第三次作品(專題)(3-2):淺度機器學習分類器的評比實驗

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作品目標:

- 利用多元羅吉斯回歸、支援向量機 SVM 和神經網路對資料進行分類學習與測試。
- 學習分類器的原理並進行評比實驗。

本專題計畫執行分類器比較,即採用三種分類器分別對三組資料進行分類學習與測試。其中分類器包括: (1)多元羅吉斯回歸 (Multinomial Logistic Regression) (2)支援向量機 (Support Vector Machine) (3)神經網路 (Neural Network)

三組資料包括: (1)來自 3 個產區, 178 瓶葡萄酒, 含 13 種葡萄酒成分。 (2)來自 AT&T 40 個人的人臉影像共 400 張,每張大小 64×64。 (3)來自 Yale Face 38 人的人臉影像共 2410 張,每張大小 192×168。

此檔案以 AT&T 40 個人的人臉影像資料進行分類學習與測試。

先讀取資料並設定變數,同時將資料標準化。

```
import pandas as pd
import numpy as np
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split

# Read data
df = pd.read_csv('D:\\vs\\venv_name\\face_data.csv')
X = np.array(df.iloc[:, :-1]) # 排除最後一欄標籤
y = np.array(df.iloc[:, -1]) # 標籤欄
# Split data into training and testing data
X_train, X_test, y_train, y_test = train_test_split(
X, y, test_size=0.30)
# Standardize data
scaler = StandardScaler()
X_train_ = scaler.fit_transform(X_train)
X_test_ = scaler.fit_transform(X_test)
```

- (1)多元羅吉斯回歸 (Multinomial Logistic Regression)
- (a)原始資料
- 1.使用 lbfgs 的演算法

```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report

opts = dict(tol = le-6, max_iter = int(le6), verbose=1)
solver = 'lbfgs' # 'lbfgs' is the default
```

```
# solver = 'liblinear'
# solver = 'newton-cg'
clf_original = LogisticRegression(solver = solver, **opts)
clf_original.fit(X_train_, y_train)
y_pred = clf_original.predict(X_test_)
# 測試資料之準確率回報
print(f"{accuracy_score(y_test, y_pred):.2%}\n")
print(f"{clf_original.score(X_test_, y_test):.2%}\n")
print(classification_report(y_test, y_pred))

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.
```

93.33%

	precision	recall	f1-score	support
0	1.00	0.75	0.86	4
1	1.00	1.00	1.00	4
2	1.00	1.00	1.00	2
2 3	0.80	0.80	0.80	2 5 5 2
4	1.00	0.80	0.89	5
5 6	1.00	1.00	1.00	2
6	1.00	1.00	1.00	4
7	1.00	1.00	1.00	1
8	1.00	1.00	1.00	1 3 2
9 10	1.00	1.00	1.00	6
11	1.00 1.00	$1.00 \\ 1.00$	1.00 1.00	4
12	1.00	0.83	0.91	6
13	1.00	1.00	1.00	1
14	1.00	1.00	1.00	2
15	0.50	1.00	0.67	
16	1.00	1.00	1.00	1 1 3 5 4
17	1.00	1.00	1.00	3
18	1.00	1.00	1.00	5
19	1.00	1.00	1.00	
21	0.00	0.00	0.00	1
22	0.80	1.00	0.89	4
23	1.00	1.00	1.00	2
24	0.50	1.00	0.67	1
25	1.00	0.60	0.75	5
26	1.00	1.00	1.00	5 2 3 4
27	1.00	1.00	1.00	3
28 29	1.00	1.00	1.00	4 2
30	0.67 1.00	1.00 0.80	0.80 0.89	5
31	1.00	1.00	1.00	4
21	1.00	1.00	1.00	4

```
32
                   1.00
                             1.00
                                       1.00
                                                     2
                                                     4
          33
                   1.00
                             1.00
                                       1.00
                                                     3
          34
                   1.00
                             1.00
                                       1.00
                                                     3
          35
                   1.00
                             1.00
                                       1.00
                                                     4
          36
                   1.00
                             1.00
                                       1.00
                                                     3
          37
                   1.00
                             1.00
                                       1.00
                                                     2
          38
                   0.67
                             1.00
                                       0.80
          39
                   0.33
                             1.00
                                       0.50
                                                     1
                                       0.93
                                                   120
    accuracy
                   0.90
                             0.94
                                       0.91
                                                   120
   macro avq
                             0.93
                                       0.93
                                                   120
weighted avg
                   0.95
[Parallel(n jobs=1)]: Done
                             1 out of 1 | elapsed: 22.3s finished
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

2.使用 liblinear 的演算法

```
from sklearn.linear_model import LogisticRegression from sklearn.metrics import accuracy_score, classification_report opts = dict(tol = le-6, max_iter = int(le6), verbose=1) solver = 'liblinear' # solver = 'newton-cg' clf_original = LogisticRegression(solver = solver, **opts) clf_original.fit(X_train_, y_train) y_pred = clf_original.predict(X_test_) # 測試資料之準確率回報 print(f"{accuracy_score(y_test, y_pred):.2%}\n") print(f"{clf_original.score(X_test_, y_test):.2%}\n") print(classification_report(y_test, y_pred)) [LibLinear]86.67%
```

d:\vs\venv_name\lib\site-packages\sklearn\metrics\
 _classification.py:1344: UndefinedMetricWarning: Precision and F-score

```
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
    _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
    _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
```

3.使用 newton-cg 的演算法

```
from sklearn.linear_model import LogisticRegression from sklearn.metrics import accuracy_score, classification_report opts = dict(tol = le-6, max_iter = int(le6), verbose=1) solver = 'newton-cg' clf_original = LogisticRegression(solver = solver, **opts) clf_original.fit(X_train_, y_train) y_pred = clf_original.predict(X_test_) # 測試資料之準確率回報 print(f"{accuracy_score(y_test, y_pred):.2%}\n") print(f"{clf_original.score(X_test_, y_test):.2%}\n") print(classification_report(y_test, y_pred)) [Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.

93.33%
```

		11	£1	
	precision	recall	f1-score	support
0	1.00	0.75	0.86	4
1	1.00	1.00	1.00	4
2	1.00	1.00	1.00	2
3	0.80	0.80	0.80	5
4	1.00	0.80	0.89	5
5	1.00	1.00	1.00	2
6	1.00	1.00	1.00	4
7	1.00	1.00	1.00	1
8	1.00	1.00	1.00	3
9	1.00	1.00	1.00	2
10	1.00	1.00	1.00	6
11	1.00	1.00	1.00	4

```
12
                      1.00
                                  0.83
                                             0.91
                                                             6
           13
                      1.00
                                  1.00
                                             1.00
                                                             1
           14
                      1.00
                                  1.00
                                             1.00
                                                             2
                                                             1
           15
                      0.50
                                  1.00
                                             0.67
                                  1.00
                                                             1
           16
                      1.00
                                             1.00
                                                             3
           17
                      1.00
                                  1.00
                                             1.00
                                                             5
           18
                      1.00
                                  1.00
                                             1.00
           19
                      1.00
                                  1.00
                                             1.00
                                                             4
           21
                                                             1
                      0.00
                                  0.00
                                             0.00
                                                             4
           22
                      0.80
                                  1.00
                                             0.89
                                                             2
           23
                      1.00
                                  1.00
                                             1.00
                                                             1
           24
                      0.50
                                  1.00
                                             0.67
           25
                                             0.75
                                                             5
                      1.00
                                  0.60
                                                             2
           26
                      1.00
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           27
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                                  1.00
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           30
                      1.00
                                  0.80
                                             0.89
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                      1.00
                                  1.00
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                      1.00
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                                                             3
           35
                      1.00
                                  1.00
                                             1.00
                                                             4
           36
                      1.00
                                  1.00
                                             1.00
           37
                      1.00
                                  1.00
                                             1.00
                                                             3
                                                             2
           38
                      0.67
                                  1.00
                                             0.80
           39
                      0.33
                                  1.00
                                             0.50
                                                             1
                                             0.93
                                                          120
    accuracy
                      0.90
                                  0.94
                                             0.91
                                                          120
   macro avg
                                  0.93
weighted avg
                      0.95
                                             0.93
                                                          120
```

```
[Parallel(n jobs=1)]: Done
                             1 out of 1 | elapsed:
                                                      11.2s finished
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
_classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

討論:

- 使用 lbfgs 的演算法時,準確率為93.33%。
- 使用 liblinear 的演算法時,準確率為86.67%。
- 使用 newton-cg 的演算法時,準確率為93.33%。
- 綜上所述, lbfgs 和 newton-cg 的準確率相同,且高於 liblinear。

(b)主成分資料

1.取 10 個主成分並使用 lbfqs 的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 10).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = 1e-6, max_iter = int(1e6), verbose=1)
solver = 'lbfgs' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.

82.50%

[Parallel(n_jobs=1)]: Done 1 out of 1 | elapsed: 0.6s finished
```

2.取 30 個主成分並使用 lbfgs 的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 30).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = le-6, max_iter = int(le6), verbose=1)
solver = 'lbfgs' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.

93.33%

[Parallel(n_jobs=1)]: Done 1 out of 1 | elapsed: 0.4s finished
```

3.取 50 個主成分並使用 lbfgs 的演算法

4.取10個主成分並使用 liblinear 的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 10).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = 1e-6, max_iter = int(1e6), verbose=1)
solver = 'liblinear' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")
[LibLinear]72.50%
```

5.取 30 個主成分並使用 liblinear 的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 30).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = 1e-6, max_iter = int(1e6), verbose=1)
solver = 'liblinear' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")
[LibLinear]90.00%
```

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 50).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = le-6, max_iter = int(le6), verbose=1)
solver = 'liblinear' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")
[LibLinear]92.50%
```

7.取10個主成分並使用 newton-cg 的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 10).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = 1e-6, max_iter = int(1e6), verbose=1)
solver = 'newton-cg' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.

82.50%

[Parallel(n_jobs=1)]: Done  1 out of  1 | elapsed:  0.8s finished
```

8.取30個主成分並使用newton-cg的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 30).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = le-6, max_iter = int(le6), verbose=1)
solver = 'newton-cg' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")
```

92.50% [Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers. [Parallel(n_jobs=1)]: Done 1 out of 1 | elapsed: 0.1s finished

9.取 50 個主成分並使用 newton-cg 的演算法

```
from sklearn.decomposition import PCA
pca = PCA(n_components = 50).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
opts = dict(tol = le-6, max_iter = int(le6), verbose=1)
solver = 'newton-cg' # 'lbfgs' is the default
clf_PCA = LogisticRegression(solver = solver, **opts)
clf_PCA.fit(Z_train, y_train)
y_pred = clf_PCA.predict(Z_test)
print(f"{clf_PCA.score(Z_test, y_test):.2%}\n")
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.

