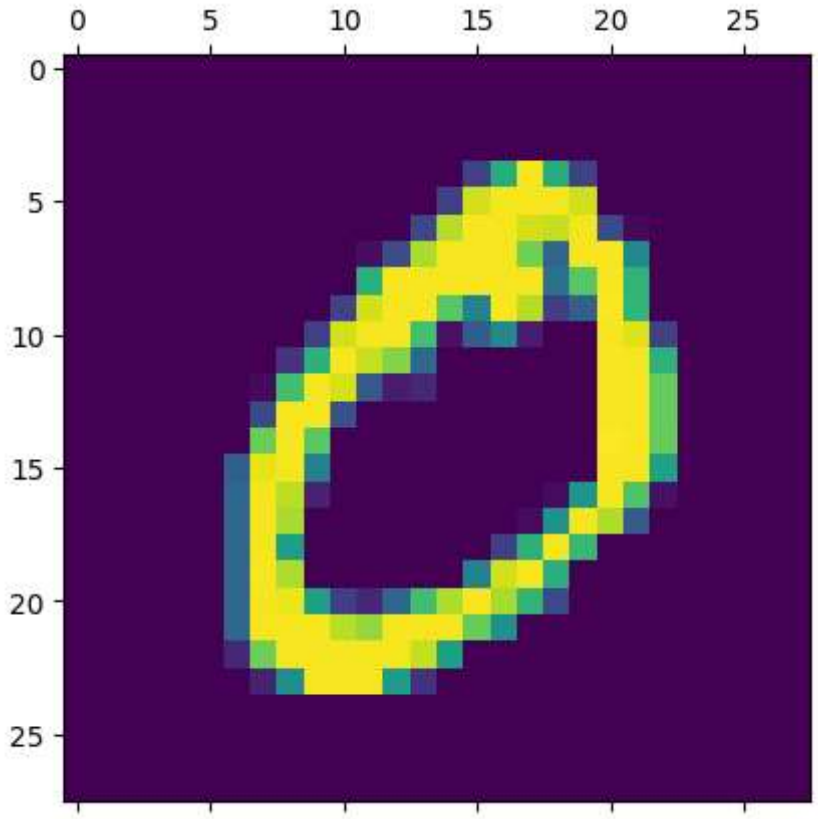
In [8]:
```
#importing necessary libraries
import tensorflow as tf
from tensorflow import keras
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import random
%matplotlib inline
```

In [9]:
```
mnist = tf.keras.datasets.mnist
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz (https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz)
11490434/11490434 [==============================] - 2s 0us/step
```

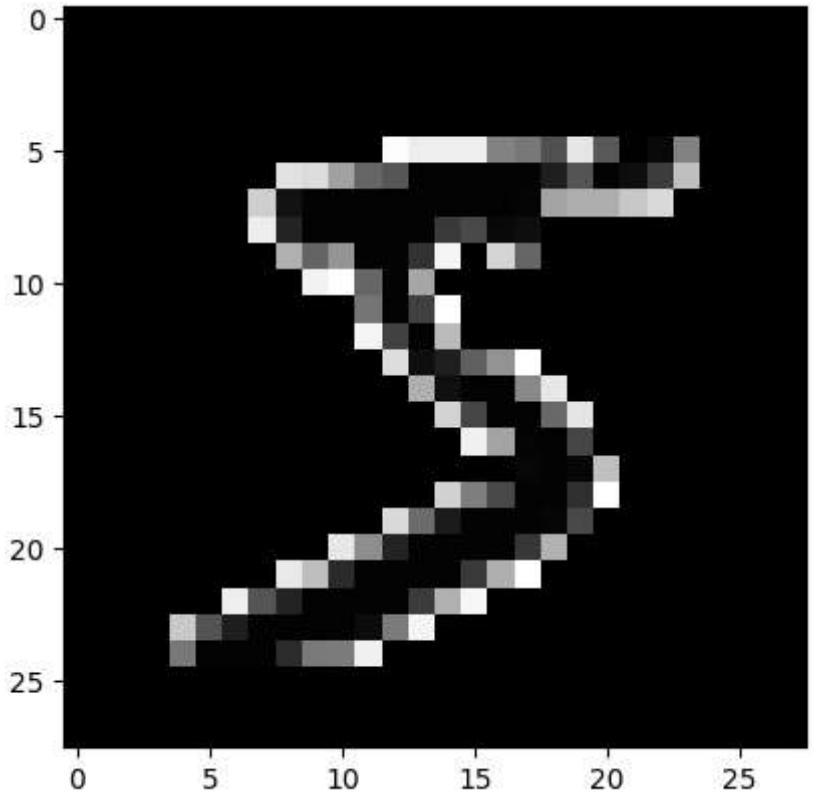
In [10]:
```
plt.matshow(x_train[1])
```

