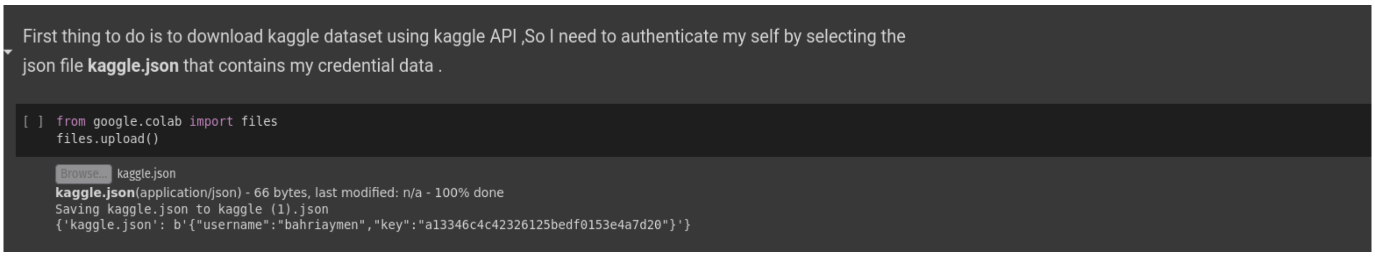
DL EXAM
Sentiment Analysis from text and Images

1st Step:

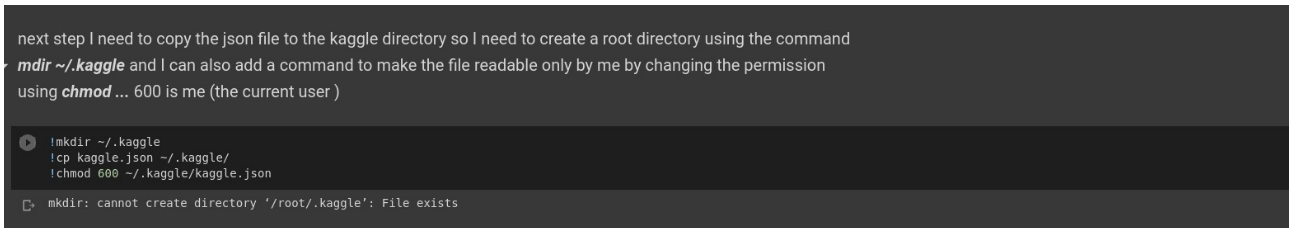
The First step is to load the data which is straightforward with the help of Kaggle API



First thing to do is to download kaggle dataset using kaggle API ,So I need to authenticate my self by selecting the json file **kaggle.json** that contains my credential data .

```
[ ] from google.colab import files
    files.upload()
```

```
Browse... kaggle.json
kaggle.json(application/json) - 66 bytes, last modified: n/a - 100% done
Saving kaggle.json to kaggle (1).json
{'kaggle.json': b'{"username":"bahriaymen","key":"a13346c4c42326125bedf0153e4a7d20"}'}
```



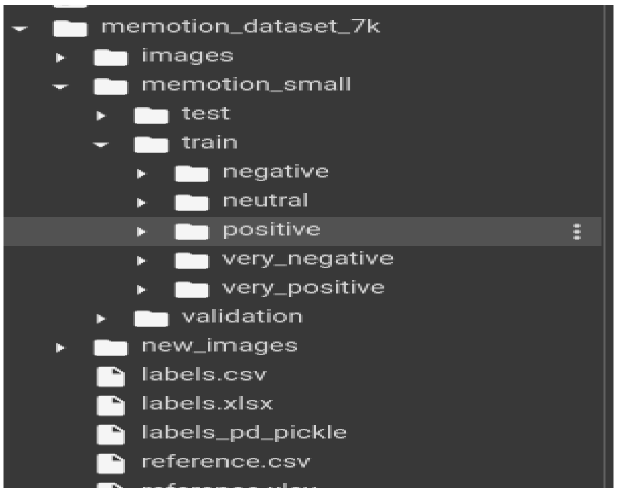
next step I need to copy the json file to the kaggle directory so I need to create a root directory using the command ***mdir ~/.kaggle*** and I can also add a command to make the file readable only by me by changing the permission using ***chmod ...*** 600 is me (the current user)

```
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle/
!chmod 600 ~/.kaggle/kaggle.json
```

```
mkdir: cannot create directory '/root/.kaggle': File exists
```

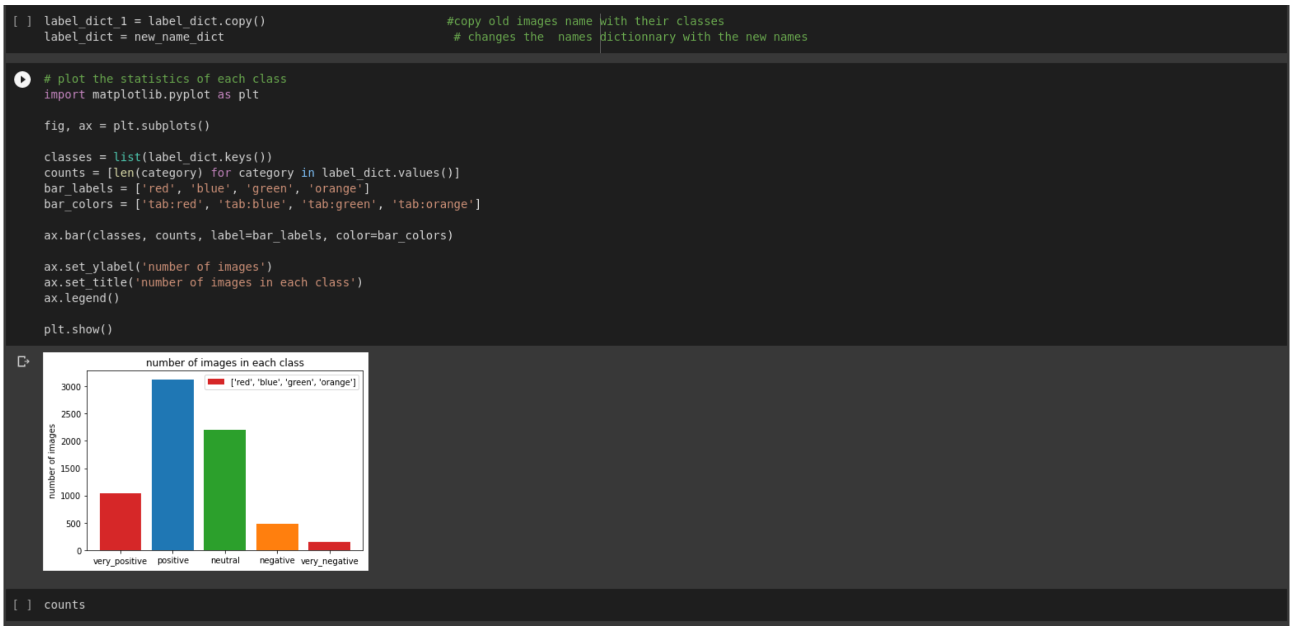
2nd Step :

After Unzipping the data an important step (that we see it important is to split the images of each class rename them according to their class and move them to subdirectories of train ,validation and test ,this step is the most important step because it helps us use the dataset object later by calling image_dataset_from_directory ,which in turns will generate batches of data from each class ,reshaped to our desired shape ,i.e (300,300) and their corresponding labels



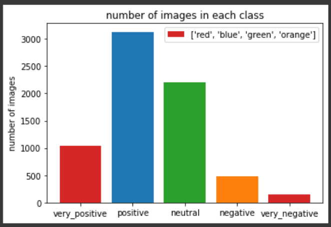
```
memotion_dataset_7k
    images
    memotion_small
        test
        train
            negative
            neutral
            positive
            very_negative
            very_positive
        validation
    new_images
    labels.csv
    labels.xlsx
    labels_pd_pickle
    reference.csv
```

after runing the code cell we end up with those directories ,the dataset object used later will list all subdirectories lets say for training and returns an iterable object that we will feed it into our model



```
[ ] label_dict_1 = label_dict.copy()                         #copy old images name with their classes
    label_dict = new_name_dict                                # changes the  names dictionnary with the new names
```

```
# plot the statistics of each class
import matplotlib.pyplot as plt

fig, ax = plt.subplots()

classes = list(label_dict.keys())
counts = [len(category) for category in label_dict.values()]
bar_labels = ['red', 'blue', 'green', 'orange']
bar_colors = ['tab:red', 'tab:blue', 'tab:green', 'tab:orange']

ax.bar(classes, counts, label=bar_labels, color=bar_colors)

ax.set_ylabel('number of images')
ax.set_title('number of images in each class')
ax.legend()

plt.show()
```

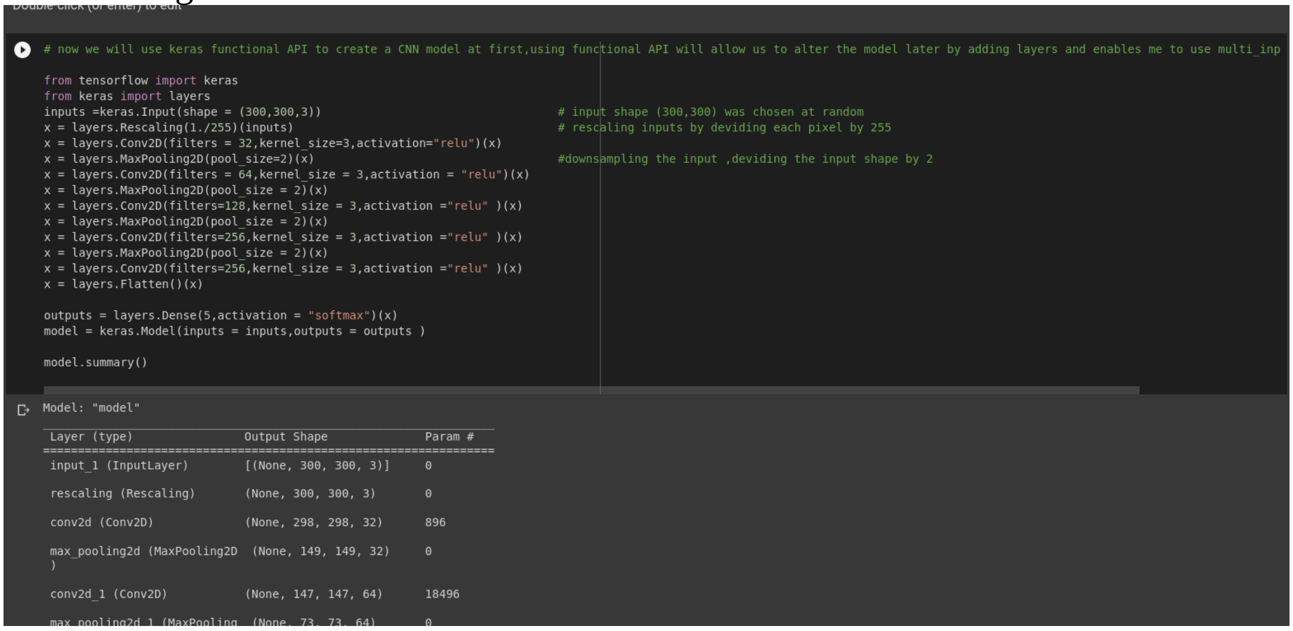


```
[ ] counts
```

the data distribution is very unbalanced ,classes negative and very negative contains a small number of samples ,so the model will be not able to generalize on those tow classes and will certainly overfits on the others .

3rd Step :

We can now prepare a basic model architecture ,since we are dealing with images ,CNN models will be the best choice because as opposed to dense layers ,they learn features from their position in images and can recognize them anywhere later when testing the model



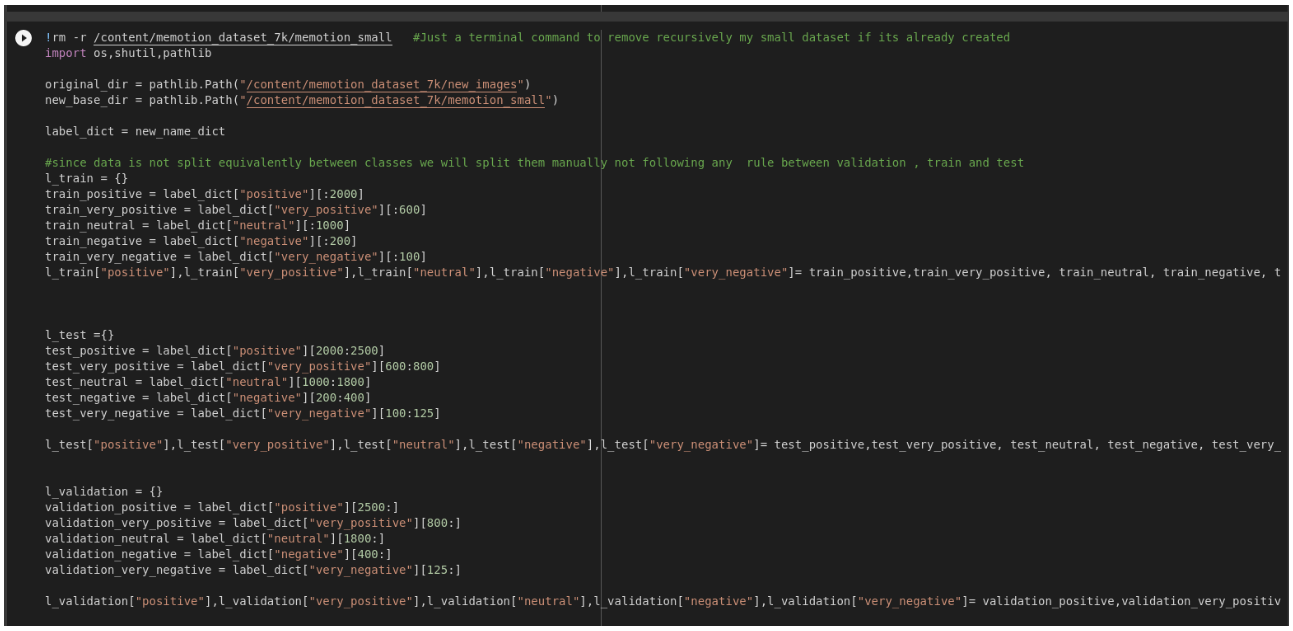
```
# now we will use keras functional API to create a CNN model at first,using functional API will allow us to alter the model later by adding layers and enables me to use multi_inp

from tensorflow import keras
from keras import layers
inputs =keras.Input(shape = (300,300,3))                                   # input shape (300,300) was chosen at random
x = layers.Rescaling(1./255)(inputs)                                      # rescaling inputs by deviding each pixel by 255
x = layers.Conv2D(filters = 32,kernel_size=3,activation="relu")(x)
x = layers.MaxPooling2D(pool_size=2)(x)                                   #downsampling the input ,deviding the input shape by 2
x = layers.Conv2D(filters = 64,kernel_size = 3,activation = "relu")(x)
x = layers.MaxPooling2D(pool_size = 2)(x)
x = layers.Conv2D(filters=128,kernel_size = 3,activation ="relu" )(x)
x = layers.MaxPooling2D(pool_size = 2)(x)
x = layers.Conv2D(filters=256,kernel_size = 3,activation ="relu" )(x)
x = layers.MaxPooling2D(pool_size = 2)(x)
x = layers.Conv2D(filters=256,kernel_size = 3,activation ="relu" )(x)
x = layers.Flatten()(x)

outputs = layers.Dense(5,activation = "softmax")(x)
model = keras.Model(inputs = inputs,outputs = outputs )

model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 300, 300, 3)]     0

 rescaling (Rescaling)       (None, 300, 300, 3)       0

 conv2d (Conv2D)             (None, 298, 298, 32)      896

 max_pooling2d (MaxPooling2D  (None, 149, 149, 32)     0
 )

 conv2d_1 (Conv2D)           (None, 147, 147, 64)      18496

 max_pooling2d_1 (MaxPooling  (None, 73, 73, 64)       0
```

The MaxPooling layers used will downsample the feature maps by halving them(deviding by 2 the dimension of their outputs it consists of extracting windows from the input feature maps(output of convolution layers) and outputting the max value of each channel.