95.00%

[Parallel(n_jobs=1)]: Done  1 out of  1 | elapsed: 0.2s finished
```

討論:

使用 lbfqs 的演算法:

- 取 10 個主成分時,準確率為82.50%。
- 取 30 個主成分時,準確率為 93.33%。
- 取 50 個主成分時,準確率為 94.17%。

使用 liblinear 的演算法:

- 取 10 個主成分時,準確率為 72.50%。
- 取30個主成分時,準確率為90.00%。
- 取 50 個主成分時,準確率為 92.50%。

使用 newton-cg 的演算法:

- 取 10 個主成分時,準確率為82.50%。
- 取 30 個主成分時,準確率為 92.50%。
- 取 50 個主成分時,準確率為 95.00%。

小結:

- 使用 liblinear 的演算法時,準確率最低,使用 lbfgs 的演算法和使用 newton-cg 的演算法 所得之準確率差不多。
- 取愈多主成分,準確率愈高。
- (2)支援向量機 (Support Vector Machine)
- (a)原始資料
- 1.使用 kernel="linear"

21

22

```
from sklearn.svm import SVC, LinearSVC
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
\# opts = dict(C = C, decision function shape = 'ovo', \
# tol = 1e-6, max iter = int(1e6))
clf_svm = SVC(kernel="linear", **opts)
# clf_svm = SVC(kernel="rbf", gamma=0.2, **opts)
# clf_svm = SVC(kernel="poly", degree=3, gamma="auto", **opts)
# clf_svm = LinearSVC(**opts) # one vs the rest
clf svm.fit(X train , y train)
predictions = clf svm.predict(X test )
print(f"{accuracy score(y test, predictions):.2%}\n")
print(classification report(y test, predictions))
91.67%
                precision
                               recall f1-score
                                                      support
                      1.00
                                  0.75
                                              0.86
                                                             4
             0
             1
                      1.00
                                  1.00
                                              1.00
                                                             4
             2
                                                             2
                      1.00
                                  0.50
                                             0.67
             3
                                                             5
                      0.80
                                  0.80
                                              0.80
             4
                                                             5
                      1.00
                                  0.80
                                             0.89
             5
                                                             2
                      1.00
                                  1.00
                                              1.00
             6
                      1.00
                                  1.00
                                              1.00
                                                             4
             7
                                                             1
                      1.00
                                  1.00
                                              1.00
             8
                                                             3
                      1.00
                                  1.00
                                              1.00
             9
                                                             2
                      1.00
                                  1.00
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                                                             6
            10
                      1.00
                                  1.00
                                              1.00
            11
                      1.00
                                  1.00
                                              1.00
                                                             4
                                                             6
            12
                      1.00
                                  0.67
                                             0.80
           13
                      1.00
                                  1.00
                                              1.00
                                                             1
                                                             2
           14
                      0.67
                                  1.00
                                             0.80
            15
                      0.50
                                                             1
                                  1.00
                                             0.67
                                                             1
           16
                      1.00
                                  1.00
                                             1.00
           17
                                                             3
                      1.00
                                  1.00
                                              1.00
                                                             5
           18
                      1.00
                                  1.00
                                             1.00
                                  1.00
           19
                                              1.00
                                                             4
                      1.00
           20
                      0.00
                                  0.00
                                             0.00
                                                             0
```

0.00

1.00

0.00

0.89

1

4

0.00

0.80

```
23
                   1.00
                              1.00
                                        1.00
                                                      2
                   0.50
                                        0.67
                                                      1
          24
                              1.00
                                                      5
          25
                   0.75
                              0.60
                                        0.67
                                                      2
          26
                   1.00
                              1.00
                                        1.00
                                                      3
                                        1.00
          27
                   1.00
                              1.00
                                                      4
          28
                   1.00
                              1.00
                                        1.00
                                                      2
          29
                   0.67
                              1.00
                                        0.80
          30
                   1.00
                              0.80
                                        0.89
                                                      5
                              1.00
                                                      4
          31
                   1.00
                                        1.00
                                                      2
          32
                   1.00
                              1.00
                                        1.00
                                                      4
          33
                   1.00
                              1.00
                                        1.00
                                                      3
                              1.00
          34
                   1.00
                                        1.00
          35
                                        1.00
                                                      3
                   1.00
                              1.00
                                                      4
                   1.00
                              1.00
          36
                                        1.00
                                                      3
          37
                   1.00
                              1.00
                                        1.00
                                                      2
                              1.00
                                        0.80
          38
                   0.67
                   0.50
          39
                              1.00
                                        0.67
                                        0.92
                                                    120
    accuracy
                   0.87
                              0.90
                                        0.87
                                                    120
   macro avg
                   0.94
                              0.92
                                        0.92
                                                    120
weighted avg
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
```

d:\vs\venv name\lib\site-packages\sklearn\metrics\

classification.py:1344: UndefinedMetricWarning: Recall and F-score

```
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
_warn_prf(average, modifier, msg_start, len(result))
```

2.使用 kernel="rbf"

```
from sklearn.svm import SVC, LinearSVC
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
# opts = dict(C = C, decision function shape = 'ovo', \
# tol = 1e-6, max iter = int(1e6))
#clf svm = SVC(kernel="linear", **opts)
clf_svm = SVC(kernel="rbf", gamma='auto', **opts)
# clf_svm = SVC(kernel="poly", degree=3, gamma="auto", **opts)
# clf svm = LinearSVC(**opts) # one vs the rest
clf svm.fit(X train_, y_train)
predictions = clf svm.predict(X test )
print(f"{accuracy_score(y_test, predictions):.2%}\n")
print(classification report(y test, predictions))
84.17%
               precision
                             recall f1-score
                                                 support
           0
                    1.00
                               0.50
                                         0.67
                                                       4
           1
                                                       4
                    1.00
                               1.00
                                         1.00
                                                       2
           2
                    1.00
                               0.50
                                         0.67
           3
                               0.40
                                         0.50
                                                       5
                    0.67
                                                       5
           4
                    1.00
                               0.80
                                         0.89
                                                       2
           5
                    1.00
                                         1.00
                               1.00
           6
                                                       4
                    1.00
                               1.00
                                         1.00
           7
                                                       1
                    1.00
                               1.00
                                         1.00
           8
                                                       3
                    1.00
                               1.00
                                         1.00
                                                       2
           9
                    1.00
                               1.00
                                         1.00
           10
                    1.00
                               1.00
                                         1.00
                                                       6
                                                       4
           11
                    1.00
                               1.00
                                         1.00
           12
                    1.00
                               0.50
                                         0.67
                                                       6
                                                       1
          13
                    1.00
                               1.00
                                         1.00
                                                       2
           14
                    1.00
                               1.00
                                         1.00
          15
                                                       1
                    0.33
                               1.00
                                         0.50
                                                       1
          16
                    1.00
                               1.00
                                         1.00
           17
                    1.00
                               1.00
                                         1.00
                                                       3
                                                       5
           18
                    1.00
                               1.00
                                         1.00
                                                       4
          19
                    1.00
                               1.00
                                         1.00
                                                       0
          20
                    0.00
                               0.00
                                         0.00
                                                       1
          21
                    0.00
                               0.00
                                         0.00
          22
                    0.80
                               1.00
                                         0.89
                                                       4
                                                       2
          23
                    1.00
                               1.00
                                         1.00
          24
                    0.33
                               1.00
                                         0.50
```

```
25
                   1.00
                              0.60
                                        0.75
                                                     5
                                                     2
                                        1.00
          26
                   1.00
                              1.00
                                                     3
          27
                   1.00
                              1.00
                                        1.00
                                                     4
          28
                   1.00
                              0.75
                                        0.86
                                                     2
          29
                   1.00
                              1.00
                                        1.00
                                                     5
          30
                   1.00
                              0.20
                                        0.33
                                                     4
          31
                   1.00
                              1.00
                                        1.00
          32
                   1.00
                              1.00
                                        1.00
                                                     2
          33
                   1.00
                                                     4
                              1.00
                                        1.00
                                                     3
          34
                   1.00
                              0.67
                                        0.80
                                                     3
          35
                   1.00
                              1.00
                                        1.00
                              1.00
                                                     4
          36
                   1.00
                                        1.00
          37
                   1.00
                              1.00
                                        1.00
                                                     3
                   0.50
                              1.00
                                        0.67
                                                     2
          38
          39
                   0.12
                              1.00
                                        0.22
                                                     1
                                        0.84
                                                   120
    accuracy
   macro avq
                   0.87
                              0.85
                                        0.82
                                                   120
                   0.94
                              0.84
                                        0.86
                                                   120
weighted avg
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
_classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
```

_classification.py:1344: UndefinedMetricWarning: Recall and F-score are ill-defined and being set to 0.0 in labels with no true samples.

```
Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
```

3.使用 kernel="poly"

```
from sklearn.svm import SVC, LinearSVC
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
\# opts = dict(C = C, decision function shape = 'ovo', \
# tol = 1e-6, max iter = int(1e6))
#clf_svm = SVC(kernel="linear", **opts)
\# cl\overline{f}_{svm} = SVC(kernel="rbf", gamma=0.2, **opts)
clf_svm = SVC(kernel="poly", degree=1, gamma="auto", **opts)
# clf svm = LinearSVC(**opts) # one vs the rest
clf_svm.fit(X_train_, y_train)
predictions = clf_svm.predict(X test )
print(f"{accuracy score(y test, predictions):.2%}\n")
print(classification report(y test, predictions))
82.50%
               precision
                             recall f1-score
                                                  support
            0
                    1.00
                               0.50
                                          0.67
                                                        4
            1
                    1.00
                               1.00
                                          1.00
                                                        4
            2
                                                        2
                               0.50
                    1.00
                                          0.67
                                                        5
            3
                    0.67
                               0.40
                                          0.50
                                                        5
            4
                    1.00
                               0.80
                                          0.89
                                                        2
            5
                    1.00
                               1.00
                                          1.00
            6
                    1.00
                               1.00
                                          1.00
                                                        4
            7
                                                        1
                    1.00
                               1.00
                                          1.00
                                                        3
            8
                               1.00
                    1.00
                                          1.00
            9
                                                        2
                    1.00
                               1.00
                                          1.00
           10
                    1.00
                               1.00
                                          1.00
                                                        6
           11
                    1.00
                               1.00
                                          1.00
                                                        4
                                                        6
           12
                    1.00
                               0.33
                                          0.50
           13
                    1.00
                               1.00
                                          1.00
                                                        1
                                                        2
           14
                    0.67
                               1.00
                                          0.80
           15
                    0.33
                               1.00
                                          0.50
                                                        1
                                                        1
           16
                    1.00
                               1.00
                                          1.00
           17
                    1.00
                               1.00
                                                        3
                                          1.00
                                                        5
           18
                    1.00
                               1.00
                                          1.00
                                                        4
           19
                    1.00
                               1.00
                                          1.00
                                                        0
           20
                    0.00
                               0.00
                                          0.00
                                                        1
           21
                    0.00
                               0.00
                                          0.00
           22
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
           23
                    1.00
                               1.00
                                          1.00
                                                        1
           24
                    0.33
                               1.00
                                          0.50
                                                        5
           25
                    1.00
                               0.60
                                          0.75
```

```
26
                   1.00
                              1.00
                                        1.00
                                                     2
                                                     3
          27
                   1.00
                              1.00
                                        1.00
          28
                   1.00
                              0.50
                                        0.67
                                                     4
                                                     2
          29
                   0.67
                              1.00
                                        0.80
                                                     5
          30
                   1.00
                              0.20
                                        0.33
                                                     4
          31
                   1.00
                              1.00
                                        1.00
                                                     2
          32
                   1.00
                              1.00
                                        1.00
          33
                   1.00
                              1.00
                                        1.00
                                                     4
                                                     3
          34
                   1.00
                              0.67
                                        0.80
                                                     3
          35
                   1.00
                              1.00
                                        1.00
                                                     4
          36
                   1.00
                              1.00
                                        1.00
                                                     3
          37
                   1.00
                              1.00
                                        1.00
                   0.40
                                        0.57
                                                     2
          38
                              1.00
                                                     1
          39
                   0.12
                              1.00
                                        0.22
                                        0.82
                                                   120
    accuracy
                   0.85
                                                   120
                              0.84
                                        0.80
   macro avq
weighted avg
                   0.93
                              0.82
                                        0.84
                                                   120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
_classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

討論:

- 使用 kernel="linear"時,準確率為91.67%。
- 使用 kernel="rbf"時, 準確率為84.17%。
- 使用 kernel="poly"時,準確率為82.50%。
- 綜上所述, kernel="linear"之準確率最高, kernel="rbf"次之, kernel="poly"之準確率最低。

(b)主成分資料

1.取 10 個主成分並使用 kernel="linear"

19

20

1.00

0.00

0.75

0.00

0.86

0.00

4

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n_components = 10).fit(X_train_)
Z_train = pca.transform(X_train_)
Z test = pca.transform(X test )
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max_iter = int(1e6))
clf svm = SVC(kernel="linear", **opts)
clf svm.fit(Z train, y train)
predictions = clf svm.predict(Z test)
print(f"{clf_svm.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
85.83%
               precision
                             recall f1-score
                                                 support
           0
                    1.00
                               1.00
                                         1.00
                                                       4
           1
                    1.00
                               1.00
                                         1.00
                                                       4
           2
                    1.00
                               1.00
                                                       2
                                         1.00
                              0.40
                                                       5
           3
                    0.50
                                         0.44
           4
                    1.00
                              0.80
                                         0.89
                                                       5
           5
                                                       2
                              1.00
                    0.67
                                         0.80
           6
                              0.75
                                                       4
                    1.00
                                         0.86
           7
                                                       1
                    1.00
                              1.00
                                         1.00
           8
                                                       3
                    1.00
                              1.00
                                         1.00
           9
                              1.00
                                                       2
                    1.00
                                         1.00
          10
                    1.00
                              0.83
                                         0.91
                                                       6
                    1.00
                               1.00
                                         1.00
                                                       4
          11
          12
                    0.50
                              0.33
                                         0.40
                                                       6
          13
                    1.00
                              1.00
                                         1.00
                                                       1
                                                       2
                    0.50
          14
                               1.00
                                         0.67
                                         0.50
                                                       1
          15
                    0.33
                              1.00
          16
                    1.00
                              1.00
                                         1.00
                                                       1
                                                       3
          17
                    1.00
                              1.00
                                         1.00
          18
                    0.83
                              1.00
                                         0.91
                                                       5
```

```
21
                    1.00
                              1.00
                                         1.00
                                                       1
          22
                    0.80
                                         0.89
                                                       4
                              1.00
                                                       2
          23
                    1.00
                              1.00
                                         1.00
                                                       1
          24
                    0.50
                              1.00
                                         0.67
                              0.60
                                                       5
          25
                    1.00
                                         0.75
                                                       2
          26
                    1.00
                              1.00
                                         1.00
                                                       3
          27
                    1.00
                              1.00
                                         1.00
          28
                    1.00
                              0.75
                                         0.86
                                                       4
                                                       2
          29
                    1.00
                              1.00
                                         1.00
                                                       5
          30
                    1.00
                              1.00
                                         1.00
                                                       4
          31
                    1.00
                              1.00
                                         1.00
                                                       2
          32
                    1.00
                              1.00
                                         1.00
          33
                                         1.00
                                                       4
                    1.00
                              1.00
                              1.00
                                                       3
          34
                    1.00
                                         1.00
                                                       3
          35
                    0.50
                              0.33
                                         0.40
                                                       4
                              1.00
          36
                    1.00
                                         1.00
                                                       3
          37
                    1.00
                              0.67
                                         0.80
                                                       2
          38
                    0.67
                              1.00
                                         0.80
          39
                    0.50
                              1.00
                                         0.67
                                         0.86
                                                     120
    accuracy
   macro avg
                    0.86
                              0.88
                                         0.85
                                                     120
weighted avg
                    0.89
                              0.86
                                         0.86
                                                     120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

2.取 30 個主成分並使用 kernel="linear"

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC

pca = PCA(n_components = 30).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)
```

```
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
clf_svm = SVC(kernel="linear", **opts)
clf svm.fit(Z train, y train)
predictions = clf svm.predict(Z test)
print(f"{clf_svm.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
93.33%
                              recall f1-score
               precision
                                                   support
            0
                                                          4
                     1.00
                                1.00
                                           1.00
            1
                                1.00
                                                          4
                     1.00
                                           1.00
                                                          2
            2
                     0.50
                                0.50
                                           0.50
                                                         5
            3
                     1.00
                                0.80
                                           0.89
                                                         5
            4
                     1.00
                                0.80
                                           0.89
                                                          2
            5
                     0.67
                                1.00
                                           0.80
            6
                                                          4
                     1.00
                                1.00
                                           1.00
            7
                                                          1
                     1.00
                                1.00
                                           1.00
            8
                     1.00
                                1.00
                                           1.00
                                                          3
                                                          2
            9
                     1.00
                                1.00
                                           1.00
                                                          6
           10
                     1.00
                                1.00
                                           1.00
                                                          4
           11
                     1.00
                                1.00
                                           1.00
                                                          6
           12
                                0.67
                     1.00
                                           0.80
           13
                     1.00
                                                          1
                                1.00
                                           1.00
                                                          2
           14
                     0.67
                                1.00
                                           0.80
           15
                     1.00
                                1.00
                                           1.00
                                                          1
                     1.00
                                           1.00
                                                          1
           16
                                1.00
                                                          3
           17
                     1.00
                                1.00
                                           1.00
                                                          5
           18
                     1.00
                                1.00
                                           1.00
                                                          4
           19
                     1.00
                                1.00
                                           1.00
           21
                                                          1
                     0.00
                                0.00
                                           0.00
           22
                     0.80
                                                          4
                                1.00
                                           0.89
                                                          2
           23
                     1.00
                                1.00
                                           1.00
                                                          1
           24
                     0.50
                                1.00
                                           0.67
                                                         5
           25
                     0.75
                                0.60
                                           0.67
                                                         2
           26
                     1.00
                                1.00
                                           1.00
                                                          3
           27
                     1.00
                                1.00
                                           1.00
                                                          4
           28
                     1.00
                                1.00
                                           1.00
                                                         2
           29
                     0.67
                                1.00
                                           0.80
                                                         5
           30
                     1.00
                                1.00
                                           1.00
           31
                     1.00
                                1.00
                                           1.00
                                                          4
                                                         2
           32
                     1.00
                                1.00
                                           1.00
                                                          4
           33
                     1.00
                                1.00
                                           1.00
           34
                                                         3
                     1.00
                                1.00
                                           1.00
                                                          3
           35
                     1.00
                                1.00
                                           1.00
                                                          4
           36
                     1.00
                                1.00
                                           1.00
           37
                                                          3
                     1.00
                                1.00
                                           1.00
```

38

0.67

1.00

0.80

2

```
39
                   1.00
                             1.00
                                       1.00
                                                    1
                                       0.93
                                                  120
    accuracy
                   0.90
                             0.93
                                       0.91
                                                  120
   macro avg
                   0.94
                             0.93
                                       0.93
weighted avg
                                                  120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

3.取 50 個主成分並使用 kernel="linear"

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n components = 50).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
clf_svm = SVC(kernel="linear", **opts)
clf_svm.fit(Z_train, y_train)
predictions = clf svm.predict(Z test)
print(f"{clf_svm.score(Z_test, y_test):.2%}\n")
print(classification_report(y_test, predictions))
94.17%
                            recall f1-score
              precision
                                                support
           0
                    1.00
                              1.00
                                        1.00
                                                      4
           1
                    1.00
                              1.00
                                        1.00
                                                      4
                                                      2
           2
                    1.00
                              1.00
                                        1.00
           3
                                                      5
                    0.80
                              0.80
                                        0.80
                                                      5
           4
                    1.00
                              0.80
                                        0.89
           5
                                                      2
                    0.67
                              1.00
                                        0.80
           6
                    1.00
                              1.00
                                        1.00
                                                      4
```

	_				_
	7	1.00	1.00	1.00	1
	8	1.00	1.00	1.00	3 2
	9	1.00	1.00	1.00	
	10	1.00	1.00	1.00	6
	11	1.00	1.00	1.00	4
	12	1.00	0.67	0.80	6
	13	1.00	1.00	1.00	1
	14	0.67	1.00	0.80	2
	15	1.00	1.00	1.00	1
	16	1.00	1.00	1.00	1
	17	1.00	1.00	1.00	3
	18	1.00	1.00	1.00	5
	19	1.00	1.00	1.00	4
	21	0.00	0.00	0.00	1
	22	0.80	1.00	0.89	4
	23	1.00	1.00	1.00	2
	24	0.50	1.00	0.67	1
	25	1.00	0.60	0.75	5
	26	1.00	1.00	1.00	2
	27	1.00	1.00	1.00	3
	28	1.00	1.00	1.00	4
	29	0.67	1.00	0.80	2
	30	1.00	1.00	1.00	5
	31	1.00	1.00	1.00	4
	32	1.00	1.00	1.00	2
	33	1.00	1.00	1.00	4
	34	1.00	1.00	1.00	3
	35	1.00	1.00	1.00	3
	36	1.00	1.00	1.00	4
	37	1.00	1.00	1.00	3
	38	0.67	1.00	0.80	2
	39	1.00	1.00	1.00	1
					_
accu	racy			0.94	120
macro	-	0.92	0.95	0.92	120
weighted	_	0.95	0.94	0.94	120
5	3		-	-	

```
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
   _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
   _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
   classification.py:1344: UndefinedMetricWarning: Precision and F-score
```

are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior. _warn_prf(average, modifier, msg_start, len(result))

4.取10 個主成分並使用 kernel="rbf"

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n components = 10).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X_test_)
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
clf svm = SVC(kernel="rbf", **opts)
clf_svm.fit(Z_train, y_train)
predictions = clf svm.predict(Z test)
print(f"{clf svm.score(Z test, y test):.2%}\n")
print(classification report(y test, predictions))
60.83%
               precision
                             recall f1-score
                                                 support
           0
                    1.00
                               0.50
                                          0.67
                                                        4
           1
                    1.00
                               1.00
                                          1.00
                                                        4
           2
                                                        2
                    0.20
                               0.50
                                          0.29
           3
                                                        5
                    0.50
                               0.20
                                          0.29
           4
                                                        5
                    1.00
                               0.40
                                          0.57
           5
                                                        2
                    1.00
                               1.00
                                          1.00
           6
                                                        4
                    0.60
                               0.75
                                          0.67
           7
                                                        1
                    1.00
                               1.00
                                          1.00
                                                        3
           8
                    1.00
                               1.00
                                          1.00
                                                        2
           9
                    1.00
                               1.00
                                          1.00
          10
                    1.00
                               0.33
                                                        6
                                          0.50
                                                        4
          11
                    1.00
                               1.00
                                          1.00
                                                        6
          12
                    1.00
                               0.17
                                          0.29
          13
                    1.00
                               1.00
                                          1.00
                                                        1
                                                        2
          14
                    0.40
                               1.00
                                          0.57
                               0.00
                                                        1
          15
                    0.00
                                          0.00
                                                        1
          16
                    0.50
                               1.00
                                          0.67
          17
                                                        3
                    1.00
                               1.00
                                          1.00
          18
                    0.20
                               0.20
                                         0.20
                                                        5
          19
                    0.50
                               0.25
                                          0.33
                                                        4
          20
                    0.00
                               0.00
                                          0.00
                                                        0
                                                        1
          21
                    1.00
                               1.00
                                          1.00
          22
                    0.50
                               0.50
                                          0.50
                                                        4
          23
                                                        2
                    0.67
                               1.00
                                          0.80
          24
                    0.33
                               1.00
                                          0.50
                                                        1
```

```
25
                   0.00
                              0.00
                                        0.00
                                                      5
                                                     2
          26
                   1.00
                              1.00
                                        1.00
                                                      3
          27
                   0.67
                              0.67
                                        0.67
                                                      4
          28
                   1.00
                              0.25
                                        0.40
                                                      2
          29
                   0.67
                              1.00
                                        0.80
                                                      5
          30
                   1.00
                              0.20
                                        0.33
                                                      4
          31
                   0.67
                              1.00
                                        0.80
          32
                   1.00
                              1.00
                                        1.00
                                                      2
          33
                                        1.00
                                                      4
                   1.00
                              1.00
                                                      3
          34
                   1.00
                              0.33
                                        0.50
                                                      3
                   0.50
          35
                              0.33
                                        0.40
                                                      4
          36
                   1.00
                              1.00
                                        1.00
          37
                   0.75
                              1.00
                                        0.86
                                                      3
                   0.40
                              1.00
                                        0.57
                                                      2
          38
          39
                   0.17
                              1.00
                                        0.29
                                                      1
                                        0.61
                                                    120
    accuracy
   macro avq
                   0.71
                              0.69
                                        0.64
                                                    120
                   0.75
                              0.61
                                        0.61
                                                    120
weighted avg
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
_classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
```

samples. Use `zero_division` parameter to control this behavior.

