Московский государственный технический университет им. Н. Э. Баумана

Курс «Технологии машинного обучения»

Отчёт по лабораторной работе №5

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Цель лабораторной работы: изучение ансамблей моделей машинного обучения.

Задание:

1. Выберите набор данных (датасет) для решения задачи классификации или регресии.
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 ансамблевые модели:
   - две модели группы бэггинга (бэггинг или случайный лес или сверхслучайные деревья);
   - AdaBoost;
   - градиентный бустинг.
5. Оцените качество моделей с помощью одной из подходящих для задачи метрик. Сравните качество полученных моделей.

Ход выполнения:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.pipeline import Pipeline
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import RobustScaler, OneHotEncoder
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier, AdaBoostClassifier, ExtraTreesClassifier
from sklearn.metrics import classification_report, accuracy_score, confusion_matrix, ConfusionMatrixDisplay
```

[89]:
```
data = pd.read_csv("heart.csv")
data.head()
```

[89]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

[90]:
```
data = data.rename(
    columns = {'cp':'chest_pain_type',
               'trestbps':'resting_blood_pressure',
               'chol': 'cholesterol',
               'fbs': 'fasting_blood_sugar',
               'restecg' : 'resting_electrocardiogram',
               'thalach': 'max_heart_rate_achieved',
               'exang': 'exercise_induced_angina',
               'oldpeak': 'st_depression',
               'slope': 'st_slope',
               'ca':'num_major_vessels',
               'thal': 'thalassemia'},
    errors="raise")
```

Первичный анализ датасета

[91]:
```
data.shape
```

[91]:
```
(303, 14)
```

[92]:
```
data.isnull().sum() # --> нет пропусков в данных
```

[92]:
```
age                         0
,sex                         0
,chest_pain_type             0
,resting_blood_pressure      0
,cholesterol                 0
,fasting_blood_sugar         0
,resting_electrocardiogram   0
,max_heart_rate_achieved     0
,exercise_induced_angina     0
,st_depression               0
,st_slope                    0
,num_major_vessels           0
,thalassemia                 0
,target                      0
,dtype: int64
```

[93]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
,RangeIndex: 303 entries, 0 to 302
,Data columns (total 14 columns):
, #   Column                     Non-Null Count  Dtype
,---  ------                     --------------  -----
, 0   age                        303 non-null    int64
, 1   sex                        303 non-null    int64
, 2   chest_pain_type            303 non-null    int64
, 3   resting_blood_pressure     303 non-null    int64
, 4   cholesterol                303 non-null    int64
, 5   fasting_blood_sugar        303 non-null    int64
, 6   resting_electrocardiogram  303 non-null    int64
, 7   max_heart_rate_achieved    303 non-null    int64
, 8   exercise_induced_angina    303 non-null    int64
, 9   st_depression              303 non-null    float64
, 10  st_slope                   303 non-null    int64
, 11  num_major_vessels          303 non-null    int64
, 12  thalassemia                303 non-null    int64
, 13  target                     303 non-null    int64
,dtypes: float64(1), int64(13)
,memory usage: 33.3 KB
```

[94]:
```python
# Заменяем значения в столбце 'sex'
data["sex"] = data["sex"].replace({0: "female", 1: "male"})

# Заменяем значения в столбце 'chest_pain_type'
data["chest_pain_type"] = data["chest_pain_type"].replace(
    {
        0: "typical angina",
        1: "atypical angina",
        2: "non-anginal pain",
        3: "asymptomatic",
    }
)

# Заменяем значения в столбце 'fasting_blood_sugar'
data["fasting_blood_sugar"] = data["fasting_blood_sugar"].replace(
    {0: "lower than 120mg/ml", 1: "greater than 120mg/ml"}
)

# Заменяем значения в столбце 'resting_electrocardiogram'
data["resting_electrocardiogram"] = data["resting_electrocardiogram"].replace(
    {0: "normal", 1: "ST-T wave abnormality", 2: "left ventricular hypertrophy"}
)

# Заменяем значения в столбце 'exercise_induced_angina'
data["exercise_induced_angina"] = data["exercise_induced_angina"].replace(
    {0: "no", 1: "yes"}
)

# Заменяем значения в столбце 'st_slope'
data["st_slope"] = data["st_slope"].replace(
    {0: "upsloping", 1: "flat", 2: "downsloping"}
)

# Заменяем значения в столбце 'thalassemia'
data["thalassemia"] = data["thalassemia"].replace(
    {1: "fixed defect", 2: "normal", 3: "reversable defect"}
)
```

