Parshvanath Charitable Trust's

A. P. SHAH INSTITUTE OF TECHNOLOGY, THANE

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Department of Information Technology

Handwritten Digit Recognition

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1. Introduction

- Handwritten Digit Recognition is the ability of computers to recognize human handwritten digits.
- It is not an easy task for the machines, because handwritten digits are not perfect and can be made with many different flavors.
- Handwritten digit recognition is the solution to this problem which uses the image of a digit and recognize the digit present in the image.

- **Problem Identified :**
  - Time was spent on recognizing digits manually, which could be automated with great accuracy.
- **Solution Proposed:**
  - A model can be developed to recognize the human handwritten digits effectively.
  - To predicts the actual handwritten digit considering the shape and the images of the same.

2. Technology Stack

Technologies Used: -

1. Python

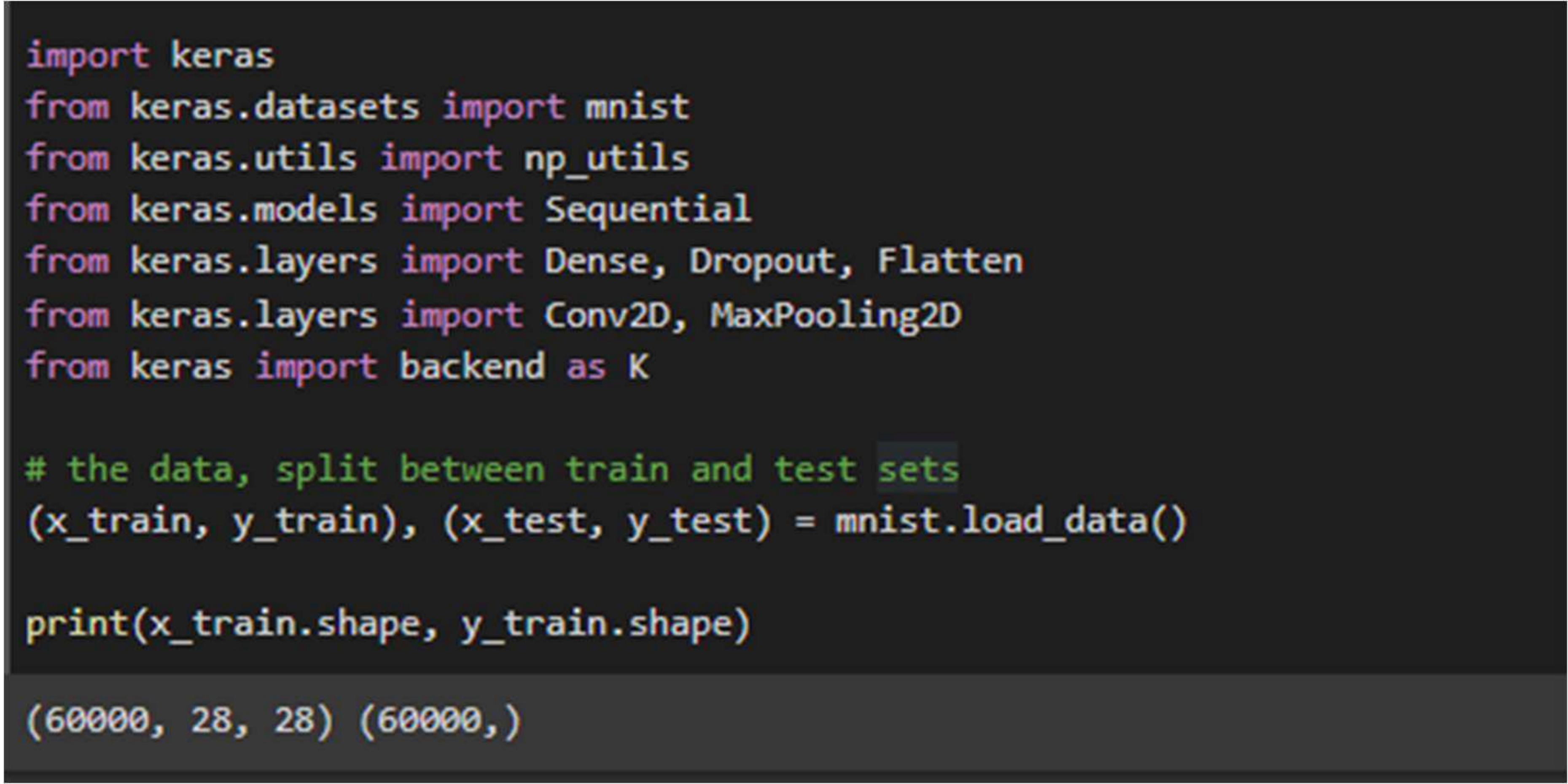
2. Tkinter

3. Numpy

4. Keras

3. Implementation

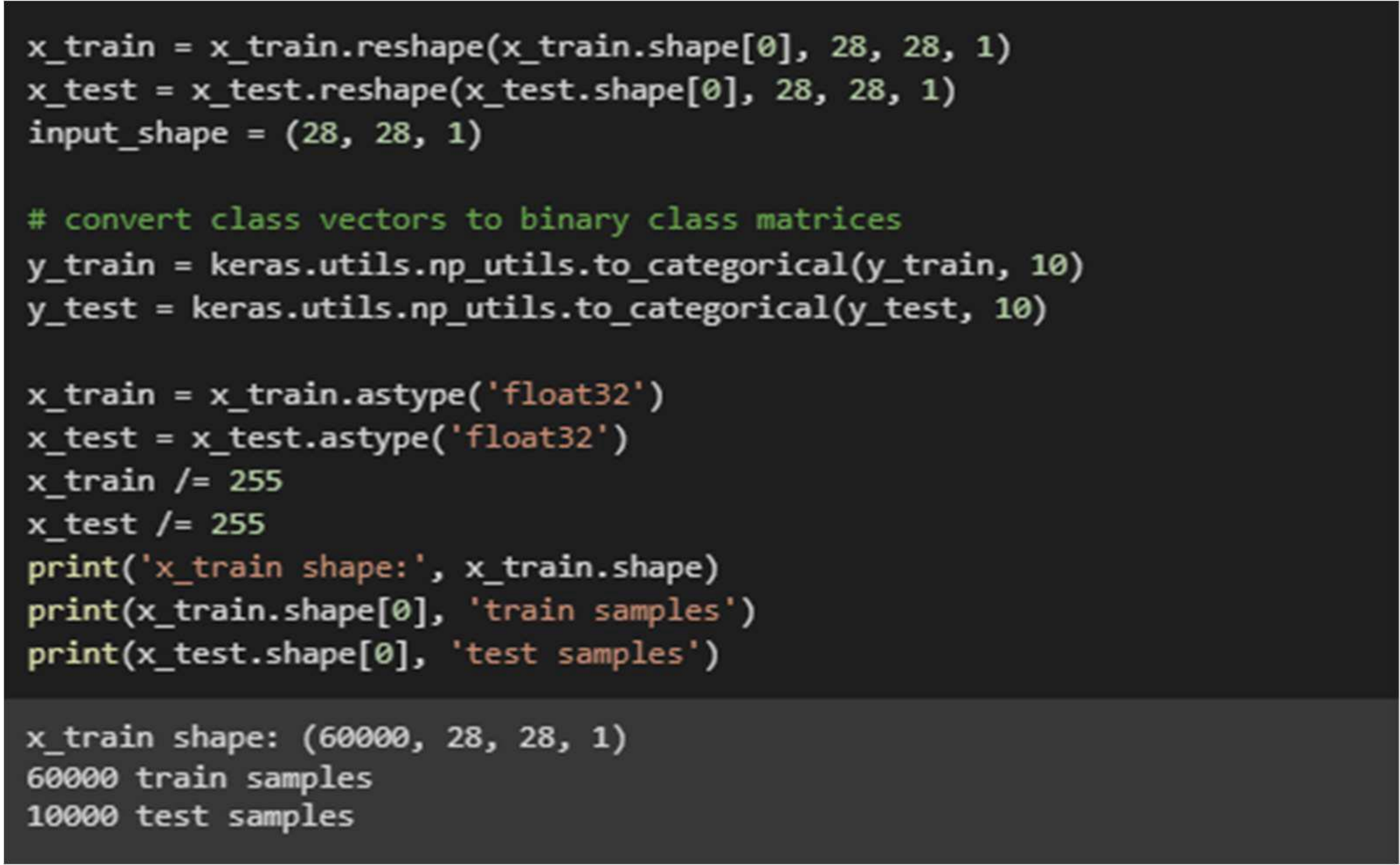
- **Import the Dataset**



```
import keras
from keras.datasets import mnist
from keras.utils import np_utils
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D
from keras import backend as K

# the data, split between train and test sets
(x_train, y_train), (x_test, y_test) = mnist.load_data()

print(x_train.shape, y_train.shape)
```

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

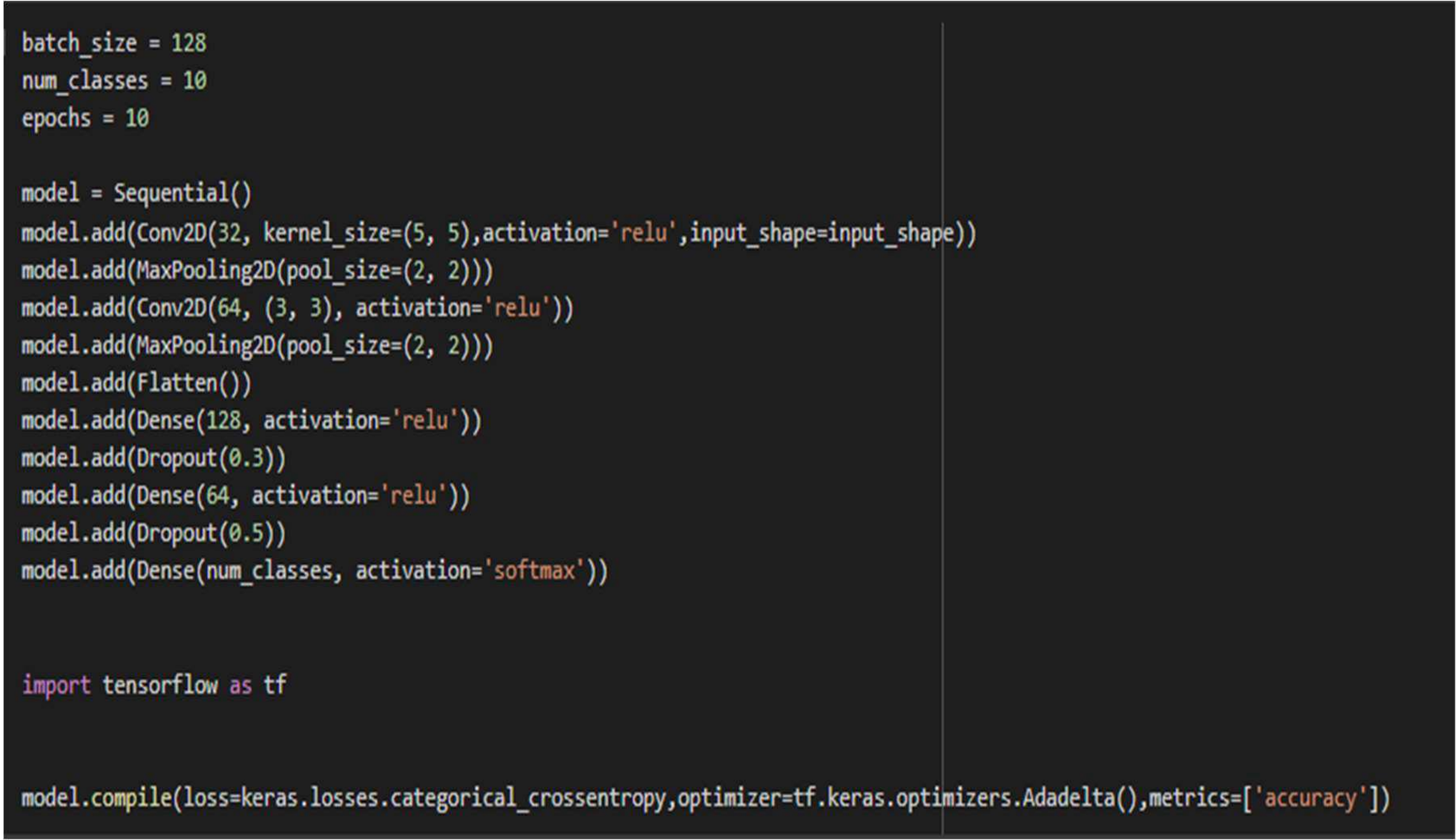
- **Pre-processing the data**



```
x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)
x_test = x_test.reshape(x_test.shape[0], 28, 28, 1)
input_shape = (28, 28, 1)

# convert class vectors to binary class matrices
y_train = keras.utils.np_utils.to_categorical(y_train, 10)
y_test = keras.utils.np_utils.to_categorical(y_test, 10)

x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')
```

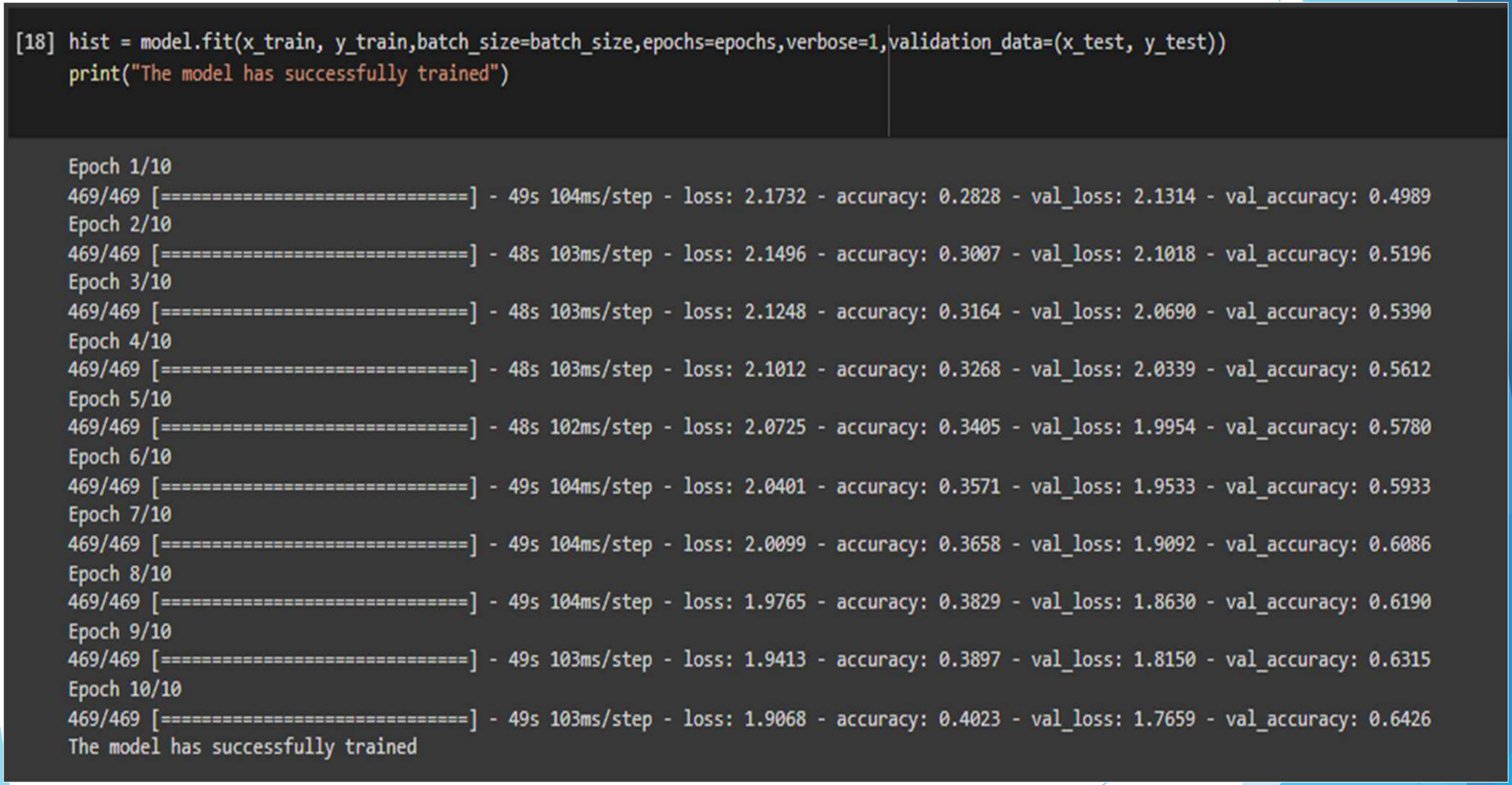
```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
```

- **Creating the Model**



```
batch_size = 128
num_classes = 10
epochs = 10

model = Sequential()
model.add(Conv2D(32, kernel_size=(5, 5),activation='relu',input_shape=input_shape))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.3))
model.add(Dense(64, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))


import tensorflow as tf


model.compile(loss=keras.losses.categorical_crossentropy,optimizer=tf.keras.optimizers.Adadelta(),metrics=['accuracy'])
```

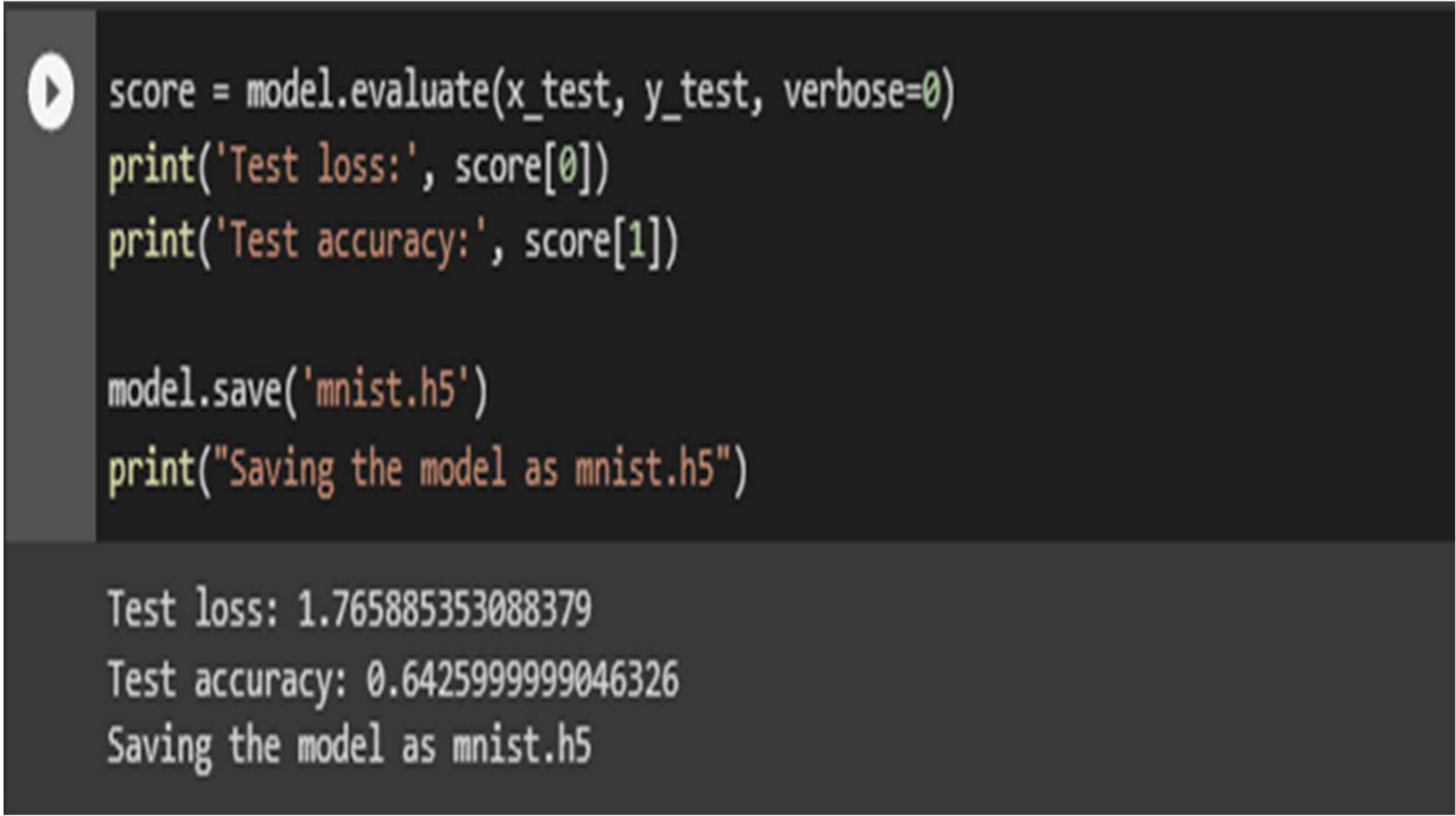
- **Training the Model**



```
[18] hist = model.fit(x_train, y_train,batch_size=batch_size,epochs=epochs,verbose=1,validation_data=(x_test, y_test))
     print("The model has successfully trained")
```

```
Epoch 1/10
469/469 [==============================] - 49s 104ms/step - loss: 2.1732 - accuracy: 0.2828 - val_loss: 2.1314 - val_accuracy: 0.4989
Epoch 2/10
469/469 [==============================] - 48s 103ms/step - loss: 2.1496 - accuracy: 0.3007 - val_loss: 2.1018 - val_accuracy: 0.5196
Epoch 3/10
469/469 [==============================] - 48s 103ms/step - loss: 2.1248 - accuracy: 0.3164 - val_loss: 2.0690 - val_accuracy: 0.5390
Epoch 4/10
469/469 [==============================] - 48s 103ms/step - loss: 2.1012 - accuracy: 0.3268 - val_loss: 2.0339 - val_accuracy: 0.5612
Epoch 5/10
469/469 [==============================] - 48s 102ms/step - loss: 2.0725 - accuracy: 0.3405 - val_loss: 1.9954 - val_accuracy: 0.5780
Epoch 6/10
469/469 [==============================] - 49s 104ms/step - loss: 2.0401 - accuracy: 0.3571 - val_loss: 1.9533 - val_accuracy: 0.5933
Epoch 7/10
469/469 [==============================] - 49s 104ms/step - loss: 2.0099 - accuracy: 0.3658 - val_loss: 1.9092 - val_accuracy: 0.6086
Epoch 8/10
469/469 [==============================] - 49s 104ms/step - loss: 1.9765 - accuracy: 0.3829 - val_loss: 1.8630 - val_accuracy: 0.6190
Epoch 9/10
469/469 [==============================] - 49s 103ms/step - loss: 1.9413 - accuracy: 0.3897 - val_loss: 1.8150 - val_accuracy: 0.6315
Epoch 10/10
469/469 [==============================] - 49s 103ms/step - loss: 1.9068 - accuracy: 0.4023 - val_loss: 1.7659 - val_accuracy: 0.6426
The model has successfully trained
```

