Московский государственный технический университет им. Н.Э. Баумана

Факультет «Информатика и системы управления»

Кафедра «Системы обработки информации и управления»

«Методы машинного обучения»

Отчет по Лабораторной работе №5

Линейные модели, SVM и деревья решений.

Выполнила:

студентка группы ИУ5-22М

Петрова Ирина

Проверил: доцент, к.т.н.

Гапанюк Ю. Е.

Москва, 2020

Лабораторная работа №5. Линейные модели, SVM и деревья решений.

Цель лабораторной работы: изучение линейных моделей, SVM и деревьев решений.

Требования к отчету: отчет по лабораторной работе должен содержать:

- титульный лист; описание задания; текст программы;
- экранные формы с примерами выполнения
- программы.
-

Задание:

1. Выберите набор данных (датасет) для решения задачи классификации или регрессии.
2. В случае необходимости проведите удаление или заполнение пропусков и кодирование категориальных признаков.
3. С использованием метода train_test_split разделите выборку на обучающую и тестовую.
4. Обучите следующие модели:
    - одну из линейных
    - моделей; SVM; дерево
    - решений.
5. Оцените качество моделей с помощью трех подходящих для задачи метрик. Сравните качество полученных моделей.
6. Произведите для каждой модели подбор одного гиперпараметра с использованием GridSearchCV и кросс-валидации.
7. Повторите пункт 4 для найденных оптимальных значений гиперпараметров. Сравните качество полученных моделей с качеством моделей, полученных в пункте 4.

Текстовое описание набора данных

Используется набор данных, использующий данные химического анализа для установления происхождения вина: https://archive.ics.uci.edu/ml/datasets/Wine (https://archive.ics.uci.edu/ml/datasets/Wine)

Эти данные являются результатами химического анализа вин, выращенных в одном регионе Италии, но полученных из трех различных сортов. В результате анализа было определено 13 компонентов, содержащихся в каждом из трех видов вин.

Датасет содержит следующие колонки:

- Алкоголь
- Яблочная кислота
- Зола
- Щелочность золы
- Магний
- Всего фенолов
- Флаваноиды
- Нефлаваноидные фенолы
- Проантоцианы
- Интенсивность цвета
- Оттенок
- OD280 / OD315 (разбавленность вина)
- Пролин

1. Выбор датасета

In [65]:

```
from IPython.display import Image
import numpy as np import pandas
as pd
from sklearn.model_selection import train_test_split
from sklearn.datasets import load_wine
from sklearn.neighbors import KNeighborsRegressor, KNeighborsClassifier
from sklearn.model_selection import cross_val_score, cross_validate
from sklearn.model_selection import KFold, RepeatedKFold, LeaveOneOut, LeavePOut, Shuff
leSplit, StratifiedKFold
from sklearn.metrics import accuracy_score, balanced_accuracy_score
from sklearn.metrics import precision_score, recall_score, f1_score, classification_rep
ort
from sklearn.metrics import confusion_matrix
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_squared_log_e
rror, median_absolute_error, r2_score
from sklearn.metrics import roc_curve, roc_auc_score
from sklearn.model_selection import GridSearchCV, RandomizedSearchCV
from sklearn.model_selection import learning_curve, validation_curve
import seaborn as sns import matplotlib.pyplot as plt from typing
import Dict, Tuple
from sklearn.linear_model import LinearRegression, BayesianRidge
from sklearn.tree import DecisionTreeRegressor
%matplotlib inline  sns.set(style="ticks")
```

In [2]:

```
wine = load_wine()
```

In [3]:

```
data = pd.DataFrame(data= np.c_[wine['data'], wine['target']],
                     columns= wine['feature_names'] + ['target'])
data
```

Out[3]:

	alcohol	malic_acid	ash	alcalinity_of_ash	magnesium	total_phenols	flavanoids	nonf

0	14.23	1.71	2.43	15.6	127.0	2.80	3.06
1	13.20	1.78	2.14	11.2	100.0	2.65	2.76
2	13.16	2.36	2.67	18.6	101.0	2.80	3.24
3	14.37	1.95	2.50	16.8	113.0	3.85	3.49
4	13.24 2.59 2.87 21.0 118.0 2.80 2.69 **...**						
173	13.71	5.65	2.45	20.5	95.0	1.68	0.61
174	13.40	3.91	2.48	23.0	102.0	1.80	0.75
175	13.27	4.28	2.26	20.0	120.0	1.59	0.69
176	13.17	2.59	2.37	20.0	120.0	1.65	0.68
177	14.13	4.10	2.74	24.5	96.0	2.05	0.76

178 rows × 14 columns

3. Разделение выборки на обучающую и тестовую

In [4]:

```
# Разделение выборки на обучающую и тестовую
wine_X_train, wine_X_test, wine_y_train, wine_y_test = train_test_split(
    wine.data, wine.target, test_size=0.5, random_state=1)
```

