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**Кафедра «Системы обработки информации и управления»**

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

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[140]:
```
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')
```

[5]:
```
data = pd.read_csv("advertising.csv")
```

[6]:
```
data.head(2)
```

[6]:

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

[7]:
```
data.describe()
```

[7]:

| | 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 |

[8]:
```
data.info()
```

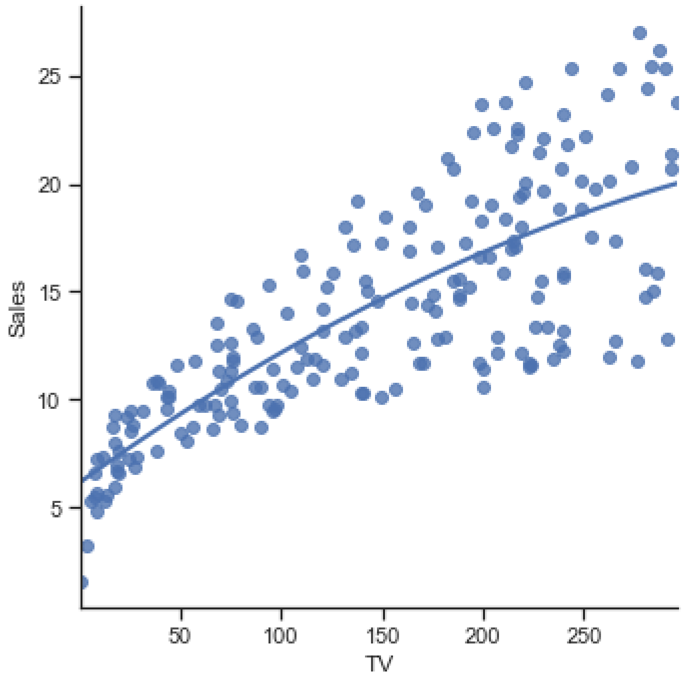
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 200 entries, 1 to 200
Data columns (total 4 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   TV         200 non-null    float64
 1   Radio      200 non-null    float64
 2   Newspaper  200 non-null    float64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

[9]:
```python
data.columns
```

[9]:
```
Index(['TV', 'Radio', 'Newspaper', 'Sales'], dtype='object')
```

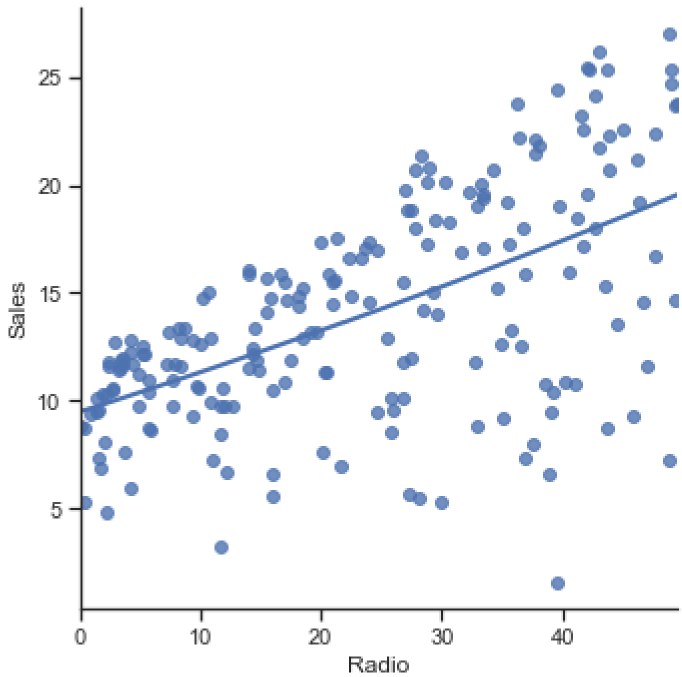
[12]:
```python
sns.lmplot(x="TV", y="Sales", data=data, order=2, ci=None)
```

[12]:
```
<seaborn.axisgrid.FacetGrid at 0x133706f10>
```



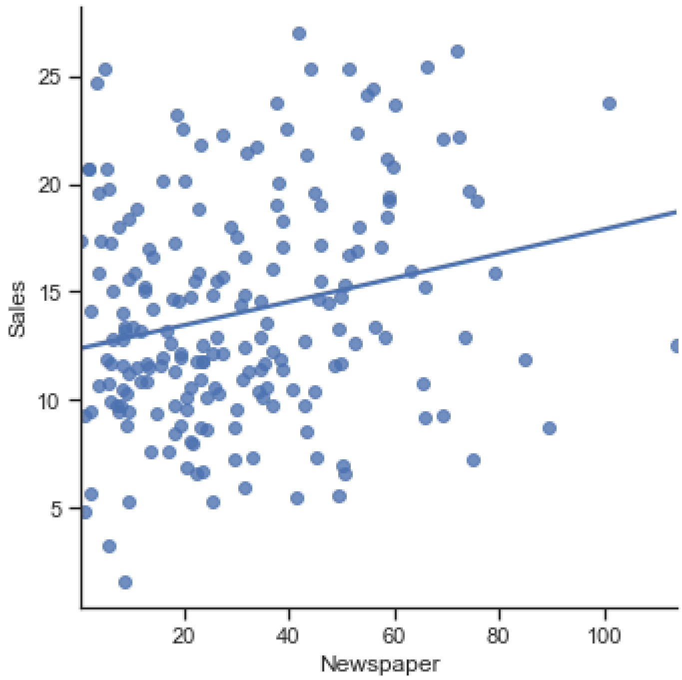

[15]:
```python
sns.lmplot(x="Radio", y="Sales", data=data, order=2, ci=None)
```

