準備資料

In [ ]:

```
!gdown --id 1-M8SaDoY5ZxVuZED_ONfPwc_a3t_zXh5
```

```
/usr/local/lib/python3.10/dist-packages/gdown/cli.py:121: FutureWarning: O
ption `--id` was deprecated in version 4.3.1 and will be removed in 5.0. Y
ou don't need to pass it anymore to use a file ID.
  warnings.warn(
Downloading...
From: https://drive.google.com/uc?id=1-M8SaDoY5ZxVuZED_ONfPwc_a3t_zXh5
To: /content/MNIST.zip
100% 16.0M/16.0M [00:00<00:00, 40.8MB/s]
```

In [ ]:

```
!unzip MNIST.zip
```

```
Archive:  MNIST.zip
  inflating: mnist_test.csv
  inflating: mnist_train.csv
```

In [ ]:

```
!ls
```

```
mnist_test.csv  mnist_train.csv  MNIST.zip  sample_data
```

In [ ]:

```
import pandas as pd
import numpy as np

import seaborn as sns
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
from sklearn import datasets
from sklearn.manifold import TSNE
from sklearn.decomposition import PCA
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import StandardScaler
```

In [ ]:

```
train = pd.read_csv("mnist_train.csv")
train
```

Out[ ]:

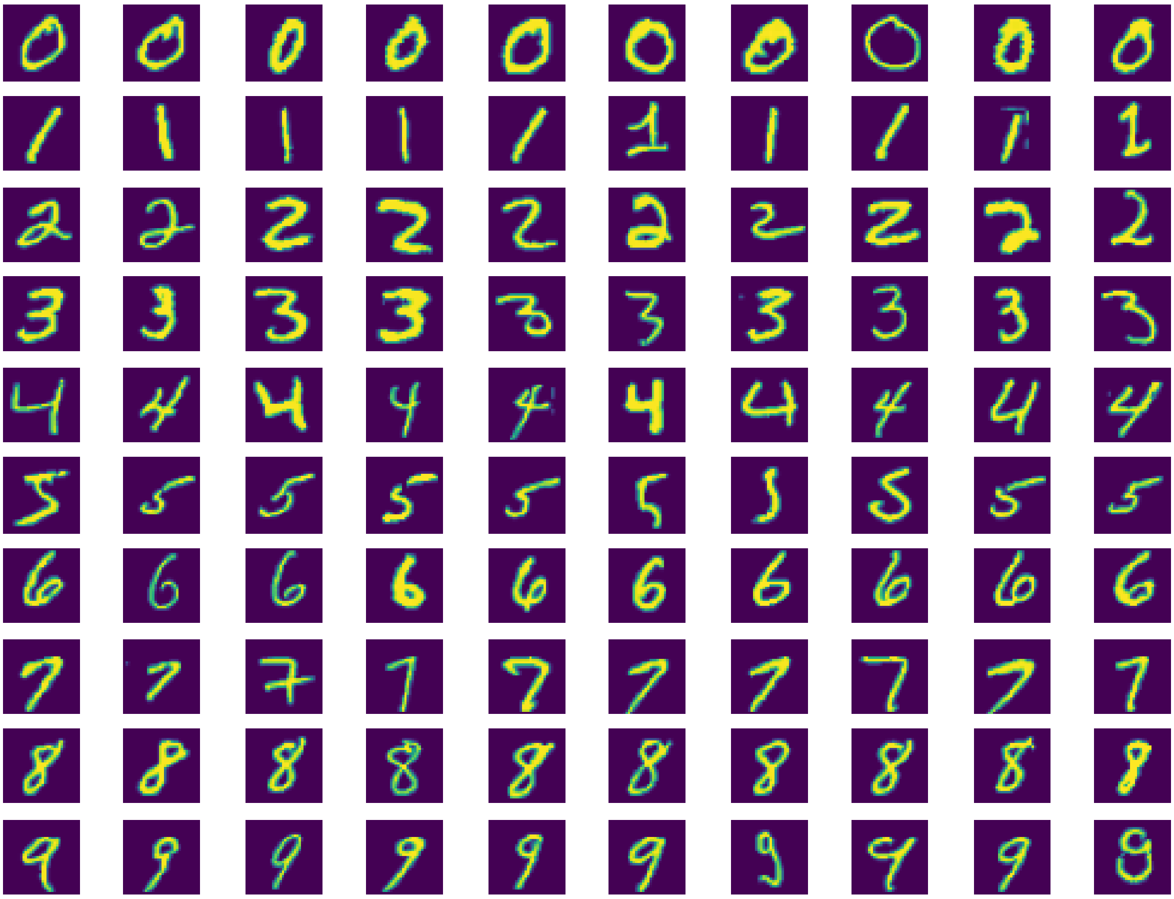
	label	1x1	1x2	1x3	1x4	1x5	1x6	1x7	1x8	1x9	...	28x19	28x20	28x21
0	5	0	0	0	0	0	0	0	0	0	...	0	0	0
1	0	0	0	0	0	0	0	0	0	0	...	0	0	0
2	4	0	0	0	0	0	0	0	0	0	...	0	0	0
3	1	0	0	0	0	0	0	0	0	0	...	0	0	0
4	9	0	0	0	0	0	0	0	0	0	...	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
59995	8	0	0	0	0	0	0	0	0	0	...	0	0	0
59996	3	0	0	0	0	0	0	0	0	0	...	0	0	0
59997	5	0	0	0	0	0	0	0	0	0	...	0	0	0
59998	6	0	0	0	0	0	0	0	0	0	...	0	0	0
59999	8	0	0	0	0	0	0	0	0	0	...	0	0	0

