: 1.07s remaining: 240ms
817: learn: 0.0066356 total: 1.07s remaining: 239ms
818: learn: 0.0066265 total: 1.07s remaining: 237ms
819: learn: 0.0066145 total: 1.07s remaining: 236ms
820: learn: 0.0066071 total: 1.07s remaining: 235ms
821: learn: 0.0066001 total: 1.08s remaining: 233ms
822: learn: 0.0065909 total: 1.08s remaining: 232ms
823: learn: 0.0065813 total: 1.08s remaining: 230ms
824: learn: 0.0065706 total: 1.08s remaining: 229ms
825: learn: 0.0065643 total: 1.08s remaining: 228ms
826: learn: 0.0065575 total: 1.08s remaining: 226ms
827: learn: 0.0065493 total: 1.08s remaining: 225ms
828: learn: 0.0065391 total: 1.08s remaining: 224ms
829: learn: 0.0065303 total: 1.09s remaining: 222ms
830: learn: 0.0065222 total: 1.09s remaining: 221ms
831: learn: 0.0065151 total: 1.09s remaining: 220ms
832: learn: 0.0065062 total: 1.09s remaining: 219ms
833: learn: 0.0064988 total: 1.09s remaining: 217ms
834: learn: 0.0064911 total: 1.09s remaining: 216ms
835: learn: 0.0064799 total: 1.09s remaining: 215ms
836: learn: 0.0064742 total: 1.09s remaining: 213ms
837: learn: 0.0064648 total: 1.09s remaining: 212ms
838: learn: 0.0064589 total: 1.1s remaining: 211ms
839: learn: 0.0064551 total: 1.1s remaining: 210ms
840: learn: 0.0064507 total: 1.1s remaining: 209ms
841: learn: 0.0064430 total: 1.1s remaining: 207ms
842: learn: 0.0064334 total: 1.11s remaining: 206ms
843: learn: 0.0064269 total: 1.11s remaining: 205ms
844: learn: 0.0064177 total: 1.11s remaining: 203ms
845: learn: 0.0064072 total: 1.11s remaining: 202ms
846: learn: 0.0063961 total: 1.11s remaining: 201ms
847: learn: 0.0063891 total: 1.11s remaining: 199ms
848: learn: 0.0063822 total: 1.11s remaining: 198ms
849: learn: 0.0063734 total: 1.11s remaining: 197ms
850: learn: 0.0063657 total: 1.12s remaining: 195ms
851: learn: 0.0063522 total: 1.12s remaining: 194ms
852: learn: 0.0063457 total: 1.12s remaining: 193ms
853: learn: 0.0063391 total: 1.12s remaining: 191ms
854: learn: 0.0063259 total: 1.12s remaining: 190ms
855: learn: 0.0063208 total: 1.12s remaining: 189ms
856: learn: 0.0063146 total: 1.12s remaining: 188ms
857: learn: 0.0063093 total: 1.13s remaining: 186ms
858: learn: 0.0062941 total: 1.13s remaining: 185ms
859: learn: 0.0062836 total: 1.13s remaining: 184ms
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860: learn: 0.0062761 total: 1.13s remaining: 182ms
861: learn: 0.0062688 total: 1.13s remaining: 181ms
862: learn: 0.0062633 total: 1.13s remaining: 180ms
863: learn: 0.0062566 total: 1.13s remaining: 178ms
864: learn: 0.0062496 total: 1.13s remaining: 177ms
865: learn: 0.0062447 total: 1.13s remaining: 176ms
866: learn: 0.0062373 total: 1.14s remaining: 174ms
867: learn: 0.0062257 total: 1.14s remaining: 173ms
868: learn: 0.0062206 total: 1.14s remaining: 172ms
869: learn: 0.0062095 total: 1.14s remaining: 170ms
870: learn: 0.0062009 total: 1.14s remaining: 169ms
871: learn: 0.0061853 total: 1.14s remaining: 168ms
872: learn: 0.0061785 total: 1.14s remaining: 166ms
873: learn: 0.0061731 total: 1.14s remaining: 165ms
874: learn: 0.0061663 total: 1.15s remaining: 164ms
875: learn: 0.0061531 total: 1.15s remaining: 162ms
876: learn: 0.0061459 total: 1.15s remaining: 161ms
877: learn: 0.0061384 total: 1.15s remaining: 160ms
878: learn: 0.0061286 total: 1.15s remaining: 158ms
879: learn: 0.0061168 total: 1.15s remaining: 157ms
880: learn: 0.0061111 total: 1.15s remaining: 156ms
881: learn: 0.0061037 total: 1.15s remaining: 154ms
882: learn: 0.0060937 total: 1.16s remaining: 153ms
883: learn: 0.0060870 total: 1.16s remaining: 152ms
884: learn: 0.0060723 total: 1.16s remaining: 150ms
885: learn: 0.0060633 total: 1.16s remaining: 149ms
886: learn: 0.0060484 total: 1.16s remaining: 148ms
887: learn: 0.0060374 total: 1.16s remaining: 147ms
888: learn: 0.0060322 total: 1.16s remaining: 145ms
889: learn: 0.0060247 total: 1.16s remaining: 144ms
890: learn: 0.0060174 total: 1.17s remaining: 143ms
891: learn: 0.0060133 total: 1.17s remaining: 141ms
892: learn: 0.0060055 total: 1.17s remaining: 140ms
893: learn: 0.0059992 total: 1.17s remaining: 139ms
894: learn: 0.0059850 total: 1.17s remaining: 137ms
895: learn: 0.0059788 total: 1.17s remaining: 136ms
896: learn: 0.0059713 total: 1.17s remaining: 135ms
897: learn: 0.0059575 total: 1.17s remaining: 133ms
898: learn: 0.0059504 total: 1.18s remaining: 132ms
899: learn: 0.0059360 total: 1.18s remaining: 131ms
900: learn: 0.0059321 total: 1.18s remaining: 129ms
901: learn: 0.0059262 total: 1.18s remaining: 128ms
902: learn: 0.0059208 total: 1.18s remaining: 127ms
903: learn: 0.0059131 total: 1.18s remaining: 125ms
904: learn: 0.0058998 total: 1.18s remaining: 124ms
905: learn: 0.0058919 total: 1.18s remaining: 123ms
906: learn: 0.0058848 total: 1.18s remaining: 121ms
907: learn: 0.0058771 total: 1.19s remaining: 120ms
908: learn: 0.0058724 total: 1.19s remaining: 119ms
909: learn: 0.0058654 total: 1.19s remaining: 118ms
910: learn: 0.0058600 total: 1.19s remaining: 116ms
911: learn: 0.0058491 total: 1.19s remaining: 115ms
912: learn: 0.0058381 total: 1.19s remaining: 114ms
913: learn: 0.0058319 total: 1.19s remaining: 112ms
914: learn: 0.0058218 total: 1.19s remaining: 111ms
915: learn: 0.0058164 total: 1.2s remaining: 110ms
916: learn: 0.0058036 total: 1.2s remaining: 108ms
917: learn: 0.0057946 total: 1.2s remaining: 107ms
918: learn: 0.0057894 total: 1.2s remaining: 106ms
919: learn: 0.0057847 total: 1.2s remaining: 104ms
920: learn: 0.0057803 total: 1.2s remaining: 103ms
921: learn: 0.0057754 total: 1.2s remaining: 102ms
922: learn: 0.0057689 total: 1.2s remaining: 100ms
923: learn: 0.0057585 total: 1.21s remaining: 99.1ms
924: learn: 0.0057549 total: 1.21s remaining: 97.8ms
925: learn: 0.0057485 total: 1.21s remaining: 96.5ms
926: learn: 0.0057442 total: 1.21s remaining: 95.2ms
927: learn: 0.0057361 total: 1.21s remaining: 93.9ms
928: learn: 0.0057240 total: 1.21s remaining: 92.6ms
929: learn: 0.0057172 total: 1.21s remaining: 91.3ms
930: learn: 0.0057065 total: 1.21s remaining: 90ms
931: learn: 0.0056963 total: 1.21s remaining: 88.6ms
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932: learn: 0.0056880 total: 1.22s remaining: 87.3ms
933: learn: 0.0056829 total: 1.22s remaining: 86ms
934: learn: 0.0056738 total: 1.22s remaining: 84.7ms
935: learn: 0.0056652 total: 1.22s remaining: 83.4ms
936: learn: 0.0056590 total: 1.22s remaining: 82.1ms
937: learn: 0.0056532 total: 1.22s remaining: 80.8ms
938: learn: 0.0056491 total: 1.22s remaining: 79.5ms
939: learn: 0.0056371 total: 1.22s remaining: 78.2ms
940: learn: 0.0056312 total: 1.23s remaining: 76.9ms
941: learn: 0.0056259 total: 1.23s remaining: 75.6ms
942: learn: 0.0056174 total: 1.23s remaining: 74.2ms
943: learn: 0.0056074 total: 1.23s remaining: 72.9ms
944: learn: 0.0056032 total: 1.23s remaining: 71.6ms
945: learn: 0.0055930 total: 1.23s remaining: 70.3ms
946: learn: 0.0055886 total: 1.23s remaining: 69ms
947: learn: 0.0055827 total: 1.23s remaining: 67.7ms
948: learn: 0.0055731 total: 1.24s remaining: 66.4ms
949: learn: 0.0055655 total: 1.24s remaining: 65.1ms
950: learn: 0.0055536 total: 1.24s remaining: 63.8ms
951: learn: 0.0055462 total: 1.24s remaining: 62.5ms
952: learn: 0.0055395 total: 1.24s remaining: 61.2ms
953: learn: 0.0055278 total: 1.24s remaining: 59.9ms
954: learn: 0.0055165 total: 1.24s remaining: 58.6ms
955: learn: 0.0055083 total: 1.24s remaining: 57.3ms
956: learn: 0.0054991 total: 1.25s remaining: 56ms
957: learn: 0.0054913 total: 1.25s remaining: 54.7ms
958: learn: 0.0054854 total: 1.25s remaining: 53.4ms
959: learn: 0.0054787 total: 1.25s remaining: 52ms
960: learn: 0.0054712 total: 1.25s remaining: 50.7ms
961: learn: 0.0054638 total: 1.25s remaining: 49.4ms
962: learn: 0.0054559 total: 1.25s remaining: 48.2ms
963: learn: 0.0054471 total: 1.25s remaining: 46.9ms
964: learn: 0.0054416 total: 1.26s remaining: 45.6ms
965: learn: 0.0054381 total: 1.26s remaining: 44.3ms
966: learn: 0.0054320 total: 1.26s remaining: 43ms
967: learn: 0.0054261 total: 1.26s remaining: 41.7ms
968: learn: 0.0054222 total: 1.26s remaining: 40.4ms
969: learn: 0.0054168 total: 1.26s remaining: 39ms
970: learn: 0.0054121 total: 1.26s remaining: 37.7ms
971: learn: 0.0054067 total: 1.26s remaining: 36.4ms
972: learn: 0.0054005 total: 1.27s remaining: 35.1ms
973: learn: 0.0053961 total: 1.27s remaining: 33.8ms
974: learn: 0.0053867 total: 1.27s remaining: 32.5ms
975: learn: 0.0053772 total: 1.27s remaining: 31.2ms
976: learn: 0.0053729 total: 1.27s remaining: 29.9ms
977: learn: 0.0053653 total: 1.27s remaining: 28.6ms
978: learn: 0.0053597 total: 1.27s remaining: 27.3ms
979: learn: 0.0053481 total: 1.27s remaining: 26ms
980: learn: 0.0053420 total: 1.27s remaining: 24.7ms
981: learn: 0.0053372 total: 1.28s remaining: 23.4ms
982: learn: 0.0053309 total: 1.28s remaining: 22.1ms
983: learn: 0.0053262 total: 1.28s remaining: 20.8ms
984: learn: 0.0053206 total: 1.28s remaining: 19.5ms
985: learn: 0.0053160 total: 1.29s remaining: 18.3ms
986: learn: 0.0053124 total: 1.29s remaining: 17ms
987: learn: 0.0053074 total: 1.29s remaining: 15.7ms
988: learn: 0.0052999 total: 1.29s remaining: 14.4ms
989: learn: 0.0052954 total: 1.29s remaining: 13.1ms
990: learn: 0.0052893 total: 1.29s remaining: 11.8ms
991: learn: 0.0052833 total: 1.3s remaining: 10.5ms
992: learn: 0.0052783 total: 1.3s remaining: 9.15ms
993: learn: 0.0052737 total: 1.3s remaining: 7.84ms
994: learn: 0.0052629 total: 1.3s remaining: 6.54ms
995: learn: 0.0052559 total: 1.3s remaining: 5.23ms
996: learn: 0.0052474 total: 1.3s remaining: 3.92ms
997: learn: 0.0052413 total: 1.3s remaining: 2.61ms
998: learn: 0.0052284 total: 1.3s remaining: 1.31ms
999: learn: 0.0052186 total: 1.31s remaining: 0us
```

Out[139]:

```
<catboost.core.CatBoostClassifier at 0x7ff2eff4a6d0>
```

- **Confusion matrix and Accuracy Score :**

In [140]:

```
from sklearn.metrics import confusion_matrix, accuracy_score
y_pred_cb = clf_cb.predict(X_test)
cm_cb = confusion_matrix(y_test, y_pred_cb)
print(cm_cb)
accuracy_score(y_test, y_pred_cb)
```

```
[[240   0   0   0]
 [ 79   0   0   0]
 [ 17   0   0   0]
 [ 10   0   0   0]]
```

Out[140]:

```
0.6936416184971098
```

- **K-Fold Cross Validation :**

In [141]:

```
from sklearn.model_selection import cross_val_score
accuracies_cb = cross_val_score(estimator = clf_cb, X = X_train, y = y_train, cv = 10)
print(f"Accuracy: {accuracies_cb.mean()*100:.2f} %")
print(f"Standard Deviation: {accuracies_cb.std()*100:.2f} %")
```

```
Streaming output truncated to the last 5000 lines.
6: learn: 0.8101642 total: 7.79ms remaining: 1.1s
7: learn: 0.7643373 total: 8.59ms remaining: 1.06s
8: learn: 0.7129046 total: 9.65ms remaining: 1.06s
9: learn: 0.6789517 total: 10.7ms remaining: 1.06s
10: learn: 0.6370075 total: 11.9ms remaining: 1.07s
11: learn: 0.6040444 total: 13ms remaining: 1.07s
12: learn: 0.5738393 total: 14.2ms remaining: 1.08s
13: learn: 0.5476943 total: 15.2ms remaining: 1.07s
14: learn: 0.5188107 total: 16.3ms remaining: 1.07s
15: learn: 0.4947099 total: 17.7ms remaining: 1.09s
16: learn: 0.4733621 total: 19.5ms remaining: 1.13s
17: learn: 0.4520790 total: 21.4ms remaining: 1.17s
18: learn: 0.4315793 total: 23.1ms remaining: 1.19s
19: learn: 0.4125734 total: 24.7ms remaining: 1.21s
20: learn: 0.3957448 total: 25.8ms remaining: 1.2s
21: learn: 0.3835707 total: 26.8ms remaining: 1.19s
22: learn: 0.3685739 total: 27.9ms remaining: 1.18s
23: learn: 0.3577568 total: 29ms remaining: 1.18s
24: learn: 0.3461874 total: 30ms remaining: 1.17s
25: learn: 0.3341785 total: 31.2ms remaining: 1.17s
26: learn: 0.3250651 total: 32.2ms remaining: 1.16s
27: learn: 0.3164593 total: 33.2ms remaining: 1.15s
28: learn: 0.3079367 total: 34.2ms remaining: 1.14s
29: learn: 0.3000071 total: 35.2ms remaining: 1.14s
30: learn: 0.2909347 total: 36.2ms remaining: 1.13s
31: learn: 0.2824990 total: 37.3ms remaining: 1.13s
32: learn: 0.2749213 total: 38.3ms remaining: 1.12s
33: learn: 0.2682986 total: 39.4ms remaining: 1.12s
34: learn: 0.2615423 total: 40.4ms remaining: 1.11s
35: learn: 0.2557997 total: 41.5ms remaining: 1.11s
36: learn: 0.2505227 total: 42.5ms remaining: 1.11s
37: learn: 0.2439090 total: 43.6ms remaining: 1.1s
38: learn: 0.2383695 total: 44.7ms remaining: 1.1s
39: learn: 0.2333656 total: 49.3ms remaining: 1.18s
40: learn: 0.2277117 total: 50.5ms remaining: 1.18s
41: learn: 0.2229440 total: 51.6ms remaining: 1.18s
42: learn: 0.2178028 total: 53.6ms remaining: 1.19s
43: learn: 0.2142128 total: 54.9ms remaining: 1.19s
44: learn: 0.2099574 total: 56.3ms remaining: 1.19s
45: learn: 0.2062425 total: 57.6ms remaining: 1.19s
46: learn: 0.2017269 total: 62.2ms remaining: 1.26s
```

```
47: learn: 0.1975541 total: 63.5ms remaining: 1.26s
48: learn: 0.1928254 total: 65.3ms remaining: 1.27s
49: learn: 0.1897078 total: 66.8ms remaining: 1.27s
50: learn: 0.1868091 total: 68.3ms remaining: 1.27s
51: learn: 0.1844192 total: 69.8ms remaining: 1.27s
52: learn: 0.1808682 total: 71.1ms remaining: 1.27s
53: learn: 0.1773994 total: 73.1ms remaining: 1.28s
54: learn: 0.1743812 total: 74.1ms remaining: 1.27s
55: learn: 0.1716468 total: 75.1ms remaining: 1.27s
56: learn: 0.1685409 total: 76.3ms remaining: 1.26s
57: learn: 0.1653564 total: 77.3ms remaining: 1.25s
58: learn: 0.1629674 total: 78.4ms remaining: 1.25s
59: learn: 0.1603331 total: 79.7ms remaining: 1.25s
60: learn: 0.1582811 total: 80.7ms remaining: 1.24s
61: learn: 0.1554947 total: 81.9ms remaining: 1.24s
62: learn: 0.1530890 total: 83ms remaining: 1.23s
63: learn: 0.1510938 total: 84ms remaining: 1.23s
64: learn: 0.1489732 total: 85ms remaining: 1.22s
65: learn: 0.1468568 total: 86ms remaining: 1.22s
66: learn: 0.1453731 total: 87ms remaining: 1.21s
67: learn: 0.1437295 total: 88.1ms remaining: 1.21s
68: learn: 0.1413982 total: 89.1ms remaining: 1.2s
69: learn: 0.1391930 total: 90.1ms remaining: 1.2s
70: learn: 0.1375320 total: 91.2ms remaining: 1.19s
71: learn: 0.1356795 total: 92.2ms remaining: 1.19s
72: learn: 0.1335098 total: 93.2ms remaining: 1.18s
73: learn: 0.1319904 total: 94.2ms remaining: 1.18s
74: learn: 0.1299738 total: 95.2ms remaining: 1.17s
75: learn: 0.1283693 total: 96.3ms remaining: 1.17s
76: learn: 0.1268032 total: 97.3ms remaining: 1.17s
77: learn: 0.1254690 total: 98.3ms remaining: 1.16s
78: learn: 0.1240919 total: 99.3ms remaining: 1.16s
79: learn: 0.1229764 total: 100ms remaining: 1.15s
80: learn: 0.1218093 total: 101ms remaining: 1.15s
81: learn: 0.1199895 total: 102ms remaining: 1.15s
82: learn: 0.1184209 total: 103ms remaining: 1.14s
83: learn: 0.1168995 total: 104ms remaining: 1.14s
84: learn: 0.1158158 total: 105ms remaining: 1.14s
85: learn: 0.1144986 total: 107ms remaining: 1.13s
86: learn: 0.1135169 total: 108ms remaining: 1.13s
87: learn: 0.1119866 total: 109ms remaining: 1.12s
88: learn: 0.1105378 total: 110ms remaining: 1.12s
89: learn: 0.1089764 total: 111ms remaining: 1.12s
90: learn: 0.1077362 total: 112ms remaining: 1.11s
91: learn: 0.1064411 total: 113ms remaining: 1.11s
92: learn: 0.1055415 total: 114ms remaining: 1.11s
93: learn: 0.1046018 total: 115ms remaining: 1.11s
94: learn: 0.1031659 total: 116ms remaining: 1.1s
95: learn: 0.1020980 total: 120ms remaining: 1.13s
96: learn: 0.1011703 total: 122ms remaining: 1.13s
97: learn: 0.1002529 total: 123ms remaining: 1.13s
98: learn: 0.0988426 total: 124ms remaining: 1.13s
99: learn: 0.0975392 total: 126ms remaining: 1.13s
100: learn: 0.0965795 total: 127ms remaining: 1.13s
101: learn: 0.0957793 total: 129ms remaining: 1.14s
102: learn: 0.0946106 total: 131ms remaining: 1.14s
103: learn: 0.0938494 total: 133ms remaining: 1.15s
104: learn: 0.0924533 total: 134ms remaining: 1.14s
105: learn: 0.0917393 total: 135ms remaining: 1.14s
106: learn: 0.0907335 total: 136ms remaining: 1.14s
107: learn: 0.0899413 total: 137ms remaining: 1.13s
108: learn: 0.0892524 total: 138ms remaining: 1.13s
109: learn: 0.0884757 total: 139ms remaining: 1.13s
110: learn: 0.0876497 total: 140ms remaining: 1.12s
111: learn: 0.0869224 total: 141ms remaining: 1.12s
112: learn: 0.0861375 total: 142ms remaining: 1.11s
113: learn: 0.0853665 total: 143ms remaining: 1.11s
114: learn: 0.0844730 total: 144ms remaining: 1.11s
115: learn: 0.0835783 total: 145ms remaining: 1.11s
116: learn: 0.0826086 total: 146ms remaining: 1.1s
117: learn: 0.0817091 total: 147ms remaining: 1.1s
118: learn: 0.0808825 total: 148ms remaining: 1.1s
```

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119: learn: 0.0802858 total: 149ms remaining: 1.09s
120: learn: 0.0796514 total: 150ms remaining: 1.09s
121: learn: 0.0791027 total: 151ms remaining: 1.09s
122: learn: 0.0783714 total: 152ms remaining: 1.08s
123: learn: 0.0776510 total: 153ms remaining: 1.08s
124: learn: 0.0770858 total: 154ms remaining: 1.08s
125: learn: 0.0765778 total: 155ms remaining: 1.08s
126: learn: 0.0758194 total: 156ms remaining: 1.07s
127: learn: 0.0752017 total: 158ms remaining: 1.07s
128: learn: 0.0746162 total: 159ms remaining: 1.07s
129: learn: 0.0739930 total: 160ms remaining: 1.07s
130: learn: 0.0732217 total: 161ms remaining: 1.07s
131: learn: 0.0727665 total: 162ms remaining: 1.06s
132: learn: 0.0720594 total: 163ms remaining: 1.06s
133: learn: 0.0712563 total: 164ms remaining: 1.06s
134: learn: 0.0707960 total: 165ms remaining: 1.06s
135: learn: 0.0702780 total: 166ms remaining: 1.06s
136: learn: 0.0698902 total: 167ms remaining: 1.05s
137: learn: 0.0692555 total: 168ms remaining: 1.05s
138: learn: 0.0688404 total: 169ms remaining: 1.05s
139: learn: 0.0682021 total: 170ms remaining: 1.05s
140: learn: 0.0676983 total: 172ms remaining: 1.05s
141: learn: 0.0672868 total: 173ms remaining: 1.04s
142: learn: 0.0667897 total: 174ms remaining: 1.04s
143: learn: 0.0663675 total: 175ms remaining: 1.04s
144: learn: 0.0659766 total: 176ms remaining: 1.04s
145: learn: 0.0656301 total: 177ms remaining: 1.04s
146: learn: 0.0651749 total: 178ms remaining: 1.03s
147: learn: 0.0646590 total: 179ms remaining: 1.03s
148: learn: 0.0642299 total: 180ms remaining: 1.03s
149: learn: 0.0637016 total: 181ms remaining: 1.03s
150: learn: 0.0632774 total: 183ms remaining: 1.03s
151: learn: 0.0627282 total: 184ms remaining: 1.02s
152: learn: 0.0623806 total: 185ms remaining: 1.02s
153: learn: 0.0619808 total: 186ms remaining: 1.02s
154: learn: 0.0616458 total: 187ms remaining: 1.02s
155: learn: 0.0611350 total: 188ms remaining: 1.02s
156: learn: 0.0606720 total: 189ms remaining: 1.01s
157: learn: 0.0601684 total: 190ms remaining: 1.01s
158: learn: 0.0598376 total: 191ms remaining: 1.01s
159: learn: 0.0592968 total: 192ms remaining: 1.01s
160: learn: 0.0589682 total: 193ms remaining: 1.01s
161: learn: 0.0584463 total: 194ms remaining: 1s
162: learn: 0.0579858 total: 195ms remaining: 1s
163: learn: 0.0575280 total: 196ms remaining: 1s
164: learn: 0.0570262 total: 197ms remaining: 999ms
165: learn: 0.0566506 total: 199ms remaining: 998ms
166: learn: 0.0562993 total: 200ms remaining: 996ms
167: learn: 0.0558572 total: 201ms remaining: 994ms
168: learn: 0.0554413 total: 202ms remaining: 992ms
169: learn: 0.0549725 total: 203ms remaining: 990ms
170: learn: 0.0546931 total: 204ms remaining: 988ms
171: learn: 0.0542562 total: 205ms remaining: 986ms
172: learn: 0.0538614 total: 206ms remaining: 984ms
173: learn: 0.0533288 total: 207ms remaining: 982ms
174: learn: 0.0530747 total: 208ms remaining: 980ms
175: learn: 0.0527248 total: 209ms remaining: 978ms
176: learn: 0.0523444 total: 210ms remaining: 977ms
177: learn: 0.0519915 total: 211ms remaining: 975ms
178: learn: 0.0517190 total: 212ms remaining: 974ms
179: learn: 0.0514042 total: 213ms remaining: 972ms
180: learn: 0.0511838 total: 214ms remaining: 970ms
181: learn: 0.0507597 total: 215ms remaining: 968ms
182: learn: 0.0504749 total: 216ms remaining: 966ms
183: learn: 0.0501702 total: 218ms remaining: 965ms
184: learn: 0.0498766 total: 219ms remaining: 963ms
185: learn: 0.0494622 total: 220ms remaining: 961ms
186: learn: 0.0491497 total: 221ms remaining: 960ms
187: learn: 0.0489027 total: 222ms remaining: 959ms
188: learn: 0.0485352 total: 223ms remaining: 958ms
189: learn: 0.0481947 total: 224ms remaining: 956ms
190: learn: 0.0479852 total: 225ms remaining: 954ms
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191: learn: 0.0477245 total: 227ms remaining: 953ms
192: learn: 0.0473801 total: 228ms remaining: 952ms
193: learn: 0.0470449 total: 229ms remaining: 950ms
194: learn: 0.0467842 total: 230ms remaining: 949ms
195: learn: 0.0465358 total: 232ms remaining: 952ms
196: learn: 0.0462966 total: 235ms remaining: 956ms
197: learn: 0.0460140 total: 236ms remaining: 955ms
198: learn: 0.0457238 total: 237ms remaining: 954ms
199: learn: 0.0455371 total: 238ms remaining: 954ms
200: learn: 0.0451768 total: 244ms remaining: 970ms
201: learn: 0.0448772 total: 246ms remaining: 972ms
202: learn: 0.0445226 total: 249ms remaining: 978ms
203: learn: 0.0442819 total: 252ms remaining: 982ms
204: learn: 0.0438849 total: 253ms remaining: 981ms
205: learn: 0.0436642 total: 258ms remaining: 994ms
206: learn: 0.0434104 total: 259ms remaining: 993ms
207: learn: 0.0431564 total: 264ms remaining: 1s
208: learn: 0.0429816 total: 265ms remaining: 1s
209: learn: 0.0427531 total: 269ms remaining: 1.01s
210: learn: 0.0425199 total: 272ms remaining: 1.02s
211: learn: 0.0423383 total: 274ms remaining: 1.02s
212: learn: 0.0420996 total: 275ms remaining: 1.02s
213: learn: 0.0418305 total: 277ms remaining: 1.02s
214: learn: 0.0416160 total: 278ms remaining: 1.01s
215: learn: 0.0413515 total: 279ms remaining: 1.01s
216: learn: 0.0411326 total: 280ms remaining: 1.01s
217: learn: 0.0409763 total: 281ms remaining: 1.01s
218: learn: 0.0407561 total: 282ms remaining: 1s
219: learn: 0.0405170 total: 283ms remaining: 1s
220: learn: 0.0403680 total: 284ms remaining: 1s
221: learn: 0.0401131 total: 285ms remaining: 999ms
222: learn: 0.0398317 total: 286ms remaining: 997ms
223: learn: 0.0395903 total: 287ms remaining: 994ms
224: learn: 0.0393240 total: 288ms remaining: 992ms
225: learn: 0.0391666 total: 289ms remaining: 990ms
226: learn: 0.0389055 total: 290ms remaining: 988ms
227: learn: 0.0387128 total: 291ms remaining: 986ms
228: learn: 0.0385513 total: 292ms remaining: 983ms
229: learn: 0.0383043 total: 293ms remaining: 981ms
230: learn: 0.0381243 total: 294ms remaining: 979ms
231: learn: 0.0379047 total: 295ms remaining: 978ms
232: learn: 0.0376562 total: 296ms remaining: 975ms
233: learn: 0.0375336 total: 297ms remaining: 973ms
234: learn: 0.0373927 total: 298ms remaining: 971ms
235: learn: 0.0372168 total: 299ms remaining: 969ms
236: learn: 0.0370780 total: 300ms remaining: 967ms
237: learn: 0.0368697 total: 301ms remaining: 965ms
238: learn: 0.0366942 total: 302ms remaining: 963ms
239: learn: 0.0365662 total: 304ms remaining: 961ms
240: learn: 0.0363848 total: 305ms remaining: 959ms
241: learn: 0.0362230 total: 306ms remaining: 957ms
242: learn: 0.0359431 total: 308ms remaining: 958ms
243: learn: 0.0357461 total: 310ms remaining: 961ms
244: learn: 0.0355727 total: 311ms remaining: 960ms
245: learn: 0.0353726 total: 313ms remaining: 959ms
246: learn: 0.0352594 total: 314ms remaining: 958ms
247: learn: 0.0350988 total: 315ms remaining: 957ms
248: learn: 0.0349839 total: 318ms remaining: 959ms
249: learn: 0.0348786 total: 319ms remaining: 958ms
250: learn: 0.0347086 total: 320ms remaining: 956ms
251: learn: 0.0345026 total: 321ms remaining: 954ms
252: learn: 0.0343898 total: 322ms remaining: 952ms
253: learn: 0.0342455 total: 323ms remaining: 950ms
254: learn: 0.0340765 total: 325ms remaining: 948ms
255: learn: 0.0339359 total: 326ms remaining: 946ms
256: learn: 0.0338185 total: 327ms remaining: 944ms
257: learn: 0.0337201 total: 328ms remaining: 942ms
258: learn: 0.0335699 total: 329ms remaining: 941ms
259: learn: 0.0334690 total: 330ms remaining: 939ms
260: learn: 0.0333162 total: 331ms remaining: 937ms
261: learn: 0.0331798 total: 332ms remaining: 936ms
262: learn: 0.0330201 total: 333ms remaining: 934ms
```

