# Линейные модели, SVM и деревья решений

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:
   1. одну из линейных моделей (линейную или полиномиальную регрессию при решении задачи регрессии, логистическую регрессию при решении задачи классификации);
   2. SVM;
   3. дерево решений.
5. Оцените качество моделей с помощью двух подходящих для задачи метрик. Сравните качество полученных моделей.
6. Постройте график, показывающий важность признаков в дереве решений.
7. Визуализируйте дерево решений или выведите правила дерева решений в текстовом виде.

## Ход работы

### Выбор и загрузка датасета

# %matplotlib inline  
# sns.set(style="ticks")  
  
import pandas as pd  
import numpy as np  
import seaborn as sns  
import matplotlib.pyplot as plt  
from sklearn.datasets import \*  
from sklearn.preprocessing import MinMaxScaler  
from sklearn.model\_selection import train\_test\_split  
from sklearn.linear\_model import LogisticRegression  
from sklearn import svm, tree  
from sklearn.tree import DecisionTreeClassifier  
from sklearn.metrics import accuracy\_score  
from sklearn.metrics import confusion\_matrix, ConfusionMatrixDisplay  
from operator import itemgetter  
  
def make\_dataframe(ds\_function):  
 ds = ds\_function()  
 df = pd.DataFrame(data= np.c\_[ds['data'], ds['target']],  
 columns= list(ds['feature\_names']) + ['target'])  
 return df  
  
wine = load\_wine()  
  
df = make\_dataframe(load\_wine)

# Первые 5 строк датасета  
df.head()

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   
  
 flavanoids nonflavanoid\_phenols proanthocyanins color\_intensity hue   
0 3.06 0.28 2.29 5.64 1.04 \  
1 2.76 0.26 1.28 4.38 1.05   
2 3.24 0.30 2.81 5.68 1.03   
3 3.49 0.24 2.18 7.80 0.86   
4 2.69 0.39 1.82 4.32 1.04   
  
 od280/od315\_of\_diluted\_wines proline target   
0 3.92 1065.0 0.0   
1 3.40 1050.0 0.0   
2 3.17 1185.0 0.0   
3 3.45 1480.0 0.0   
4 2.93 735.0 0.0

df.dtypes

alcohol float64  
malic\_acid float64  
ash float64  
alcalinity\_of\_ash float64  
magnesium float64  
total\_phenols float64  
flavanoids float64  
nonflavanoid\_phenols float64  
proanthocyanins float64  
color\_intensity float64  
hue float64  
od280/od315\_of\_diluted\_wines float64  
proline float64  
target float64  
dtype: object

# Проверим наличие пустых значений  
# Цикл по колонкам датасета  
for col in df.columns:  
 # Количество пустых значений - все значения заполнены  
 temp\_null\_count = df[df[col].isnull()].shape[0]  
 print('{} - {}'.format(col, temp\_null\_count))

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

### Разделение на тестовую и обучающую выборки

y = df['target']  
x = df.drop('target', axis = 1)  
  
scaler = MinMaxScaler()  
scaled\_data = scaler.fit\_transform(x)  
  
x\_train, x\_test, y\_train, y\_test = train\_test\_split(scaled\_data, y, test\_size = 0.4, random\_state = 0)  
  
print(f"Обучающая выборка:\n{x\_train, y\_train}")  
print(f"Тестовая выборка:\n{x\_test, y\_test}")