Out[10]:
```
<matplotlib.image.AxesImage at 0x16be1545af0>
```



In [11]:
```
plt.imshow(-x_train[0], cmap="gray")
```

Out[11]:
```
<matplotlib.image.AxesImage at 0x16be3652fa0>
```



In [12]:
```
x_train = x_train / 255
x_test = x_test / 255
```

In [13]:
```
model = keras.Sequential([
keras.layers.Flatten(input_shape=(28, 28)),
keras.layers.Dense(128, activation="relu"),
keras.layers.Dense(10, activation="softmax")
])

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
_________________________________________________________________
```

In [14]:
```
model.compile(optimizer="sgd",
loss="sparse_categorical_crossentropy",
metrics=['accuracy'])
```

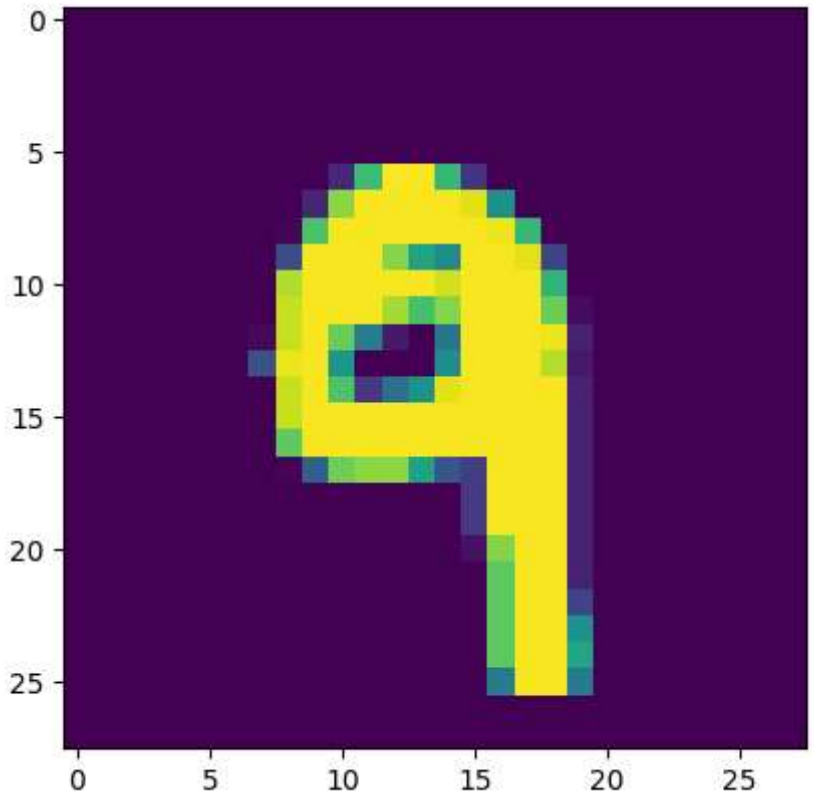
In [15]:
```
history=model.fit(x_train,
y_train,validation_data=(x_test,y_test),epochs=10)
```

```
Epoch 1/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.6533 - accuracy: 0.8343 - val_loss: 0.3664 - val_acc
uracy: 0.9004
Epoch 2/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.3399 - accuracy: 0.9052 - val_loss: 0.2998 - val_acc
uracy: 0.9168
Epoch 3/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2904 - accuracy: 0.9179 - val_loss: 0.2646 - val_acc
uracy: 0.9267
Epoch 4/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2593 - accuracy: 0.9269 - val_loss: 0.2403 - val_acc
uracy: 0.9337
Epoch 5/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2364 - accuracy: 0.9341 - val_loss: 0.2225 - val_acc
uracy: 0.9378
Epoch 6/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.2176 - accuracy: 0.9393 - val_loss: 0.2051 - val_acc
uracy: 0.9416
Epoch 7/10
1875/1875 [==============================] - 5s 2ms/step - loss: 0.2020 - accuracy: 0.9438 - val_loss: 0.1925 - val_acc
uracy: 0.9457
Epoch 8/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.1888 - accuracy: 0.9471 - val_loss: 0.1803 - val_acc
uracy: 0.9489
Epoch 9/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.1772 - accuracy: 0.9505 - val_loss: 0.1725 - val_acc
uracy: 0.9501
Epoch 10/10
1875/1875 [==============================] - 4s 2ms/step - loss: 0.1674 - accuracy: 0.9529 - val_loss: 0.1635 - val_acc
uracy: 0.9524
```