[95]:
```python
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
,RangeIndex: 303 entries, 0 to 302
,Data columns (total 14 columns):
, #   Column                     Non-Null Count  Dtype
,---  ------                     --------------  -----
, 0   age                        303 non-null    int64
, 1   sex                        303 non-null    object
, 2   chest_pain_type            303 non-null    object
, 3   resting_blood_pressure     303 non-null    int64
, 4   cholesterol                303 non-null    int64
, 5   fasting_blood_sugar        303 non-null    object
, 6   resting_electrocardiogram  303 non-null    object
, 7   max_heart_rate_achieved    303 non-null    int64
, 8   exercise_induced_angina    303 non-null    object
, 9   st_depression              303 non-null    float64
, 10  st_slope                   303 non-null    object
, 11  num_major_vessels          303 non-null    int64
, 12  thalassemia                303 non-null    object
, 13  target                     303 non-null    int64
,dtypes: float64(1), int64(6), object(7)
,memory usage: 33.3+ KB
```

[96]:
```python
data.head()
```

[96]: ,,,

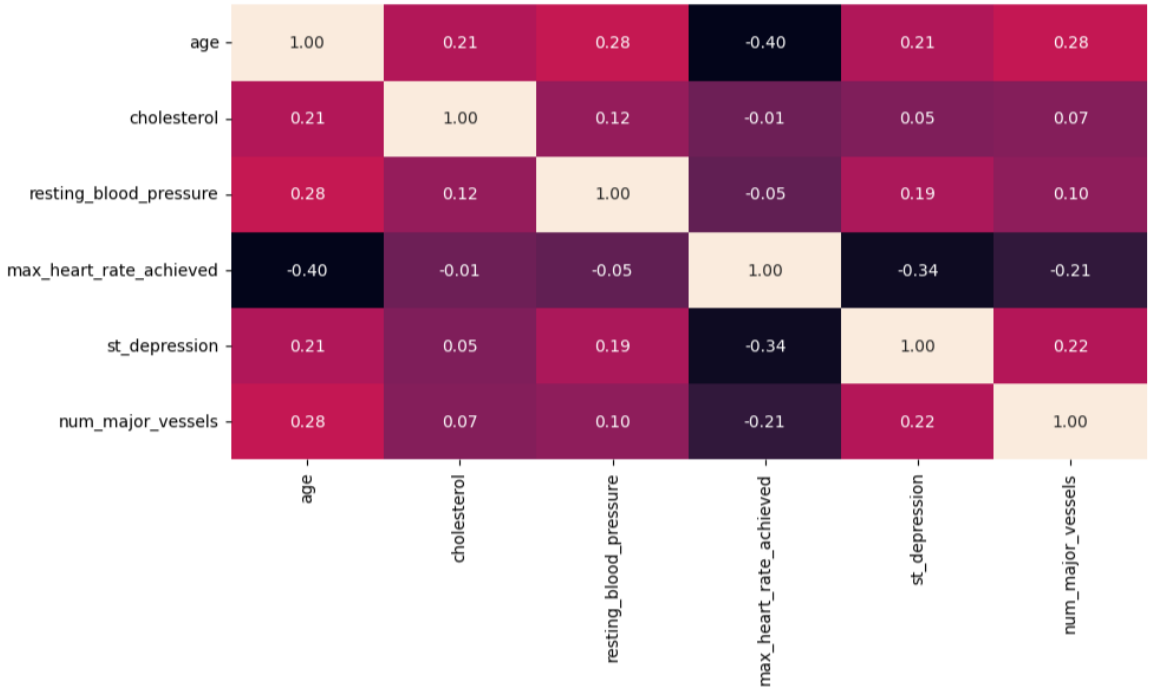
	age	sex	chest_pain_type	resting_blood_pressure	cholesterol	fasting_blood_sugar	resting_electrocardiogram	max_heart_rate_achieved	exercise_induced_angina	st_depression	st_slope	num_major_vessels	thalassemia	target
0	63	male	asymptomatic	145	233	greater than 120mg/ml	normal	150	no	2.3	upsloping	0	fixed defect	1
1	37	male	non-anginal pain	130	250	lower than 120mg/ml	ST-T wave abnormality	187	no	3.5	upsloping	0	normal	1
2	41	female	atypical angina	130	204	lower than 120mg/ml	normal	172	no	1.4	downsloping	0	normal	1
3	56	male	atypical angina	120	236	lower than 120mg/ml	ST-T wave abnormality	178	no	0.8	downsloping	0	normal	1
4	57	female	typical angina	120	354	lower than 120mg/ml	ST-T wave abnormality	163	yes	0.6	downsloping	0	normal	1