[15]:
```
<seaborn.axisgrid.FacetGrid at 0x1357f9d90>
```



[16]:
```
sns.lmplot(x="Newspaper", y="Sales", data=data, order=2, ci=None)
```

[16]: <seaborn.axisgrid.FacetGrid at 0x135878550>




[18]:
```
data.corr()
```

[18]:

| | 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 |

## 0.1. Между TV и Sales есть корреляция 0.78

[152]:
```
x = data["TV"].values
y = data["Sales"].values

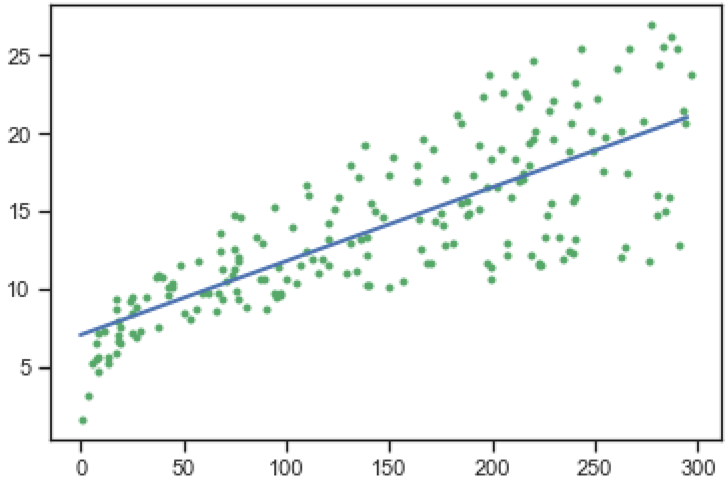
reg = BayesianRidge(fit_intercept=True).fit(x.reshape(-1, 1), y.reshape(-1, 1))
reg.coef_
reg.intercept_
```

[152]: 7.054854152265513

[153]:
```
def func(w, b, x):
    return w*x + b
```

[154]:
```
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))
```

[155]:
```
plt.plot(x, y, 'g.')
plt.plot(x_t, y_t, 'b', linewidth=2.0)
plt.show()
```



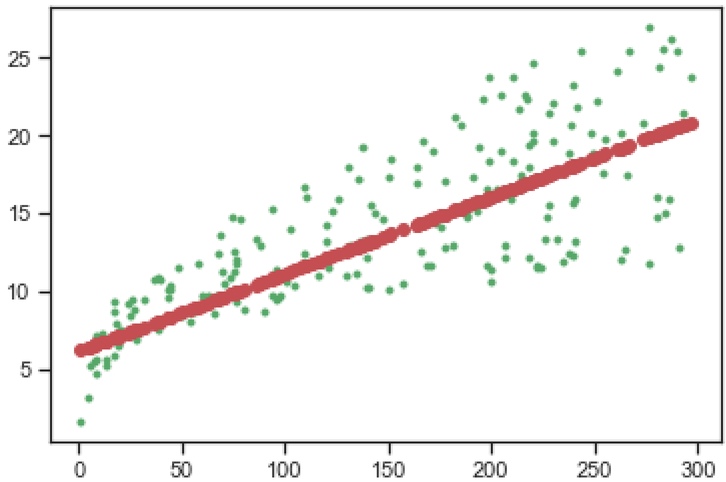

#### 0.1.1. Модель линейной регрессии дала неплохой результат

## 0.2. SVM

[156]:
```
from sklearn.svm import SVC, NuSVC, LinearSVC, OneClassSVM, SVR, NuSVR, LinearSVR
```

[157]:
```
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')
```

[157]:
```
[<matplotlib.lines.Line2D at 0x13e5a9b10>]
```



## 0.3. Деревья решений

[158]:
```
dec_tree = DecisionTreeRegressor(random_state=1, max_depth=5)
dec_tree.fit(data, data["Sales"])
dec_tree
```

[158]:
```
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')
```

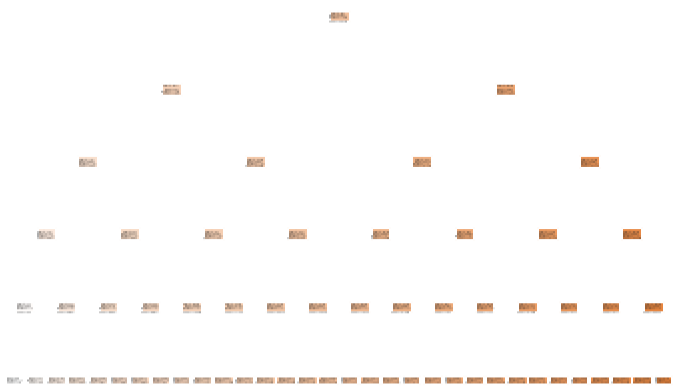
[159]:
```
dec_predict = dec_tree.predict(data)
```

[160]:
```
from sklearn import tree
tree.plot_tree(dec_tree, filled=True)
```

[160]:
```
[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, 54.359999999999985, '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, 54.359999999999985, '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, 54.359999999999985, '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, 54.359999999999985, '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, 54.359999999999985, '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, 54.359999999999985, '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, 54.359999999999985, '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')]
```



## 0.4. Метрики качества

[161]:
```
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
```

## 0.5. Подбор гиперпараметров. Кросс-валидация

[162]:
```
from sklearn.model_selection import cross_validate
```

[111]:
```
scoring = {'mean': 'neg_mean_absolute_error', 'square': 'neg_mean_squared_error', 'r2': 'r2'}
```

[163]:
```
scores_regr = cross_validate(BayesianRidge(fit_intercept=True),
                    x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_regr
```

[163]:
```
{'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])}
```

[164]:
```
scores_svm = cross_validate(LinearSVR(C=1.0, max_iter=10000),
                    x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_svm
```

[164]:
```
{'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])}
```

[165]:
```
scores_dec = cross_validate(DecisionTreeRegressor(random_state=1, max_depth=3),
                    data, data["Sales"], cv=5, scoring=scoring)
scores_dec
```

[165]:
```
{'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])}
```

[166]:
```
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:  -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

## 0.6. Оптимизация с помощью решетчатого поиска

[167]:
```
from sklearn.model_selection import GridSearchCV
```

[168]:
```
n_range = np.array(range(1,10,1))
tuned_parameters = [{'max_depth': n_range}]
tuned_parameters
```

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

[169]:
```
%%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
```

[169]:
```
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)
```

[170]:
```
# Лучшая модель
clf_gs.best_estimator_
```

[170]:
```
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')
```

[171]:
```
clf_gs.best_score_
```

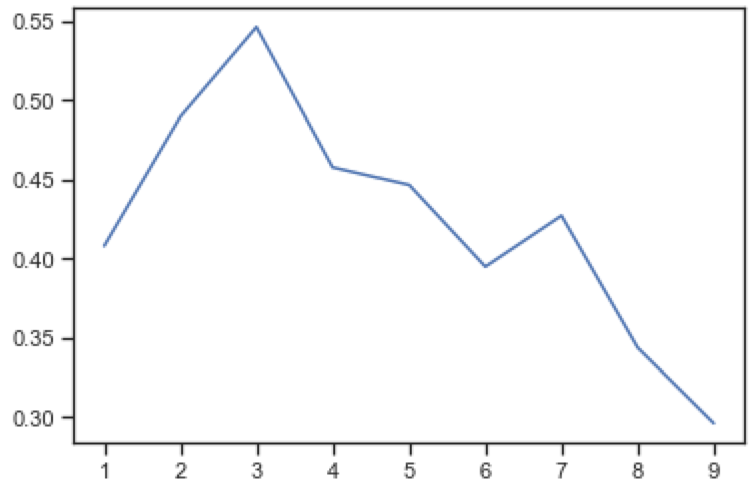
[171]: 0.5464056968965096

[172]:
```
clf_gs.best_params_
```

[172]: {'max_depth': 3}

[173]:
```
plt.plot(n_range, clf_gs.cv_results_['mean_test_score'])
```

[173]: [<matplotlib.lines.Line2D at 0x1365b10d0>]




### 0.6.1. Оптимизация SVM

[174]:
```
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]}
```

[175]:
```
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 …
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[CV] C=0.1, epsilon=0.2 …
[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
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[CV] C=0.1, epsilon=0.4 …
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[CV] C=0.1, epsilon=0.4 …
[CV] … C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.5 …
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[CV] … C=0.1, epsilon=0.5, total=   0.0s
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[CV] C=0.1, epsilon=0.6 …

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[CV] … C=0.1, epsilon=0.6, total=   0.0s
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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

[CV] … C=1, epsilon=0.1, total=   0.0s
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[CV] C=1, epsilon=0.1 …
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[CV] C=100, epsilon=0.6 …
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[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
```

[175]:
```
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)
```

[176]:
```
grid.best_estimator_
```

[176]:
```
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)
```

[177]:
```
grid.best_score_
```

[177]:
```
0.5440492644611755
```

[178]:
```
grid.best_params_
```

[178]:
```
{'C': 10, 'epsilon': 1.0}
```

[182]:
```
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)
```

[182]:
```
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)
```

[186]:
```
grid_regr.best_estimator_
```

[186]:
```
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)
```

[187]:
```
grid_regr.best_score_
```

[187]:
```
0.6017531508217578
```

[188]:
```
grid_regr.best_params_
```

[188]:
```
{'alpha_1': 1e-05, 'alpha_2': 1e-09, 'lambda_1': 1e-10, 'lambda_2': 0.0001}
```

[189]:
```
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)
```

[190]:
```
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

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