In [2]:

```
import numpy as np
import pandas as pd
from typing import Dict, Tuple
from scipy import stats
from scipy.optimize import fmin_tnc
from IPython.display import Image
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsRegressor, KNeighborsClassifier
from sklearn.metrics import accuracy_score, balanced_accuracy_score
from sklearn.metrics import precision_score, recall_score, f1_score, classification_report
from sklearn.metrics import confusion_matrix
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_squared_log_error, median_absolute_error, r2_score, root_mean_squared_error
from sklearn.metrics import roc_curve, roc_auc_score
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import SGDRegressor
from sklearn.linear_model import SGDClassifier
from sklearn import linear_model
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
sns.set(style="ticks")
```

In [3]:

```
mpg = pd.read_csv('C:\\MGTU\\6 semestr\\TMO\\auto-mpg.csv')
```

In [4]:

```
mpg.head()
```

Out[4]:

	mpg	cylinders	displacement	horsepower	weight	acceleration	model year	origin	car name
0	18.0	8	307.0	130	3504	12.0	70	1	chevrolet chevelle malibu
1	15.0	8	350.0	165	3693	11.5	70	1	buick skylark 320
2	18.0	8	318.0	150	3436	11.0	70	1	plymouth satellite
3	16.0	8	304.0	150	3433	12.0	70	1	amc rebel sst
4	17.0	8	302.0	140	3449	10.5	70	1	ford torino

In [5]:

```
mpg.shape
```

Out[5]:

```
(398, 9)
```

In [6]:

```
mpg.dtypes
```

Out[6]:

```
mpg             float64
cylinders         int64
displacement    float64
horsepower       object
weight            int64
acceleration    float64
model year        int64
origin            int64
car name         object
car name          object
dtype: object
```

In [7]:

```
mpg = mpg[mpg['horsepower'] != '?']
mpg['horsepower'] = mpg['horsepower'].astype(float)
```

In [8]:

```
mpg.isnull().sum()
```

Out[8]:

```
mpg             0
cylinders       0
displacement    0
horsepower      0
weight          0
acceleration    0
model year      0
origin          0
car name        0
dtype: int64
```

In [9]:

```
mpg.dtypes
```

Out[9]:

```
mpg             float64
cylinders         int64
displacement    float64
horsepower      float64
weight            int64
acceleration    float64
model year        int64
origin            int64
car name         object
dtype: object
```

In [10]:

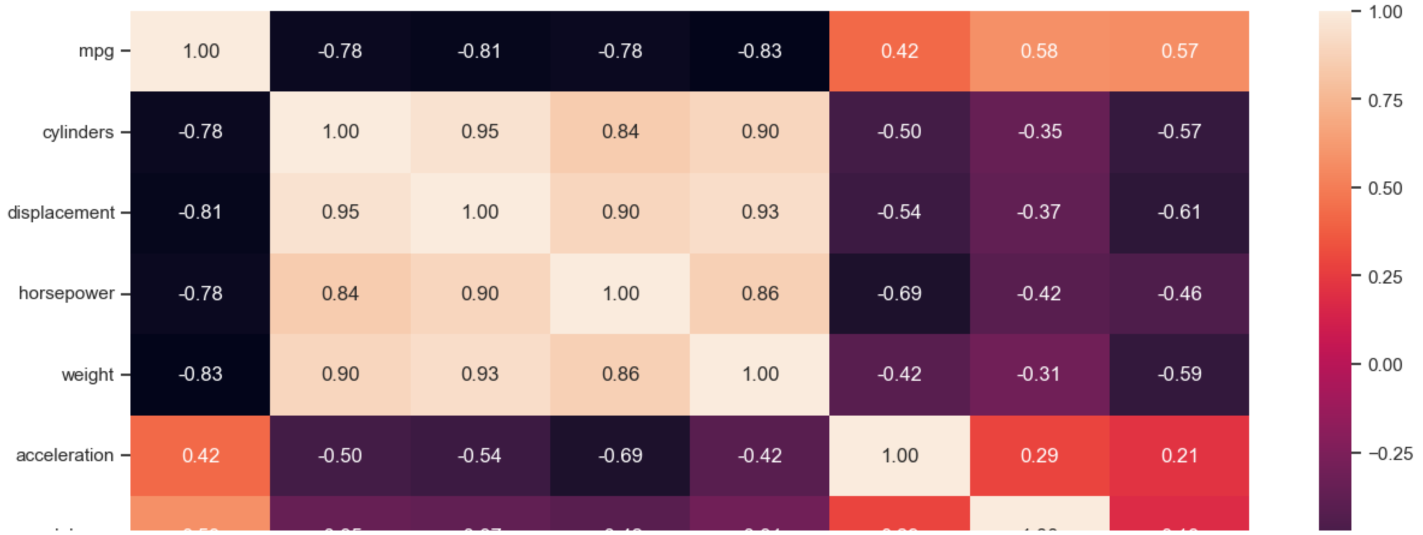
```
mpg = mpg.drop(columns=['car name'])
```

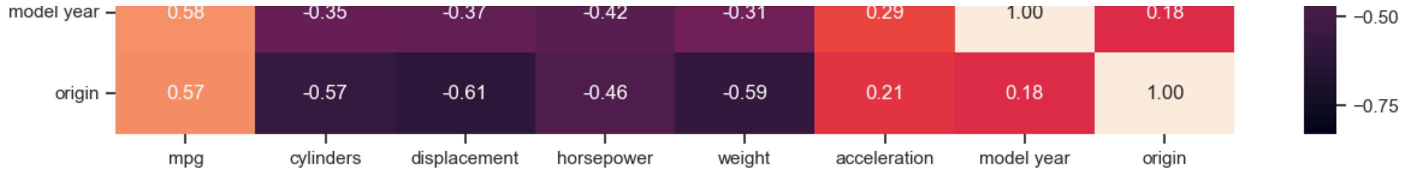
In [11]:

```
# Построение корреляционной матрицы
fig, ax = plt.subplots(figsize=(15,7))
sns.heatmap(mpg.corr(method='pearson'), ax=ax, annot=True, fmt='.2f')
```

Out[11]:

```
<Axes: >
```



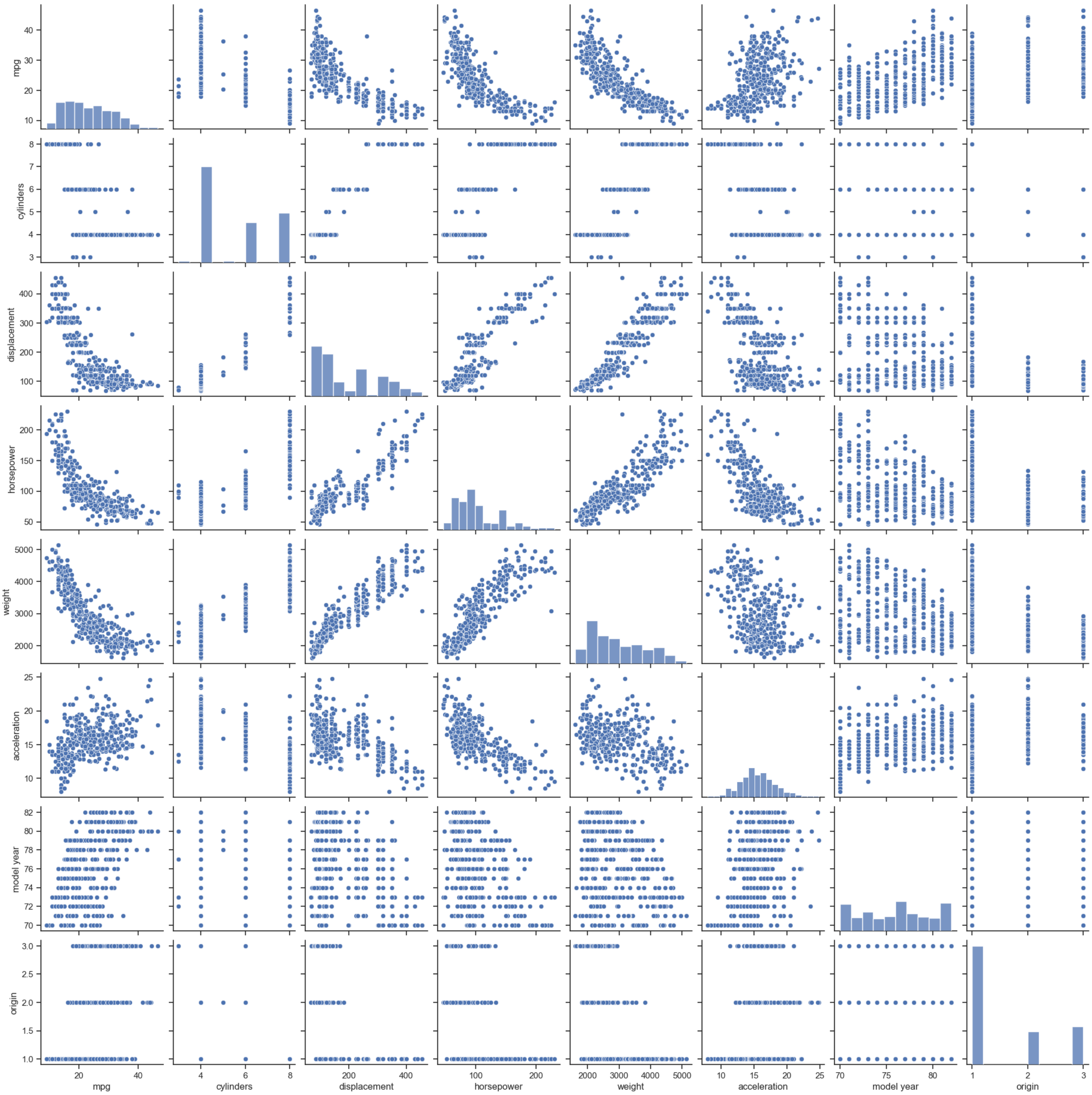


In [12]:

```
sns.pairplot(mpg)
```

Out[12]:

```
<seaborn.axisgrid.PairGrid at 0x2263bab66d0>
```



In [13]:

```
X = mpg.drop(columns=['mpg'])   # Признаки
y = mpg['mpg']   # Целевая переменная

# Разделение данных на обучающую и тестовую выборки
mpg_X_train, mpg_X_test, mpg_y_train, mpg_y_test = train_test_split(X, y, test_size=0.2,
random_state=1)
```

In [14]:

```
reg = LinearRegression().fit(mpg_X_train, mpg_y_train)
```

In [15]:

```
r2_score(mpg_y_train, reg.predict(mpg_X_train))
```

Out[15]:

```
0.8180487829836617
```

In [16]:

```
r2_score(mpg_y_test, reg.predict(mpg_X_test))
```

Out[16]:

```
0.8266335797333633
```

In [17]:

```
mean_absolute_error(mpg_y_test, reg.predict(mpg_X_test))
```

Out[17]:

```
2.5990189844591645
```

In [18]:

```
reg.coef_
```

Out[18]:

```
array([-0.14528154,  0.01745309, -0.00667237, -0.0070697 ,  0.18951236,
        0.73877038,  1.37640208])
```

In [19]:

```
ridge = linear_model.Ridge().fit(mpg_X_train, mpg_y_train)
```

In [20]:

```
r2_score(mpg_y_train, ridge.predict(mpg_X_train))
```

Out[20]:

```
0.8180478723499435
```

In [21]:

```
from sklearn.preprocessing import PolynomialFeatures
poly = PolynomialFeatures(degree=2)  # Задаем степень полинома
X_train_poly = poly.fit_transform(mpg_X_train)
X_test_poly = poly.transform(mpg_X_test)

# Создание и обучение модели линейной регрессии
model = LinearRegression()
model.fit(X_train_poly, mpg_y_train)

# Предсказание на тестовой выборке
y_pred = model.predict(X_test_poly)
```

In [22]:

```
r2_score(mpg_y_test, y_pred)
```

Out[22]:

```
0.8580639971878854
```

In [23]:

```
mean_absolute_error(mpg_y_test, y_pred)
```

Out[23]:

```
2.174549224909089
```

In [24]:

```
model.coef_
```

Out[24]:

```
array([-4.67436941e-08,  4.31291051e+00, -5.18949013e-01, -3.30531452e-01,
        2.82122780e-02, -9.79503107e+00, -1.04696086e+01, -2.70011338e+01,
       -8.02695107e-01,  3.89476353e-02, -5.39505042e-03, -8.80589599e-04,
        2.69170373e-01, -6.05795997e-02,  8.86922677e-01, -4.44438506e-04,
        8.31456111e-04,  2.10058140e-05, -2.78178511e-04,  3.75894548e-03,
        2.27816750e-02,  3.34185357e-05, -5.50186562e-05,  1.68385470e-03,
        3.18324864e-03,  1.97753504e-02,  1.38782342e-06, -1.10177456e-04,
       -3.96611889e-04, -1.65467197e-03,  4.84198248e-02,  7.91450641e-02,
        5.76104838e-01,  6.62581479e-02,  1.93185358e-01, -1.70135239e-01])
```

In [25]:

```
ridgep = linear_model.Ridge().fit(X_train_poly, mpg_y_train)
```

```
C:\Python311\Lib\site-packages\sklearn\linear_model\_ridge.py:204: LinAlgWarning: Ill-con
ditioned matrix (rcond=9.2937e-17): result may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

In [26]:

```
r2_score(mpg_y_test, ridgep.predict(X_test_poly))
```

Out[26]:

```
0.8691013907626597
```

In [27]:

```
mean_absolute_error(mpg_y_test, ridgep.predict(X_test_poly))
```

Out[27]:

```
2.0462791651404157
```

In [28]:

```
X_polinomial = X.copy()
```

In [29]:

```
X_polinomial['displacement'] = X_polinomial['displacement']**0.5
X_polinomial['horsepower'] = X_polinomial['horsepower']**0.5
X_polinomial['weight'] = X_polinomial['weight']**0.5
# X_polinomial['acceleration'] = X_polinomial['acceleration']**2
```

In [30]:

```
mpg_X_train_p, mpg_X_test_p, mpg_y_train_p, mpg_y_test_p = train_test_split(X_polinomial
, y, test_size=0.2, random_state=1)
```

In [31]:

```
reg_p = LinearRegression().fit(mpg_X_train_p, mpg_y_train_p)
```

In [32]:

```
r2_score(mpg_y_train_p, reg_p.predict(mpg_X_train_p))
```

Out[32]:

```
0.8320797685210071
```

In [33]:

```
r2_score(mpg_y_test_p, reg_p.predict(mpg_X_test_p))
```

Out[33]:

```
0.834803468131058
```

In [34]:

```
mean_absolute_error(mpg_y_test_p, reg_p.predict(mpg_X_test_p))
```

Out[34]:

```
2.4542097908987466
```

In [101]:

```
reg_p.coef_
```

Out[101]:

```
array([ 0.47374252,  0.01232144, -0.53462164, -0.66598948,  0.0348323 ,
        0.72504408,  1.06710951])
```

In [102]:

```
from sklearn.preprocessing import MinMaxScaler
sc0 = MinMaxScaler()
sc0_data = sc0.fit_transform(X)
```

In [103]:

```
mpg_X_train_0, mpg_X_test_0, mpg_y_train_0, mpg_y_test_0 = train_test_split(sc0_data , y
, test_size=0.2, random_state=1)
```

In [104]:

```
reg0 = LinearRegression().fit(mpg_X_train_0, mpg_y_train_0)
```

In [105]:

```
r2_score(mpg_y_test_0, reg0.predict(mpg_X_test_0))
```

Out[105]:

```
0.8266335797333633
```

SVM

In [106]:

```
from sklearn.svm import SVR
mpg_X_train_1, mpg_X_test_1, mpg_y_train_1, mpg_y_test_1 = train_test_split(X , y, test_
size=0.2, random_state=1)
```

In [107]:

```
svr_1 = SVR()
svr_1.fit(mpg_X_train_1, mpg_y_train_1)
```

Out[107]:

▼ SVR i ?

```
SVR()
```

In [108]:

```
mpg_y_pred_1 = svr_1.predict(mpg_X_test_1)
```

In [109]:

```
r2_score(mpg_y_test_1, mpg_y_pred_1)
```

Out[109]:

```
0.6723760369735721
```

In [110]:

```
mean_absolute_error(mpg_y_test_1, mpg_y_pred_1)
```

Out[110]:

```
3.3219120724007896
```

In [111]:

```
X.describe()
```

Out[111]:

	cylinders	displacement	horsepower	weight	acceleration	model year	origin
count	392.000000	392.000000	392.000000	392.000000	392.000000	392.000000	392.000000
mean	5.471939	194.411990	104.469388	2977.584184	15.541327	75.979592	1.576531
std	1.705783	104.644004	38.491160	849.402560	2.758864	3.683737	0.805518
min	3.000000	68.000000	46.000000	1613.000000	8.000000	70.000000	1.000000
25%	4.000000	105.000000	75.000000	2225.250000	13.775000	73.000000	1.000000
50%	4.000000	151.000000	93.500000	2803.500000	15.500000	76.000000	1.000000
75%	8.000000	275.750000	126.000000	3614.750000	17.025000	79.000000	2.000000
max	8.000000	455.000000	230.000000	5140.000000	24.800000	82.000000	3.000000

In [125]:

```
y.describe()
```

Out[125]:

```
count    392.000000
mean      23.445918
std        7.805007
min        9.000000
25%       17.000000
50%       22.750000
75%       29.000000
max       46.600000
Name: mpg, dtype: float64
```

In [112]:

```
from sklearn.preprocessing import MinMaxScaler
sc1 = MinMaxScaler()
sc1_data = sc1.fit_transform(X)
```

In [113]:

```
mpg_X_train_2, mpg_X_test_2, mpg_y_train_2, mpg_y_test_2 = train_test_split(sc1_data , y
, test_size=0.2, random_state=1)
```

In [114]:

```
sc1_data[:2]
```

Out[114]:

```
array([[1.        , 0.61757106, 0.45652174, 0.5361497 , 0.23809524,
        0.        , 0.        ],
       [1.        , 0.72868217, 0.64673913, 0.58973632, 0.20833333,
        0.        , 0.        ]])
```

In [115]:

```
svr_2 = SVR()
svr_2.fit(mpg_X_train_2, mpg_y_train_2)
```

Out[115]:

▼ SVR i ?

```
SVR()
```

In [116]:

```
mpg_y_pred_2 = svr_2.predict(mpg_X_test_2)
```

In [117]:

```
r2_score(mpg_y_test_2, mpg_y_pred_2)
```

Out[117]:

```
0.8285144007639063
```

In [118]:

```
mean_absolute_error(mpg_y_test_2, mpg_y_pred_2)
```

Out[118]:

```
2.282145913146911
```

Деревья решений

In [119]:

```
from sklearn.tree import DecisionTreeRegressor
mpg_tree_regr = DecisionTreeRegressor(random_state=1).fit(mpg_X_train, mpg_y_train)
mpg_y_test_predict = mpg_tree_regr.predict(mpg_X_test)
r2_score(mpg_y_test, mpg_y_test_predict)
```

Out[119]:

```
0.8355452168674431
```

In [120]:

```
mean_absolute_error(mpg_y_test, mpg_y_test_predict)
```

Out[120]:

```
2.4721518987341775
```

In [121]:

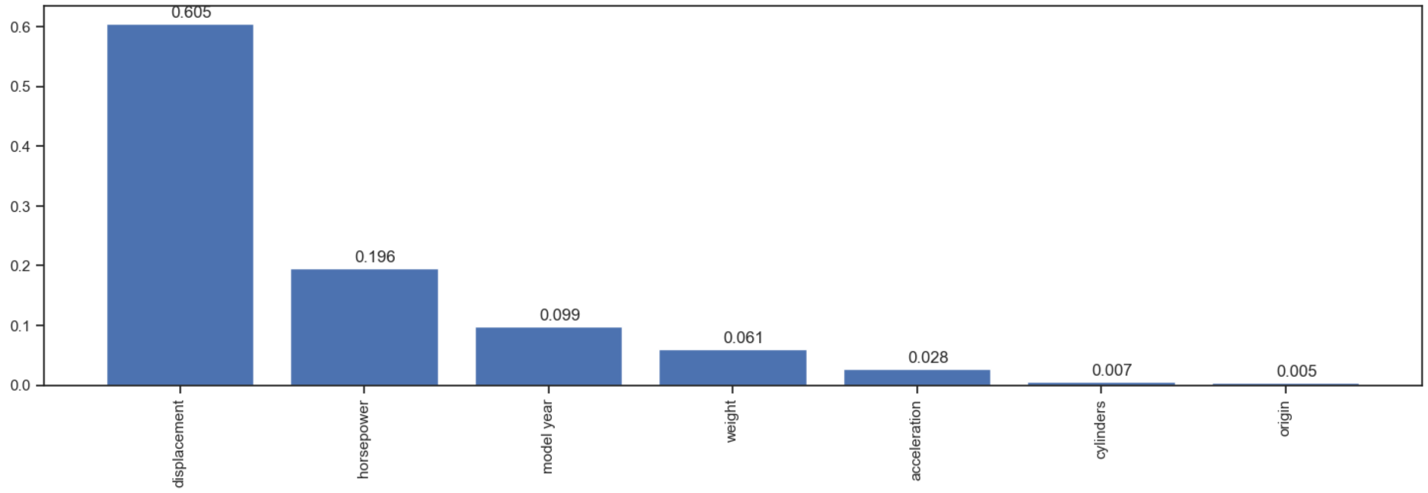
```
from operator import itemgetter

def draw_feature_importances(tree_model, X_dataset, figsize=(18,5)):
    """
    Вывод важности признаков в виде графика
    """
    # Сортировка значений важности признаков по убыванию
    list_to_sort = list(zip(X_dataset.columns.values, tree_model.feature_importances_))
    sorted_list = sorted(list_to_sort, key=itemgetter(1), reverse = True)
    # Названия признаков
    labels = [x for x,_ in sorted_list]
    # Важности признаков
    data = [x for _,x in sorted_list]
    # Вывод графика
    fig, ax = plt.subplots(figsize=figsize)
    ind = np.arange(len(labels))
    plt.bar(ind, data)
    plt.xticks(ind, labels, rotation='vertical')
    # Вывод значений
    for a,b in zip(ind, data):
        plt.text(a-0.05, b+0.01, str(round(b,3)))
    plt.show()
    return labels, data
```

График важности признаков в дереве решений

In [122]:

```
mpg_tree_regr_fl, mpg_tree_regr_fd = draw_feature_importances(mpg_tree_regr, X)
```



Правила дерева решений в текстовом виде

In [123]:

```
from IPython.core.display import HTML
from sklearn.tree import export_text
tree_rules = export_text(mpg_tree_regr, feature_names=list(X.columns))
HTML('<pre>' + tree_rules + '</pre>')
```

Out[123]:

```
|--- displacement <= 190.50
|   |--- horsepower <= 70.50
|   |   |--- model year <= 77.50
|   |   |   |--- weight <= 1829.50
|   |   |   |   |--- origin <= 2.50
|   |   |   |   |   |--- value: [36.00]
|   |   |   |   |--- origin >  2.50
|   |   |   |   |   |--- weight <= 1631.00
|   |   |   |   |   |   |--- value: [35.00]
|   |   |   |   |   |--- weight >  1631.00
|   |   |   |   |   |   |--- weight <= 1784.00
|   |   |   |   |   |   |   |--- value: [31.00]
|   |   |   |   |   |   |--- weight >  1784.00
|   |   |   |   |   |   |   |--- value: [33.00]
|   |   |   |--- weight >  1829.50
|   |   |   |   |--- horsepower <= 60.50
|   |   |   |   |   |--- displacement <= 91.00
|   |   |   |   |   |   |--- value: [29.00]
|   |   |   |   |   |--- displacement >  91.00
|   |   |   |   |   |   |--- acceleration <= 21.55
|   |   |   |   |   |   |   |--- acceleration <= 19.75
|   |   |   |   |   |   |   |--- acceleration <= 19.75
|   |   |   |   |   |   |   |   |--- value: [27.00]
|   |   |   |   |   |   |   |--- acceleration >  19.75
|   |   |   |   |   |   |   |   |--- value: [26.00]
|   |   |   |   |   |   |--- acceleration >  21.55
|   |   |   |   |   |   |   |--- model year <= 74.00
|   |   |   |   |   |   |   |   |--- value: [23.00]
|   |   |   |   |   |   |   |--- model year >  74.00
|   |   |   |   |   |   |   |   |--- value: [24.50]
|   |   |   |   |--- horsepower >  60.50
|   |   |   |   |   |--- origin <= 2.50
|   |   |   |   |   |   |--- weight <= 1981.50
|   |   |   |   |   |   |   |--- weight <= 1946.00
|   |   |   |   |   |   |   |   |--- value: [29.00]
|   |   |   |   |   |   |   |--- weight >  1946.00
|   |   |   |   |   |   |   |   |--- value: [26.00]
|   |   |   |   |   |   |--- weight >  1981.50
|   |   |   |   |   |   |   |--- model year <= 72.50
|   |   |   |   |   |   |   |   |--- value: [30.00]
|   |   |   |   |   |   |   |--- model year >  72.50
|   |   |   |   |   |   |   |   |--- model year <= 75.50
|   |   |   |   |   |   |   |   |   |--- value: [31.00]
|   |   |   |   |   |   |   |   |--- model year >  75.50
|   |   |   |   |   |   |   |   |   |--- value: [30.50]
|   |   |   |   |   |--- origin >  2.50
|   |   |   |   |   |   |--- model year <= 76.50
|   |   |   |   |   |   |   |--- horsepower <= 66.00
|   |   |   |   |   |   |   |   |--- value: [32.00]
|   |   |   |   |   |   |   |--- horsepower >  66.00
|   |   |   |   |   |   |   |   |--- horsepower <= 68.50
|   |   |   |   |   |   |   |   |   |--- value: [31.00]
|   |   |   |   |   |   |   |   |--- horsepower >  68.50
|   |   |   |   |   |   |   |   |   |--- value: [32.00]
|   |   |   |   |   |   |--- model year >  76.50
|   |   |   |   |   |   |   |--- value: [30.00]
|   |   |--- model year >  77.50
|   |   |   |--- weight <= 2132.50
|   |   |   |   |--- acceleration <= 20.45
|   |   |   |   |   |--- acceleration <= 14.10
|   |   |   |   |   |   |--- value: [44.60]
|   |   |   |   |   |--- acceleration >  14.10
|   |   |   |   |   |   |--- weight <= 2067.50
|   |   |   |   |   |   |   |--- horsepower <= 64.50
|   |   |   |   |   |   |   |   |--- acceleration <= 19.10
|   |   |   |   |   |   |   |   |   |--- acceleration <= 16.25
|   |   |   |   |   |   |   |   |   |   |--- value: [35.10]
|   |   |   |   |   |   |   |   |   |--- acceleration >  16.25
|   |   |   |   |   |   |   |   |   |   |--- weight <= 1921.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- weight >  1921.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |--- acceleration >  19.10
|   |   |   |   |   |   |   |   |   |--- value: [32.80]
|   |   |   |   |   |   |   |--- horsepower >  64.50
|   |   |   |   |   |   |   |   |--- acceleration <= 18.70
|   |   |   |   |   |   |   |   |   |--- model year <= 80.50
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 15.80
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  15.80
|   |   |   |   |   |   |   |   |   |   |   |--- value: [37.20]
|   |   |   |   |   |   |   |   |   |--- model year >  80.50
|   |   |   |   |   |   |   |   |   |--- model year >  80.50
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 18.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  18.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [37.00]
|   |   |   |   |   |   |   |   |--- acceleration >  18.70
|   |   |   |   |   |   |   |   |   |--- value: [31.80]
|   |   |   |   |   |   |--- weight >  2067.50
|   |   |   |   |   |   |   |--- displacement <= 88.50
|   |   |   |   |   |   |   |   |--- acceleration <= 18.25
|   |   |   |   |   |   |   |   |   |--- value: [46.60]
|   |   |   |   |   |   |   |   |--- acceleration >  18.25
|   |   |   |   |   |   |   |   |   |--- model year <= 79.00
|   |   |   |   |   |   |   |   |   |   |--- value: [39.40]
|   |   |   |   |   |   |   |   |   |--- model year >  79.00
|   |   |   |   |   |   |   |   |   |   |--- value: [40.80]
|   |   |   |   |   |   |   |--- displacement >  88.50
|   |   |   |   |   |   |   |   |--- weight <= 2122.50
|   |   |   |   |   |   |   |   |   |--- value: [32.10]
|   |   |   |   |   |   |   |   |--- weight >  2122.50
|   |   |   |   |   |   |   |   |   |--- acceleration <= 16.00
|   |   |   |   |   |   |   |   |   |   |--- model year <= 80.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [37.30]
|   |   |   |   |   |   |   |   |   |   |--- model year >  80.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [38.00]
|   |   |   |   |   |   |   |   |   |--- acceleration >  16.00
|   |   |   |   |   |   |   |   |   |   |--- value: [36.00]
|   |   |   |   |--- acceleration >  20.45
|   |   |   |   |   |--- acceleration <= 21.60
|   |   |   |   |   |   |--- value: [43.10]
|   |   |   |   |   |--- acceleration >  21.60
|   |   |   |   |   |   |--- model year <= 81.00
|   |   |   |   |   |   |   |--- value: [44.30]
|   |   |   |   |   |   |--- model year >  81.00
|   |   |   |   |   |   |   |--- value: [44.00]
|   |   |   |--- weight >  2132.50
|   |   |   |   |--- displacement <= 101.50
|   |   |   |   |   |--- displacement <= 97.50
|   |   |   |   |   |   |--- value: [33.80]
|   |   |   |   |   |--- displacement >  97.50
|   |   |   |   |   |   |--- origin <= 2.00
|   |   |   |   |   |   |   |--- horsepower <= 66.50
|   |   |   |   |   |   |   |   |--- value: [29.90]
|   |   |   |   |   |   |   |--- horsepower >  66.50
|   |   |   |   |   |   |   |   |--- value: [30.00]
|   |   |   |   |   |   |--- origin >  2.00
|   |   |   |   |   |   |   |--- value: [29.50]
|   |   |   |   |--- displacement >  101.50
|   |   |   |   |   |--- acceleration <= 20.85
|   |   |   |   |   |   |--- displacement <= 114.50
|   |   |   |   |   |   |   |--- acceleration <= 15.90
|   |   |   |   |   |   |   |   |--- acceleration <= 14.05
|   |   |   |   |   |   |   |   |   |--- value: [34.20]
|   |   |   |   |   |   |   |   |--- acceleration >  14.05
|   |   |   |   |   |   |   |   |   |--- horsepower <= 66.50
|   |   |   |   |   |   |   |   |   |   |--- value: [34.70]
|   |   |   |   |   |   |   |   |   |--- horsepower >  66.50
|   |   |   |   |   |   |   |   |   |   |--- value: [34.50]
|   |   |   |   |   |   |   |--- acceleration >  15.90
|   |   |   |   |   |   |   |   |--- value: [34.00]
|   |   |   |   |   |   |--- displacement >  114.50
|   |   |   |   |   |   |--- displacement >  114.50
|   |   |   |   |   |   |   |--- value: [36.40]
|   |   |   |   |   |--- acceleration >  20.85
|   |   |   |   |   |   |--- value: [30.00]
|   |--- horsepower >  70.50
|   |   |--- model year <= 79.50
|   |   |   |--- weight <= 2271.50
|   |   |   |   |--- cylinders <= 3.50
|   |   |   |   |   |--- value: [18.00]
|   |   |   |   |--- cylinders >  3.50
|   |   |   |   |   |--- model year <= 76.50
|   |   |   |   |   |   |--- weight <= 2219.50
|   |   |   |   |   |   |   |--- acceleration <= 15.15
|   |   |   |   |   |   |   |   |--- weight <= 2094.00
|   |   |   |   |   |   |   |   |   |--- acceleration <= 13.35
|   |   |   |   |   |   |   |   |   |   |--- value: [29.50]
|   |   |   |   |   |   |   |   |   |--- acceleration >  13.35
|   |   |   |   |   |   |   |   |   |   |--- value: [30.00]
|   |   |   |   |   |   |   |   |--- weight >  2094.00
|   |   |   |   |   |   |   |   |   |--- origin <= 2.50
|   |   |   |   |   |   |   |   |   |   |--- value: [28.00]
|   |   |   |   |   |   |   |   |   |--- origin >  2.50
|   |   |   |   |   |   |   |   |   |   |--- value: [27.00]
|   |   |   |   |   |   |   |--- acceleration >  15.15
|   |   |   |   |   |   |   |   |--- horsepower <= 81.50
|   |   |   |   |   |   |   |   |   |--- origin <= 2.50
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 16.25
|   |   |   |   |   |   |   |   |   |   |   |--- value: [24.00]
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  16.25
|   |   |   |   |   |   |   |   |   |   |   |--- value: [25.00]
|   |   |   |   |   |   |   |   |   |--- origin >  2.50
|   |   |   |   |   |   |   |   |   |   |--- value: [28.00]
|   |   |   |   |   |   |   |   |--- horsepower >  81.50
|   |   |   |   |   |   |   |   |   |--- weight <= 2210.50
|   |   |   |   |   |   |   |   |   |   |--- value: [27.00]
|   |   |   |   |   |   |   |   |   |--- weight >  2210.50
|   |   |   |   |   |   |   |   |   |   |--- value: [29.00]
|   |   |   |   |   |   |--- weight >  2219.50
|   |   |   |   |   |   |   |--- weight <= 2241.50
|   |   |   |   |   |   |   |   |--- origin <= 1.50
|   |   |   |   |   |   |   |   |   |--- model year <= 71.50
|   |   |   |   |   |   |   |   |   |   |--- value: [23.00]
|   |   |   |   |   |   |   |   |   |--- model year >  71.50
|   |   |   |   |   |   |   |   |   |   |--- value: [21.00]
|   |   |   |   |   |   |   |   |--- origin >  1.50
|   |   |   |   |   |   |   |   |   |--- value: [25.00]
|   |   |   |   |   |   |   |--- weight >  2241.50
|   |   |   |   |   |   |   |   |--- displacement <= 119.00
|   |   |   |   |   |   |   |   |   |--- value: [26.00]
|   |   |   |   |   |   |   |   |--- displacement >  119.00
|   |   |   |   |   |   |   |   |   |--- value: [28.00]
|   |   |   |   |   |--- model year >  76.50
|   |   |   |   |   |   |--- weight <= 2247.50
|   |   |   |   |   |   |   |--- weight <= 1965.00
|   |   |   |   |   |   |   |   |--- value: [29.00]
|   |   |   |   |   |   |   |--- weight >  1965.00
|   |   |   |   |   |   |   |   |--- horsepower <= 76.50
|   |   |   |   |   |   |   |   |   |--- displacement <= 97.00
|   |   |   |   |   |   |   |   |   |   |--- value: [31.50]
|   |   |   |   |   |   |   |   |   |--- displacement >  97.00
|   |   |   |   |   |   |   |   |   |   |--- value: [30.90]
|   |   |   |   |   |   |   |   |   |   |--- value: [30.90]
|   |   |   |   |   |   |   |   |--- horsepower >  76.50
|   |   |   |   |   |   |   |   |   |--- weight <= 2172.50
|   |   |   |   |   |   |   |   |   |   |--- value: [30.00]
|   |   |   |   |   |   |   |   |   |--- weight >  2172.50
|   |   |   |   |   |   |   |   |   |   |--- value: [30.50]
|   |   |   |   |   |   |--- weight >  2247.50
|   |   |   |   |   |   |   |--- value: [26.00]
|   |   |   |--- weight >  2271.50
|   |   |   |   |--- horsepower <= 117.50
|   |   |   |   |   |--- model year <= 73.50
|   |   |   |   |   |   |--- model year <= 70.50
|   |   |   |   |   |   |   |--- acceleration <= 16.25
|   |   |   |   |   |   |   |   |--- value: [24.00]
|   |   |   |   |   |   |   |--- acceleration >  16.25
|   |   |   |   |   |   |   |   |--- value: [25.00]
|   |   |   |   |   |   |--- model year >  70.50
|   |   |   |   |   |   |   |--- weight <= 2278.50
|   |   |   |   |   |   |   |   |--- value: [24.00]
|   |   |   |   |   |   |   |--- weight >  2278.50
|   |   |   |   |   |   |   |   |--- horsepower <= 111.00
|   |   |   |   |   |   |   |   |   |--- weight <= 2354.50
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 18.75
|   |   |   |   |   |   |   |   |   |   |   |--- value: [19.00]
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  18.75
|   |   |   |   |   |   |   |   |   |   |   |--- value: [20.00]
|   |   |   |   |   |   |   |   |   |--- weight >  2354.50
|   |   |   |   |   |   |   |   |   |   |--- horsepower <= 108.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 5
|   |   |   |   |   |   |   |   |   |   |--- horsepower >  108.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [24.00]
|   |   |   |   |   |   |   |   |--- horsepower >  111.00
|   |   |   |   |   |   |   |   |   |--- value: [18.00]
|   |   |   |   |   |--- model year >  73.50
|   |   |   |   |   |   |--- horsepower <= 97.50
|   |   |   |   |   |   |   |--- horsepower <= 81.50
|   |   |   |   |   |   |   |   |--- model year <= 75.50
|   |   |   |   |   |   |   |   |   |--- model year <= 74.50
|   |   |   |   |   |   |   |   |   |   |--- weight <= 2496.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [26.00]
|   |   |   |   |   |   |   |   |   |   |--- weight >  2496.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [25.00]
|   |   |   |   |   |   |   |   |   |--- model year >  74.50
|   |   |   |   |   |   |   |   |   |   |--- value: [23.00]
|   |   |   |   |   |   |   |   |--- model year >  75.50
|   |   |   |   |   |   |   |   |   |--- displacement <= 162.00
|   |   |   |   |   |   |   |   |   |   |--- model year <= 77.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [26.50]
|   |   |   |   |   |   |   |   |   |   |--- model year >  77.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |--- displacement >  162.00
|   |   |   |   |   |   |   |   |   |   |--- value: [25.40]
|   |   |   |   |   |   |   |--- horsepower >  81.50
|   |   |   |   |   |   |   |   |--- weight <= 2785.00
|   |   |   |   |   |   |   |   |   |--- displacement <= 145.50
|   |   |   |   |   |   |   |   |   |   |--- weight <= 2398.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- weight >  2398.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 7
|   |   |   |   |   |   |   |   |   |--- displacement >  145.50
|   |   |   |   |   |   |   |   |   |   |--- value: [28.40]
|   |   |   |   |   |   |   |   |   |   |--- value: [28.40]
|   |   |   |   |   |   |   |   |--- weight >  2785.00
|   |   |   |   |   |   |   |   |   |--- horsepower <= 86.50
|   |   |   |   |   |   |   |   |   |   |--- value: [23.80]
|   |   |   |   |   |   |   |   |   |--- horsepower >  86.50
|   |   |   |   |   |   |   |   |   |   |--- displacement <= 130.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [23.00]
|   |   |   |   |   |   |   |   |   |   |--- displacement >  130.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |--- horsepower >  97.50
|   |   |   |   |   |   |   |--- model year <= 78.50
|   |   |   |   |   |   |   |   |--- weight <= 2812.50
|   |   |   |   |   |   |   |   |   |--- model year <= 76.00
|   |   |   |   |   |   |   |   |   |   |--- value: [25.00]
|   |   |   |   |   |   |   |   |   |--- model year >  76.00
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 16.20
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  16.20
|   |   |   |   |   |   |   |   |   |   |   |--- value: [23.20]
|   |   |   |   |   |   |   |   |--- weight >  2812.50
|   |   |   |   |   |   |   |   |   |--- horsepower <= 100.00
|   |   |   |   |   |   |   |   |   |   |--- value: [22.00]
|   |   |   |   |   |   |   |   |   |--- horsepower >  100.00
|   |   |   |   |   |   |   |   |   |   |--- displacement <= 143.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- displacement >  143.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [19.00]
|   |   |   |   |   |   |   |--- model year >  78.50
|   |   |   |   |   |   |   |   |--- value: [26.80]
|   |   |   |   |--- horsepower >  117.50
|   |   |   |   |   |--- weight <= 3275.00
|   |   |   |   |   |   |--- value: [17.00]
|   |   |   |   |   |--- weight >  3275.00
|   |   |   |   |   |   |--- horsepower <= 126.50
|   |   |   |   |   |   |   |--- value: [16.50]
|   |   |   |   |   |   |--- horsepower >  126.50
|   |   |   |   |   |   |   |--- value: [16.20]
|   |   |--- model year >  79.50
|   |   |   |--- weight <= 2407.50
|   |   |   |   |--- model year <= 81.50
|   |   |   |   |   |--- model year <= 80.50
|   |   |   |   |   |   |--- value: [32.20]
|   |   |   |   |   |--- model year >  80.50
|   |   |   |   |   |   |--- displacement <= 106.00
|   |   |   |   |   |   |   |--- value: [33.00]
|   |   |   |   |   |   |--- displacement >  106.00
|   |   |   |   |   |   |   |--- value: [33.70]
|   |   |   |   |--- model year >  81.50
|   |   |   |   |   |--- origin <= 1.50
|   |   |   |   |   |   |--- value: [34.00]
|   |   |   |   |   |--- origin >  1.50
|   |   |   |   |   |   |--- value: [36.00]
|   |   |   |--- weight >  2407.50
|   |   |   |   |--- displacement <= 134.50
|   |   |   |   |   |--- cylinders <= 3.50
|   |   |   |   |   |   |--- value: [23.70]
|   |   |   |   |   |--- cylinders >  3.50
|   |   |   |   |   |   |--- acceleration <= 15.30
|   |   |   |   |   |   |   |--- acceleration <= 14.95
|   |   |   |   |   |   |   |   |--- value: [32.90]
|   |   |   |   |   |   |   |--- acceleration >  14.95
|   |   |   |   |   |   |   |--- acceleration >  14.95
|   |   |   |   |   |   |   |   |--- value: [35.00]
|   |   |   |   |   |   |--- acceleration >  15.30
