Защищено:
Гапанюк Ю.Е.

"__"_____2022 г.

Демонстрация:
Гапанюк Ю.Е.

"__"_____2022 г.

Отчет по лабораторной работе № 6 по курсу Технологии машинного обучения ГУИМЦ

Тема работы: " Разработайте макет веб-приложения, предназначенного для анализа данных."

9
(количество листов)
Вариант № **3**

ИСПОЛНИТЕЛЬ:

студент группы ИУ5Ц-84Б _____
(подпись)

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Москва, МГТУ - 2022

In[1]

```
import streamlit as st
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split, learning_curve
from sklearn.metrics import plot_confusion_matrix, accuracy_score, roc_curve,
roc_auc_score, f1_score
from sklearn.preprocessing import MinMaxScaler
from catboost import Pool, CatBoostClassifier

# Запуск приложения streamlit run /Users/liza/Desktop/LR6/Lol.py [ARGUMENTS]
def load():
    col_list = ['Pelvic_incidence',
                'Pelvic_tilt',
                'Lumbar_lordosis_angle',
                'Sacral_slope',
                'Pelvic_radius',
                'Degree_spondylolisthesis',
                'Pelvic_slope',
                'Direct_tilt',
                'Thoracic_slope',
                'Cervical_tilt',
                'Sacrum_angle',
                'Scoliosis_slope',
                'Class_att',
                'To_drop']
    data = pd.read_csv('/Users/liza/Desktop/LR6/Dataset_spine.csv', names=col_list,
header=1, sep=",")
    data.drop('To_drop', axis=1, inplace=True)
    return data

# Готовим данные к ML
def preprocess_data(data):
    scale_cols = ['Pelvic_incidence',
                  'Pelvic_tilt',
                  'Lumbar_lordosis_angle',
                  'Sacral_slope',
                  'Pelvic_radius',
                  'Degree_spondylolisthesis',
                  'Pelvic_slope',
                  'Direct_tilt',
                  'Thoracic_slope',
                  'Cervical_tilt',
                  'Sacrum_angle',
                  'Scoliosis_slope']
    sc1 = MinMaxScaler()
    sc1_data = sc1.fit_transform(data[scale_cols])
    for i in range(len(scale_cols)):
        data[scale_cols[i]] = sc1_data[:, i]
    data['Class_att'] = data['Class_att'].map({'Abnormal': 1, 'Normal': 0})
    # Разделим данные на целевой столбец и признаки
    X = data.drop("Class_att", axis=1)
    Y = data["Class_att"]
    # С использованием метода train_test_split разделим выборку на обучающую и тестовую
    X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.25,
random_state=1)
    return X_train, X_test, Y_train, Y_test
```

```
# Отрисовка графика ROC_CURVE
def draw_roc_curve(y_true, y_score, ax, pos_label=1, average='micro'):
    fpr, tpr, thresholds = roc_curve(y_true, y_score,
                                     pos_label=pos_label)
    roc_auc_value = roc_auc_score(y_true, y_score, average=average)
    # plt.figure()
    lw = 2
    ax.plot(fpr, tpr, color='darkorange',
            lw=lw, label='ROC curve (area = %0.2f)' % roc_auc_value)
    ax.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
    ax.set_xlim([0.0, 1.0])
    ax.set_xlim([0.0, 1.05])
    ax.set_xlabel('False Positive Rate')
    ax.set_ylabel('True Positive Rate')
    ax.set_title('Receiver operating characteristic')
    ax.legend(loc="lower right")

# Вывод метрик ML
def print_metrics(X_train, Y_train, X_test, Y_test, clf):
    clf.fit(X_train, Y_train)
    target = clf.predict(X_test)
    test_score = accuracy_score(Y_test, target)
    roc_res = clf.predict_proba(X_test)
    roc_auc = roc_auc_score(Y_test, roc_res[:, 1])
    f1_test_score = f1_score(Y_test, target)
    st.write(f"accuracy (точность): {test_score}")
    st.write(f"f1 метрика: {f1_test_score}")
    st.write(f"ROC AUC: {roc_auc}")
    fig1, ax1 = plt.subplots()
    draw_roc_curve(Y_test, roc_res[:, 1], ax1)
    st.pyplot(fig1)
    fig2, ax2 = plt.subplots(figsize=(10, 5))
    plot_confusion_matrix(clf, X_test, Y_test, ax=ax2, display_labels=['1', '0'], cmap
= 'Purples', normalize='true')
    ax2.set(title="Confusion matrix")
    st.pyplot(fig2)
    return test_score

# Вывод кривой обучения
def plot_learning_curve(data_X, data_y, clf, name='accuracy', scoring='accuracy'):
    train_sizes, train_scores, test_scores = learning_curve(estimator=clf,
scoring=scoring, X=data_X, y=data_y, train_sizes=np.linspace(0.1, 1.0, 10), cv=5)
    train_mean = np.mean(train_scores, axis=1)
    train_std = np.std(train_scores, axis=1)
    test_mean = np.mean(test_scores, axis=1)
    test_std = np.std(test_scores, axis=1)
    fig = plt.figure(figsize=(7, 5))
    plt.plot(train_sizes, train_mean, color='blue', marker='o', markersize=5,
label=f'тренировочная {name}-мера')
    plt.fill_between(train_sizes, train_mean + train_std, train_mean - train_std,
alpha=0.15, color='blue')
    plt.plot(train_sizes, test_mean, color='green', linestyle='--', marker='s',
markersize=5,
             label=f'проверочная {name}-мера')
    plt.fill_between(train_sizes, test_mean + test_std, test_mean - test_std,
alpha=0.15, color='green')
    plt.grid()
    plt.legend(loc='lower right')
    plt.xlabel('Число тренировочных образцов')
    plt.ylabel(f'{name}-мера')
    st.pyplot(fig)
```

```
if __name__ == '__main__':
    st.title('Метод градиентного бустинга')
    data = load()
    data_X_train, data_X_test, data_y_train, data_y_test = preprocess_data(data)

    # Будем показывать матрицу только по запросу, чттобы не тормозить процесс
    if st.checkbox('Показать корреляционную матрицу'):
        fig_corr, ax = plt.subplots(figsize=(20, 20))
        sns.heatmap(data.corr(), annot=True, cmap = 'Purples', fmt='.3f')
        st.pyplot(fig_corr)

    # Выбор гиперпараметров в сайдбаре
    st.sidebar.subheader('Гиперпараметры :')
    estimators = st.sidebar.slider('Количество деревьев: ', min_value=1, max_value=100,
value=5, step=1)
    max_depth = st.sidebar.slider('Максимальная глубина', min_value=1, max_value=10,
value=4, step=1)
    eval_metric = st.sidebar.selectbox('Оптимизируемая метрика:', ('Accuracy', 'F1',
'AUC'))

    # Вывод результатов
    translation_dict = {'Accuracy': 'accuracy', 'F1': 'f1', 'AUC': 'roc_auc'}
    gd = CatBoostClassifier(n_estimators=estimators, max_depth=max_depth,
eval_metric=eval_metric, random_state=1)