4. Обучение моделей

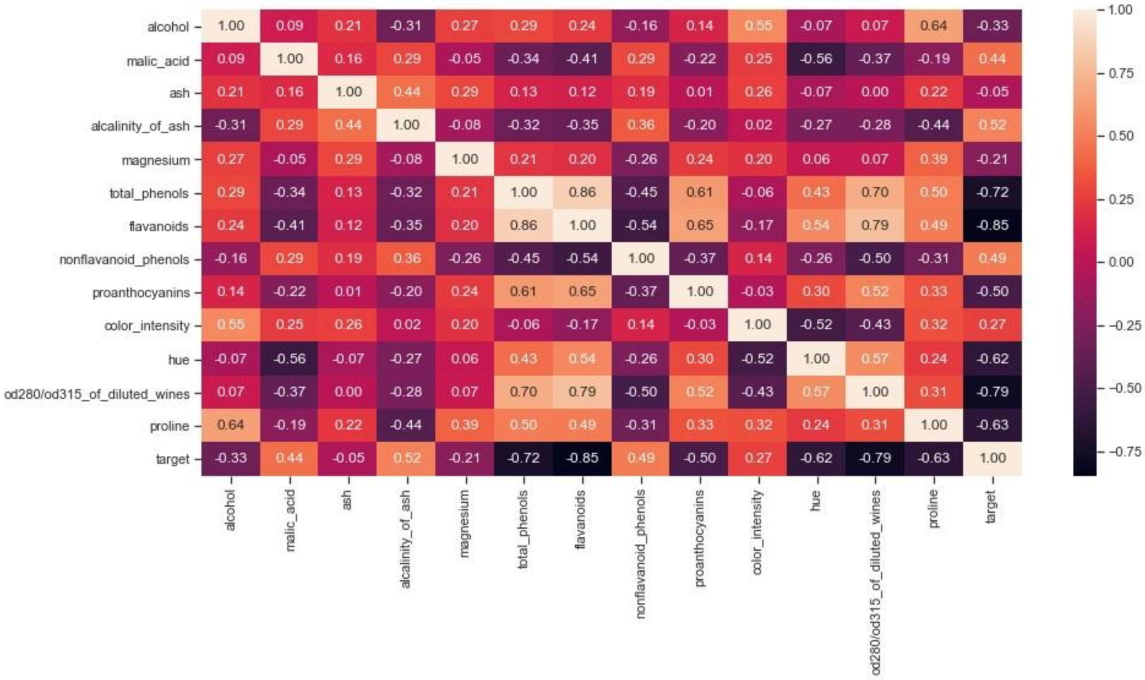
4.1. Обучение линейной модели

In [6]:

```
#Построим корреляционную матрицу fig, ax =
plt.subplots(figsize=(15,7)) sns.heatmap(data.corr(method='pearson'),
ax=ax, annot=True, fmt='.2f')
```

