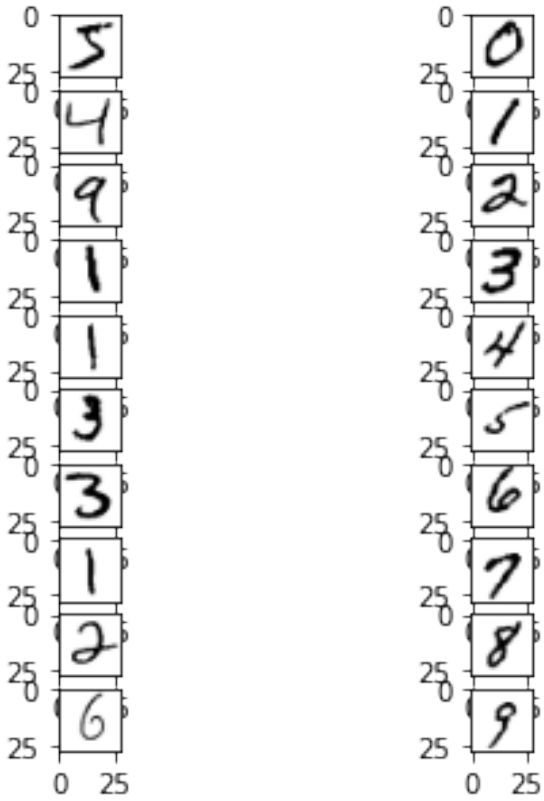
COURSE OUTCOME-4

PROGRAM NO-1

Aim: Programs on feedforward network to classify any standard dataset available in the public domain

```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense
from tensorflow.keras.optimizers import SGD
from matplotlib import pyplot as plt

(x_train,y_train),(x_valid,y_valid) = mnist.load_data()

x_train.shape

(60000, 28, 28)

y_train.shape

(60000,)

y_train[0:12]

array([5, 0, 4, 1, 9, 2, 1, 3, 1, 4, 3, 5], dtype=uint8)

plt.figure(figsize=(5,5))
for k in range(20):
  plt.subplot(10,2,k+1)
  plt.imshow(x_train[k],cmap='Greys')
  plt.axis('on')
plt.show()
```



```
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```

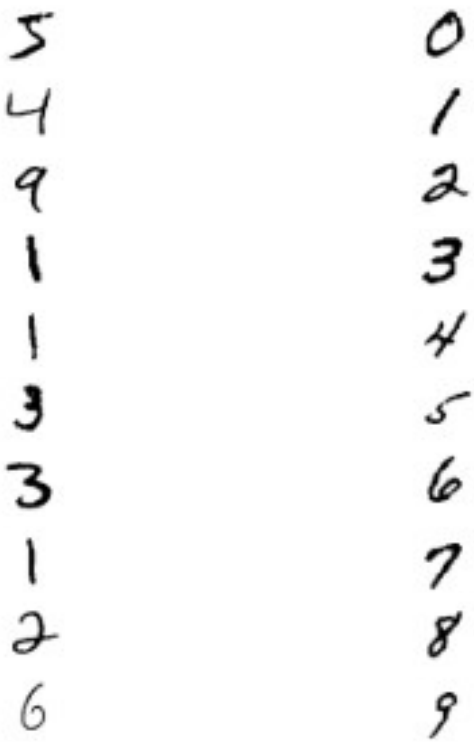

```
plt.figure(figsize=(5,5))
for k in range(20):
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```
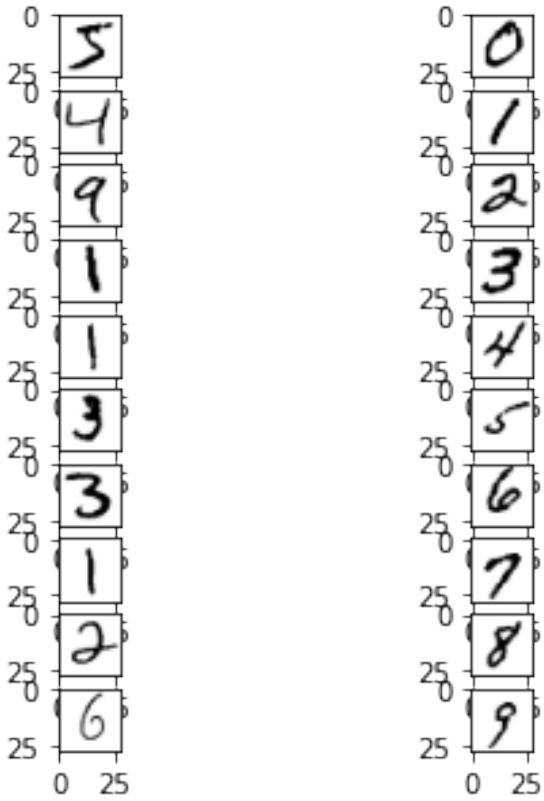
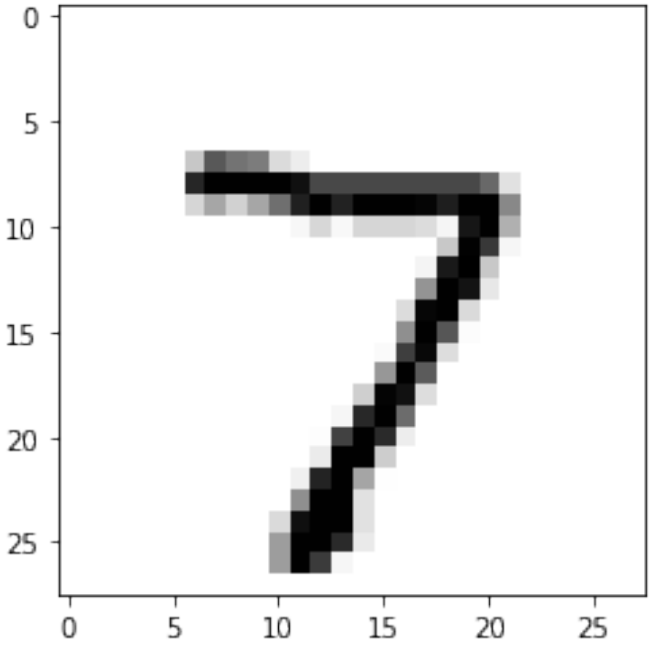



```
plt.imshow(x_valid[0],cmap='Greys')
```

```
<matplotlib.image.AxesImage at 0x7fd83619e610>
```



```
y_valid.shape
```

```
(10000,)
```

```
x_valid[0]
```

```
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,  84, 185, 159, 151,  60,  36,
0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
          0,   0],
       [  0,   0,   0,   0,   0,   0, 222, 254, 254, 254, 254, 241,
198,
        198, 198, 198, 198, 198, 198, 198, 170,  52,   0,   0,   0,
0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,  67, 114,  72, 114, 163, 227,
254,
```

```
         225, 254, 254, 254, 250, 229, 254, 254, 140,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  17,
66,
          14,  67,  67,  67,  59,  21, 236, 254, 106,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0,   0,   0,   0,  83, 253, 209,  18,   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, 129, 254, 238,  44,   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, 133, 254, 187,   5,   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, 126, 254, 182,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,  75, 251, 240,  57,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
```

```
          19, 221, 254, 166,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
3,
         203, 254, 219,  35,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
38,
         254, 254,  77,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  31,
224,
         254, 115,   1,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 133,
254,
         254,  52,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  61, 242,
254,
         254,  52,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 121, 254,
254,
         219,  40,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 121, 254,
207,
          18,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0],
        [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
0,
           0,   0]], dtype=uint8)
```

```
y_valid[0]
```

```
7
```

preprocess data

```
x_train = x_train.reshape(60000,784).astype('float32')
x_valid = x_valid.reshape(10000,784).astype('float32')

x_train/=255
x_valid/=255

from keras import utils as np_utils
n_classes = 10
y_train = keras.utils.np_utils.to_categorical(y_train,n_classes)
y_valid= keras.utils.np_utils.to_categorical(y_valid,n_classes)

y_valid[0]

array([0., 0., 0., 0., 0., 0., 0., 1., 0., 0.], dtype=float32)

y_train[0]

array([0., 0., 0., 0., 0., 1., 0., 0., 0., 0.], dtype=float32)

x_valid[0]

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.        , 0.32941177, 0.7254902 , 0.62352943,
0.5921569 , 0.23529412, 0.14117648, 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, 0.7764706 , 0.7764706 , 0.7764706 , 0.7764706 ,
0.7764706 , 0.7764706 , 0.7764706 , 0.7764706 , 0.6666667 ,
0.20392157, 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.2627451 , 0.44705883,
0.28235295, 0.44705883, 0.6392157 , 0.8901961 , 0.99607843,
0.88235295, 0.99607843, 0.99607843, 0.99607843, 0.98039216,
0.8980392 , 0.99607843, 0.99607843, 0.54901963, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.06666667, 0.25882354, 0.05490196, 0.2627451 ,
0.2627451 , 0.2627451 , 0.23137255, 0.08235294, 0.9254902 ,
0.99607843, 0.41568628, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.3254902 , 0.99215686, 0.81960785, 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.        , 0.08627451, 0.9137255 ,
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.        ,
0.        , 0.5058824 , 0.99607843, 0.93333334, 0.17254902,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
```

```
0.        , 0.        , 0.        , 0.23137255, 0.9764706 ,
0.99607843, 0.24313726, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.52156866, 0.99607843, 0.73333335, 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, 0.8039216 ,
0.972549  , 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, 0.7137255 , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.29411766, 0.9843137 ,
0.9411765 , 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.        ,
0.07450981, 0.8666667 , 0.99607843, 0.6509804 , 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, 0.79607844, 0.99607843,
0.85882354, 0.13725491, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.14901961, 0.99607843, 0.99607843, 0.3019608 , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.12156863, 0.8784314 , 0.99607843,
0.4509804 , 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.        ,
```

```
        0.52156866, 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, 0.9490196 , 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, 0.85882354, 0.15686275,
        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,
        0.8117647 , 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.        ], dtype=float32)
```

```
x_train[0]
```

```
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, 0.53333336, 0.6862745 , 0.10196079,
0.6509804 , 1.        , 0.96862745, 0.49803922, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.11764706, 0.14117648, 0.36862746, 0.6039216 ,
0.6666667 , 0.99215686, 0.99215686, 0.99215686, 0.99215686,
0.99215686, 0.88235295, 0.6745098 , 0.99215686, 0.9490196 ,
0.7647059 , 0.2509804 , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.19215687, 0.93333334,
0.99215686, 0.99215686, 0.99215686, 0.99215686, 0.99215686,
0.99215686, 0.99215686, 0.99215686, 0.9843137 , 0.3647059 ,
0.32156864, 0.32156864, 0.21960784, 0.15294118, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.07058824, 0.85882354, 0.99215686, 0.99215686,
0.99215686, 0.99215686, 0.99215686, 0.7764706 , 0.7137255 ,
0.96862745, 0.94509804, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.3137255 , 0.6117647 , 0.41960785, 0.99215686, 0.99215686,
0.8039216 , 0.04313726, 0.        , 0.16862746, 0.6039216 ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.05490196,
0.00392157, 0.6039216 , 0.99215686, 0.3529412 , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.54509807,
0.99215686, 0.74509805, 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.        , 0.04313726, 0.74509805, 0.99215686,
