Московский государственный технический университет им. Н.Э. Баумана
Кафедра «Системы обработки информации и управления»

Лабораторная работа №5
по курсу «Методы машинного обучения»
на тему
«Линейные модели, SVM и деревья решений.»

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```python
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn import preprocessing, svm
from sklearn import model_selection
from sklearn.model_selection import train_test_split
from sklearn.linear_model import BayesianRidge
from sklearn.tree import DecisionTreeClassifier,
DecisionTreeRegressor, export_graphviz
from sklearn.metrics import r2_score
%matplotlib inline
sns.set(style="ticks")

import warnings
warnings.filterwarnings('ignore')
```

```python
data = pd.read_csv("advertising.csv")
```

```python
data.head(2)
```

	TV	Radio	Newspaper	Sales
1	230.1	37.8	69.2	22.1
2	44.5	39.3	45.1	10.4

```python
data.describe()
```

	TV	Radio	Newspaper	Sales
count	200.000000	200.000000	200.000000	200.000000
mean	147.042500	23.264000	30.554000	14.022500
std	85.854236	14.846809	21.778621	5.217457
min	0.700000	0.000000	0.300000	1.600000
25%	74.375000	9.975000	12.750000	10.375000
50%	149.750000	22.900000	25.750000	12.900000
75%	218.825000	36.525000	45.100000	17.400000
max	296.400000	49.600000	114.000000	27.000000

```
data.info()
```

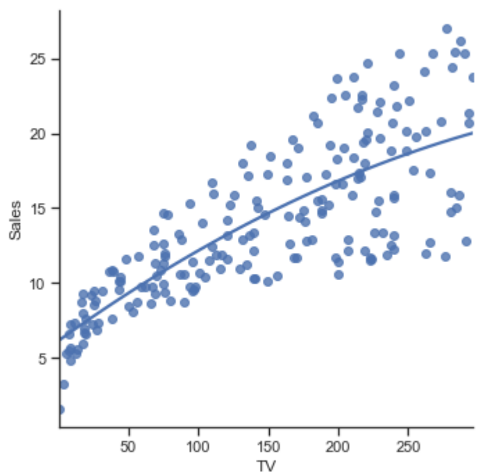
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 200 entries, 1 to 200
Data columns (total 4 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   TV         200 non-null    float64
 1   Radio      200 non-null    float64
 2   Newspaper  200 non-null    float64
 3   Sales      200 non-null    float64
dtypes: float64(4)
memory usage: 7.8 KB
```

```
data.columns
```

```
Index(['TV', 'Radio', 'Newspaper', 'Sales'], dtype='object')
```

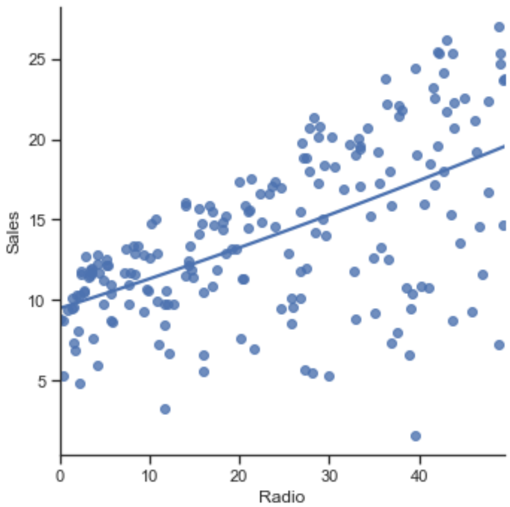
```
sns.lmplot(x="TV", y="Sales", data=data, order=2, ci=None)
```

```
<seaborn.axisgrid.FacetGrid at 0x133706f10>
```



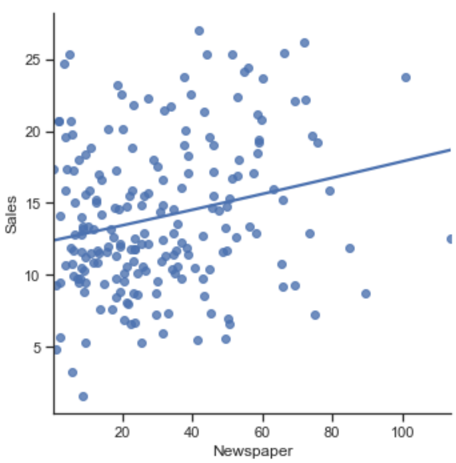
```
sns.lmplot(x="Radio", y="Sales", data=data, order=2, ci=None)
```

<seaborn.axisgrid.FacetGrid at 0x1357f9d90>




```
sns.lmplot(x="Newspaper", y="Sales", data=data, order=2, ci=None)
```

<seaborn.axisgrid.FacetGrid at 0x135878550>



```
data.corr()
```

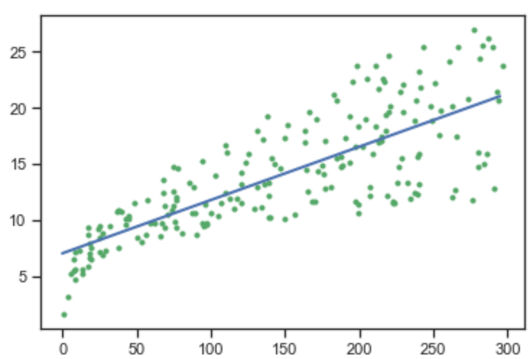
	TV	Radio	Newspaper	Sales
TV	1.000000	0.054809	0.056648	0.782224
Radio	0.054809	1.000000	0.354104	0.576223
Newspaper	0.056648	0.354104	1.000000	0.228299
Sales	0.782224	0.576223	0.228299	1.000000

Между TV и Sales есть корреляция 0.78

```
x = data["TV"].values
y = data["Sales"].values

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

```
7.054854152265513
```

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

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))

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



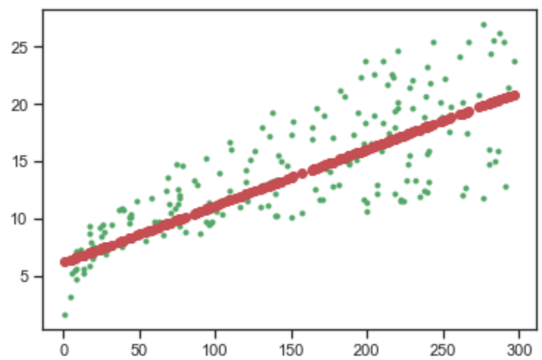
Модель линейной регрессии дала неплохой результат

SVM

```
from sklearn.svm import SVC, NuSVC, LinearSVC, OneClassSVM, SVR,
NuSVR, LinearSVR
```

```
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')
```

```
[<matplotlib.lines.Line2D at 0x13e5a9b10>]
```



Деревья решений

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

```
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')
```

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

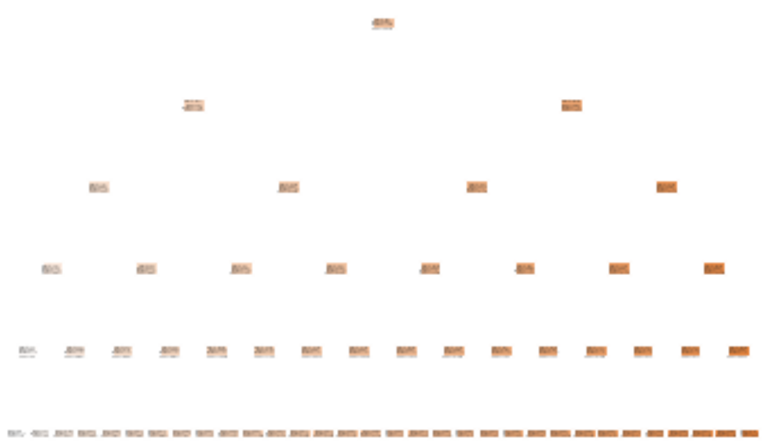
```python
from sklearn import tree
tree.plot_tree(dec_tree, filled=True)
```

```
[Text(167.4, 199.32, 'X[3] <= 15.1\nmse = 27.086\nsamples = 200\nvalue
= 14.023'),
 Text(83.7, 163.07999999999998, 'X[3] <= 10.0\nmse = 7.31\nsamples =
125\nvalue = 10.67'),
 Text(41.85, 126.83999999999999, 'X[3] <= 7.45\nmse = 3.527\nsamples =
45\nvalue = 7.767'),
 Text(20.925, 90.6, 'X[0] <= 4.75\nmse = 2.173\nsamples = 18\nvalue =
5.872'),
 Text(10.4625, 54.359999999999985, 'X[3] <= 2.4\nmse = 0.64\nsamples =
2\nvalue = 2.4'),
 Text(5.23125, 18.119999999999976, 'mse = 0.0\nsamples = 1\nvalue =
1.6'),
 Text(15.693750000000001, 18.119999999999976, 'mse = -0.0\nsamples =
1\nvalue = 3.2'),
 Text(31.387500000000003, 54.359999999999985, 'X[3] <= 6.25\nmse =
0.669\nsamples = 16\nvalue = 6.306'),
 Text(26.15625, 18.119999999999976, 'mse = 0.108\nsamples = 7\nvalue =
5.443'),
 Text(36.61875, 18.119999999999976, 'mse = 0.075\nsamples = 9\nvalue =
6.978'),
 Text(62.775000000000006, 90.6, 'X[3] <= 9.0\nmse = 0.442\nsamples =
27\nvalue = 9.03'),
 Text(52.3125, 54.359999999999985, 'X[3] <= 8.25\nmse = 0.18\nsamples
= 12\nvalue = 8.375'),
 Text(47.081250000000004, 18.119999999999976, 'mse = 0.052\nsamples =
4\nvalue = 7.825'),
 Text(57.54375, 18.119999999999976, 'mse = 0.017\nsamples = 8\nvalue =
8.65'),
 Text(73.2375, 54.359999999999985, 'X[3] <= 9.55\nmse = 0.034\nsamples
= 15\nvalue = 9.553'),
 Text(68.00625000000001, 18.119999999999976, 'mse = 0.013\nsamples =
7\nvalue = 9.386'),
 Text(78.46875, 18.119999999999976, 'mse = 0.008\nsamples = 8\nvalue =
```

```
9.7'),
 Text(125.55000000000001, 126.83999999999999, 'X[3] <= 12.55\nmse =
2.031\nsamples = 80\nvalue = 12.302'),
 Text(104.625, 90.6, 'X[3] <= 11.1\nmse = 0.487\nsamples = 48\nvalue =
11.317'),
 Text(94.16250000000001, 54.359999999999985, 'X[3] <= 10.55\nmse =
0.083\nsamples = 19\nvalue = 10.558'),
 Text(88.93125, 18.119999999999976, 'mse = 0.024\nsamples = 9\nvalue =
10.3'),
 Text(99.39375, 18.119999999999976, 'mse = 0.023\nsamples = 10\nvalue
= 10.79'),
 Text(115.0875, 54.359999999999985, 'X[3] <= 11.85\nmse =
0.127\nsamples = 29\nvalue = 11.814'),
 Text(109.85625, 18.119999999999976, 'mse = 0.034\nsamples = 17\nvalue
= 11.565'),
 Text(120.31875000000001, 18.119999999999976, 'mse = 0.047\nsamples =
12\nvalue = 12.167'),
 Text(146.475, 90.6, 'X[3] <= 13.8\nmse = 0.703\nsamples = 32\nvalue =
13.781'),
 Text(136.01250000000002, 54.359999999999985, 'X[3] <= 13.05\nmse =
0.091\nsamples = 17\nvalue = 13.047'),
 Text(130.78125, 18.119999999999976, 'mse = 0.014\nsamples = 9\nvalue
= 12.789'),
 Text(141.24375, 18.119999999999976, 'mse = 0.017\nsamples = 8\nvalue
= 13.338'),
 Text(156.9375, 54.359999999999985, 'X[3] <= 14.45\nmse =
0.094\nsamples = 15\nvalue = 14.613'),
 Text(151.70625, 18.119999999999976, 'mse = 0.022\nsamples = 4\nvalue
= 14.175'),
 Text(162.16875000000002, 18.119999999999976, 'mse = 0.026\nsamples =
11\nvalue = 14.773'),
 Text(251.10000000000002, 163.07999999999998, 'X[3] <= 20.45\nmse =
10.081\nsamples = 75\nvalue = 19.611'),
 Text(209.25, 126.83999999999999, 'X[3] <= 17.8\nmse = 2.413\nsamples
= 47\nvalue = 17.519'),
 Text(188.32500000000002, 90.6, 'X[3] <= 16.35\nmse = 0.603\nsamples =
27\nvalue = 16.348'),
 Text(177.8625, 54.359999999999985, 'X[3] <= 15.65\nmse =
0.084\nsamples = 14\nvalue = 15.657'),
 Text(172.63125, 18.119999999999976, 'mse = 0.023\nsamples = 7\nvalue
```

```
= 15.4'),
 Text(183.09375, 18.119999999999976, 'mse = 0.013\nsamples = 7\nvalue
= 15.914'),
 Text(198.7875, 54.35999999999985, 'X[3] <= 17.05\nmse =
0.095\nsamples = 13\nvalue = 17.092'),
 Text(193.55625, 18.119999999999976, 'mse = 0.026\nsamples = 5\nvalue
= 16.76'),
 Text(204.01875, 18.119999999999976, 'mse = 0.025\nsamples = 8\nvalue
= 17.3'),
 Text(230.175, 90.6, 'X[3] <= 19.1\nmse = 0.505\nsamples = 20\nvalue =
19.1'),
 Text(219.7125, 54.35999999999985, 'X[3] <= 18.7\nmse =
0.162\nsamples = 10\nvalue = 18.5'),
 Text(214.48125000000002, 18.119999999999976, 'mse = 0.043\nsamples =
6\nvalue = 18.2'),
 Text(224.94375, 18.119999999999976, 'mse = 0.002\nsamples = 4\nvalue
= 18.95'),
 Text(240.63750000000002, 54.35999999999985, 'X[3] <= 19.75\nmse =
0.128\nsamples = 10\nvalue = 19.7'),
 Text(235.40625, 18.119999999999976, 'mse = 0.039\nsamples = 6\nvalue
= 19.45'),
 Text(245.86875, 18.119999999999976, 'mse = 0.027\nsamples = 4\nvalue
= 20.075'),
 Text(292.95, 126.83999999999999, 'X[3] <= 23.45\nmse = 3.285\nsamples
= 28\nvalue = 23.121'),
 Text(272.02500000000003, 90.6, 'X[3] <= 21.75\nmse = 0.581\nsamples =
16\nvalue = 21.744'),
 Text(261.5625, 54.35999999999985, 'X[3] <= 21.0\nmse =
0.149\nsamples = 8\nvalue = 21.088'),
 Text(256.33125, 18.119999999999976, 'mse = 0.002\nsamples = 4\nvalue
= 20.725'),
 Text(266.79375, 18.119999999999976, 'mse = 0.032\nsamples = 4\nvalue
= 21.45'),
 Text(282.4875, 54.35999999999985, 'X[3] <= 22.5\nmse =
0.153\nsamples = 8\nvalue = 22.4'),
 Text(277.25625, 18.119999999999976, 'mse = 0.042\nsamples = 5\nvalue
= 22.16'),
 Text(287.71875, 18.119999999999976, 'mse = 0.08\nsamples = 3\nvalue =
22.8'),
 Text(313.875, 90.6, 'X[3] <= 25.05\nmse = 0.984\nsamples = 12\nvalue
```

```
= 24.958'),
 Text(303.4125, 54.35999999999985, 'X[3] <= 24.0\nmse =
0.133\nsamples = 6\nvalue = 24.1'),
 Text(298.18125000000003, 18.119999999999976, 'mse = 0.002\nsamples =
3\nvalue = 23.767'),
 Text(308.64375, 18.119999999999976, 'mse = 0.042\nsamples = 3\nvalue
= 24.433'),
 Text(324.33750000000003, 54.35999999999985, 'X[3] <= 25.85\nmse =
0.361\nsamples = 6\nvalue = 25.817'),
 Text(319.10625, 18.119999999999976, 'mse = 0.002\nsamples = 4\nvalue
= 25.425'),
 Text(329.56875, 18.119999999999976, 'mse = 0.16\nsamples = 2\nvalue =
26.6')]
```



Метрики качества

```
from sklearn.metrics import mean_absolute_error, mean_squared_error,
mean_squared_log_error, 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:  2.550919383216356
Средняя квадратичная ошибка:  10.512821002854928
Коэффициент детерминации:  0.6118688451058344


Метрики для SVM-модели:

Средняя абсолютная ошибка:  2.5708683334350892
Средняя квадратичная ошибка:  10.859652690875892
Коэффициент детерминации:  0.5990638916505333


Метрики для Decision Tree:

Средняя абсолютная ошибка:  0.14353164841694266
Средняя квадратичная ошибка:  0.03201810934980053
Коэффициент детерминации:  0.9988178980926156
```

Подбор гиперпараметров. Кросс-валидация

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

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

scores_regr = cross_validate(BayesianRidge(fit_intercept=True),
                             x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_regr
```

```
{'fit_time': array([0.00085902, 0.00085711, 0.00055289]),
 'score_time': array([0.00140524, 0.00080299, 0.00078702]),
 'test_mean': array([-2.51215213, -2.46200408, -2.76711466]),
 'test_square': array([-10.83437466,  -9.33658309, -11.90833409]),
 'test_r2': array([0.61497417, 0.65311667, 0.53715304])}
```

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

```
{'fit_time': array([0.03139281, 0.02713585, 0.02338099]),
 'score_time': array([0.00076604, 0.00061393, 0.00054908]),
 'test_mean': array([-2.54098772, -2.37148251, -3.1291242 ]),
 'test_square': array([-11.0231287 ,  -9.81978964, -15.84997398]),
 'test_r2': array([0.60826634, 0.63516403, 0.38395142])}
```

```
scores_dec = cross_validate(DecisionTreeRegressor(random_state=1,
max_depth=3),
                             data, data["Sales"], cv=5, scoring=scoring)
scores_dec
```

```
{'fit_time': array([0.00271297, 0.0020709 , 0.00206208, 0.00199294,
0.00195193]),
 'score_time': array([0.0018599 , 0.00148034, 0.00148678, 0.00142694,
0.0014143 ]),
 'test_mean': array([-0.72293478, -0.7307461 , -0.66116873,
-0.85487267, -0.91550049]),
 'test_square': array([-0.64975012, -0.70991464, -0.63349151,
-1.4104023 , -1.08449788]),
 'test_r2': array([0.97486214, 0.97589358, 0.97175881, 0.95176776,
0.95938815])}
```

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

```python
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:  -2.580423621885709
Средняя квадратичная ошибка:  -10.693097277894969
Коэффициент детерминации:  0.601747959666948


Метрики для SVM-модели:

Средняя абсолютная ошибка:  -2.6805314771806956
Средняя квадратичная ошибка:  -12.23096410841425
Коэффициент детерминации:  0.5424605962417798


Метрики для Decision Tree:

Средняя абсолютная ошибка:  -0.7770445553321956
Средняя квадратичная ошибка:  -0.8976112886827845
Коэффициент детерминации:  0.9667340888852873
```

Оптимизация с помощью решетчатого поиска

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

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

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

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

```
CPU times: user 48.9 ms, sys: 1.26 ms, total: 50.2 ms
Wall time: 49.2 ms
```

```
GridSearchCV(cv=5, error_score=nan,
             estimator=DecisionTreeRegressor(ccp_alpha=0.0,
criterion='mse',
                                             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=False,
             scoring='r2', verbose=0)
```

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

```
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')
```

```
clf_gs.best_score_
```

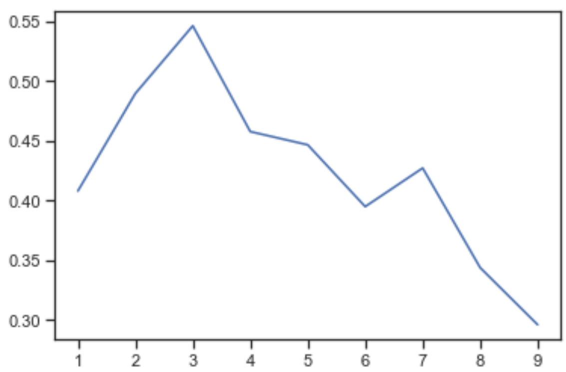
```
0.5464056968965096
```

```
clf_gs.best_params_
```

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

```
plt.plot(n_range, clf_gs.cv_results_['mean_test_score'])
```

```
[<matplotlib.lines.Line2D at 0x1365b10d0>]
```



Оптимизация SVM

```
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]}

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
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[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
[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
[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 ...............................................
[CV] ................................ C=0.1, epsilon=0.4, total=   0.0s
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[CV] C=0.1, epsilon=0.7 ...............................................
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[CV] .................................. C=1, epsilon=0.1, total=   0.0s
[CV] C=1, epsilon=0.1 .................................................
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```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s
remaining:    0.0s


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[CV] ................................. C=1, epsilon=0.4, total=   0.0s
[CV] C=1, epsilon=0.4 ................................................
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[CV] ................................ C=1, epsilon=0.7, total=   0.0s
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[CV] ................................. C=1, epsilon=1.0, total=   0.0s
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[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.1 ...............................................
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[CV] ................................ C=10, epsilon=0.4, total=   0.0s
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[CV] ................................ C=10, epsilon=0.5, total=   0.0s
[CV] C=10, epsilon=0.5 ...............................................
[CV] ................................ C=10, epsilon=0.5, total=   0.0s
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[CV] .......................... C=10, epsilon=0.8, total=   0.0s
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[CV] ................................ C=10, epsilon=1.0, total=   0.0s
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[CV] ................................ C=10, epsilon=1.0, total=   0.0s
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[CV] ............................... C=100, epsilon=0.1, total=   0.0s
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[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
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[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
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[CV] ................................ C=100, epsilon=0.3, total=   0.0s
[CV] C=100, epsilon=0.3 ................................................
[CV] ................................ C=100, epsilon=0.3, total=   0.0s
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[CV] ................................ C=100, epsilon=0.3, total=   0.0s
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[CV] C=100, epsilon=0.4 ................................................
[CV] ................................ C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ................................................
[CV] ................................ C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ................................................
[CV] ................................ C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ................................................
[CV] ................................ C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.5 ................................................
[CV] ................................ C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ................................................
[CV] ................................ C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ................................................
[CV] ................................ C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ................................................
[CV] ................................ C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ................................................
[CV] ................................ C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.6 ................................................
[CV] ................................ C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ................................................
[CV] ................................ C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ................................................
```

```
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ..............................................
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ..............................................
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.7 ..............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ..............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ..............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ..............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ..............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.8 ..............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ..............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ..............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ..............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ..............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.9 ..............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ..............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ..............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ..............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ..............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=1.0 ..............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
```

```
[CV] C=100, epsilon=1.0 ..............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ..............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ..............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ..............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s


[Parallel(n_jobs=1)]: Done 200 out of 200 | elapsed:    0.8s finished
```

```
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=1000,
                                 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=False,
             scoring=None, verbose=2)
```

```
grid.best_estimator_
```

```
LinearSVR(C=10, dual=True, epsilon=1.0, fit_intercept=True,
          intercept_scaling=1.0, loss='epsilon_insensitive',
max_iter=1000,
          random_state=None, tol=0.0001, verbose=0)
```

```
grid.best_score_
```

```
0.5440492644611755
```

```
grid.best_params_
```

```
{'C': 10, 'epsilon': 1.0}
```

```
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)
```

```
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-10, 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-11, 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=False,
             scoring=None, verbose=0)
```

```
grid_regr.best_estimator_
```

```
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=300,
              normalize=False, tol=0.001, verbose=False)
```

```
grid_regr.best_score_
```

```
0.6017531508217578
```

```
grid_regr.best_params_
```

```
{'alpha_1': 1e-05, 'alpha_2': 1e-09, 'lambda_1': 1e-10, 'lambda_2':
0.0001}
```

```
reg = BayesianRidge(fit_intercept=True, alpha_1=1e-05, alpha_2=1e-09,
lambda_1=1e-10, lambda_2=0.0001).fit(x.reshape(-1, 1), y.reshape(-1,
1))
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["Sales"])
dec_predict = dec_tree.predict(data)

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:  2.5508292802546
Средняя квадратичная ошибка:  10.512794897173503
Коэффициент детерминации:  0.6118698089221382


Метрики для SVM-модели:

Средняя абсолютная ошибка:  2.5996867264932724
Средняя квадратичная ошибка:  11.18839596468356
Коэффициент детерминации:  0.586926758668624


Метрики для Decision Tree:

Средняя абсолютная ошибка:  0.7095532407407409
Средняя квадратичная ошибка:  0.7222188657407407
Коэффициент детерминации:  0.9733358303760538
```

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