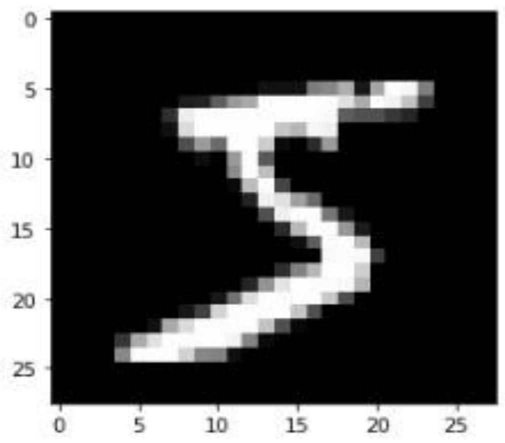
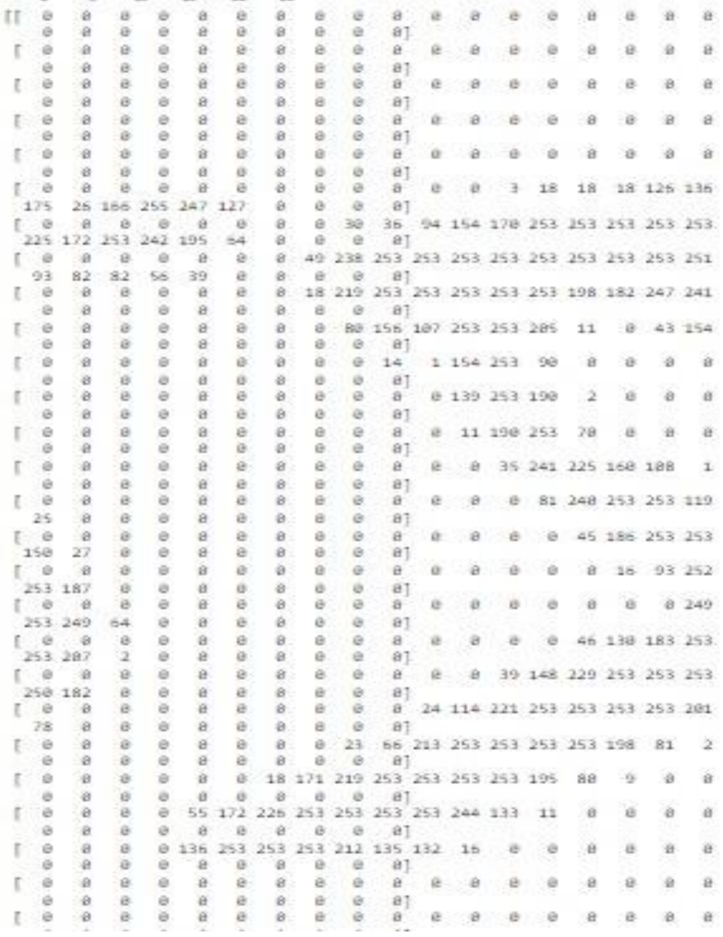
Source Code and Output

```
import numpy as np

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.optimizers import RMSprop
from tensorflow.keras.datasets import mnist import
matplotlib.pyplot as plt from sklearn import metrics
# Load the OCR dataset

# The MNIST dataset is a built-in dataset provided by Keras.
# It consists of 70,000 28x28 grayscale images, each of which displays a single handwritten digit from 0
to 9.
# The training set consists of 60,000 images, while the test set has 10,000 images.

(x_train, y_train), (x_test, y_test) = mnist.load_data()

# X_train and X_test are our array of images while y_train and y_test are our array of labels for each
image.
# The first tuple contains the training set features (X_train) and the training set labels (y_train).
# The second tuple contains the testing set features (X_test) and the testing set labels (y_test).
# For example, if the image shows a handwritten 7, then the label will be the intger 7.

plt.imshow(x_train[0], cmap='gray') # imshow() function which simply displays an image.
plt.show() # cmap is responsible for mapping a specific colormap to the values found in the array that
you passed as the first argument.
# This is because of the format that all the images in the dataset have:
# 1. All the images are grayscale, meaning they only contain black, white and grey.
# 2. The images are 28 pixels by 25 pixels in size (28x28).
print(x_train[0])

# image data is just an array of digits. You can almost make out a 5 from the pattern of the digits in the
array.
# Array of 28 values
# a grayscale pixel is stored as a digit between 0 and 255 where 0 is black, 255 is white and values in
between are different shades of gray.
```

# Therefore, each value in the [28][28] array tells the computer which color to put in that position when.





```
[[  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   3  18  18  18 126 136
  175  26 166 255 247 127   0   0   0   0]
 [  0   0   0   0   0   0   0   0  30  36  94 154 170 253 253 253 253 253
  225 172 253 242 195  64   0   0   0   0]
 [  0   0   0   0   0   0   0  49 238 253 253 253 253 253 253 253 253 251
   93  82  82  56  39   0   0   0   0   0]
 [  0   0   0   0   0   0   0  18 219 253 253 253 253 253 198 182 247 241
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0  80 156 107 253 253 205  11   0  43 154
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0  14   1 154 253  90   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0 139 253 190   2   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0  11 190 253  70   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  35 241 225 160 108   1
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0  81 240 253 253 119
   25   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  45 186 253 253
  150  27   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16  93 252
  253 187   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 249
  253 249  64   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  46 130 183 253
  253 207   2   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  39 148 229 253 253 253
  250 182   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0  24 114 221 253 253 253 253 201
   78   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0  23  66 213 253 253 253 253 198  81   2
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0  18 171 219 253 253 253 253 195  80   9   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0  55 172 226 253 253 253 253 244 133  11   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0 136 253 253 253 212 135 132  16   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
```

# reformat our X_train array and our X_test array because they do not have the correct shape.

# Reshape the data to fit the model

```
print("X_train shape", x_train.shape)
print("y_train shape", y_train.shape)
print("X_test shape", x_test.shape)
print("y_test shape", y_test.shape)
```

# Here you can see that for the training sets we have 60,000 elements and the testing sets have 10,000 elements.

# y_train and y_test only have 1 dimensional shapes because they are just the labels of each element.

# x_train and x_test have 3 dimensional shapes because they have a width and height (28x28 pixels) for each element.

# (60000, 28, 28) 1st parameter in the tuple shows us how much image we have 2nd and 3rd parameters are the pixel values from x to y (28x28)

# The pixel value varies between 0 to 255.

# (60000,) Training labels with integers from 0-9 with dtype of uint8. It has the shape (60000,).

```
# (10000, 28, 28) Testing data that consists of grayscale images. It has the shape (10000, 28, 28) and the
dtype of uint8. The pixel value varies between 0 to 255.
# (10000,) Testing labels that consist of integers from 0-9 with dtype uint8. It has the shape (10000,).
X_train shape (60000, 28, 28) y_train shape (60000,) X_test shape (10000, 28, 28) y_test shape
(10000,)
# X: Training data of shape (n_samples, n_features)
# y: Training label values of shape (n_samples, n_labels)
# 2D array of height and width, 28 pixels by 28 pixels will just become 784 pixels (28 squared). #
Remember that X_train has 60,000 elemenets, each with 784 total pixels so will become shape (60000,
784).
# Whereas X_test has 10,000 elements, each with each with 784 total pixels so will become shape
(10000, 784).
x_train = x_train.reshape(60000, 784)
x_test = x_test.reshape(10000, 784)
x_train = x_train.astype('float32') # use 32-bit precision when training a neural network, so at one point
the training data will have to be converted to 32 bit floats. Since the dataset fits easily in RAM, we might
as well convert to float immediately.
x_test = x_test.astype('float32')
x_train /= 255 # Each image has Intensity from 0 to 255 x_test
/= 255

# Regarding the division by 255, this is the maximum value of a byte (the input feature's type before the
conversion to float32),
# so this will ensure that the input features are scaled between 0.0 and 1.0.
# Convert class vectors to binary class matrices
num_classes = 10
y_train = np.eye(num_classes)[y_train] # Return a 2-D array with ones on the diagonal and zeros
elsewhere. y_test = np.eye(num_classes)[y_test] # f your particular categories is present then it mark as 1
else 0 in remain row
# Define the model architecture
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(784,))) # Input cosist of 784 Neuron ie 784 input,
512 in the hidden layer
model.add(Dropout(0.2)) # DROP OUT RATIO 20%
model.add(Dense(512, activation='relu')) #returns a sequence of another vectors of dimension 512
model.add(Dropout(0.2)) model.add(Dense(num_classes, activation='softmax')) # 10 neurons ie
output node in the output layer.
# Compile the model
model.compile(loss='categorical_crossentropy', # for a multi-class classification problem
            optimizer=RMSprop(), metrics=['accuracy'])
# Train the model batch_size = 128 # batch_size argument is passed to the layer to define a batch
size for the inputs.
epochs = 20
history = model.fit(x_train, y_train,
                 batch_size=batch_size,
                 epochs=epochs,
                 verbose=1, # verbose=1 will show you an animated progress bar eg. [==========]
                       validation_data=(x_test, y_test)) # Using validation_data means you are providing the
training set and validation set yourself,
 # 60000image/128=469 batch each
# Evaluate the model
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0]) print('Test accuracy:',
score[1])
Test loss: 0.08541901409626007
Test accuracy: 0.9851999878883362
```