0.27450982, 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
```

```
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.13725491, 0.94509804, 0.88235295, 0.627451  ,
0.42352942, 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.        ,
0.31764707, 0.9411765 , 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.        , 0.1764706 ,
0.7294118 , 0.99215686, 0.99215686, 0.5882353 , 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 , 0.3647059 ,
0.9882353 , 0.99215686, 0.73333335, 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.9764706 , 0.99215686,
0.9764706 , 0.2509804 , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.18039216, 0.50980395,
0.7176471 , 0.99215686, 0.99215686, 0.8117647 , 0.00784314,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.15294118,
0.5803922 , 0.8980392 , 0.99215686, 0.99215686, 0.99215686,
0.98039216, 0.7137255 , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.09411765, 0.44705883, 0.8666667 , 0.99215686, 0.99215686,
0.99215686, 0.99215686, 0.7882353 , 0.30588236, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.09019608, 0.25882354, 0.8352941 , 0.99215686,
0.99215686, 0.99215686, 0.99215686, 0.7764706 , 0.31764707,
0.00784314, 0.        , 0.        , 0.        , 0.        ,
```

```
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.07058824, 0.67058825, 0.85882354,
       0.99215686, 0.99215686, 0.99215686, 0.99215686, 0.7647059 ,
       0.3137255 , 0.03529412, 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.21568628, 0.6745098 ,
       0.8862745 , 0.99215686, 0.99215686, 0.99215686, 0.99215686,
       0.95686275, 0.52156866, 0.04313726, 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.        , 0.        , 0.        , 0.        ,
       0.        , 0.53333336, 0.99215686, 0.99215686, 0.99215686,
       0.83137256, 0.5294118 , 0.5176471 , 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.        ], dtype=float32)
```

```
x_valid[3]
```

```
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.        , 0.04313726,
0.5882353 , 0.99215686, 0.7921569 , 0.12156863, 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.14509805, 0.9843137 , 0.9843137 ,
0.99215686, 0.41960785, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.08235294,
0.77254903, 0.9843137 , 0.9843137 , 0.99215686, 0.41960785,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.43137255, 0.74509805, 0.9843137 , 0.9843137 ,
0.9843137 , 0.99215686, 0.6627451 , 0.42745098, 0.24313726,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.99215686,
0.9843137 , 0.9843137 , 0.9843137 , 0.9843137 , 0.99215686,
0.9843137 , 0.9843137 , 0.8627451 , 0.2       , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.7137255 , 1.        , 0.99215686, 0.99215686,
0.99215686, 0.99215686, 0.91764706, 0.87058824, 0.99215686,
0.99215686, 0.99215686, 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.24705882, 0.8666667 ,
0.99215686, 0.9843137 , 0.9843137 , 0.9843137 , 0.5764706 ,
0.3019608 , 0.24313726, 0.5019608 , 0.9843137 , 0.9843137 ,
0.4117647 , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
0.        , 0.        , 0.        , 0.        , 0.        ,
```

0.1254902 , 0.90588236, 0.9843137 , 0.99215686, 0.9843137 ,
0.8627451 , 0.5372549 , 0.03921569, 0.   , 0.   ,
0.12156863, 0.9019608 , 0.9843137 , 0.9529412 , 0.44313726,
0.01960784, 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.14509805, 0.9843137 ,
0.9843137 , 0.99215686, 0.7372549 , 0.07843138, 0.   ,
0.   , 0.   , 0.   , 0.   , 0.42745098,
0.9843137 , 0.99215686, 0.9843137 , 0.13725491, 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.14509805, 0.9843137 , 0.9843137 , 0.7882353 ,
0.11764706, 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.12156863, 0.78431374, 0.99215686,
0.9843137 , 0.13725491, 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.14509805,
0.99215686, 0.99215686, 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.1254902 , 0.7921569 , 1.   , 0.99215686, 0.6431373 ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.54901963, 0.9843137 , 0.9843137 ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.42745098, 0.9843137 ,
0.99215686, 0.9843137 , 0.13725491, 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.8509804 , 0.9843137 , 0.9843137 , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.08235294,
0.24705882, 0.90588236, 0.9843137 , 0.99215686, 0.9019608 ,
0.11764706, 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.8509804 , 0.9843137 ,
0.9843137 , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.5647059 , 0.9843137 , 0.9843137 ,
0.9843137 , 0.8666667 , 0.23921569, 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.8509804 , 0.9843137 , 0.9843137 , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.7137255 ,
0.8666667 , 0.9843137 , 0.9843137 , 0.9843137 , 0.7058824 ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.85490197,
0.99215686, 0.99215686, 0.28627452, 0.28627452, 0.89411765,
0.99215686, 0.99215686, 1.   , 0.99215686, 0.99215686,
0.99215686, 0.99215686, 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,
0.   , 0.   , 0.   , 0.   , 0.   ,

```
        0.        , 0.        , 0.44313726, 0.9843137 , 0.9843137 ,
        0.99215686, 0.9843137 , 0.9843137 , 0.9843137 , 0.9843137 ,
        0.99215686, 0.9843137 , 0.9843137 , 0.9843137 , 0.5764706 ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.12156863, 0.9019608 , 0.9843137 , 0.99215686, 0.9843137 ,
        0.9843137 , 0.9843137 , 0.9843137 , 0.99215686, 0.9019608 ,
        0.7411765 , 0.13725491, 0.03921569, 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.24313726,
        0.5568628 , 0.99215686, 0.9843137 , 0.9843137 , 0.9843137 ,
        0.9843137 , 0.99215686, 0.41960785, 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.28235295,
        0.68235296, 0.9843137 , 0.6784314 , 0.2784314 , 0.28235295,
        0.11764706, 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        , 0.        ,
        0.        , 0.        , 0.        , 0.        ], dtype=float32)
```

```python
y_valid[3]
```

```
array([1., 0., 0., 0., 0., 0., 0., 0., 0., 0.], dtype=float32)
```

```python
model = Sequential()
```

```
model.add(Dense(64, activation='sigmoid', input_shape=(784,)))    #64
neurons in the hidden layer 784 inputs

#final layer
model.add(Dense(10, activation='softmax'))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 64)                50240

 dense_1 (Dense)             (None, 10)                650

=================================================================
Total params: 50,890
Trainable params: 50,890
Non-trainable params: 0
_________________________________________________________________
```

```
(64*784) #wi xi total weights at input
```

```
50176
```

```
(64*784)+64
```

```
50240
```

```
(10*64)
```

```
640
```

```
(10*64)+10
```

```
650
```

```
((10*64)+10) +((64*784)+64)
```

```
50890
```

```
model.compile(loss='mean_squared_error',optimizer=SGD(learning_rate=0.
03),metrics=['accuracy'])

history= model.fit(x_train,y_train,batch_size=128,epochs=75,verbose=1)

#overbose=0 will show you nothing
#verbose=1 will show you an animated progress bar like this:
#progress bar
#overbose=2 will just mention the number of epoch like this:
```

```
Epoch 1/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0593
```

```
- accuracy: 0.6446
Epoch 2/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0579
- accuracy: 0.6593
Epoch 3/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0565
- accuracy: 0.6744
Epoch 4/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0552
- accuracy: 0.6880
Epoch 5/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0539
- accuracy: 0.7019
Epoch 6/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0526
- accuracy: 0.7151
Epoch 7/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0514
- accuracy: 0.7260
Epoch 8/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0503
- accuracy: 0.7379
Epoch 9/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0492
- accuracy: 0.7463
Epoch 10/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0481
- accuracy: 0.7545
Epoch 11/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0470
- accuracy: 0.7629
Epoch 12/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0460
- accuracy: 0.7695
Epoch 13/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0451
- accuracy: 0.7768
Epoch 14/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0441
- accuracy: 0.7839
Epoch 15/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0433
- accuracy: 0.7900
Epoch 16/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0424
- accuracy: 0.7962
Epoch 17/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0416
- accuracy: 0.8018
Epoch 18/75
```

```
469/469 [==============================] - 2s 3ms/step - loss: 0.0407
- accuracy: 0.8069
Epoch 19/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0400
- accuracy: 0.8123
Epoch 20/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0392
- accuracy: 0.8166
Epoch 21/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0385
- accuracy: 0.8205
Epoch 22/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0378
- accuracy: 0.8244
Epoch 23/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0371
- accuracy: 0.8277
Epoch 24/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0365
- accuracy: 0.8307
Epoch 25/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0358
- accuracy: 0.8335
Epoch 26/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0352
- accuracy: 0.8358
Epoch 27/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0346
- accuracy: 0.8384
Epoch 28/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0341
- accuracy: 0.8405
Epoch 29/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0335
- accuracy: 0.8425
Epoch 30/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0330
- accuracy: 0.8442
Epoch 31/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0325
- accuracy: 0.8461
Epoch 32/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0320
- accuracy: 0.8476
Epoch 33/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0316
- accuracy: 0.8487
Epoch 34/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0311
- accuracy: 0.8500
```

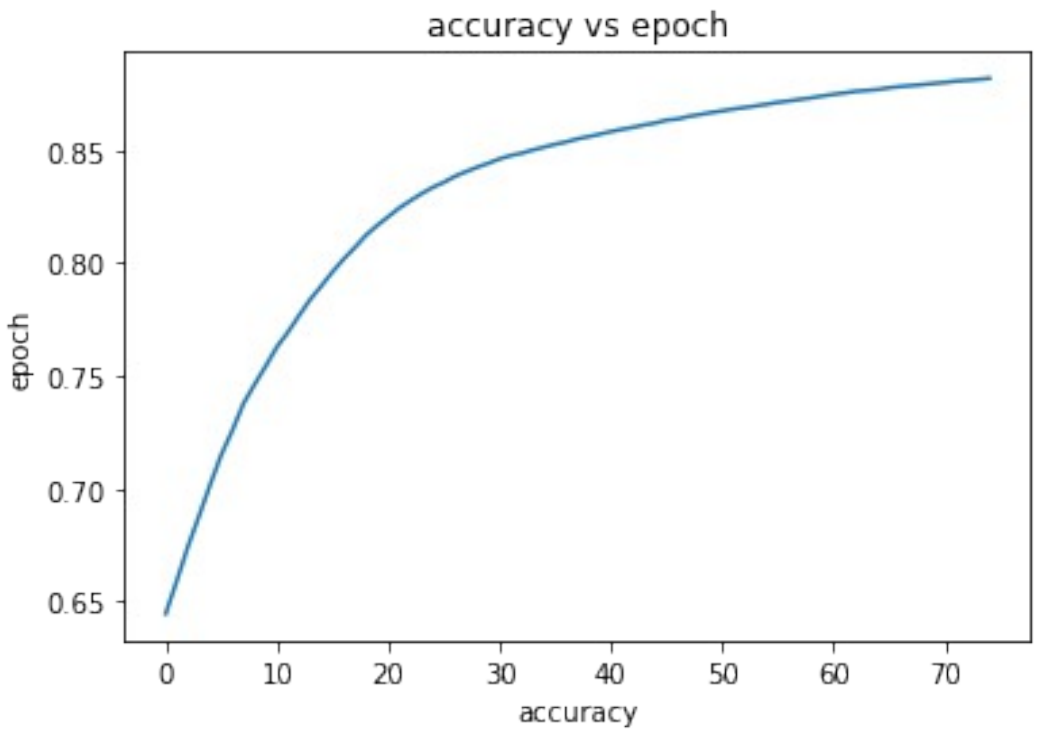
```
Epoch 35/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0307
- accuracy: 0.8513
Epoch 36/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0303
- accuracy: 0.8526
Epoch 37/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0299
- accuracy: 0.8536
Epoch 38/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0295
- accuracy: 0.8550
Epoch 39/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0291
- accuracy: 0.8559
Epoch 40/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0288
- accuracy: 0.8571
Epoch 41/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0284
- accuracy: 0.8582
Epoch 42/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0281
- accuracy: 0.8592
Epoch 43/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0278
- accuracy: 0.8601
Epoch 44/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0275
- accuracy: 0.8612
Epoch 45/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0272
- accuracy: 0.8620
Epoch 46/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0269
- accuracy: 0.8633
Epoch 47/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0266
- accuracy: 0.8638
Epoch 48/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0263
- accuracy: 0.8649
Epoch 49/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0261
- accuracy: 0.8658
Epoch 50/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0258
- accuracy: 0.8666
Epoch 51/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0256
```

```
- accuracy: 0.8674
Epoch 52/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0253
- accuracy: 0.8682
Epoch 53/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0251
- accuracy: 0.8688
Epoch 54/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0249
- accuracy: 0.8696
Epoch 55/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0247
- accuracy: 0.8703
Epoch 56/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0244
- accuracy: 0.8712
Epoch 57/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0242
- accuracy: 0.8718
Epoch 58/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0240
- accuracy: 0.8725
Epoch 59/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0238
- accuracy: 0.8731
Epoch 60/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0237
- accuracy: 0.8740
Epoch 61/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0235
- accuracy: 0.8747
Epoch 62/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0233
- accuracy: 0.8753
Epoch 63/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0231
- accuracy: 0.8760
Epoch 64/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0230
- accuracy: 0.8764
Epoch 65/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0228
- accuracy: 0.8768
Epoch 66/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0227
- accuracy: 0.8777
Epoch 67/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0225
- accuracy: 0.8781
Epoch 68/75
```

```
469/469 [==============================] - 1s 3ms/step - loss: 0.0224
- accuracy: 0.8786
Epoch 69/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0222
- accuracy: 0.8790
Epoch 70/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0221
- accuracy: 0.8795
Epoch 71/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0219
- accuracy: 0.8800
Epoch 72/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0218
- accuracy: 0.8806
Epoch 73/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0217
- accuracy: 0.8809
Epoch 74/75
469/469 [==============================] - 2s 3ms/step - loss: 0.0215
- accuracy: 0.8813
Epoch 75/75
469/469 [==============================] - 1s 3ms/step - loss: 0.0214
- accuracy: 0.8818
```

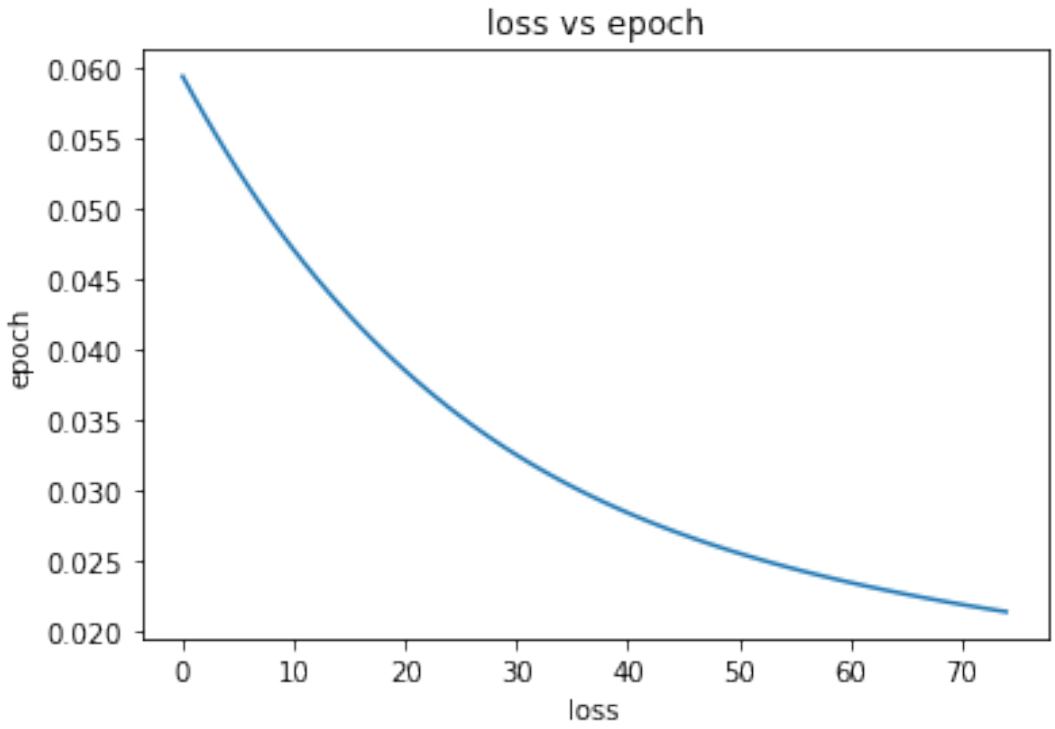
```
plt.plot(history.history['accuracy'])
plt.title('accuracy vs epoch')
plt.xlabel('accuracy')
plt.ylabel('epoch')
```

```
Text(0, 0.5, 'epoch')
```




```
plt.plot(history.history['loss'])
plt.title('loss vs epoch')
plt.xlabel('loss')
plt.ylabel('epoch')
```

```
Text(0, 0.5, 'epoch')
```



Result: The program is executed successfully and obtained the output.

PROGRAM NO-2

Aim: Programs on convolutional neural network to classify images from any standard dataset in the public domain.

```
import tensorflow as tf
from tensorflow.keras import datasets,layers,models
import matplotlib.pyplot as plt
import numpy as np
from sklearn.metrics import classification_report

(xtrain,ytrain),(xtest,ytest) = datasets.cifar10.load_data()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-
python.tar.gz
170500096/170498071 [==============================] - 6s 0us/step
170508288/170498071 [==============================] - 6s 0us/step
```

```
xtrain.shape
```

```
(50000, 32, 32, 3)
```

```
xtest.shape
```

```
(10000, 32, 32, 3)
```

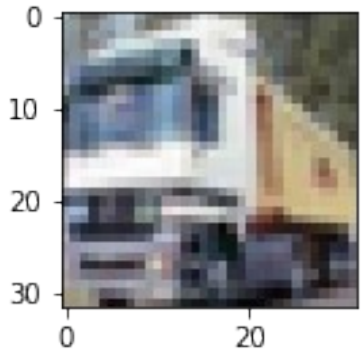
```
classes =
['airplane','automobile','bird','cat','deer','dog','frog','horse','shi
p','truck']
```

```
def plot_sample(x,y,index):
  plt.figure(figsize=(14,2))
  plt.imshow(x[index])
  plt.imshow(y[index])


plot_sample(xtrain,ytrain,1)
```

```
---------------------------------------------------------------------------
-----
TypeError                                 Traceback (most recent call
last)
<ipython-input-24-024740e61cba> in <module>()
----> 1 plot_sample(xtrain,ytrain,1)

<ipython-input-23-dd56c6c969e7> in plot_sample(x, y, index)
      2   plt.figure(figsize=(14,2))
      3   plt.imshow(x[index])
----> 4   plt.imshow(y[index])
      5

/usr/local/lib/python3.7/dist-packages/matplotlib/pyplot.py in
```

```
imshow(X, cmap, norm, aspect, interpolation, alpha, vmin, vmax,
origin, extent, shape, filternorm, filterrad, imlim, resample, url,
data, **kwargs)
   2649         filternorm=filternorm, filterrad=filterrad,
imlim=imlim,
   2650         resample=resample, url=url, **({"data": data} if data
is not
-> 2651         None else {}), **kwargs)
   2652     sci(__ret)
   2653     return __ret

/usr/local/lib/python3.7/dist-packages/matplotlib/__init__.py in
inner(ax, data, *args, **kwargs)
   1563     def inner(ax, *args, data=None, **kwargs):
   1564         if data is None:
-> 1565             return func(ax, *map(sanitize_sequence, args),
**kwargs)
   1566
   1567         bound = new_sig.bind(ax, *args, **kwargs)

/usr/local/lib/python3.7/dist-packages/matplotlib/cbook/deprecation.py
in wrapper(*args, **kwargs)
    356                 f"%(removal)s.  If any parameter follows
{name!r}, they "
    357                 f"should be pass as keyword, not
positionally.")
--> 358         return func(*args, **kwargs)
    359
    360     return wrapper

/usr/local/lib/python3.7/dist-packages/matplotlib/cbook/deprecation.py
in wrapper(*args, **kwargs)
    356                 f"%(removal)s.  If any parameter follows
{name!r}, they "
    357                 f"should be pass as keyword, not
positionally.")
--> 358         return func(*args, **kwargs)
    359
    360     return wrapper

/usr/local/lib/python3.7/dist-packages/matplotlib/axes/_axes.py in
imshow(self, X, cmap, norm, aspect, interpolation, alpha, vmin, vmax,
origin, extent, shape, filternorm, filterrad, imlim, resample, url,
**kwargs)
   5624                                 resample=resample, **kwargs)
   5625
-> 5626         im.set_data(X)
   5627         im.set_alpha(alpha)
   5628         if im.get_clip_path() is None:
```

```
/usr/local/lib/python3.7/dist-packages/matplotlib/image.py in
set_data(self, A)
    697                 or self._A.ndim == 3 and self._A.shape[-1] in
[3, 4]):
    698             raise TypeError("Invalid shape {} for image data"
--> 699                             .format(self._A.shape))
    700
    701         if self._A.ndim == 3:

TypeError: Invalid shape (1,) for image data
```




```
#Normalize
xtrain = xtrain/255
xtest = xtest/255

#model
cnn = models.Sequential([
          #feature extraction
          layers.Conv2D(filters=32,activation='relu',kernel_size =
(3,3),input_shape=(32,32,3)),
          layers.MaxPooling2D((2,2)),
          layers.Conv2D(filters=64,activation='relu',kernel_size =
(3,3),input_shape =(32,32,3)),
          layers.MaxPooling2D((2,2)),

          #classification
          layers.Flatten(),
          layers.Dense(64,activation='relu'),
          layers.Dense(10,activation='softmax')

])

cnn.compile(optimizer='adam',loss='sparse_categorical_crossentropy',me
trics=['accuracy'])

cnn.fit(xtrain,ytrain,epochs=20)

Epoch 1/20
1563/1563 [==============================] - 42s 27ms/step - loss:
```

```
2.3028 - accuracy: 0.0963
Epoch 2/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0993
Epoch 3/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0958
Epoch 4/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0975
Epoch 5/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0967
Epoch 6/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3027 - accuracy: 0.0974
Epoch 7/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0972
Epoch 8/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0977
Epoch 9/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0978
Epoch 10/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3027 - accuracy: 0.0979
Epoch 11/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0972
Epoch 12/20
1563/1563 [==============================] - 42s 27ms/step - loss:
2.3028 - accuracy: 0.0973
Epoch 13/20
1563/1563 [==============================] - 43s 27ms/step - loss:
2.3028 - accuracy: 0.0977
Epoch 14/20
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0984
Epoch 15/20
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0995
Epoch 16/20
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0981
Epoch 17/20
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0982
Epoch 18/20
```

```
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0982
Epoch 19/20
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0996
Epoch 20/20
1563/1563 [==============================] - 43s 28ms/step - loss:
2.3028 - accuracy: 0.0966

<keras.callbacks.History at 0x7f9e5c739b50>
```

```
ypred = cnn.predict(xtest)
```

```
cnn.evaluate(xtest,ytest)
```

```
313/313 [==============================] - 3s 9ms/step - loss: 2.3027
- accuracy: 0.1000

[2.3026859760284424, 0.10000000149011612]
```

```
ytest=ytest.reshape(-1,)
ypred=cnn.predict(xtest)
```

```
yclasses=[np.argmax(element) for element in ypred]
print('classification report:\
n',classification_report(ytest,yclasses))
```

```
classification report:
               precision    recall  f1-score   support

           0       0.00      0.00      0.00      1000
           1       0.10      1.00      0.18      1000
           2       0.00      0.00      0.00      1000
           3       0.00      0.00      0.00      1000
           4       0.00      0.00      0.00      1000
           5       0.00      0.00      0.00      1000
           6       0.00      0.00      0.00      1000
           7       0.00      0.00      0.00      1000
           8       0.00      0.00      0.00      1000
           9       0.00      0.00      0.00      1000

    accuracy                           0.10     10000
   macro avg       0.01      0.10      0.02     10000
weighted avg       0.01      0.10      0.02     10000


/usr/local/lib/python3.7/dist-packages/sklearn/metrics/
_classification.py:1318: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification
```

```
.py:1318: UndefinedMetricWarning: Precision and F-score are ill-
defined and being set to 0.0 in labels with no predicted samples. Use
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification
.py:1318: UndefinedMetricWarning: Precision and F-score are ill-
defined and being set to 0.0 in labels with no predicted samples. Use
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Result: The program is executed successfully and obtained the output.