In [16]:
```
test_loss,test_acc=model.evaluate(x_test,y_test)
print("Loss=%.3f" %test_loss)
print("Accuracy=%.3f" %test_acc)
```

```
313/313 [==============================] - 1s 2ms/step - loss: 0.1635 - accuracy: 0.9524
Loss=0.164
Accuracy=0.952
```

In [17]:
```
n=random.randint(0,9999)
plt.imshow(x_test[n])
plt.show()
```



In [18]:
```
x_train
```

Out[18]:
```
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., ..., 0., 0., 0.],
        [0., 0., 0., ..., 0., 0., 0.],
        ...,
        [0., 0., 0., ..., 0., 0., 0.],
```

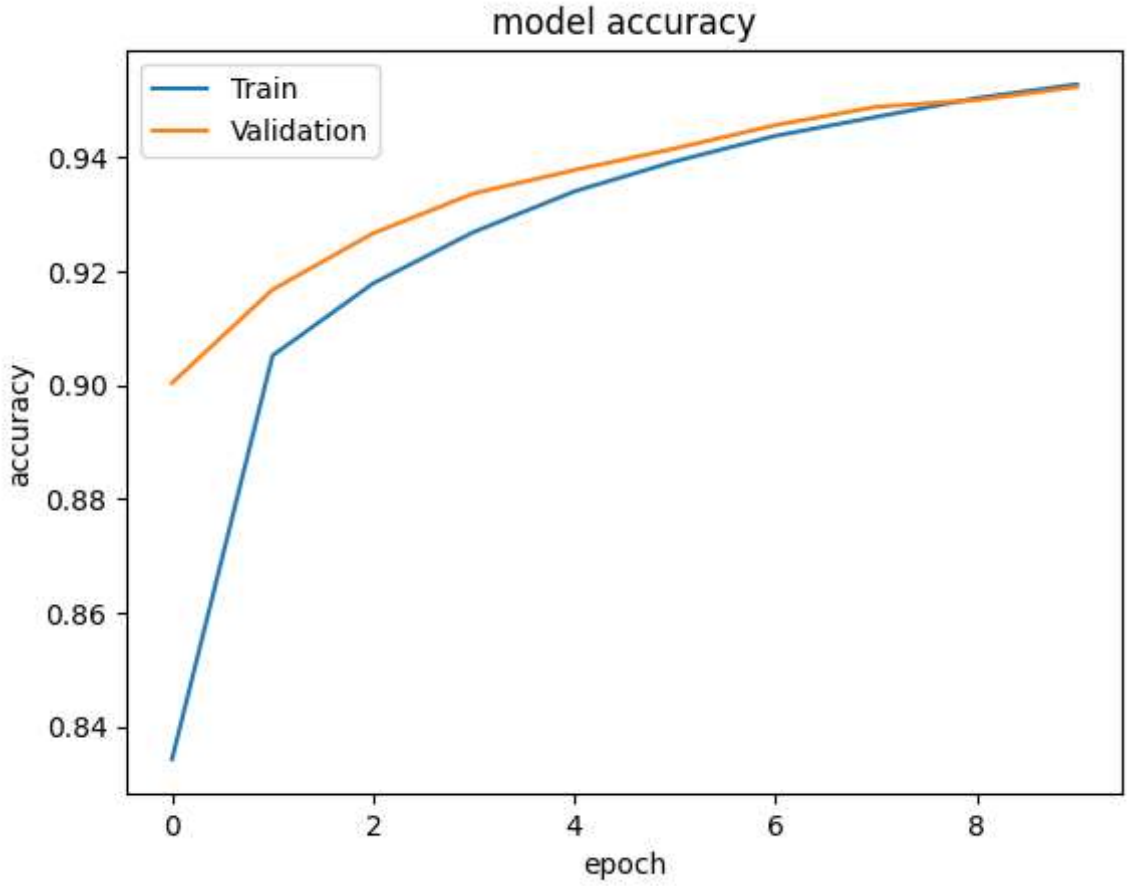
```
 [0., 0., 0., ..., 0., 0., 0.],
 [0., 0., 0., ..., 0., 0., 0.]],

[[0., 0., 0., ..., 0., 0., 0.],
 [0., 0., 0., ..., 0., 0., 0.],
 [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 [19]:
```
x_test
```

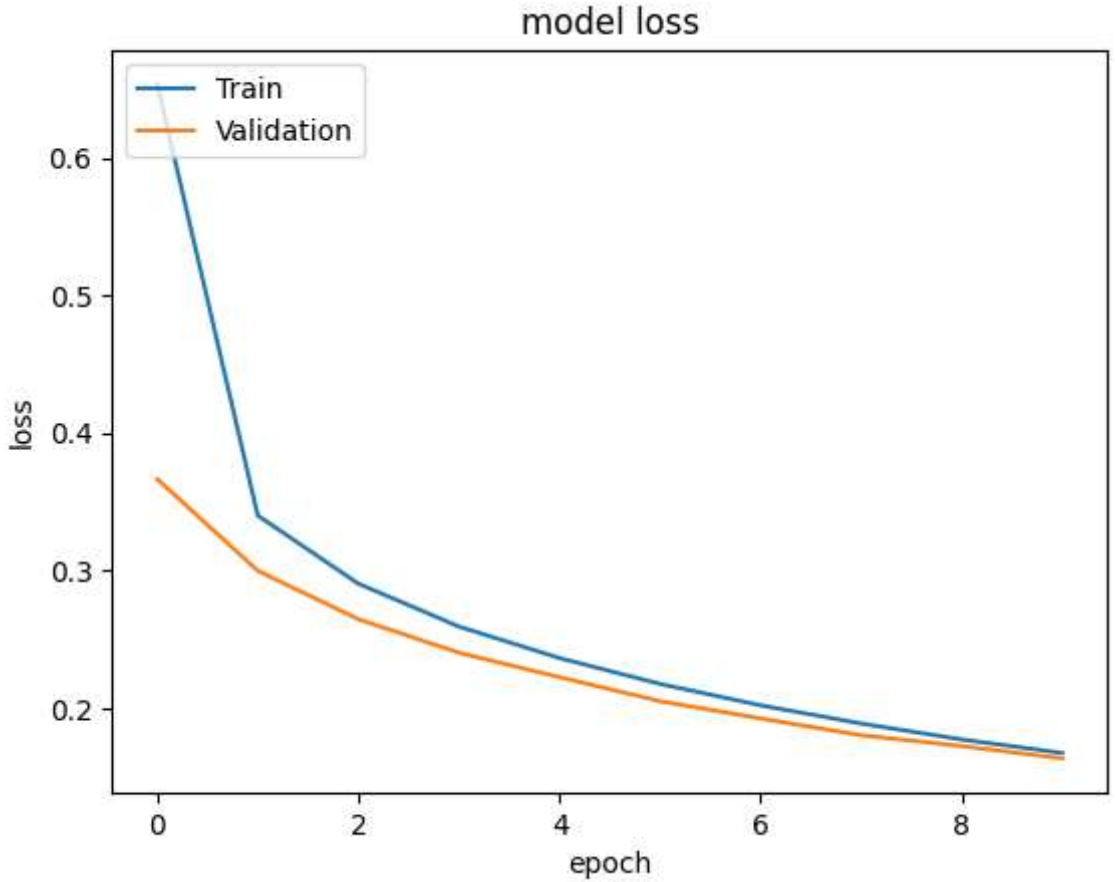
Out[19]:
```
array([[[0., 0., 0., ..., 0., 0., 0.],
        [0., 0., 0., ..., 0., 0., 0.],
        [0., 0., 0., ..., 0., 0., 0.],
        ...,
        [0., 0., 0., ..., 0., 0., 0.],
        [0., 0., 0., ..., 0., 0., 0.],
        [0., 0., 0., ..., 0., 0., 0.]],

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

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

[[0., 0., 0., ..., 0., 0., 0.],
 [0., 0., 0., ..., 0., 0., 0.],
 [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 [20]:
```
# history.history()
history.history.keys()
# dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])

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()
```



In [21]:
```
# history.history()
history.history.keys()
# dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])

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()
```



In [ ]: