

```
import tensorflow as tf
from tensorflow import keras
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

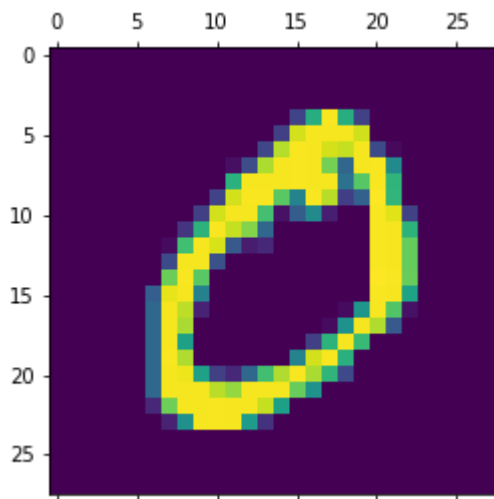
```
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()
```

Downloading data from <https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist11490434/11490434> [=====] - 0s 0us/step



```
plt.matshow(x_train[1])
```

<matplotlib.image.AxesImage at 0x7f0112c58d90>



```
x_train[0]
```

```
array([[ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  3,
        18, 18, 18, 126, 136, 175, 26, 166, 255, 247, 127,  0,  0,
```



```
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.01176471, 0.07058824, 0.07058824,
 0.07058824, 0.49411765, 0.53333333, 0.68627451, 0.10196078,
 0.65098039, 1.      , 0.96862745, 0.49803922, 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.11764706, 0.14117647,
 0.36862745, 0.60392157, 0.66666667, 0.99215686, 0.99215686,
 0.99215686, 0.99215686, 0.99215686, 0.88235294, 0.6745098 ,
 0.99215686, 0.94901961, 0.76470588, 0.25098039, 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.19215686, 0.93333333, 0.99215686,
 0.99215686, 0.99215686, 0.99215686, 0.99215686, 0.99215686,
 0.99215686, 0.99215686, 0.98431373, 0.36470588, 0.32156863,
 0.32156863, 0.21960784, 0.15294118, 0.      , 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.07058824, 0.85882353, 0.99215686,
 0.99215686, 0.99215686, 0.99215686, 0.99215686, 0.77647059,
 0.71372549, 0.96862745, 0.94509804, 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
 0.      , 0.      , 0.      , 0.31372549, 0.61176471,
 0.41960784, 0.99215686, 0.99215686, 0.80392157, 0.04313725,
 0.      , 0.16862745, 0.60392157, 0.      , 0.      ,
```

```
x_train.shape
```

```
(60000, 28, 28)
```

```
y_train.shape
```

```
(60000,)
```

```
model = keras.Sequential([
    keras.layers.Flatten(input_shape = (28,28)),
```

```
keras.layers.Dense(1000, activation = "relu"),
keras.layers.Dense(10, activation = "sigmoid")
])
```

```
model.compile(
    optimizer = "sgd",
    loss = "sparse_categorical_crossentropy",
    metrics = ["accuracy"]
)
```

```
model.fit(x_train, y_train, epochs = 7)
```

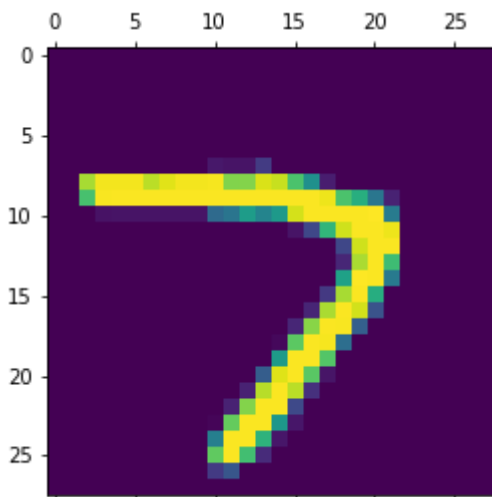
```
Epoch 1/7
1875/1875 [=====] - 13s 7ms/step - loss: 0.5892 - accuracy:
Epoch 2/7
1875/1875 [=====] - 12s 6ms/step - loss: 0.3143 - accuracy:
Epoch 3/7
1875/1875 [=====] - 12s 6ms/step - loss: 0.2670 - accuracy:
Epoch 4/7
1875/1875 [=====] - 12s 7ms/step - loss: 0.2368 - accuracy:
Epoch 5/7
1875/1875 [=====] - 12s 6ms/step - loss: 0.2140 - accuracy:
Epoch 6/7
1875/1875 [=====] - 13s 7ms/step - loss: 0.1960 - accuracy:
Epoch 7/7
1875/1875 [=====] - 13s 7ms/step - loss: 0.1804 - accuracy:
<keras.callbacks.History at 0x7f0112a19890>
```

```
model.evaluate(x_test, y_test)
```

```
313/313 [=====] - 1s 4ms/step - loss: 0.1749 - accuracy: 0.9
[0.17485949397087097, 0.9502000212669373]
```

```
plt.matshow(x_test[70])
```

```
<matplotlib.image.AxesImage at 0x7f0111926e90>
```



```
y_test[70]
```

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