    result = print_metrics(data_X_train, data_y_train, data_X_test, data_y_test, gd)
    data_X = pd.concat([data_X_train, data_X_test])
    data_y = pd.concat([data_y_train, data_y_test])
    plot_learning_curve(data_X, data_y, gd, name=translation_dict.get(eval_metric),
scoring=translation_dict.get(eval_metric))
    # Показать данные
    if st.checkbox('Показать первые 10 строк датасета "Dataset_spine"'):
        st.write(data.head(10))
```

```
out[1]
Learning rate set to 0.5
0:      learn: 0.8311688       total: 1.08ms  remaining: 4.32ms
1:      learn: 0.8441558       total: 1.82ms  remaining: 2.73ms
2:      learn: 0.8571429       total: 2.58ms  remaining: 1.72ms
3:      learn: 0.8744589       total: 3.27ms  remaining: 818us
4:      learn: 0.8614719       total: 4.03ms  remaining: 0us
Learning rate set to 0.269978
0:      learn: 1.0000000       total: 501us   remaining: 2.01ms
1:      learn: 0.9583333       total: 1.01ms  remaining: 1.51ms
2:      learn: 1.0000000       total: 1.54ms  remaining: 1.03ms
3:      learn: 1.0000000       total: 2.06ms  remaining: 516us
4:      learn: 1.0000000       total: 2.54ms  remaining: 0us
Learning rate set to 0.366178
0:      learn: 0.7959184       total: 430us   remaining: 1.72ms
1:      learn: 0.8775510       total: 899us   remaining: 1.35ms
2:      learn: 0.8979592       total: 1.36ms  remaining: 909us
3:      learn: 0.9387755       total: 1.74ms  remaining: 434us
4:      learn: 0.9387755       total: 2.29ms  remaining: 0us
Learning rate set to 0.436657
0:      learn: 0.9054054       total: 467us   remaining: 1.87ms
1:      learn: 0.8783784       total: 982us   remaining: 1.47ms
2:      learn: 0.8918919       total: 1.49ms  remaining: 991us
3:      learn: 0.9189189       total: 1.95ms  remaining: 486us
4:      learn: 0.9054054       total: 2.45ms  remaining: 0us
Learning rate set to 0.492303
```

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0:      learn: 0.8877551       total: 484us    remaining: 1.94ms
1:      learn: 0.8775510       total: 1.06ms   remaining: 1.59ms
2:      learn: 0.8673469       total: 1.6ms    remaining: 1.07ms
3:      learn: 0.8877551       total: 2.15ms   remaining: 537us
4:      learn: 0.8979592       total: 2.7ms    remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8943089       total: 632us    remaining: 2.53ms
1:      learn: 0.8943089       total: 1.16ms   remaining: 1.74ms
2:      learn: 0.8943089       total: 1.67ms   remaining: 1.12ms
3:      learn: 0.8861789       total: 2.37ms   remaining: 593us
4:      learn: 0.9024390       total: 2.96ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8175676       total: 515us    remaining: 2.06ms
1:      learn: 0.8310811       total: 1.19ms   remaining: 1.78ms
2:      learn: 0.8716216       total: 1.75ms   remaining: 1.17ms
3:      learn: 0.8851351       total: 2.29ms   remaining: 572us
4:      learn: 0.8986486       total: 2.84ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8197674       total: 561us    remaining: 2.24ms
1:      learn: 0.8720930       total: 1.23ms   remaining: 1.85ms