Обучающая выборка:  
(array([[0.58157895, 0.64031621, 0.4973262 , ..., 0.27642276, 0.63369963,  
 0.28673324],  
 [0.80789474, 0.28063241, 0.5026738 , ..., 0.62601626, 0.6959707 ,  
 0.87874465],  
 [0.15263158, 0.12055336, 0.71657754, ..., 0.3902439 , 0.72893773,  
 0.28673324],  
 ...,  
 [0.36578947, 0.17193676, 0.44385027, ..., 0.47154472, 0.61904762,  
 0.04778887],  
 [0.75526316, 0.18577075, 0.40641711, ..., 0.3495935 , 0.75457875,  
 0.5042796 ],  
 [0.82368421, 0.34980237, 0.59893048, ..., 0.11382114, 0.16117216,  
 0.2724679 ]]), 43 0.0  
10 0.0  
109 1.0  
73 1.0  
171 2.0  
 ...   
103 1.0  
67 1.0  
117 1.0  
47 0.0  
172 2.0  
Name: target, Length: 106, dtype: float64)  
Тестовая выборка:  
(array([[0.71315789, 0.18379447, 0.47593583, 0.29896907, 0.52173913,  
 0.55862069, 0.54008439, 0.1509434 , 0.38170347, 0.38993174,  
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 0. , 0.07326007, 0.14407989],  
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 0.17886179, 0.31135531, 0.06704708],  
 [0.50789474, 0.53557312, 0.52941176, 0.40721649, 0.39130435,  
 0.14137931, 0.07594937, 0.50943396, 0.16719243, 0.34129693,  
 0.16260163, 0.17582418, 0.2831669 ],  
 [0.69473684, 0.10079051, 0.29946524, 0.3814433 , 0.26086957,  
 0.3862069 , 0.30590717, 0.35849057, 0.10094637, 0.21501706,  
 0.6097561 , 0.43589744, 0.2510699 ],  
 [0.56052632, 0.3201581 , 0.70053476, 0.41237113, 0.33695652,  
 0.62758621, 0.61181435, 0.32075472, 0.75709779, 0.37542662,  
 0.44715447, 0.6959707 , 0.64693295],  
 [0.35263158, 0.03952569, 0. , 0. , 0.19565217,  
 0.34482759, 0.04852321, 0.28301887, 0.00315457, 0.05716724,  
 0.46341463, 0.2014652 , 0.17261056],  
 [0.37894737, 0.1541502 , 0.44919786, 0.43298969, 1. ,  
 0.52413793, 0.407173 , 0.35849057, 0.90536278, 0.11262799,  
 0.55284553, 0.4981685 , 0.4700428 ],  
 [0.20526316, 0.27272727, 0.73796791, 0.56185567, 0.69565217,  
 0.2137931 , 0.1371308 , 0.01886792, 0.36277603, 0.10409556,  
 0.38211382, 0.36263736, 0.24750357]]), 54 0.0  
151 2.0  
63 1.0  
55 0.0  
123 1.0  
 ...   
62 1.0  
2 0.0  
59 1.0  
95 1.0  
96 1.0  
Name: target, Length: 72, dtype: float64)

### Логическая регрессия

lr = LogisticRegression(random\_state=0)  
lr\_prediction = lr.fit(x\_train, y\_train).predict(x\_test)

### SVM

svc = svm.SVC(random\_state=0)  
svc\_prediction = svc.fit(x\_train, y\_train).predict(x\_test)

### Дерево решений

dt = DecisionTreeClassifier(random\_state=0)  
dt\_prediction = dt.fit(x\_train, y\_train).predict(x\_test)

### Оценка качества решений

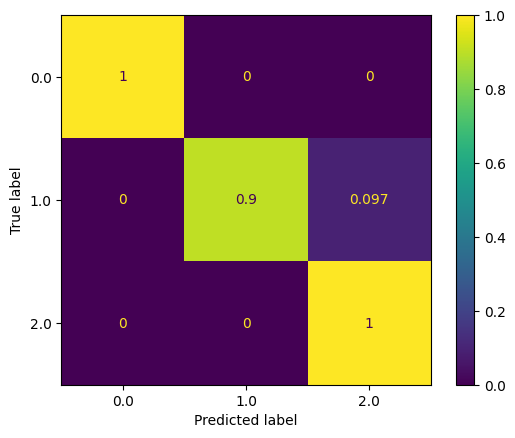
print("Logistic regression: ", accuracy\_score(y\_test, lr\_prediction))  
print("SVM: ", accuracy\_score(y\_test, svc\_prediction))  
print("Decision tree: ", accuracy\_score(y\_test, dt\_prediction))

Logistic regression: 0.9583333333333334  
SVM: 0.9722222222222222  
Decision tree: 0.9166666666666666

print("Logistic regression: ", accuracy\_score(y\_test, lr\_prediction))  
  
cm = confusion\_matrix(y\_test, lr\_prediction, labels=np.unique(df.target), normalize='true')  
disp = ConfusionMatrixDisplay(confusion\_matrix=cm, display\_labels=np.unique(df.target))  
disp.plot()

Logistic regression: 0.9583333333333334

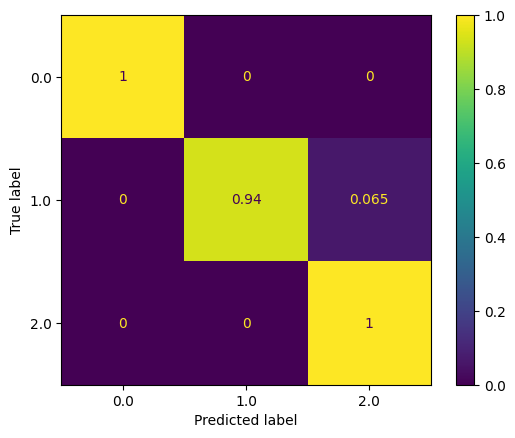
<sklearn.metrics.\_plot.confusion\_matrix.ConfusionMatrixDisplay at 0x7fd15177dd90>



print("SVM: ", accuracy\_score(y\_test, svc\_prediction))  
  
cm = confusion\_matrix(y\_test, svc\_prediction, labels=np.unique(df.target), normalize='true')  
disp = ConfusionMatrixDisplay(confusion\_matrix=cm, display\_labels=np.unique(df.target))  
disp.plot()

SVM: 0.9722222222222222

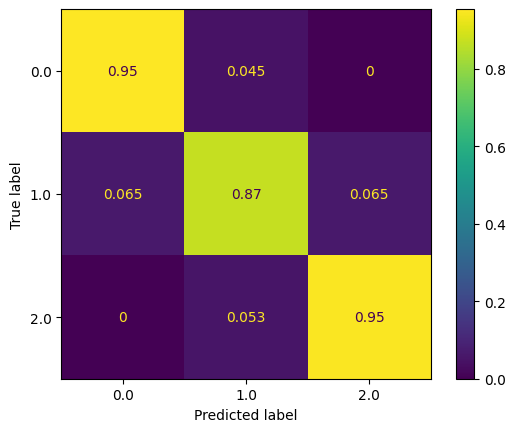
<sklearn.metrics.\_plot.confusion\_matrix.ConfusionMatrixDisplay at 0x7fd132dae8e0>



print("Decision tree: ", accuracy\_score(y\_test, dt\_prediction))  
  
cm = confusion\_matrix(y\_test, dt\_prediction, labels=np.unique(df.target), normalize='true')  
disp = ConfusionMatrixDisplay(confusion\_matrix=cm, display\_labels=np.unique(df.target))  
disp.plot()

Decision tree: 0.9166666666666666

<sklearn.metrics.\_plot.confusion\_matrix.ConfusionMatrixDisplay at 0x7fd132dae820>



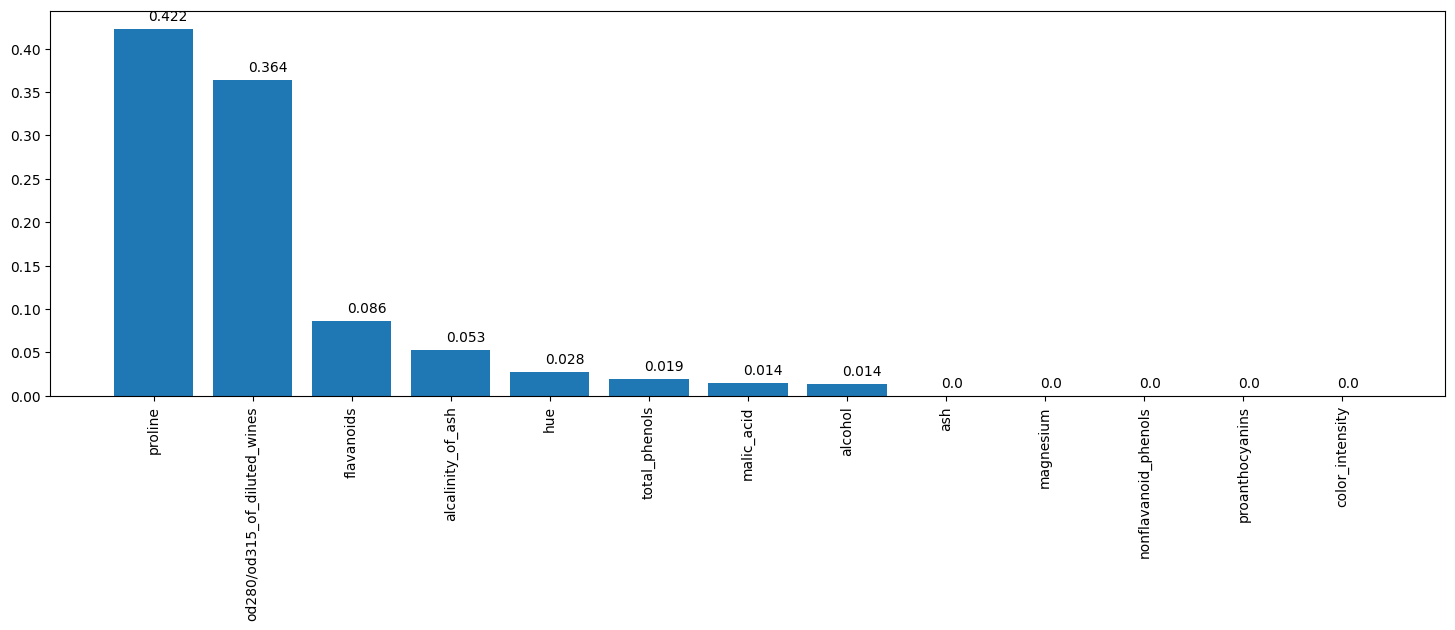
### Важность признаков

list(zip(x.columns.values, dt.feature\_importances\_))

[('alcohol', 0.013502594973104024),  
 ('malic\_acid', 0.014274171828709938),  
 ('ash', 0.0),  
 ('alcalinity\_of\_ash', 0.053018352506636925),  
 ('magnesium', 0.0),  
 ('total\_phenols', 0.019032229104946584),  
 ('flavanoids', 0.0858859795341857),  
 ('nonflavanoid\_phenols', 0.0),  
 ('proanthocyanins', 0.0),  
 ('color\_intensity', 0.0),  
 ('hue', 0.02777676680181396),  
 ('od280/od315\_of\_diluted\_wines', 0.36405154845343657),  
 ('proline', 0.4224583567971662)]

def draw\_feature\_importances(tree\_model, X\_dataset, figsize=(18,5)):  
 # Sorting the values of the importance of features in descending order  
 list\_to\_sort = list(zip(X\_dataset.columns.values, tree\_model.feature\_importances\_))  
 sorted\_list = sorted(list\_to\_sort, key=itemgetter(1), reverse = True)  
 # Features names  
 labels = [x for x,\_ in sorted\_list]  
 # Features importance  
 data = [x for \_,x in sorted\_list]  
 # Graph output  
 fig, ax = plt.subplots(figsize=figsize)  
 ind = np.arange(len(labels))  
 plt.bar(ind, data)  
 plt.xticks(ind, labels, rotation='vertical')  
 # Values output  
 for a,b in zip(ind, data):  
 plt.text(a-0.05, b+0.01, str(round(b,3)))  
 plt.show()  
 return labels, data

dt\_fl, dt\_fd = draw\_feature\_importances(dt, x)



### Визуализация дерева решений

tree.plot\_tree(dt)

[Text(0.5, 0.9166666666666666, 'x[12] <= 0.34\ngini = 0.661\nsamples = 106\nvalue = [37, 40, 29]'),  
 Text(0.25, 0.75, 'x[11] <= 0.337\ngini = 0.501\nsamples = 66\nvalue = [1, 38, 27]'),  
 Text(0.125, 0.5833333333333334, 'x[3] <= 0.356\ngini = 0.133\nsamples = 28\nvalue = [0, 2, 26]'),  
 Text(0.0625, 0.4166666666666667, 'gini = 0.0\nsamples = 2\nvalue = [0, 2, 0]'),  
 Text(0.1875, 0.4166666666666667, 'gini = 0.0\nsamples = 26\nvalue = [0, 0, 26]'),  
 Text(0.375, 0.5833333333333334, 'x[6] <= 0.113\ngini = 0.101\nsamples = 38\nvalue = [1, 36, 1]'),  
 Text(0.3125, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue = [0, 0, 1]'),  
 Text(0.4375, 0.4166666666666667, 'x[0] <= 0.554\ngini = 0.053\nsamples = 37\nvalue = [1, 36, 0]'),  
 Text(0.375, 0.25, 'gini = 0.0\nsamples = 35\nvalue = [0, 35, 0]'),  
 Text(0.5, 0.25, 'x[1] <= 0.411\ngini = 0.5\nsamples = 2\nvalue = [1, 1, 0]'),  
 Text(0.4375, 0.08333333333333333, 'gini = 0.0\nsamples = 1\nvalue = [0, 1, 0]'),  
 Text(0.5625, 0.08333333333333333, 'gini = 0.0\nsamples = 1\nvalue = [1, 0, 0]'),  
 Text(0.75, 0.75, 'x[6] <= 0.282\ngini = 0.185\nsamples = 40\nvalue = [36, 2, 2]'),  
 Text(0.625, 0.5833333333333334, 'x[5] <= 0.136\ngini = 0.444\nsamples = 3\nvalue = [0, 1, 2]'),  
 Text(0.5625, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue = [0, 1, 0]'),  
 Text(0.6875, 0.4166666666666667, 'gini = 0.0\nsamples = 2\nvalue = [0, 0, 2]'),  
 Text(0.875, 0.5833333333333334, 'x[10] <= 0.663\ngini = 0.053\nsamples = 37\nvalue = [36, 1, 0]'),  
 Text(0.8125, 0.4166666666666667, 'gini = 0.0\nsamples = 36\nvalue = [36, 0, 0]'),  
 Text(0.9375, 0.4166666666666667, 'gini = 0.0\nsamples = 1\nvalue = [0, 1, 0]')]

