```
import tensorflow
from tensorflow import keras
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense, Flatten

(X_train,y_train),(X_test,y_test)=keras.datasets.mnist.load_data()

X_test.shape
```

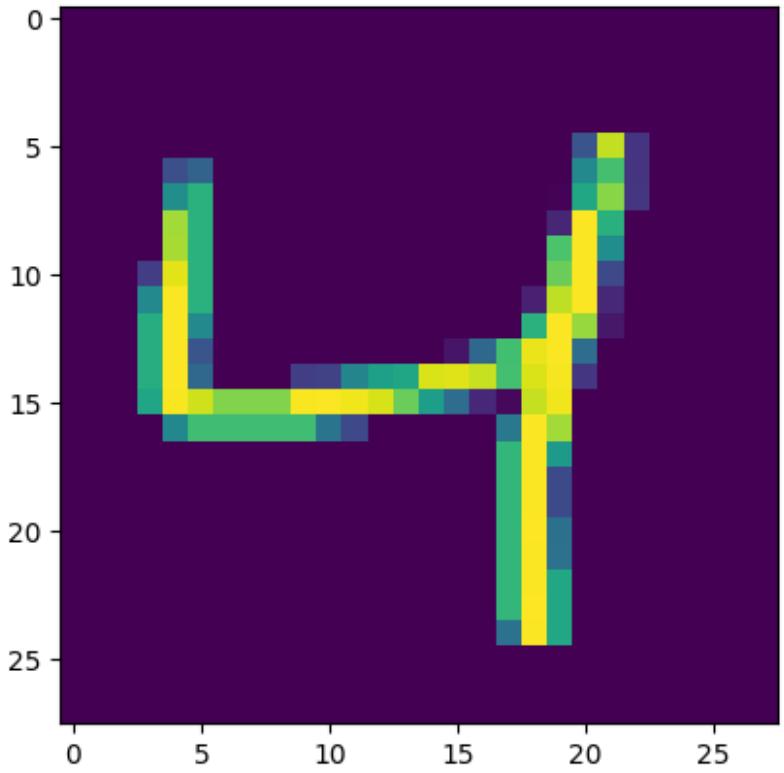
```
(10000, 28, 28)
```

```
y_train
```

```
array([5, 0, 4, ..., 5, 6, 8], dtype=uint8)
```

```
import matplotlib.pyplot as plt
plt.imshow(X_train[2])
```

```
<matplotlib.image.AxesImage at 0x1ef507a9040>
```




```
X_train = X_train/255

X_test = X_test/255
X_train[0]
```

```
array([[0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
```

```
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         0.65098039, 1.        , 0.96862745, 0.49803922, 0.        ,
         0.        , 0.        , 0.        ],
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         0.99215686, 0.99215686, 0.99215686, 0.88235294, 0.6745098 ,
         0.99215686, 0.94901961, 0.76470588, 0.25098039, 0.        ,
         0.        , 0.        , 0.        ],
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         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,
```

```
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        0.41960784, 0.99215686, 0.99215686, 0.80392157, 0.04313725,
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       [0.        , 0.        , 0.        , 0.        , 0.        ,
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        0.        , 0.        , 0.        , 0.        , 0.        ,
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```

```
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        0.83529412, 0.99215686, 0.99215686, 0.99215686, 0.99215686,
        0.77647059, 0.31764706, 0.00784314, 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
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        0.99215686, 0.99215686, 0.99215686, 0.76470588, 0.31372549,
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        0.        , 0.        , 0.        , 0.        , 0.        ,
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```

```
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        0.        , 0.        , 0.        , 0.        , 0.        ,
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       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
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        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ]])

model = Sequential()
model.add(Flatten(input_shape=(28,28)))
model.add(Dense(128,activation='relu'))
model.add(Dense(32,activation='relu'))
model.add(Dense(10,activation='softmax'))


model.summary()

Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 flatten (Flatten)           (None, 784)               0         
                                                                 
 dense (Dense)               (None, 128)               100480    
                                                                 
 dense_1 (Dense)             (None, 32)                4128      
                                                                 
 dense_2 (Dense)             (None, 10)                330       
                                                                 
=================================================================
Total params: 104938 (409.91 KB)
Trainable params: 104938 (409.91 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

model.compile(loss='sparse_categorical_crossentropy',optimizer='Adam',
metrics=['accuracy'])
```

```
history=model.fit(X_train,y_train,epochs=25,validation_split=0.2)

Epoch 1/25
1500/1500 [==============================] - 10s 2ms/step - loss:
0.2967 - accuracy: 0.9147 - val_loss: 0.1461 - val_accuracy: 0.9572
Epoch 2/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.1269 - accuracy: 0.9633 - val_loss: 0.1152 - val_accuracy: 0.9657
Epoch 3/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0887 - accuracy: 0.9735 - val_loss: 0.1076 - val_accuracy: 0.9692
Epoch 4/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0665 - accuracy: 0.9792 - val_loss: 0.1081 - val_accuracy: 0.9668
Epoch 5/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0507 - accuracy: 0.9840 - val_loss: 0.1078 - val_accuracy: 0.9687
Epoch 6/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0409 - accuracy: 0.9870 - val_loss: 0.1025 - val_accuracy: 0.9697
Epoch 7/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0340 - accuracy: 0.9887 - val_loss: 0.1188 - val_accuracy: 0.9693
Epoch 8/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0280 - accuracy: 0.9907 - val_loss: 0.0895 - val_accuracy: 0.9764
Epoch 9/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0219 - accuracy: 0.9925 - val_loss: 0.1061 - val_accuracy: 0.9734
Epoch 10/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0209 - accuracy: 0.9928 - val_loss: 0.1195 - val_accuracy: 0.9722
Epoch 11/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0168 - accuracy: 0.9947 - val_loss: 0.1105 - val_accuracy: 0.9744
Epoch 12/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0179 - accuracy: 0.9944 - val_loss: 0.1146 - val_accuracy: 0.9745
Epoch 13/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0144 - accuracy: 0.9952 - val_loss: 0.1227 - val_accuracy: 0.9738
Epoch 14/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0115 - accuracy: 0.9959 - val_loss: 0.1246 - val_accuracy: 0.9769
Epoch 15/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0125 - accuracy: 0.9957 - val_loss: 0.1297 - val_accuracy: 0.9735
Epoch 16/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0127 - accuracy: 0.9959 - val_loss: 0.1266 - val_accuracy: 0.9755
```

```
Epoch 17/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0127 - accuracy: 0.9960 - val_loss: 0.1437 - val_accuracy: 0.9733
Epoch 18/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0104 - accuracy: 0.9969 - val_loss: 0.1757 - val_accuracy: 0.9712
Epoch 19/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0094 - accuracy: 0.9970 - val_loss: 0.1379 - val_accuracy: 0.9745
Epoch 20/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0110 - accuracy: 0.9963 - val_loss: 0.1536 - val_accuracy: 0.9740
Epoch 21/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0058 - accuracy: 0.9979 - val_loss: 0.1471 - val_accuracy: 0.9742
Epoch 22/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0103 - accuracy: 0.9964 - val_loss: 0.1657 - val_accuracy: 0.9737
Epoch 23/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0089 - accuracy: 0.9970 - val_loss: 0.1787 - val_accuracy: 0.9734
Epoch 24/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0098 - accuracy: 0.9968 - val_loss: 0.1597 - val_accuracy: 0.9747
Epoch 25/25
1500/1500 [==============================] - 3s 2ms/step - loss:
0.0067 - accuracy: 0.9978 - val_loss: 0.1638 - val_accuracy: 0.9758
```

```
y_prob = model.predict(X_test)
```

```
313/313 [==============================] - 1s 1ms/step
```

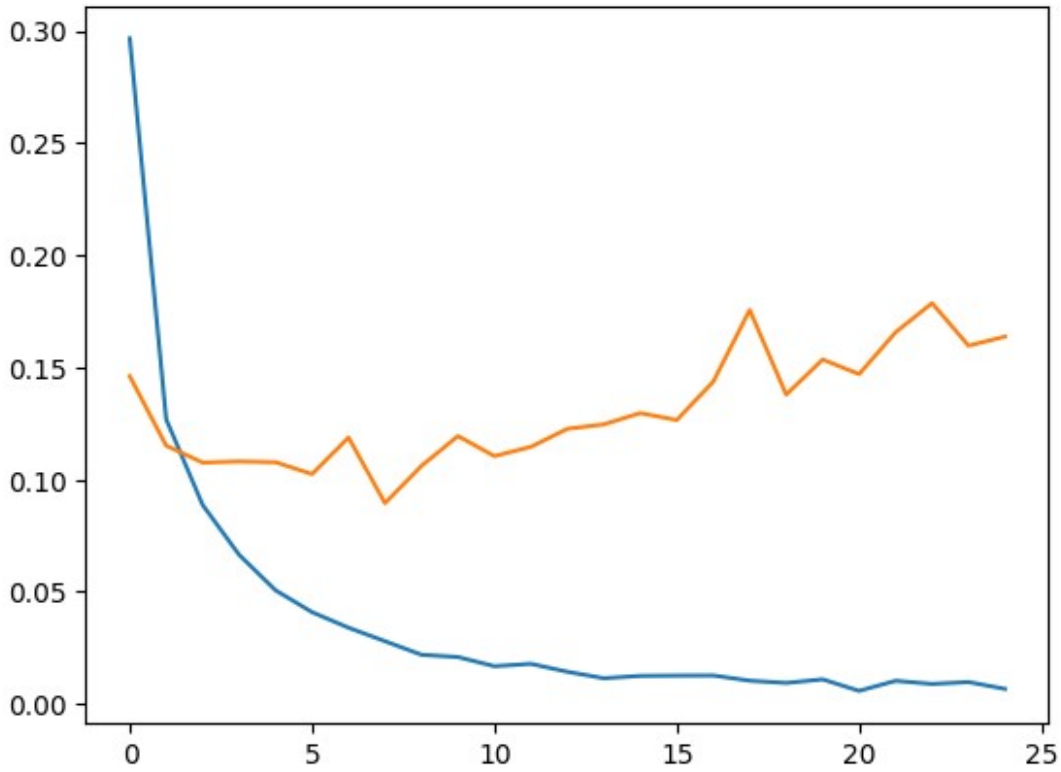
```
y_pred = y_prob.argmax(axis=1)
```

```
from sklearn.metrics import accuracy_score
accuracy_score(y_test,y_pred)
```

```
0.9767
```

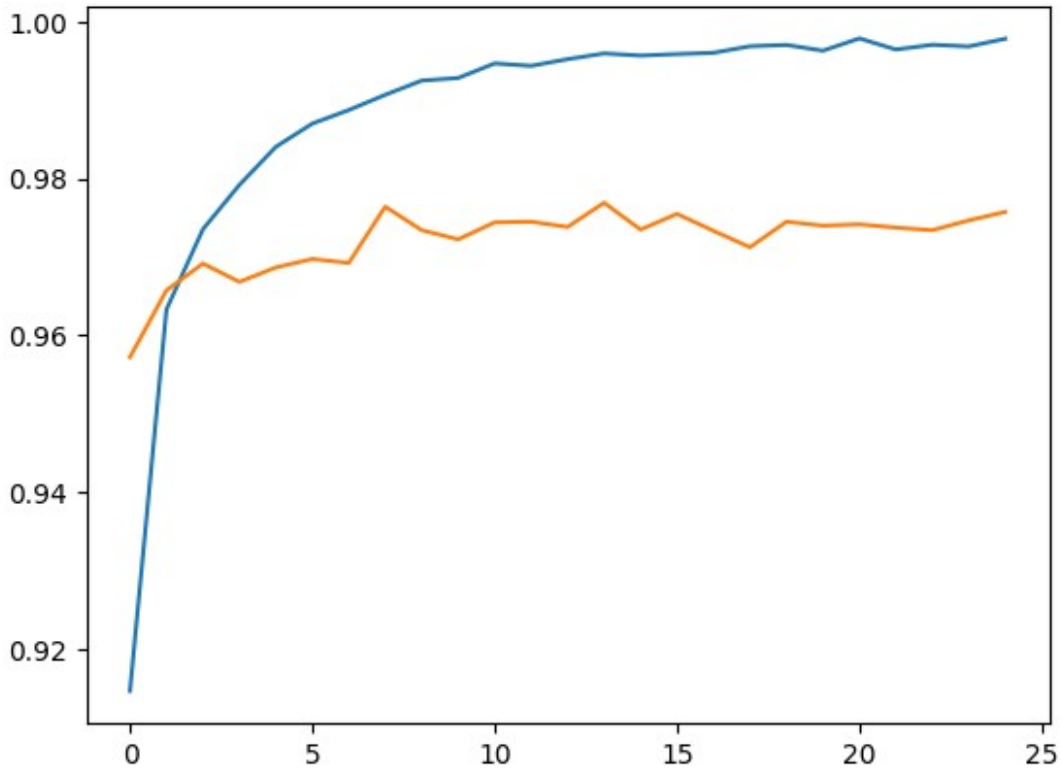
```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
```

```
[<matplotlib.lines.Line2D at 0x1ef725f4220>]
```



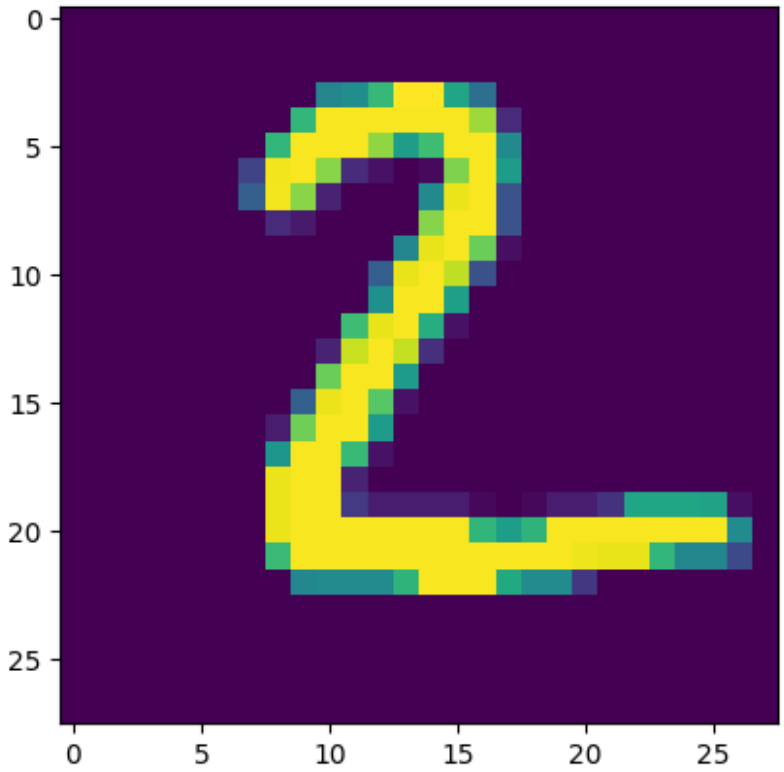

```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
```

```
[<matplotlib.lines.Line2D at 0x1ef72657b20>]
```




```
plt.imshow(X_test[1])
```

```
<matplotlib.image.AxesImage at 0x1ef72695d00>
```




```
model.predict(X_test[1].reshape(1,28,28)).argmax(axis=1)
```

```
1/1 [==============================] - 0s 83ms/step
```

```
array([2], dtype=int64)
```