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263: learn: 0.0328257 total: 334ms remaining: 932ms
264: learn: 0.0326960 total: 336ms remaining: 931ms
265: learn: 0.0325467 total: 337ms remaining: 929ms
266: learn: 0.0323881 total: 338ms remaining: 927ms
267: learn: 0.0322079 total: 340ms remaining: 929ms
268: learn: 0.0321073 total: 343ms remaining: 932ms
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270: learn: 0.0318660 total: 347ms remaining: 934ms
271: learn: 0.0316628 total: 355ms remaining: 949ms
272: learn: 0.0315276 total: 356ms remaining: 947ms
273: learn: 0.0313640 total: 357ms remaining: 945ms
274: learn: 0.0311619 total: 358ms remaining: 944ms
275: learn: 0.0310308 total: 359ms remaining: 942ms
276: learn: 0.0309497 total: 360ms remaining: 940ms
277: learn: 0.0307973 total: 361ms remaining: 938ms
278: learn: 0.0306595 total: 362ms remaining: 936ms
279: learn: 0.0305094 total: 363ms remaining: 935ms
280: learn: 0.0303287 total: 365ms remaining: 933ms
281: learn: 0.0301980 total: 366ms remaining: 931ms
282: learn: 0.0300697 total: 367ms remaining: 929ms
283: learn: 0.0299894 total: 368ms remaining: 927ms
284: learn: 0.0299002 total: 369ms remaining: 925ms
285: learn: 0.0297896 total: 370ms remaining: 923ms
286: learn: 0.0296614 total: 371ms remaining: 921ms
287: learn: 0.0295303 total: 372ms remaining: 920ms
288: learn: 0.0294208 total: 373ms remaining: 918ms
289: learn: 0.0293280 total: 374ms remaining: 916ms
290: learn: 0.0291938 total: 375ms remaining: 914ms
291: learn: 0.0290655 total: 377ms remaining: 913ms
292: learn: 0.0289133 total: 378ms remaining: 911ms
293: learn: 0.0287883 total: 379ms remaining: 909ms
294: learn: 0.0286624 total: 380ms remaining: 907ms
295: learn: 0.0285299 total: 381ms remaining: 906ms
296: learn: 0.0284063 total: 382ms remaining: 904ms
297: learn: 0.0282906 total: 383ms remaining: 902ms
298: learn: 0.0281269 total: 384ms remaining: 900ms
299: learn: 0.0280284 total: 385ms remaining: 898ms
300: learn: 0.0278743 total: 386ms remaining: 896ms
301: learn: 0.0277285 total: 387ms remaining: 894ms
302: learn: 0.0275992 total: 388ms remaining: 893ms
303: learn: 0.0274891 total: 389ms remaining: 891ms
304: learn: 0.0273199 total: 390ms remaining: 889ms
305: learn: 0.0272456 total: 391ms remaining: 887ms
306: learn: 0.0271315 total: 392ms remaining: 886ms
307: learn: 0.0269986 total: 393ms remaining: 884ms
308: learn: 0.0268971 total: 394ms remaining: 882ms
309: learn: 0.0268063 total: 395ms remaining: 880ms
310: learn: 0.0267109 total: 396ms remaining: 878ms
311: learn: 0.0266369 total: 397ms remaining: 877ms
312: learn: 0.0265440 total: 399ms remaining: 875ms
313: learn: 0.0264350 total: 400ms remaining: 873ms
314: learn: 0.0263567 total: 401ms remaining: 871ms
315: learn: 0.0262445 total: 402ms remaining: 869ms
316: learn: 0.0261213 total: 403ms remaining: 868ms
317: learn: 0.0260323 total: 404ms remaining: 866ms
318: learn: 0.0259283 total: 405ms remaining: 864ms
319: learn: 0.0258328 total: 406ms remaining: 862ms
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321: learn: 0.0256576 total: 408ms remaining: 859ms
322: learn: 0.0255535 total: 409ms remaining: 857ms
323: learn: 0.0254665 total: 410ms remaining: 855ms
324: learn: 0.0253648 total: 411ms remaining: 853ms
325: learn: 0.0252666 total: 412ms remaining: 852ms
326: learn: 0.0251841 total: 413ms remaining: 850ms
327: learn: 0.0251039 total: 414ms remaining: 849ms
328: learn: 0.0249979 total: 419ms remaining: 854ms
329: learn: 0.0248782 total: 423ms remaining: 859ms
330: learn: 0.0248198 total: 424ms remaining: 858ms
331: learn: 0.0247232 total: 429ms remaining: 862ms
332: learn: 0.0246473 total: 431ms remaining: 863ms
333: learn: 0.0245514 total: 433ms remaining: 864ms
334: learn: 0.0244873 total: 436ms remaining: 865ms
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335: learn: 0.0243737 total: 438ms remaining: 865ms
336: learn: 0.0242852 total: 439ms remaining: 863ms
337: learn: 0.0241824 total: 440ms remaining: 861ms
338: learn: 0.0240964 total: 441ms remaining: 860ms
339: learn: 0.0240092 total: 442ms remaining: 858ms
340: learn: 0.0239300 total: 443ms remaining: 856ms
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342: learn: 0.0237872 total: 445ms remaining: 853ms
343: learn: 0.0237343 total: 446ms remaining: 851ms
344: learn: 0.0236724 total: 447ms remaining: 849ms
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349: learn: 0.0232930 total: 454ms remaining: 842ms
350: learn: 0.0232061 total: 455ms remaining: 842ms
351: learn: 0.0231100 total: 457ms remaining: 840ms
352: learn: 0.0230530 total: 458ms remaining: 839ms
353: learn: 0.0229617 total: 459ms remaining: 837ms
354: learn: 0.0228886 total: 461ms remaining: 837ms
355: learn: 0.0228063 total: 462ms remaining: 835ms
356: learn: 0.0227191 total: 463ms remaining: 833ms
357: learn: 0.0226351 total: 464ms remaining: 831ms
358: learn: 0.0225704 total: 465ms remaining: 830ms
359: learn: 0.0224983 total: 466ms remaining: 828ms
360: learn: 0.0224291 total: 467ms remaining: 826ms
361: learn: 0.0223656 total: 468ms remaining: 825ms
362: learn: 0.0222871 total: 469ms remaining: 823ms
363: learn: 0.0222104 total: 470ms remaining: 821ms
364: learn: 0.0221053 total: 471ms remaining: 819ms
365: learn: 0.0220518 total: 472ms remaining: 817ms
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367: learn: 0.0218559 total: 474ms remaining: 814ms
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369: learn: 0.0217311 total: 476ms remaining: 810ms
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377: learn: 0.0211431 total: 484ms remaining: 797ms
378: learn: 0.0210636 total: 485ms remaining: 795ms
379: learn: 0.0209915 total: 486ms remaining: 793ms
380: learn: 0.0209351 total: 487ms remaining: 791ms
381: learn: 0.0208759 total: 488ms remaining: 790ms
382: learn: 0.0207908 total: 489ms remaining: 788ms
383: learn: 0.0206880 total: 493ms remaining: 791ms
384: learn: 0.0206295 total: 495ms remaining: 791ms
385: learn: 0.0205681 total: 498ms remaining: 792ms
386: learn: 0.0204863 total: 501ms remaining: 793ms
387: learn: 0.0204378 total: 503ms remaining: 793ms
388: learn: 0.0203918 total: 506ms remaining: 794ms
389: learn: 0.0203517 total: 508ms remaining: 795ms
390: learn: 0.0203112 total: 511ms remaining: 795ms
391: learn: 0.0202656 total: 512ms remaining: 794ms
392: learn: 0.0201796 total: 513ms remaining: 792ms
393: learn: 0.0201187 total: 514ms remaining: 790ms
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395: learn: 0.0199886 total: 516ms remaining: 787ms
396: learn: 0.0199505 total: 517ms remaining: 785ms
397: learn: 0.0198898 total: 518ms remaining: 783ms
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803: learn: 0.0084130 total: 1.01s remaining: 247ms
804: learn: 0.0083996 total: 1.01s remaining: 246ms
805: learn: 0.0083889 total: 1.01s remaining: 244ms
806: learn: 0.0083792 total: 1.01s remaining: 243ms
807: learn: 0.0083667 total: 1.02s remaining: 242ms
808: learn: 0.0083581 total: 1.02s remaining: 240ms
809: learn: 0.0083469 total: 1.02s remaining: 239ms
810: learn: 0.0083254 total: 1.02s remaining: 238ms
811: learn: 0.0083154 total: 1.02s remaining: 236ms
812: learn: 0.0083068 total: 1.02s remaining: 235ms
813: learn: 0.0082968 total: 1.02s remaining: 234ms
814: learn: 0.0082760 total: 1.02s remaining: 232ms
815: learn: 0.0082597 total: 1.02s remaining: 231ms
816: learn: 0.0082445 total: 1.03s remaining: 230ms
817: learn: 0.0082349 total: 1.03s remaining: 229ms
818: learn: 0.0082221 total: 1.03s remaining: 227ms
819: learn: 0.0082114 total: 1.03s remaining: 226ms
820: learn: 0.0082010 total: 1.03s remaining: 225ms
821: learn: 0.0081868 total: 1.03s remaining: 223ms
822: learn: 0.0081764 total: 1.03s remaining: 222ms
823: learn: 0.0081694 total: 1.03s remaining: 221ms
824: learn: 0.0081600 total: 1.03s remaining: 219ms
825: learn: 0.0081476 total: 1.03s remaining: 218ms
826: learn: 0.0081379 total: 1.04s remaining: 217ms
827: learn: 0.0081292 total: 1.04s remaining: 215ms
828: learn: 0.0081203 total: 1.04s remaining: 214ms
829: learn: 0.0081085 total: 1.04s remaining: 213ms
830: learn: 0.0080959 total: 1.04s remaining: 212ms
831: learn: 0.0080861 total: 1.04s remaining: 211ms
832: learn: 0.0080776 total: 1.04s remaining: 210ms
833: learn: 0.0080683 total: 1.05s remaining: 209ms
834: learn: 0.0080590 total: 1.05s remaining: 207ms
835: learn: 0.0080494 total: 1.05s remaining: 206ms
836: learn: 0.0080407 total: 1.05s remaining: 205ms
837: learn: 0.0080272 total: 1.06s remaining: 204ms
838: learn: 0.0080173 total: 1.06s remaining: 203ms

839: learn: 0.0080020 total: 1.06s remaining: 202ms
840: learn: 0.0079853 total: 1.06s remaining: 201ms
841: learn: 0.0079762 total: 1.06s remaining: 199ms
842: learn: 0.0079623 total: 1.06s remaining: 198ms
843: learn: 0.0079511 total: 1.06s remaining: 197ms
844: learn: 0.0079403 total: 1.06s remaining: 195ms
845: learn: 0.0079260 total: 1.06s remaining: 194ms
846: learn: 0.0079183 total: 1.07s remaining: 193ms
847: learn: 0.0079030 total: 1.07s remaining: 191ms
848: learn: 0.0078942 total: 1.07s remaining: 190ms
849: learn: 0.0078797 total: 1.07s remaining: 189ms
850: learn: 0.0078662 total: 1.07s remaining: 187ms
851: learn: 0.0078513 total: 1.07s remaining: 186ms
852: learn: 0.0078354 total: 1.07s remaining: 185ms
853: learn: 0.0078288 total: 1.07s remaining: 183ms
854: learn: 0.0078204 total: 1.07s remaining: 182ms
855: learn: 0.0078120 total: 1.07s remaining: 181ms
856: learn: 0.0077986 total: 1.08s remaining: 180ms
857: learn: 0.0077782 total: 1.08s remaining: 178ms
858: learn: 0.0077696 total: 1.08s remaining: 177ms
859: learn: 0.0077507 total: 1.08s remaining: 176ms
860: learn: 0.0077430 total: 1.08s remaining: 174ms
861: learn: 0.0077341 total: 1.08s remaining: 173ms
862: learn: 0.0077242 total: 1.08s remaining: 172ms
863: learn: 0.0077147 total: 1.08s remaining: 171ms
864: learn: 0.0077010 total: 1.08s remaining: 169ms
865: learn: 0.0076910 total: 1.08s remaining: 168ms
866: learn: 0.0076729 total: 1.09s remaining: 167ms
867: learn: 0.0076574 total: 1.09s remaining: 165ms
868: learn: 0.0076437 total: 1.09s remaining: 164ms
869: learn: 0.0076352 total: 1.09s remaining: 163ms
870: learn: 0.0076269 total: 1.09s remaining: 162ms
871: learn: 0.0076088 total: 1.09s remaining: 160ms
872: learn: 0.0076022 total: 1.09s remaining: 159ms
873: learn: 0.0075888 total: 1.09s remaining: 158ms
874: learn: 0.0075785 total: 1.09s remaining: 156ms
875: learn: 0.0075648 total: 1.09s remaining: 155ms
876: learn: 0.0075587 total: 1.1s remaining: 154ms
877: learn: 0.0075510 total: 1.1s remaining: 152ms
878: learn: 0.0075419 total: 1.1s remaining: 151ms
879: learn: 0.0075290 total: 1.1s remaining: 150ms
880: learn: 0.0075228 total: 1.1s remaining: 149ms
881: learn: 0.0075175 total: 1.1s remaining: 148ms
882: learn: 0.0075073 total: 1.1s remaining: 146ms
883: learn: 0.0074980 total: 1.1s remaining: 145ms
884: learn: 0.0074854 total: 1.11s remaining: 144ms
885: learn: 0.0074783 total: 1.11s remaining: 143ms
886: learn: 0.0074687 total: 1.11s remaining: 141ms
887: learn: 0.0074618 total: 1.11s remaining: 140ms
888: learn: 0.0074462 total: 1.11s remaining: 139ms
889: learn: 0.0074377 total: 1.11s remaining: 138ms
890: learn: 0.0074290 total: 1.11s remaining: 136ms
891: learn: 0.0074220 total: 1.11s remaining: 135ms
892: learn: 0.0074124 total: 1.11s remaining: 134ms
893: learn: 0.0074025 total: 1.12s remaining: 132ms
894: learn: 0.0073922 total: 1.12s remaining: 131ms
895: learn: 0.0073790 total: 1.12s remaining: 130ms
896: learn: 0.0073713 total: 1.12s remaining: 129ms
897: learn: 0.0073635 total: 1.12s remaining: 127ms
898: learn: 0.0073534 total: 1.12s remaining: 126ms
899: learn: 0.0073406 total: 1.12s remaining: 125ms
900: learn: 0.0073351 total: 1.12s remaining: 123ms
901: learn: 0.0073261 total: 1.12s remaining: 122ms
902: learn: 0.0073156 total: 1.13s remaining: 121ms
903: learn: 0.0073055 total: 1.13s remaining: 120ms
904: learn: 0.0072987 total: 1.13s remaining: 118ms
905: learn: 0.0072836 total: 1.13s remaining: 117ms
906: learn: 0.0072763 total: 1.13s remaining: 116ms
907: learn: 0.0072643 total: 1.13s remaining: 115ms
908: learn: 0.0072584 total: 1.13s remaining: 113ms
909: learn: 0.0072508 total: 1.13s remaining: 112ms
910: learn: 0.0072436 total: 1.13s remaining: 111ms

911: learn: 0.0072270 total: 1.13s remaining: 109ms
912: learn: 0.0072156 total: 1.14s remaining: 108ms
913: learn: 0.0072036 total: 1.14s remaining: 107ms
914: learn: 0.0071947 total: 1.14s remaining: 106ms
915: learn: 0.0071866 total: 1.14s remaining: 104ms
916: learn: 0.0071772 total: 1.14s remaining: 103ms
917: learn: 0.0071700 total: 1.14s remaining: 102ms
918: learn: 0.0071629 total: 1.14s remaining: 101ms
919: learn: 0.0071534 total: 1.15s remaining: 99.6ms
920: learn: 0.0071453 total: 1.15s remaining: 98.4ms
921: learn: 0.0071328 total: 1.15s remaining: 97.3ms
922: learn: 0.0071262 total: 1.16s remaining: 96.7ms
923: learn: 0.0071159 total: 1.16s remaining: 95.5ms
924: learn: 0.0071106 total: 1.16s remaining: 94.2ms
925: learn: 0.0071049 total: 1.16s remaining: 93ms
926: learn: 0.0070977 total: 1.17s remaining: 91.8ms
927: learn: 0.0070902 total: 1.17s remaining: 90.5ms
928: learn: 0.0070815 total: 1.17s remaining: 89.2ms
929: learn: 0.0070745 total: 1.17s remaining: 88ms
930: learn: 0.0070664 total: 1.17s remaining: 86.7ms
931: learn: 0.0070572 total: 1.17s remaining: 85.4ms
932: learn: 0.0070492 total: 1.17s remaining: 84.1ms
933: learn: 0.0070424 total: 1.17s remaining: 82.9ms
934: learn: 0.0070356 total: 1.17s remaining: 81.6ms
935: learn: 0.0070210 total: 1.17s remaining: 80.3ms
936: learn: 0.0070123 total: 1.18s remaining: 79.1ms
937: learn: 0.0069988 total: 1.18s remaining: 77.8ms
938: learn: 0.0069869 total: 1.18s remaining: 76.5ms
939: learn: 0.0069787 total: 1.18s remaining: 75.3ms
940: learn: 0.0069680 total: 1.18s remaining: 74ms
941: learn: 0.0069589 total: 1.18s remaining: 72.7ms
942: learn: 0.0069513 total: 1.18s remaining: 71.4ms
943: learn: 0.0069432 total: 1.18s remaining: 70.2ms
944: learn: 0.0069351 total: 1.18s remaining: 68.9ms
945: learn: 0.0069273 total: 1.19s remaining: 67.7ms
946: learn: 0.0069183 total: 1.19s remaining: 66.4ms
947: learn: 0.0069099 total: 1.19s remaining: 65.1ms
948: learn: 0.0069032 total: 1.19s remaining: 63.9ms
949: learn: 0.0068962 total: 1.19s remaining: 62.6ms
950: learn: 0.0068891 total: 1.19s remaining: 61.3ms
951: learn: 0.0068806 total: 1.19s remaining: 60.1ms
952: learn: 0.0068762 total: 1.19s remaining: 58.8ms
953: learn: 0.0068652 total: 1.19s remaining: 57.5ms
954: learn: 0.0068593 total: 1.19s remaining: 56.3ms
955: learn: 0.0068519 total: 1.2s remaining: 55ms
956: learn: 0.0068438 total: 1.2s remaining: 53.8ms
957: learn: 0.0068376 total: 1.2s remaining: 52.5ms
958: learn: 0.0068272 total: 1.2s remaining: 51.2ms
959: learn: 0.0068190 total: 1.2s remaining: 50ms
960: learn: 0.0068103 total: 1.2s remaining: 48.7ms
961: learn: 0.0067995 total: 1.2s remaining: 47.5ms
962: learn: 0.0067931 total: 1.2s remaining: 46.2ms
963: learn: 0.0067858 total: 1.2s remaining: 44.9ms
964: learn: 0.0067728 total: 1.2s remaining: 43.7ms
965: learn: 0.0067684 total: 1.21s remaining: 42.4ms
966: learn: 0.0067601 total: 1.21s remaining: 41.2ms
967: learn: 0.0067514 total: 1.21s remaining: 39.9ms
968: learn: 0.0067469 total: 1.21s remaining: 38.7ms
969: learn: 0.0067395 total: 1.21s remaining: 37.4ms
970: learn: 0.0067278 total: 1.21s remaining: 36.2ms
971: learn: 0.0067187 total: 1.21s remaining: 34.9ms
972: learn: 0.0067124 total: 1.21s remaining: 33.7ms
973: learn: 0.0067002 total: 1.21s remaining: 32.4ms
974: learn: 0.0066895 total: 1.22s remaining: 31.2ms
975: learn: 0.0066809 total: 1.22s remaining: 29.9ms
976: learn: 0.0066688 total: 1.22s remaining: 28.6ms
977: learn: 0.0066607 total: 1.22s remaining: 27.4ms
978: learn: 0.0066529 total: 1.22s remaining: 26.1ms
979: learn: 0.0066480 total: 1.22s remaining: 24.9ms
980: learn: 0.0066335 total: 1.22s remaining: 23.7ms
981: learn: 0.0066289 total: 1.23s remaining: 22.5ms
982: learn: 0.0066201 total: 1.23s remaining: 21.2ms

983: learn: 0.0066060 total: 1.23s remaining: 20ms
984: learn: 0.0065987 total: 1.23s remaining: 18.8ms
985: learn: 0.0065929 total: 1.23s remaining: 17.5ms
986: learn: 0.0065855 total: 1.24s remaining: 16.3ms
987: learn: 0.0065779 total: 1.24s remaining: 15ms
988: learn: 0.0065716 total: 1.24s remaining: 13.8ms
989: learn: 0.0065645 total: 1.24s remaining: 12.5ms
990: learn: 0.0065565 total: 1.24s remaining: 11.3ms
991: learn: 0.0065456 total: 1.24s remaining: 10ms
992: learn: 0.0065355 total: 1.25s remaining: 8.8ms
993: learn: 0.0065299 total: 1.25s remaining: 7.54ms
994: learn: 0.0065231 total: 1.25s remaining: 6.29ms
995: learn: 0.0065190 total: 1.25s remaining: 5.03ms
996: learn: 0.0065053 total: 1.25s remaining: 3.77ms
997: learn: 0.0064982 total: 1.25s remaining: 2.52ms
998: learn: 0.0064862 total: 1.26s remaining: 1.26ms
999: learn: 0.0064731 total: 1.26s remaining: 0us
Learning rate set to 0.080013
0: learn: 1.2523551 total: 1.06ms remaining: 1.06s
1: learn: 1.1616861 total: 2.17ms remaining: 1.08s
2: learn: 1.0628158 total: 3.22ms remaining: 1.07s
3: learn: 0.9937873 total: 4.25ms remaining: 1.06s
4: learn: 0.9245979 total: 5.29ms remaining: 1.05s
5: learn: 0.8711331 total: 6.33ms remaining: 1.05s
6: learn: 0.8205067 total: 7.41ms remaining: 1.05s
7: learn: 0.7750342 total: 8.16ms remaining: 1.01s
8: learn: 0.7231164 total: 9.2ms remaining: 1.01s
9: learn: 0.6878163 total: 10.1ms remaining: 1s
10: learn: 0.6456732 total: 11.2ms remaining: 1s
11: learn: 0.6149478 total: 12.2ms remaining: 1s
12: learn: 0.5877633 total: 13ms remaining: 987ms
13: learn: 0.5615418 total: 14ms remaining: 989ms
14: learn: 0.5360548 total: 15.1ms remaining: 991ms
15: learn: 0.5147151 total: 16.1ms remaining: 991ms
16: learn: 0.4889029 total: 17.2ms remaining: 996ms
17: learn: 0.4713450 total: 18.2ms remaining: 995ms
18: learn: 0.4515003 total: 19.3ms remaining: 995ms
19: learn: 0.4375966 total: 20.2ms remaining: 989ms
20: learn: 0.4268949 total: 21.2ms remaining: 988ms
21: learn: 0.4083144 total: 22.2ms remaining: 988ms
22: learn: 0.3962135 total: 23.3ms remaining: 988ms
23: learn: 0.3807000 total: 24.3ms remaining: 989ms
24: learn: 0.3700325 total: 25.3ms remaining: 988ms
25: learn: 0.3555308 total: 26.3ms remaining: 987ms
26: learn: 0.3442426 total: 27.4ms remaining: 987ms
27: learn: 0.3318670 total: 28.4ms remaining: 986ms
28: learn: 0.3213786 total: 29.4ms remaining: 986ms
29: learn: 0.3114541 total: 30.8ms remaining: 995ms
30: learn: 0.3024268 total: 45ms remaining: 1.41s
31: learn: 0.2940679 total: 46.8ms remaining: 1.42s
32: learn: 0.2862982 total: 48ms remaining: 1.41s
33: learn: 0.2803180 total: 49.2ms remaining: 1.4s
34: learn: 0.2742473 total: 50.5ms remaining: 1.39s
35: learn: 0.2668118 total: 51.5ms remaining: 1.38s
36: learn: 0.2614901 total: 52.6ms remaining: 1.37s
37: learn: 0.2561092 total: 54.8ms remaining: 1.39s
38: learn: 0.2503023 total: 58ms remaining: 1.43s
39: learn: 0.2447421 total: 59.5ms remaining: 1.43s
40: learn: 0.2395003 total: 60.8ms remaining: 1.42s
41: learn: 0.2348726 total: 63.4ms remaining: 1.45s
42: learn: 0.2302051 total: 66.1ms remaining: 1.47s
43: learn: 0.2246387 total: 68.9ms remaining: 1.5s
44: learn: 0.2215061 total: 71.1ms remaining: 1.51s
45: learn: 0.2173323 total: 72.2ms remaining: 1.5s
46: learn: 0.2129110 total: 73.2ms remaining: 1.48s
47: learn: 0.2100510 total: 74.3ms remaining: 1.47s
48: learn: 0.2063216 total: 75.4ms remaining: 1.46s
49: learn: 0.2018880 total: 76.4ms remaining: 1.45s
50: learn: 0.1981118 total: 77.5ms remaining: 1.44s
51: learn: 0.1943747 total: 78.5ms remaining: 1.43s
52: learn: 0.1913249 total: 79.5ms remaining: 1.42s
53: learn: 0.1885680 total: 80.5ms remaining: 1.41s

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54: learn: 0.1854874 total: 81.6ms remaining: 1.4s
55: learn: 0.1829042 total: 82.6ms remaining: 1.39s
56: learn: 0.1791580 total: 83.6ms remaining: 1.38s
57: learn: 0.1756738 total: 84.6ms remaining: 1.37s
58: learn: 0.1726982 total: 85.7ms remaining: 1.37s
59: learn: 0.1697722 total: 86.7ms remaining: 1.36s
60: learn: 0.1671085 total: 87.7ms remaining: 1.35s
61: learn: 0.1643972 total: 89ms remaining: 1.35s
62: learn: 0.1626462 total: 90.1ms remaining: 1.34s
63: learn: 0.1610534 total: 91ms remaining: 1.33s
64: learn: 0.1583718 total: 92.4ms remaining: 1.33s
65: learn: 0.1563531 total: 93.4ms remaining: 1.32s
66: learn: 0.1541143 total: 94.4ms remaining: 1.31s
67: learn: 0.1519421 total: 95.5ms remaining: 1.31s
68: learn: 0.1495012 total: 96.6ms remaining: 1.3s
69: learn: 0.1479016 total: 97.6ms remaining: 1.3s
70: learn: 0.1461442 total: 98.6ms remaining: 1.29s
71: learn: 0.1439140 total: 99.6ms remaining: 1.28s
72: learn: 0.1421694 total: 101ms remaining: 1.28s
73: learn: 0.1402083 total: 102ms remaining: 1.27s
74: learn: 0.1380202 total: 103ms remaining: 1.27s
75: learn: 0.1361776 total: 104ms remaining: 1.26s
76: learn: 0.1340241 total: 105ms remaining: 1.26s
77: learn: 0.1325618 total: 106ms remaining: 1.25s
78: learn: 0.1307917 total: 107ms remaining: 1.25s
79: learn: 0.1287869 total: 108ms remaining: 1.24s
80: learn: 0.1272663 total: 109ms remaining: 1.24s
81: learn: 0.1259827 total: 110ms remaining: 1.23s
82: learn: 0.1243170 total: 111ms remaining: 1.23s
83: learn: 0.1229194 total: 112ms remaining: 1.22s
84: learn: 0.1212510 total: 114ms remaining: 1.23s
85: learn: 0.1197009 total: 121ms remaining: 1.29s
86: learn: 0.1185065 total: 123ms remaining: 1.29s
87: learn: 0.1170760 total: 124ms remaining: 1.29s
88: learn: 0.1158258 total: 127ms remaining: 1.3s
89: learn: 0.1143861 total: 128ms remaining: 1.29s
90: learn: 0.1130104 total: 129ms remaining: 1.29s
91: learn: 0.1117468 total: 130ms remaining: 1.28s
92: learn: 0.1106627 total: 131ms remaining: 1.28s
93: learn: 0.1093982 total: 132ms remaining: 1.27s
94: learn: 0.1083746 total: 133ms remaining: 1.27s
95: learn: 0.1072676 total: 136ms remaining: 1.28s
96: learn: 0.1061368 total: 137ms remaining: 1.28s
97: learn: 0.1050922 total: 138ms remaining: 1.27s
98: learn: 0.1038822 total: 139ms remaining: 1.27s
99: learn: 0.1029786 total: 140ms remaining: 1.26s
100: learn: 0.1019714 total: 141ms remaining: 1.26s
101: learn: 0.1006847 total: 142ms remaining: 1.25s
102: learn: 0.0997489 total: 143ms remaining: 1.25s
103: learn: 0.0985614 total: 144ms remaining: 1.24s
104: learn: 0.0974622 total: 145ms remaining: 1.24s
105: learn: 0.0965975 total: 146ms remaining: 1.24s
106: learn: 0.0955302 total: 148ms remaining: 1.23s
107: learn: 0.0944863 total: 149ms remaining: 1.23s
108: learn: 0.0933841 total: 150ms remaining: 1.23s
109: learn: 0.0925542 total: 151ms remaining: 1.22s
110: learn: 0.0916178 total: 152ms remaining: 1.22s
111: learn: 0.0907311 total: 153ms remaining: 1.21s
112: learn: 0.0899394 total: 154ms remaining: 1.21s
113: learn: 0.0892248 total: 155ms remaining: 1.21s
114: learn: 0.0885245 total: 156ms remaining: 1.2s
115: learn: 0.0878490 total: 158ms remaining: 1.2s
116: learn: 0.0870190 total: 159ms remaining: 1.2s
117: learn: 0.0863812 total: 160ms remaining: 1.2s
118: learn: 0.0854329 total: 161ms remaining: 1.19s
119: learn: 0.0846461 total: 162ms remaining: 1.19s
120: learn: 0.0838730 total: 163ms remaining: 1.19s
121: learn: 0.0831138 total: 165ms remaining: 1.18s
122: learn: 0.0824513 total: 166ms remaining: 1.18s
123: learn: 0.0818303 total: 167ms remaining: 1.18s
124: learn: 0.0812825 total: 168ms remaining: 1.17s
125: learn: 0.0807133 total: 169ms remaining: 1.17s
```

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126: learn: 0.0801298 total: 170ms remaining: 1.17s
127: learn: 0.0795053 total: 171ms remaining: 1.16s
128: learn: 0.0789235 total: 173ms remaining: 1.17s
129: learn: 0.0781347 total: 175ms remaining: 1.17s
130: learn: 0.0774658 total: 176ms remaining: 1.17s
131: learn: 0.0769093 total: 177ms remaining: 1.16s
132: learn: 0.0762556 total: 178ms remaining: 1.16s
133: learn: 0.0755130 total: 179ms remaining: 1.16s
134: learn: 0.0748824 total: 180ms remaining: 1.15s
135: learn: 0.0742619 total: 181ms remaining: 1.15s
136: learn: 0.0736762 total: 182ms remaining: 1.15s
137: learn: 0.0729918 total: 183ms remaining: 1.15s
138: learn: 0.0725209 total: 184ms remaining: 1.14s
139: learn: 0.0718467 total: 186ms remaining: 1.14s
140: learn: 0.0714007 total: 187ms remaining: 1.14s
141: learn: 0.0709835 total: 188ms remaining: 1.14s
142: learn: 0.0705642 total: 189ms remaining: 1.13s
143: learn: 0.0701386 total: 190ms remaining: 1.13s
144: learn: 0.0695460 total: 191ms remaining: 1.13s
145: learn: 0.0690287 total: 192ms remaining: 1.12s
146: learn: 0.0685309 total: 193ms remaining: 1.12s
147: learn: 0.0679954 total: 194ms remaining: 1.12s
148: learn: 0.0675221 total: 195ms remaining: 1.12s
149: learn: 0.0669484 total: 196ms remaining: 1.11s
150: learn: 0.0664662 total: 198ms remaining: 1.11s
151: learn: 0.0660314 total: 199ms remaining: 1.11s
152: learn: 0.0654437 total: 200ms remaining: 1.1s
153: learn: 0.0650912 total: 201ms remaining: 1.1s
154: learn: 0.0646640 total: 202ms remaining: 1.1s
155: learn: 0.0641623 total: 203ms remaining: 1.1s
156: learn: 0.0638115 total: 204ms remaining: 1.1s
157: learn: 0.0634131 total: 206ms remaining: 1.09s
158: learn: 0.0629963 total: 207ms remaining: 1.09s
159: learn: 0.0626235 total: 208ms remaining: 1.09s
160: learn: 0.0622329 total: 209ms remaining: 1.09s
161: learn: 0.0618271 total: 210ms remaining: 1.08s
162: learn: 0.0615030 total: 211ms remaining: 1.08s
163: learn: 0.0611367 total: 212ms remaining: 1.08s
164: learn: 0.0607782 total: 213ms remaining: 1.08s
165: learn: 0.0601683 total: 214ms remaining: 1.07s
166: learn: 0.0596719 total: 215ms remaining: 1.07s
167: learn: 0.0592009 total: 216ms remaining: 1.07s
168: learn: 0.0588206 total: 217ms remaining: 1.07s
169: learn: 0.0584688 total: 218ms remaining: 1.06s
170: learn: 0.0581740 total: 220ms remaining: 1.06s
171: learn: 0.0578190 total: 221ms remaining: 1.06s
172: learn: 0.0575268 total: 222ms remaining: 1.06s
173: learn: 0.0571326 total: 223ms remaining: 1.06s
174: learn: 0.0568029 total: 226ms remaining: 1.07s
175: learn: 0.0563264 total: 232ms remaining: 1.08s
176: learn: 0.0560829 total: 233ms remaining: 1.08s
177: learn: 0.0557517 total: 237ms remaining: 1.09s
178: learn: 0.0552741 total: 238ms remaining: 1.09s
179: learn: 0.0549473 total: 239ms remaining: 1.09s
180: learn: 0.0545213 total: 248ms remaining: 1.12s
181: learn: 0.0541823 total: 251ms remaining: 1.13s
182: learn: 0.0539233 total: 254ms remaining: 1.13s
183: learn: 0.0534937 total: 255ms remaining: 1.13s
184: learn: 0.0530923 total: 256ms remaining: 1.13s
185: learn: 0.0526646 total: 257ms remaining: 1.13s
186: learn: 0.0522928 total: 258ms remaining: 1.12s
187: learn: 0.0520411 total: 259ms remaining: 1.12s
188: learn: 0.0517021 total: 260ms remaining: 1.12s
189: learn: 0.0513496 total: 262ms remaining: 1.11s
190: learn: 0.0510575 total: 263ms remaining: 1.11s
191: learn: 0.0507650 total: 264ms remaining: 1.11s
192: learn: 0.0504648 total: 265ms remaining: 1.11s
193: learn: 0.0500329 total: 266ms remaining: 1.1s
194: learn: 0.0496254 total: 267ms remaining: 1.1s
195: learn: 0.0492417 total: 268ms remaining: 1.1s
196: learn: 0.0489113 total: 269ms remaining: 1.1s
197: learn: 0.0486813 total: 270ms remaining: 1.09s
```

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198: learn: 0.0482785 total: 272ms remaining: 1.09s
199: learn: 0.0480434 total: 273ms remaining: 1.09s
200: learn: 0.0477058 total: 274ms remaining: 1.09s
201: learn: 0.0473939 total: 275ms remaining: 1.09s
202: learn: 0.0470186 total: 276ms remaining: 1.08s
203: learn: 0.0467861 total: 277ms remaining: 1.08s
204: learn: 0.0464776 total: 278ms remaining: 1.08s
205: learn: 0.0461928 total: 279ms remaining: 1.07s
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207: learn: 0.0456909 total: 283ms remaining: 1.08s
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209: learn: 0.0451733 total: 285ms remaining: 1.07s
210: learn: 0.0449997 total: 286ms remaining: 1.07s
211: learn: 0.0447688 total: 287ms remaining: 1.06s
212: learn: 0.0445066 total: 288ms remaining: 1.06s
213: learn: 0.0442767 total: 289ms remaining: 1.06s
214: learn: 0.0441069 total: 290ms remaining: 1.06s
215: learn: 0.0438442 total: 291ms remaining: 1.06s
216: learn: 0.0435152 total: 292ms remaining: 1.05s
217: learn: 0.0431822 total: 293ms remaining: 1.05s
218: learn: 0.0430026 total: 294ms remaining: 1.05s
219: learn: 0.0427995 total: 295ms remaining: 1.05s
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221: learn: 0.0422751 total: 303ms remaining: 1.06s
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239: learn: 0.0386886 total: 324ms remaining: 1.03s
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244: learn: 0.0378490 total: 330ms remaining: 1.02s
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269: learn: 0.0337167 total: 358ms remaining: 968ms
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773: learn: 0.0092434 total: 981ms remaining: 286ms
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845: learn: 0.0083418 total: 1.06s remaining: 194ms

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917: learn: 0.0075386 total: 1.16s remaining: 104ms
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965: learn: 0.0070805 total: 1.22s remaining: 43ms
966: learn: 0.0070728 total: 1.22s remaining: 41.7ms
967: learn: 0.0070643 total: 1.22s remaining: 40.5ms
968: learn: 0.0070593 total: 1.23s remaining: 39.2ms
969: learn: 0.0070497 total: 1.23s remaining: 37.9ms
970: learn: 0.0070417 total: 1.23s remaining: 36.7ms
971: learn: 0.0070377 total: 1.23s remaining: 35.4ms
972: learn: 0.0070263 total: 1.23s remaining: 34.1ms
973: learn: 0.0070112 total: 1.23s remaining: 32.9ms
974: learn: 0.0070043 total: 1.23s remaining: 31.6ms
975: learn: 0.0069967 total: 1.23s remaining: 30.3ms
976: learn: 0.0069904 total: 1.23s remaining: 29.1ms
977: learn: 0.0069787 total: 1.24s remaining: 27.8ms
978: learn: 0.0069699 total: 1.24s remaining: 26.5ms
979: learn: 0.0069646 total: 1.24s remaining: 25.3ms
980: learn: 0.0069540 total: 1.24s remaining: 24ms
981: learn: 0.0069480 total: 1.24s remaining: 22.7ms
982: learn: 0.0069336 total: 1.24s remaining: 21.5ms
983: learn: 0.0069287 total: 1.24s remaining: 20.2ms
984: learn: 0.0069203 total: 1.24s remaining: 19ms
985: learn: 0.0069091 total: 1.25s remaining: 17.7ms
986: learn: 0.0069026 total: 1.25s remaining: 16.4ms
987: learn: 0.0068979 total: 1.25s remaining: 15.2ms
988: learn: 0.0068876 total: 1.25s remaining: 13.9ms
989: learn: 0.0068813 total: 1.25s remaining: 12.6ms
```

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990: learn: 0.0068772 total: 1.25s remaining: 11.4ms
991: learn: 0.0068718 total: 1.25s remaining: 10.1ms
992: learn: 0.0068649 total: 1.25s remaining: 8.84ms
993: learn: 0.0068602 total: 1.25s remaining: 7.57ms
994: learn: 0.0068462 total: 1.25s remaining: 6.31ms
995: learn: 0.0068402 total: 1.26s remaining: 5.05ms
996: learn: 0.0068258 total: 1.26s remaining: 3.78ms
997: learn: 0.0068165 total: 1.26s remaining: 2.52ms
998: learn: 0.0068082 total: 1.26s remaining: 1.26ms
999: learn: 0.0067982 total: 1.26s remaining: 0us
Learning rate set to 0.080013
0: learn: 1.2500772 total: 9.11ms remaining: 9.1s
1: learn: 1.1581279 total: 10.6ms remaining: 5.27s
2: learn: 1.0584231 total: 11.9ms remaining: 3.96s
3: learn: 0.9884649 total: 34ms remaining: 8.47s
4: learn: 0.9193039 total: 35.2ms remaining: 7.01s
5: learn: 0.8633079 total: 36.3ms remaining: 6.01s
6: learn: 0.8133827 total: 37.3ms remaining: 5.29s
7: learn: 0.7677462 total: 38.1ms remaining: 4.73s
8: learn: 0.7221000 total: 39.1ms remaining: 4.31s
9: learn: 0.6825031 total: 40.1ms remaining: 3.97s
10: learn: 0.6468971 total: 41.2ms remaining: 3.7s
11: learn: 0.6149863 total: 42.2ms remaining: 3.47s
12: learn: 0.5858407 total: 43.2ms remaining: 3.28s
13: learn: 0.5562013 total: 44.3ms remaining: 3.12s
14: learn: 0.5303864 total: 45.3ms remaining: 2.98s
15: learn: 0.5060095 total: 46.4ms remaining: 2.85s
16: learn: 0.4839682 total: 47.4ms remaining: 2.74s
17: learn: 0.4664724 total: 48.5ms remaining: 2.64s
18: learn: 0.4453982 total: 49.5ms remaining: 2.55s
19: learn: 0.4284360 total: 50.4ms remaining: 2.47s
20: learn: 0.4113700 total: 51.7ms remaining: 2.41s
21: learn: 0.3979354 total: 52.8ms remaining: 2.35s
22: learn: 0.3818139 total: 53.8ms remaining: 2.28s
23: learn: 0.3708584 total: 54.8ms remaining: 2.23s
24: learn: 0.3593291 total: 55.9ms remaining: 2.18s
25: learn: 0.3482552 total: 56.9ms remaining: 2.13s
26: learn: 0.3371308 total: 58ms remaining: 2.09s
27: learn: 0.3273855 total: 59ms remaining: 2.05s
28: learn: 0.3189842 total: 60.4ms remaining: 2.02s
29: learn: 0.3093239 total: 61.5ms remaining: 1.99s
30: learn: 0.3003914 total: 62.5ms remaining: 1.95s
31: learn: 0.2915256 total: 63.8ms remaining: 1.93s
32: learn: 0.2853188 total: 64.8ms remaining: 1.9s
33: learn: 0.2779595 total: 65.9ms remaining: 1.87s
34: learn: 0.2695768 total: 67ms remaining: 1.85s
35: learn: 0.2637206 total: 68.1ms remaining: 1.82s
36: learn: 0.2582652 total: 69.2ms remaining: 1.8s
37: learn: 0.2521337 total: 70.2ms remaining: 1.78s
38: learn: 0.2463231 total: 71.2ms remaining: 1.75s
39: learn: 0.2409584 total: 73.4ms remaining: 1.76s
40: learn: 0.2362122 total: 75.8ms remaining: 1.77s
41: learn: 0.2307475 total: 77.2ms remaining: 1.76s
42: learn: 0.2258539 total: 79.2ms remaining: 1.76s
43: learn: 0.2218717 total: 82.1ms remaining: 1.78s
44: learn: 0.2175120 total: 83.6ms remaining: 1.77s
45: learn: 0.2135989 total: 85ms remaining: 1.76s
46: learn: 0.2091770 total: 86.1ms remaining: 1.75s
47: learn: 0.2049139 total: 87ms remaining: 1.73s
48: learn: 0.2011301 total: 88.1ms remaining: 1.71s
49: learn: 0.1979935 total: 89.1ms remaining: 1.69s
50: learn: 0.1944324 total: 90.1ms remaining: 1.68s
51: learn: 0.1917707 total: 91.2ms remaining: 1.66s
52: learn: 0.1884185 total: 92.2ms remaining: 1.65s
53: learn: 0.1851696 total: 93ms remaining: 1.63s
54: learn: 0.1823824 total: 94ms remaining: 1.61s
55: learn: 0.1791742 total: 95ms remaining: 1.6s
56: learn: 0.1763161 total: 96ms remaining: 1.59s
57: learn: 0.1733074 total: 97.1ms remaining: 1.58s
58: learn: 0.1708520 total: 98.3ms remaining: 1.57s
59: learn: 0.1679203 total: 99.3ms remaining: 1.56s
60: learn: 0.1657446 total: 100ms remaining: 1.54s
```