[ ]:
```
# Числовые признаки
num_feats = ['age', 'cholesterol', 'resting_blood_pressure', 'max_heart_rate_achieved', 'st_depression', 'num_major_vessels']

# Категориальные признаки
bin_feats = ['sex', 'fasting_blood_sugar', 'exercise_induced_angina']
nom_feats= ['chest_pain_type', 'resting_electrocardiogram', 'st_slope', 'thalassemia']
cat_feats = nom_feats + bin_feats
```

[100]:
```
df_ = data[num_feats]
fig, ax = plt.subplots(figsize=(10,5))
sns.heatmap(df_.corr(method='pearson'), ax=ax, annot=True, fmt='.2f', cbar=False)
```

[100]:
```
<Axes: >
```



Разделение выборки

[101]:
```
x = data.drop(['target'], axis=1)
y = data['target']

x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2, random_state=10)
```

Масштабирование данных

[109]:
```
num_pipeline = Pipeline([("scaling", RobustScaler())])

cat_pipeline = Pipeline([("onehot", OneHotEncoder())])
for col in cat_feats:
    x_train[col] = x_train[col].astype(str)
    x_test[col] = x_test[col].astype(str)

preprocessor = ColumnTransformer(
    [
        ("categorical", cat_pipeline, cat_feats),
        ("numerical", num_pipeline, num_feats),
    ],
    remainder="passthrough",
)

process_pipeline = Pipeline([("preprocessor", preprocessor)])

x_train_scaled = process_pipeline.fit_transform(x_train)
x_test_scaled = process_pipeline.transform(x_test)
```

Обучение моделей

Случайный лес

[110]:
```
rf_cl = RandomForestClassifier(random_state=10, n_jobs=-1)
rf_cl.fit(x_train_scaled, y_train)
```

[110]:
```
RandomForestClassifier(n_jobs=-1, random_state=10)
```
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

RandomForestClassifier
?Documentation for RandomForestClassifieriFitted
```
RandomForestClassifier(n_jobs=-1, random_state=10)
```

Сверхслучайные деревья

[111]:
```
et_cl = ExtraTreesClassifier(random_state=10, n_jobs=-1)
et_cl.fit(x_train_scaled, y_train)
```

[111]:
```
ExtraTreesClassifier(n_jobs=-1, random_state=10)
```
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

ExtraTreesClassifier
?Documentation for ExtraTreesClassifieriFitted
```
ExtraTreesClassifier(n_jobs=-1, random_state=10)
```

AdaBoost

[112]:
```
ab_cl = AdaBoostClassifier(random_state=10)
ab_cl.fit(x_train_scaled, y_train)
```

[112]:
```
AdaBoostClassifier(random_state=10)
```
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

AdaBoostClassifier
?Documentation for AdaBoostClassifieriFitted
```
AdaBoostClassifier(random_state=10)
```

Градиентный бустинг

[113]:
```
gb_cl = GradientBoostingClassifier(loss="exponential", random_state=10)
gb_cl.fit(x_train_scaled, y_train)
```

[113]:
```
GradientBoostingClassifier(loss='exponential', random_state=10)
```
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

GradientBoostingClassifier
?Documentation for GradientBoostingClassifieriFitted
```
GradientBoostingClassifier(loss='exponential', random_state=10)
```

Оценка качества моделей

Основные метрики

Accuracy

Процент (долю в диапазоне от 0 до 1) правильно определенных классов.

Precision

$precision = \frac{TP}{TP+FP}$

Доля верно предсказанных классификатором положительных объектов, из всех объектов, которые классификатор верно или неверно определил как положительные.

Recall

$recall = \frac{TP}{TP+FN}$

Доля верно предсказанных классификатором положительных объектов, из всех действительно положительных объектов.

F1-мера

$F_1 = 2 \cdot \frac{precision \cdot recall}{precision + recall}$

[114]:
```
y_pred_rf = rf_cl.predict(x_test_scaled)
print(classification_report(y_test, y_pred_rf))
```

```
              precision    recall  f1-score   support

           0       0.85      0.80      0.82        35
           1       0.75      0.81      0.78        26

    accuracy                           0.80        61
   macro avg       0.80      0.80      0.80        61
weighted avg       0.81      0.80      0.80        61
```

[115]:
```
y_pred_et = et_cl.predict(x_test_scaled)
print(classification_report(y_test, y_pred_et))
```

```
              precision    recall  f1-score   support

           0       0.85      0.80      0.82        35
           1       0.75      0.81      0.78        26

    accuracy                           0.80        61
   macro avg       0.80      0.80      0.80        61
weighted avg       0.81      0.80      0.80        61
```

[116]:
```
y_pred_ab = ab_cl.predict(x_test_scaled)
print(classification_report(y_test, y_pred_ab))
```

```
              precision    recall  f1-score   support

           0       0.84      0.77      0.81        35
           1       0.72      0.81      0.76        26

    accuracy                           0.79        61
   macro avg       0.78      0.79      0.78        61
weighted avg       0.79      0.79      0.79        61
```

[117]:
```
y_pred_gb = gb_cl.predict(x_test_scaled)
print(classification_report(y_test, y_pred_gb))
```

```
              precision    recall  f1-score   support

           0       0.85      0.80      0.82        35
           1       0.75      0.81      0.78        26

    accuracy                           0.80        61
   macro avg       0.80      0.80      0.80        61
weighted avg       0.81      0.80      0.80        61
```

[118]:
```
cm_rf = confusion_matrix(y_test, y_pred_rf)
cm_et = confusion_matrix(y_test, y_pred_et)
cm_ab = confusion_matrix(y_test, y_pred_ab)
cm_gb = confusion_matrix(y_test, y_pred_gb)

fig, axes = plt.subplots(1, 4, figsize=(15, 5))

disp1 = ConfusionMatrixDisplay(confusion_matrix=cm_rf)
disp1.plot(ax=axes[0], cmap=plt.cm.Blues)
axes[0].set_title('Случайный лес')

disp2 = ConfusionMatrixDisplay(confusion_matrix=cm_et)
disp2.plot(ax=axes[1], cmap=plt.cm.Blues)
axes[1].set_title('Сверхслучайные деревья')

disp3 = ConfusionMatrixDisplay(confusion_matrix=cm_ab)
disp3.plot(ax=axes[2], cmap=plt.cm.Blues)
axes[2].set_title('AdaBoost')

disp4 = ConfusionMatrixDisplay(confusion_matrix=cm_gb)
disp3.plot(ax=axes[3], cmap=plt.cm.Blues)
axes[3].set_title('Градиентный бустинг')

plt.tight_layout()
plt.show()
```