Assignment_03_Q2

June 24, 2021

[1]:
```
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
```

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

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/mnist.npz
11493376/11490434 [==============================] - 8s 1us/step
```

[3]:
```
len(X_train)
```

[3]: 60000

[4]:
```
len(X_test)
```

[4]: 10000

[5]:
```
X_train.shape
```

[5]: (60000, 28, 28)

[6]:
```
X_train[0].shape
```

[6]: (28, 28)

[9]:
```
X_train[1]
```

[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,
```

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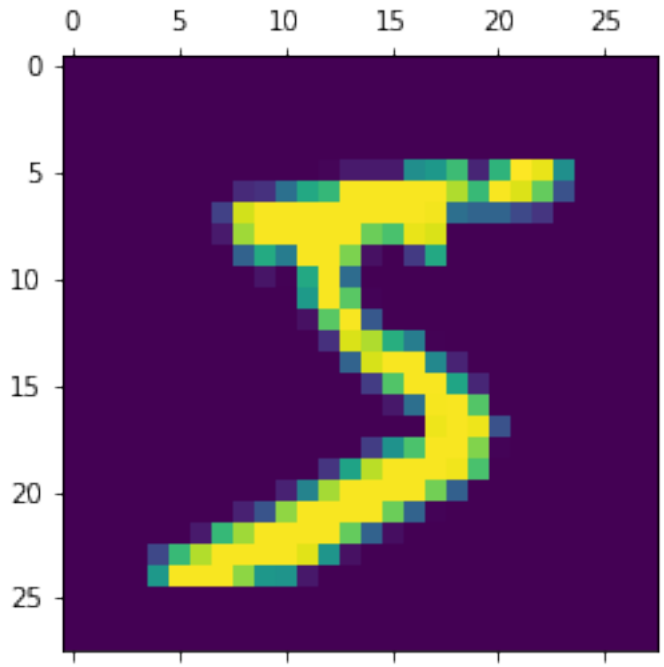
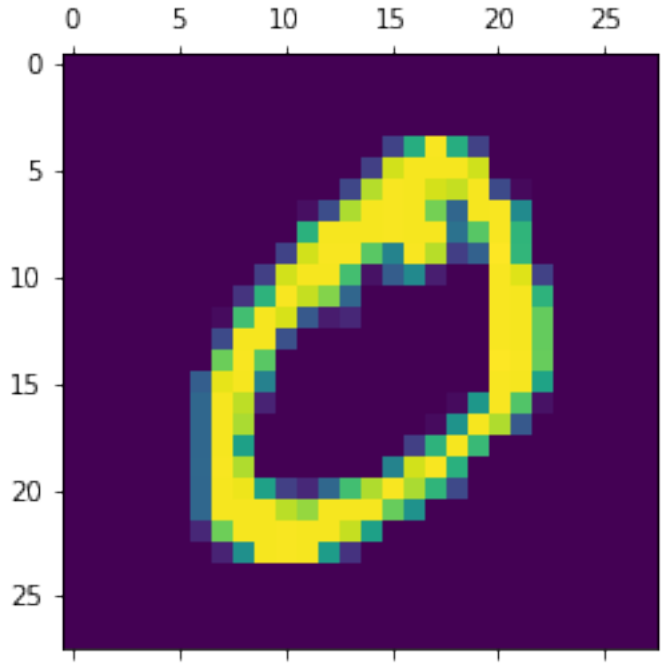
         0,   0]], dtype=uint8)
```

[12]:
```python
for i in range(0,9):
    plt.matshow(X_train[i])
```


0
5
10
15
20
25
0
5
10
15
20
25


0
5
10
15
20
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0
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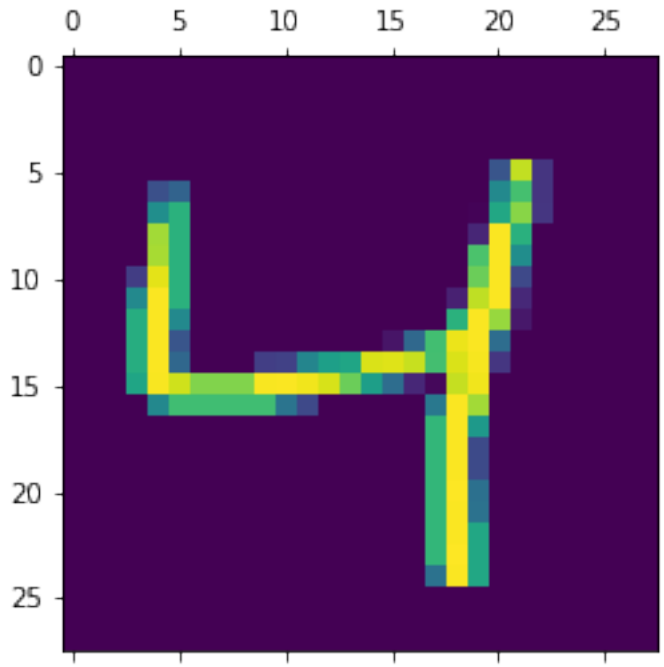
