Bharat Data Science Internship

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Task 3 :Number Recognition

- Objectiove: Handwritten digit recognition system not only detects scanned images of handwritten digits.Handwritten digit recognition using MNIST dataset is a major project made with the help of Neural Network.

- Dataset Description:
- The MNIST database (Modified National Institute of Standards and Technology database) is a large collection of handwritten digits. It has a training set of 60,000 examples, and a test set of 10,000 examples. It is a subset of a larger NIST Special Database 3 (digits written by employees of the United States Census Bureau) and Special Database 1 (digits written by high school students) which contain monochrome images of handwritten digits. The digits have been size-normalized and centered in a fixed-size image. The original black and white (bilevel) images from NIST were size normalized to fit in a 20x20 pixel box while preserving their aspect ratio. The resulting images contain grey levels as a result of the anti-aliasing technique used by the normalization algorithm. the images were centered in a 28x28 image by computing the center of mass of the pixels, and translating the image so as to position this point at the center of the 28x28 field.

In [1]:
```
import tensorflow
from tensorflow import keras
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense,Flatten
```

In [2]:
```
(X_train,y_train),(X_test,y_test) = keras.datasets.mnist.load_data()
```

In [3]:
```
X_test.shape
```

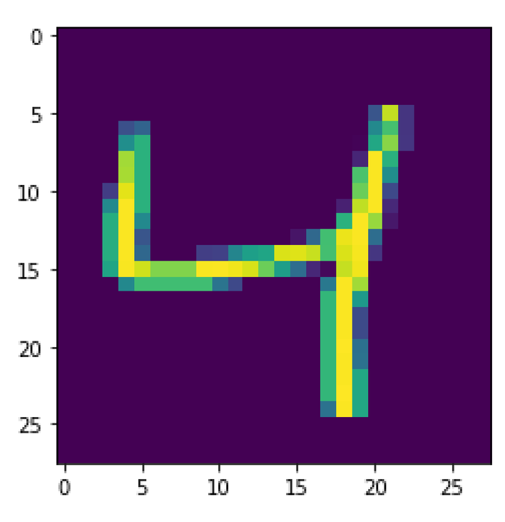
Out[3]:
```
(10000, 28, 28)
```

In [4]:
```
y_train
```

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

In [5]:
```
import matplotlib.pyplot as plt
plt.imshow(X_train[2])
```

Out[5]:
```
<matplotlib.image.AxesImage at 0x17f0fe24d00>
```



In [6]:
```
X_train = X_train/255
X_test = X_test/255
```

In [7]:
```
X_train[0]
```

Out[7]:
```
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,
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        0.        , 0.        , 0.        ],
       [0.        , 0.        , 0.        , 0.        , 0.        ,
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        0.00784314, 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        ],
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        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 [8]:
```
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 [9]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 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: 104,938
Trainable params: 104,938
Non-trainable params: 0
_________________________________________________________________
```

In [10]:
```
model.compile(loss='sparse_categorical_crossentropy',optimizer='Adam',metrics=['accuracy'])
```

In [11]:
```
history = model.fit(X_train,y_train,epochs=25,validation_split=0.2)
```

```
Epoch 1/25
1500/1500 [==============================] - 12s 7ms/step - loss: 0.3020 - accuracy: 0.9104 - val_loss: 0.1696 - val_accuracy: 0.9511
Epoch 2/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.1258 - accuracy: 0.9624 - val_loss: 0.1202 - val_accuracy: 0.9661
Epoch 3/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0852 - accuracy: 0.9740 - val_loss: 0.1071 - val_accuracy: 0.9705
Epoch 4/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0644 - accuracy: 0.9796 - val_loss: 0.1115 - val_accuracy: 0.9676
Epoch 5/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0495 - accuracy: 0.9845 - val_loss: 0.0909 - val_accuracy: 0.9742
Epoch 6/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0393 - accuracy: 0.9873 - val_loss: 0.1171 - val_accuracy: 0.9688
Epoch 7/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0311 - accuracy: 0.9904 - val_loss: 0.1058 - val_accuracy: 0.9721
Epoch 8/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0285 - accuracy: 0.9909 - val_loss: 0.1094 - val_accuracy: 0.9727
Epoch 9/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0229 - accuracy: 0.9924 - val_loss: 0.0963 - val_accuracy: 0.9762
Epoch 10/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0204 - accuracy: 0.9931 - val_loss: 0.1099 - val_accuracy: 0.9746
Epoch 11/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0188 - accuracy: 0.9936 - val_loss: 0.1150 - val_accuracy: 0.9750
Epoch 12/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0143 - accuracy: 0.9950 - val_loss: 0.1076 - val_accuracy: 0.9759
Epoch 13/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0138 - accuracy: 0.9956 - val_loss: 0.1192 - val_accuracy: 0.9757
Epoch 14/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0131 - accuracy: 0.9955 - val_loss: 0.1145 - val_accuracy: 0.9768
Epoch 15/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0113 - accuracy: 0.9964 - val_loss: 0.1336 - val_accuracy: 0.9731
Epoch 16/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0141 - accuracy: 0.9954 - val_loss: 0.1292 - val_accuracy: 0.9756
Epoch 17/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0110 - accuracy: 0.9964 - val_loss: 0.1291 - val_accuracy: 0.9772
Epoch 18/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0105 - accuracy: 0.9968 - val_loss: 0.1273 - val_accuracy: 0.9761
Epoch 19/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0065 - accuracy: 0.9979 - val_loss: 0.1215 - val_accuracy: 0.9776
Epoch 20/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0138 - accuracy: 0.9955 - val_loss: 0.1399 - val_accuracy: 0.9758
Epoch 21/25
1500/1500 [==============================] - 7s 5ms/step - loss: 0.0066 - accuracy: 0.9980 - val_loss: 0.1336 - val_accuracy: 0.9772
Epoch 22/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0089 - accuracy: 0.9970 - val_loss: 0.1479 - val_accuracy: 0.9762
Epoch 23/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0086 - accuracy: 0.9970 - val_loss: 0.1450 - val_accuracy: 0.9764
Epoch 24/25
1500/1500 [==============================] - 8s 5ms/step - loss: 0.0079 - accuracy: 0.9974 - val_loss: 0.1395 - val_accuracy: 0.9777
Epoch 25/25
1500/1500 [==============================] - 9s 6ms/step - loss: 0.0073 - accuracy: 0.9978 - val_loss: 0.1885 - val_accuracy: 0.9728
```

In [12]:
```
y_prob = model.predict(X_test)
```

```
313/313 [==============================] - 1s 4ms/step
```

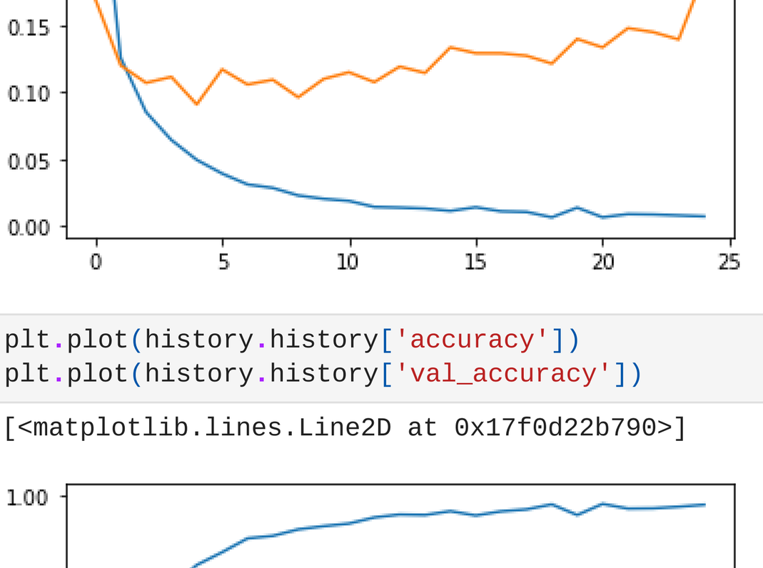
In [13]:
```
y_pred = y_prob.argmax(axis=1)
```

In [14]:
```
from sklearn.metrics import accuracy_score
accuracy_score(y_test,y_pred)
```

Out[14]:
```
0.974
```

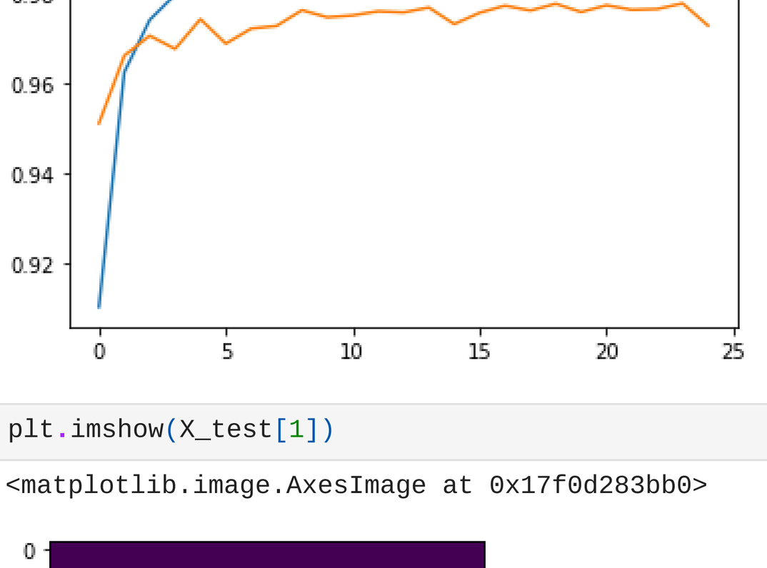
In [15]:
```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
```

Out[15]:
```
[<matplotlib.lines.Line2D at 0x17f0d1af550>]
```



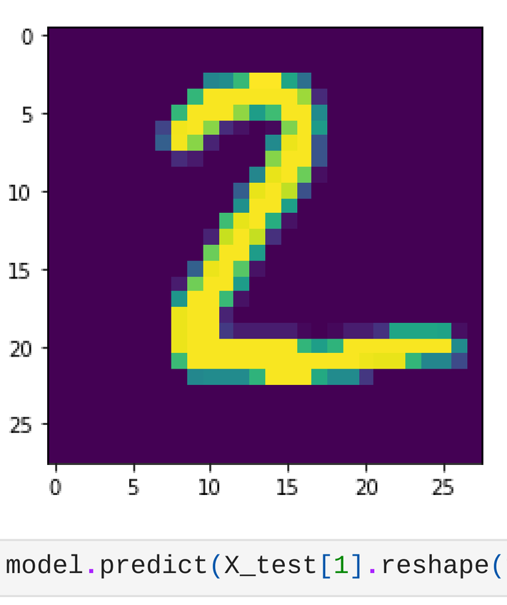
In [16]:
```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
```

Out[16]:
```
[<matplotlib.lines.Line2D at 0x17f0d22b790>]
```



In [17]:
```
plt.imshow(X_test[1])
```

Out[17]:
```
<matplotlib.image.AxesImage at 0x17f0d283bb0>
```



In [18]:
```
model.predict(X_test[1].reshape(1,28,28)).argmax(axis=1)
```

```
1/1 [==============================] - 0s 44ms/step
```

Out[18]:
```
array([2], dtype=int64)
```

Suggestions are always Welcome!

Thank You!