Compiled Report on Handwritten Recognition of Digits

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Introduction:

To make machines more intelligent, the developers are diving into machine learning and deep learning techniques. A human learns to perform a task by practicing and repeating it again and again so that it memorizes how to perform the tasks. Then the neurons in his brain automatically trigger and they can quickly perform the task they have learned. Deep learning is also very similar to this. It uses different types of neural network architectures for different types of problems. For example – object recognition, image and sound classification, object detection, image segmentation, etc.

What is Handwritten Digit Recognition?

The handwritten digit recognition is the ability of computers to recognize human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different flavors. The handwritten digit recognition is the solution to this problem which uses the image of a digit and recognizes the digit present in the image. We are going to implement a handwritten digit recognition app using the MNIST dataset. We will be using a special type of deep neural network that is ***Convolutional Neural Networks***. In the end, we are going to build a GUI in which you can draw the digit and recognize it straight away.

Prerequisites:

The interesting Python project requires you to have basic knowledge of Python programming, deep learning with Keras library and the Tkinter library for building GUI.

Install the necessary libraries for this project using this command:

```
pip install numpy, tensorflow, keras, pillow,
```

The MNIST dataset

This is probably one of the most popular datasets among machine learning and deep learning enthusiasts. The MNIST dataset contains 60,000 training images of handwritten digits from zero to nine and 10,000 images for testing. So, the MNIST dataset has 10 different classes. The handwritten digits images are represented as a 28×28 matrix where each cell contains grayscale pixel value.

Implementation and source code of Handwritten Digit Recognition:

1. Import the libraries and load the dataset

First, we are going to import all the modules that we are going to need for training our model. The Keras library already contains some datasets and MNIST is one of them. So we can easily import the dataset and start working with it.
The **mnist.load_data()** method returns us the training data, its labels and also the testing data and its labels.

```
import keras
from keras.datasets import mnist
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)
```

2. Preprocess the data

The image data cannot be fed directly into the model so we need to perform some operations and process the data to make it ready for our neural network. The dimension of the training data is (60000,28,28). The CNN model will require one more dimension so we reshape the matrix to shape (60000,28,28,1).

```
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.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)
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')
```

3. Create the model

Now we will create our CNN model in Python data science project. A CNN model generally consists of convolutional and pooling layers. It works better for data that are represented as grid structures, this is the reason why CNN works well for image classification problems. The dropout layer is used to deactivate some of the neurons and while training, it reduces offer fitting of the model. We will then compile the model with the Adadelta optimizer.

```
batch_size = 128
num_classes = 10
epochs = 10
model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3),activation='relu',input_shape=input_shape))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))
model.compile(loss=keras.losses.categorical_crossentropy,optimizer=keras.optimizers.Adadelta(),metrics=['
accuracy'])
```

4. Train the model

The **model.fit() function** of Keras will start the training of the model. **It** takes the training data, validation data, epochs, and batch size.
It takes some time to train the model. After training, we save the weights and model definition in the ‘mnist.h5’ file.

```
1. hist = model.fit(x_train, y_train,batch_size=batch_size,epochs=epochs,verbose=1,validation_data=(x_test, y_test))
2. print("The model has successfully trained")
3.
4. model.save('mnist.h5')
5. print("Saving the model as mnist.h5")
```

5. Evaluate the model

We have 10,000 images in our dataset which will be used to evaluate how good our model works. The testing data was not involved in the training of the data therefore, it is new data for our model. The MNIST dataset is well balanced so we can get around 99% accuracy.

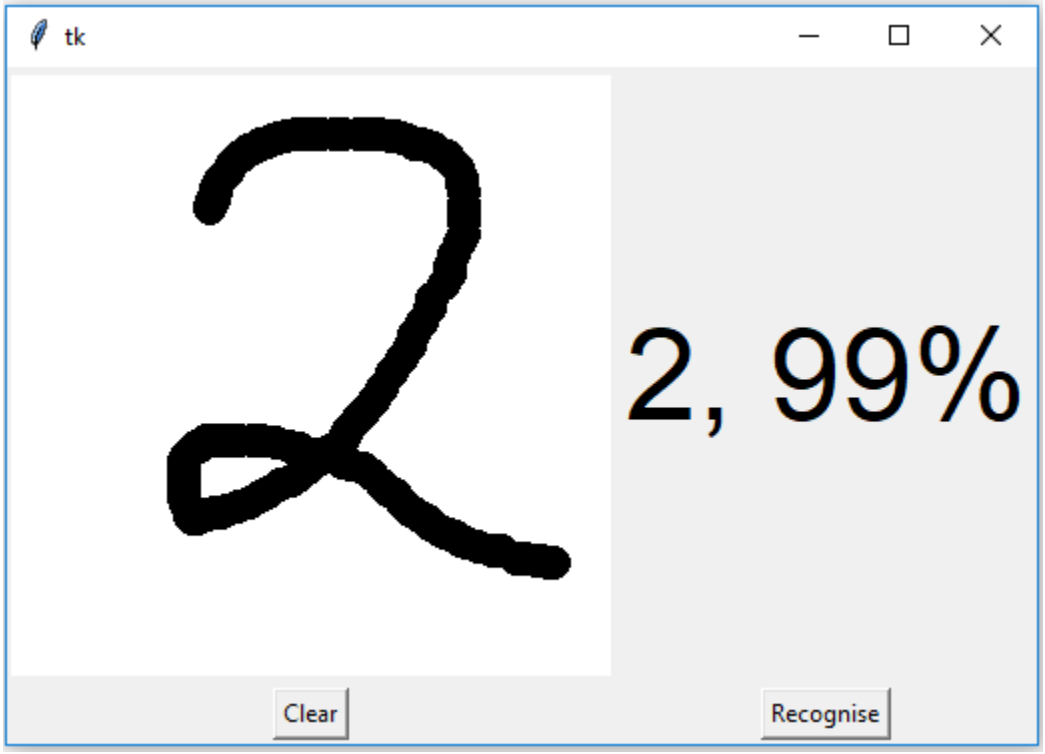
```
1. score = model.evaluate(x_test, y_test, verbose=0)
2. print('Test loss:', score[0])
3. print('Test accuracy:', score[1])
```