2:      learn: 0.8837209       total: 2.05ms   remaining: 1.36ms
3:      learn: 0.8837209       total: 2.98ms   remaining: 745us
4:      learn: 0.8953488       total: 3.64ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8375635       total: 648us    remaining: 2.59ms
1:      learn: 0.8426396       total: 1.25ms   remaining: 1.88ms
2:      learn: 0.8730964       total: 2.03ms   remaining: 1.35ms
3:      learn: 0.8934010       total: 2.76ms   remaining: 689us
4:      learn: 0.9187817       total: 3.59ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8783784       total: 604us    remaining: 2.42ms
1:      learn: 0.8828829       total: 1.32ms   remaining: 1.98ms
2:      learn: 0.8918919       total: 1.98ms   remaining: 1.32ms
3:      learn: 0.9009009       total: 2.74ms   remaining: 685us
4:      learn: 0.9144144       total: 3.63ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8704453       total: 661us    remaining: 2.64ms
1:      learn: 0.8825911       total: 1.37ms   remaining: 2.05ms
2:      learn: 0.8906883       total: 2.01ms   remaining: 1.34ms
3:      learn: 0.9028340       total: 2.73ms   remaining: 682us
4:      learn: 0.9068826       total: 3.42ms   remaining: 0us
Learning rate set to 0.269978
0:      learn: 0.9583333       total: 390us    remaining: 1.56ms
1:      learn: 0.9583333       total: 794us    remaining: 1.19ms
2:      learn: 0.9583333       total: 1.21ms   remaining: 807us
3:      learn: 0.9583333       total: 1.6ms    remaining: 401us
4:      learn: 0.9166667       total: 2.04ms   remaining: 0us
Learning rate set to 0.366178
0:      learn: 0.8571429       total: 375us    remaining: 1.5ms
1:      learn: 0.9183673       total: 1.12ms   remaining: 1.68ms
2:      learn: 0.9795918       total: 1.6ms    remaining: 1.07ms
3:      learn: 0.9387755       total: 2.12ms   remaining: 530us
4:      learn: 0.9795918       total: 2.71ms   remaining: 0us
Learning rate set to 0.436657
0:      learn: 0.8108108       total: 391us    remaining: 1.56ms
1:      learn: 0.8108108       total: 1.17ms   remaining: 1.75ms
2:      learn: 0.8783784       total: 1.72ms   remaining: 1.15ms
3:      learn: 0.9054054       total: 2.15ms   remaining: 536us
4:      learn: 0.9189189       total: 2.63ms   remaining: 0us
Learning rate set to 0.492303
0:      learn: 0.7653061       total: 414us    remaining: 1.66ms
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1:      learn: 0.8571429       total: 970us   remaining: 1.46ms
2:      learn: 0.8469388       total: 1.47ms  remaining: 981us
3:      learn: 0.8673469       total: 2.23ms  remaining: 557us
4:      learn: 0.8877551       total: 2.82ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8130081       total: 681us   remaining: 2.72ms
1:      learn: 0.8130081       total: 1.4ms   remaining: 2.11ms
2:      learn: 0.8130081       total: 1.94ms  remaining: 1.29ms
3:      learn: 0.8617886       total: 2.56ms  remaining: 641us
4:      learn: 0.8617886       total: 3.2ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.7972973       total: 500us   remaining: 2ms
1:      learn: 0.7905405       total: 1.34ms  remaining: 2.01ms
2:      learn: 0.8378378       total: 1.98ms  remaining: 1.32ms
3:      learn: 0.8310811       total: 2.61ms  remaining: 652us
4:      learn: 0.8716216       total: 3.33ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8023256       total: 521us   remaining: 2.09ms
1:      learn: 0.8139535       total: 1.1ms   remaining: 1.66ms
2:      learn: 0.8430233       total: 1.63ms  remaining: 1.09ms
3:      learn: 0.8313953       total: 2.29ms  remaining: 571us
4:      learn: 0.8720930       total: 2.81ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8172589       total: 544us   remaining: 2.18ms
1:      learn: 0.8071066       total: 1.21ms  remaining: 1.82ms
2:      learn: 0.8324873       total: 1.77ms  remaining: 1.18ms
3:      learn: 0.8629442       total: 2.42ms  remaining: 606us
4:      learn: 0.8629442       total: 3.03ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8288288       total: 578us   remaining: 2.31ms
1:      learn: 0.8198198       total: 1.24ms  remaining: 1.86ms
2:      learn: 0.8558559       total: 1.82ms  remaining: 1.22ms
3:      learn: 0.8693694       total: 2.46ms  remaining: 615us
4:      learn: 0.8693694       total: 3.16ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8421053       total: 556us   remaining: 2.23ms
1:      learn: 0.8542510       total: 1.4ms   remaining: 2.1ms
2:      learn: 0.8461538       total: 2.08ms  remaining: 1.39ms
3:      learn: 0.8866397       total: 2.76ms  remaining: 691us
4:      learn: 0.8906883       total: 3.39ms  remaining: 0us
Learning rate set to 0.269978
0:      learn: 0.9583333       total: 275us   remaining: 1.1ms
1:      learn: 0.9583333       total: 685us   remaining: 1.03ms
2:      learn: 0.9583333       total: 1.06ms  remaining: 704us
3:      learn: 0.9583333       total: 1.45ms  remaining: 361us
4:      learn: 0.9166667       total: 1.79ms  remaining: 0us
Learning rate set to 0.366178
0:      learn: 0.8571429       total: 446us   remaining: 1.78ms
1:      learn: 0.9183673       total: 917us   remaining: 1.38ms
2:      learn: 0.9795918       total: 1.32ms  remaining: 879us
3:      learn: 0.9387755       total: 1.73ms  remaining: 431us
4:      learn: 0.9795918       total: 2.22ms  remaining: 0us
Learning rate set to 0.436657
0:      learn: 0.8243243       total: 362us   remaining: 1.45ms
1:      learn: 0.8108108       total: 833us   remaining: 1.25ms
2:      learn: 0.8378378       total: 1.31ms  remaining: 877us
3:      learn: 0.8513514       total: 1.81ms  remaining: 453us
4:      learn: 0.8648649       total: 2.38ms  remaining: 0us
Learning rate set to 0.492303
0:      learn: 0.8061224       total: 469us   remaining: 1.88ms
1:      learn: 0.8367347       total: 1.02ms  remaining: 1.54ms
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2:      learn: 0.8571429       total: 1.51ms  remaining: 1ms
3:      learn: 0.8775510       total: 2.06ms  remaining: 515us
4:      learn: 0.8673469       total: 2.51ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8699187       total: 464us   remaining: 1.86ms
1:      learn: 0.8617886       total: 1.09ms  remaining: 1.63ms
2:      learn: 0.8780488       total: 1.58ms  remaining: 1.05ms
3:      learn: 0.8780488       total: 2.29ms  remaining: 572us
4:      learn: 0.9105691       total: 2.95ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8175676       total: 469us   remaining: 1.88ms
1:      learn: 0.8378378       total: 1.03ms  remaining: 1.54ms
2:      learn: 0.8310811       total: 1.55ms  remaining: 1.03ms
3:      learn: 0.8783784       total: 2.1ms   remaining: 525us
4:      learn: 0.8648649       total: 2.64ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8488372       total: 825us   remaining: 3.3ms
1:      learn: 0.8546512       total: 1.56ms  remaining: 2.34ms
2:      learn: 0.8662791       total: 2.09ms  remaining: 1.39ms
3:      learn: 0.8837209       total: 2.63ms  remaining: 658us
4:      learn: 0.8662791       total: 3.16ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8375635       total: 542us   remaining: 2.17ms
1:      learn: 0.8680203       total: 1.57ms  remaining: 2.35ms
2:      learn: 0.8781726       total: 2.38ms  remaining: 1.59ms
3:      learn: 0.8984772       total: 2.95ms  remaining: 738us
4:      learn: 0.9086294       total: 3.55ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8423423       total: 539us   remaining: 2.16ms
1:      learn: 0.8513514       total: 1.22ms  remaining: 1.83ms
2:      learn: 0.8513514       total: 1.84ms  remaining: 1.23ms
3:      learn: 0.8603604       total: 2.73ms  remaining: 681us
4:      learn: 0.8693694       total: 3.53ms  remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8502024       total: 553us   remaining: 2.21ms
1:      learn: 0.8623482       total: 1.43ms  remaining: 2.14ms
2:      learn: 0.8704453       total: 2.12ms  remaining: 1.41ms
3:      learn: 0.8947368       total: 2.88ms  remaining: 720us
4:      learn: 0.8825911       total: 3.91ms  remaining: 0us
Learning rate set to 0.269978
0:      learn: 0.9583333       total: 305us   remaining: 1.22ms
1:      learn: 0.9583333       total: 799us   remaining: 1.2ms
2:      learn: 0.9583333       total: 1.29ms  remaining: 857us
3:      learn: 0.9583333       total: 1.81ms  remaining: 453us
4:      learn: 0.9166667       total: 2.17ms  remaining: 0us
Learning rate set to 0.366178
0:      learn: 0.8571429       total: 429us   remaining: 1.72ms
1:      learn: 0.9183673       total: 1.01ms  remaining: 1.51ms
2:      learn: 0.9795918       total: 1.78ms  remaining: 1.19ms
3:      learn: 0.9387755       total: 2.27ms  remaining: 567us
4:      learn: 0.9795918       total: 2.8ms   remaining: 0us
Learning rate set to 0.436657
0:      learn: 0.8243243       total: 360us   remaining: 1.44ms
1:      learn: 0.8108108       total: 982us   remaining: 1.47ms
2:      learn: 0.8378378       total: 1.54ms  remaining: 1.03ms
3:      learn: 0.8513514       total: 2.07ms  remaining: 517us
4:      learn: 0.8648649       total: 2.53ms  remaining: 0us
Learning rate set to 0.492303
0:      learn: 0.8061224       total: 462us   remaining: 1.85ms
1:      learn: 0.8367347       total: 985us   remaining: 1.48ms
2:      learn: 0.8571429       total: 1.52ms  remaining: 1.01ms
```

```
3:      learn: 0.8775510       total: 2.21ms   remaining: 552us
4:      learn: 0.8673469       total: 2.88ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8699187       total: 464us    remaining: 1.86ms
1:      learn: 0.8617886       total: 1.01ms   remaining: 1.51ms
2:      learn: 0.8780488       total: 1.54ms   remaining: 1.03ms
3:      learn: 0.8780488       total: 2.19ms   remaining: 548us
4:      learn: 0.9105691       total: 2.77ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8445946       total: 681us    remaining: 2.73ms
1:      learn: 0.8986486       total: 1.33ms   remaining: 1.99ms
2:      learn: 0.8378378       total: 1.92ms   remaining: 1.28ms
3:      learn: 0.8445946       total: 2.54ms   remaining: 634us
4:      learn: 0.8716216       total: 3.17ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8139535       total: 732us    remaining: 2.93ms
1:      learn: 0.7965116       total: 1.47ms   remaining: 2.2ms
2:      learn: 0.8546512       total: 2.18ms   remaining: 1.45ms
3:      learn: 0.8779070       total: 2.86ms   remaining: 714us
4:      learn: 0.8895349       total: 3.59ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8426396       total: 758us    remaining: 3.03ms
1:      learn: 0.8426396       total: 1.5ms    remaining: 2.25ms
2:      learn: 0.8477157       total: 2.27ms   remaining: 1.51ms
3:      learn: 0.8578680       total: 3.05ms   remaining: 762us
4:      learn: 0.8527919       total: 3.73ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8603604       total: 699us    remaining: 2.8ms
1:      learn: 0.8558559       total: 1.71ms   remaining: 2.57ms
2:      learn: 0.8873874       total: 2.64ms   remaining: 1.76ms
3:      learn: 0.8918919       total: 3.49ms   remaining: 872us
4:      learn: 0.8963964       total: 4.27ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8663968       total: 595us    remaining: 2.38ms
1:      learn: 0.8582996       total: 1.76ms   remaining: 2.65ms
2:      learn: 0.8785425       total: 2.79ms   remaining: 1.86ms
3:      learn: 0.8825911       total: 3.9ms    remaining: 974us
4:      learn: 0.8866397       total: 4.74ms   remaining: 0us
Learning rate set to 0.269978
0:      learn: 0.9583333       total: 308us    remaining: 1.23ms
1:      learn: 0.9583333       total: 865us    remaining: 1.3ms
2:      learn: 0.9583333       total: 1.27ms   remaining: 844us
3:      learn: 0.9583333       total: 1.75ms   remaining: 436us
4:      learn: 0.9166667       total: 2.07ms   remaining: 0us
Learning rate set to 0.366178
0:      learn: 0.8571429       total: 348us    remaining: 1.39ms
1:      learn: 0.9183673       total: 1.04ms   remaining: 1.56ms
2:      learn: 0.9795918       total: 1.61ms   remaining: 1.07ms
3:      learn: 0.9387755       total: 2.27ms   remaining: 567us
4:      learn: 0.9795918       total: 2.79ms   remaining: 0us
Learning rate set to 0.436657
0:      learn: 0.8243243       total: 622us    remaining: 2.49ms
1:      learn: 0.8108108       total: 1.33ms   remaining: 1.99ms
2:      learn: 0.8378378       total: 2.01ms   remaining: 1.34ms
3:      learn: 0.8513514       total: 2.59ms   remaining: 648us
4:      learn: 0.8648649       total: 3.16ms   remaining: 0us
Learning rate set to 0.492303
0:      learn: 0.8061224       total: 430us    remaining: 1.72ms
1:      learn: 0.8367347       total: 1.06ms   remaining: 1.59ms
2:      learn: 0.8571429       total: 1.8ms    remaining: 1.2ms
3:      learn: 0.8775510       total: 2.38ms   remaining: 595us
```

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4:      learn: 0.8673469        total: 2.95ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8699187        total: 540us    remaining: 2.16ms
1:      learn: 0.8617886        total: 1.21ms   remaining: 1.81ms
2:      learn: 0.8780488        total: 1.88ms   remaining: 1.25ms
3:      learn: 0.8780488        total: 2.41ms   remaining: 603us
4:      learn: 0.9105691        total: 3.07ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8445946        total: 465us    remaining: 1.86ms
1:      learn: 0.8986486        total: 1.11ms   remaining: 1.66ms
2:      learn: 0.8378378        total: 1.77ms   remaining: 1.18ms
3:      learn: 0.8445946        total: 2.61ms   remaining: 653us
4:      learn: 0.8716216        total: 3.5ms    remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8139535        total: 453us    remaining: 1.81ms
1:      learn: 0.7965116        total: 1.06ms   remaining: 1.59ms
2:      learn: 0.8546512        total: 1.72ms   remaining: 1.15ms
3:      learn: 0.8779070        total: 2.48ms   remaining: 620us
4:      learn: 0.8895349        total: 3.32ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8071066        total: 539us    remaining: 2.16ms
1:      learn: 0.8121827        total: 1.22ms   remaining: 1.82ms
2:      learn: 0.8324873        total: 1.78ms   remaining: 1.18ms
3:      learn: 0.8375635        total: 2.41ms   remaining: 602us
4:      learn: 0.8680203        total: 3.31ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8108108        total: 524us    remaining: 2.1ms
1:      learn: 0.8108108        total: 1.46ms   remaining: 2.2ms
2:      learn: 0.8378378        total: 2.11ms   remaining: 1.41ms
3:      learn: 0.8558559        total: 2.76ms   remaining: 689us
4:      learn: 0.8468468        total: 3.41ms   remaining: 0us
Learning rate set to 0.5
0:      learn: 0.8137652        total: 558us    remaining: 2.23ms
1:      learn: 0.8056680        total: 1.31ms   remaining: 1.97ms
2:      learn: 0.8178138        total: 1.92ms   remaining: 1.28ms
3:      learn: 0.8947368        total: 2.52ms   remaining: 629us
4:      learn: 0.8785425        total: 3.18ms   remaining: 0us
```
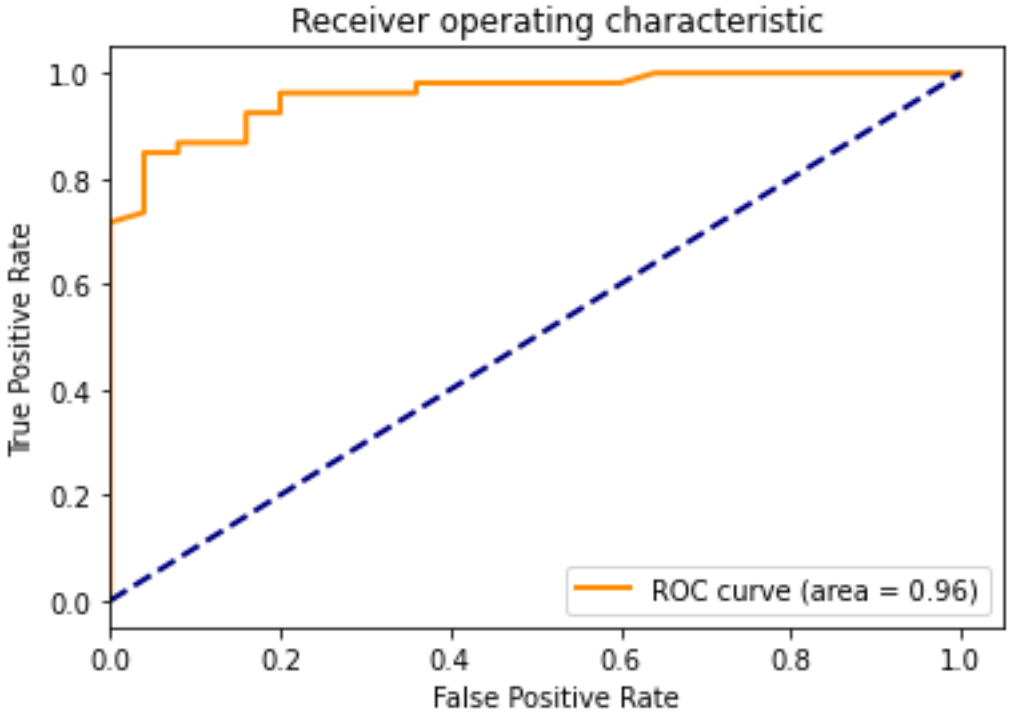
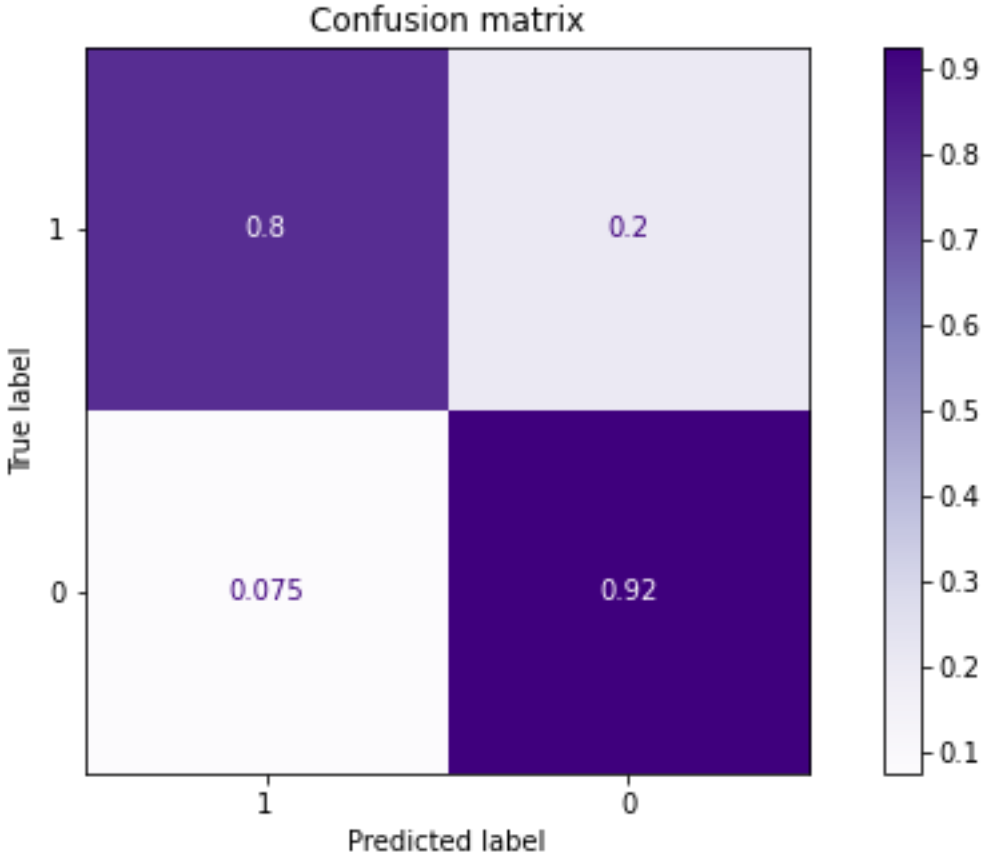
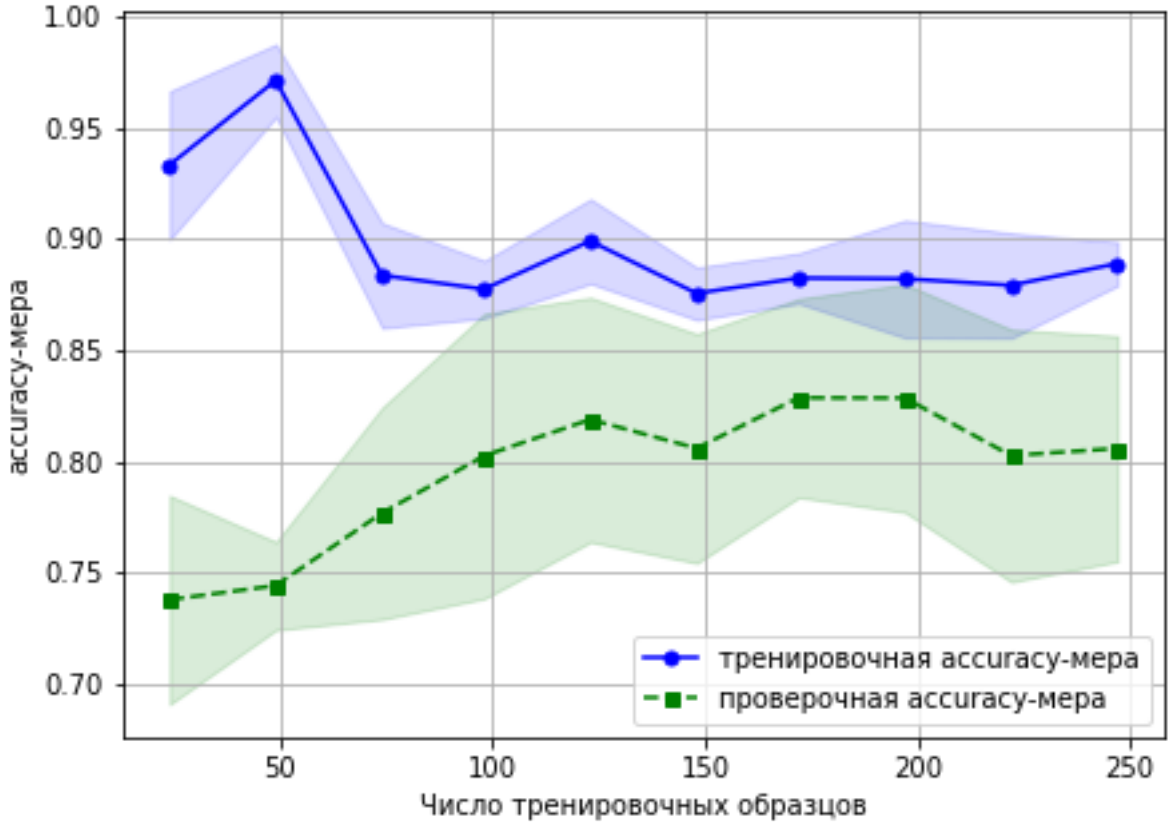




Confusion matrix
0.8
0.2
0.075
0.92
1
0
True label
1
0
Predicted label
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


1.00
0.95
0.90
0.85
0.80
0.75
0.70
accuracy-мера
50
100
150
200
250
Число тренировочных образцов
тренировочная accuracy-мера
проверочная accuracy-мера