_classification.py:1344: UndefinedMetricWarning: Recall and F-score are ill-defined and being set to 0.0 in labels with no true samples.

warn prf(average, modifier, msg start, len(result))

d:\vs\venv name\lib\site-packages\sklearn\metrics\

```
Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
```

5.取 30 個主成分並使用 kernel="rbf"

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n components = 30).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max_iter = int(1e6))
clf svm = SVC(kernel="rbf", **opts)
clf svm.fit(Z train, y train)
predictions = clf svm.predict(Z test)
print(f"{clf svm.score(Z test, y test):.2%}\n")
print(classification report(y test, predictions))
83.33%
               precision
                             recall f1-score
                                                 support
           0
                    1.00
                               0.50
                                          0.67
                                                        4
           1
                    1.00
                               1.00
                                          1.00
                                                        4
           2
                                                        2
                    1.00
                               0.50
                                          0.67
           3
                                                        5
                    0.75
                               0.60
                                          0.67
                                                        5
           4
                    1.00
                               0.80
                                          0.89
           5
                                                        2
                    1.00
                               1.00
                                          1.00
           6
                    1.00
                               1.00
                                          1.00
                                                        4
           7
                                                        1
                    1.00
                               1.00
                                          1.00
                                                        3
           8
                    1.00
                               1.00
                                          1.00
           9
                                                        2
                    1.00
                               1.00
                                          1.00
                                                        6
          10
                    1.00
                               1.00
                                          1.00
                    1.00
                               1.00
                                          1.00
                                                        4
          11
          12
                                                        6
                    1.00
                               0.33
                                          0.50
          13
                                                        1
                    1.00
                               1.00
                                          1.00
          14
                    0.67
                               1.00
                                          0.80
                                                        2
                                                        1
          15
                    0.33
                               1.00
                                          0.50
                                                        1
          16
                    1.00
                               1.00
                                          1.00
          17
                                                        3
                    1.00
                               1.00
                                          1.00
                                                        5
          18
                    1.00
                               1.00
                                          1.00
          19
                    1.00
                               1.00
                                          1.00
                                                        4
          20
                    0.00
                               0.00
                                          0.00
                                                        0
          21
                    0.00
                               0.00
                                          0.00
                                                        1
                                                        4
          22
                    0.80
                               1.00
                                          0.89
                                                        2
          23
                    1.00
                               1.00
                                          1.00
          24
                               1.00
                                          0.50
                                                        1
                    0.33
          25
                                                        5
                    1.00
                               0.60
                                          0.75
```

```
26
                   1.00
                              1.00
                                        1.00
                                                     2
                                                     3
          27
                   1.00
                              1.00
                                        1.00
          28
                   1.00
                              0.75
                                        0.86
                                                     4
                                                     2
          29
                   1.00
                              1.00
                                        1.00
                                                     5
          30
                   1.00
                              0.20
                                        0.33
                                                     4
          31
                   1.00
                              1.00
                                        1.00
                                                     2
          32
                   1.00
                              1.00
                                        1.00
          33
                   1.00
                              1.00
                                        1.00
                                                     4
                                                     3
          34
                   1.00
                              0.33
                                        0.50
                                                     3
          35
                   1.00
                              1.00
                                        1.00
                                                     4
          36
                   1.00
                              1.00
                                        1.00
                                                     3
          37
                   1.00
                              1.00
                                        1.00
                   0.50
                                                     2
          38
                              1.00
                                        0.67
                                                     1
          39
                   0.17
                              1.00
                                        0.29
                                        0.83
                                                   120
    accuracy
                              0.84
                                                   120
                   0.86
                                        0.81
   macro avq
weighted avg
                   0.94
                              0.83
                                        0.85
                                                   120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
_classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n components = 50).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max_iter = int(1e6))
clf svm = SVC(kernel="rbf", **opts)
clf svm.fit(Z train, y train)
predictions = clf svm.predict(Z test)
print(f"{clf_svm.score(Z_test, y_test):.2%}\n")
print(classification_report(y_test, predictions))
84.17%
                             recall f1-score
               precision
                                                  support
            0
                    1.00
                               0.50
                                          0.67
                                                        4
            1
                                                        4
                               1.00
                    1.00
                                          1.00
                                                        2
            2
                               0.50
                    1.00
                                          0.67
            3
                    0.75
                               0.60
                                          0.67
                                                        5
                                                        5
            4
                    1.00
                               0.80
                                          0.89
                                                        2
            5
                    1.00
                               1.00
                                          1.00
            6
                                                        4
                    1.00
                               1.00
                                          1.00
            7
                                                        1
                    1.00
                               1.00
                                          1.00
           8
                                                        3
                    1.00
                               1.00
                                          1.00
           9
                    1.00
                               1.00
                                          1.00
                                                        2
           10
                    1.00
                               1.00
                                          1.00
                                                        6
                    1.00
                               1.00
                                                        4
           11
                                          1.00
           12
                    1.00
                               0.33
                                          0.50
                                                        6
                                                        1
           13
                               1.00
                                          1.00
                    1.00
                                                        2
          14
                    0.67
                               1.00
                                          0.80
          15
                    0.33
                               1.00
                                          0.50
                                                        1
                                                        1
          16
                    1.00
                               1.00
                                          1.00
           17
                    1.00
                               1.00
                                          1.00
                                                        3
                                                        5
           18
                    1.00
                               1.00
                                          1.00
                                                        4
          19
                    1.00
                               1.00
                                          1.00
                                                        0
          20
                    0.00
                               0.00
                                          0.00
                                                        1
          21
                    0.00
                               0.00
                                          0.00
          22
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
          23
                    1.00
                               1.00
                                          1.00
                                                        1
          24
                    0.33
                               1.00
                                          0.50
                                                        5
          25
                    1.00
                               0.60
                                          0.75
                                                        2
                    1.00
          26
                               1.00
                                          1.00
          27
                    1.00
                               1.00
                                          1.00
                                                        3
                                                        4
          28
                    1.00
                               0.75
                                          0.86
                                                        2
          29
                    1.00
                               1.00
                                          1.00
```

```
30
                   1.00
                             0.20
                                        0.33
                                                     5
                             1.00
                                        1.00
                                                     4
          31
                   1.00
                                                     2
          32
                   1.00
                             1.00
                                        1.00
                                                     4
          33
                   1.00
                             1.00
                                        1.00
                                                     3
          34
                   1.00
                             0.67
                                        0.80
                                                     3
          35
                   1.00
                             1.00
                                        1.00
                                                     4
                   1.00
                             1.00
                                        1.00
          36
          37
                   1.00
                             1.00
                                        1.00
                                                     3
                   0.50
                                                     2
          38
                             1.00
                                        0.67
          39
                   0.17
                             1.00
                                        0.29
                                        0.84
                                                   120
    accuracy
   macro avq
                   0.86
                             0.85
                                        0.82
                                                   120
                   0.94
                             0.84
                                        0.86
weighted avg
                                                   120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n components = 10).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max_iter = int(1e6))
clf_svm = SVC(kernel="poly", degree=1, gamma="auto", **opts)
clf svm.fit(Z train, y train)
predictions = clf svm.predict(Z test)
print(f"{clf svm.score(Z test, y test):.2%}\n")
print(classification report(y test, predictions))
85.83%
               precision
                             recall f1-score
                                                  support
            0
                    1.00
                               1.00
                                          1.00
                                                        4
            1
                                                        4
                    1.00
                               1.00
                                          1.00
                                                        2
            2
                                          1.00
                    1.00
                               1.00
            3
                    0.50
                               0.40
                                          0.44
                                                        5
                                                        5
           4
                    1.00
                               0.80
                                          0.89
                                                        2
           5
                               1.00
                    0.67
                                          0.80
            6
                    1.00
                               0.75
                                          0.86
                                                        4
           7
                                                        1
                    1.00
                               1.00
                                          1.00
           8
                    1.00
                               1.00
                                          1.00
                                                        3
                                                        2
           9
                    1.00
                               1.00
                                          1.00
           10
                    1.00
                                          0.91
                                                        6
                               0.83
                                                        4
           11
                    1.00
                               1.00
                                          1.00
           12
                    0.50
                               0.33
                                          0.40
                                                        6
          13
                    1.00
                               1.00
                                          1.00
                                                        1
                                                        2
          14
                    0.50
                               1.00
                                          0.67
                    0.33
                                                        1
          15
                               1.00
                                          0.50
                                                        1
           16
                    1.00
                               1.00
                                          1.00
                                                        3
           17
                    1.00
                               1.00
                                          1.00
                                                        5
           18
                    0.83
                               1.00
                                          0.91
                                                        4
          19
                    1.00
                               0.75
                                          0.86
                                                        0
          20
                    0.00
                               0.00
                                          0.00
          21
                    1.00
                               1.00
                                          1.00
                                                        1
          22
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
          23
                                          1.00
                    1.00
                               1.00
                                                        1
          24
                    0.50
                               1.00
                                          0.67
          25
                                                        5
                    1.00
                               0.60
                                          0.75
                                                        2
          26
                    1.00
                               1.00
                                          1.00
          27
                                                        3
                    1.00
                               1.00
                                          1.00
                                                        4
          28
                                          0.86
                    1.00
                               0.75
                                                        2
          29
                    1.00
                               1.00
                                          1.00
                                                        5
          30
                    1.00
                               1.00
                                          1.00
                                                        4
          31
                    1.00
                               1.00
                                          1.00
```

```
32
                   1.00
                              1.00
                                        1.00
                                                     2
                                                     4
          33
                   1.00
                              1.00
                                        1.00
                                                     3
          34
                   1.00
                              1.00
                                        1.00
                                                     3
          35
                   0.50
                             0.33
                                        0.40
                                                     4
          36
                   1.00
                             1.00
                                        1.00
                                                     3
          37
                   1.00
                             0.67
                                        0.80
                                                     2
                   0.67
          38
                             1.00
                                        0.80
          39
                   0.50
                              1.00
                                        0.67
                                                     1
                                        0.86
                                                   120
    accuracy
                   0.86
                             0.88
                                        0.85
                                                   120
   macro avq
                             0.86
                                                   120
weighted avg
                   0.89
                                        0.86
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
```

8.取 30 個主成分並使用 kernel="poly"

0 1 2 3 4 5 6 7 8 9	1.00 1.00 0.50 1.00 1.00 0.67 1.00 1.00 1.00	1.00 1.00 0.50 0.80 0.80 1.00 1.00 1.00	1.00 1.00 0.50 0.89 0.89 1.00 1.00 1.00	4 4 2 5 5 2 4 1 3 2
11 12	1.00 1.00	1.00 0.67	1.00 0.80	4 6
13	1.00	1.00	1.00	1
14	0.67	1.00	0.80	2
15	1.00	1.00	1.00	1
16 17	$1.00 \\ 1.00$	$1.00 \\ 1.00$	1.00 1.00	1 3
18	1.00	1.00	1.00	5
19	1.00	1.00	1.00	5 4
21	0.00	0.00	0.00	1
22	0.80	1.00	0.89	4
23 24	1.00 0.50	$1.00 \\ 1.00$	1.00 0.67	2 1
25	0.75	0.60	0.67	5
26	1.00	1.00	1.00	5 2 3 4
27	1.00	1.00	1.00	3
28	1.00	1.00	1.00	
29 30	0.67 1.00	$1.00 \\ 1.00$	0.80 1.00	2 5 4
31	1.00	1.00	1.00	4
32	1.00	1.00	1.00	2
33	1.00	1.00	1.00	4
34 35	$1.00 \\ 1.00$	$1.00 \\ 1.00$	1.00 1.00	3
36	1.00	1.00	1.00	3 4 3 2
37	1.00	1.00	1.00	3
38	0.67	1.00	0.80	
39	1.00	1.00	1.00	1
accuracy			0.93	120
macro avg	0.90	0.93	0.91	120
weighted avg	0.94	0.93	0.93	120

d:\vs\venv_name\lib\site-packages\sklearn\metrics\
 _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
 _warn_prf(average, modifier, msg_start, len(result))