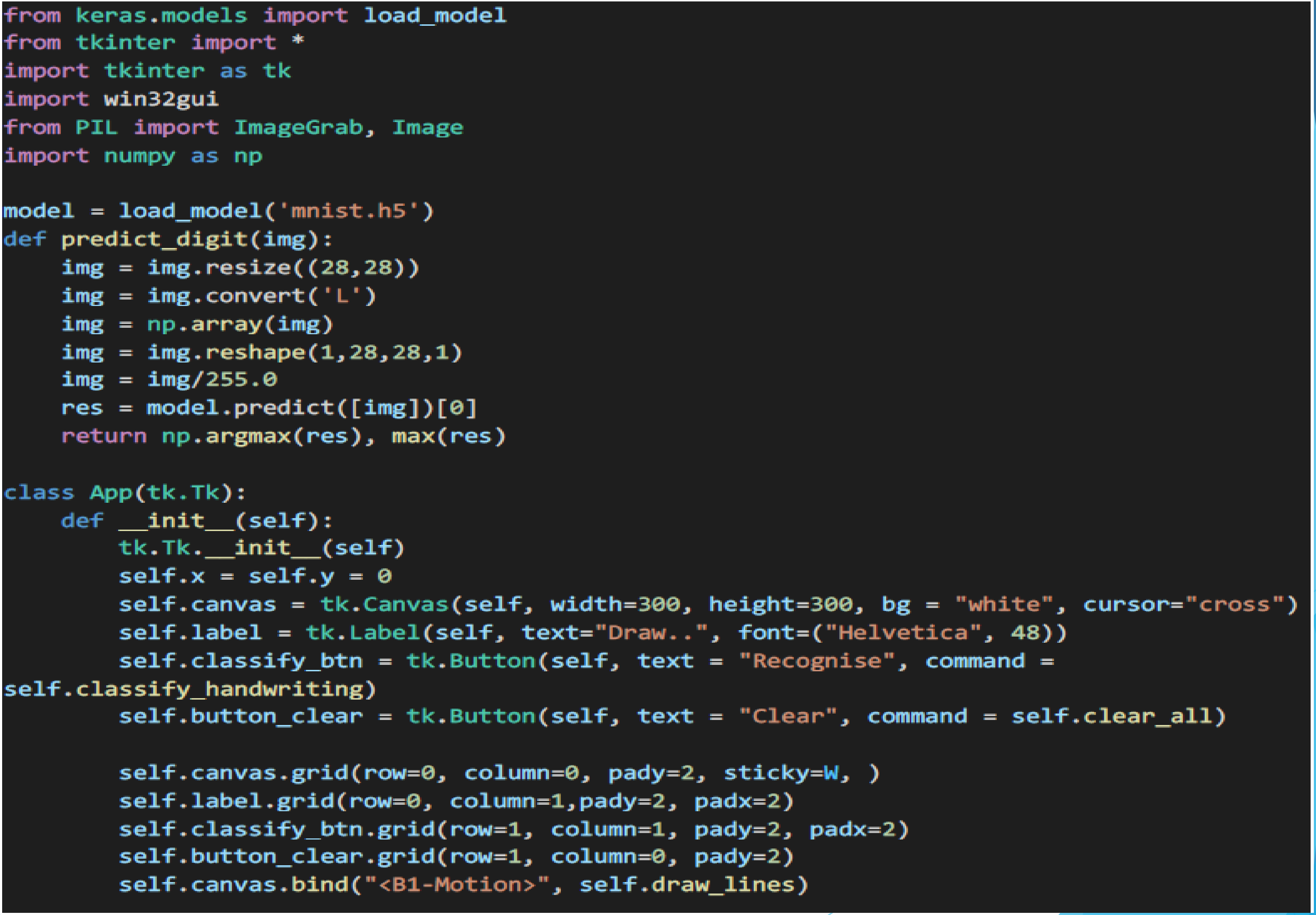
- **Evaluating the Model**



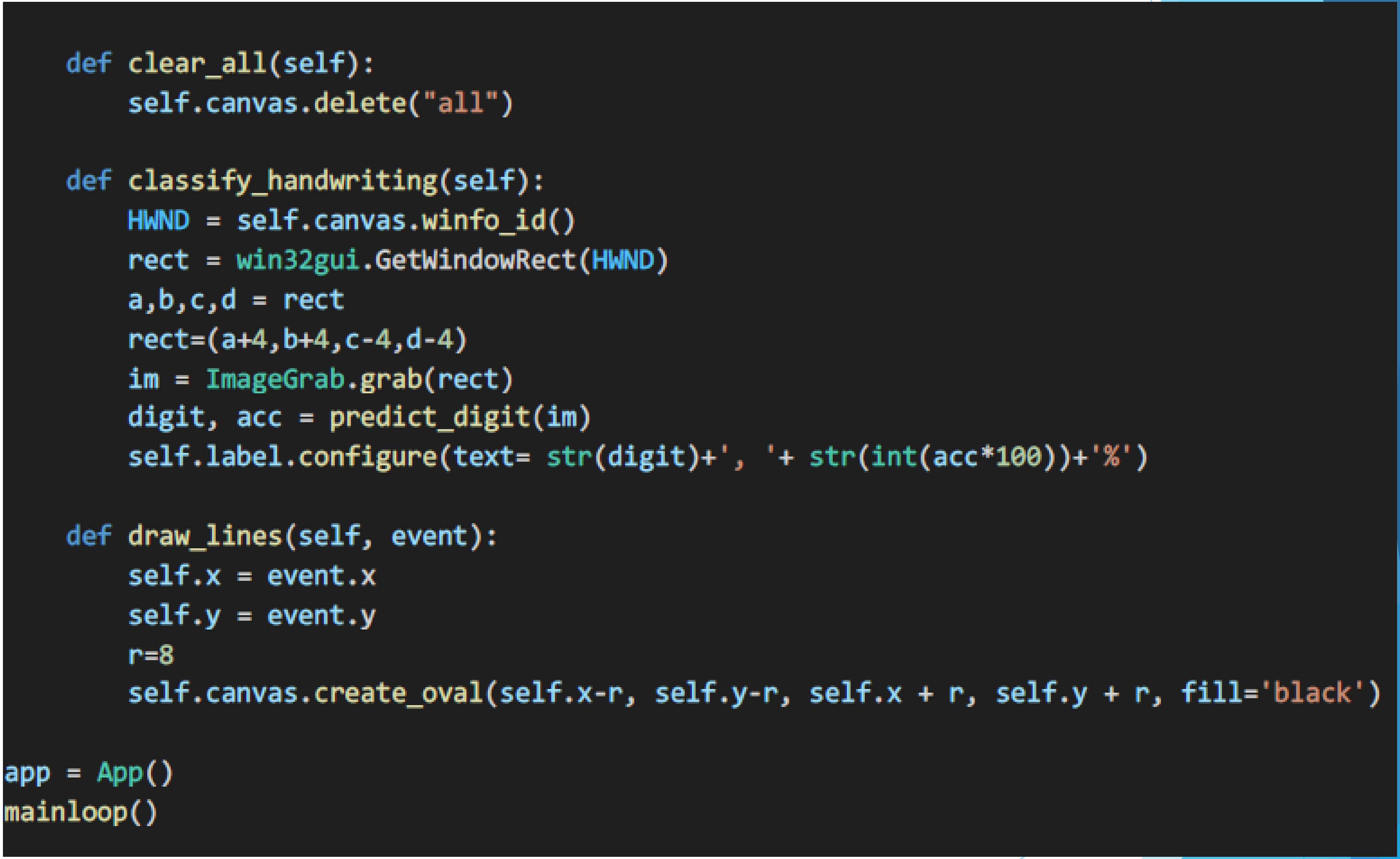
```
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])

model.save('mnist.h5')
print("Saving the model as mnist.h5")
```

```
Test loss: 1.765885353088379
Test accuracy: 0.6425999999046326
Saving the model as mnist.h5
```

