

Lecture 14

June 1, 2023

1 Naive Bayes

1.1 Import necessary libraries

```
[1]: import pandas as pd
import numpy as np
```

1.2 Import dataset

```
[2]: data = pd.read_csv("house-votes-84.csv")
```

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

```
[3]: Class Name handicapped-infants water-project-cost-sharing \
0 republican          n          y
1 republican          n          y
2 democrat           ?          y
3 democrat          n          y
4 democrat          y          y

adoption-of-the-budget-resolution physician-fee-freeze el-salvador-aid \
0          n          y          y
1          n          y          y
2          y          ?          y
3          y          n          ?
4          y          n          y

religious-groups-in-schools anti-satellite-test-ban \
0          y          n
1          y          n
2          y          n
3          y          n
4          y          n

aid-to-nicaraguan-contras mx-missile immigration \
0          n          n          y
1          n          n          n
2          n          n          n
```

3		n	n	n
4		n	n	n

	synfuels-corporation-cutback	education-spending	superfund-right-to-sue	\
0	?		y	y
1	n		y	y
2	y		n	y
3	y		n	y
4	y		?	y

	crime	duty-free-exports	export-administration-act-south-africa
0	y	n	y
1	y	n	?
2	y	n	n
3	n	n	y
4	y	y	y

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 435 entries, 0 to 434
Data columns (total 17 columns):
#   Column                                Non-Null Count  Dtype
---  -
0   Class Name                           435 non-null    object
1   handicapped-infants                  435 non-null    object
2   water-project-cost-sharing           435 non-null    object
3   adoption-of-the-budget-resolution    435 non-null    object
4   physician-fee-freeze                 435 non-null    object
5   el-salvador-aid                     435 non-null    object
6   religious-groups-in-schools          435 non-null    object
7   anti-satellite-test-ban             435 non-null    object
8   aid-to-nicaraguan-contras           435 non-null    object
9   mx-missile                           435 non-null    object
10  immigration                           435 non-null    object
11  synfuels-corporation-cutback          435 non-null    object
12  education-spending                   435 non-null    object
13  superfund-right-to-sue               435 non-null    object
14  crime                                435 non-null    object
15  duty-free-exports                    435 non-null    object
16  export-administration-act-south-africa 435 non-null    object
dtypes: object(17)
memory usage: 57.9+ KB
```

```
[5]: data.shape
```

```
[5]: (435, 17)
```

```
[6]: data.isnull().sum()
```

```
[6]: Class Name      0
handicapped-infants  0
water-project-cost-sharing  0
adoption-of-the-budget-resolution  0
physician-fee-freeze  0
el-salvador-aid      0
religious-groups-in-schools  0
anti-satellite-test-ban  0
aid-to-nicaraguan-contras  0
mx-missile            0
immigration           0
synfuels-corporation-cutback  0
education-spending   0
superfund-right-to-sue  0
crime                 0
duty-free-exports     0
export-administration-act-south-africa  0
dtype: int64
```

1.3 Split into dependent and independent variable

```
[7]: x = data.iloc[:, 1:]
y = data.iloc[:, 0]
```

```
[8]: x.head()
```

```
[8]:  handicapped-infants  water-project-cost-sharing  \
0                n                y
1                n                y
2                ?                y
3                n                y
4                y                y

    adoption-of-the-budget-resolution  physician-fee-freeze  el-salvador-aid  \
0                n                y                y
1                n                y                y
2                y                ?                y
3                y                n                ?
4                y                n                y

    religious-groups-in-schools  anti-satellite-test-ban  \
0                y                n
1                y                n
2                y                n
3                y                n
```

4		y		n
---	--	---	--	---

	aid-to-nicaraguan-contras	mx-missile	immigration	\
0	n	n	y	
1	n	n	n	
2	n	n	n	
3	n	n	n	
4	n	n	n	

	synfuels-corporation-cutback	education-spending	superfund-right-to-sue	\
0	?	y	y	
1	n	y	y	
2	y	n	y	
3	y	n	y	
4	y	?	y	

	crime	duty-free-exports	export-administration-act-south-africa
0	y	n	y
1	y	n	?
2	y	n	n
3	n	n	y
4	y	y	y

```
[9]: y.head()
```

```
[9]: 0    republican
      1    republican
      2    democrat
      3    democrat
      4    democrat
      Name: Class Name, dtype: object
```

```
[10]: names = x.columns
      names
```

```
[10]: Index(['handicapped-infants', 'water-project-cost-sharing',
            'adoption-of-the-budget-resolution', 'physician-fee-freeze',
            'el-salvador-aid', 'religious-groups-in-schools',
            'anti-satellite-test-ban', 'aid-to-nicaraguan-contras', 'mx-missile',
            'immigration', 'synfuels-corporation-cutback', 'education-spending',
            'superfund-right-to-sue', 'crime', 'duty-free-exports',
            'export-administration-act-south-africa'],
            dtype='object')
```

1.4 Manual Encoding

```
[11]: x = np.where(x=='y', 1, x)
      x = np.where(x=='n', 0, x)
      x = np.where(x=='?', 1, x)
```

```
[12]: x
```

```
[12]: array([[0, 1, 0, ..., 1, 0, 1],
            [0, 1, 0, ..., 1, 0, 1],
            [1, 1, 1, ..., 1, 0, 0],
            ...,
            [0, 1, 0, ..., 1, 0, 1],
            [0, 0, 0, ..., 1, 0, 1],
            [0, 1, 0, ..., 1, 1, 0]], dtype=object)
```

```
[13]: x = pd.DataFrame(x, columns=names)
```

```
[14]: x.head()
```

```
[14]: handicapped-infants water-project-cost-sharing \
0          0          1
1          0          1
2          1          1
3          0          1
4          1          1

adoption-of-the-budget-resolution physician-fee-freeze el-salvador-aid \
0          0          1          1
1          0          1          1
2          1          1          1
3          1          0          1
4          1          0          1

religious-groups-in-schools anti-satellite-test-ban \
0          1          0
1          1          0
2          1          0
3          1          0
4          1          0

aid-to-nicaraguan-contras mx-missile immigration \
0          0          0          1
1          0          0          0
2          0          0          0
3          0          0          0
4          0          0          0
```

	synfuels-corporation-cutback	education-spending	superfund-right-to-sue	\
0	1	1	1	
1	0	1	1	
2	1	0	1	
3	1	0	1	
4	1	1	1	

	crime	duty-free-exports	export-administration-act-south-africa
0	1	0	1
1	1	0	1
2	1	0	0
3	0	0	1
4	1	1	1

```
[15]: x.describe()
```

```
[15]:      handicapped-infants  water-project-cost-sharing  \
count                435                435
unique                 2                 2
top                   0                 1
freq                 236                243
```

	adoption-of-the-budget-resolution	physician-fee-freeze	\
count	435	435	
unique	2	2	
top	1	0	
freq	264	247	

	el-salvador-aid	religious-groups-in-schools	anti-satellite-test-ban	\
count	435	435	435	
unique	2	2	2	
top	1	1	1	
freq	227	283	253	

	aid-to-nicaraguan-contras	mx-missile	immigration	\
count	435	435	435	
unique	2	2	2	
top	1	1	1	
freq	257	229	223	

	synfuels-corporation-cutback	education-spending	\
count	435	435	
unique	2	2	
top	0	0	
freq	264	233	

	superfund-right-to-sue	crime	duty-free-exports	\
--	------------------------	-------	-------------------	---

count	435	435	435
unique	2	2	2
top	1	1	0
freq	234	265	233

export-administration-act-south-africa	
count	435
unique	2
top	1
freq	373

1.5 Split into training and testing dataset

```
[16]: from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size = 0.2,
↪random_state=0)
```

```
[17]: x_train
```

```
[17]:      handicapped-infants  water-project-cost-sharing  \
4                        1                        1
231                      0                        1
219                      0                        1
387                      1                        1
332                      1                        0
..                      ...                      ...
323                      1                        1
192                      0                        0
117                      1                        1
47                       1                        0
172                     0                        1
```

	adoption-of-the-budget-resolution	physician-fee-freeze	el-salvador-aid	\
4	1	0	1	
231	0	1	1	
219	1	0	0	
387	1	0	1	
332	1	0	0	
..	
323	1	0	1	
192	0	0	0	
117	1	1	1	
47	1	0	0	
172	1	0	0	

	religious-groups-in-schools	anti-satellite-test-ban	\
4	1	0	

231	1	0
219	0	0
387	1	0
332	0	1
..
323	1	0
192	1	1
117	0	1
47	0	1
172	0	1

	aid-to-nicaraguan-contras	mx-missile	immigration	\
4	0	0	0	
231	0	1	1	
219	1	1	0	
387	1	1	0	
332	1	1	0	
..	
323	1	1	1	
192	1	1	0	
117	0	0	0	
47	1	1	0	
172	1	1	1	

	synfuels-corporation-cutback	education-spending	superfund-right-to-sue	\
4	1	1	1	
231	0	1	1	
219	1	0	0	
387	1	0	0	
332	1	0	0	
..	
323	0	0	1	
192	1	0	0	
117	0	1	1	
47	0	0	0	
172	0	0	1	

	crime	duty-free-exports	export-administration-act-south-africa
4	1	1	1
231	1	0	1
219	1	1	1
387	1	0	1
332	0	1	1
..
323	1	0	1
192	1	1	1
117	1	0	1

47	0	0	1
172	0	1	1

[348 rows x 16 columns]

[18]: x_test

```
[18]:      handicapped-infants water-project-cost-sharing \
153          0          0
264          1          0
54           1          1
355          1          0
428          1          1
..          ...          ...
52           1          1
74           1          0
26           1          0
45           1          1
272          1          0

      adoption-of-the-budget-resolution physician-fee-freeze el-salvador-aid \
153          1          0          0
264          1          0          0
54           1          0          0
355          1          1          0
428          1          0          0
..          ...          ...          ...
52           1          0          0
74           1          0          0
26           1          0          0
45           1          0          0
272          1          0          0

      religious-groups-in-schools anti-satellite-test-ban \
153          1          1
264          0          1
54           1          1
355          0          0
428          0          1
..          ...          ...
52           0          1
74           1          1
26           0          1
45           0          1
272          0          1

      aid-to-nicaraguan-contras mx-missile immigration \
```

153	1	1	1
264	1	1	0
54	1	0	0
355	1	1	1
428	1	1	1
..
52	1	1	0
74	1	1	1
26	1	1	0
45	1	1	0
272	1	1	1

	synfuels-corporation-cutback	education-spending	superfund-right-to-sue	\
153	1	0	1	
264	0	0	0	
54	1	1	0	
355	0	0	0	
428	0	0	1	
..	
52	0	0	0	
74	1	0	0	
26	1	0	0	
45	1	0	0	
272	0	0	0	

	crime	duty-free-exports	export-administration-act-south-africa
153	1	0	1
264	0	1	1
54	1	0	1
355	1	1	1
428	0	1	1
..
52	0	1	1
74	1	1	1
26	0	1	1
45	0	1	1
272	0	1	1

[87 rows x 16 columns]

```
[19]: y_train
```

```
[19]: 4      democrat
      231    republican
      219    democrat
      387    democrat
      332    democrat
```

```

...
323     democrat
192     democrat
117    republican
47     democrat
172     democrat
Name: Class Name, Length: 348, dtype: object

```

```
[20]: y_test
```

```

[20]: 153     democrat
      264     democrat
      54     democrat
      355    republican
      428     democrat
...
      52     democrat
      74     democrat
      26     democrat
      45     democrat
      272     democrat
Name: Class Name, Length: 87, dtype: object

```

1.6 Building Model

```
[21]: from sklearn.naive_bayes import GaussianNB
      nb = GaussianNB()
```

```
[22]: nb.fit(x_train, y_train)
```

```
[22]: GaussianNB()
```

```
[23]: y_pred = nb.predict(x_test)
      y_pred
```

```

[23]: array(['democrat', 'democrat', 'democrat', 'democrat', 'democrat',
            'democrat', 'democrat', 'republican', 'republican', 'republican',
            'republican', 'democrat', 'democrat', 'democrat', 'republican',
            'republican', 'republican', 'democrat', 'democrat', 'republican',
            'democrat', 'democrat', 'republican', 'democrat', 'democrat',
            'democrat', 'republican', 'democrat', 'republican', 'democrat',
            'republican', 'democrat', 'democrat', 'democrat', 'republican',
            'democrat', 'republican', 'democrat', 'democrat', 'democrat',
            'republican', 'democrat', 'democrat', 'democrat', 'republican',
            'republican', 'democrat', 'democrat', 'republican', 'democrat',
            'republican', 'democrat', 'democrat', 'democrat', 'republican',
            'democrat', 'republican', 'democrat', 'democrat', 'republican',

```

```
'democrat', 'democrat', 'republican', 'democrat', 'democrat',
'democrat', 'republican', 'democrat', 'republican', 'republican',
'republican', 'democrat', 'republican', 'republican', 'republican',
'republican', 'democrat', 'republican', 'democrat', 'democrat',
'republican', 'republican', 'democrat', 'democrat', 'democrat',
'democrat', 'democrat'], dtype='<U10')
```

1.7 Model evaluation by using different metrics

```
[24]: from sklearn.metrics import classification_report, accuracy_score, \
      ↪confusion_matrix
```

1.7.1 Accuracy score

```
[25]: accuracy_score(y_test, y_pred)
```

```
[25]: 0.9655172413793104
```

1.7.2 Classification report

```
[26]: classification_report(y_test, y_pred)
```

```
[26]: '          precision    recall  f1-score   support\n\n democrat
0.96      0.98      0.97         52\n republican      0.97      0.94      0.96
35\n\n accuracy              0.97      87\n macro avg
0.97      0.96      0.96      87\n weighted avg      0.97      0.97      0.97
87\n'
```

1.7.3 Confusion matrix

```
[27]: confusion_matrix(y_test, y_pred)
```

```
[27]: array([[51,  1],
           [ 2, 33]])
```

2 SVM - Support Vector Machine

2.1 Import necessary libraries

```
[28]: import pandas as pd
      import numpy as np
```

2.2 Import dataset

```
[29]: data = pd.read_csv("Iris.csv")
```

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

```
[30]:
```

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
0	1	5.1	3.5	1.4	0.2	Iris-setosa
1	2	4.9	3.0	1.4	0.2	Iris-setosa
2	3	4.7	3.2	1.3	0.2	Iris-setosa
3	4	4.6	3.1	1.5	0.2	Iris-setosa
4	5	5.0	3.6	1.4	0.2	Iris-setosa

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 150 entries, 0 to 149
Data columns (total 6 columns):
#   Column                Non-Null Count  Dtype
---  -
0   Id                    150 non-null    int64
1   SepalLengthCm         150 non-null    float64
2   SepalWidthCm          150 non-null    float64
3   PetalLengthCm         150 non-null    float64
4   PetalWidthCm          150 non-null    float64
5   Species               150 non-null    object
dtypes: float64(4), int64(1), object(1)
memory usage: 7.2+ KB
```

```
[38]: data.Species.unique()
```

```
[38]: array(['Iris-setosa', 'Iris-versicolor', 'Iris-virginica'], dtype=object)
```

```
[39]: data.Species.value_counts()
```

```
[39]: Iris-setosa      50
      Iris-versicolor  50
      Iris-virginica  50
      Name: Species, dtype: int64
```

```
[40]: data.describe()
```

```
[40]:
```

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm
count	150.000000	150.000000	150.000000	150.000000	150.000000
mean	75.500000	5.843333	3.054000	3.758667	1.198667
std	43.445368	0.828066	0.433594	1.764420	0.763161
min	1.000000	4.300000	2.000000	1.000000	0.100000
25%	38.250000	5.100000	2.800000	1.600000	0.300000
50%	75.500000	5.800000	3.000000	4.350000	1.300000
75%	112.750000	6.400000	3.300000	5.100000	1.800000
max	150.000000	7.900000	4.400000	6.900000	2.500000

```
[32]: data.shape
```

```
[32]: (150, 6)
```

```
[33]: data.isnull().sum()
```

```
[33]: Id                0
      SepalLengthCm    0
      SepalWidthCm     0
      PetalLengthCm    0
      PetalWidthCm     0
      Species          0
      dtype: int64
```

```
[42]: data.drop(columns=['Id'], inplace=True)
```

```
[43]: data
```

```
[43]:
```

	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
0	5.1	3.5	1.4	0.2	Iris-setosa
1	4.9	3.0	1.4	0.2	Iris-setosa
2	4.7	3.2	1.3	0.2	Iris-setosa
3	4.6	3.1	1.5	0.2	Iris-setosa
4	5.0	3.6	1.4	0.2	Iris-setosa
..
145	6.7	3.0	5.2	2.3	Iris-virginica
146	6.3	2.5	5.0	1.9	Iris-virginica
147	6.5	3.0	5.2	2.0	Iris-virginica
148	6.2	3.4	5.4	2.3	Iris-virginica
149	5.9	3.0	5.1	1.8	Iris-virginica

```
[150 rows x 5 columns]
```

2.3 Split into dependent and independent variable

```
[47]: x = data.iloc[:, 0:4]
      y = data.iloc[:, 4]
```

```
[48]: x.head()
```

```
[48]:
```

	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm
0	5.1	3.5	1.4	0.2
1	4.9	3.0	1.4	0.2
2	4.7	3.2	1.3	0.2
3	4.6	3.1	1.5	0.2
4	5.0	3.6	1.4	0.2

```
[49]: y.head()
```

```
[49]: 0    Iris-setosa
      1    Iris-setosa
      2    Iris-setosa
      3    Iris-setosa
      4    Iris-setosa
      Name: Species, dtype: object
```

```
[50]: names = x.columns
      names
```

```
[50]: Index(['SepalLengthCm', 'SepalWidthCm', 'PetalLengthCm', 'PetalWidthCm'],
      dtype='object')
```

2.4 Split into training and testing dataset

```
[51]: from sklearn.model_selection import train_test_split
      x_train, x_test, y_train, y_test = train_test_split(x, y, test_size = 0.2,
      random_state=0)
```

```
[52]: x_train
```

```
[52]:      SepalLengthCm  SepalWidthCm  PetalLengthCm  PetalWidthCm
      137           6.4           3.1           5.5           1.8
      84           5.4           3.0           4.5           1.5
      27           5.2           3.5           1.5           0.2
      127          6.1           3.0           4.9           1.8
      132          6.4           2.8           5.6           2.2
      ..          ...           ...           ...           ...
      9            4.9           3.1           1.5           0.1
      103          6.3           2.9           5.6           1.8
      67           5.8           2.7           4.1           1.0
      117          7.7           3.8           6.7           2.2
      47           4.6           3.2           1.4           0.2
```

[120 rows x 4 columns]

```
[53]: x_test
```

```
[53]:      SepalLengthCm  SepalWidthCm  PetalLengthCm  PetalWidthCm
      114           5.8           2.8           5.1           2.4
      62           6.0           2.2           4.0           1.0
      33           5.5           4.2           1.4           0.2
      107          7.3           2.9           6.3           1.8
      7            5.0           3.4           1.5           0.2
      100          6.3           3.3           6.0           2.5
      40           5.0           3.5           1.3           0.3
      86           6.7           3.1           4.7           1.5
```

76	6.8	2.8	4.8	1.4
71	6.1	2.8	4.0	1.3
134	6.1	2.6	5.6	1.4
51	6.4	3.2	4.5	1.5
73	6.1	2.8	4.7	1.2
54	6.5	2.8	4.6	1.5
63	6.1	2.9	4.7	1.4
37	4.9	3.1	1.5	0.1
78	6.0	2.9	4.5	1.5
90	5.5	2.6	4.4	1.2
45	4.8	3.0	1.4	0.3
16	5.4	3.9	1.3	0.4
121	5.6	2.8	4.9	2.0
66	5.6	3.0	4.5	1.5
24	4.8	3.4	1.9	0.2
8	4.4	2.9	1.4	0.2
126	6.2	2.8	4.8	1.8
22	4.6	3.6	1.0	0.2
44	5.1	3.8	1.9	0.4
97	6.2	2.9	4.3	1.3
93	5.0	2.3	3.3	1.0
26	5.0	3.4	1.6	0.4

```
[54]: y_train
```

```
[54]: 137    Iris-virginica
      84    Iris-versicolor
      27      Iris-setosa
      127   Iris-virginica
      132   Iris-virginica
      ...
      9     Iris-setosa
      103   Iris-virginica
      67    Iris-versicolor
      117   Iris-virginica
      47    Iris-setosa
      Name: Species, Length: 120, dtype: object
```

```
[55]: y_test
```

```
[55]: 114    Iris-virginica
      62    Iris-versicolor
      33      Iris-setosa
      107   Iris-virginica
      7     Iris-setosa
      100   Iris-virginica
      40    Iris-setosa
```



```

86     Iris-versicolor
76     Iris-versicolor
71     Iris-versicolor
134    Iris-virginica
51     Iris-versicolor
73     Iris-versicolor
54     Iris-versicolor
63     Iris-versicolor
37     Iris-setosa
78     Iris-versicolor
90     Iris-versicolor
45     Iris-setosa
16     Iris-setosa
121    Iris-virginica
66     Iris-versicolor
24     Iris-setosa
8      Iris-setosa
126    Iris-virginica
22     Iris-setosa
44     Iris-setosa
97     Iris-versicolor
93     Iris-versicolor
26     Iris-setosa
Name: Species, dtype: object

```

2.5 Building Model

2.5.1 SVM - Linear Kernel

```
[76]: from sklearn.svm import SVC
      svc_linear = SVC(kernel='linear')
```

```
[77]: svc_linear.fit(x_train, y_train)
```

```
[77]: SVC(kernel='linear')
```

```
[78]: y_pred = svc_linear.predict(x_test)
      y_pred
```

```
[78]: array(['Iris-virginica', 'Iris-versicolor', 'Iris-setosa',
            'Iris-virginica', 'Iris-setosa', 'Iris-virginica', 'Iris-setosa',
            'Iris-versicolor', 'Iris-versicolor', 'Iris-versicolor',
            'Iris-virginica', 'Iris-versicolor', 'Iris-versicolor',
            'Iris-versicolor', 'Iris-versicolor', 'Iris-setosa',
            'Iris-versicolor', 'Iris-versicolor', 'Iris-setosa', 'Iris-setosa',
            'Iris-virginica', 'Iris-versicolor', 'Iris-setosa', 'Iris-setosa',
            'Iris-virginica', 'Iris-setosa', 'Iris-setosa', 'Iris-versicolor',
            'Iris-versicolor', 'Iris-setosa'], dtype=object)
```

2.5.2 Model evaluation by using different metrics

```
[79]: from sklearn.metrics import classification_report, accuracy_score, \n      ↪confusion_matrix
```

Accuracy score

```
[80]: accuracy_score(y_test, y_pred)
```

```
[80]: 1.0
```

Classification report

```
[81]: classification_report(y_test, y_pred)
```

```
[81]: '              precision    recall  f1-score   support\n\n 1.00          1.00          1.00         11\nIris-versicolor          1.00          1.00          1.00         6\n1.00          1.00          1.00         13\nIris-virginica          1.00          1.00          1.00         30\naccuracy                   1.00          1.00          1.00\n1.00          1.00          1.00         30\nweighted avg          1.00          1.00          1.00\n30'
```

Confusion matrix

```
[82]: confusion_matrix(y_test, y_pred)
```

```
[82]: array([[11,  0,  0],\n          [ 0, 13,  0],\n          [ 0,  0,  6]])
```

2.5.3 SVM - Non-Linear Kernel

```
[83]: from sklearn.svm import SVC\n      svc_non_linear = SVC(kernel='rbf')
```

```
[84]: svc_non_linear.fit(x_train, y_train)
```

```
[84]: SVC()
```

```
[86]: y_pred = svc_non_linear.predict(x_test)\n      y_pred
```

```
[86]: array(['Iris-virginica', 'Iris-versicolor', 'Iris-setosa',\n          'Iris-virginica', 'Iris-setosa', 'Iris-virginica', 'Iris-setosa',\n          'Iris-versicolor', 'Iris-versicolor', 'Iris-versicolor',\n          'Iris-virginica', 'Iris-versicolor', 'Iris-versicolor',\n          'Iris-versicolor', 'Iris-versicolor', 'Iris-setosa',\n          'Iris-versicolor', 'Iris-versicolor', 'Iris-setosa', 'Iris-setosa',\n          'Iris-virginica', 'Iris-versicolor', 'Iris-setosa', 'Iris-setosa',\n          'Iris-virginica', 'Iris-setosa', 'Iris-setosa', 'Iris-versicolor',\n          'Iris-versicolor', 'Iris-setosa'], dtype=object)
```

2.5.4 Model evaluation by using different metrics

```
[87]: from sklearn.metrics import classification_report, accuracy_score, \
      ↪confusion_matrix
```

Accuracy score

```
[88]: accuracy_score(y_test, y_pred)
```

```
[88]: 1.0
```

Classification report

```
[89]: classification_report(y_test, y_pred)
```

```
[89]: '
      precision    recall  f1-score   support\n\n Iris-setosa
1.00          1.00          1.00         11\nIris-versicolor
1.00          1.00          1.00         13\n Iris-virginica
1.00          1.00          1.00          6\n\n
accuracy               1.00          30\n
macro avg              1.00          1.00          1.00
weighted avg           1.00          1.00          1.00
30\n'
```

Confusion matrix

```
[90]: confusion_matrix(y_test, y_pred)
```

```
[90]: array([[11,  0,  0],
          [ 0, 13,  0],
          [ 0,  0,  6]])
```