Out[6]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x26d7775ed30>
```



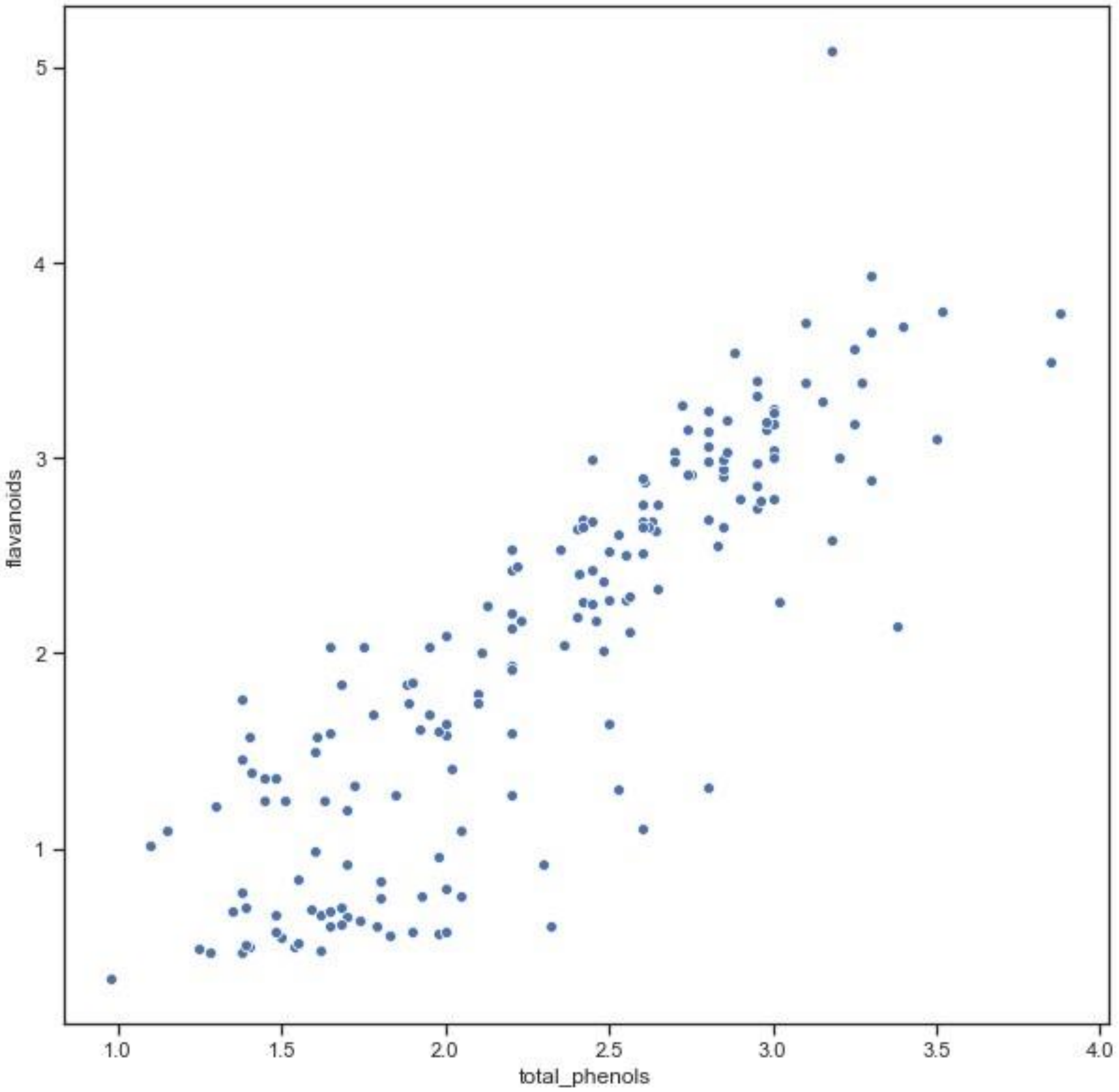
	alcohol	malic_acid	ash	alcalinity_of_ash	magnesium	total_phenols	flavanoids	nonflavanoid_phenols	proanthocyanins	color_intensity	hue	od280/od315_of_diluted_wines	proline	target
alcohol	1.00	0.09	0.21	-0.31	0.27	0.29	0.24	-0.16	0.14	0.55	-0.07	0.07	0.64	-0.33
malic_acid	0.09	1.00	0.16	0.29	-0.05	-0.34	-0.41	0.29	-0.22	0.25	-0.56	-0.37	-0.19	0.44
ash	0.21	0.16	1.00	0.44	0.29	0.13	0.12	0.19	0.01	0.26	-0.07	0.00	0.22	-0.05
alcalinity_of_ash	-0.31	0.29	0.44	1.00	-0.08	-0.32	-0.35	0.36	-0.20	0.02	-0.27	-0.28	-0.44	0.52
magnesium	0.27	-0.05	0.29	-0.08	1.00	0.21	0.20	-0.26	0.24	0.20	0.06	0.07	0.39	-0.21
total_phenols	0.29	-0.34	0.13	-0.32	0.21	1.00	0.86	-0.45	0.61	-0.06	0.43	0.70	0.50	-0.72
flavanoids	0.24	-0.41	0.12	-0.35	0.20	0.86	1.00	-0.54	0.65	-0.17	0.54	0.79	0.49	-0.85
nonflavanoid_phenols	-0.16	0.29	0.19	0.36	-0.26	-0.45	-0.54	1.00	-0.37	0.14	-0.26	-0.50	-0.31	0.49
proanthocyanins	0.14	-0.22	0.01	-0.20	0.24	0.61	0.65	-0.37	1.00	-0.03	0.30	0.52	0.33	-0.50
color_intensity	0.55	0.25	0.26	0.02	0.20	-0.06	-0.17	0.14	-0.03	1.00	-0.52	-0.43	0.32	0.27
hue	-0.07	-0.56	-0.07	-0.27	0.06	0.43	0.54	-0.26	0.30	-0.52	1.00	0.57	0.24	-0.62
od280/od315_of_diluted_wines	0.07	-0.37	0.00	-0.28	0.07	0.70	0.79	-0.50	0.52	-0.43	0.57	1.00	0.31	-0.79
proline	0.64	-0.19	0.22	-0.44	0.39	0.50	0.49	-0.31	0.33	0.32	0.24	0.31	1.00	-0.63
target	-0.33	0.44	-0.05	0.52	-0.21	-0.72	-0.85	0.49	-0.50	0.27	-0.62	-0.79	-0.63	1.00

In [31]:

```
fig, ax = plt.subplots(figsize=(10,10))
sns.scatterplot(ax=ax, x='total_phenols', y='flavanoids', data=data)
```

```
Out[31]:
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x26d774ae048>
```



Между признаком "total_phenols" и признаком "flavanoids" существует зависимость, близкая к линейной, коэффициент корреляции = 0,86

Попробуем восстановить данную линейную зависимость.

```
In [80]:
```

```
x = data['total_phenols'].values
y = data['flavanoids'].values
```

```
In [85]:
```

```
reg = BayesianRidge(fit_intercept=True).fit(x.reshape(-1, 1), y)
reg.coef_
reg.intercept_
```

```
Out[85]:
```

```
-1.1315823825415343
```

```
In [86]:
```

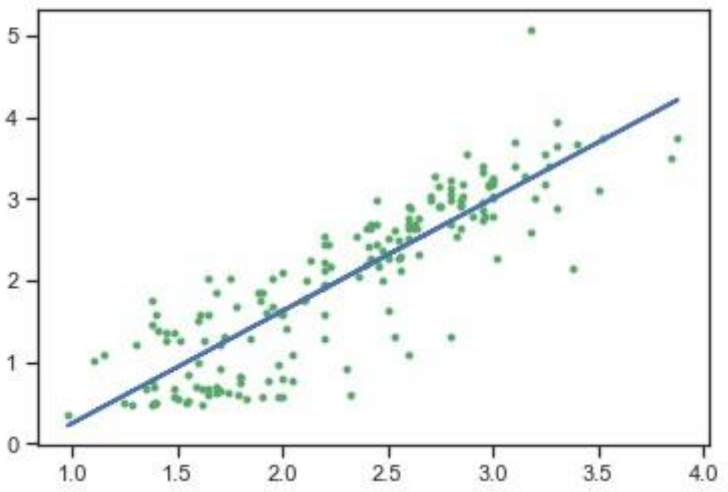
```
def func(w, b, x):
    return w*x + b
```

In [87]:

```
x_t = list(range(0, 300, 5))
y_t = [func(reg.coef_[0], reg.intercept_, x) for x in x_t]

y_tt = reg.predict(x.reshape(-1, 1)) In [90]:
```

```
plt.plot(x, y, 'g.')
plt.plot(x, y_tt, 'b', linewidth=2.0)
plt.show()
```



4.2. Обучение SVM

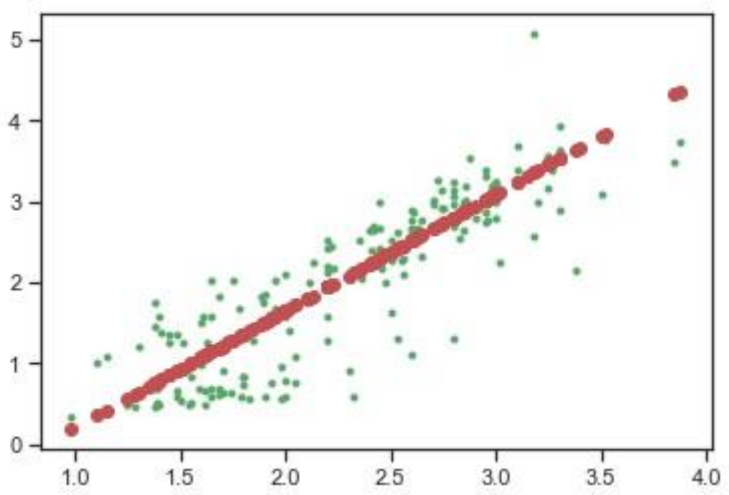
In [42]:
```
from sklearn.svm import SVC, NuSVC, LinearSVC, OneClassSVM, SVR, NuSVR,

LinearSVR In [94]:
```

```
lin_SVR = LinearSVR(C=1.0, max_iter=10000)
lin_SVR.fit(x.reshape(-1, 1), y)
predict = lin_SVR.predict(x.reshape(-1, 1))
plt.plot(x, y, 'g.')
plt.plot(x, predict, 'ro')
```

Out[94]:

```
[<matplotlib.lines.Line2D at 0x26d79bd51d0>]
```



4.3. Обучение дерева решений

In [53]:

```
dec_tree = DecisionTreeRegressor(random_state=1, max_depth=5)
dec_tree.fit(data, data["flavanoids"])
dec_tree
```

Out[53]:

```
DecisionTreeRegressor(ccp_alpha=0.0, criterion='mse', max_depth=5,
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=1, splitter='best')
```

In [54]:

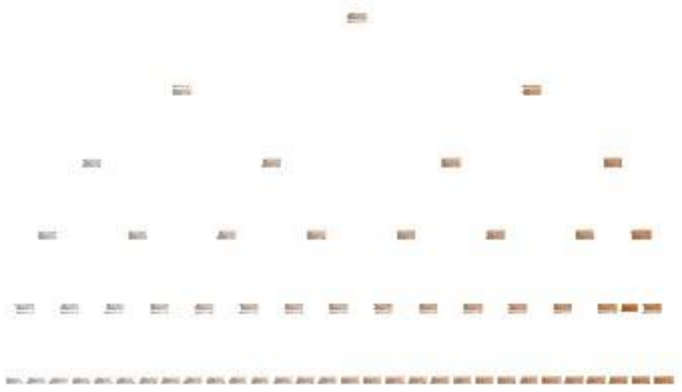
```
dec_predict = dec_tree.predict(data)
```

In [55]:

```
from sklearn import tree
tree.plot_tree(dec_tree, filled=True)
```

Out[55]:

```
[Text(176.4675, 199.32, 'X[6] <= 1.93\nmse = 0.992\nsamples = 178\nvalue =
2.029'), Text(89.28, 163.07999999999998, 'X[6] <= 1.15\nmse =
0.209\nsamples = 79 \nvalue = 1.063'),
 Text(44.64, 126.83999999999999, 'X[6] <= 0.725\nmse = 0.035\nsamples = 44
\nvalue = 0.695'),
 Text(22.32, 90.6, 'X[6] <= 0.555\nmse = 0.007\nsamples = 28\nvalue = 0.57
7'),
 Text(11.16, 54.359999999999985, 'X[12] <= 442.5\nmse = 0.003\nsamples = 1
0\nvalue = 0.483'),
 Text(5.58, 18.119999999999976, 'mse = 0.0\nsamples = 1\nvalue = 0.34'),
 Text(16.740000000000002, 18.119999999999976, 'mse = 0.001\nsamples = 9\nv
alue = 0.499'),
 Text(33.480000000000004, 54.359999999999985, 'X[6] <= 0.64\nmse = 0.002\n
samples = 18\nvalue = 0.629'),
 Text(27.9, 18.119999999999976, 'mse = 0.0\nsamples = 10\nvalue = 0.591'),
 Text(39.06, 18.119999999999976, 'mse = 0.0\nsamples = 8\nvalue = 0.678'),
 Text(66.96000000000001, 90.6, 'X[6] <= 0.88\nmse = 0.015\nsamples = 16\nv
alue = 0.902'),
 Text(55.8, 54.359999999999985, 'X[6] <= 0.79\nmse = 0.001\nsamples = 8\nv
alue = 0.794'),
 Text(50.22, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 0.762'),
 Text(61.38, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 0.825'),
 Text(78.12, 54.359999999999985, 'X[6] <= 1.005\nmse = 0.005\nsamples = 8
\nvalue = 1.011'),
 Text(72.54, 18.119999999999976, 'mse = 0.001\nsamples = 4\nvalue = 0.94
8'),
 Text(83.7, 18.119999999999976, 'mse = 0.001\nsamples = 4\nvalue = 1.07
5'),
 Text(133.92000000000002, 126.83999999999999, 'X[6] <= 1.535\nmse = 0.045
\nsamples = 35\nvalue = 1.526'),
 Text(111.6, 90.6, 'X[6] <= 1.34\nmse = 0.007\nsamples = 16\nvalue = 1.32
1'),
 Text(100.44, 54.359999999999985, 'X[5] <= 1.71\nmse = 0.001\nsamples = 10
\nvalue = 1.266'),
 Text(94.86, 18.119999999999976, 'mse = 0.0\nsamples = 5\nvalue = 1.234'),
 Text(106.02, 18.119999999999976, 'mse = 0.0\nsamples = 5\nvalue = 1.29
8'),
 Text(122.76, 54.359999999999985, 'X[6] <= 1.435\nmse = 0.003\nsamples = 6
\nvalue = 1.413'),
 Text(117.18, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 1.38'),
 Text(128.34, 18.119999999999976, 'mse = 0.0\nsamples = 2\nvalue = 1.48'),
 Text(156.24, 90.6, 'X[6] <= 1.72\nmse = 0.012\nsamples = 19\nvalue = 1.69
8'),
 Text(145.08, 54.359999999999985, 'X[6] <= 1.625\nmse = 0.002\nsamples = 1
1\nvalue = 1.615'),
 Text(139.5, 18.119999999999976, 'mse = 0.0\nsamples = 7\nvalue = 1.587'),
 Text(150.66, 18.119999999999976, 'mse = 0.001\nsamples = 4\nvalue = 1.66
5'),
 Text(167.4, 54.359999999999985, 'X[6] <= 1.815\nmse = 0.003\nsamples = 8
\nvalue = 1.812'),
 Text(161.82, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 1.76
2'),
 Text(172.98, 18.119999999999976, 'mse = 0.001\nsamples = 4\nvalue = 1.86
2'),
 Text(263.6550000000003, 163.07999999999998, 'X[6] <= 2.825\nmse = 0.278
\nsamples = 99\nvalue = 2.8'),
 Text(223.2, 126.83999999999999, 'X[6] <= 2.39\nmse = 0.065\nsamples = 53
\nvalue = 2.411'),
 Text(200.88, 90.6, 'X[6] <= 2.155\nmse = 0.013\nsamples = 24\nvalue = 2.1
6'),
 Text(189.72, 54.359999999999985, 'X[6] <= 2.065\nmse = 0.003\nsamples = 1
1\nvalue = 2.05'),
 Text(184.14000000000001, 18.119999999999976, 'mse = 0.001\nsamples = 7\nv
alue = 2.011'),
 Text(195.3, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 2.118'),
 Text(212.04, 54.359999999999985, 'X[6] <= 2.225\nmse = 0.003\nsamples = 1
3\nvalue = 2.252'),
 Text(206.46, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 2.18
5'),
 Text(217.62, 18.119999999999976, 'mse = 0.002\nsamples = 9\nvalue = 2.28
2'),
 Text(245.52, 90.6, 'X[6] <= 2.595\nmse = 0.013\nsamples = 29\nvalue = 2.6
19'),
 Text(234.36, 54.359999999999985, 'X[6] <= 2.475\nmse = 0.003\nsamples = 1
1\nvalue = 2.495'),
 Text(228.78, 18.119999999999976, 'mse = 0.0\nsamples = 4\nvalue = 2.43'),
 Text(239.94, 18.119999999999976, 'mse = 0.001\nsamples = 7\nvalue = 2.53
1'),
 Text(256.68, 54.359999999999985, 'X[6] <= 2.715\nmse = 0.003\nsamples = 1
8\nvalue = 2.696'),
 Text(251.1, 18.119999999999976, 'mse = 0.001\nsamples = 12\nvalue = 2.65
8'),
 Text(262.26, 18.119999999999976, 'mse = 0.0\nsamples = 6\nvalue = 2.77'),
 Text(304.11, 126.83999999999999, 'X[6] <= 3.445\nmse = 0.149\nsamples = 4
6\nvalue = 3.248'),
 Text(290.16, 90.6, 'X[6] <= 3.12\nmse = 0.024\nsamples = 36\nvalue = 3.09
2'),
 Text(279.0, 54.359999999999985, 'X[6] <= 2.955\nmse = 0.004\nsamples = 20
\nvalue = 2.97'),
 Text(273.42, 18.119999999999976, 'mse = 0.001\nsamples = 8\nvalue = 2.90
3'),
 Text(284.58, 18.119999999999976, 'mse = 0.001\nsamples = 12\nvalue = 3.01
4'),
 Text(301.32, 54.359999999999985, 'X[6] <= 3.28\nmse = 0.008\nsamples = 16
\nvalue = 3.246'),
 Text(295.74, 18.119999999999976, 'mse = 0.002\nsamples = 11\nvalue = 3.19
5'),
 Text(306.9, 18.119999999999976, 'mse = 0.002\nsamples = 5\nvalue = 3.35
8'),
 Text(318.06, 90.6, 'X[0] <= 11.965\nmse = 0.194\nsamples = 10\nvalue = 3.
809'),
 Text(312.48, 54.359999999999985, 'mse = 0.0\nsamples = 1\nvalue = 5.08'),
 Text(323.64, 54.359999999999985, 'X[6] <= 3.655\nmse = 0.016\nsamples = 9
\nvalue = 3.668'),
 Text(318.06, 18.119999999999976, 'mse = 0.003\nsamples = 4\nvalue = 3.55
8'),
 Text(329.22, 18.119999999999976, 'mse = 0.008\nsamples = 5\nvalue = 3.75
6')]
```



5. Оценка качества моделей

In [95]:

```
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_squared_log_e
rror, median_absolute_error, r2_score

print("Метрики для линейной модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, y_tt))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, y_tt))
print("Коэффициент детерминации: ", r2_score(y, y_tt))

print("\n\nМетрики для SVM-модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, predict))
print("Коэффициент детерминации: ", r2_score(y, predict))


print("\n\nМетрики для Decision Tree:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, dec_predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, dec_predict))
print("Коэффициент детерминации: ", r2_score(y, dec_predict))
```

```
Метрики для линейной модели:

Средняя абсолютная ошибка:  0.38837557197701433
Средняя квадратичная ошибка:  0.25054108150179827
Коэффициент детерминации:  0.7474673224538837


Метрики для SVM-модели:

Средняя абсолютная ошибка:  0.38178925184594825
Средняя квадратичная ошибка:  0.2543772448091098
Коэффициент детерминации:  0.7436006647956162

Метрики для Decision Tree:

Средняя абсолютная ошибка:  0.023708586669260 83
Средняя квадратичная ошибка:  0.0010085943301392747
Коэффициент детерминации:  0.998983388172426
```

6. Подбор гиперпараметра K с использованием GridSearchCV и кросс-валидации

In [60]:

```
from sklearn.model_selection import cross_validate
```

In [61]:

```
scoring = {'mean': 'neg_mean_absolute_error', 'square': 'neg_mean_squared_error', 'r2':
'r2'}
```

In [96]:

```
scores_regr = cross_validate(BayesianRidge(fit_intercept=True),
                             x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_regr Out[96]:
```

```
{'fit_time': array([0.00102735, 0.00096703, 0.00151944]),
 'score_time': array([0.00098944, 0.00099707, 0.00098562]),
 'test_mean': array([-0.46738065, -0.43402138, -0.70598688]),
 'test_square': array([-0.27485104, -0.31021826, -0.68273128]),
 'test_r2': array([-0.10777762,  0.05992159,  0.10814324])}
```

In [97]:

```
scores_svm = cross_validate(LinearSVR(C=1.0, max_iter=10000),
                           x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_svm Out[97]:
```

```
{'fit_time': array([0.00199437, 0.00099778, 0.00150585]),
 'score_time': array([0.00099707, 0.00099897, 0.0009973 ]),
 'test_mean': array([-0.37651991, -0.40821794, -0.73564537]),
 'test_square': array([-0.19049266, -0.2878672 , -0.74572873]),
 'test_r2': array([0.23222591, 0.12765374, 0.02584923])}
```

In [99]:

```
scores_dec = cross_validate(DecisionTreeRegressor(random_state=1, max_depth=3),
                           data, data["flavanoids"], cv=5, scoring=scoring)
scores_dec Out[99]:
```

```
{'fit_time': array([0.00298786, 0.00349998, 0.00299144, 0.00199628, 0.0019
9485]),
 'score_time': array([0.00199771, 0.00250411, 0.00199318, 0.00199485, 0.00
099635]),
 'test_mean': array([-0.19587302, -0.14458327, -0.1097615 , -0.13096384,
0.15244473]),
 'test_square': array([-0.06617504, -0.03283525, -0.01646075, -0.07348624,
-0.03362549]),
 'test_r2': array([0.60597266, 0.94997735, 0.94259156, 0.92856868, 0.58323
408])}
```

In [100]:

```
print("Метрики для линейной модели:\n")
print("Средняя абсолютная ошибка: ", np.mean(scores_regr['test_mean']))
print("Средняя квадратичная ошибка: ", np.mean(scores_regr['test_square']))
print("Коэффициент детерминации: ", np.mean(scores_regr['test_r2']))

print("\n\nМетрики для SVM-модели:\n")
print("Средняя абсолютная ошибка: ", np.mean(scores_svm['test_mean']))
print("Средняя квадратичная ошибка: ", np.mean(scores_svm['test_square']))
print("Коэффициент детерминации: ", np.mean(scores_svm['test_r2']))


print("\n\nМетрики для Decision Tree:\n")
print("Средняя абсолютная ошибка: ", np.mean(scores_dec['test_mean']))
print("Средняя квадратичная ошибка: ", np.mean(scores_dec['test_square']))
print("Коэффициент детерминации: ", np.mean(scores_dec['test_r2']))
```

```
Метрики для линейной модели:

Средняя абсолютная ошибка:  -0.5357963043273647
Средняя квадратичная ошибка:  -0.4226001955008612
Коэффициент детерминации:  0.02009573828329725
```

```
Метрики для SVM-модели:

Средняя абсолютная ошибка:  -0.5067944091381511
Средняя квадратичная ошибка:  -0.4080295312633375
Коэффициент детерминации:  0.12857629245499136


Метрики для Decision Tree:

Средняя абсолютная ошибка:  -0.1467252733358278
Средняя квадратичная ошибка:  -0.044516553835920666 Коэффициент
детерминации:  0.8020688669114537
```

7. Оптимизация модели с помощью решетчатого поиска

In [101]:

```
from sklearn.model_selection import GridSearchCV
```

In [102]:

```
n_range = np.array(range(1,10,1))
tuned_parameters = [{'max_depth': n_range}]
tuned_parameters
```

Out[102]:

```
[{'max_depth': array([1, 2, 3, 4, 5, 6, 7, 8, 9])}]
```

In [103]:

```
%%time
clf_gs = GridSearchCV(DecisionTreeRegressor(), tuned_parameters, cv=5, scoring='r2')
clf_gs.fit(x.reshape(-1, 1), y)
```

```
Wall time: 44.5 ms
```

Out[103]:

```
GridSearchCV(cv=5, error_score=nan,
 estimator=DecisionTreeRegressor(ccp_alpha=0.0, criterion='ms
           e',                                              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=[{'max_depth': array([1, 2, 3, 4, 5, 6, 7, 8,
9])}],             pre_dispatch='2*n_jobs', refit=True,
 return_train_score=Fals
e,             scoring='r2',
 verbose=0)
```

In [104]:

```
# Лучшая модель
clf_gs.best_estimator_
```

Out[104]:

```
DecisionTreeRegressor(ccp_alpha=0.0, criterion='mse', max_depth=3,
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') In [105]:
```

```
clf_gs.best_score_
```

Out[105]:

```
-0.9567860362862277
```

In [106]:

```
clf_gs.best_params_
```

Out[106]:

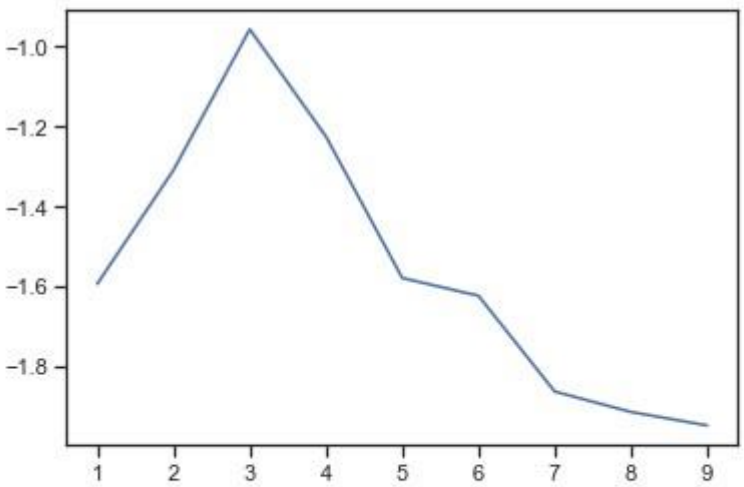
```
{'max_depth': 3}
```

In [107]: plt.plot(n_range,

```
clf_gs.cv_results_['mean_test_score'])
```

Out[107]: [<matplotlib.lines.Line2D at

0x26d797c71d0>]



Оптимизация SVM

In [108]:

```
param_grid = {'C': [0.1,1, 10, 100], 'epsilon': [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8
, 0.9, 1.0]}
```

In [109]:

```
grid = GridSearchCV(LinearSVR(),param_grid,refit=True,verbose=2) grid.fit(x.reshape(-
1, 1),y)
```

```
Fitting 5 folds for each of 40 candidates, totalling 200 fits
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
```

```
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
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[CV] ............................... C=0.1, epsilon=0.9, total=   0.0s
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[CV] C=1, epsilon=0.2 ................................................
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[CV] ................................. C=1, epsilon=0.2, total=   0.0s
[CV] C=1, epsilon=0.2 ................................................
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[CV] C=1, epsilon=0.5 ................................................
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[CV] C=1, epsilon=0.8 ................................................
```

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[CV] ................................. C=1, epsilon=0.8, total=   0.0s
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[CV] ................................. C=1, epsilon=0.8, total=   0.0s
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[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
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[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
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[CV] ................................ C=10, epsilon=0.3, total=   0.0s
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[CV] ................................ C=10, epsilon=0.3, total=   0.0s
[CV] C=10, epsilon=0.3 ...............................................
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent wo
rkers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:
0.0s
d:\документы\магистратура\2 семестр\ммо + пис\лабы\virtualenvs\tensorflow
\lib\site-packages\sklearn\svm\_base.py:947: ConvergenceWarning: Liblinear
failed to converge, increase the number of iterations.   "the number of
iterations.", ConvergenceWarning)
```

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\lib\site-packages\sklearn\svm\_base.py:947: ConvergenceWarning: Liblinear
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failed to converge, increase the number of iterations.   "the number of
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\lib\site-packages\sklearn\svm\_base.py:947: ConvergenceWarning: Liblinear
failed to converge, increase the number of iterations.
  "the number of iterations.", ConvergenceWarning)
[Parallel(n_jobs=1)]: Done 200 out of 200 | elapsed:    0.4s finished
d:\документы\магистратура\2 семестр\ммо + пис\лабы\virtualenvs\tensorflow
\lib\site-packages\sklearn\svm\_base.py:947: ConvergenceWarning: Liblinear
failed to converge, increase the number of iterations.   "the number of
iterations.", ConvergenceWarning)
```

Out[109]:

```
GridSearchCV(cv=None, error_score=nan,
             estimator=LinearSVR(C=1.0, dual=True, epsilon=0.0,
fit_intercept=True, intercept_scaling=1.
0,
                                 loss='epsilon_insensitive', max_iter=100
0,
                                 random_state=None, tol=0.0001, verbose=
0),
             iid='deprecated', n_jobs=None,
param_grid={'C': [0.1, 1, 10, 100],
                         'epsilon': [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.
8,
                                     0.9, 1.0]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,              scoring=None, verbose=2) In [110]:
```

```
grid.best_estimator_
```

Out[110]:

```
LinearSVR(C=100, dual=True, epsilon=0.7, fit_intercept=True,
          intercept_scaling=1.0, loss='epsilon_insensitive', max_iter=100
0,           random_state=None, tol=0.0001,
```

verbose=0) In [111]:

```
grid.best_score_
```

Out[111]:

```
-0.43105343219963677
```

In [112]:

```
grid.best_params_
```

Out[112]:

```
{'C': 100, 'epsilon': 0.7}
```

In [113]:

```
parameters = {"alpha_1": np.logspace(-13,-5,10),
              "alpha_2": np.logspace(-9,-3,10),
              "lambda_1": np.logspace(-10,-5,10),
              "lambda_2": np.logspace(-11,-4,10)}

grid_regr = GridSearchCV(BayesianRidge(), parameters, cv=3, n_jobs=-1)
grid_regr.fit(x.reshape(-1, 1), y)
```

Out[113]:

```
GridSearchCV(cv=3, error_score=nan,
 estimator=BayesianRidge(alpha_1=1e-06, alpha_2=1e-06,
 alpha_init=None, compute_score=False,
 copy_X=True, fit_intercept=True,
 lambda_1=1e-06, lambda_2=1e-06,
 lambda_init=None, n_iter=300,
 normalize=False, tol=0.001,
 verbose=False),             iid='deprecated', n_jobs=-1,
             param_grid={'alpha_1': array([1.00000000e-13, 7.74263683e-13,
5.99484250e-...
                         'lambda_1': array([1.00000000e-10, 3.59381366e-1
0, 1.29154967e-09, 4.64158883e-09,
       1.66810054e-08, 5.99484250e-08, 2.15443469e-07, 7.74263683e-07,
       2.78255940e-06, 1.00000000e-05]),
                         'lambda_2': array([1.00000000e-11, 5.99484250e-1
1, 3.59381366e-10, 2.15443469e-09,
       1.29154967e-08, 7.74263683e-08, 4.64158883e-07, 2.78255940e-06,
  1.66810054e-05, 1.00000000e-04])},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,             scoring=None,
 verbose=0)
```

In [114]:

```
grid_regr.best_estimator_
```

Out[114]:

```
BayesianRidge(alpha_1=1e-05, alpha_2=1e-09, alpha_init=None,
compute_score=False, copy_X=True, fit_intercept=True,
lambda_1=1e-10, lambda_2=0.0001, lambda_init=None, n_iter=30
0,                normalize=False, tol=0.001,

verbose=False) In [115]:
```

```
grid_regr.best_score_
```

Out[115]:

```
0.020096691882994306
```

In [116]:

```
grid_regr.best_params_
```

Out[116]:

```
{'alpha_1': 1e-05, 'alpha_2': 1e-09, 'lambda_1': 1e-10, 'lambda_2': 0.000
1}
```

In [118]:

```
reg = BayesianRidge(fit_intercept=True, alpha_1=1e-05, alpha_2=1e-09, lambda_1=1e-10, l
ambda_2=0.0001).fit(x.reshape(-1, 1), y) y_tt = reg.predict(x.reshape(-1, 1))

lin_SVR = LinearSVR(C=1.0, max_iter=10000, epsilon=1.0)
lin_SVR.fit(x.reshape(-1, 1), y) predict =
lin_SVR.predict(x.reshape(-1, 1))

dec_tree = DecisionTreeRegressor(random_state=1, max_depth=3)
dec_tree.fit(data, data["flavanoids"]) dec_predict =
dec_tree.predict(data)
```

In [119]:

```
print("Метрики для линейной модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, y_tt))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, y_tt))
print("Коэффициент детерминации: ", r2_score(y, y_tt))

print("\n\nМетрики для SVM-модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, predict))
print("Коэффициент детерминации: ", r2_score(y, predict))


print("\n\nМетрики для Decision Tree:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, dec_predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, dec_predict))
print("Коэффициент детерминации: ", r2_score(y, dec_predict))
```

```
Метрики для линейной модели:

Средняя абсолютная ошибка:  0.38837555082790887
Средняя квадратичная ошибка:  0.25054108092618З
Коэффициент детерминации:  0.7474673230340746


Метрики для SVM-модели:

Средняя абсолютная ошибка:  0.48790666940376964
```

```
Средняя квадратичная ошибка:  0.3272402021600858
Коэффициент детерминации:  0.6701585067132962


Метрики для Decision Tree:

Средняя абсолютная ошибка:  0.10946302125260202
Средняя квадратичная ошибка:  0.02407692877866564
Коэффициент детерминации:  0.9757316793911902
```

После подбора параметров модели показали лучший результат, чем без подбора.