0
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10
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20
25
0
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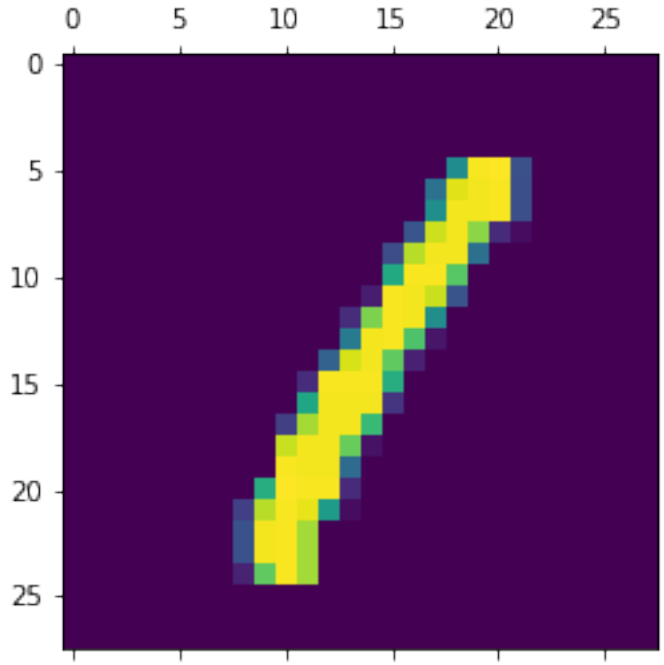
0
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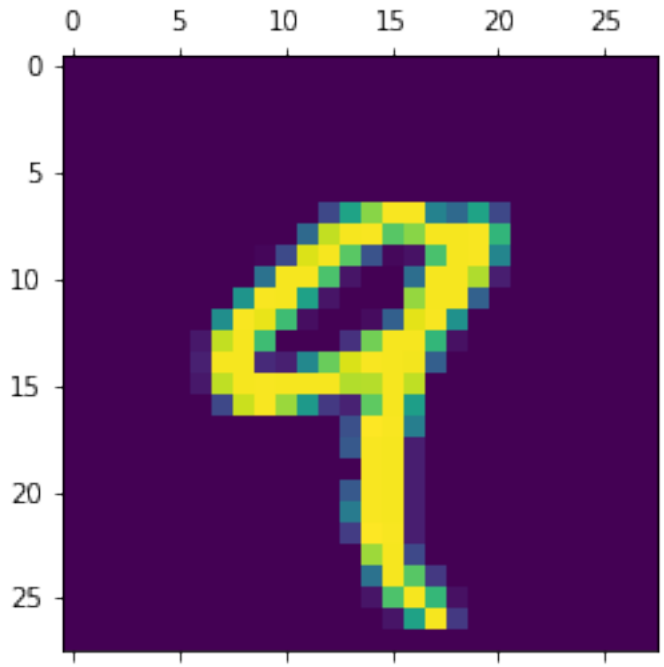
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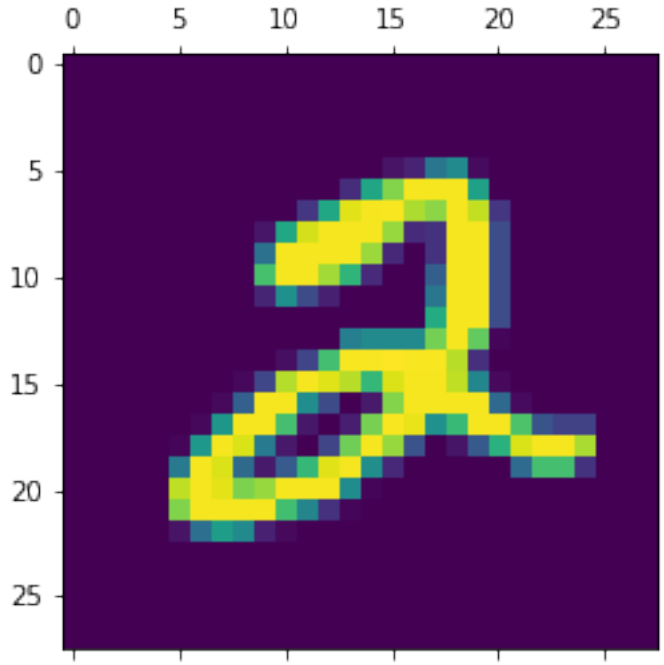
0
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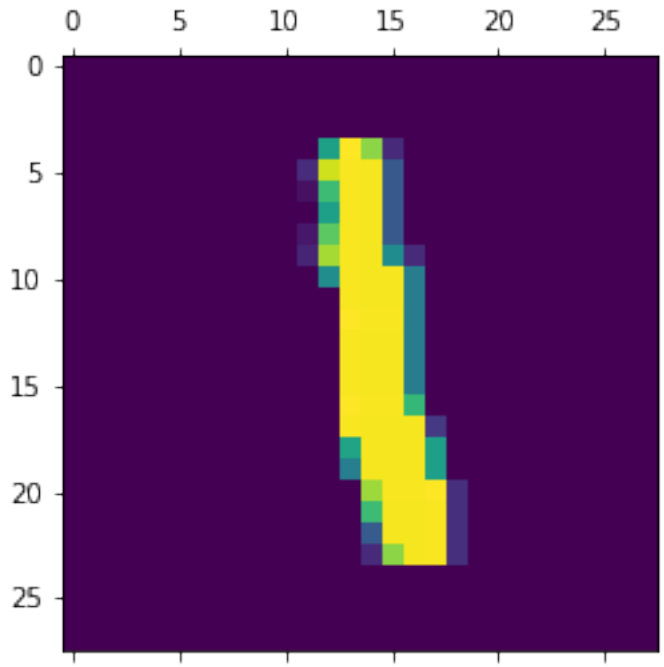
0
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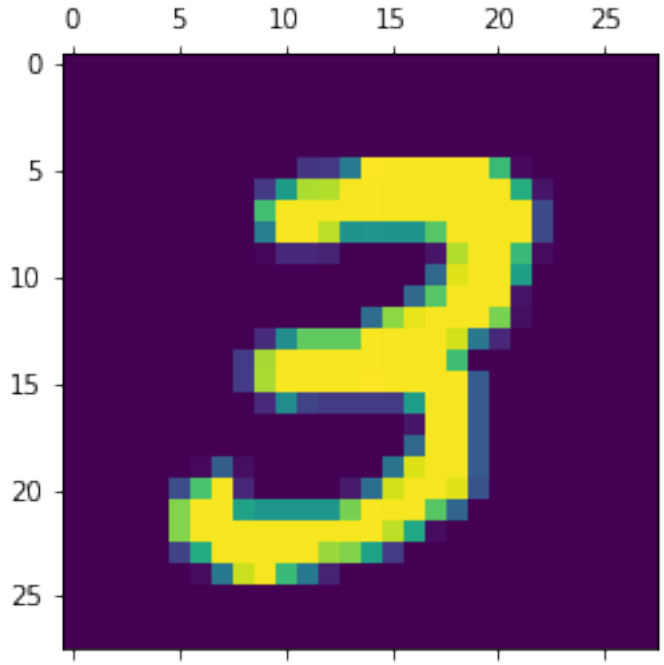
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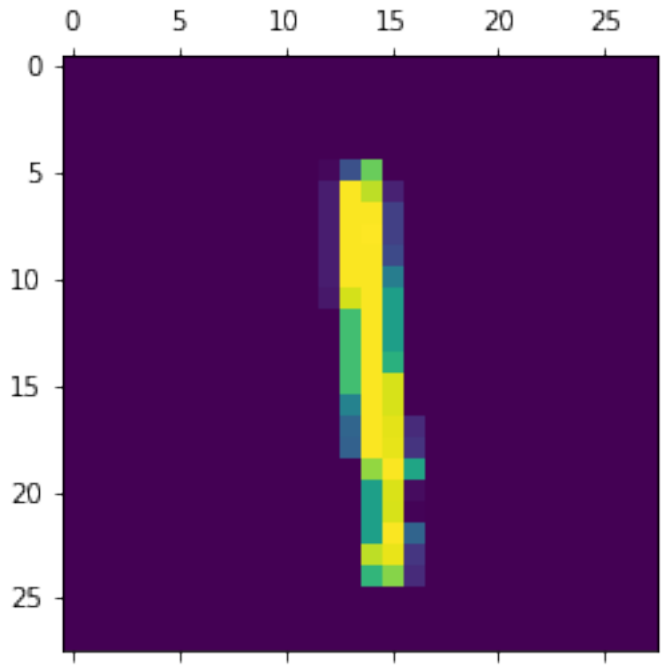

[24]:
```
X_train = X_train /255
X_test = X_test/255  ## normalize between 0 and 1
```

[25]:
```
X_train[0]
```

[25]:
```
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        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
```

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 3.89081123e-03, 2.99884660e-03, 1.23029604e-03, 1.38408304e-04,
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 0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00],
```

```
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         3.89081123e-03, 3.89081123e-03, 3.89081123e-03, 3.75240292e-03,
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         3.26028451e-03, 2.07612457e-03, 2.02998847e-03, 2.46059208e-04,
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         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
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         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
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        [0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
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         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
         0.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00]])
```

[26]:

```
X_train_flattened = X_train.reshape(len(X_train),28*28)
X_test_flattend = X_test.reshape(len(X_test),28*28)
```

[27]:

```
X_train_flattened.reshape
```

[27]:

```
<function ndarray.reshape>
```

[28]:

```
X_test_flattend[0]
```

[28]:

```
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.        ,
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0.        , 0.        , 0.        , 0.        , 0.        ,
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0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
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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.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.32941176, 0.7254902 , 0.62352941,
0.59215686, 0.23529412, 0.14117647, 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.87058824, 0.99607843, 0.99607843, 0.99607843, 0.99607843,
0.94509804, 0.77647059, 0.77647059, 0.77647059, 0.77647059,
0.77647059, 0.77647059, 0.77647059, 0.77647059, 0.66666667,
```

```
0.20392157, 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.2627451 , 0.44705882,
0.28235294, 0.44705882, 0.63921569, 0.89019608, 0.99607843,
0.88235294, 0.99607843, 0.99607843, 0.99607843, 0.98039216,
0.89803922, 0.99607843, 0.99607843, 0.54901961, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.06666667, 0.25882353, 0.05490196, 0.2627451 ,
0.2627451 , 0.2627451 , 0.23137255, 0.08235294, 0.9254902 ,
0.99607843, 0.41568627, 0.        , 0.        , 0.        ,
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.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
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1.        , 0.3254902 , 0.        , 0.        , 0.        ,
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.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.23137255, 0.97647059,
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0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.52156863, 0.99607843, 0.73333333, 0.01960784,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.03529412, 0.80392157,
0.97254902, 0.22745098, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
```

```
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.49411765, 0.99607843, 0.71372549, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.29411765, 0.98431373,
0.94117647, 0.22352941, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.0745098 , 0.86666667, 0.99607843, 0.65098039, 0.        ,
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.        , 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.        ,
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0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.52156863, 0.99607843, 0.99607843, 0.20392157, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.23921569, 0.94901961, 0.99607843,
0.99607843, 0.20392157, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.4745098 , 0.99607843, 0.99607843, 0.85882353, 0.15686275,
```

```
        0.        , 0.        , 0.        , 0.        , 0.        ,
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        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.4745098 , 0.99607843,
        0.81176471, 0.07058824, 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        ])
```

[29]:
```
## model

model = keras.Sequential([
    keras.layers.Dense(10,input_shape=(784,),
                       activation='sigmoid')
])
model.compile(optimizer='adam',
              loss = 'sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.fit(X_train_flattened,y_train,epochs=5)
```

```
Epoch 1/5
1875/1875 [==============================] - 1s 673us/step - loss: 2.1882 -
accuracy: 0.5921
Epoch 2/5
1875/1875 [==============================] - 1s 661us/step - loss: 1.9774 -
accuracy: 0.7078
Epoch 3/5
1875/1875 [==============================] - 1s 780us/step - loss: 1.7910 -
accuracy: 0.7380
Epoch 4/5
1875/1875 [==============================] - 2s 817us/step - loss: 1.6270 -
accuracy: 0.7609
Epoch 5/5
1875/1875 [==============================] - 2s 840us/step - loss: 1.4842 -
accuracy: 0.7745
```

[29]:
```
<tensorflow.python.keras.callbacks.History at 0x7f63ad7e32e0>
```

[30]:
```
model.evaluate(X_test_flattend,y_test)
```

```
313/313 [==============================] - 0s 491us/step - loss: 30.2073 -
```

```
accuracy: 0.6940
```

[30]:
```
[30.207311630249023, 0.6940000057220459]
```

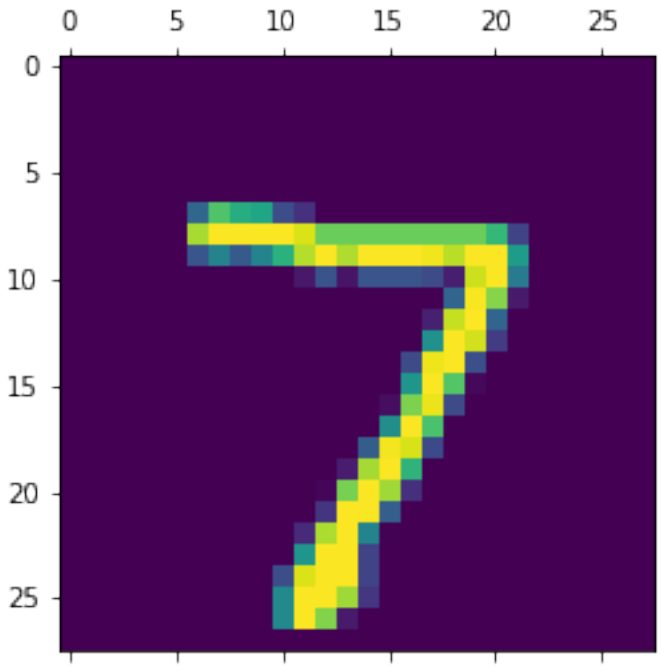
[36]:
```
y_predicted = model.predict(X_test_flattend)
```

[37]:
```
y_predicted[0]
```

[37]:
```
array([3.1505969e-20, 0.0000000e+00, 0.0000000e+00, 1.2640622e-20,
       1.2207242e-29, 0.0000000e+00, 0.0000000e+00, 1.0000000e+00,
       3.8738608e-02, 1.0000000e+00], dtype=float32)
```

[38]:
```
plt.matshow(X_test[0])
```

[38]:
```
<matplotlib.image.AxesImage at 0x7f638598cd30>
```



[40]:
```
y_predicted_labels = [np.argmax(i) for i in y_predicted]
y_predicted_labels[:5]
```