60000 rows × 785 columns

In [ ]:

```
def show_images(df, label_col, num_images):

    # 清空暫存
    plt.clf()

    # 讓圖片照順序
    labels = sorted(df[label_col].unique())

    # 建立 subplot
    f, axarr = plt.subplots(len(labels), num_images)

    for row, label in enumerate(labels):
        df_sub = df[df[label_col] == label]
        X = df_sub.drop(label_col, axis=1)
        for col in range(0, num_images):
            mat_data = X.iloc[col].values.reshape(28,28)  #reshape images
            axarr[row,col].imshow(mat_data) #plot the data
            axarr[row,col].axis('off')

show_images(train, 'label', 10)
```

```
<Figure size 640x480 with 0 Axes>
```



PCA

In [ ]:

```
X = train.drop('label', axis=1).values
y = train['label'].values
```

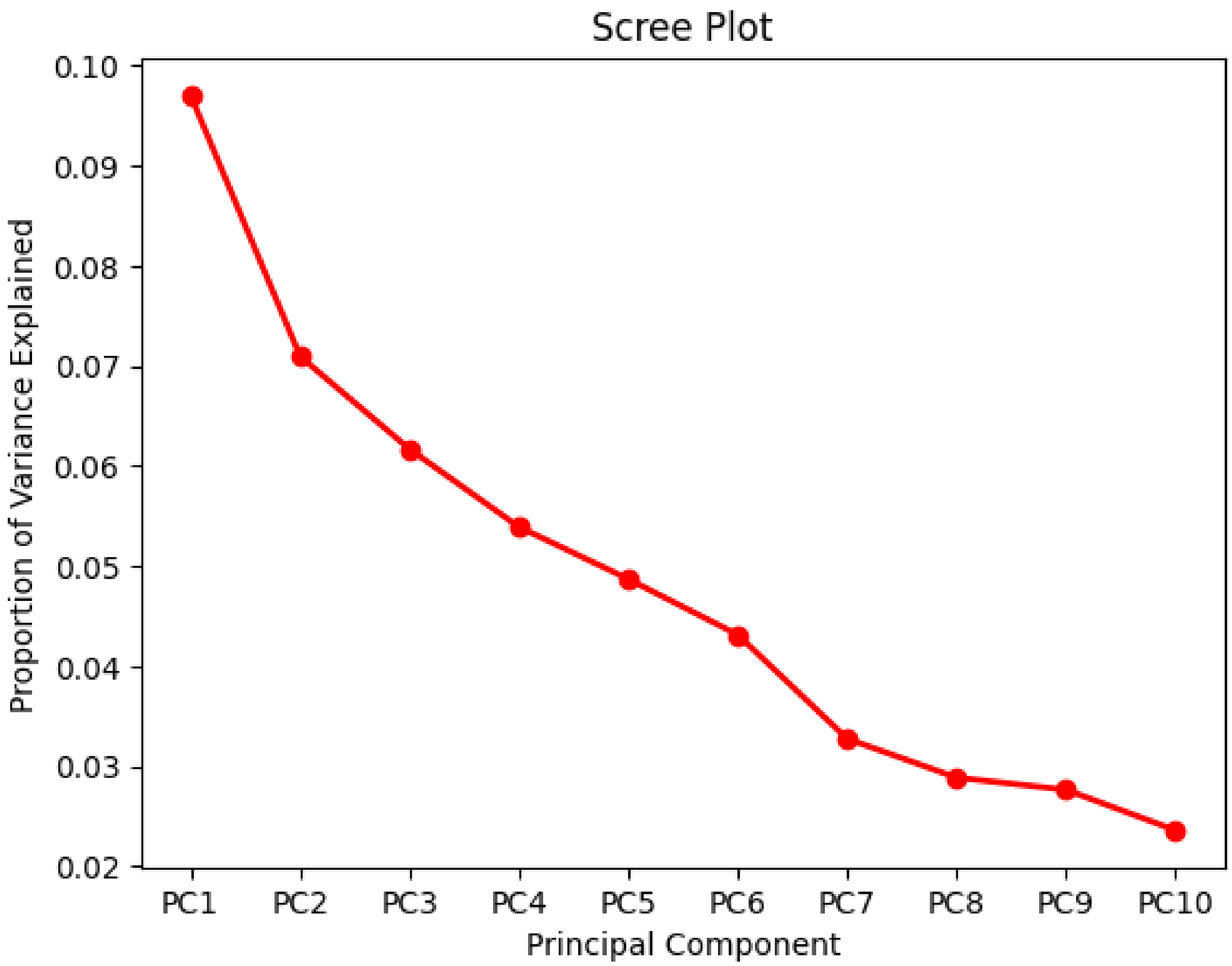
先觀察前 10 個的貢獻度

In [ ]:

```
pca = PCA(n_components=10, random_state=0)
X_pca_10 = pca.fit(X).transform(X)
```

In [ ]:

```
PC_values = [f'PC{i}'for i in (np.arange(pca.n_components_) + 1).astype(str
plt.plot(PC_values, pca.explained_variance_ratio_, 'ro-', linewidth=2)
plt.title('Scree Plot')
plt.xlabel('Principal Component')
plt.ylabel('Proportion of Variance Explained')
plt.show()
```



需要注意 **PCA** 的結果是固定的，不用再重新 **fit**

```
In [ ]: pd.DataFrame(X_pca_10)
```

Out[ ]:

	0	1	2	3	4	5	
0	123.932593	-312.674259	-24.513772	-555.757311	-27.298887	-232.471331	23
1	1011.718375	-294.857043	596.339480	-460.766251	-827.274918	-181.951550	-4
2	-51.849606	392.173169	-188.509488	521.012049	-306.680587	-1.830585	-85
3	-799.127031	-607.197201	273.651411	105.878687	-1.854637	699.657520	-47
4	-382.754941	730.542871	16.353833	-241.697250	98.161802	43.231378	-9
...	...	...	...	...	...	...	
59995	-99.621762	-293.475566	135.940226	-347.124050	304.275492	236.995399	-49
59996	152.757806	-687.899699	-88.932378	-650.013444	198.409353	184.774328	-48
59997	-178.053447	160.078226	-257.612911	-714.649966	-210.314974	-462.458756	-46
59998	130.606068	-5.591941	513.858382	342.703231	-521.164424	-540.557392	-10
59999	-173.435953	-24.718799	556.018936	-120.861710	-197.999637	233.027149	-46

60000 rows × 10 columns

In [ ]:

```
pca_test = PCA(n_components=2, random_state=0)
X_pca_test = pca_test.fit_transform(X)
pd.DataFrame(X_pca_test)
```

Out[ ]:

	0	1
0	123.927999	-312.670779
1	1011.720562	-294.835325
2	-51.852594	392.167907
3	-799.126365	-607.176613
4	-382.752613	730.531346
...	...	...
59995	-99.622519	-293.505147
59996	152.754769	-687.916951
59997	-178.053575	160.072952
59998	130.608651	-5.592387
59999	-173.433311	-24.717447

60000 rows × 2 columns

我們可以直接透過對應位置取 **PC1、PC2 ...**

In [ ]:

```
# use PCA to reduce dimension from 64 to 2 (PC! 、PC2)
X_pca_2d = X_pca_10[:, :2]
print('Dimensions after PCA-2D:', X_pca_2d.shape)
```

```
Dimensions after PCA-2D: (60000, 2)
```

In [ ]:

```
# use PCA to reduce dimension from 64 to 3 (PC! 、PC2 、PC3)
X_pca_3d = X_pca_10[:, :3]
print('Dimensions after PCA-3D:', X_pca_3d.shape)
```

```
Dimensions after PCA-3D: (60000, 3)
```

TSNE

tsne 比較耗效能，colab 上提供的 cpu 運算資源有限，這邊先抽樣 500 筆代表

In [ ]:

```
sample500 = train.sample(1000)
sample500
```

Out[ ]:

	label	1x1	1x2	1x3	1x4	1x5	1x6	1x7	1x8	1x9	...	28x19	28x20	28x21
33878	2	0	0	0	0	0	0	0	0	0	...	0	0	0
31538	3	0	0	0	0	0	0	0	0	0	...	0	0	0
20970	2	0	0	0	0	0	0	0	0	0	...	0	0	0
48646	4	0	0	0	0	0	0	0	0	0	...	0	0	0
943	0	0	0	0	0	0	0	0	0	0	...	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
29369	9	0	0	0	0	0	0	0	0	0	...	0	0	0
31679	1	0	0	0	0	0	0	0	0	0	...	0	0	0
33974	9	0	0	0	0	0	0	0	0	0	...	0	0	0
47172	0	0	0	0	0	0	0	0	0	0	...	0	0	0
29000	2	0	0	0	0	0	0	0	0	0	...	0	0	0

1000 rows × 785 columns

In [ ]:

```
s_X = sample500.drop('label', axis=1).values
s_y = sample500['label'].values
```

In [ ]:

```
# use tSNE to reduce dimension from 64 to 2
tsne = make_pipeline(StandardScaler(), TSNE(n_components=2, init='pca', rar
X_tsne_2d = tsne.fit_transform(s_X, s_y)
print('Dimensions after tSNE-2D:', X_tsne_2d.shape)
```

```
Dimensions after tSNE-2D: (1000, 2)
```

In [ ]:

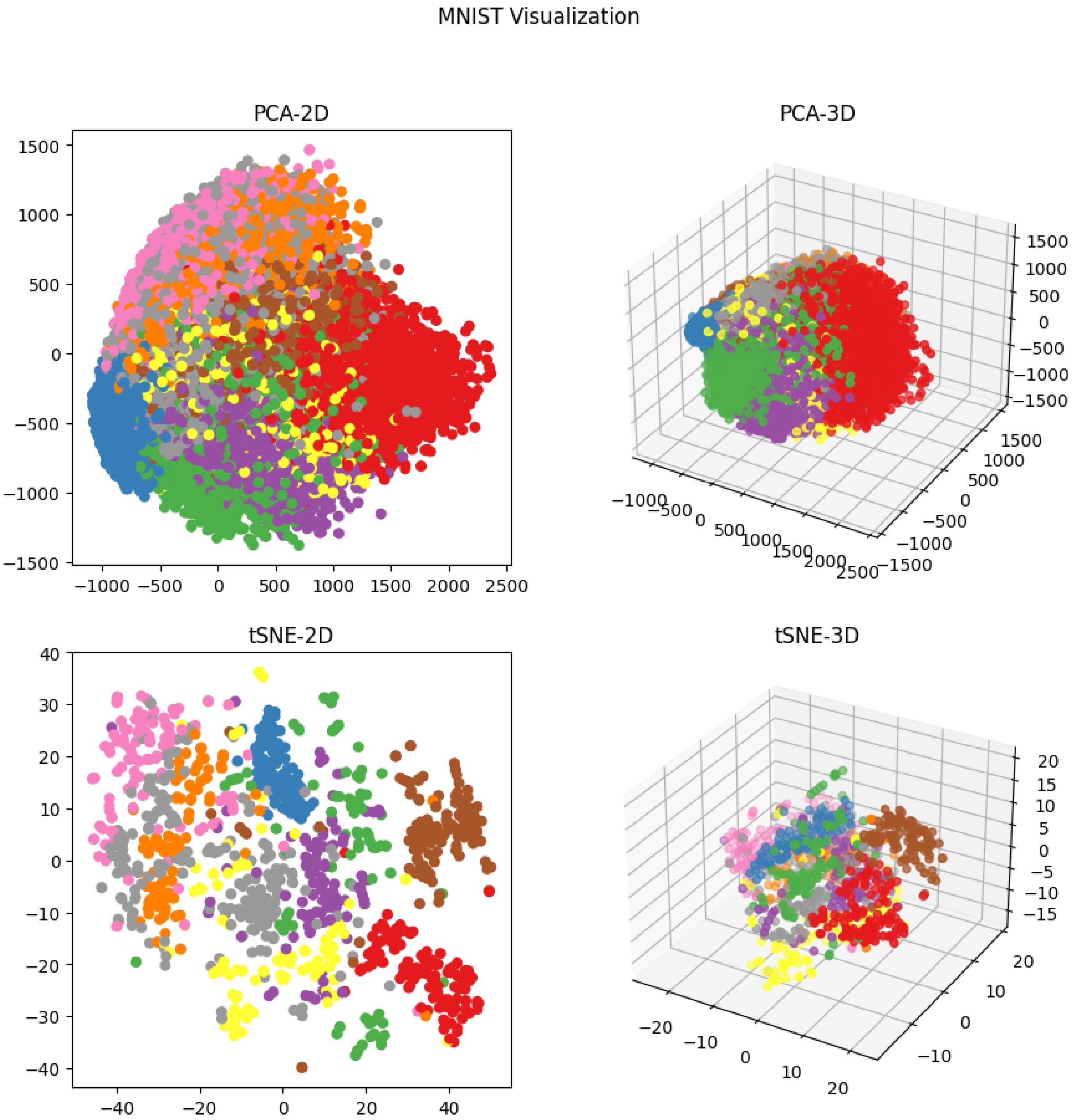
```
# use tSNE to reduce dimension from 64 to 3
tsne = make_pipeline(StandardScaler(), TSNE(n_components=3, init='pca', rar
X_tsne_3d = tsne.fit_transform(s_X, s_y)
print('Dimensions after tSNE-3D:', X_tsne_3d.shape)
```

```
Dimensions after tSNE-3D: (1000, 3)
```

視覺化

In [ ]:

```
# plot the points projected with PCA and tSNE
fig = plt.figure(figsize=(10,10))
fig.suptitle('MNIST Visualization')

ax = fig.add_subplot(221)
ax.title.set_text('PCA-2D')
ax.scatter(X_pca_2d[:, 0], X_pca_2d[:, 1], c=y, s=30, cmap='Set1')

ax = fig.add_subplot(222, projection='3d')
ax.title.set_text('PCA-3D')
ax.scatter(X_pca_3d[:, 0], X_pca_3d[:, 1], X_pca_3d[:, 2], c=y, cmap='Set1'

ax = fig.add_subplot(223)
ax.title.set_text('tSNE-2D')
ax.scatter(X_tsne_2d[:, 0], X_tsne_2d[:, 1], c=s_y, s=30, cmap='Set1')

ax = fig.add_subplot(224, projection='3d')
ax.title.set_text('tSNE-3D')
ax.scatter(X_tsne_3d[:, 0], X_tsne_3d[:, 1], X_tsne_3d[:, 2], c=s_y, cmap='

plt.show()
```


MNIST Visualization
PCA-2D
1500
1000
500
0
−500
−1000
−1500
−1000 −500 0 500 1000 1500 2000 2500
PCA-3D
1500
1000
500
0
−500
−1000
−1500
−1000 −500 0 500 1000 1500 2000 2500
1500 1000 500 0 −500 −1000 −1500
tSNE-2D
40
30
20
10
0
−10
−20
−30
−40
−40 −20 0 20 40
tSNE-3D
20
15
10
5
0
−5
−10
−15
−20 −10 0 10 20
20 10 0 −10