In [1]:

```
#importing necessary libraries
import tensorflow as tf
from tensorflow import keras
```

In [2]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import random
%matplotlib inline
```

In [3]:

```
#import dataset and split into train and test data
mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```

In [4]:

```
#to see length of training dataset
len(x_train)
```

Out[4]:

```
60000
```

In [5]:

```
##to see length of testing dataset
len(x_test)
```

Out[5]:

```
10000
```

In [6]:

```
x_train.shape

```

Out[6]:

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

In [7]:

```
#shape of testing dataset  10,000 images having 28*28 size
x_test.shape
```

Out[7]:

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

In [12]:

```

x_train[0]
```

Out[12]:

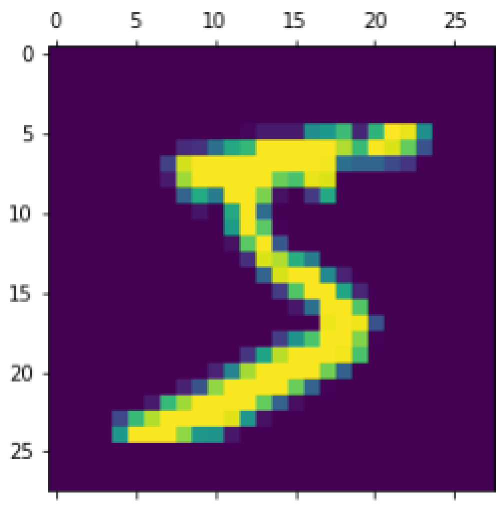
```
array([[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 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

In [8]:

```
#to see how first image look
plt.matshow(x_train[0])
```

Out[8]:

```
<matplotlib.image.AxesImage at 0x29b1cccc130>
```



In [9]:

```
#normalize the images by scaling pixel intensities to the range 0,1

x_train = x_train / 255
x_test = x_test / 255
```

In [10]:

```
x_train[0]
```

Out[10]:

```
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.     ],
```

In [ ]:

```
#Define the network architecture using Keras
```

In [11]:

```
model = keras.Sequential([
        keras.layers.Flatten(input_shape=(28, 28)),
        keras.layers.Dense(128, activation= 'relu'),
        keras.layers.Dense(10, activation= 'softmax')
])
```

In [12]:

```
model.summary()
```

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

 dense (Dense)               (None, 128)               100480

 dense_1 (Dense)             (None, 10)                1290

=================================================================
Total params: 101,770
Trainable params: 101,770
Non-trainable params: 0
_________________________________________________________________
```

Compile the model

In [13]:

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

Train the model

In [14]:

```
history=model.fit(x_train, y_train,validation_data=(x_test,y_test),epochs=10)
```

```
Epoch 1/10
1875/1875 [==============================] - 12s 4ms/step - loss: 0.6387 - a ccuracy:
0.8416 - val_loss: 0.3590 - val_accuracy: 0.9026
Epoch 2/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3385 - ac curacy:
0.9053 - val_loss: 0.2948 - val_accuracy: 0.9180
Epoch 3/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2921 - ac curacy:
0.9172 - val_loss: 0.2657 - val_accuracy: 0.9257
Epoch 4/10
1875/1875 [==============================] - 7s 3ms/step - loss: 0.2625 - ac curacy:
0.9252 - val_loss: 0.2436 - val_accuracy: 0.9330
Epoch 5/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.2393 - ac curacy:
0.9330 - val_loss: 0.2254 - val_accuracy: 0.9366
Epoch 6/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.2205 - ac curacy:
0.9377 - val_loss: 0.2107 - val_accuracy: 0.9400
Epoch 7/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.2042 - ac curacy:
0.9424 - val_loss: 0.1938 - val_accuracy: 0.9437
Epoch 8/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.1900 - ac curacy:
0.9466 - val_loss: 0.1837 - val_accuracy: 0.9466
Epoch 9/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.1777 - ac curacy:
0.9500 - val_loss: 0.1717 - val_accuracy: 0.9497
Epoch 10/10
1875/1875 [==============================] - 7s 4ms/step - loss: 0.1670 - ac curacy:
0.9529 - val_loss: 0.1627 - val_accuracy: 0.9518
```

Evaluate the model

In [15]:

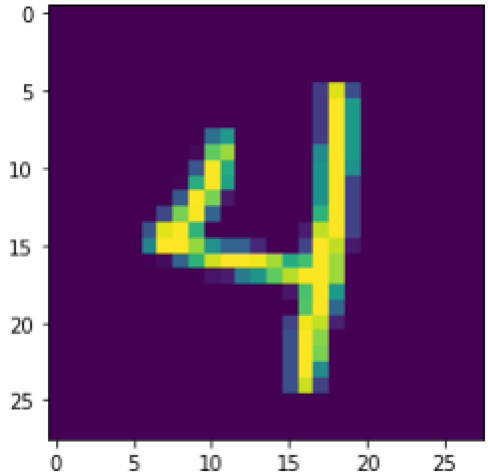
```
test_loss,test_acc=model.evaluate(x_test,y_test)
print("Loss=%.3f" %test_loss)
print("Accuracy=%.3f" %test_acc)
```

```
313/313 [==============================] - 1s 3ms/step - loss: 0.1627 - accu
racy: 0.9518
Loss=0.163
Accuracy=0.952
```

Making Prediction on New Data

In [18]:

```
n=random.randint(0,9999)
plt.imshow(x_test[n])
plt.show()
```



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In [19]:

```
#we use predict() on new data
predicted_value=model.predict(x_test)
print("Handwritten number in the image is= %d" %np.argmax(predicted_value[n]))
```

```
313/313 [==============================] - 1s 2ms/step
Handwritten number in the image is= 4
```

Plot graph for Accuracy and Loss

In [20]:

```

```

In [21]:

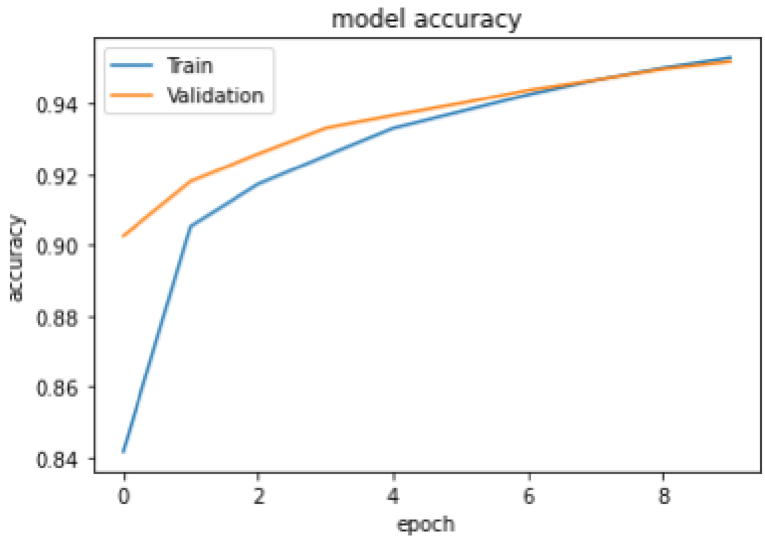
```
history.history.keys()
```

Out[21]:

```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

In [22]:

```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend([ 'Train', 'Validation'], loc= 'upper left')
plt.show()
```



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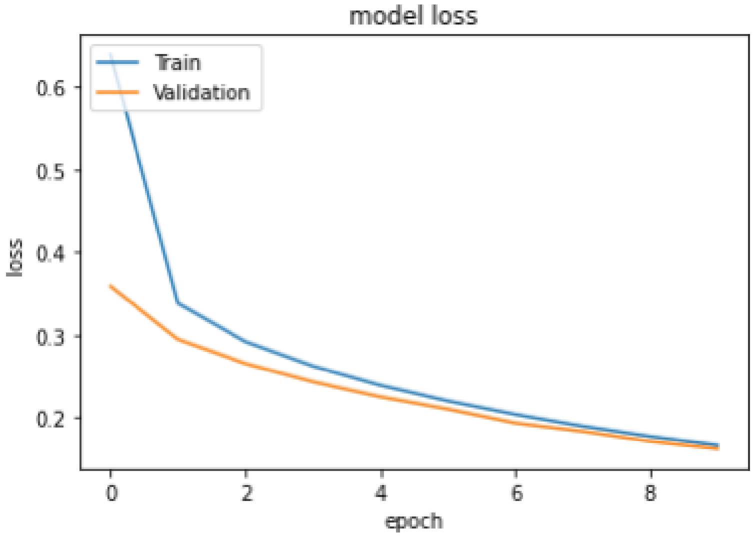
n [23]:

```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend([ 'Train', 'Validation'], loc= 'upper left')
plt.show()
```



graph represents the model’s loss

In [24]:

```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Training Loss and accuracy')
plt.ylabel('accuracy/Loss')
plt.xlabel('epoch')
plt.legend([ 'accuracy', 'val_accuracy', 'loss', 'val_loss'])
plt.show()
```