```
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
    _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
    _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
    _warn_prf(average, modifier, msg_start, len(result))
```

9.取 50 個主成分並使用 kernel="poly"

17

1.00

1.00

1.00

```
from sklearn.decomposition import PCA
from sklearn.svm import SVC, LinearSVC
pca = PCA(n components = 50).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
C = 1 # SVM regularization parameter
opts = dict(C = C, tol = 1e-6, max iter = int(1e6))
clf svm = SVC(kernel="poly", degree=1, gamma="auto", **opts)
clf svm.fit(Z train, y train)
predictions = clf svm.predict(Z test)
print(f"{clf_svm.score(Z_test, y_test):.2%}\n")
print(classification_report(y_test, predictions))
94.17%
               precision
                            recall f1-score
                                                 support
           0
                    1.00
                               1.00
                                         1.00
                                                       4
           1
                    1.00
                               1.00
                                         1.00
                                                       4
           2
                                                       2
                    1.00
                               1.00
                                         1.00
           3
                    0.80
                              0.80
                                         0.80
                                                       5
           4
                                                       5
                    1.00
                              0.80
                                         0.89
           5
                                                       2
                    0.67
                               1.00
                                         0.80
           6
                    1.00
                               1.00
                                         1.00
                                                       4
           7
                                                       1
                    1.00
                               1.00
                                         1.00
                                                       3
           8
                    1.00
                               1.00
                                         1.00
           9
                                                       2
                    1.00
                              1.00
                                         1.00
                                                       6
          10
                    1.00
                               1.00
                                         1.00
                    1.00
                               1.00
                                         1.00
                                                       4
          11
          12
                    1.00
                              0.67
                                         0.80
                                                       6
          13
                    1.00
                              1.00
                                         1.00
                                                       1
                                                       2
          14
                    0.67
                              1.00
                                         0.80
          15
                    1.00
                               1.00
                                         1.00
                                                       1
                    1.00
                              1.00
                                         1.00
                                                       1
          16
```

3

```
18
                      1.00
                                  1.00
                                             1.00
                                                             5
                                  1.00
           19
                                             1.00
                                                             4
                      1.00
           21
                      0.00
                                  0.00
                                             0.00
                                                             1
                                                             4
           22
                      0.80
                                  1.00
                                             0.89
                                                             2
           23
                      1.00
                                  1.00
                                             1.00
                                                             1
           24
                      0.50
                                  1.00
                                             0.67
           25
                                                             5
                      1.00
                                  0.60
                                             0.75
           26
                      1.00
                                  1.00
                                             1.00
                                                             2
                                                             3
           27
                                             1.00
                      1.00
                                  1.00
                                                             4
           28
                      1.00
                                  1.00
                                             1.00
                                                             2
           29
                      0.67
                                  1.00
                                             0.80
                                                             5
           30
                      1.00
                                  1.00
                                             1.00
           31
                      1.00
                                  1.00
                                             1.00
                                                             4
                                                             2
                      1.00
                                  1.00
           32
                                             1.00
           33
                      1.00
                                  1.00
                                             1.00
                                                             4
                                                             3
           34
                                  1.00
                      1.00
                                             1.00
                                                             3
           35
                      1.00
                                  1.00
                                             1.00
                                                             4
           36
                      1.00
                                  1.00
                                             1.00
                                                             3
           37
                      1.00
                                  1.00
                                             1.00
           38
                      0.67
                                  1.00
                                             0.80
                                                             2
           39
                      1.00
                                  1.00
                                             1.00
                                                             1
                                             0.94
                                                          120
    accuracy
                      0.92
                                  0.95
                                             0.92
                                                          120
   macro avq
weighted avg
                      0.95
                                  0.94
                                             0.94
                                                          120
```

d:\vs\venv name\lib\site-packages\sklearn\metrics\

_classification.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero division` parameter to control this behavior.

warn prf(average, modifier, msg start, len(result))

d:\vs\venv name\lib\site-packages\sklearn\metrics\

_classification.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.

_warn_prf(average, modifier, msg_start, len(result))

d:\vs\venv name\lib\site-packages\sklearn\metrics\

_classification.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.

warn prf(average, modifier, msg start, len(result))

討論:

使用 kernel="linear":

- 取 10 個主成分時,準確率為85.83%。
- 取30個主成分時,準確率為93.33%。
- 取 50 個主成分時,準確率為 94.17%。

使用 kernel="rbf":

- 取 10 個主成分時,準確率為60.83%。
- 取 30 個主成分時,準確率為83.33%。
- 取 50 個主成分時,準確率為 84.17%。

使用 kernel="poly":

- 取10個主成分時,準確率為85.83%。
- 取30個主成分時,準確率為93.33%。
- 取 50 個主成分時,準確率為 94.17%。

小結:

- 使用 kernel="linear"和使用 kernel="poly"之準確率相同,使用 kernel="rbf"準確率最低。
- 取愈多主成分,準確率愈高。
- (3)神經網路 (Neural Network)

5

6

7

0.67

1.00

1.00

- (a)原始資料
- 1.使用 activation = 'logistic'且 hidden_layers = (30,)

```
from sklearn.neural network import MLPClassifier
# hidden layers = (512,) # one hidden layer
# activation = 'relu' # the default
hidden layers = (30,)
activation = 'logistic'
opts = dict(hidden layer sizes = hidden layers , verbose = False, \
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(X_train_, y_train)
predictions = clf MLP.predict(X test )
print(f"{accuracy_score(y_test, predictions):.2%}\n")
print(classification report(y test, predictions))
88.33%
                           recall f1-score
                                               support
              precision
           0
                             0.25
                                                     4
                   0.33
                                        0.29
           1
                             0.75
                   1.00
                                        0.86
                                                     4
                                                     2
           2
                   0.00
                             0.00
                                        0.00
                             0.40
                                                     5
           3
                   1.00
                                        0.57
                                                     5
           4
                             0.80
                                        0.89
                   1.00
```

1.00

1.00

1.00

0.80

1.00

1.00

2

4

1

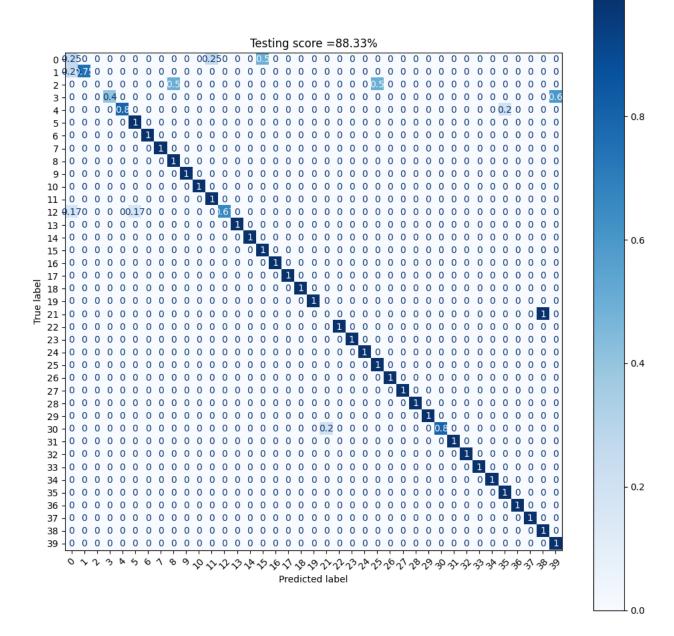
8	0.75	1.00	0.86	3	
9	1.00	1.00	1.00	2 6	
10	1.00	1.00	1.00		
11 12	0.80	1.00 0.67	0.89 0.80	4 6	
13	1.00 1.00	1.00	1.00	1	
14	1.00	1.00	1.00	2	
15	0.33	1.00	0.50	1	
16	1.00	1.00	1.00	1	
17	1.00	1.00	1.00	3	
18	1.00	1.00	1.00	5	
19	1.00	1.00	1.00	4	
21	0.00	0.00	0.00	1	
22	1.00	1.00	1.00	4	
23	1.00	1.00	1.00	2	
24	1.00	1.00	1.00	2 1	
25	0.83	1.00	0.91		
26	1.00	1.00	1.00	5 2	
27	1.00	1.00	1.00	3	
28	1.00	1.00	1.00	4	
29	1.00	1.00	1.00	2	
30	1.00	0.80	0.89	5	
31	1.00	1.00	1.00	4	
32	1.00	1.00	1.00	2	
33	1.00	1.00	1.00	4	
34	1.00	1.00	1.00	3	
35	0.75	1.00	0.86	3	
36	1.00	1.00	1.00	4	
37	1.00	1.00	1.00	3	
38	0.67	1.00	0.80	2	
39	0.25	1.00	0.40	1	
accuracy			0.88	120	
macro avg	0.86	0.89	0.85	120	
weighted avg	0.90	0.88	0.88	120	
3 3					

```
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
   _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
   _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   _warn_prf(average, modifier, msg_start, len(result))
```

d:\vs\venv_name\lib\site-packages\sklearn\metrics\
 _classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted

```
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(\frac{1}{1}, figsize=(\frac{12}{12}))
score = 100*clf_MLP.score(X_test_, y_test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf_MLP,
X_test_,
y_test,
xticks rotation=45, #'vertical',
# display_labels=class_names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
)
disp.ax_.set_title(title)
plt.show()
```





2.使用 activation = 'relu'且 hidden layers = (512,)

```
from sklearn.neural_network import MLPClassifier
hidden_layers = (512,) # one hidden layer
activation = 'relu' # the default
# hidden_layers = (30,)
# activation = 'logistic'
opts = dict(hidden_layer_sizes = hidden_layers , verbose = False, \
activation = activation, tol = 1e-6, max_iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
```

```
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(X_train_, y_train)
predictions = clf MLP.predict(X test )
print(f"{accuracy_score(y_test, predictions):.2%}\n")
print(classification_report(y_test, predictions))
87.50%
               precision
                              recall f1-score
                                                   support
            0
                     0.80
                                1.00
                                           0.89
                                                          4
            1
                     1.00
                                1.00
                                           1.00
                                                          4
            2
                     0.67
                                                          2
                                1.00
                                           0.80
                                                          5
            3
                     1.00
                                0.60
                                           0.75
                                                         5
            4
                     1.00
                                0.80
                                           0.89
                                                         2
            5
                     1.00
                                1.00
                                           1.00
            6
                     1.00
                                1.00
                                           1.00
                                                         4
            7
                                                          1
                     1.00
                                1.00
                                           1.00
                                                          3
            8
                                1.00
                                           1.00
                     1.00
            9
                     1.00
                                1.00
                                           1.00
                                                          2
                                                          6
           10
                     1.00
                                1.00
                                           1.00
           11
                     1.00
                                1.00
                                           1.00
                                                         4
                                                          6
           12
                     1.00
                                0.50
                                           0.67
                                                          1
           13
                                1.00
                                           1.00
                     1.00
           14
                                                          2
                     0.67
                                1.00
                                           0.80
                     0.50
           15
                                                          1
                                1.00
                                           0.67
                                                          1
           16
                     1.00
                                1.00
                                           1.00
           17
                     1.00
                                           1.00
                                                          3
                                1.00
                                                          5
           18
                     1.00
                                1.00
                                           1.00
                                                          4
           19
                     0.80
                                1.00
                                           0.89
                                                          1
           21
                     0.14
                                1.00
                                           0.25
           22
                                                          4
                     0.80
                                1.00
                                           0.89
           23
                     0.67
                                                          2
                                1.00
                                           0.80
                                                          1
           24
                     1.00
                                1.00
                                           1.00
                                                          5
           25
                     1.00
                                0.80
                                           0.89
                                                          2
           26
                     1.00
                                1.00
                                           1.00
                                                          3
           27
                     1.00
                                1.00
                                           1.00
           28
                                                          4
                     1.00
                                1.00
                                           1.00
                                                          2
           29
                     1.00
                                1.00
                                           1.00
                                                          5
           30
                     1.00
                                0.40
                                           0.57
                                                          4
           31
                     1.00
                                1.00
                                           1.00
                                                         2
           32
                     1.00
                                1.00
                                           1.00
                                                          4
           33
                     1.00
                                0.50
                                           0.67
                                                          3
           34
                     1.00
                                1.00
                                           1.00
           35
                                                         3
                     1.00
                                0.33
                                           0.50
                                                          4
           36
                     1.00
                                0.75
                                           0.86
```

38

39

1.00

1.00

0.33

1.00

1.00

1.00

1.00

1.00

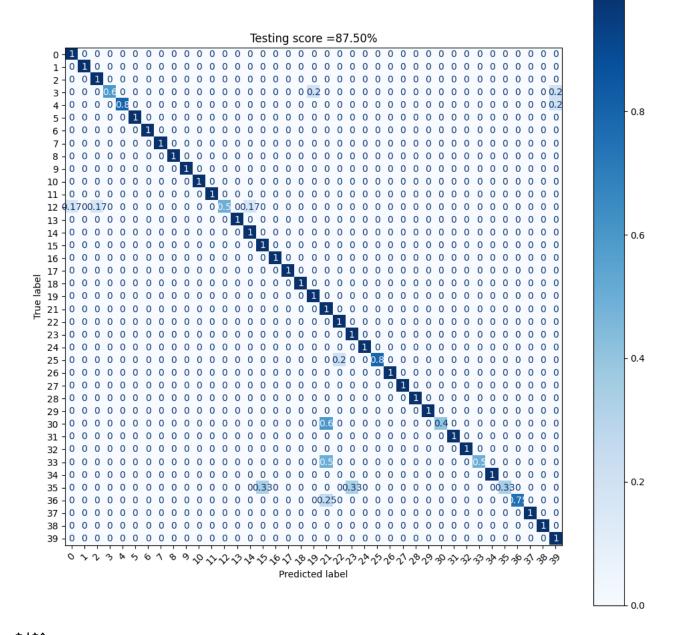
0.50

3

2

```
0.88
                                                    120
    accuracy
                    0.91
                              0.91
                                         0.88
                                                     120
   macro avg
weighted avg
                    0.95
                              0.88
                                         0.88
                                                    120
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(\frac{1}{1}, figsize=(\frac{12}{12}))
score = 100*clf_MLP.score(X_test_, y_test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from_estimator(
clf_MLP,
X_test_,
y_test,
xticks rotation=45, #'vertical',
# display labels=class names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
disp.ax_.set_title(title)
plt.show()
```





討論:

- 使用 activation = 'logistic'且 hidden_layers = (30,)時,準確率為88.33%。
- 使用 activation = 'relu'且 hidden_layers = (512,)時,準確率為 87.50%。
- 綜上所述,使用 activation = 'logistic'且 hidden_layers = (30,)之準確率較高。

(b)主成分資料

1.取 10 個主成分並使用 activation = 'logistic'且 hidden_layers = (30,)

```
from sklearn.decomposition import PCA
from sklearn.neural_network import MLPClassifier
```

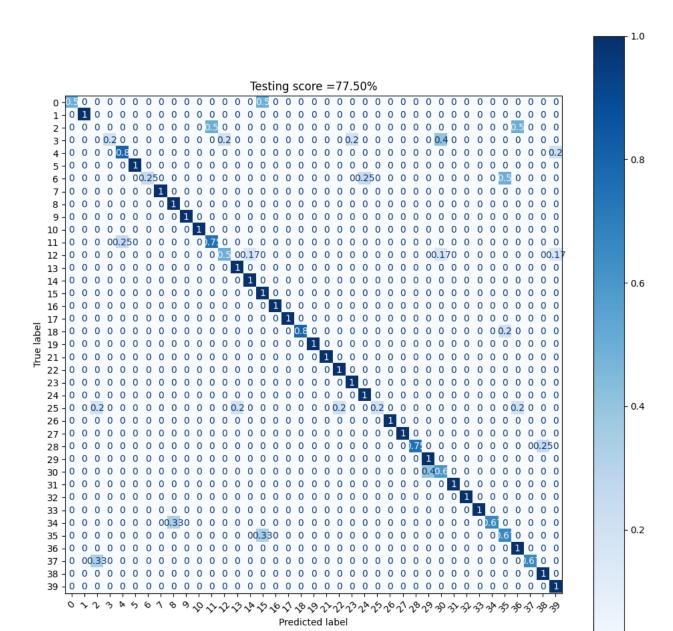
```
pca = PCA(n components = 10).fit(X train)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
hidden layers = (30,)
activation = 'logistic'
opts = dict(hidden layer sizes = hidden layers , verbose = False, \
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(Z_train, y_train)
predictions = clf MLP.predict(Z test)
print(f"{clf_MLP.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
77.50%
               precision
                             recall f1-score
                                                 support
           0
                    1.00
                               0.50
                                          0.67
                                                        4
                                                        4
           1
                    1.00
                               1.00
                                          1.00
           2
                                                        2
                    0.00
                               0.00
                                          0.00
           3
                                                        5
                    1.00
                               0.20
                                          0.33
                                                        5
           4
                    0.80
                               0.80
                                          0.80
                                                        2
           5
                    1.00
                               1.00
                                          1.00
                               0.25
           6
                                                        4
                    1.00
                                          0.40
           7
                                                        1
                    1.00
                               1.00
                                          1.00
                                                        3
           8
                    0.75
                               1.00
                                          0.86
           9
                    1.00
                               1.00
                                          1.00
                                                        2
           10
                                                        6
                    1.00
                               1.00
                                          1.00
          11
                    0.75
                               0.75
                                                        4
                                          0.75
                               0.50
                                                        6
           12
                    0.75
                                          0.60
           13
                    0.50
                               1.00
                                          0.67
                                                        1
                                                        2
           14
                    0.67
                               1.00
                                          0.80
           15
                    0.25
                               1.00
                                          0.40
                                                        1
          16
                    1.00
                               1.00
                                          1.00
                                                        1
                                                        3
           17
                    1.00
                               1.00
                                          1.00
          18
                               0.80
                                                        5
                    1.00
                                          0.89
          19
                                                        4
                    1.00
                               1.00
                                          1.00
                                                        1
          21
                    1.00
                               1.00
                                          1.00
          22
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
          23
                    0.67
                               1.00
                                          0.80
                                                        1
          24
                    0.50
                               1.00
                                          0.67
                                                        5
          25
                    1.00
                               0.20
                                          0.33
                                                        2
                               1.00
                                          1.00
          26
                    1.00
          27
                               1.00
                                          1.00
                                                        3
                    1.00
```

1.00

0.75

0.86

```
29
                    0.50
                              1.00
                                         0.67
                                                       2
                                                      5
          30
                    0.50
                              0.60
                                         0.55
                                                      4
          31
                    1.00
                              1.00
                                         1.00
                                                      2
          32
                    1.00
                              1.00
                                         1.00
                                                       4
          33
                    1.00
                              1.00
                                         1.00
                                                      3
          34
                    1.00
                              0.67
                                         0.80
                                                      3
          35
                    0.40
                              0.67
                                         0.50
          36
                    0.67
                              1.00
                                         0.80
                                                      4
                                                      3
          37
                    1.00
                              0.67
                                         0.80
                                                      2
          38
                    0.67
                              1.00
                                         0.80
          39
                    0.33
                              1.00
                                         0.50
                                                       1
    accuracy
                                         0.78
                                                    120
                    0.81
                              0.83
                                         0.77
                                                    120
   macro avq
                                         0.76
                                                    120
weighted avg
                    0.85
                              0.78
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(1, 1, figsize=(12, 12))
score = 100*clf MLP.score(Z test, y test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf_MLP,
Z test,
y_test,
xticks_rotation=45, #'vertical',
# display labels=class names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
)
disp.ax .set title(title)
plt.show()
```



2.取 30 個主成分並使用 activation = 'logistic'且 hidden_layers = (30,)

```
from sklearn.decomposition import PCA
from sklearn.neural_network import MLPClassifier

pca = PCA(n_components = 30).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)

hidden_layers = (30,)
activation = 'logistic'
opts = dict(hidden_layer_sizes = hidden_layers , verbose = False, \
```

0.0

```
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(Z_train, y_train)
predictions = clf MLP.predict(Z test)
print(f"{clf_MLP.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
85.00%
                             recall f1-score
               precision
                                                 support
           0
                    0.67
                               0.50
                                          0.57
                                                        4
           1
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
           2
                    0.50
                               0.50
                                          0.50
           3
                                                       5
                    1.00
                               0.40
                                          0.57
           4
                                                        5
                    1.00
                               0.80
                                          0.89
                                                        2
           5
                                          1.00
                    1.00
                               1.00
           6
                               0.75
                                                        4
                    1.00
                                          0.86
           7
                                                        1
                    1.00
                               1.00
                                          1.00
           8
                    1.00
                               1.00
                                          1.00
                                                        3
                                                       2
           9
                    1.00
                               1.00
                                          1.00
          10
                                                        6
                    0.86
                               1.00
                                          0.92
                                                        4
          11
                    0.80
                               1.00
                                          0.89
          12
                                                        6
                    0.80
                               0.67
                                          0.73
          13
                    1.00
                               1.00
                                          1.00
                                                        1
          14
                                          0.80
                                                        2
                    0.67
                               1.00
                                                        1
          15
                    0.25
                               1.00
                                          0.40
                                                        1
          16
                    1.00
                               1.00
                                          1.00
                                                        3
          17
                    1.00
                               1.00
                                          1.00
                                                        5
          18
                    1.00
                               1.00
                                          1.00
          19
                               0.75
                                                        4
                    1.00
                                          0.86
                                                        1
          21
                    0.00
                               0.00
                                          0.00
          22
                    1.00
                               0.75
                                          0.86
                                                        4
                                                        2
          23
                    1.00
                               1.00
                                          1.00
```

5

2

3

4

2

5

4

2

4

3

3

24

25

26

27

28

29

30

31

32

33

34

35

36

0.50

1.00

1.00

1.00

1.00

0.67

1.00

0.80

1.00

1.00

1.00

0.67

0.75

1.00

0.60

1.00

1.00

1.00

1.00

0.80

1.00

1.00

1.00

1.00

0.67

0.75

0.67

0.75

1.00

1.00

1.00

0.80

0.89

0.89

1.00

1.00

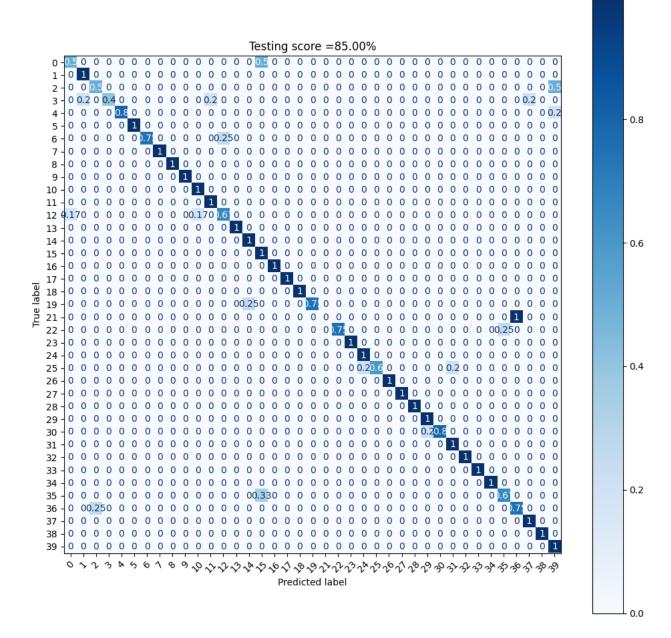
1.00

0.67

0.75

```
37
                   0.75
                             1.00
                                       0.86
                                                     3
                   1.00
                             1.00
                                                     2
          38
                                       1.00
          39
                   0.33
                             1.00
                                       0.50
                                                     1
                                                   120
                                       0.85
    accuracy
                   0.84
                             0.87
                                       0.83
                                                   120
   macro avg
                   0.89
                                                   120
weighted avg
                             0.85
                                       0.85
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
 warn prf(average, modifier, msg start, len(result))
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(1, 1, figsize=(12,12))
score = 100*clf MLP.score(Z test, y test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf MLP,
Z test,
y test,
xticks rotation=45, #'vertical',
# display labels=class names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
)
disp.ax .set title(title)
plt.show()
```





3.取 50 個主成分並使用 activation = 'logistic'且 hidden_layers = (30,)

```
from sklearn.decomposition import PCA
from sklearn.neural_network import MLPClassifier

pca = PCA(n_components = 50).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)

hidden_layers = (30,)
activation = 'logistic'
opts = dict(hidden_layer_sizes = hidden_layers , verbose = False, \
```

```
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(Z_train, y_train)
predictions = clf MLP.predict(Z test)
print(f"{clf_MLP.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
86.67%
                             recall f1-score
               precision
                                                 support
           0
                    0.67
                               0.50
                                          0.57
                                                        4
           1
                    1.00
                               1.00
                                          1.00
                                                        4
                                                        2
           2
                    1.00
                               0.50
                                          0.67
           3
                                                        5
                    0.60
                               0.60
                                          0.60
           4
                                                        5
                    1.00
                               0.80
                                          0.89
                                                        2
           5
                    0.67
                               1.00
                                          0.80
           6
                    1.00
                                                        4
                               1.00
                                          1.00
           7
                                                        1
                    1.00
                               1.00
                                          1.00
           8
                    1.00
                               1.00
                                          1.00
                                                        3
                                                        2
           9
                    1.00
                               1.00
                                          1.00
          10
                                          1.00
                                                        6
                    1.00
                               1.00
                                                        4
          11
                    1.00
                               0.75
                                          0.86
          12
                                                        6
                    1.00
                               0.67
                                          0.80
          13
                    1.00
                               1.00
                                          1.00
                                                        1
          14
                                                        2
                    1.00
                               1.00
                                          1.00
                                                        1
          15
                    0.33
                               1.00
                                          0.50
                                                        1
          16
                    0.50
                               1.00
                                          0.67
                                                        3
          17
                    1.00
                                          1.00
                               1.00
                                                        5
          18
                    0.83
                               1.00
                                          0.91
          19
                               0.50
                                                        4
                    1.00
                                          0.67
                                                        1
          21
                    0.00
                               0.00
                                          0.00
          22
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
          23
                    1.00
                               1.00
                                          1.00
          24
                                                        1
                    1.00
                               1.00
                                          1.00
```

26

27

28

29

30

31

32

33

34

35

36

0.67

1.00

1.00

1.00

0.67

1.00

1.00

1.00

1.00

1.00

1.00

1.00

0.40

1.00

1.00

1.00

1.00

0.80

1.00

1.00

1.00

1.00

1.00

1.00

0.50

1.00

1.00

1.00

0.80

0.89

1.00

1.00

1.00

1.00

1.00

1.00

5

2

3

4

2

5

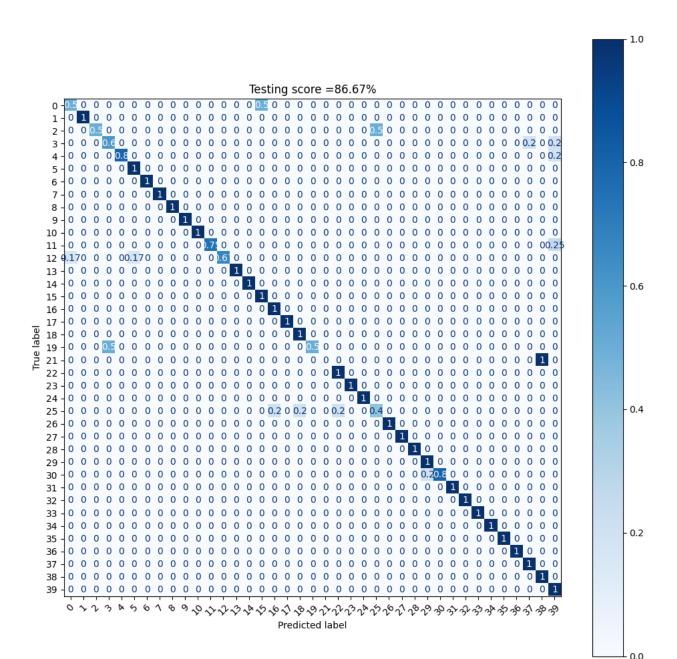
4

2

4

3

```
37
                   0.75
                             1.00
                                       0.86
                                                     3
                             1.00
                                       0.80
                                                     2
          38
                   0.67
          39
                   0.25
                             1.00
                                       0.40
                                                     1
                                                   120
                                       0.87
    accuracy
                   0.86
                             0.89
                                       0.85
                                                   120
   macro avg
                   0.90
                                       0.87
                                                   120
weighted avg
                             0.87
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
 warn prf(average, modifier, msg start, len(result))
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(1, 1, figsize=(12,12))
score = 100*clf MLP.score(Z test, y test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf MLP,
Z test,
y test,
xticks rotation=45, #'vertical',
# display labels=class names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
)
disp.ax .set title(title)
plt.show()
```



4.取 10 個主成分並使用使用 activation = 'relu'且 hidden_layers = (512,)

```
from sklearn.decomposition import PCA
from sklearn.neural_network import MLPClassifier

pca = PCA(n_components = 10).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)

hidden_layers = (512,)
activation = 'relu'
opts = dict(hidden_layer_sizes = hidden_layers , verbose = False, \
```

```
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(Z_train, y_train)
predictions = clf MLP.predict(Z test)
print(f"{clf_MLP.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
80.00%
                             recall f1-score
               precision
                                                 support
            0
                    1.00
                               0.25
                                          0.40
                                                        4
            1
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
            2
                    0.67
                               1.00
                                          0.80
            3
                                                        5
                    0.33
                               0.20
                                          0.25
           4
                                                        5
                    0.80
                               0.80
                                          0.80
                                                        2
           5
                               1.00
                                          1.00
                    1.00
            6
                               0.50
                                          0.67
                                                        4
                    1.00
           7
                                                        1
                    1.00
                               1.00
                                          1.00
           8
                    1.00
                               1.00
                                          1.00
                                                        3
                                                        2
           9
                    1.00
                               1.00
                                          1.00
           10
                                                        6
                    1.00
                               0.83
                                          0.91
                                                        4
           11
                    1.00
                               0.75
                                          0.86
                    0.50
           12
                                                        6
                               0.17
                                          0.25
          13
                    1.00
                               1.00
                                          1.00
                                                        1
          14
                    0.67
                                          0.80
                                                        2
                               1.00
                                                        1
           15
                    0.20
                               1.00
                                          0.33
                                                        1
          16
                    1.00
                               1.00
                                          1.00
                                                        3
           17
                    1.00
                                          1.00
                               1.00
                                                        5
          18
                    0.83
                               1.00
                                          0.91
          19
                    0.67
                                                        4
                               1.00
                                          0.80
                                                        0
          20
                    0.00
                               0.00
                                          0.00
          21
                    1.00
                               1.00
                                          1.00
                                                        1
                                                        4
          22
                    0.80
                               1.00
                                          0.89
                                                        2
          23
                    1.00
                               1.00
                                          1.00
                                                        1
          24
                    0.50
                               1.00
                                          0.67
          25
                               0.20
                                                        5
                    1.00
                                          0.33
                                                        2
          26
                    1.00
                                          1.00
                               1.00
                                                        3
          27
                    1.00
                               1.00
                                          1.00
          28
                    0.80
                               1.00
                                          0.89
                                                        4
                                                        2
          29
                    1.00
                               1.00
                                          1.00
```

31

32

33

34

35

0.80

1.00

1.00

1.00

1.00

0.50

0.80

1.00

1.00

1.00

1.00

0.67

0.80

1.00

1.00

1.00

1.00

0.57

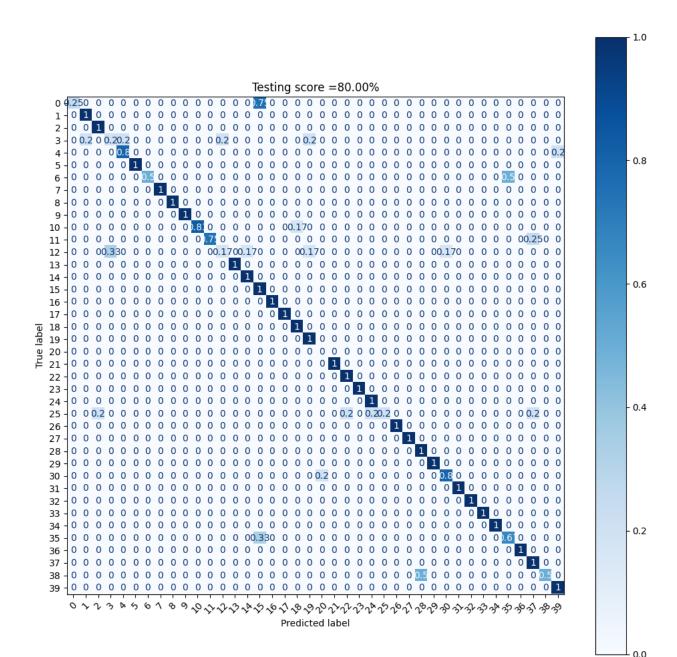
5

4

2

4

```
1.00
                             1.00
                                        1.00
                                                     4
          36
                             1.00
                   0.60
                                                     3
          37
                                        0.75
                                                     2
          38
                   1.00
                             0.50
                                        0.67
                   0.50
          39
                             1.00
                                        0.67
                                                     1
                                        0.80
                                                   120
    accuracy
                   0.82
                             0.84
                                        0.80
                                                   120
   macro avg
weighted avg
                   0.84
                             0.80
                                        0.78
                                                   120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(1, 1, figsize=(12,12))
score = 100*clf MLP.score(Z test, y test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf MLP,
Z test,
y test,
xticks rotation=45, #'vertical',
# display labels=class names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
disp.ax .set title(title)
plt.show()
```



5.取 30 個主成分並使用使用 activation = 'relu'且 hidden layers = (512,)

```
from sklearn.decomposition import PCA
from sklearn.neural_network import MLPClassifier

pca = PCA(n_components = 30).fit(X_train_)
Z_train = pca.transform(X_train_)
Z_test = pca.transform(X_test_)

hidden_layers = (512,)
activation = 'relu'
opts = dict(hidden_layer_sizes = hidden_layers , verbose = False, \
```

```
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf_MLP.fit(Z_train, y_train)
predictions = clf MLP.predict(Z test)
print(f"{clf_MLP.score(Z_test, y_test):.2%}\n")
print(classification report(y test, predictions))
88.33%
                             recall f1-score
               precision
                                                  support
            0
                    1.00
                               0.75
                                          0.86
                                                        4
            1
                    0.67
                               1.00
                                          0.80
                                                        4
                                                        2
            2
                    0.50
                               0.50
                                          0.50
            3
                                                        5
                    0.67
                               0.40
                                          0.50
            4
                                                        5
                    1.00
                               0.80
                                          0.89
                                                        2
            5
                               1.00
                                          1.00
                    1.00
            6
                    1.00
                               1.00
                                                        4
                                          1.00
            7
                                                        1
                    1.00
                               1.00
                                          1.00
            8
                    1.00
                               1.00
                                          1.00
                                                        3
                                                        2
            9
                    1.00
                               1.00
                                          1.00
           10
                               1.00
                                                        6
                    1.00
                                          1.00
                                                        4
           11
                    1.00
                               1.00
                                          1.00
           12
                                                        6
                    1.00
                               0.50
                                          0.67
           13
                    1.00
                               1.00
                                          1.00
                                                        1
           14
                                                        2
                    1.00
                               1.00
                                          1.00
                                                        1
           15
                    0.50
                               1.00
                                          0.67
                                                        1
           16
                    1.00
                               1.00
                                          1.00
                                                        3
           17
                    1.00
                               1.00
                                          1.00
                                                        5
           18
                    1.00
                               1.00
                                          1.00
           19
                                                        4
                    1.00
                               1.00
                                          1.00
                                                        0
           20
                    0.00
                               0.00
                                          0.00
           21
                    0.00
                               0.00
                                          0.00
                                                        1
                                                        4
           22
                    0.80
                               1.00
                                          0.89
                                                        2
          23
                    1.00
                               1.00
                                          1.00
                                                        1
           24
                    0.33
                               1.00
                                          0.50
           25
                                                        5
                    0.75
                               0.60
                                          0.67
                                                        2
           26
                    1.00
                               1.00
                                          1.00
                                                        3
           27
                    1.00
                               1.00
                                          1.00
           28
                    1.00
                               1.00
                                          1.00
                                                        4
                                                        2
           29
                    0.50
                               1.00
                                          0.67
                                                        5
           30
                    1.00
                               0.60
                                          0.75
                                                        4
           31
                    1.00
                               1.00
                                          1.00
                                                        2
          32
                    1.00
                               1.00
                                          1.00
           33
                    1.00
                               1.00
                                          1.00
                                                        4
                                                        3
           34
                    1.00
                               1.00
                                          1.00
```

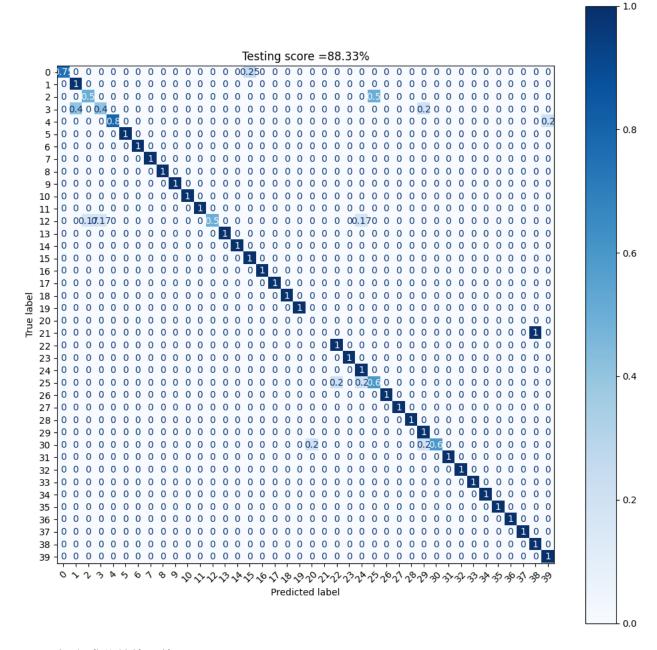
1.00

1.00

1.00

```
1.00
                                       1.00
                                                     4
          36
                   1.00
                                                     3
          37
                   1.00
                             1.00
                                       1.00
                                                     2
          38
                   0.67
                             1.00
                                       0.80
                   0.50
          39
                             1.00
                                       0.67
                                                     1
                                       0.88
                                                   120
    accuracy
                   0.85
                             0.88
                                       0.85
                                                   120
   macro avg
weighted avg
                   0.91
                             0.88
                                       0.88
                                                   120
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
_classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
   warn prf(average, modifier, msg start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Recall and F-score
are ill-defined and being set to 0.0 in labels with no true samples.
Use `zero_division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(1, 1, figsize=(12,12))
score = 100*clf MLP.score(Z test, y test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf MLP,
Z test,
y_test,
```

```
xticks_rotation=45, #'vertical',
# display_labels=class_names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
)
disp.ax_.set_title(title)
plt.show()
```



6.取 50 個主成分並使用使用 activation = 'relu'且 hidden_layers = (512,)

```
from sklearn.decomposition import PCA
from sklearn.neural network import MLPClassifier
pca = PCA(n components = 50).fit(X_train_)
Z train = pca.transform(X train )
Z test = pca.transform(X test )
hidden layers = (512,)
activation = 'relu'
opts = dict(hidden layer sizes = hidden layers , verbose = False, \
activation = activation, tol = 1e-6, max iter = int(1e6))
# solver = 'sgd' # not efficient, need more tuning
# solver = 'lbfgs' # not suitable here
solver = 'adam' # default solver
clf MLP = MLPClassifier(solver = solver, **opts)
clf MLP.fit(Z train, y train)
predictions = clf MLP.predict(Z test)
print(f"{clf MLP.score(Z test, y test):.2%}\n")
print(classification_report(y_test, predictions))
90.83%
               precision
                            recall f1-score
                                                support
                    1.00
                              1.00
                                         1.00
                                                       4
           0
           1
                                                       4
                    0.80
                              1.00
                                         0.89
           2
                                                       2
                    1.00
                              0.50
                                         0.67
                                                       5
           3
                    0.75
                              0.60
                                         0.67
                                                       5
           4
                              0.80
                    1.00
                                         0.89
           5
                                                       2
                    0.67
                              1.00
                                         0.80
           6
                                                       4
                    1.00
                              1.00
                                         1.00
           7
                    1.00
                              1.00
                                         1.00
                                                       1
           8
                                                       3
                    1.00
                              1.00
                                         1.00
           9
                                                       2
                    1.00
                              1.00
                                         1.00
                                                       6
          10
                    1.00
                              1.00
                                         1.00
          11
                    1.00
                              1.00
                                         1.00
                                                       4
                    1.00
                                         0.80
                                                       6
          12
                              0.67
          13
                    1.00
                              1.00
                                         1.00
                                                       1
                                                       2
          14
                    0.67
                              1.00
                                         0.80
          15
                                                       1
                    1.00
                              1.00
                                         1.00
                    1.00
                              1.00
                                                       1
          16
                                         1.00
          17
                                                       3
                    1.00
                              1.00
                                         1.00
                                                       5
          18
                    1.00
                              1.00
                                         1.00
          19
                    0.75
                              0.75
                                         0.75
                                                       4
                                                       1
          21
                    0.00
                              0.00
                                         0.00
                                                       4
          22
                    0.80
                              1.00
                                         0.89
```

24

25

26

1.00

1.00

0.80

1.00

1.00

1.00

0.80

1.00

1.00

1.00

0.80

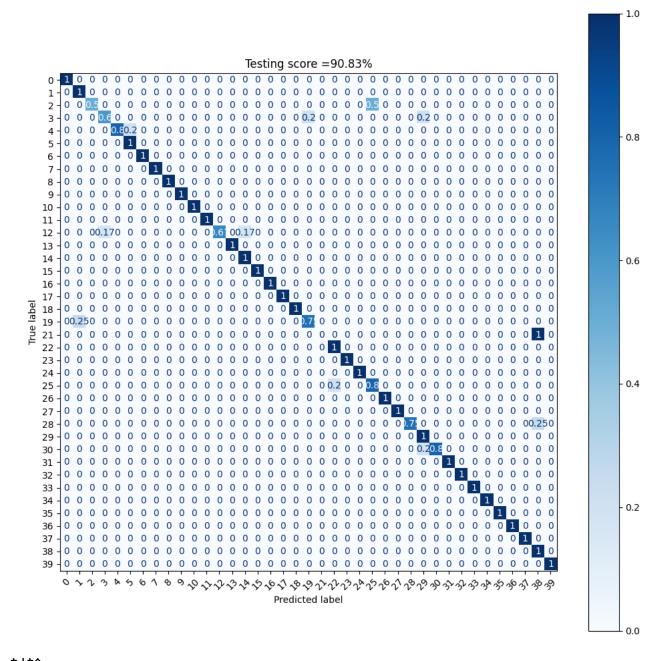
1.00

2

1

5

```
27
                   1.00
                              1.00
                                        1.00
                                                      3
                                                      4
          28
                   1.00
                              0.75
                                        0.86
                                                      2
          29
                   0.50
                              1.00
                                        0.67
                                                      5
          30
                   1.00
                              0.80
                                        0.89
                                                      4
          31
                   1.00
                              1.00
                                        1.00
                                                      2
          32
                   1.00
                              1.00
                                        1.00
                                                      4
          33
                   1.00
                              1.00
                                        1.00
          34
                   1.00
                              1.00
                                        1.00
                                                      3
          35
                                                      3
                   1.00
                              1.00
                                        1.00
                                                      4
          36
                   1.00
                              1.00
                                        1.00
                                                      3
          37
                   1.00
                              1.00
                                        1.00
                                                      2
          38
                   0.50
                              1.00
                                        0.67
          39
                                        1.00
                                                      1
                   1.00
                              1.00
    accuracy
                                        0.91
                                                    120
                   0.90
                              0.91
                                        0.90
                                                    120
   macro avq
                   0.92
                              0.91
                                        0.91
                                                   120
weighted avg
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
d:\vs\venv name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
d:\vs\venv_name\lib\site-packages\sklearn\metrics\
classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero division` parameter to control this behavior.
  warn prf(average, modifier, msg start, len(result))
import matplotlib.pyplot as plt
from sklearn.metrics import ConfusionMatrixDisplay
fig, ax = plt.subplots(1, 1, figsize=(12,12))
score = 100*clf MLP.score(Z test, y test)
title = 'Testing score ={:.2f}%'.format(score)
disp = ConfusionMatrixDisplay.from estimator(
clf MLP.
Z test,
y test,
xticks rotation=45, #'vertical',
# display labels=class names,
cmap=plt.cm.Blues,
normalize='true',
ax = ax
)
```



討論:

使用 activation = 'logistic'且 hidden_layers = (30,):

- 取 10 個主成分時,準確率為 77.50%。
- 取 30 個主成分時,準確率為85.00%。
- 取 50 個主成分時,準確率為86.67%。

使用 activation = 'relu'且 hidden_layers = (512,):

- 取 10 個主成分時,準確率為80.00%。
- 取 30 個主成分時,準確率為88.33%。
- 取 50 個主成分時,準確率為 90.83%。

小結:

- 使用 activation = 'relu'和 hidden_layers = (512,)時,準確率較高。
- 取愈多主成分,準確率愈高。

總結:

依照準確率比較:

- · 多元羅吉斯回歸 (Multinomial Logistic Regression) (1)使用 lbfgs 演算法時,需要取 30 個主成分,準確率才會和原始資料相同。(2)使用 liblinear 演算法時,需要取 30 個主成分,準確率才會比原始資料高。(3)使用 newton-cg 演算法時,需要取 50 個主成分,準確率才會比原始資料高。(4)使用 newton-cg 演算法且取 50 個主成分有最高的準確率 95.00%。
- 支援向量機 (Support Vector Machine) (1)使用 kernel='linear'時,需要取 30 個主成分,準確率才會比原始資料高。 (2)使用 kernel='rbf'時,需要取 50 個主成分,準確率才會和原始資料相同。 (3)使用 kernel='poly'時,只需要取 10 個主成分,準確率就比原始資料高。 (4)取 50 個主成分且使用 kernel='linear'(或 kernel='poly')有最高的準確率 94.17%。
- · 神經網路 (Neural Network) (1)在原始資料中,使用 activation = 'logistic'且 hidden_layers = (30,)之準確率較使用 activation = 'relu'且 hidden_layers = (512,) 高;但主成分資料卻相反。 (2)在主成分資料中,無論是何種 activation 和 hidden_layers , 取愈多主成分,準確率愈高。 (3)原始資料和使用 activation = 'relu'且 hidden_layers = (512,)且取 50 個主成分有最高的準確率 90.83%。

綜上所述:

- 我認為最佳分類器為多元羅吉斯回歸中取 50 個主成分且使用 newton-cg 演算法',因為它的準確率為所有分類器中最高(95.00%)。
- 由於資料樣本數較小,因此無論何種分類器執行時間都很短。