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61: learn: 0.1628471 total: 101ms remaining: 1.53s
62: learn: 0.1605525 total: 102ms remaining: 1.52s
63: learn: 0.1581739 total: 103ms remaining: 1.51s
64: learn: 0.1558305 total: 105ms remaining: 1.5s
65: learn: 0.1539712 total: 106ms remaining: 1.5s
66: learn: 0.1521901 total: 107ms remaining: 1.49s
67: learn: 0.1500660 total: 108ms remaining: 1.48s
68: learn: 0.1481401 total: 109ms remaining: 1.47s
69: learn: 0.1463156 total: 110ms remaining: 1.46s
70: learn: 0.1444261 total: 111ms remaining: 1.45s
71: learn: 0.1424579 total: 112ms remaining: 1.44s
72: learn: 0.1404553 total: 113ms remaining: 1.44s
73: learn: 0.1386107 total: 114ms remaining: 1.43s
74: learn: 0.1371297 total: 115ms remaining: 1.42s
75: learn: 0.1354544 total: 116ms remaining: 1.41s
76: learn: 0.1336858 total: 117ms remaining: 1.41s
77: learn: 0.1315952 total: 119ms remaining: 1.4s
78: learn: 0.1301648 total: 120ms remaining: 1.39s
79: learn: 0.1288969 total: 121ms remaining: 1.39s
80: learn: 0.1272623 total: 122ms remaining: 1.38s
81: learn: 0.1254804 total: 123ms remaining: 1.37s
82: learn: 0.1241555 total: 124ms remaining: 1.37s
83: learn: 0.1230160 total: 125ms remaining: 1.36s
84: learn: 0.1215994 total: 126ms remaining: 1.36s
85: learn: 0.1202765 total: 127ms remaining: 1.35s
86: learn: 0.1188928 total: 128ms remaining: 1.34s
87: learn: 0.1177659 total: 129ms remaining: 1.34s
88: learn: 0.1165517 total: 130ms remaining: 1.33s
89: learn: 0.1153459 total: 131ms remaining: 1.33s
90: learn: 0.1139640 total: 132ms remaining: 1.32s
91: learn: 0.1123675 total: 134ms remaining: 1.32s
92: learn: 0.1112453 total: 135ms remaining: 1.31s
93: learn: 0.1096326 total: 136ms remaining: 1.31s
94: learn: 0.1082105 total: 137ms remaining: 1.3s
95: learn: 0.1072893 total: 138ms remaining: 1.3s
96: learn: 0.1062514 total: 139ms remaining: 1.29s
97: learn: 0.1052130 total: 140ms remaining: 1.29s
98: learn: 0.1039448 total: 141ms remaining: 1.29s
99: learn: 0.1025896 total: 143ms remaining: 1.28s
100: learn: 0.1014851 total: 144ms remaining: 1.28s
101: learn: 0.1006107 total: 145ms remaining: 1.27s
102: learn: 0.0995084 total: 146ms remaining: 1.27s
103: learn: 0.0985202 total: 147ms remaining: 1.26s
104: learn: 0.0973620 total: 148ms remaining: 1.26s
105: learn: 0.0963473 total: 149ms remaining: 1.26s
106: learn: 0.0956303 total: 150ms remaining: 1.25s
107: learn: 0.0948513 total: 151ms remaining: 1.25s
108: learn: 0.0937671 total: 152ms remaining: 1.24s
109: learn: 0.0926127 total: 153ms remaining: 1.24s
110: learn: 0.0915442 total: 155ms remaining: 1.24s
111: learn: 0.0906043 total: 156ms remaining: 1.23s
112: learn: 0.0896757 total: 157ms remaining: 1.23s
113: learn: 0.0889235 total: 158ms remaining: 1.23s
114: learn: 0.0881907 total: 159ms remaining: 1.22s
115: learn: 0.0872946 total: 160ms remaining: 1.22s
116: learn: 0.0862646 total: 161ms remaining: 1.22s
117: learn: 0.0855428 total: 162ms remaining: 1.21s
118: learn: 0.0848798 total: 163ms remaining: 1.21s
119: learn: 0.0842868 total: 164ms remaining: 1.21s
120: learn: 0.0837568 total: 165ms remaining: 1.2s
121: learn: 0.0831513 total: 167ms remaining: 1.2s
122: learn: 0.0826017 total: 168ms remaining: 1.2s
123: learn: 0.0819510 total: 169ms remaining: 1.19s
124: learn: 0.0813589 total: 170ms remaining: 1.19s
125: learn: 0.0804848 total: 171ms remaining: 1.18s
126: learn: 0.0799133 total: 172ms remaining: 1.18s
127: learn: 0.0792717 total: 173ms remaining: 1.18s
128: learn: 0.0786248 total: 174ms remaining: 1.17s
129: learn: 0.0780231 total: 175ms remaining: 1.17s
130: learn: 0.0774225 total: 176ms remaining: 1.17s
131: learn: 0.0767277 total: 177ms remaining: 1.17s
132: learn: 0.0760987 total: 178ms remaining: 1.16s
```

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133: learn: 0.0756531 total: 180ms remaining: 1.17s
134: learn: 0.0750912 total: 183ms remaining: 1.17s
135: learn: 0.0745904 total: 184ms remaining: 1.17s
136: learn: 0.0741507 total: 185ms remaining: 1.17s
137: learn: 0.0735237 total: 187ms remaining: 1.17s
138: learn: 0.0730939 total: 190ms remaining: 1.17s
139: learn: 0.0723229 total: 193ms remaining: 1.19s
140: learn: 0.0718817 total: 196ms remaining: 1.19s
141: learn: 0.0712090 total: 197ms remaining: 1.19s
142: learn: 0.0708014 total: 198ms remaining: 1.19s
143: learn: 0.0702488 total: 199ms remaining: 1.18s
144: learn: 0.0698069 total: 200ms remaining: 1.18s
145: learn: 0.0694159 total: 201ms remaining: 1.18s
146: learn: 0.0689835 total: 202ms remaining: 1.17s
147: learn: 0.0685187 total: 203ms remaining: 1.17s
148: learn: 0.0680409 total: 204ms remaining: 1.17s
149: learn: 0.0673269 total: 205ms remaining: 1.16s
150: learn: 0.0667422 total: 206ms remaining: 1.16s
151: learn: 0.0663551 total: 207ms remaining: 1.16s
152: learn: 0.0657082 total: 209ms remaining: 1.16s
153: learn: 0.0653127 total: 213ms remaining: 1.17s
154: learn: 0.0649831 total: 214ms remaining: 1.17s
155: learn: 0.0645338 total: 216ms remaining: 1.17s
156: learn: 0.0639527 total: 218ms remaining: 1.17s
157: learn: 0.0635977 total: 219ms remaining: 1.17s
158: learn: 0.0632234 total: 220ms remaining: 1.16s
159: learn: 0.0629374 total: 221ms remaining: 1.16s
160: learn: 0.0625802 total: 222ms remaining: 1.16s
161: learn: 0.0619520 total: 223ms remaining: 1.15s
162: learn: 0.0615822 total: 224ms remaining: 1.15s
163: learn: 0.0612014 total: 225ms remaining: 1.15s
164: learn: 0.0607096 total: 226ms remaining: 1.14s
165: learn: 0.0601246 total: 227ms remaining: 1.14s
166: learn: 0.0598628 total: 228ms remaining: 1.14s
167: learn: 0.0594177 total: 229ms remaining: 1.13s
168: learn: 0.0590347 total: 230ms remaining: 1.13s
169: learn: 0.0585935 total: 231ms remaining: 1.13s
170: learn: 0.0580359 total: 232ms remaining: 1.13s
171: learn: 0.0575440 total: 233ms remaining: 1.12s
172: learn: 0.0570980 total: 234ms remaining: 1.12s
173: learn: 0.0565878 total: 235ms remaining: 1.12s
174: learn: 0.0563006 total: 236ms remaining: 1.11s
175: learn: 0.0558515 total: 237ms remaining: 1.11s
176: learn: 0.0555070 total: 238ms remaining: 1.11s
177: learn: 0.0551237 total: 239ms remaining: 1.1s
178: learn: 0.0546651 total: 240ms remaining: 1.1s
179: learn: 0.0542366 total: 241ms remaining: 1.1s
180: learn: 0.0539062 total: 242ms remaining: 1.1s
181: learn: 0.0534861 total: 244ms remaining: 1.1s
182: learn: 0.0531225 total: 247ms remaining: 1.1s
183: learn: 0.0527571 total: 252ms remaining: 1.12s
184: learn: 0.0523591 total: 260ms remaining: 1.15s
185: learn: 0.0520061 total: 262ms remaining: 1.15s
186: learn: 0.0516258 total: 265ms remaining: 1.15s
187: learn: 0.0513670 total: 267ms remaining: 1.15s
188: learn: 0.0510941 total: 269ms remaining: 1.16s
189: learn: 0.0506808 total: 271ms remaining: 1.15s
190: learn: 0.0503031 total: 272ms remaining: 1.15s
191: learn: 0.0499185 total: 273ms remaining: 1.15s
192: learn: 0.0496434 total: 274ms remaining: 1.14s
193: learn: 0.0493560 total: 275ms remaining: 1.14s
194: learn: 0.0490322 total: 276ms remaining: 1.14s
195: learn: 0.0487841 total: 277ms remaining: 1.14s
196: learn: 0.0485113 total: 278ms remaining: 1.13s
197: learn: 0.0482241 total: 279ms remaining: 1.13s
198: learn: 0.0479903 total: 280ms remaining: 1.13s
199: learn: 0.0477639 total: 281ms remaining: 1.12s
200: learn: 0.0475390 total: 282ms remaining: 1.12s
201: learn: 0.0473327 total: 283ms remaining: 1.12s
202: learn: 0.0471458 total: 285ms remaining: 1.12s
203: learn: 0.0469231 total: 286ms remaining: 1.11s
204: learn: 0.0465533 total: 287ms remaining: 1.11s
```

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205: learn: 0.0463621 total: 288ms remaining: 1.11s
206: learn: 0.0460784 total: 289ms remaining: 1.11s
207: learn: 0.0456908 total: 290ms remaining: 1.1s
208: learn: 0.0454869 total: 291ms remaining: 1.1s
209: learn: 0.0452605 total: 292ms remaining: 1.1s
210: learn: 0.0450128 total: 294ms remaining: 1.1s
211: learn: 0.0448232 total: 295ms remaining: 1.09s
212: learn: 0.0445626 total: 296ms remaining: 1.09s
213: learn: 0.0443071 total: 297ms remaining: 1.09s
214: learn: 0.0440185 total: 298ms remaining: 1.09s
215: learn: 0.0437182 total: 299ms remaining: 1.09s
216: learn: 0.0434665 total: 301ms remaining: 1.08s
217: learn: 0.0432593 total: 302ms remaining: 1.08s
218: learn: 0.0429443 total: 303ms remaining: 1.08s
219: learn: 0.0427235 total: 304ms remaining: 1.08s
220: learn: 0.0424293 total: 305ms remaining: 1.07s
221: learn: 0.0422013 total: 306ms remaining: 1.07s
222: learn: 0.0419814 total: 307ms remaining: 1.07s
223: learn: 0.0417742 total: 308ms remaining: 1.07s
224: learn: 0.0415076 total: 309ms remaining: 1.06s
225: learn: 0.0413424 total: 311ms remaining: 1.06s
226: learn: 0.0410611 total: 312ms remaining: 1.06s
227: learn: 0.0408546 total: 313ms remaining: 1.06s
228: learn: 0.0406285 total: 314ms remaining: 1.06s
229: learn: 0.0404375 total: 315ms remaining: 1.05s
230: learn: 0.0401964 total: 316ms remaining: 1.05s
231: learn: 0.0400330 total: 317ms remaining: 1.05s
232: learn: 0.0398253 total: 318ms remaining: 1.05s
233: learn: 0.0395253 total: 320ms remaining: 1.05s
234: learn: 0.0393682 total: 321ms remaining: 1.04s
235: learn: 0.0391866 total: 322ms remaining: 1.04s
236: learn: 0.0390049 total: 323ms remaining: 1.04s
237: learn: 0.0387536 total: 324ms remaining: 1.04s
238: learn: 0.0386118 total: 325ms remaining: 1.04s
239: learn: 0.0384174 total: 327ms remaining: 1.03s
240: learn: 0.0382491 total: 328ms remaining: 1.03s
241: learn: 0.0379756 total: 329ms remaining: 1.03s
242: learn: 0.0377900 total: 330ms remaining: 1.03s
243: learn: 0.0375982 total: 331ms remaining: 1.02s
244: learn: 0.0374777 total: 332ms remaining: 1.02s
245: learn: 0.0373095 total: 333ms remaining: 1.02s
246: learn: 0.0371673 total: 334ms remaining: 1.02s
247: learn: 0.0369941 total: 335ms remaining: 1.02s
248: learn: 0.0368676 total: 336ms remaining: 1.01s
249: learn: 0.0367282 total: 337ms remaining: 1.01s
250: learn: 0.0365921 total: 339ms remaining: 1.01s
251: learn: 0.0364331 total: 340ms remaining: 1.01s
252: learn: 0.0362527 total: 341ms remaining: 1s
253: learn: 0.0361017 total: 342ms remaining: 1s
254: learn: 0.0359888 total: 343ms remaining: 1s
255: learn: 0.0358375 total: 344ms remaining: 1000ms
256: learn: 0.0356394 total: 345ms remaining: 997ms
257: learn: 0.0354522 total: 346ms remaining: 995ms
258: learn: 0.0353035 total: 347ms remaining: 993ms
259: learn: 0.0351032 total: 348ms remaining: 991ms
260: learn: 0.0349241 total: 349ms remaining: 988ms
261: learn: 0.0347162 total: 350ms remaining: 986ms
262: learn: 0.0345538 total: 351ms remaining: 984ms
263: learn: 0.0343851 total: 352ms remaining: 982ms
264: learn: 0.0342389 total: 353ms remaining: 980ms
265: learn: 0.0341011 total: 355ms remaining: 979ms
266: learn: 0.0339012 total: 356ms remaining: 976ms
267: learn: 0.0337682 total: 357ms remaining: 974ms
268: learn: 0.0336189 total: 360ms remaining: 978ms
269: learn: 0.0334688 total: 361ms remaining: 976ms
270: learn: 0.0333099 total: 363ms remaining: 977ms
271: learn: 0.0331227 total: 366ms remaining: 979ms
272: learn: 0.0330250 total: 368ms remaining: 981ms
273: learn: 0.0329096 total: 371ms remaining: 983ms
274: learn: 0.0327752 total: 373ms remaining: 984ms
275: learn: 0.0326368 total: 374ms remaining: 982ms
276: learn: 0.0325121 total: 375ms remaining: 979ms
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277: learn: 0.0323961 total: 376ms remaining: 977ms
278: learn: 0.0322524 total: 377ms remaining: 975ms
279: learn: 0.0321547 total: 378ms remaining: 973ms
280: learn: 0.0320215 total: 379ms remaining: 971ms
281: learn: 0.0318144 total: 381ms remaining: 969ms
282: learn: 0.0316827 total: 381ms remaining: 967ms
283: learn: 0.0315829 total: 383ms remaining: 964ms
284: learn: 0.0314691 total: 384ms remaining: 962ms
285: learn: 0.0313679 total: 385ms remaining: 961ms
286: learn: 0.0311856 total: 386ms remaining: 959ms
287: learn: 0.0309791 total: 389ms remaining: 961ms
288: learn: 0.0308648 total: 390ms remaining: 960ms
289: learn: 0.0307755 total: 392ms remaining: 960ms
290: learn: 0.0306686 total: 395ms remaining: 962ms
291: learn: 0.0305508 total: 397ms remaining: 962ms
292: learn: 0.0304556 total: 398ms remaining: 960ms
293: learn: 0.0303625 total: 401ms remaining: 963ms
294: learn: 0.0302229 total: 403ms remaining: 963ms
295: learn: 0.0301327 total: 406ms remaining: 966ms
296: learn: 0.0300391 total: 407ms remaining: 964ms
297: learn: 0.0299089 total: 408ms remaining: 962ms
298: learn: 0.0298032 total: 409ms remaining: 960ms
299: learn: 0.0296725 total: 411ms remaining: 958ms
300: learn: 0.0295158 total: 412ms remaining: 956ms
301: learn: 0.0293720 total: 413ms remaining: 954ms
302: learn: 0.0292657 total: 414ms remaining: 952ms
303: learn: 0.0291889 total: 415ms remaining: 950ms
304: learn: 0.0290541 total: 416ms remaining: 948ms
305: learn: 0.0288806 total: 419ms remaining: 950ms
306: learn: 0.0287396 total: 420ms remaining: 948ms
307: learn: 0.0286299 total: 421ms remaining: 945ms
308: learn: 0.0285446 total: 422ms remaining: 943ms
309: learn: 0.0284456 total: 423ms remaining: 941ms
310: learn: 0.0282912 total: 424ms remaining: 939ms
311: learn: 0.0282089 total: 425ms remaining: 937ms
312: learn: 0.0280869 total: 426ms remaining: 935ms
313: learn: 0.0279643 total: 428ms remaining: 936ms
314: learn: 0.0277735 total: 435ms remaining: 945ms
315: learn: 0.0276286 total: 436ms remaining: 945ms
316: learn: 0.0275422 total: 438ms remaining: 945ms
317: learn: 0.0274623 total: 440ms remaining: 944ms
318: learn: 0.0273531 total: 442ms remaining: 943ms
319: learn: 0.0272643 total: 444ms remaining: 943ms
320: learn: 0.0271606 total: 445ms remaining: 941ms
321: learn: 0.0270318 total: 446ms remaining: 939ms
322: learn: 0.0269310 total: 447ms remaining: 937ms
323: learn: 0.0268065 total: 448ms remaining: 935ms
324: learn: 0.0267407 total: 449ms remaining: 933ms
325: learn: 0.0266145 total: 450ms remaining: 931ms
326: learn: 0.0264564 total: 452ms remaining: 930ms
327: learn: 0.0263441 total: 453ms remaining: 929ms
328: learn: 0.0262565 total: 455ms remaining: 927ms
329: learn: 0.0261548 total: 456ms remaining: 925ms
330: learn: 0.0260469 total: 457ms remaining: 923ms
331: learn: 0.0259468 total: 458ms remaining: 922ms
332: learn: 0.0258744 total: 459ms remaining: 919ms
333: learn: 0.0257262 total: 460ms remaining: 918ms
334: learn: 0.0256184 total: 461ms remaining: 916ms
335: learn: 0.0255270 total: 462ms remaining: 913ms
336: learn: 0.0253886 total: 463ms remaining: 911ms
337: learn: 0.0252905 total: 464ms remaining: 909ms
338: learn: 0.0251895 total: 465ms remaining: 907ms
339: learn: 0.0251249 total: 466ms remaining: 905ms
340: learn: 0.0250136 total: 467ms remaining: 903ms
341: learn: 0.0249309 total: 468ms remaining: 901ms
342: learn: 0.0248543 total: 469ms remaining: 899ms
343: learn: 0.0247711 total: 470ms remaining: 897ms
344: learn: 0.0246455 total: 471ms remaining: 895ms
345: learn: 0.0245731 total: 472ms remaining: 893ms
346: learn: 0.0244917 total: 473ms remaining: 891ms
347: learn: 0.0243875 total: 474ms remaining: 889ms
348: learn: 0.0243061 total: 475ms remaining: 887ms

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349: learn: 0.0241799 total: 477ms remaining: 885ms
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754: learn: 0.0094774 total: 1s remaining: 326ms
755: learn: 0.0094625 total: 1.01s remaining: 325ms
756: learn: 0.0094458 total: 1.01s remaining: 323ms
757: learn: 0.0094264 total: 1.01s remaining: 322ms
758: learn: 0.0094132 total: 1.01s remaining: 321ms
759: learn: 0.0093977 total: 1.01s remaining: 319ms
760: learn: 0.0093865 total: 1.01s remaining: 318ms
761: learn: 0.0093694 total: 1.01s remaining: 316ms
762: learn: 0.0093600 total: 1.01s remaining: 315ms
763: learn: 0.0093505 total: 1.01s remaining: 314ms
764: learn: 0.0093403 total: 1.02s remaining: 312ms
765: learn: 0.0093308 total: 1.02s remaining: 311ms
766: learn: 0.0093177 total: 1.02s remaining: 310ms
767: learn: 0.0093035 total: 1.02s remaining: 308ms
768: learn: 0.0092889 total: 1.02s remaining: 307ms
769: learn: 0.0092775 total: 1.02s remaining: 305ms
770: learn: 0.0092676 total: 1.02s remaining: 304ms
771: learn: 0.0092590 total: 1.02s remaining: 303ms
772: learn: 0.0092448 total: 1.03s remaining: 301ms
773: learn: 0.0092351 total: 1.03s remaining: 300ms
774: learn: 0.0092192 total: 1.03s remaining: 299ms
775: learn: 0.0091985 total: 1.03s remaining: 297ms
776: learn: 0.0091840 total: 1.03s remaining: 296ms
777: learn: 0.0091674 total: 1.03s remaining: 294ms
778: learn: 0.0091583 total: 1.03s remaining: 293ms
779: learn: 0.0091447 total: 1.03s remaining: 292ms
780: learn: 0.0091238 total: 1.03s remaining: 290ms
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781: learn: 0.0091094 total: 1.04s remaining: 289ms
782: learn: 0.0090997 total: 1.04s remaining: 287ms
783: learn: 0.0090850 total: 1.04s remaining: 286ms
784: learn: 0.0090766 total: 1.04s remaining: 285ms
785: learn: 0.0090641 total: 1.04s remaining: 283ms
786: learn: 0.0090528 total: 1.04s remaining: 282ms
787: learn: 0.0090277 total: 1.04s remaining: 281ms
788: learn: 0.0090142 total: 1.04s remaining: 279ms
789: learn: 0.0090041 total: 1.04s remaining: 278ms
790: learn: 0.0089934 total: 1.04s remaining: 276ms
791: learn: 0.0089812 total: 1.05s remaining: 275ms
792: learn: 0.0089707 total: 1.05s remaining: 274ms
793: learn: 0.0089539 total: 1.05s remaining: 272ms
794: learn: 0.0089419 total: 1.05s remaining: 271ms
795: learn: 0.0089197 total: 1.05s remaining: 270ms
796: learn: 0.0089086 total: 1.05s remaining: 268ms
797: learn: 0.0088960 total: 1.05s remaining: 267ms
798: learn: 0.0088765 total: 1.05s remaining: 265ms
799: learn: 0.0088609 total: 1.06s remaining: 264ms
800: learn: 0.0088493 total: 1.06s remaining: 263ms
801: learn: 0.0088338 total: 1.06s remaining: 261ms
802: learn: 0.0088260 total: 1.06s remaining: 260ms
803: learn: 0.0088128 total: 1.06s remaining: 258ms
804: learn: 0.0088039 total: 1.06s remaining: 257ms
805: learn: 0.0087923 total: 1.06s remaining: 256ms
806: learn: 0.0087772 total: 1.06s remaining: 254ms
807: learn: 0.0087512 total: 1.06s remaining: 253ms
808: learn: 0.0087380 total: 1.06s remaining: 252ms
809: learn: 0.0087248 total: 1.07s remaining: 250ms
810: learn: 0.0087127 total: 1.07s remaining: 249ms
811: learn: 0.0086936 total: 1.07s remaining: 247ms
812: learn: 0.0086833 total: 1.07s remaining: 246ms
813: learn: 0.0086618 total: 1.07s remaining: 245ms
814: learn: 0.0086490 total: 1.07s remaining: 243ms
815: learn: 0.0086373 total: 1.07s remaining: 242ms
816: learn: 0.0086163 total: 1.07s remaining: 240ms
817: learn: 0.0086030 total: 1.07s remaining: 239ms
818: learn: 0.0085906 total: 1.07s remaining: 238ms
819: learn: 0.0085672 total: 1.08s remaining: 236ms
820: learn: 0.0085532 total: 1.08s remaining: 235ms
821: learn: 0.0085460 total: 1.08s remaining: 234ms
822: learn: 0.0085389 total: 1.08s remaining: 232ms
823: learn: 0.0085253 total: 1.08s remaining: 231ms
824: learn: 0.0085064 total: 1.08s remaining: 229ms
825: learn: 0.0084989 total: 1.08s remaining: 228ms
826: learn: 0.0084862 total: 1.08s remaining: 227ms
827: learn: 0.0084686 total: 1.08s remaining: 225ms
828: learn: 0.0084525 total: 1.08s remaining: 224ms
829: learn: 0.0084419 total: 1.09s remaining: 223ms
830: learn: 0.0084290 total: 1.09s remaining: 221ms
831: learn: 0.0084218 total: 1.09s remaining: 220ms
832: learn: 0.0084150 total: 1.09s remaining: 219ms
833: learn: 0.0084026 total: 1.09s remaining: 217ms
834: learn: 0.0083948 total: 1.09s remaining: 216ms
835: learn: 0.0083837 total: 1.09s remaining: 215ms
836: learn: 0.0083693 total: 1.1s remaining: 213ms
837: learn: 0.0083596 total: 1.1s remaining: 212ms
838: learn: 0.0083508 total: 1.1s remaining: 211ms
839: learn: 0.0083371 total: 1.1s remaining: 209ms
840: learn: 0.0083222 total: 1.1s remaining: 208ms
841: learn: 0.0083154 total: 1.1s remaining: 207ms
842: learn: 0.0083007 total: 1.1s remaining: 206ms
843: learn: 0.0082914 total: 1.11s remaining: 205ms
844: learn: 0.0082812 total: 1.11s remaining: 204ms
845: learn: 0.0082687 total: 1.11s remaining: 203ms
846: learn: 0.0082471 total: 1.12s remaining: 202ms
847: learn: 0.0082367 total: 1.12s remaining: 201ms
848: learn: 0.0082294 total: 1.12s remaining: 200ms
849: learn: 0.0082078 total: 1.12s remaining: 198ms
850: learn: 0.0081927 total: 1.13s remaining: 197ms
851: learn: 0.0081778 total: 1.13s remaining: 196ms
852: learn: 0.0081671 total: 1.13s remaining: 194ms

853: learn: 0.0081582 total: 1.13s remaining: 193ms
854: learn: 0.0081501 total: 1.13s remaining: 192ms
855: learn: 0.0081401 total: 1.13s remaining: 190ms
856: learn: 0.0081289 total: 1.13s remaining: 189ms
857: learn: 0.0081187 total: 1.13s remaining: 187ms
858: learn: 0.0080980 total: 1.13s remaining: 186ms
859: learn: 0.0080866 total: 1.13s remaining: 185ms
860: learn: 0.0080790 total: 1.14s remaining: 183ms
861: learn: 0.0080700 total: 1.14s remaining: 182ms
862: learn: 0.0080602 total: 1.14s remaining: 181ms
863: learn: 0.0080517 total: 1.14s remaining: 179ms
864: learn: 0.0080385 total: 1.14s remaining: 178ms
865: learn: 0.0080302 total: 1.14s remaining: 177ms
866: learn: 0.0080210 total: 1.14s remaining: 175ms
867: learn: 0.0080010 total: 1.14s remaining: 174ms
868: learn: 0.0079899 total: 1.14s remaining: 172ms
869: learn: 0.0079820 total: 1.14s remaining: 171ms
870: learn: 0.0079704 total: 1.15s remaining: 170ms
871: learn: 0.0079612 total: 1.15s remaining: 168ms
872: learn: 0.0079505 total: 1.15s remaining: 167ms
873: learn: 0.0079392 total: 1.15s remaining: 166ms
874: learn: 0.0079251 total: 1.16s remaining: 165ms
875: learn: 0.0079155 total: 1.16s remaining: 164ms
876: learn: 0.0079058 total: 1.16s remaining: 162ms
877: learn: 0.0078939 total: 1.16s remaining: 161ms
878: learn: 0.0078810 total: 1.16s remaining: 160ms
879: learn: 0.0078731 total: 1.16s remaining: 158ms
880: learn: 0.0078671 total: 1.16s remaining: 157ms
881: learn: 0.0078602 total: 1.16s remaining: 156ms
882: learn: 0.0078495 total: 1.16s remaining: 154ms
883: learn: 0.0078403 total: 1.17s remaining: 153ms
884: learn: 0.0078323 total: 1.17s remaining: 152ms
885: learn: 0.0078232 total: 1.17s remaining: 150ms
886: learn: 0.0078040 total: 1.17s remaining: 149ms
887: learn: 0.0077902 total: 1.17s remaining: 147ms
888: learn: 0.0077785 total: 1.17s remaining: 146ms
889: learn: 0.0077709 total: 1.17s remaining: 145ms
890: learn: 0.0077616 total: 1.17s remaining: 143ms
891: learn: 0.0077451 total: 1.17s remaining: 142ms
892: learn: 0.0077298 total: 1.17s remaining: 141ms
893: learn: 0.0077192 total: 1.18s remaining: 139ms
894: learn: 0.0077109 total: 1.18s remaining: 138ms
895: learn: 0.0077027 total: 1.18s remaining: 137ms
896: learn: 0.0076960 total: 1.18s remaining: 135ms
897: learn: 0.0076867 total: 1.18s remaining: 134ms
898: learn: 0.0076703 total: 1.18s remaining: 133ms
899: learn: 0.0076624 total: 1.18s remaining: 131ms
900: learn: 0.0076537 total: 1.18s remaining: 130ms
901: learn: 0.0076401 total: 1.18s remaining: 129ms
902: learn: 0.0076288 total: 1.18s remaining: 127ms
903: learn: 0.0076154 total: 1.19s remaining: 126ms
904: learn: 0.0076087 total: 1.19s remaining: 125ms
905: learn: 0.0075938 total: 1.19s remaining: 123ms
906: learn: 0.0075860 total: 1.19s remaining: 122ms
907: learn: 0.0075778 total: 1.19s remaining: 121ms
908: learn: 0.0075689 total: 1.19s remaining: 119ms
909: learn: 0.0075552 total: 1.19s remaining: 118ms
910: learn: 0.0075436 total: 1.19s remaining: 117ms
911: learn: 0.0075368 total: 1.19s remaining: 115ms
912: learn: 0.0075280 total: 1.2s remaining: 114ms
913: learn: 0.0075179 total: 1.2s remaining: 113ms
914: learn: 0.0075096 total: 1.2s remaining: 111ms
915: learn: 0.0075031 total: 1.2s remaining: 110ms
916: learn: 0.0074937 total: 1.2s remaining: 109ms
917: learn: 0.0074874 total: 1.2s remaining: 108ms
918: learn: 0.0074789 total: 1.21s remaining: 106ms
919: learn: 0.0074727 total: 1.21s remaining: 105ms
920: learn: 0.0074646 total: 1.21s remaining: 104ms
921: learn: 0.0074505 total: 1.21s remaining: 102ms
922: learn: 0.0074372 total: 1.21s remaining: 101ms
923: learn: 0.0074276 total: 1.21s remaining: 99.6ms
924: learn: 0.0074196 total: 1.21s remaining: 98.3ms

925: learn: 0.0074085 total: 1.21s remaining: 96.9ms
926: learn: 0.0074015 total: 1.21s remaining: 95.6ms
927: learn: 0.0073920 total: 1.21s remaining: 94.3ms
928: learn: 0.0073841 total: 1.22s remaining: 93ms
929: learn: 0.0073762 total: 1.22s remaining: 91.6ms
930: learn: 0.0073708 total: 1.22s remaining: 90.3ms
931: learn: 0.0073585 total: 1.22s remaining: 89ms
932: learn: 0.0073528 total: 1.22s remaining: 87.6ms
933: learn: 0.0073433 total: 1.22s remaining: 86.3ms
934: learn: 0.0073352 total: 1.22s remaining: 85ms
935: learn: 0.0073226 total: 1.22s remaining: 83.7ms
936: learn: 0.0073131 total: 1.22s remaining: 82.3ms
937: learn: 0.0072969 total: 1.23s remaining: 81ms
938: learn: 0.0072913 total: 1.23s remaining: 79.7ms
939: learn: 0.0072843 total: 1.23s remaining: 78.4ms
940: learn: 0.0072769 total: 1.23s remaining: 77ms
941: learn: 0.0072690 total: 1.23s remaining: 75.7ms
942: learn: 0.0072599 total: 1.23s remaining: 74.4ms
943: learn: 0.0072506 total: 1.23s remaining: 73.1ms
944: learn: 0.0072371 total: 1.23s remaining: 71.8ms
945: learn: 0.0072272 total: 1.23s remaining: 70.4ms
946: learn: 0.0072198 total: 1.23s remaining: 69.1ms
947: learn: 0.0072067 total: 1.24s remaining: 67.8ms
948: learn: 0.0071995 total: 1.24s remaining: 66.5ms
949: learn: 0.0071936 total: 1.24s remaining: 65.1ms
950: learn: 0.0071882 total: 1.24s remaining: 63.8ms
951: learn: 0.0071788 total: 1.24s remaining: 62.5ms
952: learn: 0.0071731 total: 1.24s remaining: 61.2ms
953: learn: 0.0071613 total: 1.24s remaining: 59.9ms
954: learn: 0.0071533 total: 1.24s remaining: 58.6ms
955: learn: 0.0071476 total: 1.24s remaining: 57.2ms
956: learn: 0.0071423 total: 1.24s remaining: 55.9ms
957: learn: 0.0071288 total: 1.25s remaining: 54.6ms
958: learn: 0.0071196 total: 1.25s remaining: 53.3ms
959: learn: 0.0071084 total: 1.25s remaining: 52ms
960: learn: 0.0070968 total: 1.25s remaining: 50.7ms
961: learn: 0.0070853 total: 1.25s remaining: 49.4ms
962: learn: 0.0070795 total: 1.25s remaining: 48.1ms
963: learn: 0.0070717 total: 1.25s remaining: 46.8ms
964: learn: 0.0070658 total: 1.25s remaining: 45.4ms
965: learn: 0.0070569 total: 1.25s remaining: 44.1ms
966: learn: 0.0070472 total: 1.25s remaining: 42.8ms
967: learn: 0.0070407 total: 1.26s remaining: 41.5ms
968: learn: 0.0070332 total: 1.26s remaining: 40.2ms
969: learn: 0.0070255 total: 1.26s remaining: 38.9ms
970: learn: 0.0070145 total: 1.26s remaining: 37.6ms
971: learn: 0.0070052 total: 1.26s remaining: 36.3ms
972: learn: 0.0069993 total: 1.26s remaining: 35ms
973: learn: 0.0069934 total: 1.26s remaining: 33.7ms
974: learn: 0.0069821 total: 1.26s remaining: 32.4ms
975: learn: 0.0069733 total: 1.26s remaining: 31.1ms
976: learn: 0.0069659 total: 1.26s remaining: 29.8ms
977: learn: 0.0069574 total: 1.26s remaining: 28.5ms
978: learn: 0.0069504 total: 1.27s remaining: 27.2ms
979: learn: 0.0069457 total: 1.27s remaining: 25.9ms
980: learn: 0.0069400 total: 1.27s remaining: 24.6ms
981: learn: 0.0069318 total: 1.27s remaining: 23.3ms
982: learn: 0.0069244 total: 1.27s remaining: 22ms
983: learn: 0.0069180 total: 1.27s remaining: 20.7ms
984: learn: 0.0069094 total: 1.27s remaining: 19.4ms
985: learn: 0.0069022 total: 1.27s remaining: 18.1ms
986: learn: 0.0068955 total: 1.27s remaining: 16.8ms
987: learn: 0.0068883 total: 1.27s remaining: 15.5ms
988: learn: 0.0068815 total: 1.28s remaining: 14.2ms
989: learn: 0.0068733 total: 1.28s remaining: 12.9ms
990: learn: 0.0068622 total: 1.28s remaining: 11.7ms
991: learn: 0.0068570 total: 1.29s remaining: 10.4ms
992: learn: 0.0068473 total: 1.29s remaining: 9.1ms
993: learn: 0.0068415 total: 1.29s remaining: 7.81ms
994: learn: 0.0068362 total: 1.3s remaining: 6.51ms
995: learn: 0.0068304 total: 1.3s remaining: 5.22ms
996: learn: 0.0068220 total: 1.3s remaining: 3.91ms

997: learn: 0.0068173 total: 1.3s remaining: 2.61ms
998: learn: 0.0068038 total: 1.3s remaining: 1.3ms
999: learn: 0.0067938 total: 1.3s remaining: 0us
Learning rate set to 0.080013
0: learn: 1.2493204 total: 1.14ms remaining: 1.14s
1: learn: 1.1534025 total: 2.19ms remaining: 1.09s
2: learn: 1.0540581 total: 3.09ms remaining: 1.03s
3: learn: 0.9849439 total: 4.13ms remaining: 1.03s
4: learn: 0.9157886 total: 5.14ms remaining: 1.02s
5: learn: 0.8594851 total: 6.33ms remaining: 1.05s
6: learn: 0.8083281 total: 7.38ms remaining: 1.05s
7: learn: 0.7626282 total: 8.12ms remaining: 1.01s
8: learn: 0.7124826 total: 9.32ms remaining: 1.03s
9: learn: 0.6785423 total: 10.3ms remaining: 1.02s
10: learn: 0.6438803 total: 11.4ms remaining: 1.02s
11: learn: 0.6123156 total: 12.4ms remaining: 1.02s
12: learn: 0.5816644 total: 13.6ms remaining: 1.03s
13: learn: 0.5520689 total: 14.6ms remaining: 1.03s
14: learn: 0.5248534 total: 15.7ms remaining: 1.03s
15: learn: 0.5021052 total: 16.8ms remaining: 1.03s
16: learn: 0.4804104 total: 17.9ms remaining: 1.03s
17: learn: 0.4593400 total: 19ms remaining: 1.04s
18: learn: 0.4383693 total: 20.1ms remaining: 1.04s
19: learn: 0.4206645 total: 21.1ms remaining: 1.03s
20: learn: 0.4041795 total: 22.2ms remaining: 1.03s
21: learn: 0.3911908 total: 23.2ms remaining: 1.03s
22: learn: 0.3754370 total: 24.3ms remaining: 1.03s
23: learn: 0.3645675 total: 25.4ms remaining: 1.03s
24: learn: 0.3515304 total: 26.4ms remaining: 1.03s
25: learn: 0.3404492 total: 27.4ms remaining: 1.03s
26: learn: 0.3300488 total: 28.6ms remaining: 1.03s
27: learn: 0.3215985 total: 29.9ms remaining: 1.04s
28: learn: 0.3130755 total: 30.9ms remaining: 1.04s
29: learn: 0.3051189 total: 32.1ms remaining: 1.04s
30: learn: 0.2961719 total: 33.2ms remaining: 1.04s
31: learn: 0.2877900 total: 34.3ms remaining: 1.04s
32: learn: 0.2800592 total: 35.3ms remaining: 1.03s
33: learn: 0.2728001 total: 36.4ms remaining: 1.03s
34: learn: 0.2665754 total: 37.5ms remaining: 1.03s
35: learn: 0.2606342 total: 38.7ms remaining: 1.04s
36: learn: 0.2553304 total: 39.9ms remaining: 1.04s
37: learn: 0.2497985 total: 41ms remaining: 1.04s
38: learn: 0.2441447 total: 42.1ms remaining: 1.04s
39: learn: 0.2395036 total: 43.2ms remaining: 1.04s
40: learn: 0.2342555 total: 44.3ms remaining: 1.03s
41: learn: 0.2289225 total: 45.4ms remaining: 1.03s
42: learn: 0.2239197 total: 46.6ms remaining: 1.04s
43: learn: 0.2203312 total: 47.6ms remaining: 1.03s
44: learn: 0.2152303 total: 48.7ms remaining: 1.03s
45: learn: 0.2110448 total: 49.8ms remaining: 1.03s
46: learn: 0.2066799 total: 50.8ms remaining: 1.03s
47: learn: 0.2022984 total: 51.9ms remaining: 1.03s
48: learn: 0.1982383 total: 53ms remaining: 1.03s
49: learn: 0.1950670 total: 54ms remaining: 1.02s
50: learn: 0.1916145 total: 55.1ms remaining: 1.02s
51: learn: 0.1890418 total: 56.2ms remaining: 1.02s
52: learn: 0.1855568 total: 57.2ms remaining: 1.02s
53: learn: 0.1823492 total: 58.3ms remaining: 1.02s
54: learn: 0.1793778 total: 59.3ms remaining: 1.02s
55: learn: 0.1763596 total: 60.3ms remaining: 1.02s
56: learn: 0.1746818 total: 61ms remaining: 1.01s
57: learn: 0.1724007 total: 62.2ms remaining: 1.01s
58: learn: 0.1696695 total: 63.2ms remaining: 1.01s
59: learn: 0.1671619 total: 64.3ms remaining: 1.01s
60: learn: 0.1647321 total: 65.3ms remaining: 1s
61: learn: 0.1629667 total: 66.3ms remaining: 1s
62: learn: 0.1605544 total: 67.4ms remaining: 1s
63: learn: 0.1576947 total: 68.4ms remaining: 1s
64: learn: 0.1552886 total: 69.5ms remaining: 1s
65: learn: 0.1530398 total: 70.6ms remaining: 999ms
66: learn: 0.1508759 total: 71.7ms remaining: 999ms
67: learn: 0.1485116 total: 72.7ms remaining: 997ms

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68: learn: 0.1460884 total: 73.9ms remaining: 998ms
69: learn: 0.1443407 total: 74.9ms remaining: 995ms
70: learn: 0.1423923 total: 75.9ms remaining: 994ms
71: learn: 0.1408571 total: 77ms remaining: 992ms
72: learn: 0.1390969 total: 78ms remaining: 991ms
73: learn: 0.1374356 total: 79.1ms remaining: 990ms
74: learn: 0.1357588 total: 80.3ms remaining: 991ms
75: learn: 0.1347395 total: 81.1ms remaining: 986ms
76: learn: 0.1326820 total: 82.1ms remaining: 984ms
77: learn: 0.1306058 total: 83.2ms remaining: 983ms
78: learn: 0.1288129 total: 84.2ms remaining: 982ms
79: learn: 0.1274516 total: 85.3ms remaining: 981ms
80: learn: 0.1259295 total: 86.4ms remaining: 980ms
81: learn: 0.1246523 total: 87.5ms remaining: 980ms
82: learn: 0.1233541 total: 88.7ms remaining: 980ms
83: learn: 0.1218854 total: 89.7ms remaining: 978ms
84: learn: 0.1205013 total: 90.7ms remaining: 977ms
85: learn: 0.1190951 total: 92.1ms remaining: 979ms
86: learn: 0.1178547 total: 93.2ms remaining: 978ms
87: learn: 0.1168513 total: 94.4ms remaining: 978ms
88: learn: 0.1156390 total: 95.4ms remaining: 976ms
89: learn: 0.1147447 total: 96.3ms remaining: 974ms
90: learn: 0.1129961 total: 97.3ms remaining: 972ms
91: learn: 0.1119955 total: 98.3ms remaining: 971ms
92: learn: 0.1106978 total: 99.4ms remaining: 969ms
93: learn: 0.1095271 total: 100ms remaining: 968ms
94: learn: 0.1086249 total: 101ms remaining: 966ms
95: learn: 0.1073862 total: 102ms remaining: 965ms
96: learn: 0.1062340 total: 103ms remaining: 963ms
97: learn: 0.1048651 total: 106ms remaining: 971ms
98: learn: 0.1038846 total: 107ms remaining: 977ms
99: learn: 0.1027184 total: 109ms remaining: 983ms
100: learn: 0.1016656 total: 110ms remaining: 983ms
101: learn: 0.1006724 total: 112ms remaining: 984ms
102: learn: 0.0996278 total: 117ms remaining: 1.02s
103: learn: 0.0984527 total: 121ms remaining: 1.04s
104: learn: 0.0976539 total: 131ms remaining: 1.12s
105: learn: 0.0965218 total: 134ms remaining: 1.13s
106: learn: 0.0957642 total: 136ms remaining: 1.13s
107: learn: 0.0948203 total: 137ms remaining: 1.13s
108: learn: 0.0939157 total: 138ms remaining: 1.13s
109: learn: 0.0927831 total: 139ms remaining: 1.12s
110: learn: 0.0919486 total: 140ms remaining: 1.12s
111: learn: 0.0907559 total: 141ms remaining: 1.12s
112: learn: 0.0900316 total: 142ms remaining: 1.11s
113: learn: 0.0892594 total: 143ms remaining: 1.11s
114: learn: 0.0884874 total: 144ms remaining: 1.11s
115: learn: 0.0875680 total: 145ms remaining: 1.1s
116: learn: 0.0866824 total: 146ms remaining: 1.1s
117: learn: 0.0858884 total: 147ms remaining: 1.1s
118: learn: 0.0851567 total: 148ms remaining: 1.1s
119: learn: 0.0844588 total: 149ms remaining: 1.09s
120: learn: 0.0838430 total: 150ms remaining: 1.09s
121: learn: 0.0831850 total: 151ms remaining: 1.09s
122: learn: 0.0826608 total: 152ms remaining: 1.08s
123: learn: 0.0819399 total: 153ms remaining: 1.08s
124: learn: 0.0811782 total: 154ms remaining: 1.08s
125: learn: 0.0803995 total: 155ms remaining: 1.08s
126: learn: 0.0795020 total: 156ms remaining: 1.07s
127: learn: 0.0788453 total: 157ms remaining: 1.07s
128: learn: 0.0781645 total: 158ms remaining: 1.07s
129: learn: 0.0776350 total: 159ms remaining: 1.07s
130: learn: 0.0768176 total: 161ms remaining: 1.06s
131: learn: 0.0759969 total: 162ms remaining: 1.06s
132: learn: 0.0752082 total: 163ms remaining: 1.06s
133: learn: 0.0746918 total: 164ms remaining: 1.06s
134: learn: 0.0741279 total: 165ms remaining: 1.05s
135: learn: 0.0735959 total: 166ms remaining: 1.05s
136: learn: 0.0730806 total: 167ms remaining: 1.05s
137: learn: 0.0726055 total: 168ms remaining: 1.05s
138: learn: 0.0718767 total: 169ms remaining: 1.04s
139: learn: 0.0711428 total: 170ms remaining: 1.04s
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140: learn: 0.0704728 total: 171ms remaining: 1.04s
141: learn: 0.0699365 total: 172ms remaining: 1.04s
142: learn: 0.0693630 total: 173ms remaining: 1.04s
143: learn: 0.0688674 total: 174ms remaining: 1.03s
144: learn: 0.0684423 total: 175ms remaining: 1.03s
145: learn: 0.0680356 total: 176ms remaining: 1.03s
146: learn: 0.0673754 total: 177ms remaining: 1.03s
147: learn: 0.0667547 total: 178ms remaining: 1.02s
148: learn: 0.0663308 total: 179ms remaining: 1.02s
149: learn: 0.0659767 total: 181ms remaining: 1.03s
150: learn: 0.0655107 total: 182ms remaining: 1.03s
151: learn: 0.0650109 total: 184ms remaining: 1.02s
152: learn: 0.0646731 total: 185ms remaining: 1.02s
153: learn: 0.0643478 total: 186ms remaining: 1.02s
154: learn: 0.0640034 total: 193ms remaining: 1.05s
155: learn: 0.0635810 total: 194ms remaining: 1.05s
156: learn: 0.0630322 total: 198ms remaining: 1.06s
157: learn: 0.0625034 total: 199ms remaining: 1.06s
158: learn: 0.0620319 total: 200ms remaining: 1.06s
159: learn: 0.0616142 total: 201ms remaining: 1.05s
160: learn: 0.0611238 total: 202ms remaining: 1.05s
161: learn: 0.0607284 total: 203ms remaining: 1.05s
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163: learn: 0.0598660 total: 205ms remaining: 1.05s
164: learn: 0.0594664 total: 206ms remaining: 1.04s
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166: learn: 0.0585877 total: 208ms remaining: 1.04s
167: learn: 0.0580867 total: 209ms remaining: 1.04s
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169: learn: 0.0573870 total: 212ms remaining: 1.03s
170: learn: 0.0570078 total: 213ms remaining: 1.03s
171: learn: 0.0566919 total: 214ms remaining: 1.03s
172: learn: 0.0562222 total: 215ms remaining: 1.03s
173: learn: 0.0558649 total: 217ms remaining: 1.03s
174: learn: 0.0552998 total: 218ms remaining: 1.03s
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178: learn: 0.0540749 total: 222ms remaining: 1.02s
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180: learn: 0.0533212 total: 225ms remaining: 1.02s
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182: learn: 0.0525828 total: 227ms remaining: 1.01s
183: learn: 0.0523517 total: 228ms remaining: 1.01s
184: learn: 0.0519574 total: 230ms remaining: 1.01s
185: learn: 0.0516515 total: 231ms remaining: 1.01s
186: learn: 0.0514319 total: 232ms remaining: 1.01s
187: learn: 0.0511368 total: 233ms remaining: 1.01s
188: learn: 0.0508254 total: 234ms remaining: 1s
189: learn: 0.0505818 total: 236ms remaining: 1s
190: learn: 0.0502030 total: 237ms remaining: 1s
191: learn: 0.0498328 total: 238ms remaining: 1s
192: learn: 0.0496072 total: 239ms remaining: 998ms
193: learn: 0.0494152 total: 240ms remaining: 996ms
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207: learn: 0.0456432 total: 257ms remaining: 977ms
208: learn: 0.0453073 total: 258ms remaining: 975ms
209: learn: 0.0451313 total: 259ms remaining: 974ms
210: learn: 0.0448576 total: 260ms remaining: 973ms
211: learn: 0.0446569 total: 261ms remaining: 971ms
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212: learn: 0.0444171 total: 262ms remaining: 970ms
213: learn: 0.0442503 total: 264ms remaining: 969ms
214: learn: 0.0439150 total: 265ms remaining: 968ms
215: learn: 0.0436079 total: 266ms remaining: 966ms
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218: learn: 0.0429243 total: 274ms remaining: 977ms
219: learn: 0.0426402 total: 275ms remaining: 975ms
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925: learn: 0.0073750 total: 1.17s remaining: 93.2ms
926: learn: 0.0073697 total: 1.17s remaining: 91.9ms
927: learn: 0.0073630 total: 1.17s remaining: 90.7ms
928: learn: 0.0073501 total: 1.17s remaining: 89.4ms
929: learn: 0.0073370 total: 1.17s remaining: 88.1ms
930: learn: 0.0073301 total: 1.17s remaining: 86.8ms
931: learn: 0.0073191 total: 1.17s remaining: 85.6ms

932: learn: 0.0073064 total: 1.17s remaining: 84.3ms
933: learn: 0.0073021 total: 1.17s remaining: 83ms
934: learn: 0.0072963 total: 1.18s remaining: 81.8ms
935: learn: 0.0072865 total: 1.18s remaining: 80.5ms
936: learn: 0.0072775 total: 1.18s remaining: 79.2ms
937: learn: 0.0072629 total: 1.18s remaining: 77.9ms
938: learn: 0.0072493 total: 1.18s remaining: 76.7ms
939: learn: 0.0072436 total: 1.18s remaining: 75.4ms
940: learn: 0.0072340 total: 1.18s remaining: 74.1ms
941: learn: 0.0072259 total: 1.18s remaining: 72.8ms
942: learn: 0.0072196 total: 1.18s remaining: 71.6ms
943: learn: 0.0072104 total: 1.18s remaining: 70.3ms
944: learn: 0.0072017 total: 1.19s remaining: 69ms
945: learn: 0.0071881 total: 1.19s remaining: 67.8ms
946: learn: 0.0071799 total: 1.19s remaining: 66.5ms
947: learn: 0.0071736 total: 1.19s remaining: 65.2ms
948: learn: 0.0071684 total: 1.19s remaining: 63.9ms
949: learn: 0.0071613 total: 1.19s remaining: 62.7ms
950: learn: 0.0071562 total: 1.19s remaining: 61.4ms
951: learn: 0.0071482 total: 1.19s remaining: 60.1ms
952: learn: 0.0071405 total: 1.19s remaining: 58.9ms
953: learn: 0.0071350 total: 1.19s remaining: 57.6ms
954: learn: 0.0071225 total: 1.2s remaining: 56.4ms
955: learn: 0.0071144 total: 1.2s remaining: 55.1ms
956: learn: 0.0071079 total: 1.2s remaining: 53.8ms
957: learn: 0.0071031 total: 1.21s remaining: 52.9ms
958: learn: 0.0070890 total: 1.21s remaining: 51.7ms
959: learn: 0.0070818 total: 1.21s remaining: 50.5ms
960: learn: 0.0070756 total: 1.21s remaining: 49.2ms
961: learn: 0.0070648 total: 1.21s remaining: 47.9ms
962: learn: 0.0070499 total: 1.21s remaining: 46.6ms
963: learn: 0.0070452 total: 1.21s remaining: 45.4ms
964: learn: 0.0070358 total: 1.22s remaining: 44.1ms
965: learn: 0.0070286 total: 1.22s remaining: 42.8ms
966: learn: 0.0070232 total: 1.22s remaining: 41.6ms
967: learn: 0.0070145 total: 1.22s remaining: 40.3ms
968: learn: 0.0070067 total: 1.22s remaining: 39ms
969: learn: 0.0070004 total: 1.22s remaining: 37.8ms
970: learn: 0.0069926 total: 1.22s remaining: 36.5ms
971: learn: 0.0069843 total: 1.22s remaining: 35.2ms
972: learn: 0.0069745 total: 1.22s remaining: 34ms
973: learn: 0.0069668 total: 1.23s remaining: 32.7ms
974: learn: 0.0069592 total: 1.23s remaining: 31.4ms
975: learn: 0.0069438 total: 1.23s remaining: 30.2ms
976: learn: 0.0069374 total: 1.23s remaining: 28.9ms
977: learn: 0.0069295 total: 1.23s remaining: 27.6ms
978: learn: 0.0069215 total: 1.23s remaining: 26.4ms
979: learn: 0.0069052 total: 1.23s remaining: 25.1ms
980: learn: 0.0068957 total: 1.23s remaining: 23.9ms
981: learn: 0.0068864 total: 1.23s remaining: 22.6ms
982: learn: 0.0068763 total: 1.23s remaining: 21.3ms
983: learn: 0.0068696 total: 1.24s remaining: 20.1ms
984: learn: 0.0068636 total: 1.24s remaining: 18.8ms
985: learn: 0.0068553 total: 1.24s remaining: 17.6ms
986: learn: 0.0068446 total: 1.24s remaining: 16.3ms
987: learn: 0.0068332 total: 1.24s remaining: 15.1ms
988: learn: 0.0068251 total: 1.24s remaining: 13.8ms
989: learn: 0.0068182 total: 1.24s remaining: 12.5ms
990: learn: 0.0068122 total: 1.24s remaining: 11.3ms
991: learn: 0.0068037 total: 1.24s remaining: 10ms
992: learn: 0.0067960 total: 1.24s remaining: 8.77ms
993: learn: 0.0067878 total: 1.25s remaining: 7.52ms
994: learn: 0.0067772 total: 1.25s remaining: 6.26ms
995: learn: 0.0067696 total: 1.25s remaining: 5.01ms
996: learn: 0.0067646 total: 1.25s remaining: 3.75ms
997: learn: 0.0067565 total: 1.25s remaining: 2.5ms
998: learn: 0.0067504 total: 1.25s remaining: 1.25ms
999: learn: 0.0067401 total: 1.25s remaining: 0us
Learning rate set to 0.080013
0: learn: 1.2481013 total: 1.07ms remaining: 1.07s
1: learn: 1.1535964 total: 2.21ms remaining: 1.1s
2: learn: 1.0556747 total: 3.15ms remaining: 1.05s

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3: learn: 0.9874263 total: 4.16ms remaining: 1.04s
4: learn: 0.9190266 total: 5.23ms remaining: 1.04s
5: learn: 0.8651064 total: 6.29ms remaining: 1.04s
6: learn: 0.8157844 total: 7.33ms remaining: 1.04s
7: learn: 0.7707766 total: 8.09ms remaining: 1s
8: learn: 0.7188589 total: 9.13ms remaining: 1s
9: learn: 0.6837185 total: 10ms remaining: 994ms
10: learn: 0.6415571 total: 11.1ms remaining: 996ms
11: learn: 0.6114013 total: 12.1ms remaining: 996ms
12: learn: 0.5846659 total: 12.9ms remaining: 980ms
13: learn: 0.5546291 total: 13.9ms remaining: 982ms
14: learn: 0.5298088 total: 15ms remaining: 983ms
15: learn: 0.5079909 total: 15.9ms remaining: 981ms
16: learn: 0.4821831 total: 17ms remaining: 983ms
17: learn: 0.4643301 total: 18ms remaining: 984ms
18: learn: 0.4479652 total: 19.1ms remaining: 984ms
19: learn: 0.4329515 total: 20.1ms remaining: 983ms
20: learn: 0.4170341 total: 21.1ms remaining: 984ms
21: learn: 0.3992415 total: 22.1ms remaining: 984ms
22: learn: 0.3839301 total: 23.3ms remaining: 992ms
23: learn: 0.3719668 total: 24.4ms remaining: 992ms
24: learn: 0.3613639 total: 25.4ms remaining: 992ms
25: learn: 0.3493617 total: 26.5ms remaining: 991ms
26: learn: 0.3372393 total: 27.5ms remaining: 990ms
27: learn: 0.3252386 total: 28.5ms remaining: 989ms
28: learn: 0.3145975 total: 29.7ms remaining: 994ms
29: learn: 0.3039820 total: 30.9ms remaining: 1000ms
30: learn: 0.2949162 total: 32ms remaining: 999ms
31: learn: 0.2866796 total: 33ms remaining: 999ms
32: learn: 0.2789778 total: 34.2ms remaining: 1s
33: learn: 0.2718689 total: 35.3ms remaining: 1s
34: learn: 0.2660329 total: 36.3ms remaining: 1s
35: learn: 0.2600418 total: 37.3ms remaining: 999ms
36: learn: 0.2545926 total: 38.3ms remaining: 997ms
37: learn: 0.2491559 total: 39.3ms remaining: 995ms
38: learn: 0.2429871 total: 40.4ms remaining: 994ms
39: learn: 0.2382046 total: 41.4ms remaining: 993ms
40: learn: 0.2330311 total: 42.4ms remaining: 992ms
41: learn: 0.2286356 total: 43.4ms remaining: 990ms
42: learn: 0.2241373 total: 44.4ms remaining: 989ms
43: learn: 0.2200218 total: 45.5ms remaining: 988ms
44: learn: 0.2152360 total: 46.5ms remaining: 987ms
45: learn: 0.2114426 total: 47.5ms remaining: 986ms
46: learn: 0.2079795 total: 48.5ms remaining: 984ms
47: learn: 0.2042313 total: 49.6ms remaining: 983ms
48: learn: 0.2004317 total: 50.6ms remaining: 982ms
49: learn: 0.1961423 total: 51.6ms remaining: 981ms
50: learn: 0.1923317 total: 52.6ms remaining: 979ms
51: learn: 0.1894078 total: 53.7ms remaining: 979ms
52: learn: 0.1860114 total: 54.7ms remaining: 977ms
53: learn: 0.1832858 total: 55.7ms remaining: 976ms
54: learn: 0.1801280 total: 56.7ms remaining: 975ms
55: learn: 0.1766202 total: 57.8ms remaining: 974ms
56: learn: 0.1744202 total: 58.8ms remaining: 972ms
57: learn: 0.1719583 total: 59.8ms remaining: 971ms
58: learn: 0.1702608 total: 60.5ms remaining: 965ms
59: learn: 0.1684268 total: 61.5ms remaining: 964ms
60: learn: 0.1651455 total: 62.6ms remaining: 963ms
61: learn: 0.1624037 total: 63.7ms remaining: 963ms
62: learn: 0.1603899 total: 64.9ms remaining: 965ms
63: learn: 0.1584409 total: 66.1ms remaining: 967ms
64: learn: 0.1563758 total: 67.2ms remaining: 966ms
65: learn: 0.1538882 total: 68.2ms remaining: 965ms
66: learn: 0.1511877 total: 69.2ms remaining: 964ms
67: learn: 0.1484444 total: 70.3ms remaining: 963ms
68: learn: 0.1458125 total: 71.3ms remaining: 962ms
69: learn: 0.1440971 total: 72.4ms remaining: 961ms
70: learn: 0.1424134 total: 73.4ms remaining: 960ms
71: learn: 0.1409528 total: 74.4ms remaining: 959ms
72: learn: 0.1389323 total: 75.4ms remaining: 958ms
73: learn: 0.1366520 total: 76.5ms remaining: 958ms
74: learn: 0.1346863 total: 77.6ms remaining: 956ms
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75: learn: 0.1332245 total: 78.6ms remaining: 955ms
76: learn: 0.1314884 total: 79.6ms remaining: 954ms
77: learn: 0.1297851 total: 80.6ms remaining: 953ms
78: learn: 0.1282553 total: 81.6ms remaining: 952ms
79: learn: 0.1261927 total: 83.9ms remaining: 965ms
80: learn: 0.1248911 total: 85.2ms remaining: 967ms
81: learn: 0.1234227 total: 86.9ms remaining: 973ms
82: learn: 0.1217366 total: 88.6ms remaining: 979ms
83: learn: 0.1203770 total: 90ms remaining: 981ms
84: learn: 0.1191290 total: 91.3ms remaining: 983ms
85: learn: 0.1177280 total: 94.8ms remaining: 1.01s
86: learn: 0.1164597 total: 95.9ms remaining: 1.01s
87: learn: 0.1149439 total: 97ms remaining: 1s
88: learn: 0.1131130 total: 98ms remaining: 1s
89: learn: 0.1117586 total: 99ms remaining: 1s
90: learn: 0.1102177 total: 100ms remaining: 999ms
91: learn: 0.1092088 total: 101ms remaining: 997ms
92: learn: 0.1080582 total: 102ms remaining: 996ms
93: learn: 0.1066177 total: 103ms remaining: 994ms
94: learn: 0.1055996 total: 104ms remaining: 992ms
95: learn: 0.1046227 total: 105ms remaining: 991ms
96: learn: 0.1034785 total: 106ms remaining: 989ms
97: learn: 0.1022034 total: 107ms remaining: 987ms
98: learn: 0.1012631 total: 108ms remaining: 985ms
99: learn: 0.1001816 total: 109ms remaining: 983ms
100: learn: 0.0992301 total: 110ms remaining: 982ms
101: learn: 0.0982055 total: 111ms remaining: 980ms
102: learn: 0.0969316 total: 112ms remaining: 978ms
103: learn: 0.0958325 total: 114ms remaining: 978ms
104: learn: 0.0948791 total: 115ms remaining: 976ms
105: learn: 0.0939500 total: 116ms remaining: 975ms
106: learn: 0.0931138 total: 117ms remaining: 973ms
107: learn: 0.0920019 total: 118ms remaining: 971ms
108: learn: 0.0908753 total: 119ms remaining: 970ms
109: learn: 0.0900560 total: 120ms remaining: 968ms
110: learn: 0.0893613 total: 121ms remaining: 967ms
111: learn: 0.0883094 total: 122ms remaining: 966ms
112: learn: 0.0876336 total: 123ms remaining: 964ms
113: learn: 0.0868222 total: 124ms remaining: 962ms
114: learn: 0.0860748 total: 125ms remaining: 961ms
115: learn: 0.0854225 total: 126ms remaining: 961ms
116: learn: 0.0848620 total: 127ms remaining: 959ms
117: learn: 0.0840755 total: 128ms remaining: 958ms
118: learn: 0.0834105 total: 129ms remaining: 956ms
119: learn: 0.0823124 total: 130ms remaining: 954ms
120: learn: 0.0817072 total: 131ms remaining: 953ms
121: learn: 0.0810671 total: 132ms remaining: 951ms
122: learn: 0.0805091 total: 133ms remaining: 950ms
123: learn: 0.0798667 total: 134ms remaining: 948ms
124: learn: 0.0793365 total: 135ms remaining: 947ms
125: learn: 0.0784524 total: 136ms remaining: 945ms
126: learn: 0.0777999 total: 137ms remaining: 944ms
127: learn: 0.0771821 total: 138ms remaining: 943ms
128: learn: 0.0765283 total: 140ms remaining: 942ms
129: learn: 0.0760803 total: 141ms remaining: 941ms
130: learn: 0.0751150 total: 142ms remaining: 939ms
131: learn: 0.0747053 total: 143ms remaining: 938ms
132: learn: 0.0739143 total: 144ms remaining: 936ms
133: learn: 0.0733076 total: 145ms remaining: 936ms
134: learn: 0.0726955 total: 146ms remaining: 935ms
135: learn: 0.0722307 total: 147ms remaining: 933ms
136: learn: 0.0715466 total: 148ms remaining: 932ms
137: learn: 0.0710974 total: 149ms remaining: 930ms
138: learn: 0.0704790 total: 150ms remaining: 929ms
139: learn: 0.0699812 total: 151ms remaining: 928ms
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141: learn: 0.0689627 total: 153ms remaining: 925ms
142: learn: 0.0684284 total: 154ms remaining: 923ms
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144: learn: 0.0674563 total: 156ms remaining: 920ms
145: learn: 0.0670674 total: 157ms remaining: 919ms
146: learn: 0.0666548 total: 158ms remaining: 917ms
```

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147: learn: 0.0659975 total: 159ms remaining: 917ms
148: learn: 0.0655543 total: 160ms remaining: 915ms
149: learn: 0.0651408 total: 161ms remaining: 914ms
150: learn: 0.0646457 total: 162ms remaining: 913ms
151: learn: 0.0641860 total: 163ms remaining: 911ms
152: learn: 0.0637279 total: 164ms remaining: 910ms
153: learn: 0.0632704 total: 165ms remaining: 908ms
154: learn: 0.0629069 total: 166ms remaining: 907ms
155: learn: 0.0624901 total: 167ms remaining: 906ms
156: learn: 0.0621674 total: 168ms remaining: 905ms
157: learn: 0.0617175 total: 169ms remaining: 903ms
158: learn: 0.0613641 total: 171ms remaining: 904ms
159: learn: 0.0609723 total: 172ms remaining: 903ms
160: learn: 0.0605722 total: 173ms remaining: 901ms
161: learn: 0.0601398 total: 174ms remaining: 900ms
162: learn: 0.0597980 total: 175ms remaining: 898ms
163: learn: 0.0591753 total: 176ms remaining: 898ms
164: learn: 0.0587730 total: 177ms remaining: 897ms
165: learn: 0.0581527 total: 178ms remaining: 895ms
166: learn: 0.0577958 total: 179ms remaining: 894ms
167: learn: 0.0572589 total: 181ms remaining: 898ms
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169: learn: 0.0565474 total: 185ms remaining: 902ms
170: learn: 0.0561584 total: 186ms remaining: 904ms
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172: learn: 0.0553600 total: 190ms remaining: 906ms
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178: learn: 0.0529712 total: 202ms remaining: 928ms
179: learn: 0.0526592 total: 203ms remaining: 927ms
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189: learn: 0.0492830 total: 214ms remaining: 911ms
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192: learn: 0.0483060 total: 217ms remaining: 907ms
193: learn: 0.0481018 total: 218ms remaining: 906ms
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196: learn: 0.0472777 total: 221ms remaining: 901ms
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199: learn: 0.0465936 total: 224ms remaining: 897ms
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213: learn: 0.0433495 total: 239ms remaining: 877ms
214: learn: 0.0431274 total: 240ms remaining: 875ms
215: learn: 0.0429168 total: 241ms remaining: 874ms
216: learn: 0.0427584 total: 242ms remaining: 873ms
217: learn: 0.0425616 total: 243ms remaining: 872ms
218: learn: 0.0423183 total: 244ms remaining: 871ms
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219: learn: 0.0420251 total: 245ms remaining: 870ms
220: learn: 0.0416977 total: 246ms remaining: 869ms
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233: learn: 0.0388289 total: 261ms remaining: 853ms
234: learn: 0.0385566 total: 262ms remaining: 852ms
235: learn: 0.0383881 total: 263ms remaining: 851ms
236: learn: 0.0380851 total: 264ms remaining: 849ms
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239: learn: 0.0374436 total: 267ms remaining: 845ms
240: learn: 0.0372582 total: 268ms remaining: 844ms
241: learn: 0.0370453 total: 269ms remaining: 843ms
242: learn: 0.0368862 total: 270ms remaining: 842ms
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271: learn: 0.0321624 total: 311ms remaining: 832ms
272: learn: 0.0319570 total: 312ms remaining: 830ms
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276: learn: 0.0314526 total: 316ms remaining: 824ms
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282: learn: 0.0306608 total: 322ms remaining: 817ms
283: learn: 0.0304743 total: 323ms remaining: 815ms
284: learn: 0.0303250 total: 324ms remaining: 814ms
285: learn: 0.0302086 total: 326ms remaining: 813ms
286: learn: 0.0300658 total: 327ms remaining: 811ms
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288: learn: 0.0297514 total: 329ms remaining: 809ms
289: learn: 0.0296377 total: 330ms remaining: 808ms
290: learn: 0.0295021 total: 331ms remaining: 806ms
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291: learn: 0.0294239 total: 332ms remaining: 805ms
292: learn: 0.0293033 total: 333ms remaining: 804ms
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297: learn: 0.0286520 total: 338ms remaining: 797ms
298: learn: 0.0285454 total: 339ms remaining: 796ms
299: learn: 0.0284680 total: 341ms remaining: 795ms
300: learn: 0.0283588 total: 342ms remaining: 793ms
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306: learn: 0.0277415 total: 348ms remaining: 786ms
307: learn: 0.0276209 total: 350ms remaining: 785ms
308: learn: 0.0274309 total: 351ms remaining: 784ms
309: learn: 0.0273442 total: 352ms remaining: 783ms
310: learn: 0.0272392 total: 353ms remaining: 781ms
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722: learn: 0.0096103 total: 842ms remaining: 323ms

723: learn: 0.0095878 total: 843ms remaining: 322ms
724: learn: 0.0095753 total: 844ms remaining: 320ms
725: learn: 0.0095583 total: 846ms remaining: 319ms
726: learn: 0.0095470 total: 847ms remaining: 318ms
727: learn: 0.0095269 total: 848ms remaining: 317ms
728: learn: 0.0095089 total: 848ms remaining: 315ms
729: learn: 0.0095014 total: 849ms remaining: 314ms
730: learn: 0.0094927 total: 851ms remaining: 313ms
731: learn: 0.0094760 total: 852ms remaining: 312ms
732: learn: 0.0094510 total: 853ms remaining: 311ms
733: learn: 0.0094192 total: 854ms remaining: 309ms
734: learn: 0.0094050 total: 855ms remaining: 308ms
735: learn: 0.0093956 total: 856ms remaining: 307ms
736: learn: 0.0093784 total: 857ms remaining: 306ms
737: learn: 0.0093654 total: 858ms remaining: 305ms
738: learn: 0.0093553 total: 859ms remaining: 303ms
739: learn: 0.0093354 total: 860ms remaining: 302ms
740: learn: 0.0093161 total: 861ms remaining: 301ms
741: learn: 0.0092998 total: 862ms remaining: 300ms
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743: learn: 0.0092754 total: 864ms remaining: 297ms
744: learn: 0.0092657 total: 865ms remaining: 296ms
745: learn: 0.0092397 total: 866ms remaining: 295ms
746: learn: 0.0092144 total: 867ms remaining: 294ms
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749: learn: 0.0091631 total: 870ms remaining: 290ms
750: learn: 0.0091431 total: 871ms remaining: 289ms
751: learn: 0.0091210 total: 872ms remaining: 288ms
752: learn: 0.0091096 total: 873ms remaining: 286ms
753: learn: 0.0090958 total: 874ms remaining: 285ms
754: learn: 0.0090796 total: 875ms remaining: 284ms
755: learn: 0.0090627 total: 876ms remaining: 283ms
756: learn: 0.0090488 total: 877ms remaining: 282ms
757: learn: 0.0090285 total: 878ms remaining: 280ms
758: learn: 0.0090160 total: 879ms remaining: 279ms
759: learn: 0.0090067 total: 880ms remaining: 278ms
760: learn: 0.0089889 total: 881ms remaining: 277ms
761: learn: 0.0089805 total: 882ms remaining: 276ms
762: learn: 0.0089673 total: 883ms remaining: 274ms
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765: learn: 0.0089253 total: 886ms remaining: 271ms
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767: learn: 0.0089039 total: 889ms remaining: 268ms
768: learn: 0.0088952 total: 890ms remaining: 267ms
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770: learn: 0.0088688 total: 892ms remaining: 265ms
771: learn: 0.0088582 total: 893ms remaining: 264ms
772: learn: 0.0088482 total: 894ms remaining: 262ms
773: learn: 0.0088375 total: 895ms remaining: 261ms
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775: learn: 0.0088123 total: 897ms remaining: 259ms
776: learn: 0.0087976 total: 900ms remaining: 258ms
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778: learn: 0.0087682 total: 903ms remaining: 256ms
779: learn: 0.0087566 total: 907ms remaining: 256ms
780: learn: 0.0087382 total: 909ms remaining: 255ms
781: learn: 0.0087172 total: 912ms remaining: 254ms
782: learn: 0.0086935 total: 913ms remaining: 253ms
783: learn: 0.0086832 total: 914ms remaining: 252ms
784: learn: 0.0086675 total: 915ms remaining: 251ms
785: learn: 0.0086605 total: 916ms remaining: 250ms
786: learn: 0.0086478 total: 917ms remaining: 248ms
787: learn: 0.0086389 total: 918ms remaining: 247ms
788: learn: 0.0086160 total: 920ms remaining: 246ms
789: learn: 0.0086068 total: 921ms remaining: 245ms
790: learn: 0.0085958 total: 922ms remaining: 244ms
791: learn: 0.0085860 total: 923ms remaining: 242ms
792: learn: 0.0085723 total: 924ms remaining: 241ms
793: learn: 0.0085626 total: 925ms remaining: 240ms
794: learn: 0.0085457 total: 926ms remaining: 239ms

795: learn: 0.0085327 total: 927ms remaining: 238ms
796: learn: 0.0085191 total: 928ms remaining: 236ms
797: learn: 0.0085112 total: 929ms remaining: 235ms
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801: learn: 0.0084557 total: 934ms remaining: 231ms
802: learn: 0.0084400 total: 935ms remaining: 229ms
803: learn: 0.0084315 total: 936ms remaining: 228ms
804: learn: 0.0084197 total: 937ms remaining: 227ms
805: learn: 0.0084090 total: 938ms remaining: 226ms
806: learn: 0.0084019 total: 939ms remaining: 225ms
807: learn: 0.0083881 total: 940ms remaining: 223ms
808: learn: 0.0083738 total: 941ms remaining: 222ms
809: learn: 0.0083628 total: 942ms remaining: 221ms
810: learn: 0.0083543 total: 944ms remaining: 220ms
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812: learn: 0.0083278 total: 946ms remaining: 218ms
813: learn: 0.0083205 total: 947ms remaining: 216ms
814: learn: 0.0083137 total: 948ms remaining: 215ms
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816: learn: 0.0082924 total: 950ms remaining: 213ms
817: learn: 0.0082798 total: 951ms remaining: 212ms
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819: learn: 0.0082590 total: 953ms remaining: 209ms
820: learn: 0.0082465 total: 954ms remaining: 208ms
821: learn: 0.0082361 total: 955ms remaining: 207ms
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823: learn: 0.0082156 total: 958ms remaining: 205ms
824: learn: 0.0082091 total: 959ms remaining: 203ms
825: learn: 0.0081905 total: 960ms remaining: 202ms
826: learn: 0.0081834 total: 961ms remaining: 201ms
827: learn: 0.0081742 total: 962ms remaining: 200ms
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829: learn: 0.0081492 total: 966ms remaining: 198ms
830: learn: 0.0081327 total: 967ms remaining: 197ms
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832: learn: 0.0081098 total: 969ms remaining: 194ms
833: learn: 0.0081026 total: 970ms remaining: 193ms
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840: learn: 0.0080232 total: 977ms remaining: 185ms
841: learn: 0.0080112 total: 978ms remaining: 183ms
842: learn: 0.0079996 total: 979ms remaining: 182ms
843: learn: 0.0079887 total: 980ms remaining: 181ms
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847: learn: 0.0079501 total: 984ms remaining: 176ms
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849: learn: 0.0079322 total: 988ms remaining: 174ms
850: learn: 0.0079144 total: 990ms remaining: 173ms
851: learn: 0.0079013 total: 991ms remaining: 172ms
852: learn: 0.0078898 total: 994ms remaining: 171ms
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854: learn: 0.0078707 total: 999ms remaining: 170ms
855: learn: 0.0078562 total: 1s remaining: 169ms
856: learn: 0.0078422 total: 1s remaining: 168ms
857: learn: 0.0078329 total: 1s remaining: 166ms
858: learn: 0.0078263 total: 1.01s remaining: 165ms
859: learn: 0.0078147 total: 1.01s remaining: 164ms
860: learn: 0.0078062 total: 1.01s remaining: 163ms
861: learn: 0.0077952 total: 1.01s remaining: 162ms
862: learn: 0.0077855 total: 1.01s remaining: 160ms
863: learn: 0.0077725 total: 1.01s remaining: 159ms
864: learn: 0.0077619 total: 1.01s remaining: 158ms
865: learn: 0.0077555 total: 1.01s remaining: 157ms
866: learn: 0.0077450 total: 1.01s remaining: 156ms

867: learn: 0.0077334 total: 1.01s remaining: 154ms
868: learn: 0.0077245 total: 1.02s remaining: 153ms
869: learn: 0.0077173 total: 1.02s remaining: 153ms
870: learn: 0.0076977 total: 1.02s remaining: 151ms
871: learn: 0.0076900 total: 1.02s remaining: 150ms
872: learn: 0.0076710 total: 1.02s remaining: 149ms
873: learn: 0.0076646 total: 1.02s remaining: 148ms
874: learn: 0.0076559 total: 1.03s remaining: 147ms
875: learn: 0.0076405 total: 1.03s remaining: 145ms
876: learn: 0.0076240 total: 1.03s remaining: 144ms
877: learn: 0.0076174 total: 1.03s remaining: 143ms
878: learn: 0.0076090 total: 1.03s remaining: 142ms
879: learn: 0.0075989 total: 1.03s remaining: 141ms
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881: learn: 0.0075727 total: 1.03s remaining: 138ms
882: learn: 0.0075609 total: 1.03s remaining: 137ms
883: learn: 0.0075470 total: 1.03s remaining: 136ms
884: learn: 0.0075379 total: 1.04s remaining: 135ms
885: learn: 0.0075259 total: 1.04s remaining: 134ms
886: learn: 0.0075130 total: 1.04s remaining: 132ms
887: learn: 0.0075036 total: 1.04s remaining: 131ms
888: learn: 0.0074913 total: 1.04s remaining: 130ms
889: learn: 0.0074755 total: 1.04s remaining: 129ms
890: learn: 0.0074652 total: 1.04s remaining: 128ms
891: learn: 0.0074517 total: 1.04s remaining: 126ms
892: learn: 0.0074368 total: 1.04s remaining: 125ms
893: learn: 0.0074279 total: 1.05s remaining: 124ms
894: learn: 0.0074167 total: 1.05s remaining: 123ms
895: learn: 0.0074027 total: 1.05s remaining: 122ms
896: learn: 0.0073928 total: 1.05s remaining: 121ms
897: learn: 0.0073823 total: 1.05s remaining: 119ms
898: learn: 0.0073746 total: 1.05s remaining: 118ms
899: learn: 0.0073649 total: 1.05s remaining: 117ms
900: learn: 0.0073587 total: 1.05s remaining: 116ms
901: learn: 0.0073481 total: 1.05s remaining: 115ms
902: learn: 0.0073351 total: 1.06s remaining: 113ms
903: learn: 0.0073221 total: 1.06s remaining: 112ms
904: learn: 0.0073142 total: 1.06s remaining: 111ms
905: learn: 0.0073091 total: 1.06s remaining: 110ms
906: learn: 0.0072955 total: 1.06s remaining: 109ms
907: learn: 0.0072873 total: 1.06s remaining: 108ms
908: learn: 0.0072780 total: 1.06s remaining: 106ms
909: learn: 0.0072681 total: 1.06s remaining: 105ms
910: learn: 0.0072599 total: 1.06s remaining: 104ms
911: learn: 0.0072493 total: 1.06s remaining: 103ms
912: learn: 0.0072426 total: 1.07s remaining: 102ms
913: learn: 0.0072303 total: 1.07s remaining: 100ms
914: learn: 0.0072241 total: 1.07s remaining: 99.3ms
915: learn: 0.0072175 total: 1.07s remaining: 98.1ms
916: learn: 0.0072080 total: 1.07s remaining: 96.9ms
917: learn: 0.0072002 total: 1.07s remaining: 95.8ms
918: learn: 0.0071891 total: 1.07s remaining: 94.6ms
919: learn: 0.0071839 total: 1.07s remaining: 93.4ms
920: learn: 0.0071784 total: 1.07s remaining: 92.3ms
921: learn: 0.0071728 total: 1.08s remaining: 91.2ms
922: learn: 0.0071636 total: 1.08s remaining: 90.1ms
923: learn: 0.0071454 total: 1.08s remaining: 88.9ms
924: learn: 0.0071353 total: 1.08s remaining: 87.7ms
925: learn: 0.0071258 total: 1.08s remaining: 86.6ms
926: learn: 0.0071169 total: 1.09s remaining: 85.7ms
927: learn: 0.0071116 total: 1.09s remaining: 84.6ms
928: learn: 0.0071061 total: 1.09s remaining: 83.6ms
929: learn: 0.0070962 total: 1.09s remaining: 82.5ms
930: learn: 0.0070915 total: 1.1s remaining: 81.4ms
931: learn: 0.0070839 total: 1.1s remaining: 80.2ms
932: learn: 0.0070717 total: 1.1s remaining: 79ms
933: learn: 0.0070668 total: 1.1s remaining: 77.8ms
934: learn: 0.0070596 total: 1.1s remaining: 76.6ms
935: learn: 0.0070478 total: 1.1s remaining: 75.4ms
936: learn: 0.0070366 total: 1.1s remaining: 74.2ms
937: learn: 0.0070247 total: 1.1s remaining: 73ms
938: learn: 0.0070180 total: 1.1s remaining: 71.8ms

```
939: learn: 0.0070085 total: 1.11s remaining: 70.6ms
940: learn: 0.0069920 total: 1.11s remaining: 69.4ms
941: learn: 0.0069863 total: 1.11s remaining: 68.3ms
942: learn: 0.0069799 total: 1.11s remaining: 67.1ms
943: learn: 0.0069737 total: 1.11s remaining: 65.9ms
944: learn: 0.0069670 total: 1.11s remaining: 64.7ms
945: learn: 0.0069531 total: 1.11s remaining: 63.5ms
946: learn: 0.0069371 total: 1.11s remaining: 62.4ms
947: learn: 0.0069280 total: 1.11s remaining: 61.2ms
948: learn: 0.0069171 total: 1.12s remaining: 60ms
949: learn: 0.0069051 total: 1.12s remaining: 58.8ms
950: learn: 0.0069001 total: 1.12s remaining: 57.6ms
951: learn: 0.0068912 total: 1.12s remaining: 56.4ms
952: learn: 0.0068773 total: 1.12s remaining: 55.3ms
953: learn: 0.0068727 total: 1.12s remaining: 54.1ms
954: learn: 0.0068656 total: 1.12s remaining: 52.9ms
955: learn: 0.0068500 total: 1.12s remaining: 51.7ms
956: learn: 0.0068444 total: 1.12s remaining: 50.5ms
957: learn: 0.0068390 total: 1.13s remaining: 49.3ms
958: learn: 0.0068250 total: 1.13s remaining: 48.2ms
959: learn: 0.0068159 total: 1.13s remaining: 47ms
960: learn: 0.0068094 total: 1.13s remaining: 45.8ms
961: learn: 0.0067993 total: 1.13s remaining: 44.6ms
962: learn: 0.0067918 total: 1.13s remaining: 43.4ms
963: learn: 0.0067833 total: 1.13s remaining: 42.3ms
964: learn: 0.0067735 total: 1.13s remaining: 41.1ms
965: learn: 0.0067650 total: 1.13s remaining: 39.9ms
966: learn: 0.0067587 total: 1.13s remaining: 38.7ms
967: learn: 0.0067498 total: 1.14s remaining: 37.5ms
968: learn: 0.0067417 total: 1.14s remaining: 36.4ms
969: learn: 0.0067349 total: 1.14s remaining: 35.2ms
970: learn: 0.0067220 total: 1.14s remaining: 34ms
971: learn: 0.0067159 total: 1.14s remaining: 32.8ms
972: learn: 0.0067073 total: 1.14s remaining: 31.7ms
973: learn: 0.0067018 total: 1.14s remaining: 30.5ms
974: learn: 0.0066902 total: 1.14s remaining: 29.3ms
975: learn: 0.0066854 total: 1.14s remaining: 28.1ms
976: learn: 0.0066794 total: 1.15s remaining: 27ms
977: learn: 0.0066712 total: 1.15s remaining: 25.8ms
978: learn: 0.0066628 total: 1.15s remaining: 24.6ms
979: learn: 0.0066576 total: 1.15s remaining: 23.4ms
980: learn: 0.0066495 total: 1.15s remaining: 22.3ms
981: learn: 0.0066407 total: 1.15s remaining: 21.1ms
982: learn: 0.0066319 total: 1.15s remaining: 19.9ms
983: learn: 0.0066203 total: 1.15s remaining: 18.7ms
984: learn: 0.0066141 total: 1.15s remaining: 17.6ms
985: learn: 0.0066042 total: 1.15s remaining: 16.4ms
986: learn: 0.0065981 total: 1.16s remaining: 15.2ms
987: learn: 0.0065884 total: 1.16s remaining: 14ms
988: learn: 0.0065801 total: 1.16s remaining: 12.9ms
989: learn: 0.0065751 total: 1.16s remaining: 11.7ms
990: learn: 0.0065693 total: 1.16s remaining: 10.5ms
991: learn: 0.0065603 total: 1.16s remaining: 9.36ms
992: learn: 0.0065553 total: 1.16s remaining: 8.19ms
993: learn: 0.0065484 total: 1.16s remaining: 7.01ms
994: learn: 0.0065381 total: 1.16s remaining: 5.84ms
995: learn: 0.0065324 total: 1.16s remaining: 4.67ms
996: learn: 0.0065280 total: 1.17s remaining: 3.51ms
997: learn: 0.0065238 total: 1.17s remaining: 2.34ms
998: learn: 0.0065171 total: 1.17s remaining: 1.17ms
999: learn: 0.0065068 total: 1.17s remaining: 0us
Accuracy: 99.42 %
Standard Deviation: 0.71 %
```

Learning curves

Here, we are explore learning curves. learning_curve is an inbuilt function in package sklearn.model_selection. It helps us to determine cross-validated training and test scores for different training set sizes. When we plot it, we get a visualisation of this and our purpose gets clear.

Here we have plotted learning curves for three classification models:

1. **Decision Trees**
2. **Random Forest Classifier**
3. **Multi Layer Perceptron**

In [142]:

```
def plot_learning_curve(estimator, title, X, y, axes=None, ylim=None, cv=None,
                        n_jobs=None, train_sizes=np.linspace(.1, 1.0, 5)):
    if axes is None:
        _, axes = plt.subplots(1, 3, figsize=(20, 5))

    axes[0].set_title(title)
    if ylim is not None:
        axes[0].set_ylim(*ylim)
    axes[0].set_xlabel("Training examples")
    axes[0].set_ylabel("Score")

    train_sizes, train_scores, test_scores, fit_times, _ = \
        learning_curve(estimator, X, y, cv=cv, n_jobs=n_jobs,
                       train_sizes=train_sizes,
                       return_times=True)
    train_scores_mean = np.mean(train_scores, axis=1)
    train_scores_std = np.std(train_scores, axis=1)
    test_scores_mean = np.mean(test_scores, axis=1)
    test_scores_std = np.std(test_scores, axis=1)
    fit_times_mean = np.mean(fit_times, axis=1)
    fit_times_std = np.std(fit_times, axis=1)

    # Plot learning curve
    axes[0].grid()
    axes[0].fill_between(train_sizes, train_scores_mean - train_scores_std,
                         train_scores_mean + train_scores_std, alpha=0.1,
                         color="r")
    axes[0].fill_between(train_sizes, test_scores_mean - test_scores_std,
                         test_scores_mean + test_scores_std, alpha=0.1,
                         color="g")
    axes[0].plot(train_sizes, train_scores_mean, 'o-', color="r",
                 label="Training score")
    axes[0].plot(train_sizes, test_scores_mean, 'o-', color="g",
                 label="Cross-validation score")
    axes[0].legend(loc="best")

    # Plot n_samples vs fit_times
    axes[1].grid()
    axes[1].plot(train_sizes, fit_times_mean, 'o-')
    axes[1].fill_between(train_sizes, fit_times_mean - fit_times_std,
                         fit_times_mean + fit_times_std, alpha=0.1)
    axes[1].set_xlabel("Training examples")
    axes[1].set_ylabel("fit_times")
    axes[1].set_title("Scalability of the model")

    # Plot fit_time vs score
    axes[2].grid()
    axes[2].plot(fit_times_mean, test_scores_mean, 'o-')
    axes[2].fill_between(fit_times_mean, test_scores_mean - test_scores_std,
                         test_scores_mean + test_scores_std, alpha=0.1)
    axes[2].set_xlabel("fit_times")
    axes[2].set_ylabel("Score")
    axes[2].set_title("Performance of the model")


    return plt
```

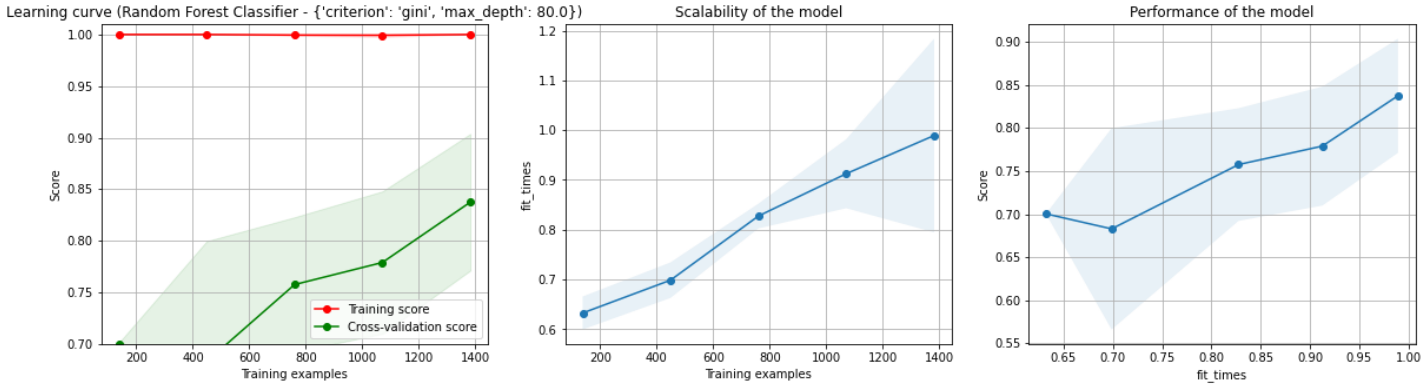
In [143]:

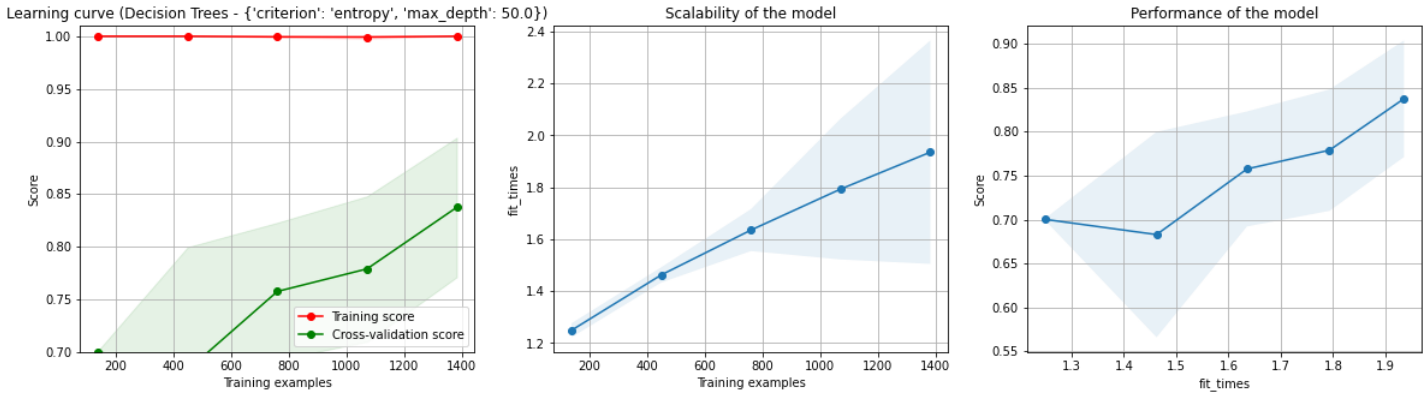
```
title = f'Learning curve (Random Forest Classifier - {gs_rfc.best_params_})'
plot_learning_curve(gs_rfc, title, X, y, ylim=(0.7, 1.01), n_jobs=4)
```

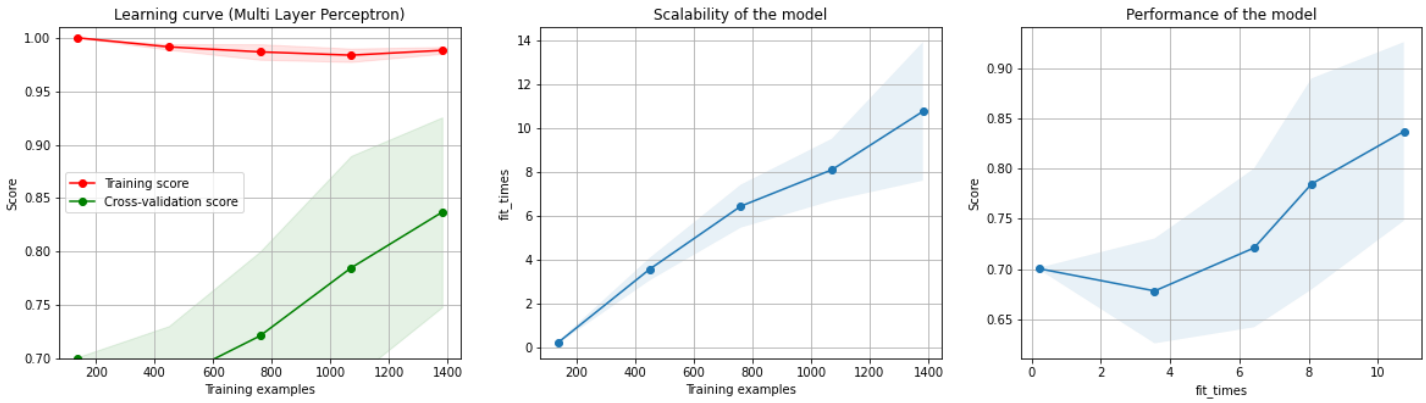
```
title = f'Learning curve (Decision Trees - {gs_dt.best_params_})'
plot_learning_curve(gs_dt, title, X, y, ylim=(0.7, 1.01), n_jobs=4)

title = f'Learning curve (Multi Layer Perceptron)'
plot_learning_curve(clf_mlp, title, X, y, ylim=(0.7, 1.01), n_jobs=4)
```

Out[143]:

```
<module 'matplotlib.pyplot' from '/usr/local/lib/python3.7/dist-packages/matplotlib/pyplot.py'>
```







Evaluating the model performance

- **This is a very important function as it will take the predictions and output of testing data from various models and present respective results' analysis in the form of:**
  - **Classification report**
  - **Confusion matrix**
  - **Accuracy score**
  - **K-Fold Cross Validation**

In [144]:

```
pip install -U prettytable
```

```
Requirement already satisfied: prettytable in /usr/local/lib/python3.7/dist-packages (2.4.0)
Requirement already satisfied: importlib-metadata in /usr/local/lib/python3.7/dist-packages (from prettytable) (4.8.2)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.7/dist-packages (from pr
```

```
Requirement already satisfied: wcwidth in /usr/local/lib/python3.7/dist-packages (from pr
ettytable) (0.2.5)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/lib/python3.7/dist-
packages (from importlib-metadata->prettytable) (3.10.0.2)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packages (from
importlib-metadata->prettytable) (3.6.0)
```

In [145]:

```
from prettytable import PrettyTable
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score
```

- **### Classification Reports :**

In [146]:

```
predictions = [y_pred_lr, y_pred_knn, y_pred_knnGS, y_pred_svc, y_pred_kernelSVC, y_pred
_nbGB, y_pred_nbBNB, y_pred_nbMNB, y_pred_dtGINI, y_pred_dtENTROPY, y_pred_dtGS, y_pred_
rfcGINI, y_pred_rfcENTROPY, y_pred_rfcGS, y_pred_mlp]
models = [
          'Logistic Regression',
          'K Nearest Neighbor',
          'K Nearest Neighbor (with Grid Search)',
          'Support Vector Machine (with Linear)',
          'Support Vector Machine (with Kernel)',
          'Naïve Bayes (with Gaussian)',
          'Naïve Bayes (with Bernoulli)',
          'Naïve Bayes (with Multinomial)',
          'Decision Tree (with GINI)',
          'Decision Tree (with Entropy)',
          'Decision Tree (with GridSearch)',
          'Random Forest (with GINI)',
          'Random Forest (with ENTROPY)',
          'Random Forest (with GridSearch)',
          'Multi Layer Perceptron'
         ]
for i in range(len(predictions)):
  print(f'\n---------------------- Classification Report of: {models[i]} ---------------
-------\n')
  print(classification_report(y_test,predictions[i]))
```

```
---------------------- Classification Report of: Logistic Regression -------------------
---

              precision    recall  f1-score   support

           0       0.87      0.95      0.91       240
           1       0.58      0.57      0.58        79
           2       0.67      0.12      0.20        17
           3       0.75      0.30      0.43        10

    accuracy                           0.80       346
   macro avg       0.72      0.48      0.53       346
weighted avg       0.79      0.80      0.78       346


---------------------- Classification Report of: K Nearest Neighbor --------------------
--

              precision    recall  f1-score   support

           0       0.98      0.99      0.99       240
           1       0.94      0.95      0.94        79
           2       1.00      0.88      0.94        17
           3       1.00      0.90      0.95        10

    accuracy                           0.97       346
   macro avg       0.98      0.93      0.95       346
weighted avg       0.97      0.97      0.97       346
```

---------- Classification Report of: K Nearest Neighbor (with Grid Search) ----------

	precision	recall	f1-score	support
0	0.98	0.99	0.99	240
1	0.95	0.92	0.94	79
2	0.94	0.94	0.94	17
3	0.90	0.90	0.90	10
accuracy			0.97	346
macro avg	0.94	0.94	0.94	346
weighted avg	0.97	0.97	0.97	346

---------- Classification Report of: Support Vector Machine (with Linear) ----------

	precision	recall	f1-score	support
0	0.90	0.93	0.91	240
1	0.73	0.68	0.71	79
2	0.93	0.76	0.84	17
3	0.90	0.90	0.90	10
accuracy			0.86	346
macro avg	0.86	0.82	0.84	346
weighted avg	0.86	0.86	0.86	346

---------- Classification Report of: Support Vector Machine (with Kernel) ----------

	precision	recall	f1-score	support
0	0.99	0.97	0.98	240
1	0.90	0.95	0.93	79
2	0.88	0.82	0.85	17
3	0.82	0.90	0.86	10
accuracy			0.96	346
macro avg	0.90	0.91	0.90	346
weighted avg	0.96	0.96	0.96	346

---------- Classification Report of: Naïve Bayes (with Gaussian) ----------

	precision	recall	f1-score	support
0	0.93	0.90	0.92	240
1	0.47	0.28	0.35	79
2	0.38	0.18	0.24	17
3	0.17	1.00	0.29	10
accuracy			0.73	346
macro avg	0.49	0.59	0.45	346
weighted avg	0.78	0.73	0.73	346

---------- Classification Report of: Naïve Bayes (with Bernoulli) ----------

	precision	recall	f1-score	support
0	0.91	0.90	0.91	240
1	0.54	0.73	0.62	79
2	0.00	0.00	0.00	17
3	0.00	0.00	0.00	10
accuracy			0.79	346
macro avg	0.36	0.41	0.38	346

```
weighted avg       0.76      0.79      0.77       346


---------------------- Classification Report of: Naïve Bayes (with Multinomial) --------
--------------

              precision    recall  f1-score   support

           0       0.76      0.96      0.85       240
           1       0.75      0.04      0.07        79
           2       0.41      0.76      0.53        17
           3       0.40      0.20      0.27        10

    accuracy                           0.72       346
   macro avg       0.58      0.49      0.43       346
weighted avg       0.73      0.72      0.64       346


---------------------- Classification Report of: Decision Tree (with GINI) -------------
---------

              precision    recall  f1-score   support

           0       0.98      1.00      0.99       240
           1       0.97      0.89      0.93        79
           2       0.81      1.00      0.89        17
           3       1.00      0.90      0.95        10

    accuracy                           0.97       346
   macro avg       0.94      0.95      0.94       346
weighted avg       0.97      0.97      0.97       346


---------------------- Classification Report of: Decision Tree (with Entropy) ----------
------------

              precision    recall  f1-score   support

           0       0.98      1.00      0.99       240
           1       0.97      0.87      0.92        79
           2       0.81      1.00      0.89        17
           3       1.00      0.90      0.95        10

    accuracy                           0.97       346
   macro avg       0.94      0.94      0.94       346
weighted avg       0.97      0.97      0.97       346


---------------------- Classification Report of: Decision Tree (with GridSearch) -------
---------------

              precision    recall  f1-score   support

           0       0.98      1.00      0.99       240
           1       0.97      0.87      0.92        79
           2       0.81      1.00      0.89        17
           3       1.00      0.90      0.95        10

    accuracy                           0.97       346
   macro avg       0.94      0.94      0.94       346
weighted avg       0.97      0.97      0.97       346


---------------------- Classification Report of: Random Forest (with GINI) -------------
---------

              precision    recall  f1-score   support

           0       0.98      1.00      0.99       240
           1       0.95      0.90      0.92        79
           2       0.82      0.82      0.82        17
           3       0.73      0.80      0.76        10
```

```
    accuracy                           0.96       346
   macro avg       0.87      0.88      0.87       346
weighted avg       0.96      0.96      0.96       346


---------------------- Classification Report of: Random Forest (with ENTROPY) ----------
------------

              precision    recall  f1-score   support

           0       0.99      1.00      1.00       240
           1       0.97      0.90      0.93        79
           2       0.76      0.76      0.76        17
           3       0.64      0.90      0.75        10

    accuracy                           0.96       346
   macro avg       0.84      0.89      0.86       346
weighted avg       0.97      0.96      0.96       346


---------------------- Classification Report of: Random Forest (with GridSearch) -------
---------------

              precision    recall  f1-score   support

           0       0.98      1.00      0.99       240
           1       0.97      0.90      0.93        79
           2       0.89      1.00      0.94        17
           3       1.00      0.90      0.95        10

    accuracy                           0.97       346
   macro avg       0.96      0.95      0.95       346
weighted avg       0.97      0.97      0.97       346


---------------------- Classification Report of: Multi Layer Perceptron ----------------
------

              precision    recall  f1-score   support

           0       1.00      1.00      1.00       240
           1       1.00      0.99      0.99        79
           2       0.94      1.00      0.97        17
           3       1.00      1.00      1.00        10

    accuracy                           1.00       346
   macro avg       0.99      1.00      0.99       346
weighted avg       1.00      1.00      1.00       346
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1272: Undefined
MetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with
no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

- **### Confusion Matrix :**

In [147]:

```
confusionMatrixTable = PrettyTable()
confusionMatrixTable.field_names = ["Model", "Confusion Matrix"]
confusionMatrixTable.add_row(["Logistic Regression", confusion_matrix(y_test, y_pred_lr)
])
confusionMatrixTable.add_row(["------------------------------", "------------------"])
confusionMatrixTable.add_row(["K Nearest Neighbor", confusion_matrix(y_test, y_pred_knn)
])
confusionMatrixTable.add_row(["K Nearest Neighbor (with Grid Search)", confusion_matrix(y
_test, y_pred_knnGS)])
confusionMatrixTable.add_row(["------------------------------", "------------------"])
```

```
confusionMatrixTable.add_row(["Support Vector Machine (with Linear)", confusion_matrix(y_
test, y_pred_svc)])
confusionMatrixTable.add_row(["Support Vector Machine (with Kernel)", confusion_matrix(y_
test, y_pred_kernelSVC)])
confusionMatrixTable.add_row(["------------------------------", "------------------"])
confusionMatrixTable.add_row(["Naïve Bayes (with Gaussian)", confusion_matrix(y_test, y_
pred_nbGB)])
confusionMatrixTable.add_row(["Naïve Bayes (with Bernoulli)", confusion_matrix(y_test, y
_pred_nbBNB)])
confusionMatrixTable.add_row(["Naïve Bayes (with Multinomial)", confusion_matrix(y_test,
y_pred_nbMNB)])
confusionMatrixTable.add_row(["------------------------------", "------------------"])
confusionMatrixTable.add_row(["Decision Tree (with GINI)", confusion_matrix(y_test, y_pr
ed_dtGINI)])
confusionMatrixTable.add_row(["Decision Tree (with Entropy)", confusion_matrix(y_test, y
_pred_dtENTROPY)])
confusionMatrixTable.add_row(["Decision Tree (with GridSearch)", confusion_matrix(y_test,
y_pred_dtGS)])
confusionMatrixTable.add_row(["------------------------------", "------------------"])
confusionMatrixTable.add_row(["Random Forest (with GINI)", confusion_matrix(y_test, y_pr
ed_rfcGINI)])
confusionMatrixTable.add_row(["Random Forest (with ENTROPY)", confusion_matrix(y_test, y
_pred_rfcENTROPY)])
confusionMatrixTable.add_row(["Random Forest (with GridSearch)", confusion_matrix(y_test
, y_pred_rfcGS)])
confusionMatrixTable.add_row(["------------------------------", "------------------"])
confusionMatrixTable.add_row(["Multi Layer Perceptron", confusion_matrix(y_test, y_pred_
mlp)])

print(confusionMatrixTable)
```

```
+---------------------------------------+---------------------+
|                 Model                 |   Confusion Matrix  |
+---------------------------------------+---------------------+
|          Logistic Regression          |  [[228  12   0   0] |
|                                       |   [ 33  45   1   0] |
|                                       |   [  1  13   2   1] |
|                                       |  [  0   7   0   3]] |
|    ------------------------------     |  ------------------ |
|           K Nearest Neighbor          |  [[238   2   0   0] |
|                                       |   [  4  75   0   0] |
|                                       |   [  0   2  15   0] |
|                                       |  [  0   1   0   9]] |
| K Nearest Neighbor (with Grid Search) |  [[238   2   0   0] |
|                                       |   [  4  73   1   1] |
|                                       |   [  0   1  16   0] |
|                                       |  [  0   1   0   9]] |
|    ------------------------------     |  ------------------ |
|  Support Vector Machine (with Linear) |  [[222  18   0   0] |
|                                       |   [ 24  54   1   0] |
|                                       |   [  2   1  13   1] |
|                                       |  [  0   1   0   9]] |
|  Support Vector Machine (with Kernel) |  [[234   6   0   0] |
|                                       |   [  2  75   2   0] |
|                                       |   [  0   1  14   2] |
|                                       |  [  0   1   0   9]] |
|    ------------------------------     |  ------------------ |
|      Naïve Bayes (with Gaussian)      |  [[216  19   0   5] |
|                                       |   [ 16  22   5  36] |
|                                       |   [  0   6   3   8] |
|                                       |  [  0   0   0  10]] |
|      Naïve Bayes (with Bernoulli)     |  [[217  23   0   0] |
|                                       |   [ 21  58   0   0] |
|                                       |   [  0  17   0   0] |
|                                       |  [  0  10   0   0]] |
|    Naïve Bayes (with Multinomial)     |  [[231   0   8   1] |
|                                       |   [ 71   3   5   0] |
|                                       |   [  2   0  13   2] |
|                                       |  [  1   1   6   2]] |
|    ------------------------------     |  ------------------ |
|       Decision Tree (with GINI)       |  [[239   1   0   0] |
|                                       |   [  5  70   4   0] |
```

```
|                                      |   [  0   0  17   0] |
|                                      |  [  0   1   0   9]] |
|      Decision Tree (with Entropy)    |  [[239   1   0   0] |
|                                      |   [  6  69   4   0] |
|                                      |   [  0   0  17   0] |
|                                      |  [  0   1   0   9]] |
|    Decision Tree (with GridSearch)   |  [[239   1   0   0] |
|                                      |   [  6  69   4   0] |
|                                      |   [  0   0  17   0] |
|                                      |  [  0   1   0   9]] |
|     ------------------------------   |  ------------------ |
|       Random Forest (with GINI)      |  [[239   1   0   0] |
|                                      |   [  4  71   3   1] |
|                                      |   [  0   1  14   2] |
|                                      |  [  0   2   0   8]] |
|      Random Forest (with ENTROPY)    |  [[240   0   0   0] |
|                                      |   [  2  71   4   2] |
|                                      |   [  0   1  13   3] |
|                                      |  [  0   1   0   9]] |
|    Random Forest (with GridSearch)   |  [[239   1   0   0] |
|                                      |   [  6  71   2   0] |
|                                      |   [  0   0  17   0] |
|                                      |  [  0   1   0   9]] |
|     ------------------------------   |  ------------------ |
|         Multi Layer Perceptron       |  [[240   0   0   0] |
|                                      |   [  0  78   1   0] |
|                                      |   [  0   0  17   0] |
|                                      |  [  0   0   0  10]] |
+--------------------------------------+---------------------+
```

- **### K-Fold Cross Validation :**

In [148]:

```
from sklearn.model_selection import cross_val_score
```

In [149]:

```
accuracies_lr = cross_val_score(estimator=clf_lr, X=X_train, y=y_train, cv=10)
accuracies_knn = cross_val_score(estimator=clf_knn, X=X_train, y=y_train, cv=10)
accuracies_knnGS = cross_val_score(estimator=gs_knn, X=X_train, y=y_train, cv=10)
accuracies_svc = cross_val_score(estimator=clf_svc, X=X_train, y=y_train, cv=10)
accuracies_kernelSVC = cross_val_score(estimator=clf_kernelSVC, X=X_train, y=y_train, cv
=10)
accuracies_nbGB = cross_val_score(estimator=clf_nbGB, X=X_train, y=y_train, cv=10)
accuracies_nbBNB = cross_val_score(estimator=clf_nbBNB, X=X_train, y=y_train, cv=10)
accuracies_nbMNB = cross_val_score(estimator=clf_nbMNB, X=X_train_mm, y=y_train, cv=10)
accuracies_dtGINI = cross_val_score(estimator=clf_dtGINI, X=X_train, y=y_train, cv=10)
accuracies_dtENTROPY = cross_val_score(estimator=clf_dtENTROPY, X=X_train, y=y_train, cv
=10)
accuracies_dt = cross_val_score(estimator=clf_dt, X=X_train, y=y_train, cv=10)
accuracies_rfcGINI = cross_val_score(estimator=clf_rfcGINI, X=X_train, y=y_train, cv=10)
accuracies_rfcENTROPY = cross_val_score(estimator=clf_rfcENTROPY, X=X_train, y=y_train,
cv=10)
accuracies_rfcGS = cross_val_score(estimator=gs_rfc, X=X_train, y=y_train, cv=10)
accuracies_mlp = cross_val_score(estimator=clf_mlp, X=X_train, y=y_train, cv=10)
```

In [150]:

```
crossValidationTable = PrettyTable()
crossValidationTable.field_names = ["Model", "Mean of Accuracy", "Standard Deviation of A
ccuracy"]
crossValidationTable.add_row(["Logistic Regression", f"{accuracies_lr.mean()*100:.2f}%",
f"{accuracies_lr.std()*100:.2f}%"])
crossValidationTable.add_row(["------------------------------", "------------------", "
------------------"])
crossValidationTable.add_row(["K Nearest Neighbor", f"{accuracies_knn.mean()*100:.2f}%",f
"{accuracies_knn.std()*100:.2f}%"])
crossValidationTable.add_row(["K Nearest Neighbor (with Grid Search)", f"{accuracies_knnG
S.mean()*100:.2f}%",f"{accuracies_knnGS.std()*100:.2f}%"])
```

```
crossValidationTable.add_row(["------------------------------", "------------------", "
------------------"])
crossValidationTable.add_row(["Support Vector Machine (with Linear)", f"{accuracies_svc.m
ean()*100:.2f}%",f"{accuracies_svc.std()*100:.2f}%" ])
crossValidationTable.add_row(["Support Vector Machine (with Kernel)", f"{accuracies_kerne
lSVC.mean()*100:.2f}%",f"{accuracies_kernelSVC.std()*100:.2f}%" ])
crossValidationTable.add_row(["------------------------------", "------------------", "
------------------"])
crossValidationTable.add_row(["Naïve Bayes (with Gaussian)", f"{accuracies_nbGB.mean()*1
00:.2f}%",f"{accuracies_nbGB.std()*100:.2f}%" ])
crossValidationTable.add_row(["Naïve Bayes (with Bernoulli)", f"{accuracies_nbBNB.mean()
*100:.2f}%",f"{accuracies_nbBNB.std()*100:.2f}%" ])
crossValidationTable.add_row(["Naïve Bayes (with Multinomial)", f"{accuracies_nbMNB.mean(
)*100:.2f}%",f"{accuracies_nbMNB.std()*100:.2f}%" ])
crossValidationTable.add_row(["------------------------------", "------------------", "
------------------"])
crossValidationTable.add_row(["Decision Tree (with GINI)", f"{accuracies_dtGINI.mean()*10
0:.2f}%",f"{accuracies_dtGINI.std()*100:.2f}%" ])
crossValidationTable.add_row(["Decision Tree (with Entropy)", f"{accuracies_dtENTROPY.mea
n()*100:.2f}%",f"{accuracies_dtENTROPY.std()*100:.2f}%" ])
crossValidationTable.add_row(["Decision Tree (with GridSearch)", f"{accuracies_dt.mean()*
100:.2f}%",f"{accuracies_dt.std()*100:.2f}%" ])
crossValidationTable.add_row(["------------------------------", "------------------", "
------------------"])
crossValidationTable.add_row(["Random Forest (with GINI)", f"{accuracies_rfcGINI.mean()*
100:.2f}%",f"{accuracies_rfcGINI.std()*100:.2f}%" ])
crossValidationTable.add_row(["Random Forest (with ENTROPY)", f"{accuracies_rfcENTROPY.m
ean()*100:.2f}%",f"{accuracies_rfcENTROPY.std()*100:.2f}%" ])
crossValidationTable.add_row(["Random Forest (with GridSearch)", f"{accuracies_rfcGS.mea
n()*100:.2f}%",f"{accuracies_rfcGS.std()*100:.2f}%" ])
crossValidationTable.add_row(["------------------------------", "------------------", "
------------------"])
crossValidationTable.add_row(["Multi Layer Perceptron", f"{accuracies_mlp.mean()*100:.2f
}%",f"{accuracies_mlp.std()*100:.2f}%" ])
print(crossValidationTable)
```

```
+--------------------------------------+--------------------+-------------------------
-------+
|                Model                 |  Mean of Accuracy  | Standard Deviation of Acc
uracy |
+--------------------------------------+--------------------+-------------------------
-------+
|          Logistic Regression         |       82.70%       |             2.67%
|
|     ------------------------------   | ------------------ |       ------------------
|
|           K Nearest Neighbor         |       96.46%       |             2.21%
|
| K Nearest Neighbor (with Grid Search) |       96.38%       |             1.80%
|
|     ------------------------------   | ------------------ |       ------------------
|
|  Support Vector Machine (with Linear) |       86.83%       |             1.98%
|
|  Support Vector Machine (with Kernel) |       96.74%       |             1.87%
|
|     ------------------------------   | ------------------ |       ------------------
|
|      Naïve Bayes (with Gaussian)      |       77.49%       |             1.85%
|
|      Naïve Bayes (with Bernoulli)     |       83.14%       |             2.21%
|
|     Naïve Bayes (with Multinomial)    |       70.19%       |             0.20%
|
|     ------------------------------   | ------------------ |       ------------------
|
|       Decision Tree (with GINI)       |       98.26%       |             0.87%
|
|      Decision Tree (with Entropy)     |       98.19%       |             1.13%
|
|    Decision Tree (with GridSearch)    |       98.12%       |             1.03%
|
```

```
|     ------------------------------    | ------------------ |       ------------------
|
|       Random Forest (with GINI)        |       97.25%       |             1.48%
|
|      Random Forest (with ENTROPY)      |       97.11%       |             1.74%
|
|    Random Forest (with GridSearch)     |       98.26%       |             0.93%
|
|     ------------------------------    | ------------------ |       ------------------
|
|         Multi Layer Perceptron         |       97.90%       |             2.09%
|
+----------------------------------------+--------------------+-------------------------
-------+
```

- **### Accuracy Table :**

In [151]:

```
accuracies = [
              accuracy_score(y_test, y_pred_lr).round(4)*100,
              accuracy_score(y_test, y_pred_knn).round(2)*100,
              accuracy_score(y_test, y_pred_knnGS).round(4)*100,
              accuracy_score(y_test, y_pred_svc).round(4)*100,
              accuracy_score(y_test, y_pred_kernelSVC).round(4)*100,
              accuracy_score(y_test, y_pred_nbGB).round(4)*100,
              accuracy_score(y_test, y_pred_nbBNB).round(3)*100,
              accuracy_score(y_test, y_pred_nbMNB).round(4)*100,
              accuracy_score(y_test, y_pred_dtGINI).round(4)*100,
              accuracy_score(y_test, y_pred_dtENTROPY).round(4)*100,
              accuracy_score(y_test, y_pred_dtGS).round(4)*100,
              accuracy_score(y_test, y_pred_rfcGINI).round(4)*100,
              accuracy_score(y_test, y_pred_rfcENTROPY).round(3)*100,
              accuracy_score(y_test, y_pred_rfcGS).round(2)*100,
              accuracy_score(y_test, y_pred_mlp).round(3)*100
]

accuracyScoreTable = PrettyTable()
accuracyScoreTable.field_names = ["Model", "Accuracy Score (in %)"]
accuracyScoreTable.add_row(["Logistic Regression", accuracies[0]])
accuracyScoreTable.add_row(["------------------------------", "------------------"])
accuracyScoreTable.add_row(["K Nearest Neighbor", accuracies[1]])
accuracyScoreTable.add_row(["K Nearest Neighbor (with Grid Search)", accuracies[2]])
accuracyScoreTable.add_row(["------------------------------", "------------------"])
accuracyScoreTable.add_row(["Support Vector Machine (with Linear)", accuracies[3]])
accuracyScoreTable.add_row(["Support Vector Machine (with Kernel)", accuracies[4]])
accuracyScoreTable.add_row(["------------------------------", "------------------"])
accuracyScoreTable.add_row(["Naïve Bayes (with Gaussian)", accuracies[5]])
accuracyScoreTable.add_row(["Naïve Bayes (with Bernoulli)", accuracies[6]])
accuracyScoreTable.add_row(["Naïve Bayes (with Multinomial)", accuracies[7]])
accuracyScoreTable.add_row(["------------------------------", "------------------"])
accuracyScoreTable.add_row(["Decision Tree (with GINI)", accuracies[8]])
accuracyScoreTable.add_row(["Decision Tree (with Entropy)", accuracies[9]])
accuracyScoreTable.add_row(["Decision Tree (with GridSearch)", accuracies[10]])
accuracyScoreTable.add_row(["------------------------------", "------------------"])
accuracyScoreTable.add_row(["Random Forest (with GINI)", accuracies[11]])
accuracyScoreTable.add_row(["Random Forest (with ENTROPY)", accuracies[12]])
accuracyScoreTable.add_row(["Random Forest (with GridSearch)", accuracies[13]])
accuracyScoreTable.add_row(["------------------------------", "------------------"])
accuracyScoreTable.add_row(["Multi Layer Perceptron", accuracies[14]])

print(accuracyScoreTable)
```

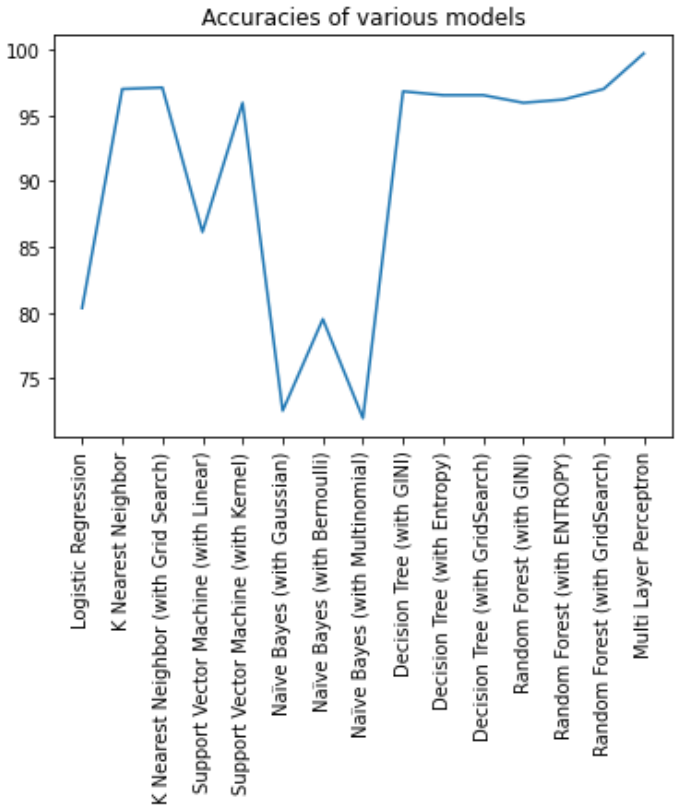
```
+----------------------------------------+----------------------+
|                 Model                  | Accuracy Score (in %) |
+----------------------------------------+----------------------+
|          Logistic Regression           |        80.35         |
|     ------------------------------     |   ------------------ |
|           K Nearest Neighbor           |         97.0         |
| K Nearest Neighbor (with Grid Search)  |        97.11         |
|     ------------------------------     |   ------------------ |
```

Support Vector Machine (with Linear)	86.13
Support Vector Machine (with Kernel)	95.95
Naïve Bayes (with Gaussian)	72.54
Naïve Bayes (with Bernoulli)	79.5
Naïve Bayes (with Multinomial)	71.97
Decision Tree (with GINI)	96.82
Decision Tree (with Entropy)	96.53
Decision Tree (with GridSearch)	96.53
Random Forest (with GINI)	95.95
Random Forest (with ENTROPY)	96.2
Random Forest (with GridSearch)	97.0
Multi Layer Perceptron	99.7

- **Visualisation :**

In [152]:

```
plt.plot(models, accuracies)
plt.xticks(rotation='vertical')
plt.title('Accuracies of various models')
plt.show()
```



Conclusion :

- **In this assignment, we performed classification on Car evaluation dataset using various classification models such as:**

  1. **Gaussian Naïve Bayes**
  2. **Bernoulli Naïve Bayes**
  3. **Multinomial Naïve Bayes**
  4. **Logistic Regression with One vs Rest**
  5. **Support Vector Machine (SVM)**
  6. **K Nearest Neighbour (KNN)**
  7. **Decision Tree**
  8. **Random Forest Classifier**

9. **Multi Layer Perceptron**

- **Out of the results obtained from various models, we reach to a conclusion that MLP, KNN, Random forests and Decision Trees provide the most accurate results. Now lets begin our analysis by comparing Decision trees with KNN.**
- **The accuracies obtained by these models are almost near to each other(~97%). Though both are non parametric methods, Decision Tree is faster as compared to KNN. The reason behind this can be attributed to the expensive real time execution taking place in KNN. Apart from this, Decision Trees also supports automatic feature interaction, a feature which KNN lacks.**
- **Important thing to be noted here is that Random Forest classifier also gives amazing accuracy which is almost comparable to decision trees. In general scenario, Random forest tends to give higher accuracy compared to Decision Trees. So now let's have a comparison between Decision Tree and Random Forest classifier to decide the best classifier for our dataset in overall manner.**
- **A decision tree is a collection of choices, whereas a random forest is a collection of decision trees. As a result, it is a lengthy yet sluggish procedure.**
- **A decision tree, on the other hand, is quick and easy to use on huge data sets, especially linear data sets. The random forest model needs extensive training.**
- **It is dependent on our needs. If we have only have a limited amount of time to work on a model, we'll almost certainly go for a decision tree. Random forests, on the other hand, are known for their predictability and stability.**
- **Now at last, let's compare Multi Layer Perceptron, rather known as Artificial Neural Network with other classifiers. The main advantages that this model provides over other classifiers :**

  1. **ANNs have the ability to learn and model non-linear and complex relationships**
  2. **ANNs can generalize — After learning from the initial inputs and their relationships, it can infer unseen relationships on unseen data as well, thus making the model generalize and predict on unseen data.**
  3. **Unlike many other prediction techniques, ANN does not impose any restrictions on the input variables (like how they should be distributed).**

- **Looking to our dataset and requirements, we conclude that MLP would be the most suitable model for the classification on our Car evaluation dataset to obtain highest accuracy. But if we want a balance between training time and accuracy, then Decision Trees with Gini Criterion would be the choice!**