In [1]:

```
import tensorflow as tf
from tensorflow import keras
```

In [2]:

```
mnist_dataset = tf.keras.datasets.mnist
```

In [3]:

```
(x_train, y_train), (x_test, y_test) = mnist_dataset.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mn
ist.npz
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 3s 0us/step
```

In [4]:

```
len(x_train)
```

Out[4]:

```
60000
```

In [5]:

```
x_train.shape
```

Out[5]:

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

In [6]:

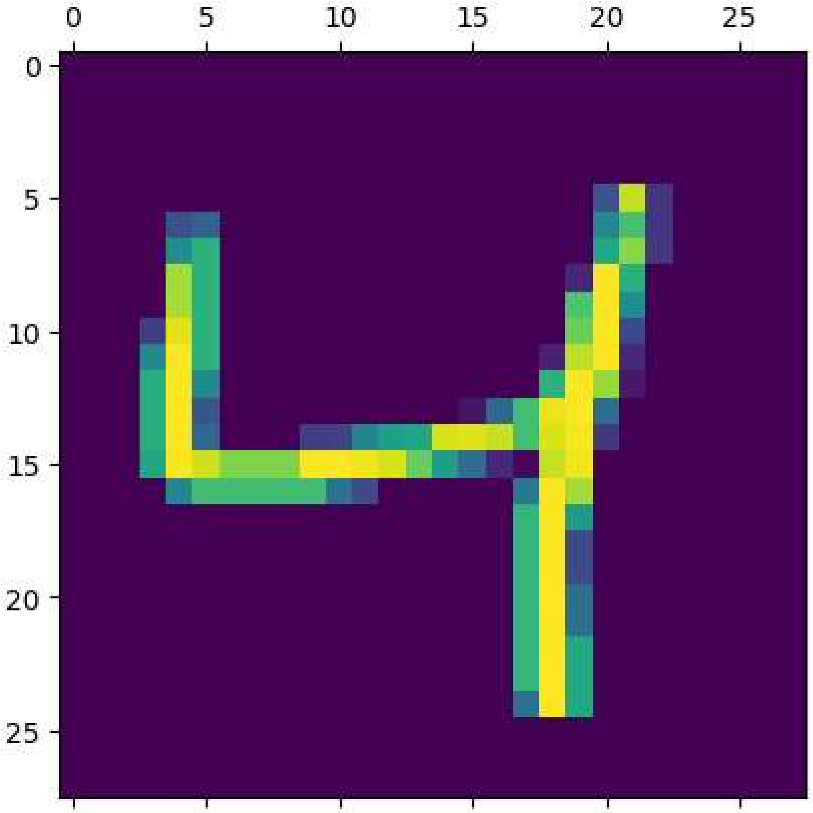
```
import matplotlib.pyplot as plt
```

In [7]:

```
plt.matshow(x_train[2])
```

Out[7]:

```
<matplotlib.image.AxesImage at 0x2074ac58590>
```



In [8]:

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

```
In [9]: x_train[0]
```

```
Out[9]:  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.        ,
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 0.        , 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.        ,
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 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,
 0.50980392, 0.71764706, 0.99215686, 0.99215686, 0.81176471,
 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.        ,
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 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 [10]:

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

```
C:\Users\SMIT DESHMUKH\AppData\Local\Programs\Python\Python313\Lib\site-packages\ker
as\src\layers\reshaping\flatten.py:37: UserWarning: Do not pass an `input_shape`/`in
put_dim` argument to a layer. When using Sequential models, prefer using an `Input(s
hape)` object as the first layer in the model instead.
  super().__init__(**kwargs)
```

In [11]:

```
model.summary()
```

```
Model: "sequential"

┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━
┃ Layer (type)                           ┃ Output Shape                 ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━
│ flatten (Flatten)                      │ (None, 784)                  │
├────────────────────────────────────────┼──────────────────────────────┼───────
│ dense (Dense)                          │ (None, 128)                  │
├────────────────────────────────────────┼──────────────────────────────┼───────
│ dense_1 (Dense)                        │ (None, 10)                   │
└────────────────────────────────────────┴──────────────────────────────┴───────

 Total params: 101,770 (397.54 KB)

 Trainable params: 101,770 (397.54 KB)

 Non-trainable params: 0 (0.00 B)
```

In [12]:

```
model.compile(optimizer='sgd',
              loss='sparse_categorical_crossentropy',

              metrics=['accuracy'])
```

In [13]:

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

```
Epoch 1/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 24s 12ms/step - accuracy: 0.8414 - loss: 0.6359 - val
_accuracy: 0.9037 - val_loss: 0.3593
Epoch 2/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 40s 11ms/step - accuracy: 0.9065 - loss: 0.3390 - val
_accuracy: 0.9195 - val_loss: 0.2944
Epoch 3/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 21s 11ms/step - accuracy: 0.9179 - loss: 0.2910 - val
_accuracy: 0.9281 - val_loss: 0.2626
Epoch 4/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 21s 11ms/step - accuracy: 0.9270 - loss: 0.2610 - val
_accuracy: 0.9344 - val_loss: 0.2411
Epoch 5/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 21s 11ms/step - accuracy: 0.9339 - loss: 0.2381 - val
_accuracy: 0.9395 - val_loss: 0.2226
Epoch 6/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 24s 12ms/step - accuracy: 0.9386 - loss: 0.2195 - val
_accuracy: 0.9425 - val_loss: 0.2083
Epoch 7/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 38s 11ms/step - accuracy: 0.9431 - loss: 0.2041 - val
_accuracy: 0.9449 - val_loss: 0.1948
Epoch 8/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 18s 10ms/step - accuracy: 0.9469 - loss: 0.1904 - val
_accuracy: 0.9492 - val_loss: 0.1840
Epoch 9/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 22s 11ms/step - accuracy: 0.9499 - loss: 0.1790 - val
_accuracy: 0.9511 - val_loss: 0.1745
Epoch 10/10
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 22s 12ms/step - accuracy: 0.9524 - loss: 0.1689 - val
_accuracy: 0.9531 - val_loss: 0.1658
```

In [14]:

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

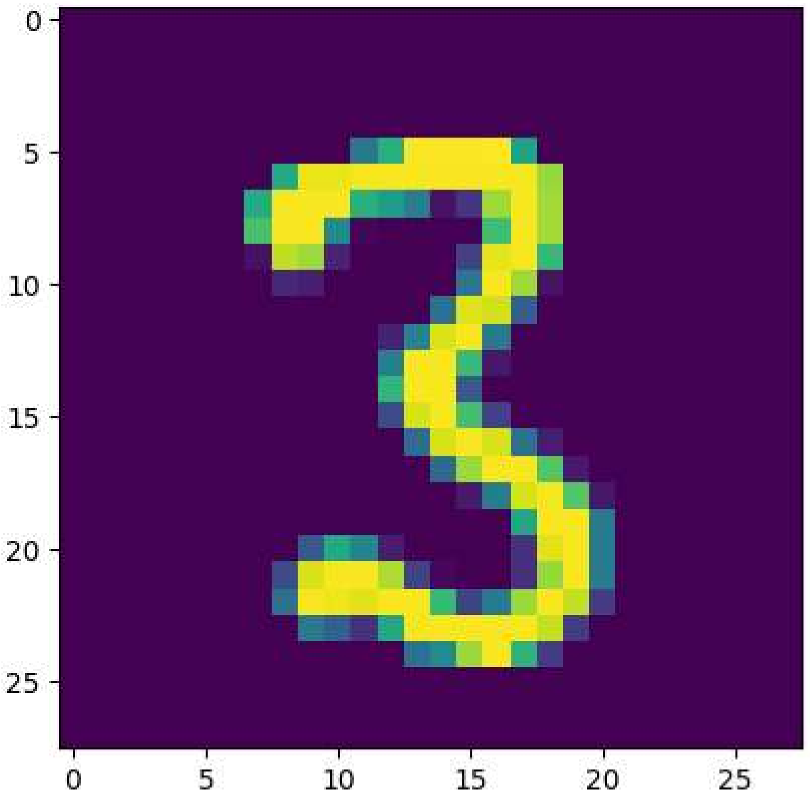
```
313/313 ━━━━━━━━━━━━━━━━━━━━ 3s 9ms/step - accuracy: 0.9531 - loss: 0.1658
Loss=0.166
Accuracy=0.953
```

In [15]:

```
import random
```

In [16]:

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



```
In [17]: import numpy as np
         predicted_value=model.predict(x_test)
         print("Handwritten number in the image is= %d" %np.argmax(predicted_value[n]))
```

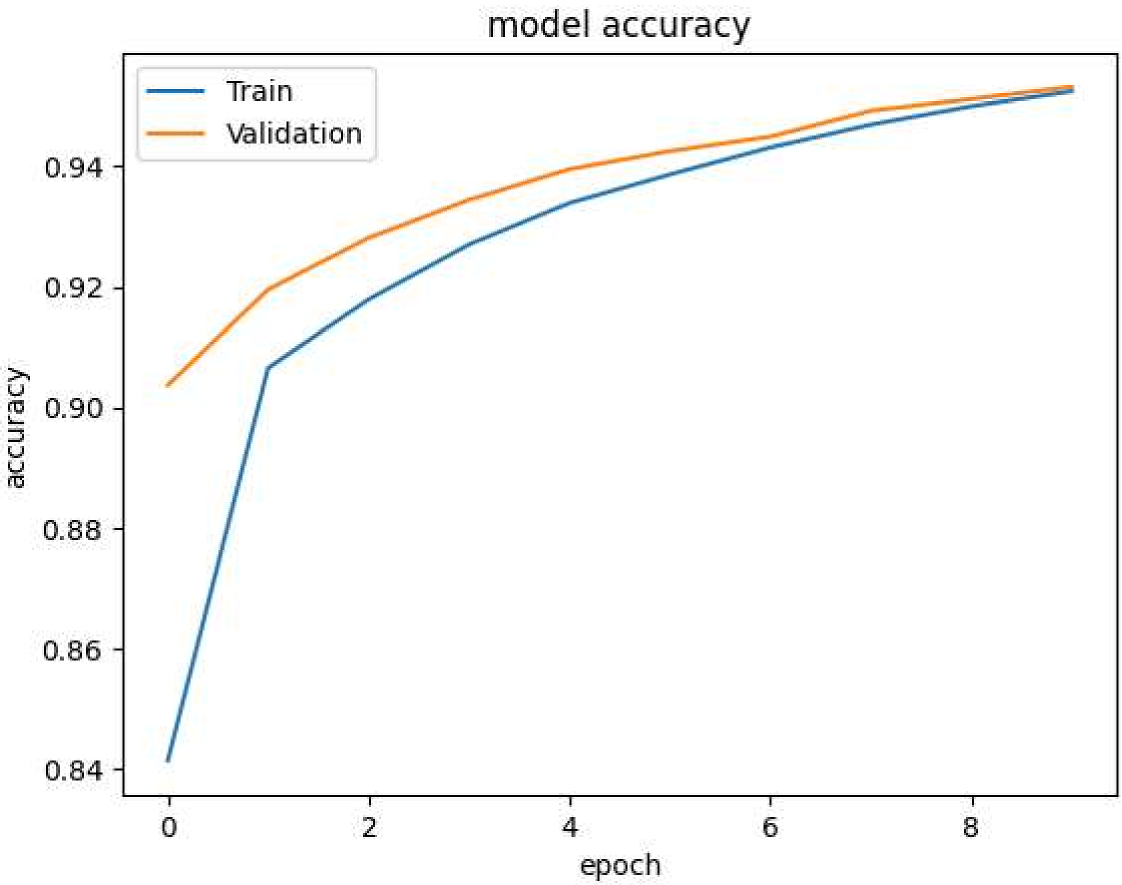
```
313/313 ━━━━━━━━━━━━━━━━━━━━ 2s 7ms/step
Handwritten number in the image is= 3
```

```
In [18]: history.history.keys()
```

```
Out[18]: dict_keys(['accuracy', 'loss', 'val_accuracy', 'val_loss'])
```

Training Accuracy

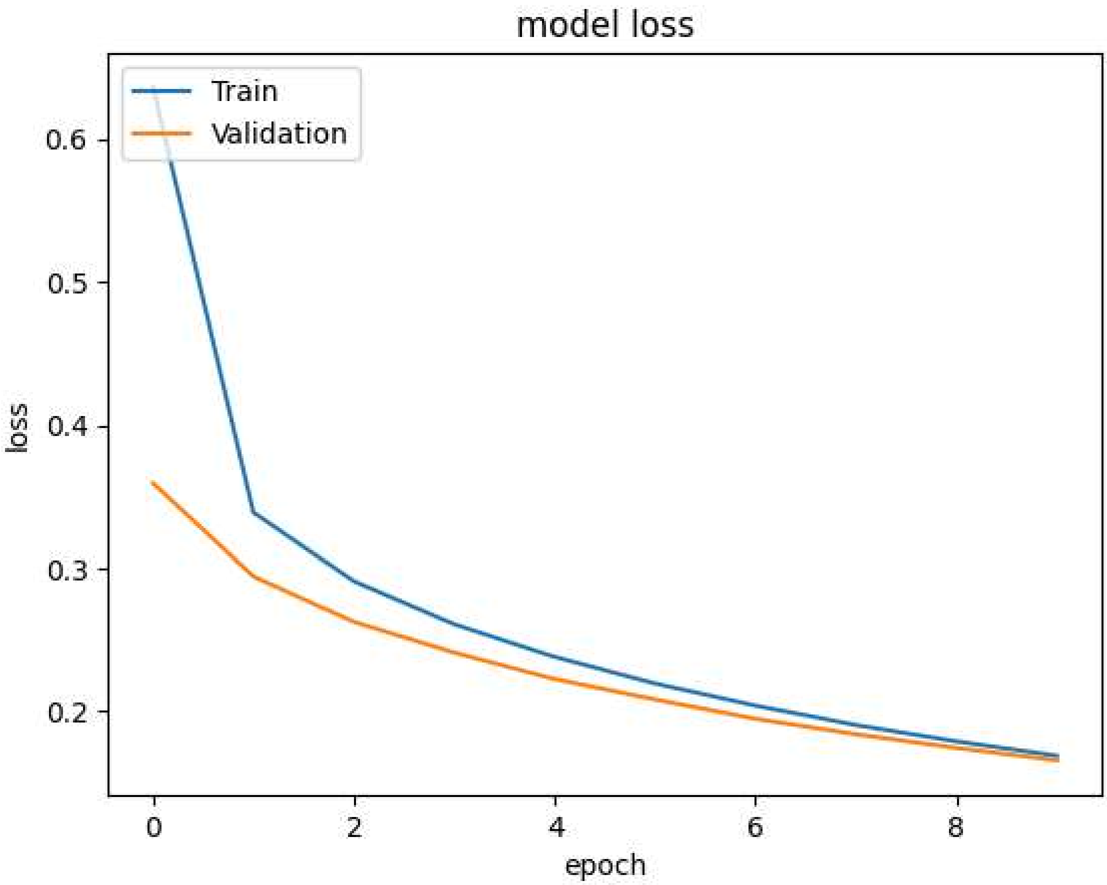
```
In [19]: plt.plot(history.history['accuracy'])
         plt.plot(history.history['val_accuracy'])
         plt.title('model accuracy')
         plt.ylabel('accuracy')
         plt.xlabel('epoch')
         plt.legend(['Train', 'Validation'], loc='upper left')
         plt.show()
```



Training Loss

In [20]:

```
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 [ ]:
```