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ДИСЦИПЛИНА:
"Технологии машинного обучения"



Отчет по лабораторной работе №5
"Линейные модели, SVM и деревья решений"

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Цель лабораторной работы: изучение линейных моделей, SVM и деревьев решений.

Задание:

1. Выберите набор данных (датасет) для решения задачи классификации или регрессии.
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 модели:
 - одну из линейных моделей;
 - SVM;
 - дерево решений.
5. Оцените качество моделей с помощью двух подходящих для задачи метрик. Сравните качество полученных моделей.

Выполненная работа:

В данной лабораторной работе модели будут строиться для решения задачи классификации. Загрузка и первичный анализ данных. Формирование DataFrame:

```
In [2]: wine = load_wine()
```

```
In [3]: # Сформируем DataFrame
wine_df = pd.DataFrame(data= np.c_[wine['data'], wine['target']],
                       columns= list(wine['feature_names']) + ['target'])
```

```
In [4]: wine_df.isnull().sum()
```

```
Out[4]: alcohol          0
malic_acid              0
ash                    0
alcalinity_of_ash       0
magnesium              0
total_phenols          0
flavanoids             0
nonflavanoid_phenols   0
proanthocyanins        0
color_intensity        0
hue                   0
od280/od315_of_diluted_wines  0
proline                0
target                 0
dtype: int64
```

```
In [5]: wine_df.head
```

```
Out[5]: <bound method NDFrame.head of      alcohol  malic_acid  ash  alcalinity_of_ash  magnesium  total_phenols  \
0      14.23      1.71  2.43          15.6      127.0          2.80
1      13.20      1.78  2.14          11.2      100.0          2.65
2      13.16      2.36  2.67          18.6      101.0          2.80
3      14.37      1.95  2.50          16.8      113.0          3.85
4      13.24      2.59  2.87          21.0      118.0          2.80
..      ...      ...  ...          ...      ...          ...
173     13.71      5.65  2.45          20.5       95.0          1.68
174     13.40      3.91  2.48          23.0      102.0          1.80
175     13.27      4.28  2.26          20.0      120.0          1.59
176     13.17      2.59  2.37          20.0      120.0          1.65
177     14.13      4.10  2.74          24.5       96.0          2.05
```

Разделение данных на обучающую и тестовую выборки. Построение модели «Логистическая регрессия»:

```

In [6]: def convert_target_to_binary(array:np.ndarray, target:int) -> np.ndarray:
# Если целевой признак совпадает с указанным, то 1 иначе 0
    res = [1 if x==target else 0 for x in array]
    return res

In [7]: bin_wine_y = convert_target_to_binary(wine.target, 2)

In [8]: wine_X_train, wine_X_test, wine_y_train, wine_y_test = train_test_split(
    wine.data, bin_wine_y, test_size=0.2, random_state=1)

In [9]: cl1 = LogisticRegression()

In [10]: cl1.fit(wine_X_train, wine_y_train)

c:\django_projects\untitled\venv\lib\site-packages\sklearn\linear_model\_logistic.py:940: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear\_model.html#logistic-regression
extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)

Out[10]: LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
    intercept_scaling=1, l1_ratio=None, max_iter=100,
    multi_class='auto', n_jobs=None, penalty='l2',
    random_state=None, solver='lbfgs', tol=0.0001, verbose=0,
    warm_start=False)

In [11]: pred_wine_y_test = cl1.predict(wine_X_test)
pred_wine_y_test

Out[11]: array([1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
    0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0])

In [12]: pred_wine_y_test_proba = cl1.predict_proba(wine_X_test)
pred_wine_y_test_proba[:10]

Out[12]: array([[6.67502815e-02, 9.33249719e-01],
    [9.99028518e-01, 9.71481719e-04],
    [9.98580105e-01, 1.41989547e-03],
    [9.99003483e-01, 9.96517066e-04],
    [9.88929037e-01, 1.10709626e-02],
    [4.53547396e-02, 9.54645260e-01],
    [9.54959671e-01, 4.50403288e-02],
    [9.98955423e-01, 1.04457706e-03],
    [7.08307657e-03, 9.92916923e-01],
    [9.68840217e-01, 3.11597833e-02]])

In [13]: # Вероятность принадлежности к 0 классу
[round(x, 4) for x in pred_wine_y_test_proba[:10,0]]

Out[13]: [0.0668, 0.999, 0.9986, 0.999, 0.9889, 0.0454, 0.955, 0.999, 0.0071, 0.9688]

In [14]: # Вероятность принадлежности к 1 классу
[round(x, 4) for x in pred_wine_y_test_proba[:10,1]]

Out[14]: [0.9332, 0.001, 0.0014, 0.001, 0.0111, 0.9546, 0.045, 0.001, 0.9929, 0.0312]

In [15]: # Сумма вероятностей равна 1
pred_wine_y_test_proba[:10,0] + pred_wine_y_test_proba[:10,1]

Out[15]: array([1., 1., 1., 1., 1., 1., 1., 1., 1., 1.])

In [16]: accuracy_score(wine_y_test, pred_wine_y_test)

Out[16]: 0.9722222222222222

```

Построение модели «SVC»:

```

In [19]: wine_X = wine.data[:, :2]
wine_y = wine.target

In [20]: def make_meshgrid(x, y, h=.02):
    """Create a mesh of points to plot in

    Parameters
    -----
    x: data to base x-axis meshgrid on
    y: data to base y-axis meshgrid on
    h: stepsize for meshgrid, optional

    Returns
    -----
    xx, yy : ndarray
    """
    x_min, x_max = x.min() - 1, x.max() + 1
    y_min, y_max = y.min() - 1, y.max() + 1
    xx, yy = np.meshgrid(np.arange(x_min, x_max, h),
        np.arange(y_min, y_max, h))
    return xx, yy

```

```
def plot_contours(ax, clf, xx, yy, **params):
    """Plot the decision boundaries for a classifier.

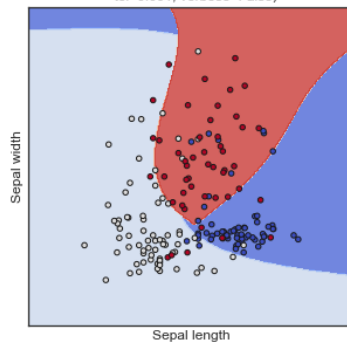
    Parameters
    -----
    ax: matplotlib axes object
    clf: a classifier
    xx: meshgrid ndarray
    yy: meshgrid ndarray
    params: dictionary of params to pass to contourf, optional
    """
    Z = clf.predict(np.c_[xx.ravel(), yy.ravel()])
    Z = Z.reshape(xx.shape)
    #Можно проверить все ли метки классов предсказываются
    #print(np.unique(Z))
    out = ax.contourf(xx, yy, Z, **params)
    return out

def plot_cl(clf):
    title = clf.__repr__
    clf.fit(wine_X, wine_y)
    fig, ax = plt.subplots(figsize=(5,5))
    X0, X1 = wine_X[:, 0], wine_X[:, 1]
    xx, yy = make_meshgrid(X0, X1)
    plot_contours(ax, clf, xx, yy, cmap=plt.cm.coolwarm, alpha=0.8)
    ax.scatter(X0, X1, c=wine_y, cmap=plt.cm.coolwarm, s=20, edgecolors='k')
    ax.set_xlim(xx.min(), xx.max())
    ax.set_ylim(yy.min(), yy.max())
    ax.set_xlabel('Sepal length')
    ax.set_ylabel('Sepal width')
    ax.set_xticks(())
    ax.set_yticks(())
    ax.set_title(title)
    plt.show()
```

```
In [21]: wine_X_train, wine_X_test, wine_y_train, wine_y_test = train_test_split(
        wine.data, wine.target, test_size=0.2, random_state=1)
```

```
In [22]: plot_cl(SVC(kernel='poly', degree=4, gamma=0.2, C=1.0))
```

```
<bound method BaseEstimator.__repr__ of SVC(C=1.0, break_ties=False, cache_size=200, class_weight=None, coef0=0.0,
      decision_function_shape='ovr', degree=4, gamma=0.2, kernel='poly',
      max_iter=1, probability=False, random_state=None, shrinking=True,
      tol=0.001, verbose=False)>
```



```
In [23]: svc = SVC(kernel='poly', degree=4, gamma=0.2, C=1.0).fit(wine_X_train, wine_y_train)
        target_svc = svc.predict(wine_X_test)
```

```
In [24]: accuracy_score(wine_y_test, target_svc)
```

```
Out[24]: 0.9444444444444444
```

Построение модели «Дерево решений»:

```
In [25]: def plot_tree_classification(title_param, ds):
    """
    Построение деревьев и вывод графиков для заданного датасета
    """

    n_classes = len(np.unique(ds.target))
    plot_colors = "ryb"
    plot_step = 0.02

    for pairidx, pair in enumerate([[0, 1], [0, 2], [0, 3],
                                     [1, 2], [1, 3], [2, 3]]):
        # We only take the two corresponding features
        X = ds.data[:, pair]
        y = ds.target

        # Train
        clf = DecisionTreeClassifier(random_state=1).fit(X, y)

        plt.title(title_param)
```

```

x_min, x_max = X[:, 0].min() - 1, X[:, 0].max() + 1
y_min, y_max = X[:, 1].min() - 1, X[:, 1].max() + 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, plot_step),
                     np.arange(y_min, y_max, plot_step))

plt.tight_layout(h_pad=0.5, w_pad=0.5, pad=2.5)

Z = clf.predict(np.c_[xx.ravel(), yy.ravel()])
Z = Z.reshape(xx.shape)
cs = plt.contourf(xx, yy, Z, cmap=plt.cm.RdYlBu)

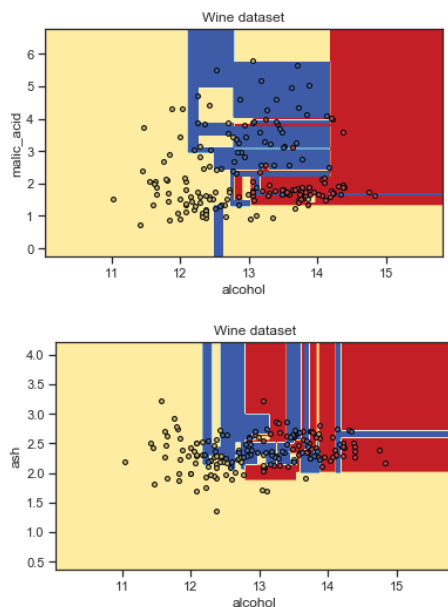
plt.xlabel(ds.feature_names[pair[0]])
plt.ylabel(ds.feature_names[pair[1]])

# Plot the training points
for i, color in zip(range(n_classes), plot_colors):
    idx = np.where(y == i)
    plt.scatter(X[idx, 0], X[idx, 1], c=color, label=ds.target_names[i],
                cmap=plt.cm.RdYlBu, edgecolor='black', s=15)

plt.show()

```

In [26]: `plot_tree_classification('Wine dataset', wine)`



In [27]: `wine_x_ds = pd.DataFrame(data=wine['data'], columns=wine['feature_names'])`
`wine_x_ds.head()`

Out[27]:

	alcohol	malic_acid	ash	alcalinity_of_ash	magnesium	total_phenols	flavanoids	nonflavanoid_phenols	proanthocyanins	color_intensity	hue	od280/od31
0	14.23	1.71	2.43	15.6	127.0	2.80	3.06	0.28	2.29	5.64	1.04	
1	13.20	1.78	2.14	11.2	100.0	2.65	2.76	0.26	1.28	4.38	1.05	
2	13.16	2.36	2.67	18.6	101.0	2.80	3.24	0.30	2.81	5.68	1.03	
3	14.37	1.95	2.50	16.8	113.0	3.85	3.49	0.24	2.18	7.80	0.86	
4	13.24	2.59	2.87	21.0	118.0	2.80	2.69	0.39	1.82	4.32	1.04	

In [28]: `# Обучим дерево на всех признаках wine`
`wine_tree_cl = DecisionTreeClassifier(random_state=1)`
`wine_tree_cl.fit(wine_x_ds, wine.target)`
`wine_tree_cl`

Out[28]: `DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None, criterion='gini',`
`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=1, splitter='best')`

```
In [29]: # Важность признаков
list(zip(wine_x_ds.columns.values, wine_tree_cl.feature_importances_))
```

```
Out[29]: [('alcohol', 0.012570564071187309),
 ('malic_acid', 0.014223159778821876),
 ('ash', 0.0),
 ('alkalinity_of_ash', 0.0),
 ('magnesium', 0.0534597951279922),
 ('total_phenols', 0.0),
 ('flavanoids', 0.16704836491408806),
 ('nonflavanoid_phenols', 0.0),
 ('proanthocyanins', 0.0),
 ('color_intensity', 0.0),
 ('hue', 0.058185091460406506),
 ('od280/od315_of_diluted_wines', 0.3120425747831769),
 ('proline', 0.38247044986432716)]
```

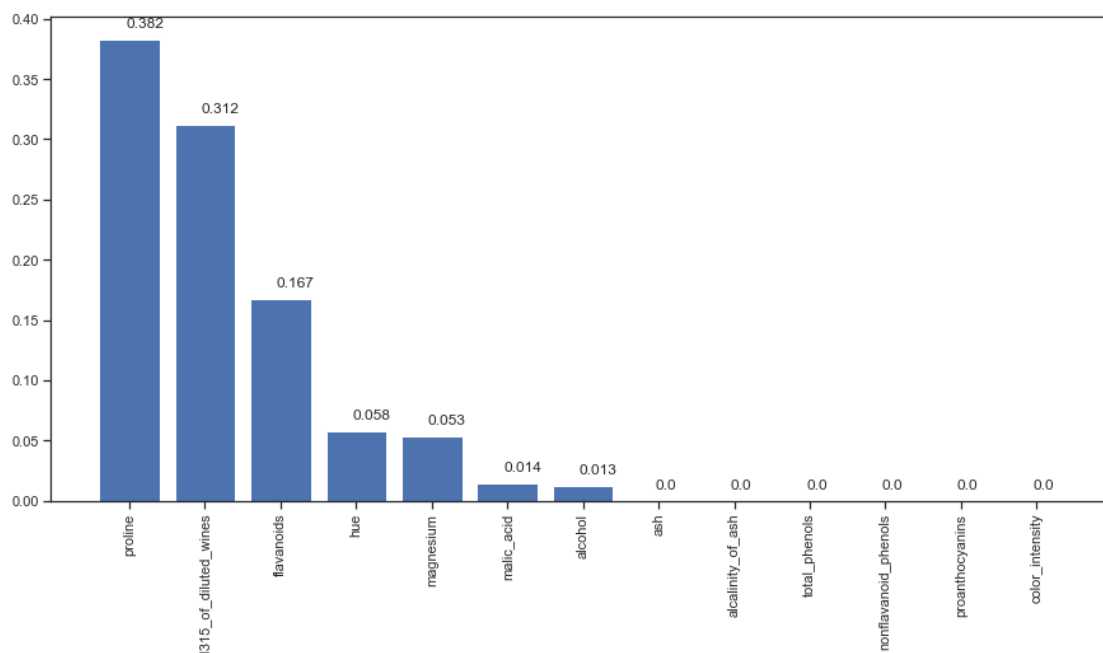
```
In [30]: # Важность признаков в сумме дает единицу
sum(wine_tree_cl.feature_importances_)
```

```
Out[30]: 1.0
```

```
In [31]: from operator import itemgetter
```

```
def draw_feature_importances(tree_model, X_dataset, figsize=(15,7)):
    """
    Вывод важности признаков в виде графика
    """
    # Сортировка значений важности признаков по убыванию
    list_to_sort = list(zip(X_dataset.columns.values, tree_model.feature_importances_))
    sorted_list = sorted(list_to_sort, key=itemgetter(1), reverse = True)
    # Названия признаков
    labels = [x for x,_ in sorted_list]
    # Важности признаков
    data = [x for _,x in sorted_list]
    # Вывод графика
    fig, ax = plt.subplots(figsize=figsize)
    ind = np.arange(len(labels))
    plt.bar(ind, data)
    plt.xticks(ind, labels, rotation='vertical')
    # Вывод значений
    for a,b in zip(ind, data):
        plt.text(a-0.05, b+0.01, str(round(b,3)))
    plt.show()
    return labels, data
```

```
In [32]: wine_tree_cl_fl, wine_tree_cl_fd = draw_feature_importances(wine_tree_cl, wine_x_ds)
```



```
In [33]: # Список признаков, отсортированный на основе важности, и значения важности
wine_tree_cl_fl, wine_tree_cl_fd
```

```
Out[33]: (['proline',
'od280/od315_of_diluted_wines',
'flavanoids',
'hue',
'magnesium',
'malic_acid',
'alcohol',
'ash',
'alcalinity_of_ash',
'total_phenols',
'nonflavanoid_phenols',
'proanthocyanins',
'color_intensity'],
[0.38247044986432716,
0.3120425747831769,
0.16704836491408806,
0.058185091460406506,
0.0534597951279922,
0.014223159778821876,
0.012570564071187309,
0.0,
0.0,
0.0,
0.0,
0.0,
0.0])
```

```
In [34]: wine_x_ds.head()
```

```
Out[34]:
```

	alcohol	malic_acid	ash	alcalinity_of_ash	magnesium	total_phenols	flavanoids	nonflavanoid_phenols	proanthocyanins	color_intensity	hue	od280/od31
0	14.23	1.71	2.43		15.6	127.0	2.80	3.06		0.28	2.29	5.64 1.04
1	13.20	1.78	2.14		11.2	100.0	2.65	2.76		0.26	1.28	4.38 1.05
2	13.16	2.36	2.67		18.6	101.0	2.80	3.24		0.30	2.81	5.68 1.03
3	14.37	1.95	2.50		16.8	113.0	3.85	3.49		0.24	2.18	7.80 0.86
4	13.24	2.59	2.87		21.0	118.0	2.80	2.69		0.39	1.82	4.32 1.04

```
In [35]: # Пересортируем признаки на основе важности
wine_x_ds_sorted = wine_x_ds[wine_tree_cl_fl]
wine_x_ds_sorted.head()
```

```
Out[35]:
```

	proline	od280/od315_of_diluted_wines	flavanoids	hue	magnesium	malic_acid	alcohol	ash	alcalinity_of_ash	total_phenols	nonflavanoid_phenols	proar
0	1065.0		3.92	3.06 1.04	127.0	1.71	14.23 2.43		15.6	2.80		0.28
1	1050.0		3.40	2.76 1.05	100.0	1.78	13.20 2.14		11.2	2.65		0.26
2	1185.0		3.17	3.24 1.03	101.0	2.36	13.16 2.67		18.6	2.80		0.30
3	1480.0		3.45	3.49 0.86	113.0	1.95	14.37 2.50		16.8	3.85		0.24
4	735.0		2.93	2.69 1.04	118.0	2.59	13.24 2.87		21.0	2.80		0.39

```
In [36]: # Разделим выборку на обучающую и тестовую
wine_X_train, wine_X_test, wine_y_train, wine_y_test = train_test_split(
    wine_x_ds_sorted, wine.target, test_size=0.5, random_state=1)
wine_X_train.shape, wine_X_test.shape
```

```
Out[36]: ((89, 13), (89, 13))
```

```
In [37]: # Обучим дерево и предскажем результаты на всех признаках
wine_tree_cl_feat_1 = DecisionTreeClassifier(random_state=1).fit(wine_X_train, wine_y_train)
wine_y_test_predict = wine_tree_cl_feat_1.predict(wine_X_test)
wine_y_test_predict.shape
```

```
Out[37]: (89,)
```

```
In [38]: # Проверим точность по классам
print_accuracy_score_for_classes(wine_y_test, wine_y_test_predict)
```

Метка	Accuracy
0	0.9393939393939394
1	0.8529411764705882
2	0.9545454545454546

Таким образом, показатели метрики Ассигасу говорят о высоком качестве всех построенных моделей.