- # Creating the GUI

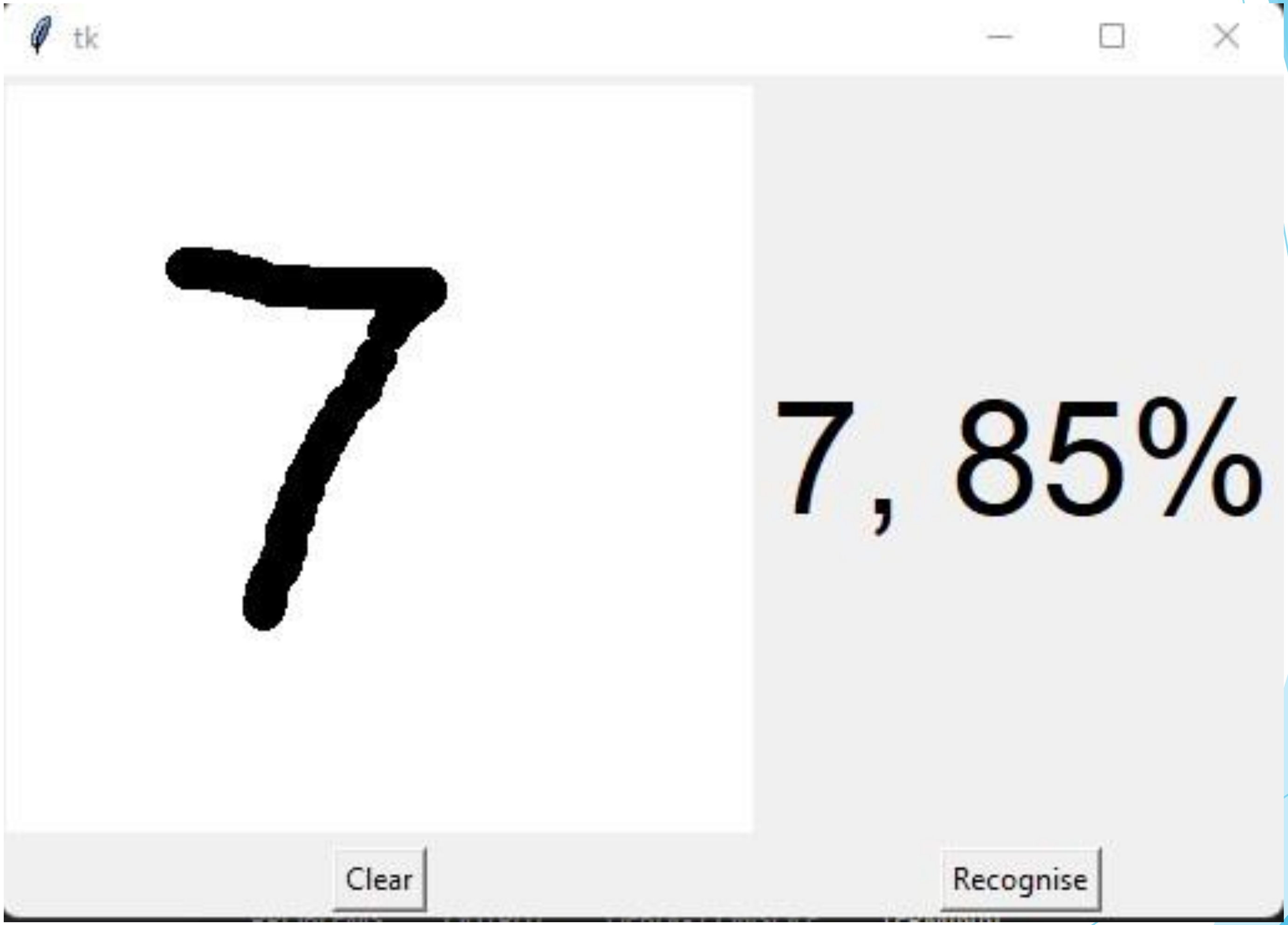


```
from keras.models import load_model
from tkinter import *
import tkinter as tk
import win32gui
from PIL import ImageGrab, Image
import numpy as np

model = load_model('mnist.h5')
def predict_digit(img):
    img = img.resize((28,28))
    img = img.convert('L')
    img = np.array(img)
    img = img.reshape(1,28,28,1)
    img = img/255.0
    res = model.predict([img])[0]
    return np.argmax(res), max(res)

class App(tk.Tk):
    def __init__(self):
        tk.Tk.__init__(self)
        self.x = self.y = 0
        self.canvas = tk.Canvas(self, width=300, height=300, bg = "white", cursor="cross")
        self.label = tk.Label(self, text="Draw..", font=("Helvetica", 48))
        self.classify_btn = tk.Button(self, text = "Recognise", command =
self.classify_handwriting)
        self.button_clear = tk.Button(self, text = "Clear", command = self.clear_all)

        self.canvas.grid(row=0, column=0, pady=2, sticky=W, )
        self.label.grid(row=0, column=1,pady=2, padx=2)
        self.classify_btn.grid(row=1, column=1, pady=2, padx=2)
        self.button_clear.grid(row=1, column=0, pady=2)
        self.canvas.bind("<B1-Motion>", self.draw_lines)
```

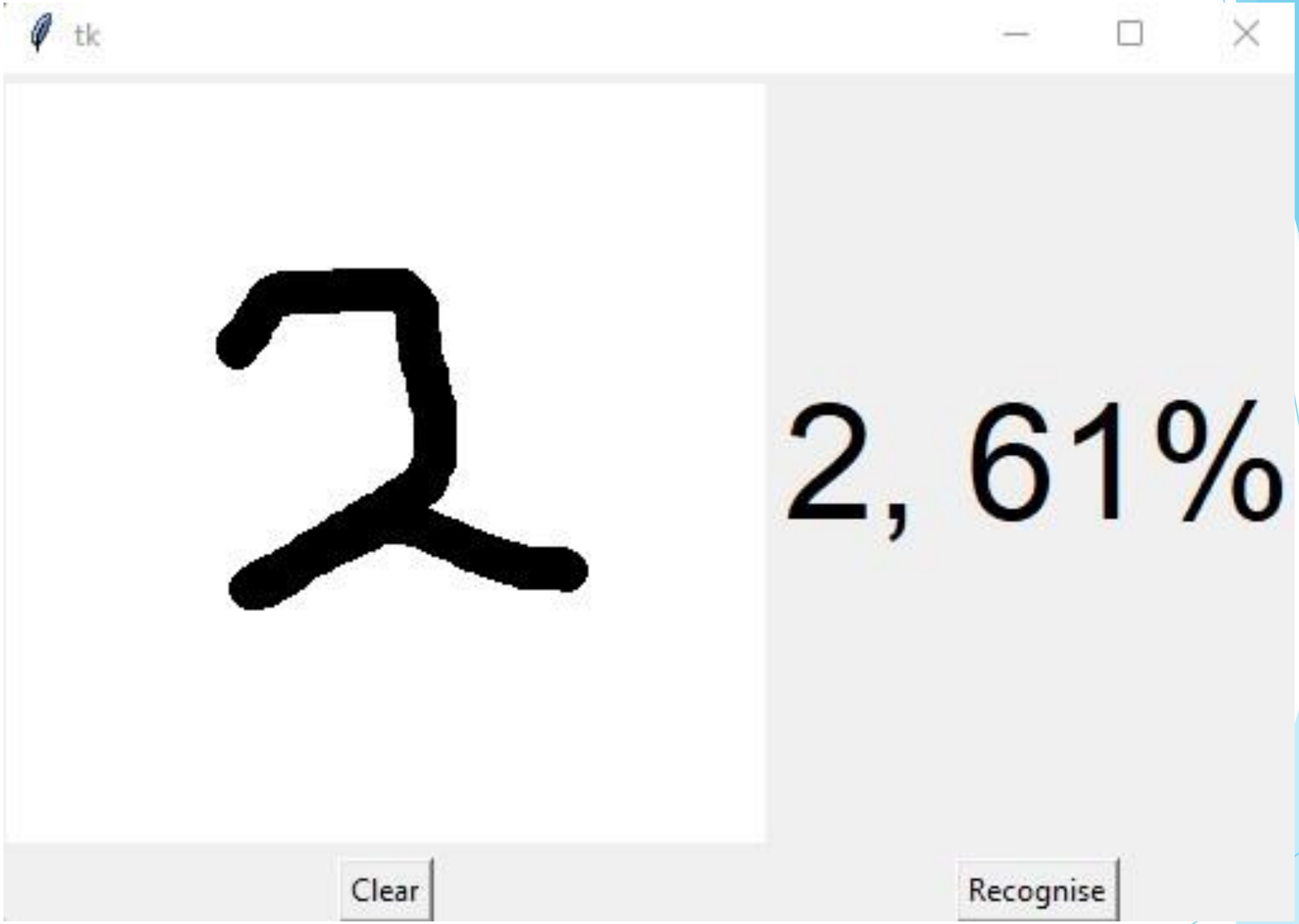


```
    def clear_all(self):
        self.canvas.delete("all")

    def classify_handwriting(self):
        HWND = self.canvas.winfo_id()
        rect = win32gui.GetWindowRect(HWND)
        a,b,c,d = rect
        rect=(a+4,b+4,c-4,d-4)
        im = ImageGrab.grab(rect)
        digit, acc = predict_digit(im)
        self.label.configure(text= str(digit)+', '+ str(int(acc*100))+'%')

    def draw_lines(self, event):
        self.x = event.x
        self.y = event.y
        r=8
        self.canvas.create_oval(self.x-r, self.y-r, self.x + r, self.y + r, fill='black')

app = App()
mainloop()
```

Result



7, 85%



2, 61%

Algorithm Used

Convolutional Neural Network (CNN)

- A Convolutional Neural Network is a Deep Learning algorithm that can take in an input image, assign importance to various aspects/objects in the image and be able to differentiate one from the other.
- Convolutional neural networks are more complex than standard multi-layer perceptrons, so we will start by using a simple structure, to begin with, that uses all of the elements for state-of-the-art results. Below summarizes the network architecture.

Conclusion

- Convolutional Neural Network is very effective for image classification purposes.
- For GUI we used Tkinter, wherein we drew a digit on canvas, then classified the digit with it’s accuracy.
- Hence, we have created a Model in Python to detect human handwritten digits.

Thank You...!!