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Кафедра «Системы обработки информации и управления»

Лабораторная работа №6
по дисциплине

«Методы машинного обучения»

на тему

«Ансамбли моделей машинного обучения.»

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1. ЛР6. Ансамбли моделей машинного обучения

[1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor
from sklearn.metrics import mean_absolute_error,accuracy_score, r2_score
```

[2]:
```
data = pd.read_csv("advertising.csv")
```

[3]:
```
data.head()
```

[3]:
```
      TV  Radio  Newspaper  Sales
1  230.1   37.8       69.2   22.1
2   44.5   39.3       45.1   10.4
3   17.2   45.9       69.3    9.3
4  151.5   41.3       58.5   18.5
5  180.8   10.8       58.4   12.9
```

[4]:
```
data_X = data[["TV", "Radio", "Newspaper"]]
```

[5]:
```
data_X
```

[5]:
```
        TV  Radio  Newspaper
1    230.1   37.8       69.2
2     44.5   39.3       45.1
3     17.2   45.9       69.3
4    151.5   41.3       58.5
5    180.8   10.8       58.4
..     ...    ...        ...
196   38.2    3.7       13.8
197   94.2    4.9        8.1
198  177.0    9.3        6.4
199  283.6   42.0       66.2
200  232.1    8.6        8.7

[200 rows x 3 columns]
```

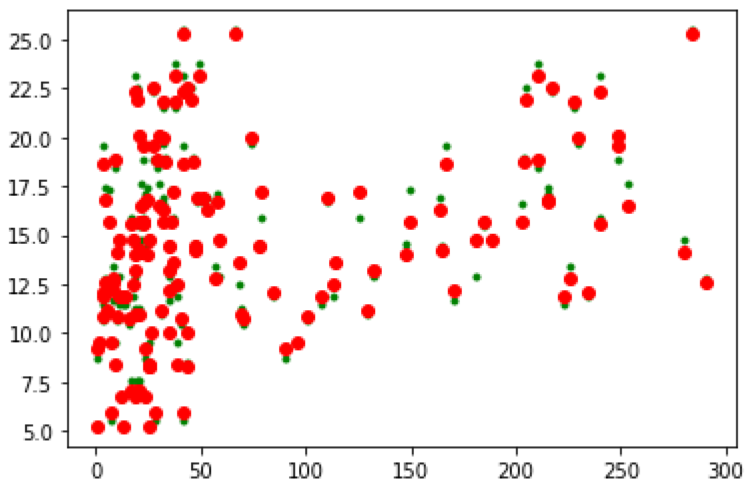
[6]:
```
data_Y = data[["Sales"]]
```

[7]:
```
X_train, X_test, y_train, y_test = train_test_split(
    data_X, data_Y, test_size=0.25, random_state=1)
```

[8]:
```
# Качество отдельных моделей
def val_mae(model):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    plt.plot(X_test, y_test, 'g.')
    plt.plot(X_test, y_pred, 'ro')
    plt.show()
    result = mean_absolute_error(y_test, y_pred)
    r2 = r2_score(y_test, y_pred)
    print(model)
    print('MAE={}'.format(result))
    print('R2={}'.format(r2))
```

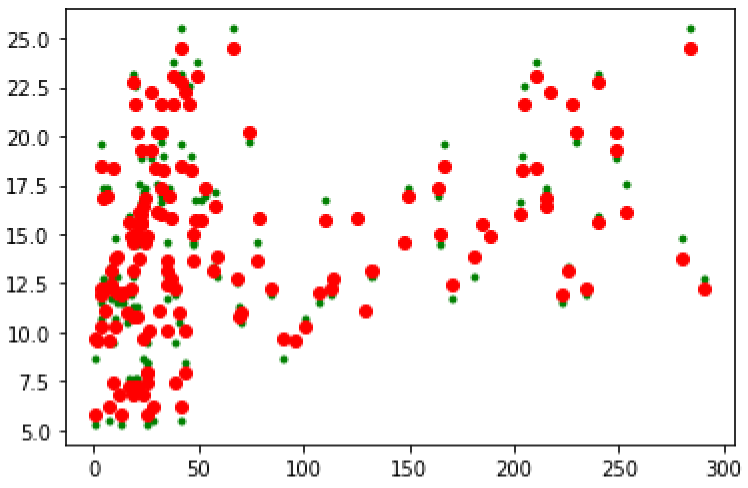
[9]:
```
for model in [
    GradientBoostingRegressor(),
    RandomForestRegressor(n_estimators=50)
]:
    val_mae(model)
    print('==========================\n\n')
```

```
/usr/local/lib/python3.7/site-packages/sklearn/ensemble/_gb.py:1454:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
  y = column_or_1d(y, warn=True)
```