[40]:
```
[7, 0, 1, 0, 0]
```

1 Confusion matrix

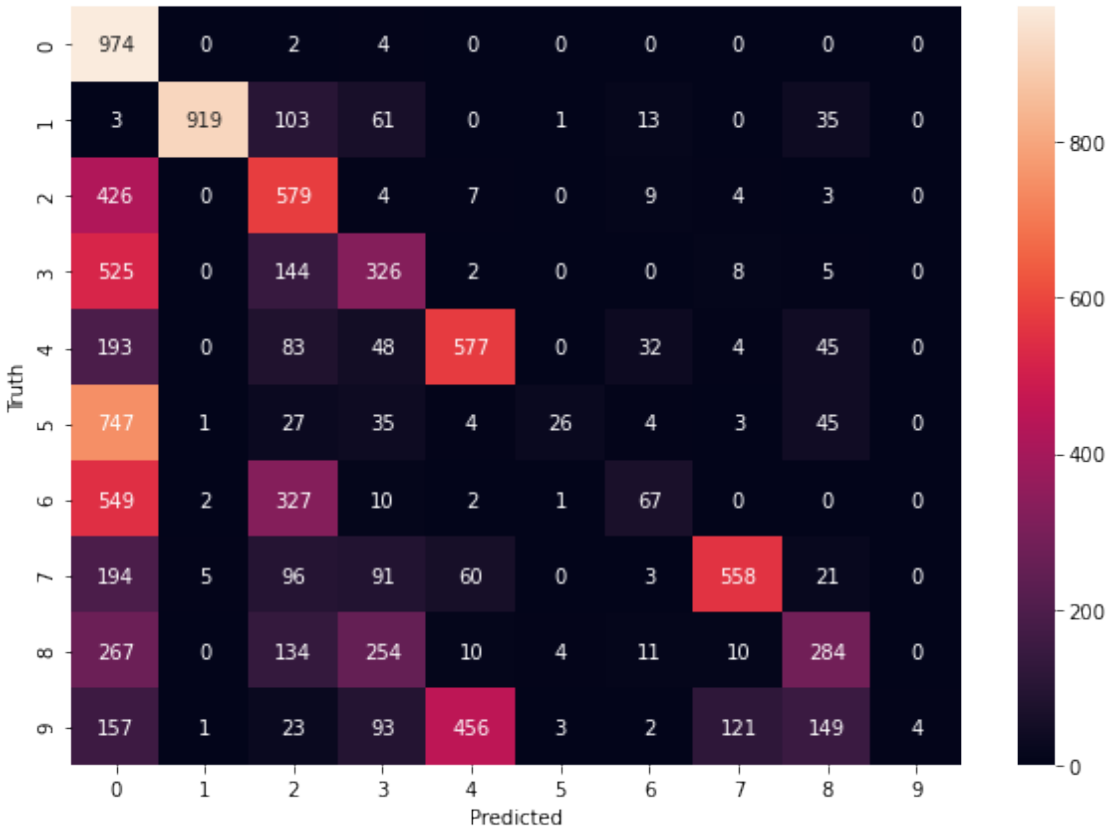
[41]:
```
cm = tf.math.confusion_matrix(labels=y_test,predictions=y_predicted_labels)
```

[43]:
```
cm
```

[43]:
```
<tf.Tensor: shape=(10, 10), dtype=int32, numpy=
array([[974,   0,   2,   4,   0,   0,   0,   0,   0,   0],
       [  3, 919, 103,  61,   0,   1,  13,   0,  35,   0],
       [426,   0, 579,   4,   7,   0,   9,   4,   3,   0],
       [525,   0, 144, 326,   2,   0,   0,   8,   5,   0],
       [193,   0,  83,  48, 577,   0,  32,   4,  45,   0],
       [747,   1,  27,  35,   4,  26,   4,   3,  45,   0],
       [549,   2, 327,  10,   2,   1,  67,   0,   0,   0],
       [194,   5,  96,  91,  60,   0,   3, 558,  21,   0],
       [267,   0, 134, 254,  10,   4,  11,  10, 284,   0],
       [157,   1,  23,  93, 456,   3,   2, 121, 149,   4]], dtype=int32)>
```

[44]:
```
import seaborn as sn
plt.figure(figsize = (10,7))
sn.heatmap(cm, annot=True, fmt='d')
plt.xlabel('Predicted')
plt.ylabel('Truth')
```

[44]:
```
Text(69.0, 0.5, 'Truth')
```


Truth
Predicted
0 974 0 2 4 0 0 0 0 0 0
1 3 919 103 61 0 1 13 0 35 0
2 426 0 579 4 7 0 9 4 3 0
3 525 0 144 326 2 0 0 8 5 0
4 193 0 83 48 577 0 32 4 45 0
5 747 1 27 35 4 26 4 3 45 0
6 549 2 327 10 2 1 67 0 0 0
7 194 5 96 91 60 0 3 558 21 0
8 267 0 134 254 10 4 11 10 284 0
9 157 1 23 93 456 3 2 121 149 4
0 1 2 3 4 5 6 7 8 9
800
600
400
200
0

[ ]: