In [ ]:
```python
import tensorflow
from tensorflow import keras
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense,Flatten
```

In [ ]:
```python
(X_train,y_train),(X_test,y_test) = keras.datasets.mnist.load_data()
```

In [ ]:
```python
X_test.shape
```

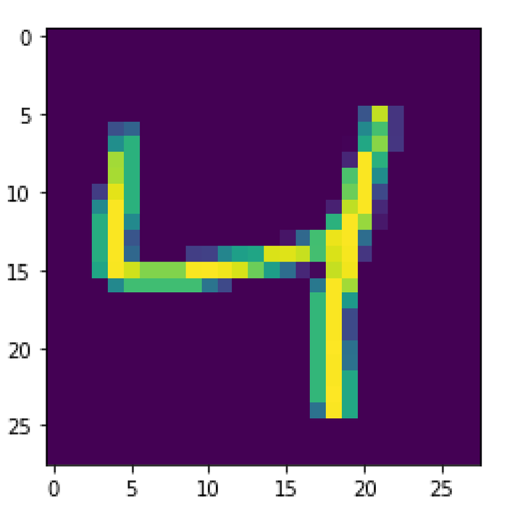
Out[ ]:
```
(10000, 28, 28)
```

In [ ]:
```python
y_train
```

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

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

Out[ ]:
```
<matplotlib.image.AxesImage at 0x7f573ed9f790>
```



In [ ]:
```python
X_train = X_train/255
X_test = X_test/255
```

In [ ]:
```python
X_train[0]
```

Out[ ]:
```
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.        , 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.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.05490196,
        0.00392157, 0.60392157, 0.99215686, 0.35294118, 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.        , 0.54509804, 0.99215686, 0.74509804, 0.00784314,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.04313725, 0.74509804, 0.99215686, 0.2745098 ,
        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.        , 0.1372549 , 0.94509804, 0.88235294,
        0.62745098, 0.42352941, 0.00392157, 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.31764706, 0.94117647,
        0.99215686, 0.99215686, 0.46666667, 0.09803922, 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.17647059,
        0.72941176, 0.99215686, 0.99215686, 0.58823529, 0.10588235,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.0627451 , 0.36470588, 0.98823529, 0.99215686, 0.73333333,
        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.        , 0.97647059, 0.99215686, 0.97647059,
        0.25098039, 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.18039216,
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        0.00784314, 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.15294118, 0.58039216, 0.89803922,
        0.99215686, 0.99215686, 0.99215686, 0.98039216, 0.71372549,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.09411765, 0.44705882, 0.86666667, 0.99215686, 0.99215686,
        0.99215686, 0.99215686, 0.78823529, 0.30588235, 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.09019608, 0.25882353,
        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.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.07058824, 0.67058824, 0.85882353, 0.99215686,
        0.99215686, 0.99215686, 0.99215686, 0.76470588, 0.31372549,
        0.03529412, 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.21568627,
        0.6745098 , 0.88627451, 0.99215686, 0.99215686, 0.99215686,
        0.99215686, 0.95686275, 0.52156863, 0.04313725, 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.53333333,
        0.99215686, 0.99215686, 0.99215686, 0.83137255, 0.52941176,
        0.51764706, 0.0627451 , 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.        ]])
```

In [ ]:
```python
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'))
```

In [ ]:
```python
model.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 flatten_4 (Flatten)         (None, 784)               0

 dense_11 (Dense)            (None, 128)               100480

 dense_12 (Dense)            (None, 32)                4128

 dense_13 (Dense)            (None, 10)                330

=================================================================
Total params: 104,938
Trainable params: 104,938
Non-trainable params: 0
_________________________________________________________________
```

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

In [ ]:
```python
history = model.fit(X_train,y_train,epochs=25,validation_split=0.2)
```

```
Epoch 1/25
1500/1500 [==============================] - 5s 3ms/step - loss: 0.2845 - accuracy: 0.9168 -
val_loss: 0.1425 - val_accuracy: 0.9570
Epoch 2/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.1164 - accuracy: 0.9638 -
val_loss: 0.1258 - val_accuracy: 0.9605
Epoch 3/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0800 - accuracy: 0.9754 -
val_loss: 0.0912 - val_accuracy: 0.9728
Epoch 4/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0594 - accuracy: 0.9817 -
val_loss: 0.1014 - val_accuracy: 0.9697
Epoch 5/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0462 - accuracy: 0.9851 -
val_loss: 0.1024 - val_accuracy: 0.9687
Epoch 6/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0377 - accuracy: 0.9881 -
val_loss: 0.1060 - val_accuracy: 0.9712
Epoch 7/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0313 - accuracy: 0.9898 -
val_loss: 0.0960 - val_accuracy: 0.9758
Epoch 8/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0283 - accuracy: 0.9902 -
val_loss: 0.1061 - val_accuracy: 0.9732
Epoch 9/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0230 - accuracy: 0.9923 -
val_loss: 0.1160 - val_accuracy: 0.9713
Epoch 10/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0179 - accuracy: 0.9939 -
val_loss: 0.1134 - val_accuracy: 0.9761
Epoch 11/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0177 - accuracy: 0.9937 -
val_loss: 0.1204 - val_accuracy: 0.9742
Epoch 12/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0156 - accuracy: 0.9947 -
val_loss: 0.1103 - val_accuracy: 0.9761
Epoch 13/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0156 - accuracy: 0.9949 -
val_loss: 0.1221 - val_accuracy: 0.9743
Epoch 14/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0121 - accuracy: 0.9960 -
val_loss: 0.1246 - val_accuracy: 0.9764
Epoch 15/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0122 - accuracy: 0.9958 -
val_loss: 0.1362 - val_accuracy: 0.9753
Epoch 16/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0100 - accuracy: 0.9964 -
val_loss: 0.1340 - val_accuracy: 0.9772
Epoch 17/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0131 - accuracy: 0.9955 -
val_loss: 0.1371 - val_accuracy: 0.9752
Epoch 18/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0101 - accuracy: 0.9968 -
val_loss: 0.1318 - val_accuracy: 0.9760
Epoch 19/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0116 - accuracy: 0.9962 -
val_loss: 0.1577 - val_accuracy: 0.9732
Epoch 20/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0093 - accuracy: 0.9969 -
val_loss: 0.1570 - val_accuracy: 0.9718
Epoch 21/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0095 - accuracy: 0.9970 -
val_loss: 0.1347 - val_accuracy: 0.9772
Epoch 22/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0076 - accuracy: 0.9975 -
val_loss: 0.1591 - val_accuracy: 0.9762
Epoch 23/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0079 - accuracy: 0.9975 -
val_loss: 0.1919 - val_accuracy: 0.9682
Epoch 24/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0078 - accuracy: 0.9974 -
val_loss: 0.1692 - val_accuracy: 0.9737
Epoch 25/25
1500/1500 [==============================] - 4s 3ms/step - loss: 0.0084 - accuracy: 0.9971 -
val_loss: 0.1647 - val_accuracy: 0.9753
```

In [ ]:
```python
y_prob = model.predict(X_test)
```

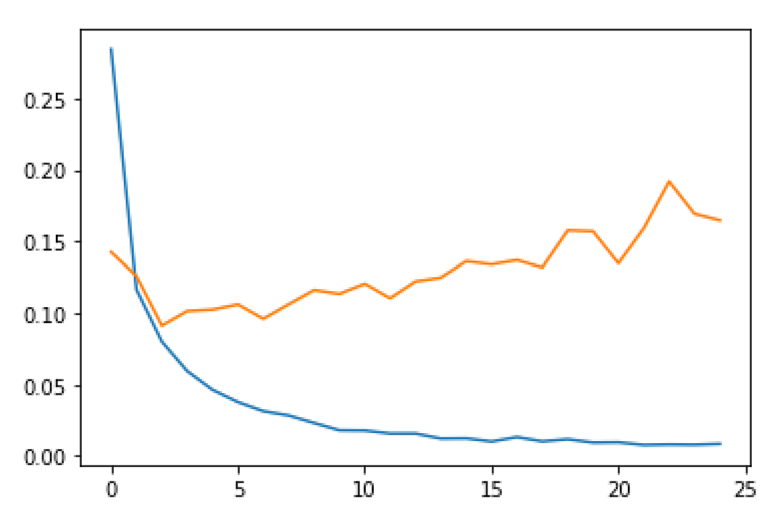
In [ ]:
```python
y_pred = y_prob.argmax(axis=1)
```

In [ ]:
```python
from sklearn.metrics import accuracy_score
accuracy_score(y_test,y_pred)
```

Out[ ]:
```
0.9755
```

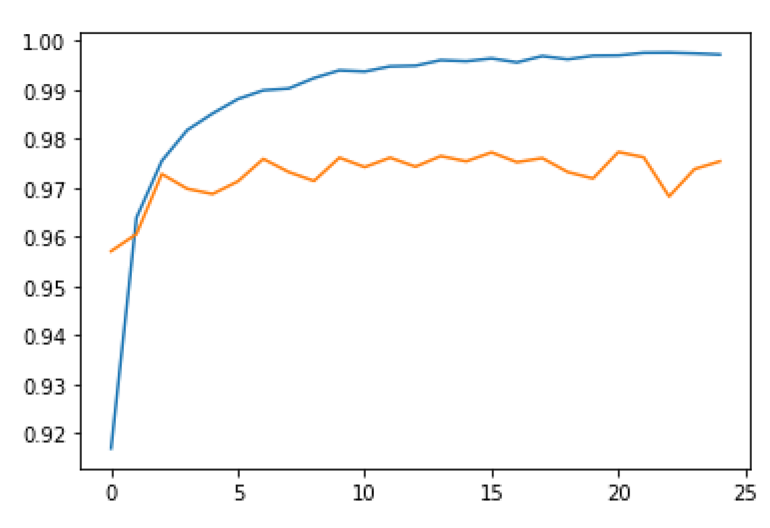
In [ ]:
```python
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
```

Out[ ]:
```
[<matplotlib.lines.Line2D at 0x7f5737a6c590>]
```



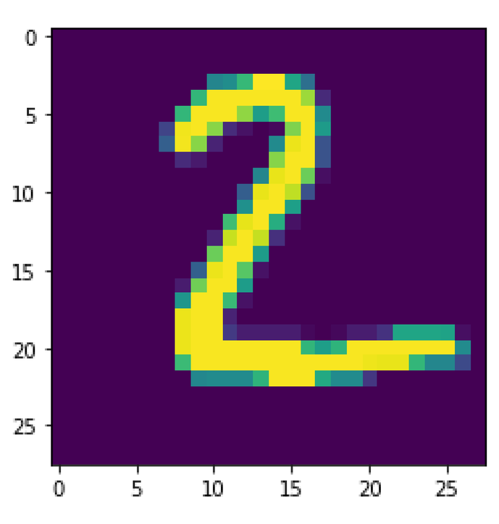
In [ ]:
```python
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
```

Out[ ]:
```
[<matplotlib.lines.Line2D at 0x7f5737831e50>]
```



In [ ]:
```python
plt.imshow(X_test[1])
```

Out[ ]:
```
<matplotlib.image.AxesImage at 0x7f5736844c50>
```



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

Out[ ]:
```
array([2])
```

In [ ]: