CS 5542 Big Data Analytics and Applications

Project report

Deep learning-based license plate recognition system

Team number: 8

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Objective:

As part of this project, we intend to create an application with a trained deep learning CNN model using the RTO API and this model is used for recognizing the characters on the vehicle's license plate from an image. By processing this image and utilizing the RTO API we can retrieve the owner's information. Finally, we are displaying all this information using Flask web application.

Scope of the project:

With the increasing number of vehicles and traffic violation has been the major cause of the road accidents. Even though the road safety rules and regulations are in place the violators are still increasing. Having a system to identify these violators will assist the law enforcement to impose the road safety rules and reduce the road accidents.

Implementation:

The main aim of our project is to retrieve the vehicle information with the help of image processing using license plate number. This work uses a real time embedded Vehicle Plate Number Recognition system to identify the license plate number.

Below are the requirements to create and train the model

1. Here we are using Google Colab and installing the required Python and Deep Learning libraries.
2. Data that contains the image or video using which we can detect the plate number and get the vehicle information.

3. Flask application installation
4. RTO API

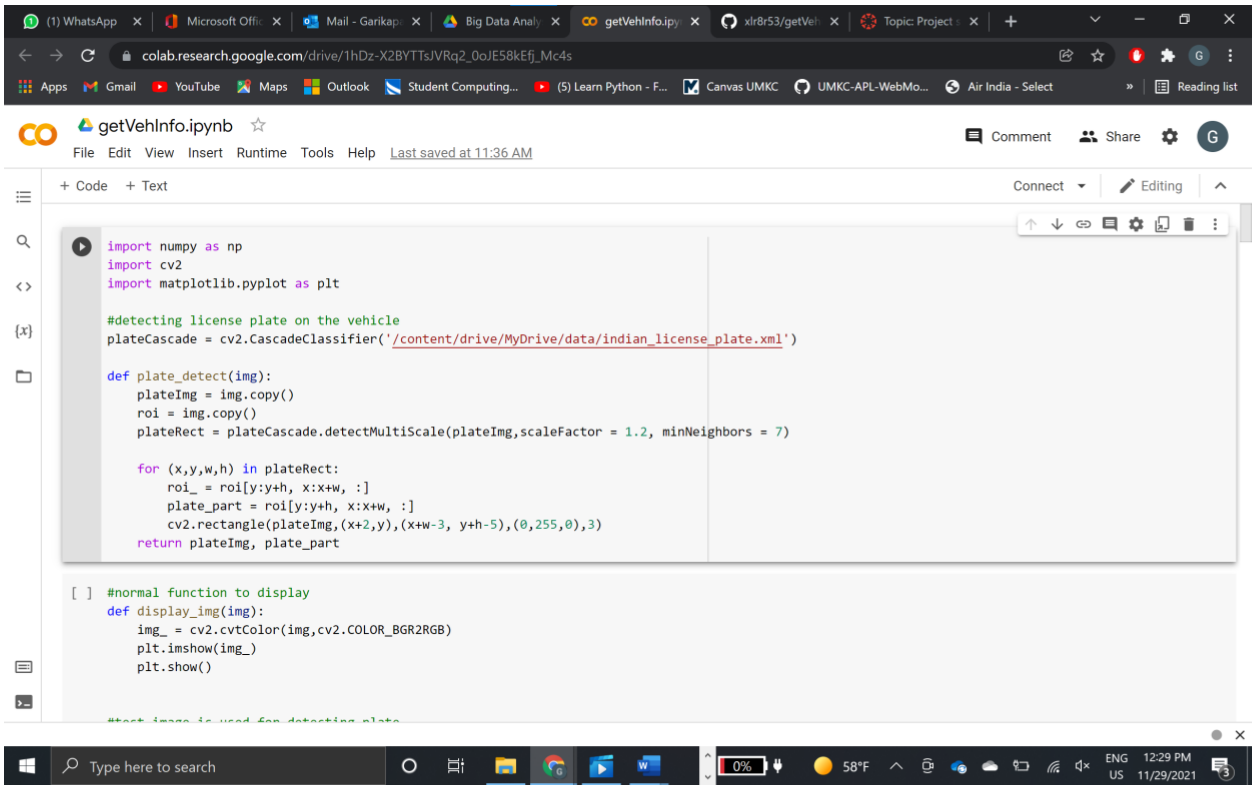
We have followed the below steps to create and train the CNN deep learning model for vehicle number plate detection.

Imported the required libraries such as Numpy, Matplotlib and Cv2. Here we are using Cascaded Classifer whose main purpose is to detect a particular region inside an image and here it is to identify the vehicle number plate region. Usually, these Cascading classifiers are trained with many positive and negative sample and this trained model is used to identify a particular region in an image.

Plate_detect() function is used to detect the vehicle number plate and mark it in green colour rectangle and crop that part and return it to a function which in turn used by display_img() function.

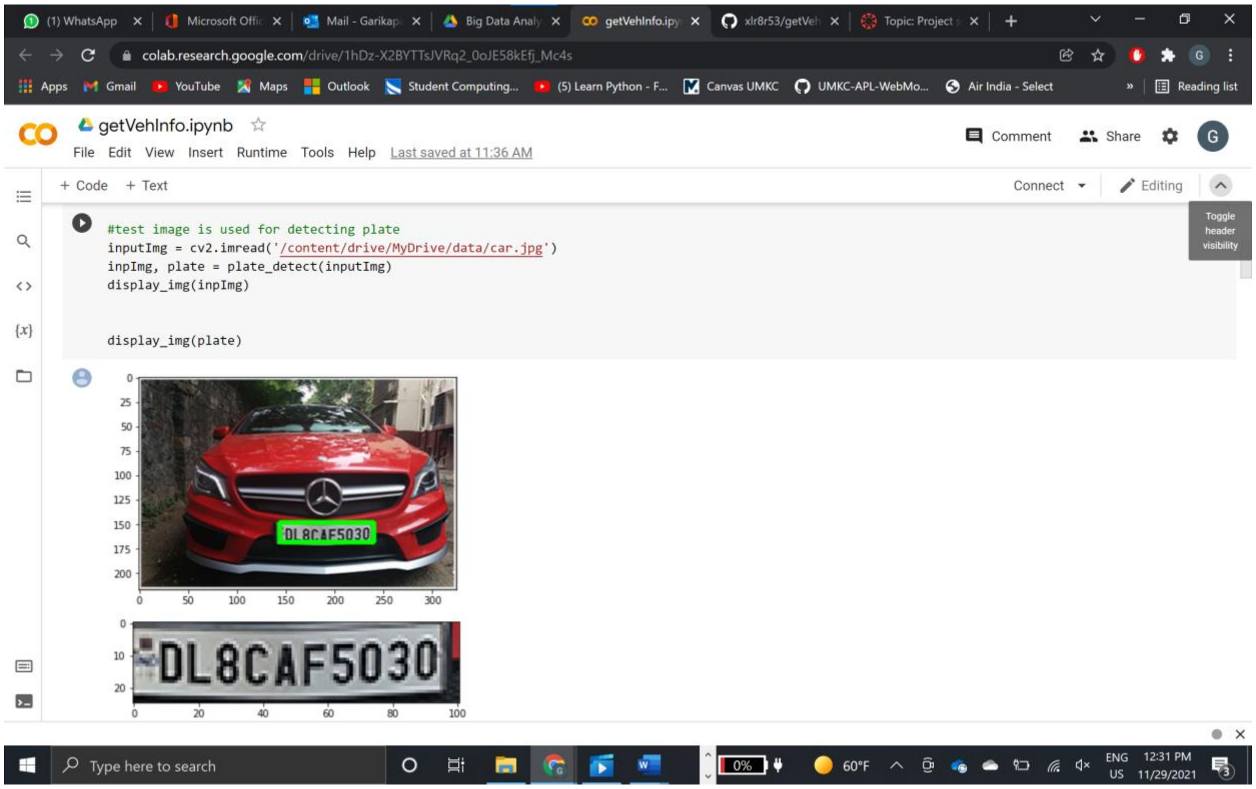
display_img() function is using img as the parameter and converting the BGR colour code to RGB colour code and displaying the image on the screen using matplotlib.

Here we are using car.jpg as the input image i.e., inputImg and using this with plate_detect() function to retrieve on the number plate.


colab.research.google.com/drive/1hDz-X2BYTTsJVRq2_0oJE58kEfj_Mc4s
getVehInfo.ipynb
File Edit View Insert Runtime Tools Help Last saved at 11:36 AM
Comment Share
+ Code + Text
Connect Editing

```
import numpy as np
import cv2
import matplotlib.pyplot as plt

#detecting license plate on the vehicle
plateCascade = cv2.CascadeClassifier('/content/drive/MyDrive/data/indian_license_plate.xml')

def plate_detect(img):
    plateImg = img.copy()
    roi = img.copy()
    plateRect = plateCascade.detectMultiScale(plateImg,scaleFactor = 1.2, minNeighbors = 7)

    for (x,y,w,h) in plateRect:
        roi_ = roi[y:y+h, x:x+w, :]
        plate_part = roi[y:y+h, x:x+w, :]
        cv2.rectangle(plateImg,(x+2,y),(x+w-3, y+h-5),(0,255,0),3)
    return plateImg, plate_part
```

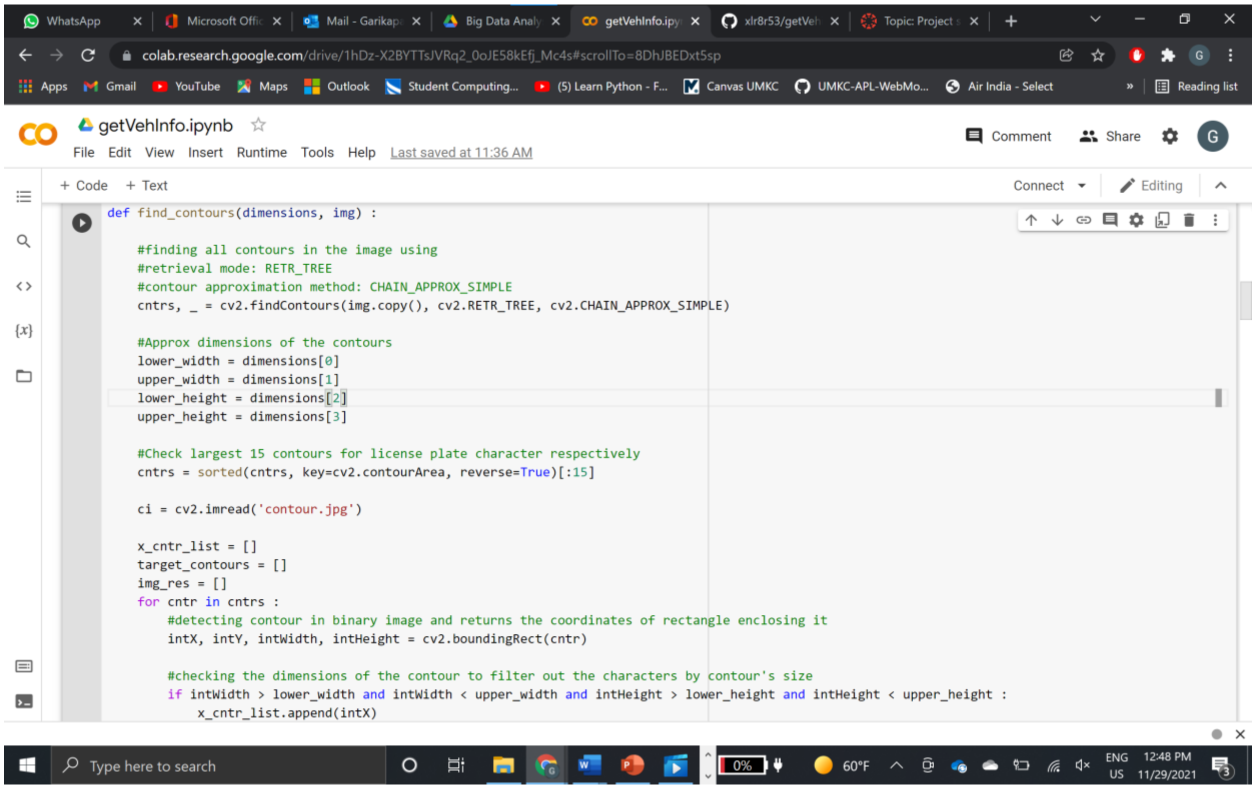
```
#normal function to display
def display_img(img):
    img_ = cv2.cvtColor(img,cv2.COLOR_BGR2RGB)
    plt.imshow(img_)
    plt.show()
```



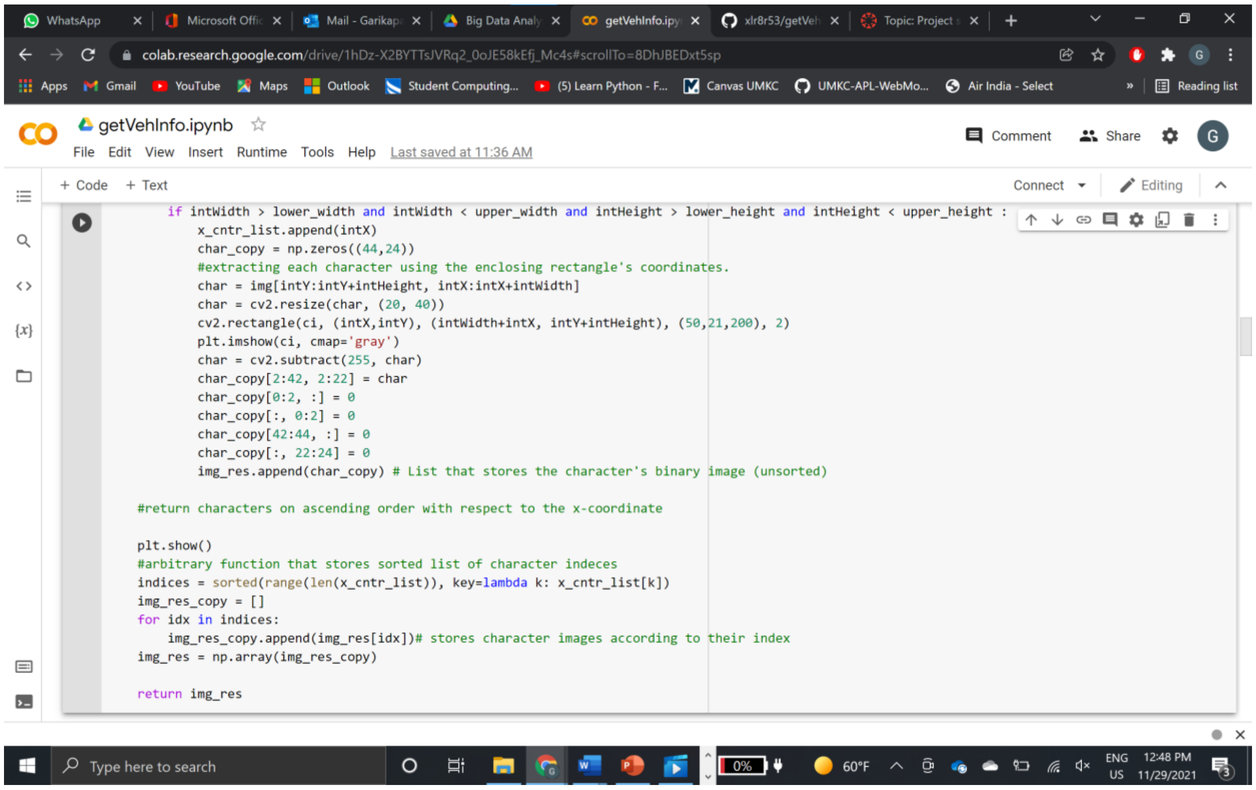
```
#test image is used for detecting plate
inputImg = cv2.imread('/content/drive/MyDrive/data/car.jpg')
inpImg, plate = plate_detect(inputImg)
display_img(inpImg)


display_img(plate)
```

Here we are preprocessing the image using the find_contours() function with the parameters such as dimension of the image and the preprocessed image. These parameters are useful in easily extracting the numbers and characters from the license plate.

This function will find the contours (Curve joining all the continuous points) in the image i.e., the outline or shape of the numbers with their position and create a rectangle around them and using this function with CV2 library we can get the boundaries of an object in the image. After identifying and cropping the numbers they are extracted and stored in img_res_copy in the form of array.



```python
def find_contours(dimensions, img) :

    #finding all contours in the image using
    #retrieval mode: RETR_TREE
    #contour approximation method: CHAIN_APPROX_SIMPLE
    cntrs, _ = cv2.findContours(img.copy(), cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)

    #Approx dimensions of the contours
    lower_width = dimensions[0]
    upper_width = dimensions[1]
    lower_height = dimensions[2]
    upper_height = dimensions[3]

    #Check largest 15 contours for license plate character respectively
    cntrs = sorted(cntrs, key=cv2.contourArea, reverse=True)[:15]

    ci = cv2.imread('contour.jpg')

    x_cntr_list = []
    target_contours = []
    img_res = []
    for cntr in cntrs :
        #detecting contour in binary image and returns the coordinates of rectangle enclosing it
        intX, intY, intWidth, intHeight = cv2.boundingRect(cntr)

        #checking the dimensions of the contour to filter out the characters by contour's size
        if intWidth > lower_width and intWidth < upper_width and intHeight > lower_height and intHeight < upper_height :
            x_cntr_list.append(intX)
```



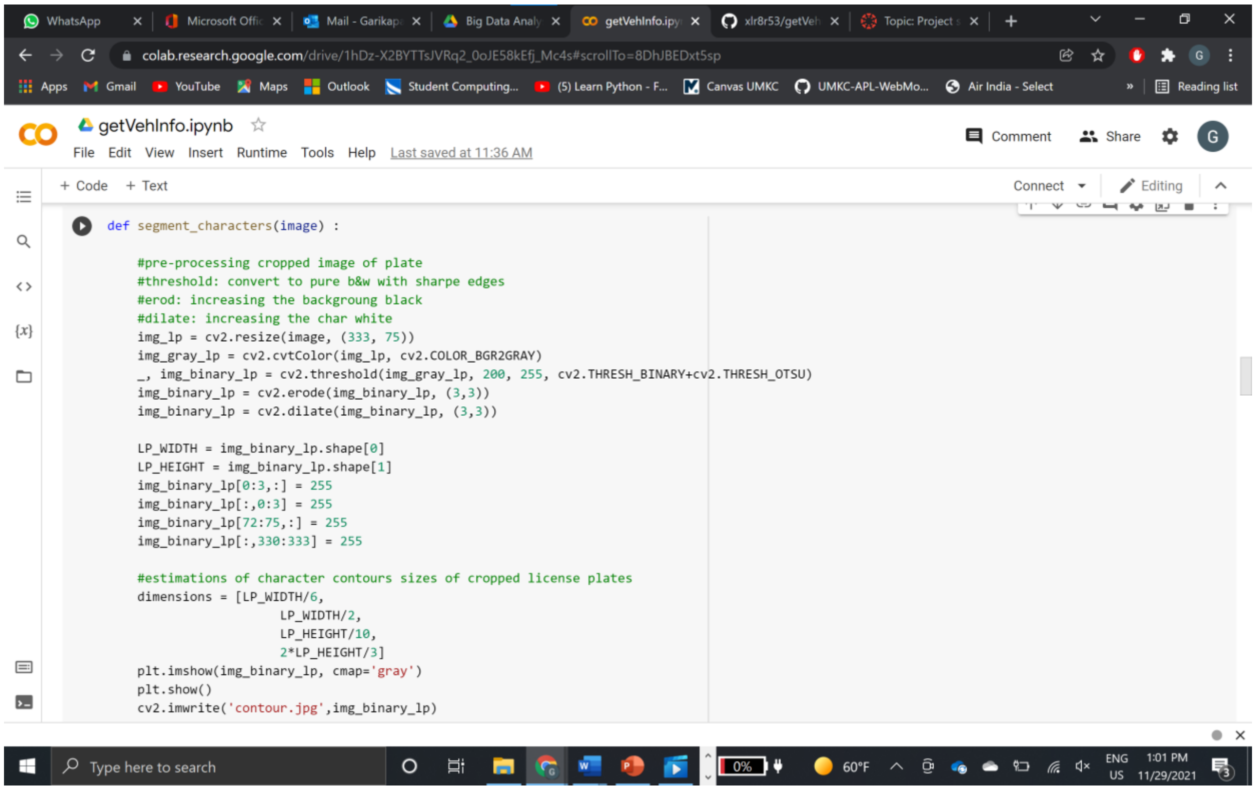
```python
        if intWidth > lower_width and intWidth < upper_width and intHeight > lower_height and intHeight < upper_height :
            x_cntr_list.append(intX)
            char_copy = np.zeros((44,24))
            #extracting each character using the enclosing rectangle's coordinates.
            char = img[intY:intY+intHeight, intX:intX+intWidth]
            char = cv2.resize(char, (20, 40))
            cv2.rectangle(ci, (intX,intY), (intWidth+intX, intY+intHeight), (50,21,200), 2)
            plt.imshow(ci, cmap='gray')
            char = cv2.subtract(255, char)
            char_copy[2:42, 2:22] = char
            char_copy[0:2, :] = 0
            char_copy[:, 0:2] = 0
            char_copy[42:44, :] = 0
            char_copy[:, 22:24] = 0
            img_res.append(char_copy) # List that stores the character's binary image (unsorted)

    #return characters on ascending order with respect to the x-coordinate

    plt.show()
    #arbitrary function that stores sorted list of character indeces
    indices = sorted(range(len(x_cntr_list)), key=lambda k: x_cntr_list[k])
    img_res_copy = []
    for idx in indices:
        img_res_copy.append(img_res[idx])# stores character images according to their index
    img_res = np.array(img_res_copy)

    return img_res
```

Character segmentation:

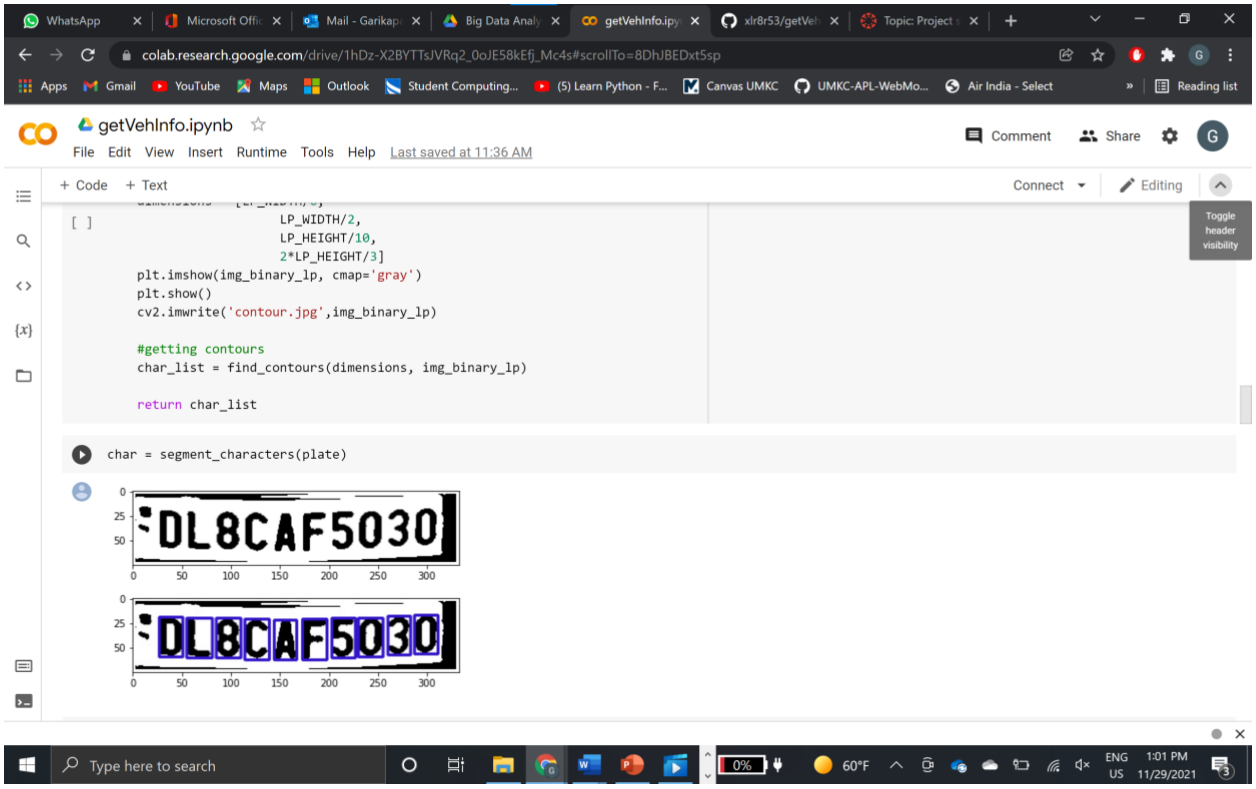
The technique of segmenting an image into multiple pieces is known as image segmentation and its main purpose is to turn the image into more meaningful.

As part of segment_character() function

- Pre processing the cropped image of the number plate
- Thresholding i.e., converting the image to pure black and white
- Erossion i.e., increasing the background to black
- Dilation which is increasing the character colour intensity to white.