```
/usr/local/lib/python3.7/site-packages/ipykernel_launcher.py:3:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  This is separate from the ipykernel package so we can avoid doing imports
until

GradientBoostingRegressor(alpha=0.9, ccp_alpha=0.0, criterion='friedman_mse',
                          init=None, learning_rate=0.1, loss='ls', 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, n_estimators=100,
                          n_iter_no_change=None, presort='deprecated',
                          random_state=None, subsample=1.0, tol=0.0001,
                    validation_fraction=0.1, verbose=0, warm_start=False)
MAE=0.48997309191670874
R2=0.9831579266623767
==========================
```



```
RandomForestRegressor(bootstrap=True, ccp_alpha=0.0, criterion='mse',
                      max_depth=None, max_features='auto', max_leaf_nodes=None,
                      max_samples=None, min_impurity_decrease=0.0,
                      min_impurity_split=None, min_samples_leaf=1,
                      min_samples_split=2, min_weight_fraction_leaf=0.0,
                      n_estimators=50, n_jobs=None, oob_score=False,
                      random_state=None, verbose=0, warm_start=False)
MAE=0.5131199999999992
R2=0.9815468551914713
==========================
```

1.1. Модель градиентного бустинга показала лучший результат на тестовой выборке

[10]:
```python
from sklearn.model_selection import RandomizedSearchCV

n_estimators = [int(x) for x in np.linspace(start = 200, stop = 2000, num = 10)]

max_features = ['auto', 'sqrt']

max_depth = [int(x) for x in np.linspace(10, 110, num = 11)]
max_depth.append(None)

min_samples_split = [2, 5, 10]
```

```
min_samples_leaf = [1, 2, 4]

bootstrap = [True, False]

random_grid = {'n_estimators': n_estimators,
              'max_features': max_features,
              'max_depth': max_depth,
              'min_samples_split': min_samples_split,
              'min_samples_leaf': min_samples_leaf,
              'bootstrap': bootstrap}
random_grid
```

[10]:
```
{'n_estimators': [200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000],
 'max_features': ['auto', 'sqrt'],
 'max_depth': [10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, None],
 'min_samples_split': [2, 5, 10],
 'min_samples_leaf': [1, 2, 4],
 'bootstrap': [True, False]}
```

[11]:
```
rf = RandomForestRegressor()

rf_random = RandomizedSearchCV(estimator = rf, param_distributions = random_grid, n_iter =
 ↪100, cv = 3, verbose=2, random_state=42, n_jobs = -1)

rf_random.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 16 concurrent workers.
[Parallel(n_jobs=-1)]: Done   9 tasks      | elapsed:    3.3s
[Parallel(n_jobs=-1)]: Done 130 tasks      | elapsed:   20.3s
[Parallel(n_jobs=-1)]: Done 300 out of 300 | elapsed:   47.8s finished
/usr/local/lib/python3.7/site-packages/sklearn/model_selection/_search.py:739:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  self.best_estimator_.fit(X, y, **fit_params)
```

[11]:
```
RandomizedSearchCV(cv=3, error_score=nan,
                   estimator=RandomForestRegressor(bootstrap=True,
                                                   ccp_alpha=0.0,
                                                   criterion='mse',
                                                   max_depth=None,
                                                   max_features='auto',
                                                   max_leaf_nodes=None,
                                                   max_samples=None,
                                                   min_impurity_decrease=0.0,
                                                   min_impurity_split=None,
                                                   min_samples_leaf=1,
                                                     min_samples_split=2,
                                                     min_weight_fraction_leaf=0.0,
                                                     n_estimators=100,
                                                     n_jobs=None,
oob_score=Fals…
             param_distributions={'bootstrap': [True, False],
                                  'max_depth': [10, 20, 30, 40, 50, 60,
                                                70, 80, 90, 100, 110,
                                                None],
                                  'max_features': ['auto', 'sqrt'],
                                  'min_samples_leaf': [1, 2, 4],
                                  'min_samples_split': [2, 5, 10],
                                  'n_estimators': [200, 400, 600, 800,
                                                   1000, 1200, 1400, 1600,
                                                   1800, 2000]},
             pre_dispatch='2*n_jobs', random_state=42, refit=True,
             return_train_score=False, scoring=None, verbose=2)
```

[12]:
```
rf_random.best_params_
```

[12]:
```
{'n_estimators': 800,
 'min_samples_split': 2,
 'min_samples_leaf': 1,
 'max_features': 'auto',
 'max_depth': 100,
 'bootstrap': True}
```

[13]:
```
def evaluate(model, test_features, test_labels):
    predictions = model.predict(test_features)
    error = mean_absolute_error(y_test, predictions)
    r2 = r2_score(y_test, predictions)
    print('Model Performance')
    print('MAE: {:0.4f}'.format(error))
    print('R2 score: {:0.4f}'.format(r2))
    print('=====================\n\n')

base_model = RandomForestRegressor(n_estimators = 10, random_state = 42)
base_model.fit(X_train, y_train)
evaluate(base_model, X_test, y_test)
```

```
Model Performance
MAE: 0.5994
R2 score: 0.9713
=====================



/usr/local/lib/python3.7/site-packages/ipykernel_launcher.py:11:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
```

```
ravel().
  # This is added back by InteractiveShellApp.init_path()
```

[14]:
```
best_random = rf_random.best_estimator_
evaluate(best_random, X_test, y_test)
```

```
Model Performance
MAE: 0.5178
R2 score: 0.9820
======================
```

Видно, что подбор гиперпараметров улучшил нашу модель, уменьшив ошибку на 0.08

[15]:
```
n_estimators = [int(x) for x in np.linspace(start = 200, stop = 2000, num = 10)]

max_features = ['auto', 'sqrt']

max_depth = [int(x) for x in np.linspace(10, 110, num = 11)]
max_depth.append(None)

min_samples_split = [2, 5, 10]

min_samples_leaf = [1, 2, 4]

bootstrap = [True, False]

random_grid_Booster = {'n_estimators': n_estimators,
            'max_features': max_features,
            'max_depth': max_depth,
            'min_samples_split': min_samples_split,
            'min_samples_leaf': min_samples_leaf,
            }
```

[16]:
```
gb = GradientBoostingRegressor()

gb_random = RandomizedSearchCV(estimator = gb, param_distributions =
  ↪random_grid_Booster, n_iter = 100, cv = 3, verbose=2, random_state=42, n_jobs = -1)

gb_random.fit(X_train, y_train)
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 16 concurrent workers.

Fitting 3 folds for each of 100 candidates, totalling 300 fits

[Parallel(n_jobs=-1)]: Done   9 tasks      | elapsed:    0.4s
[Parallel(n_jobs=-1)]: Done 221 tasks      | elapsed:    7.7s
[Parallel(n_jobs=-1)]: Done 300 out of 300 | elapsed:   10.2s finished
/usr/local/lib/python3.7/site-packages/sklearn/ensemble/_gb.py:1454:
```

```
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
  y = column_or_1d(y, warn=True)
```

[16]:
```
RandomizedSearchCV(cv=3, error_score=nan,
                   estimator=GradientBoostingRegressor(alpha=0.9, ccp_alpha=0.0,
                                                       criterion='friedman_mse',
                                                       init=None,
                                                       learning_rate=0.1,
                                                       loss='ls', 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,
                                                       n_estimators=100,
                                                       n_…
                   iid='deprecated', n_iter=100, n_jobs=-1,
                   param_distributions={'max_depth': [10, 20, 30, 40, 50, 60,
                                                      70, 80, 90, 100, 110,
                                                      None],
                                        'max_features': ['auto', 'sqrt'],
                                        'min_samples_leaf': [1, 2, 4],
                                        'min_samples_split': [2, 5, 10],
                                        'n_estimators': [200, 400, 600, 800,
                                                         1000, 1200, 1400, 1600,
                                                         1800, 2000]},
                   pre_dispatch='2*n_jobs', random_state=42, refit=True,
                   return_train_score=False, scoring=None, verbose=2)
```

[17]:
```python
gb_random.best_params_
```

[17]:
```
{'n_estimators': 1400,
 'min_samples_split': 10,
 'min_samples_leaf': 2,
 'max_features': 'auto',
 'max_depth': 40}
```

[18]:
```python
def evaluate(model, test_features, test_labels):
    predictions = model.predict(test_features)
    error = mean_absolute_error(y_test, predictions)
    r2 = r2_score(y_test, predictions)
    print('Model Performance')
    print('MAE: {:0.4f}'.format(error))
    print('R2 score: {:0.4f}'.format(r2))
    print('=====================\n\n')

base_model = GradientBoostingRegressor()
```

```
base_model.fit(X_train, y_train)
evaluate(base_model, X_test, y_test)
```

```
Model Performance
MAE: 0.4890
R2 score: 0.9832
======================
```

```
/usr/local/lib/python3.7/site-packages/sklearn/ensemble/_gb.py:1454:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
  y = column_or_1d(y, warn=True)
```

[19]:
```
best_random = gb_random.best_estimator_
evaluate(best_random, X_test, y_test)
```

```
Model Performance
MAE: 0.5078
R2 score: 0.9839
======================
```

1.2. Подбор параметров в градиентном бустинге не дал прироста качества (оно и так в целом было достаточно высокое)