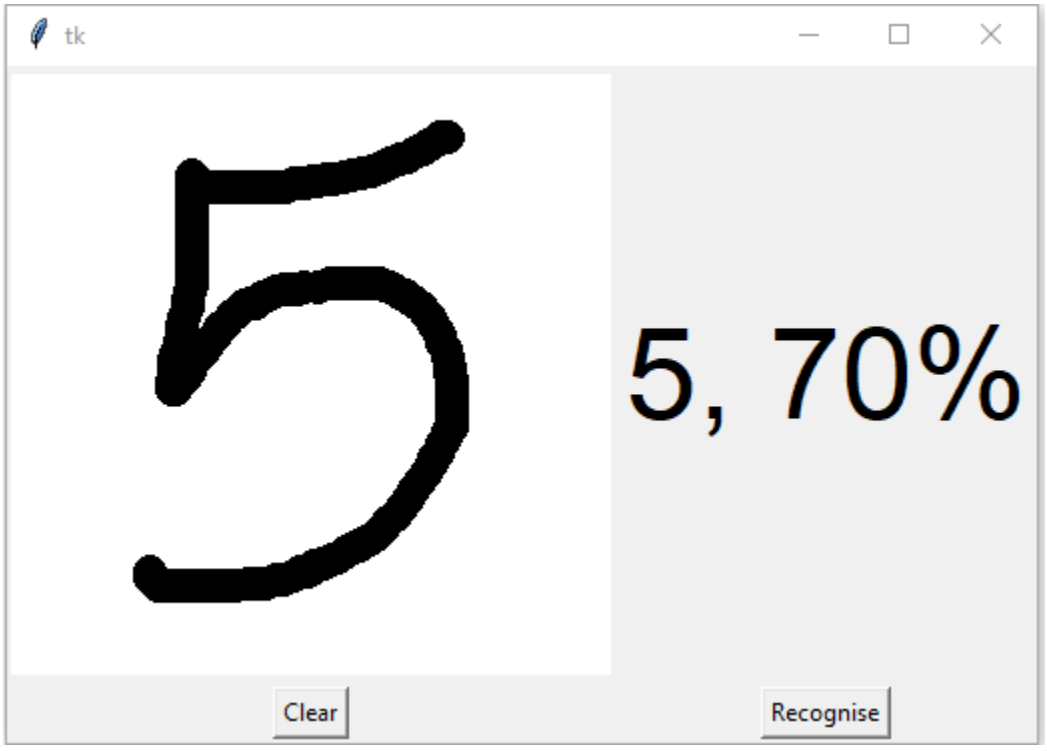
6. Create GUI to predict digits

Now for the GUI, we have created a new file in which we build an interactive window to draw digits on canvas and with a button, we can recognize the digit. The Tkinter library comes in the Python standard library. We have created a function **predict_digit()** that takes the image as input and then uses the trained model to predict the digit.
Then we create the App class which is responsible for building the GUI for our app. We create a canvas where we can draw by capturing the mouse event and with a button, we trigger the predict_digit() function and display the results.
Here’s the full code for our gui_digit_recognizer.py file:

```
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):
#resize image to 28x28 pixels
img = img.resize((28,28))
#convert rgb to grayscale
img = img.convert('L')
img = np.array(img)
#reshaping to support our model input and normalizing
img = img.reshape(1,28,28,1)
img = img/255.0
#predicting the class
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
# Creating elements
self.canvas = tk.Canvas(self, width=300, height=300, bg = "white", cursor="cross")
self.label = tk.Label(self, text="Thinking..", 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)
# Grid structure
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("<Motion>", self.start_pos)
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() # get the handle of the canvas
rect = win32gui.GetWindowRect(HWND) # get the coordinate of the canvas
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()
```

Screenshots and Results of the above Implementation:





Conclusion:

In this project, we have successfully built a Python project on handwritten digit recognition app. We have built and trained the Convolutional neural network which is very effective for image classification purposes. Later on, we build the GUI where we have drawn a digit on the canvas then we classify the digit and show the results and it calculates the equivalent percentage based on the given drawing of the digit.