|   |   |   |   |   |   |   |--- acceleration <= 18.45
|   |   |   |   |   |   |   |   |--- displacement <= 127.00
|   |   |   |   |   |   |   |   |   |--- acceleration <= 16.85
|   |   |   |   |   |   |   |   |   |   |--- value: [31.00]
|   |   |   |   |   |   |   |   |   |--- acceleration >  16.85
|   |   |   |   |   |   |   |   |   |   |--- model year <= 80.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [31.30]
|   |   |   |   |   |   |   |   |   |   |--- model year >  80.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [31.60]
|   |   |   |   |   |   |   |   |--- displacement >  127.00
|   |   |   |   |   |   |   |   |   |--- value: [29.80]
|   |   |   |   |   |   |   |--- acceleration >  18.45
|   |   |   |   |   |   |   |   |--- weight <= 2680.00
|   |   |   |   |   |   |   |   |   |--- weight <= 2632.50
|   |   |   |   |   |   |   |   |   |   |--- value: [28.00]
|   |   |   |   |   |   |   |   |   |--- weight >  2632.50
|   |   |   |   |   |   |   |   |   |   |--- value: [27.00]
|   |   |   |   |   |   |   |   |--- weight >  2680.00
|   |   |   |   |   |   |   |   |   |--- value: [31.00]
|   |   |   |   |--- displacement >  134.50
|   |   |   |   |   |--- acceleration <= 12.00
|   |   |   |   |   |   |--- value: [32.70]
|   |   |   |   |   |--- acceleration >  12.00
|   |   |   |   |   |   |--- horsepower <= 107.50
|   |   |   |   |   |   |   |--- origin <= 1.50
|   |   |   |   |   |   |   |   |--- weight <= 2832.50
|   |   |   |   |   |   |   |   |   |--- horsepower <= 98.50
|   |   |   |   |   |   |   |   |   |   |--- displacement <= 153.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- displacement >  153.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |--- horsepower >  98.50
|   |   |   |   |   |   |   |   |   |   |--- value: [27.90]
|   |   |   |   |   |   |   |   |--- weight >  2832.50
|   |   |   |   |   |   |   |   |   |--- horsepower <= 91.00
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 19.10
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  19.10
|   |   |   |   |   |   |   |   |   |   |   |--- value: [24.30]
|   |   |   |   |   |   |   |   |   |--- horsepower >  91.00
|   |   |   |   |   |   |   |   |   |   |--- value: [24.00]
|   |   |   |   |   |   |   |--- origin >  1.50
|   |   |   |   |   |   |   |   |--- acceleration <= 20.00
|   |   |   |   |   |   |   |   |   |--- acceleration <= 16.75
|   |   |   |   |   |   |   |   |   |   |--- value: [32.00]
|   |   |   |   |   |   |   |   |   |--- acceleration >  16.75
|   |   |   |   |   |   |   |   |   |   |--- value: [30.70]
|   |   |   |   |   |   |   |   |--- acceleration >  20.00
|   |   |   |   |   |   |   |   |   |--- value: [28.10]
|   |   |   |   |   |   |--- horsepower >  107.50
|   |   |   |   |   |   |   |--- weight <= 2812.50
|   |   |   |   |   |   |   |   |--- value: [23.50]
|   |   |   |   |   |   |   |--- weight >  2812.50
|   |   |   |   |   |   |   |   |--- horsepower <= 118.00
|   |   |   |   |   |   |   |   |   |--- origin <= 2.00
|   |   |   |   |   |   |   |   |   |   |--- value: [25.00]
|   |   |   |   |   |   |   |   |   |--- origin >  2.00
|   |   |   |   |   |   |   |   |   |   |--- value: [25.40]
|   |   |   |   |   |   |   |   |   |   |--- value: [23.40]
|   |   |   |   |   |   |   |   |--- horsepower >  118.00
|   |   |   |   |   |   |   |   |   |--- value: [24.20]
|--- displacement >  190.50
|   |--- horsepower <= 127.00
|   |   |--- model year <= 77.50
|   |   |   |--- displacement <= 212.50
|   |   |   |   |--- horsepower <= 96.00
|   |   |   |   |   |--- horsepower <= 85.50
|   |   |   |   |   |   |--- value: [24.00]
|   |   |   |   |   |--- horsepower >  85.50
|   |   |   |   |   |   |--- weight <= 3003.00
|   |   |   |   |   |   |   |--- displacement <= 198.50
|   |   |   |   |   |   |   |   |--- weight <= 2868.50
|   |   |   |   |   |   |   |   |   |--- value: [22.00]
|   |   |   |   |   |   |   |   |--- weight >  2868.50
|   |   |   |   |   |   |   |   |   |--- value: [23.00]
|   |   |   |   |   |   |   |--- displacement >  198.50
|   |   |   |   |   |   |   |   |--- value: [21.00]
|   |   |   |   |   |   |--- weight >  3003.00
|   |   |   |   |   |   |   |--- value: [20.00]
|   |   |   |   |--- horsepower >  96.00
|   |   |   |   |   |--- value: [18.00]
|   |   |   |--- displacement >  212.50
|   |   |   |   |--- acceleration <= 16.75
|   |   |   |   |   |--- weight <= 3396.00
|   |   |   |   |   |   |--- weight <= 3341.00
|   |   |   |   |   |   |   |--- model year <= 74.00
|   |   |   |   |   |   |   |   |--- weight <= 3315.50
|   |   |   |   |   |   |   |   |   |--- model year <= 72.00
|   |   |   |   |   |   |   |   |   |   |--- displacement <= 254.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 5
|   |   |   |   |   |   |   |   |   |   |--- displacement >  254.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [18.00]
|   |   |   |   |   |   |   |   |   |--- model year >  72.00
|   |   |   |   |   |   |   |   |   |   |--- value: [18.00]
|   |   |   |   |   |   |   |   |--- weight >  3315.50
|   |   |   |   |   |   |   |   |   |--- value: [17.00]
|   |   |   |   |   |   |   |--- model year >  74.00
|   |   |   |   |   |   |   |   |--- displacement <= 243.50
|   |   |   |   |   |   |   |   |   |--- value: [19.00]
|   |   |   |   |   |   |   |   |--- displacement >  243.50
|   |   |   |   |   |   |   |   |   |--- value: [20.00]
|   |   |   |   |   |   |--- weight >  3341.00
|   |   |   |   |   |   |   |--- value: [22.00]
|   |   |   |   |   |--- weight >  3396.00
|   |   |   |   |   |   |--- acceleration <= 15.75
|   |   |   |   |   |   |   |--- displacement <= 264.50
|   |   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |   |--- displacement >  264.50
|   |   |   |   |   |   |   |   |--- value: [15.50]
|   |   |   |   |   |   |--- acceleration >  15.75
|   |   |   |   |   |   |   |--- model year <= 76.50
|   |   |   |   |   |   |   |   |--- weight <= 3629.00
|   |   |   |   |   |   |   |   |   |--- value: [18.00]
|   |   |   |   |   |   |   |   |--- weight >  3629.00
|   |   |   |   |   |   |   |   |   |--- value: [18.50]
|   |   |   |   |   |   |   |--- model year >  76.50
|   |   |   |   |   |   |   |   |--- value: [17.50]
|   |   |   |   |--- acceleration >  16.75
|   |   |   |   |   |--- model year <= 75.50
|   |   |   |   |   |--- model year <= 75.50
|   |   |   |   |   |   |--- weight <= 3606.50
|   |   |   |   |   |   |   |--- model year <= 73.50
|   |   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |   |--- model year >  73.50
|   |   |   |   |   |   |   |   |--- value: [15.00]
|   |   |   |   |   |   |--- weight >  3606.50
|   |   |   |   |   |   |   |--- acceleration <= 19.75
|   |   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |   |--- acceleration >  19.75
|   |   |   |   |   |   |   |   |--- value: [17.00]
|   |   |   |   |   |--- model year >  75.50
|   |   |   |   |   |   |--- displacement <= 254.00
|   |   |   |   |   |   |   |--- horsepower <= 88.00
|   |   |   |   |   |   |   |   |--- value: [18.00]
|   |   |   |   |   |   |   |--- horsepower >  88.00
|   |   |   |   |   |   |   |   |--- weight <= 3577.50
|   |   |   |   |   |   |   |   |   |--- value: [18.50]
|   |   |   |   |   |   |   |   |--- weight >  3577.50
|   |   |   |   |   |   |   |   |   |--- value: [19.00]
|   |   |   |   |   |   |--- displacement >  254.00
|   |   |   |   |   |   |   |--- model year <= 76.50
|   |   |   |   |   |   |   |   |--- value: [17.50]
|   |   |   |   |   |   |   |--- model year >  76.50
|   |   |   |   |   |   |   |   |--- value: [17.00]
|   |   |--- model year >  77.50
|   |   |   |--- displacement <= 259.00
|   |   |   |   |--- weight <= 3447.50
|   |   |   |   |   |--- displacement <= 245.00
|   |   |   |   |   |   |--- horsepower <= 107.50
|   |   |   |   |   |   |   |--- acceleration <= 18.45
|   |   |   |   |   |   |   |   |--- acceleration <= 16.90
|   |   |   |   |   |   |   |   |   |--- weight <= 3017.50
|   |   |   |   |   |   |   |   |   |   |--- value: [20.20]
|   |   |   |   |   |   |   |   |   |--- weight >  3017.50
|   |   |   |   |   |   |   |   |   |   |--- horsepower <= 95.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [20.80]
|   |   |   |   |   |   |   |   |   |   |--- horsepower >  95.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [20.60]
|   |   |   |   |   |   |   |   |--- acceleration >  16.90
|   |   |   |   |   |   |   |   |   |--- weight <= 3237.50
|   |   |   |   |   |   |   |   |   |   |--- model year <= 80.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- model year >  80.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [20.20]
|   |   |   |   |   |   |   |   |   |--- weight >  3237.50
|   |   |   |   |   |   |   |   |   |   |--- horsepower <= 95.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [20.20]
|   |   |   |   |   |   |   |   |   |   |--- horsepower >  95.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [20.50]
|   |   |   |   |   |   |   |--- acceleration >  18.45
|   |   |   |   |   |   |   |   |--- value: [19.10]
|   |   |   |   |   |   |--- horsepower >  107.50
|   |   |   |   |   |   |   |--- weight <= 3387.50
|   |   |   |   |   |   |   |   |--- value: [20.60]
|   |   |   |   |   |   |   |--- weight >  3387.50
|   |   |   |   |   |   |   |   |--- value: [22.40]
|   |   |   |   |   |--- displacement >  245.00
|   |   |   |   |   |   |--- value: [18.10]
|   |   |   |   |--- weight >  3447.50
|   |   |   |   |   |--- model year <= 79.50
|   |   |   |   |   |--- model year <= 79.50
|   |   |   |   |   |   |--- value: [18.60]
|   |   |   |   |   |--- model year >  79.50
|   |   |   |   |   |   |--- value: [17.60]
|   |   |   |--- displacement >  259.00
|   |   |   |   |--- model year <= 80.00
|   |   |   |   |   |--- displacement <= 305.00
|   |   |   |   |   |   |--- value: [23.90]
|   |   |   |   |   |--- displacement >  305.00
|   |   |   |   |   |   |--- value: [23.00]
|   |   |   |   |--- model year >  80.00
|   |   |   |   |   |--- value: [26.60]
|   |--- horsepower >  127.00
|   |   |--- model year <= 76.50
|   |   |   |--- horsepower <= 191.50
|   |   |   |   |--- model year <= 70.50
|   |   |   |   |   |--- weight <= 3533.50
|   |   |   |   |   |   |--- displacement <= 305.50
|   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |--- displacement >  305.50
|   |   |   |   |   |   |   |--- value: [18.00]
|   |   |   |   |   |--- weight >  3533.50
|   |   |   |   |   |   |--- value: [15.00]
|   |   |   |   |--- model year >  70.50
|   |   |   |   |   |--- model year <= 73.50
|   |   |   |   |   |   |--- horsepower <= 155.50
|   |   |   |   |   |   |   |--- horsepower <= 142.50
|   |   |   |   |   |   |   |   |--- weight <= 4070.00
|   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |   |   |--- weight >  4070.00
|   |   |   |   |   |   |   |   |   |--- value: [13.00]
|   |   |   |   |   |   |   |--- horsepower >  142.50
|   |   |   |   |   |   |   |   |--- displacement <= 334.00
|   |   |   |   |   |   |   |   |   |--- model year <= 71.50
|   |   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |   |   |   |--- model year >  71.50
|   |   |   |   |   |   |   |   |   |   |--- weight <= 3724.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |   |   |   |   |--- weight >  3724.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |--- displacement >  334.00
|   |   |   |   |   |   |   |   |   |--- weight <= 4035.00
|   |   |   |   |   |   |   |   |   |   |--- value: [13.00]
|   |   |   |   |   |   |   |   |   |--- weight >  4035.00
|   |   |   |   |   |   |   |   |   |   |--- horsepower <= 149.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [15.00]
|   |   |   |   |   |   |   |   |   |   |--- horsepower >  149.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |--- horsepower >  155.50
|   |   |   |   |   |   |   |--- weight <= 3742.50
|   |   |   |   |   |   |   |   |--- value: [11.00]
|   |   |   |   |   |   |   |--- weight >  3742.50
|   |   |   |   |   |   |   |   |--- model year <= 71.50
|   |   |   |   |   |   |   |   |   |--- weight <= 4605.00
|   |   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |   |   |   |--- weight >  4605.00
|   |   |   |   |   |   |   |   |   |   |--- value: [13.00]
|   |   |   |   |   |   |   |   |--- model year >  71.50
|   |   |   |   |   |   |   |   |   |--- weight <= 4439.00
|   |   |   |   |   |   |   |   |   |   |--- value: [13.00]
|   |   |   |   |   |   |   |   |   |--- weight >  4439.00
|   |   |   |   |   |   |   |   |   |--- weight >  4439.00
|   |   |   |   |   |   |   |   |   |   |--- horsepower <= 168.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [12.00]
|   |   |   |   |   |   |   |   |   |   |--- horsepower >  168.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |--- model year >  73.50
|   |   |   |   |   |   |--- weight <= 4098.00
|   |   |   |   |   |   |   |--- value: [13.00]
|   |   |   |   |   |   |--- weight >  4098.00
|   |   |   |   |   |   |   |--- model year <= 74.50
|   |   |   |   |   |   |   |   |--- weight <= 4199.00
|   |   |   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |   |   |--- weight >  4199.00
|   |   |   |   |   |   |   |   |   |--- displacement <= 334.00
|   |   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |   |   |   |--- displacement >  334.00
|   |   |   |   |   |   |   |   |   |   |--- value: [13.00]
|   |   |   |   |   |   |   |--- model year >  74.50
|   |   |   |   |   |   |   |   |--- horsepower <= 149.00
|   |   |   |   |   |   |   |   |   |--- acceleration <= 13.75
|   |   |   |   |   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |   |   |   |   |   |--- acceleration >  13.75
|   |   |   |   |   |   |   |   |   |   |--- value: [15.00]
|   |   |   |   |   |   |   |   |--- horsepower >  149.00
|   |   |   |   |   |   |   |   |   |--- weight <= 4297.50
|   |   |   |   |   |   |   |   |   |   |--- acceleration <= 12.90
|   |   |   |   |   |   |   |   |   |   |   |--- value: [14.50]
|   |   |   |   |   |   |   |   |   |   |--- acceleration >  12.90
|   |   |   |   |   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |   |   |   |--- weight >  4297.50
|   |   |   |   |   |   |   |   |   |   |--- model year <= 75.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |   |   |   |   |   |--- model year >  75.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [16.50]
|   |   |   |--- horsepower >  191.50
|   |   |   |   |--- acceleration <= 10.50
|   |   |   |   |   |--- weight <= 4295.00
|   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |   |--- weight >  4295.00
|   |   |   |   |   |   |--- value: [14.00]
|   |   |   |   |--- acceleration >  10.50
|   |   |   |   |   |--- acceleration <= 13.75
|   |   |   |   |   |   |--- weight <= 4792.00
|   |   |   |   |   |   |   |--- value: [11.00]
|   |   |   |   |   |   |--- weight >  4792.00
|   |   |   |   |   |   |   |--- value: [12.00]
|   |   |   |   |   |--- acceleration >  13.75
|   |   |   |   |   |   |--- displacement <= 305.50
|   |   |   |   |   |   |   |--- value: [9.00]
|   |   |   |   |   |   |--- displacement >  305.50
|   |   |   |   |   |   |   |--- value: [10.00]
|   |   |--- model year >  76.50
|   |   |   |--- weight <= 3917.50
|   |   |   |   |--- horsepower <= 142.50
|   |   |   |   |   |--- horsepower <= 137.00
|   |   |   |   |   |   |--- acceleration <= 14.30
|   |   |   |   |   |   |   |--- value: [17.60]
|   |   |   |   |   |   |--- acceleration >  14.30
|   |   |   |   |   |   |   |--- value: [18.20]
|   |   |   |   |   |--- horsepower >  137.00
|   |   |   |   |   |   |--- weight <= 3387.50
|   |   |   |   |   |   |--- weight <= 3387.50
|   |   |   |   |   |   |   |--- value: [18.10]
|   |   |   |   |   |   |--- weight >  3387.50
|   |   |   |   |   |   |   |--- acceleration <= 13.00
|   |   |   |   |   |   |   |   |--- value: [20.20]
|   |   |   |   |   |   |   |--- acceleration >  13.00
|   |   |   |   |   |   |   |   |--- value: [19.40]
|   |   |   |   |--- horsepower >  142.50
|   |   |   |   |   |--- weight <= 3662.50
|   |   |   |   |   |   |--- value: [17.70]
|   |   |   |   |   |--- weight >  3662.50
|   |   |   |   |   |   |--- value: [17.50]
|   |   |   |--- weight >  3917.50
|   |   |   |   |--- model year <= 77.50
|   |   |   |   |   |--- displacement <= 334.50
|   |   |   |   |   |   |--- horsepower <= 137.50
|   |   |   |   |   |   |   |--- value: [15.00]
|   |   |   |   |   |   |--- horsepower >  137.50
|   |   |   |   |   |   |   |--- value: [15.50]
|   |   |   |   |   |--- displacement >  334.50
|   |   |   |   |   |   |--- value: [16.00]
|   |   |   |   |--- model year >  77.50
|   |   |   |   |   |--- weight <= 4067.00
|   |   |   |   |   |   |--- acceleration <= 13.75
|   |   |   |   |   |   |   |--- value: [16.50]
|   |   |   |   |   |   |--- acceleration >  13.75
|   |   |   |   |   |   |   |--- value: [15.50]
|   |   |   |   |   |--- weight >  4067.00
|   |   |   |   |   |   |--- model year <= 78.50
|   |   |   |   |   |   |   |--- value: [17.50]
|   |   |   |   |   |   |--- model year >  78.50
|   |   |   |   |   |   |   |--- value: [16.90]
```

Визуализация дерева решений

In [124]:

```
from sklearn.tree import export_graphviz
import graphviz
dot_data = export_graphviz(mpg_tree_regr, out_file=None,
                           feature_names=X.columns,
                           class_names=mpg['mpg'],
                           filled=True, rounded=True, special_characters=True)
graph = graphviz.Source(dot_data)
graph
```

Out[124]:

In [57]:

```
from sklearn.tree import DecisionTreeRegressor
mpg_tree_regr_d = DecisionTreeRegressor(random_state=1, max_depth=10).fit(mpg_X_train, m
pg_y_train)
mpg_y_test_predict_d = mpg_tree_regr_d.predict(mpg_X_test)
```

In [58]:

```
r2_score(mpg_y_test, mpg_y_test_predict_d)
```

Out[58]:

```
0.8458130246478665
```

In [59]:

```
root_mean_squared_error(mpg_y_test, mpg_y_test_predict_d)
```

Out[59]:

```
3.2693412103045763
```

In [60]:

```
mpg_tree_regr_fl[0:4]
```

Out[60]:

```
['displacement', 'horsepower', 'model year', 'weight']
```

In [61]:

```
sum(mpg_tree_regr_fd[0:4])
```

Out[61]:

```
0.9603184500755281
```

In [62]:

```
X.head()
```

Out[62]:

	cylinders	displacement	horsepower	weight	acceleration	model year	origin
0	8	307.0	130.0	3504	12.0	70	1
1	8	350.0	165.0	3693	11.5	70	1
2	8	318.0	150.0	3436	11.0	70	1
3	8	304.0	150.0	3433	12.0	70	1
4	8	302.0	140.0	3449	10.5	70	1

In [63]:

```
X_sorted = X[mpg_tree_regr_fl]
X_sorted.head()
```

Out[63]:

	displacement	horsepower	model year	weight	acceleration	cylinders	origin
0	307.0	130.0	70	3504	12.0	8	1
1	350.0	165.0	70	3693	11.5	8	1
2	318.0	150.0	70	3436	11.0	8	1
3	304.0	150.0	70	3433	12.0	8	1
4	302.0	140.0	70	3449	10.5	8	1

In [64]:

```
mpg_X_train_tr, mpg_X_test_tr, mpg_y_train_tr, mpg_y_test_tr = train_test_split(X_sorted
, y, test_size=0.2, random_state=1)
```

In [65]:

```
# Обучим дерево и предскажем результаты на всех признаках
mpg_tree_regr_feat_1 = DecisionTreeRegressor(random_state=1).fit(mpg_X_train_tr, mpg_y_tr
ain_tr)
mpg_y_test_predict = mpg_tree_regr_feat_1.predict(mpg_X_test_tr)
```

In [66]:

In [66]:

```
r2_score(mpg_y_test_tr, mpg_y_test_predict)
```

Out[66]:

```
0.8357771185080485
```

In [67]:

```
mpg_tree_regr_feat_2 = DecisionTreeRegressor(random_state=1).fit(
    mpg_X_train_tr[mpg_tree_regr_fl[0:4]], mpg_y_train_tr)
mpg_y_test_predict_2 = mpg_tree_regr_feat_2.predict(mpg_X_test_tr[mpg_tree_regr_fl[0:4]])
```