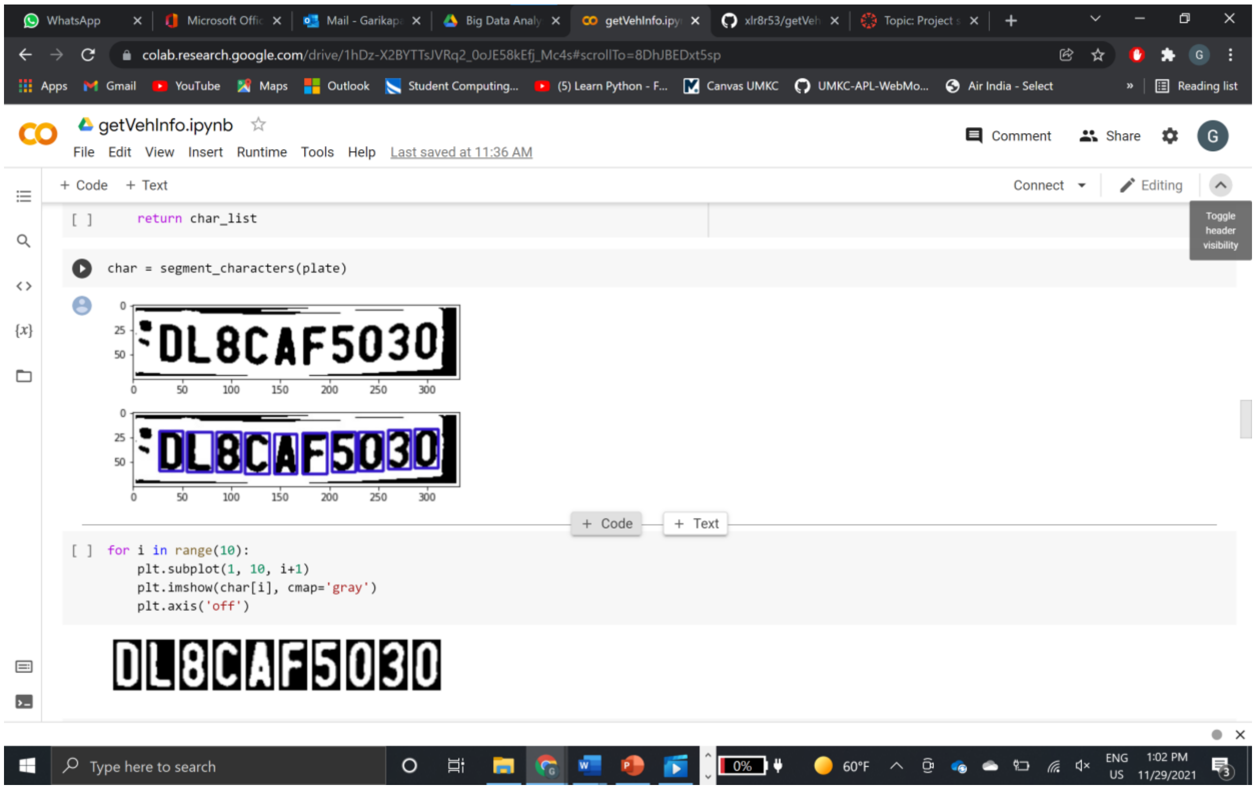


```
def segment_characters(image) :

    #pre-processing cropped image of plate
    #threshold: convert to pure b&w with sharpe edges
    #erod: increasing the backgroung black
    #dilate: increasing the char white
    img_lp = cv2.resize(image, (333, 75))
    img_gray_lp = cv2.cvtColor(img_lp, cv2.COLOR_BGR2GRAY)
    _, img_binary_lp = cv2.threshold(img_gray_lp, 200, 255, cv2.THRESH_BINARY+cv2.THRESH_OTSU)
    img_binary_lp = cv2.erode(img_binary_lp, (3,3))
    img_binary_lp = cv2.dilate(img_binary_lp, (3,3))

    LP_WIDTH = img_binary_lp.shape[0]
    LP_HEIGHT = img_binary_lp.shape[1]
    img_binary_lp[0:3,:] = 255
    img_binary_lp[:,0:3] = 255
    img_binary_lp[72:75,:] = 255
    img_binary_lp[:,330:333] = 255

    #estimations of character contours sizes of cropped license plates
    dimensions = [LP_WIDTH/6,
                       LP_WIDTH/2,
                       LP_HEIGHT/10,
                       2*LP_HEIGHT/3]
    plt.imshow(img_binary_lp, cmap='gray')
    plt.show()
    cv2.imwrite('contour.jpg',img_binary_lp)
```



```
[ ]                    LP_WIDTH/2,
                       LP_HEIGHT/10,
                       2*LP_HEIGHT/3]
    plt.imshow(img_binary_lp, cmap='gray')
    plt.show()
    cv2.imwrite('contour.jpg',img_binary_lp)

    #getting contours
    char_list = find_contours(dimensions, img_binary_lp)

    return char_list
```

```
char = segment_characters(plate)
```



```
[ ]     return char_list
```

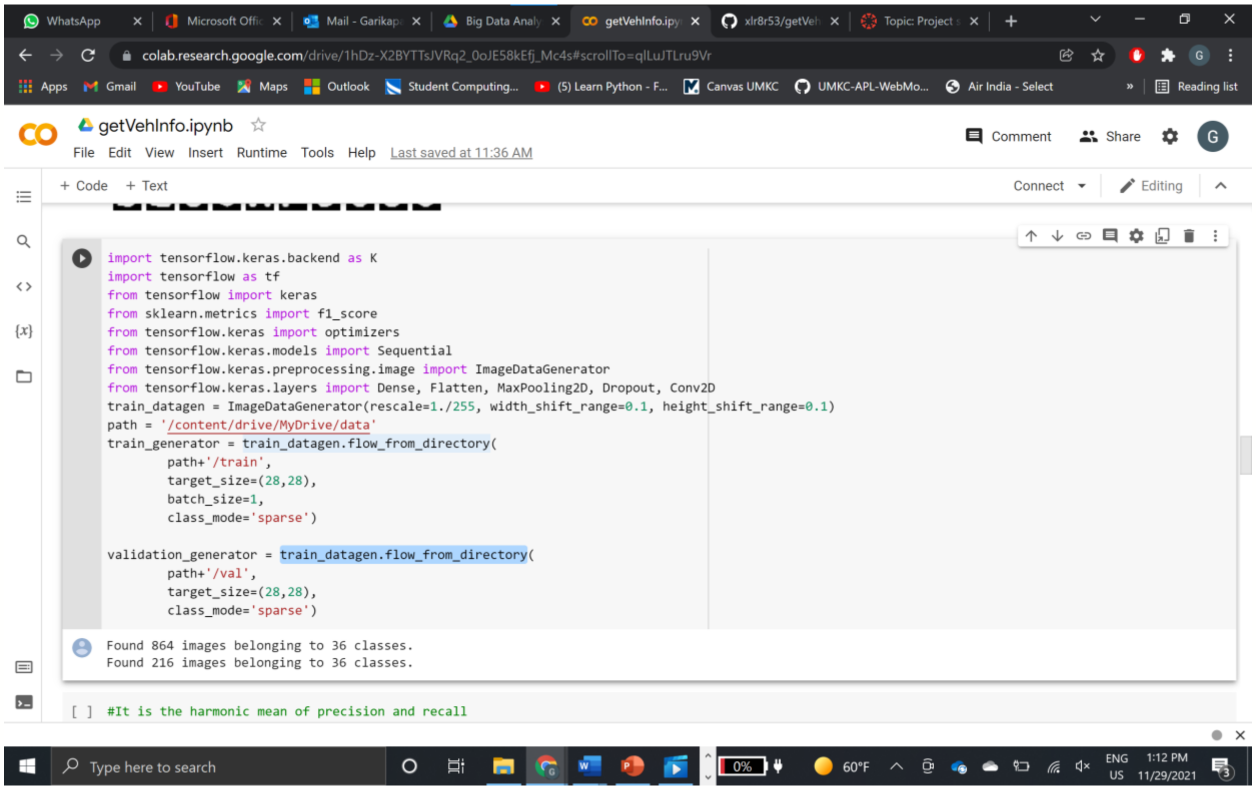
```
char = segment_characters(plate)
```

```
[ ] for i in range(10):
        plt.subplot(1, 10, i+1)
        plt.imshow(char[i], cmap='gray')
        plt.axis('off')
```

Image Augmentation:

Imported the required libraries such as Sklearn, Tensorflow and Keras model. Creating the augmented image data using the preprocessed dataset with the Keras ImageDataGenerator which allows us to make real time enhancements to the images while the model is still training so that we can apply the transformation to each training image.

train_datagen.flow_from_directory() function will give the path of the training and validation dataset.

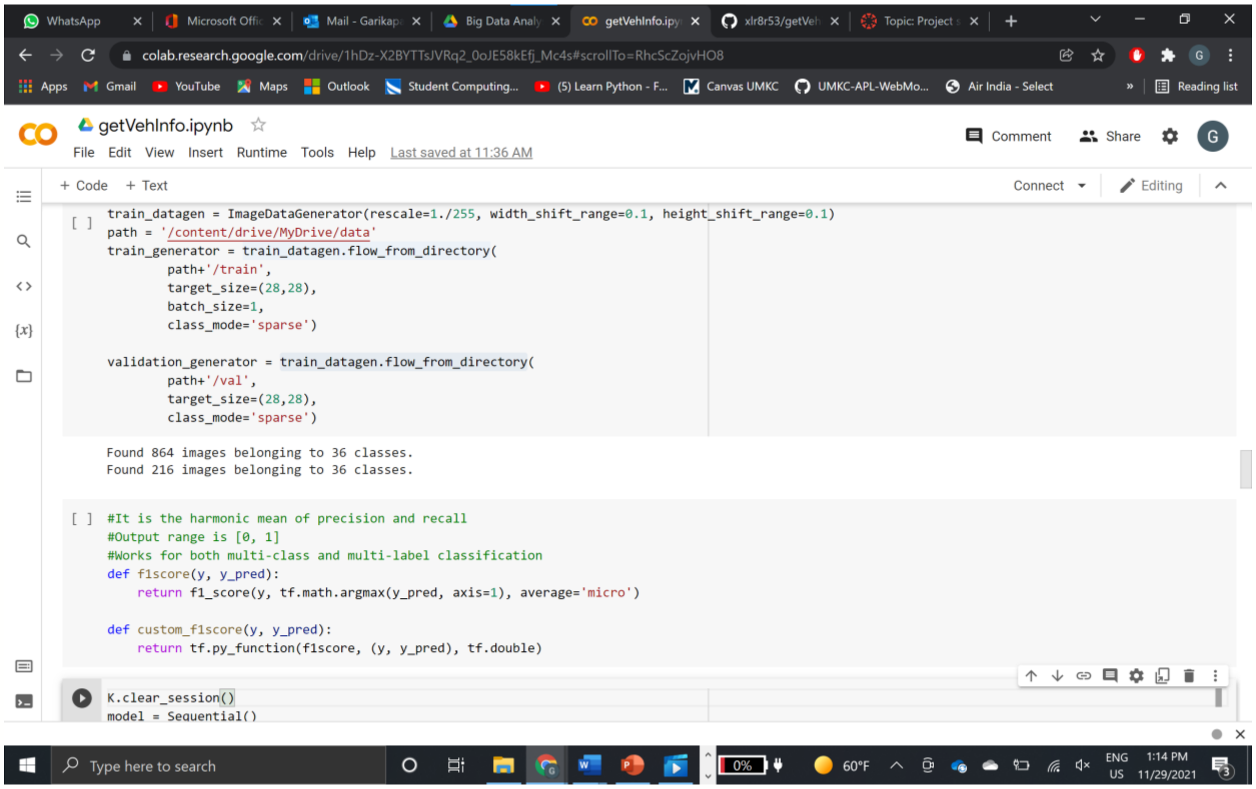


```
import tensorflow.keras.backend as K
import tensorflow as tf
from tensorflow import keras
from sklearn.metrics import f1_score
from tensorflow.keras import optimizers
from tensorflow.keras.models import Sequential
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Dense, Flatten, MaxPooling2D, Dropout, Conv2D
train_datagen = ImageDataGenerator(rescale=1./255, width_shift_range=0.1, height_shift_range=0.1)
path = '/content/drive/MyDrive/data'
train_generator = train_datagen.flow_from_directory(
        path+'/train',
        target_size=(28,28),
        batch_size=1,
        class_mode='sparse')

validation_generator = train_datagen.flow_from_directory(
        path+'/val',
        target_size=(28,28),
        class_mode='sparse')
```

```
Found 864 images belonging to 36 classes.
Found 216 images belonging to 36 classes.
```

```
[ ]  #It is the harmonic mean of precision and recall
```

Defined the f1score and custom_f1score to train themodel with more precision and accuracy.


getVehInfo.ipynb
File Edit View Insert Runtime Tools Help Last saved at 11:36 AM
+ Code + Text
Connect
Editing

```
train_datagen = ImageDataGenerator(rescale=1./255, width_shift_range=0.1, height_shift_range=0.1)
path = '/content/drive/MyDrive/data'
train_generator = train_datagen.flow_from_directory(
        path+'/train',
        target_size=(28,28),
        batch_size=1,
        class_mode='sparse')

validation_generator = train_datagen.flow_from_directory(
        path+'/val',
        target_size=(28,28),
        class_mode='sparse')
```

```
Found 864 images belonging to 36 classes.
Found 216 images belonging to 36 classes.
```

```
#It is the harmonic mean of precision and recall
#Output range is [0, 1]
#Works for both multi-class and multi-label classification
def f1score(y, y_pred):
    return f1_score(y, tf.math.argmax(y_pred, axis=1), average='micro')

def custom_f1score(y, y_pred):
    return tf.py_function(f1score, (y, y_pred), tf.double)
```

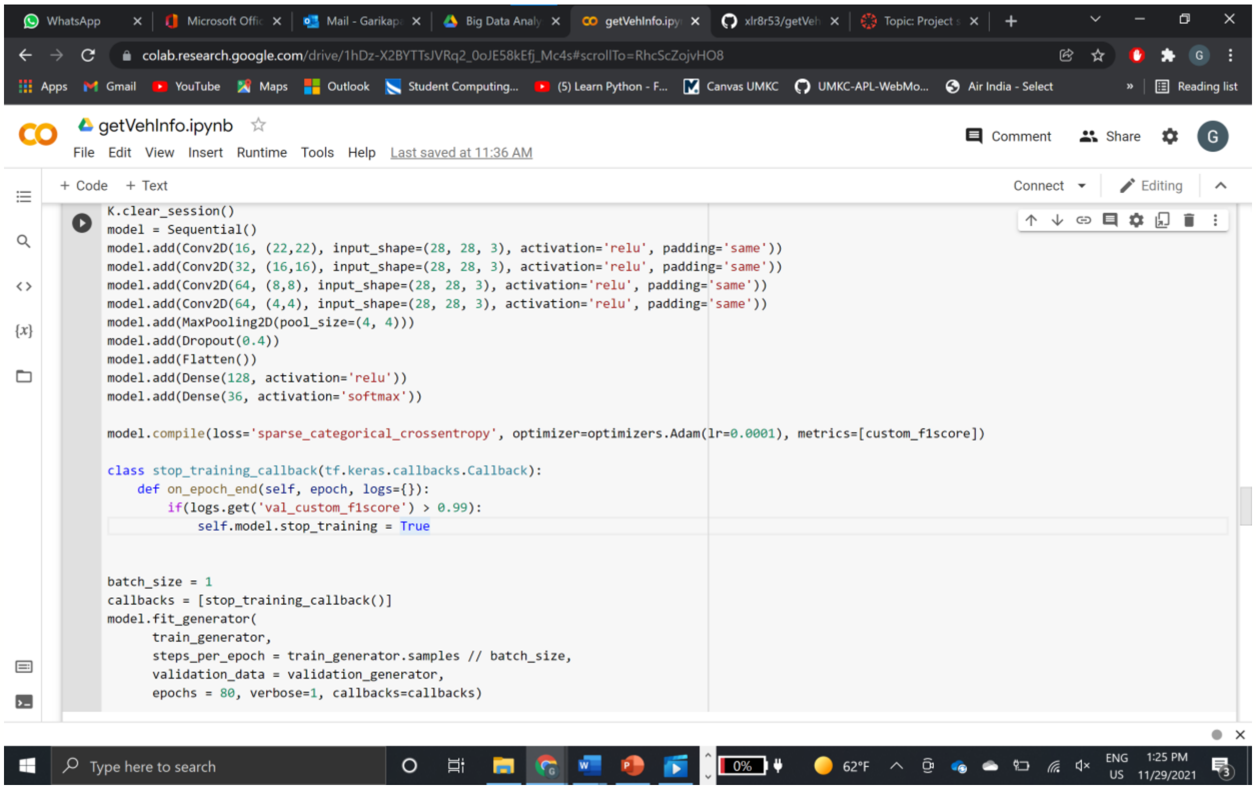
```
K.clear_session()
model = Sequential()
```

Creating and training the model:

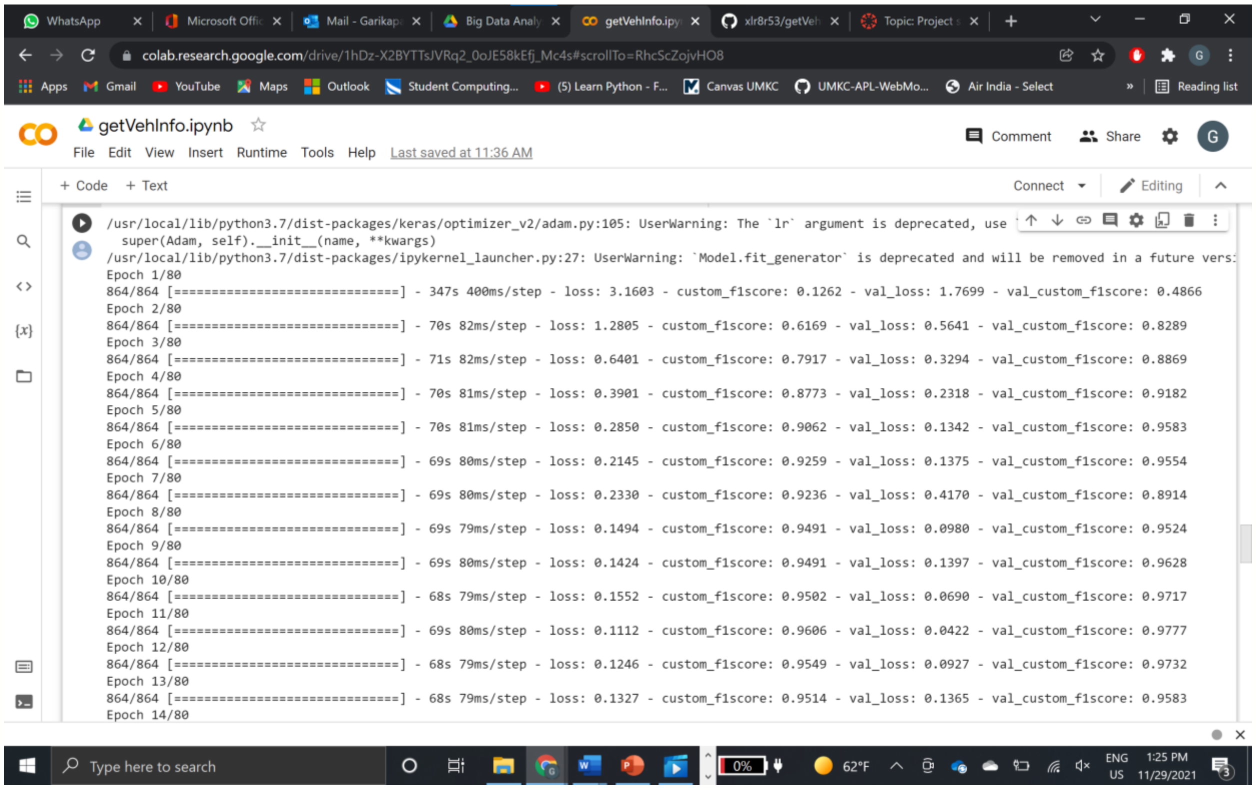
Using Keras sequential model we have added four Con2D layers with the activation function as 'relu'. Added the MaxPooling2D layer which is used for ordering the layers within a convolutional neural network and this layer helps in reducing the number of parameters and the computation of the network.

Added a Dropout() layer which helps in preventing the model from overfitting and next we have added the Flatten() layer which helps in converting the data into one dimensional array.

Added Dense() layers with the activation functions 'relu' and 'softmax'. After this we are compiling the model using "sparse_categorical_crossentropy" loss function and "Adam" optimizer.



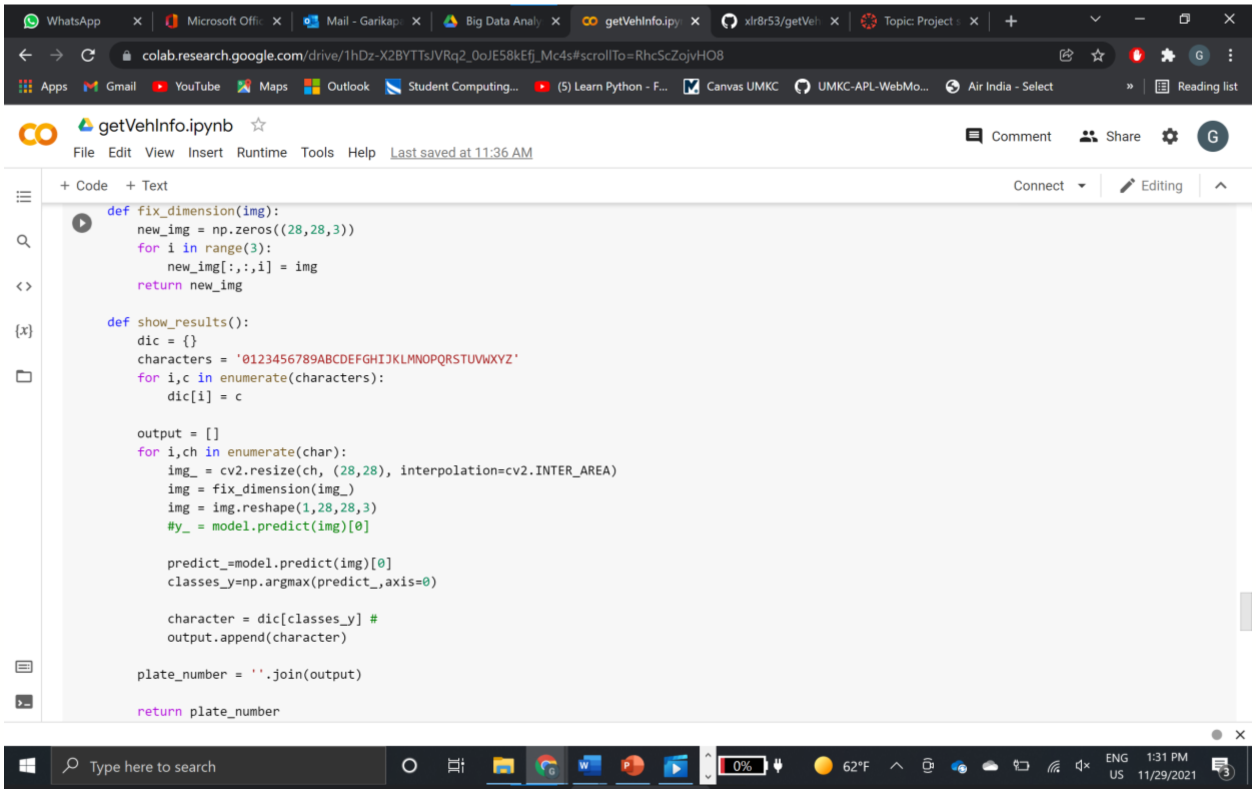
```
K.clear_session()
model = Sequential()
model.add(Conv2D(16, (22,22), input_shape=(28, 28, 3), activation='relu', padding='same'))
model.add(Conv2D(32, (16,16), input_shape=(28, 28, 3), activation='relu', padding='same'))
model.add(Conv2D(64, (8,8), input_shape=(28, 28, 3), activation='relu', padding='same'))
model.add(Conv2D(64, (4,4), input_shape=(28, 28, 3), activation='relu', padding='same'))
model.add(MaxPooling2D(pool_size=(4, 4)))
model.add(Dropout(0.4))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(36, activation='softmax'))

model.compile(loss='sparse_categorical_crossentropy', optimizer=optimizers.Adam(lr=0.0001), metrics=[custom_f1score])

class stop_training_callback(tf.keras.callbacks.Callback):
    def on_epoch_end(self, epoch, logs={}):
        if(logs.get('val_custom_f1score') > 0.99):
            self.model.stop_training = True


batch_size = 1
callbacks = [stop_training_callback()]
model.fit_generator(
      train_generator,
      steps_per_epoch = train_generator.samples // batch_size,
      validation_data = validation_generator,
      epochs = 80, verbose=1, callbacks=callbacks)
```



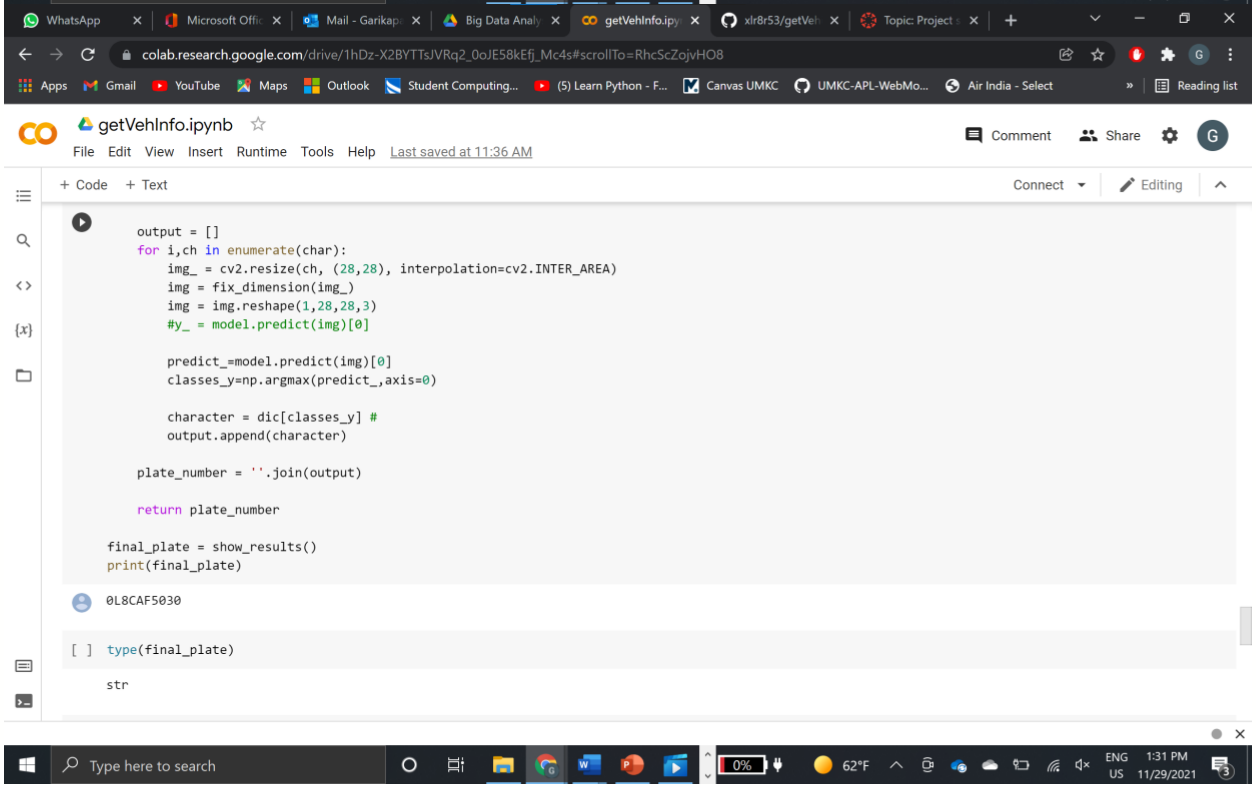
```
/usr/local/lib/python3.7/dist-packages/keras/optimizer_v2/adam.py:105: UserWarning: The `lr` argument is deprecated, use
  super(Adam, self).__init__(name, **kwargs)
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:27: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future vers
Epoch 1/80
864/864 [==============================] - 347s 400ms/step - loss: 3.1603 - custom_f1score: 0.1262 - val_loss: 1.7699 - val_custom_f1score: 0.4866
Epoch 2/80
864/864 [==============================] - 70s 82ms/step - loss: 1.2805 - custom_f1score: 0.6169 - val_loss: 0.5641 - val_custom_f1score: 0.8289
Epoch 3/80
864/864 [==============================] - 71s 82ms/step - loss: 0.6401 - custom_f1score: 0.7917 - val_loss: 0.3294 - val_custom_f1score: 0.8869
Epoch 4/80
864/864 [==============================] - 70s 81ms/step - loss: 0.3901 - custom_f1score: 0.8773 - val_loss: 0.2318 - val_custom_f1score: 0.9182
Epoch 5/80
864/864 [==============================] - 70s 81ms/step - loss: 0.2850 - custom_f1score: 0.9062 - val_loss: 0.1342 - val_custom_f1score: 0.9583
Epoch 6/80
864/864 [==============================] - 69s 80ms/step - loss: 0.2145 - custom_f1score: 0.9259 - val_loss: 0.1375 - val_custom_f1score: 0.9554
Epoch 7/80
864/864 [==============================] - 69s 80ms/step - loss: 0.2330 - custom_f1score: 0.9236 - val_loss: 0.4170 - val_custom_f1score: 0.8914
Epoch 8/80
864/864 [==============================] - 69s 79ms/step - loss: 0.1494 - custom_f1score: 0.9491 - val_loss: 0.0980 - val_custom_f1score: 0.9524
Epoch 9/80
864/864 [==============================] - 69s 80ms/step - loss: 0.1424 - custom_f1score: 0.9491 - val_loss: 0.1397 - val_custom_f1score: 0.9628
Epoch 10/80
864/864 [==============================] - 68s 79ms/step - loss: 0.1552 - custom_f1score: 0.9502 - val_loss: 0.0690 - val_custom_f1score: 0.9717
Epoch 11/80
864/864 [==============================] - 69s 80ms/step - loss: 0.1112 - custom_f1score: 0.9606 - val_loss: 0.0422 - val_custom_f1score: 0.9777
Epoch 12/80
864/864 [==============================] - 68s 79ms/step - loss: 0.1246 - custom_f1score: 0.9549 - val_loss: 0.0927 - val_custom_f1score: 0.9732
Epoch 13/80
864/864 [==============================] - 68s 79ms/step - loss: 0.1327 - custom_f1score: 0.9514 - val_loss: 0.1365 - val_custom_f1score: 0.9583
Epoch 14/80
```

stop_training_callback() function is used to stop the training of the model when the accuracy reaches 99% whichis done by checking f1score.

Using below part of the code we are displaying the number plate characters by using the functions fix_dimension() and show_result() by matching the numbers and characters.



```
def fix_dimension(img):
    new_img = np.zeros((28,28,3))
    for i in range(3):
        new_img[:,:,i] = img
    return new_img

def show_results():
    dic = {}
    characters = '0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ'
    for i,c in enumerate(characters):
        dic[i] = c

    output = []
    for i,ch in enumerate(char):
        img_ = cv2.resize(ch, (28,28), interpolation=cv2.INTER_AREA)
        img = fix_dimension(img_)
        img = img.reshape(1,28,28,3)
        #y_ = model.predict(img)[0]

        predict_=model.predict(img)[0]
        classes_y=np.argmax(predict_,axis=0)

        character = dic[classes_y] #
        output.append(character)

    plate_number = ''.join(output)

    return plate_number
```



```
    output = []
    for i,ch in enumerate(char):
        img_ = cv2.resize(ch, (28,28), interpolation=cv2.INTER_AREA)
        img = fix_dimension(img_)
        img = img.reshape(1,28,28,3)
        #y_ = model.predict(img)[0]

        predict_=model.predict(img)[0]
        classes_y=np.argmax(predict_,axis=0)

        character = dic[classes_y] #
        output.append(character)

    plate_number = ''.join(output)

    return plate_number

final_plate = show_results()
print(final_plate)
```

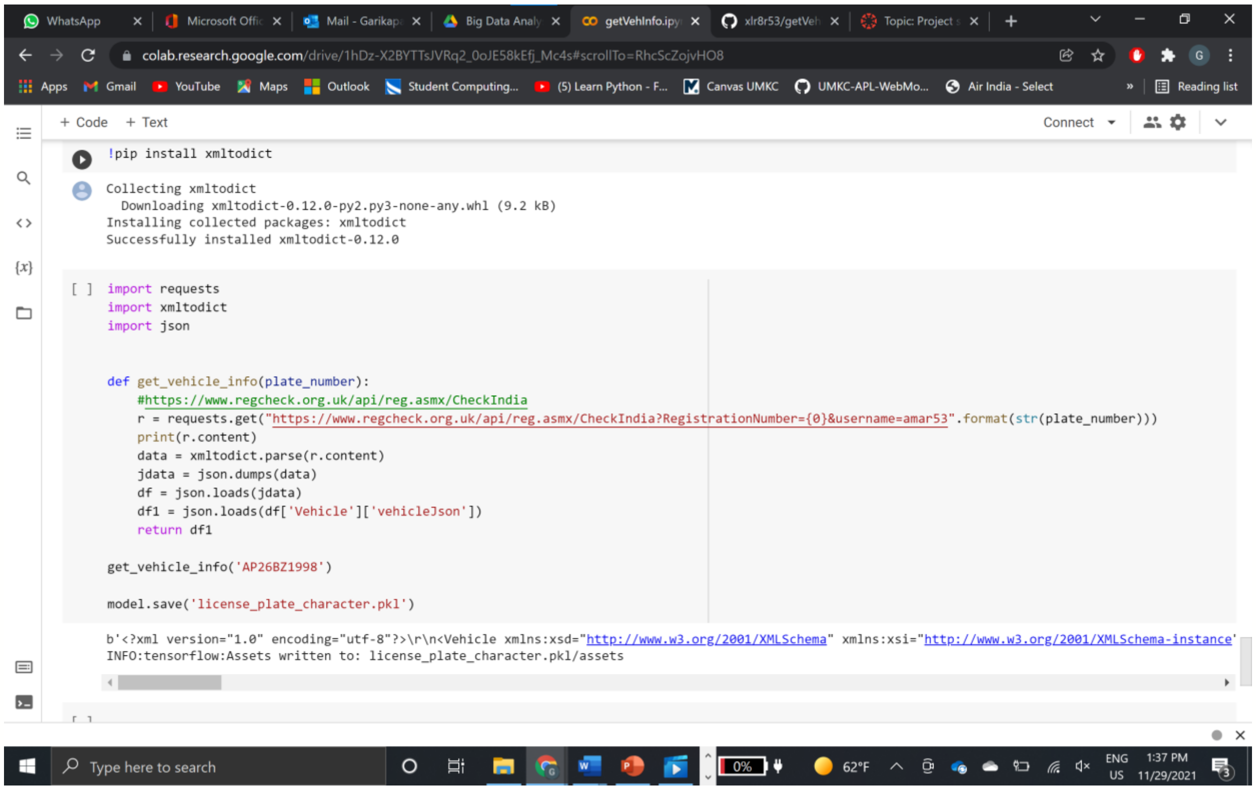
```
0L8CAF5030
```

```
type(final_plate)
```

```
str
```

Model testing using API (Getting vehicle information):

Here we have imported the required libraries such as requests, xmltodict and json. Get_vehicle_info() function is used and plate number is passed as a parameter and a request will be sent to API, but here the output we het is XML data. Using xmltodict module we are conveting the output to dictionary and in turn this will be converted to JSON.



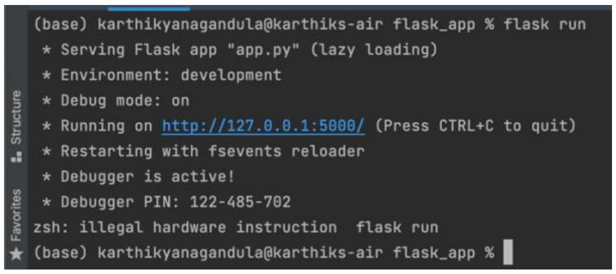
```
!pip install xmltodict

Collecting xmltodict
  Downloading xmltodict-0.12.0-py2.py3-none-any.whl (9.2 kB)
Installing collected packages: xmltodict
Successfully installed xmltodict-0.12.0
```

```
import requests
import xmltodict
import json


def get_vehicle_info(plate_number):
    #https://www.regcheck.org.uk/api/reg.asmx/CheckIndia
    r = requests.get("https://www.regcheck.org.uk/api/reg.asmx/CheckIndia?RegistrationNumber={0}&username=amar53".format(str(plate_number)))
    print(r.content)
    data = xmltodict.parse(r.content)
    jdata = json.dumps(data)
    df = json.loads(jdata)
    df1 = json.loads(df['Vehicle']['vehicleJson'])
    return df1

get_vehicle_info('AP26BZ1998')

model.save('license_plate_character.pkl')
```

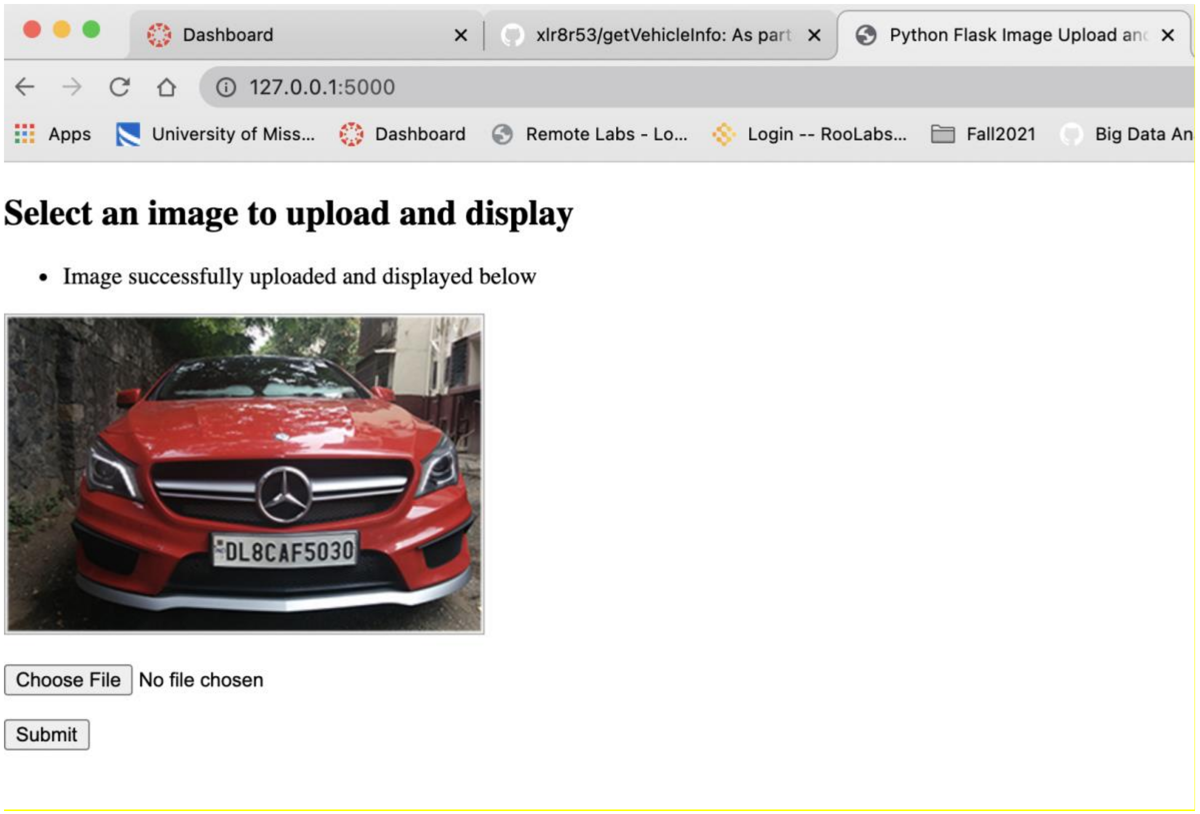
```
b'<?xml version="1.0" encoding="utf-8"?>\r\n<Vehicle xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance'
INFO:tensorflow:Assets written to: license_plate_character.pkl/assets
```

The trained model is saved in the form of pkl file.

Flask implementation: Flask is a micro framework for web development. We planned to have a single page UI, where user will have an option to upload image of vehicle and results will be rendered in the same page. We can upload and view the uploaded image, but due the mentioned issue below under challenges, we are not able to complete the work to show the results in website.



```
(base) karthikyanagandula@karthiks-air flask_app % flask run
 * Serving Flask app "app.py" (lazy loading)
 * Environment: development
 * Debug mode: on
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
 * Restarting with fsevents reloader
 * Debugger is active!
 * Debugger PIN: 122-485-702
zsh: illegal hardware instruction  flask run
(base) karthikyanagandula@karthiks-air flask_app %
```



Select an image to upload and display

- Image successfully uploaded and displayed below

Data: We have used character dataset which contains the character styles of vehicle number plates. Though we have a smaller number of images for each character, we have used data augmentation by applying different preprocessing techniques. The data contains 30 images of each character i.e., 0-9 and A-Z. We then divided the data into 80/20 for training/validation.

Use cases: This type of model can also be used

- To identify the stolen vehicles by comparing the cars passing on the roadside with the list of stolen vehicles in the real time and an alert will be generated when a match is found.
- Detecting number plate system can be useful in calculating the parking fares by identing the entry and exit timings.
- This system also helps in providing the entry access to the authorized personal.

End users:

The end users of this project might be:

- Highway patrol officers or Traffic policemen
- Security Management of a closed space gateway
- General public and many more

Challenges:

We tried to implement a flask web application to serve the model to end user, we were able to upload the image and view it on the application, but when it comes to predicting the characters using model, we need to use tensorflow package to load the model for prediction, which is not working on Macbook M1 chip due to configuration isssues. We tried many ways to solve the issue but couldn't find a solution for the above problem.

Please go through the following link for more information on TF issue for Macbook M1.

https://github.com/tensorflow/tensorflow/issues/45645

Future Scope:

The cascade classifier is not able to detect the entire plate region for certain images, which is not good for the application, to avoid this, it's better to give an edit option to change the detected region to user will yield more accuracy in finding the results for vehicle.

This can also be implemented to detect multiple vehicle information and save the results into a csv file to process further on the yielded data.

Github link: https://github.com/xlr8r53/getVehicleInfo

References:

- https://medium.com/programming-fever/license-plate-recognition-using-opencv-python-7611f85cdd6c
- https://www.researchgate.net/publication/332324949_Robust_License_Plate_Recognition_using_Neural_Networks_Trained_on_Synthetic_Images
- https://arxiv.org/ftp/arxiv/papers/1912/1912.02441.pdf