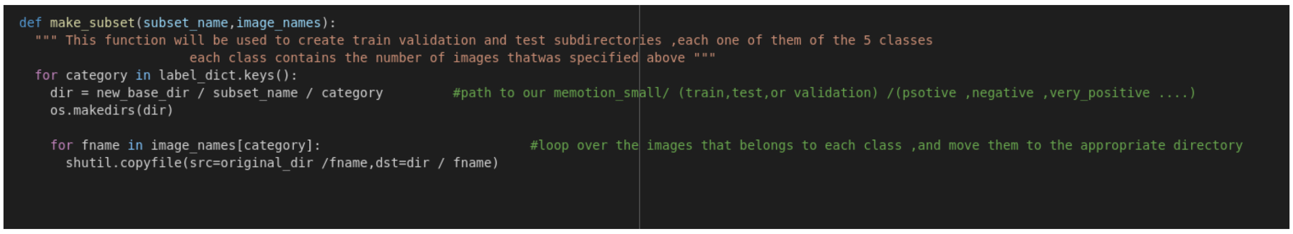
4th Step :

We need to split our data between training ,test,and validation
the number of samples chosen for each call is much random because the negative and very negative classes contains very few examples ,we tried to split them by using most of them on training (200 negative ,100 very negative) and the rest to test and validation



```
!rm -r /content/memotion_dataset_7k/memotion_small   #Just a terminal command to remove recursively my small dataset if its already created
import os,shutil,pathlib

original_dir = pathlib.Path("/content/memotion_dataset_7k/new_images")
new_base_dir = pathlib.Path("/content/memotion_dataset_7k/memotion_small")

label_dict = new_name_dict

#since data is not split equivalently between classes we will split them manually not following any  rule between validation , train and test
l_train = {}
train_positive = label_dict["positive"][:2000]
train_very_positive = label_dict["very_positive"][:600]
train_neutral = label_dict["neutral"][:1000]
train_negative = label_dict["negative"][:200]
train_very_negative = label_dict["very_negative"][:100]
l_train["positive"],l_train["very_positive"],l_train["neutral"],l_train["negative"],l_train["very_negative"]= train_positive,train_very_positive, train_neutral, train_negative, t



l_test ={}
test_positive = label_dict["positive"][2000:2500]
test_very_positive = label_dict["very_positive"][600:800]
test_neutral = label_dict["neutral"][1000:1800]
test_negative = label_dict["negative"][200:400]
test_very_negative = label_dict["very_negative"][100:125]

l_test["positive"],l_test["very_positive"],l_test["neutral"],l_test["negative"],l_test["very_negative"]= test_positive,test_very_positive, test_neutral, test_negative, test_very_


l_validation = {}
validation_positive = label_dict["positive"][2500:]
validation_very_positive = label_dict["very_positive"][800:]
validation_neutral = label_dict["neutral"][1800:]
validation_negative = label_dict["negative"][400:]
validation_very_negative = label_dict["very_negative"][125:]

l_validation["positive"],l_validation["very_positive"],l_validation["neutral"],l_validation["negative"],l_validation["very_negative"]= validation_positive,validation_very_positiv
```

Now that train,validation and test contain the chosen number of images for each class we need to create subdirectories and save data for each set accordingly ,this what the function make_subset does :

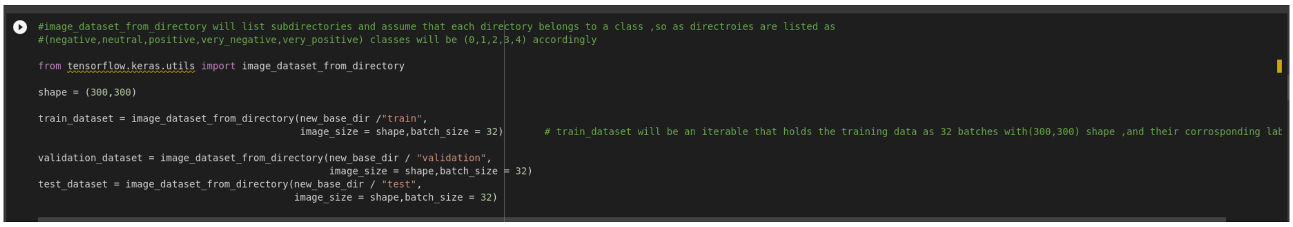


```
def make_subset(subset_name,image_names):
  """ This function will be used to create train validation and test subdirectories ,each one of them of the 5 classes
                    each class contains the number of images thatwas specified above """
  for category in label_dict.keys():
    dir = new_base_dir / subset_name / category         #path to our memotion_small/ (train,test,or validation) /(psotive ,negative ,very_positive ....)
    os.makedirs(dir)

    for fname in image_names[category]:                         #loop over the images that belongs to each class ,and move them to the appropriate directory
      shutil.copyfile(src=original_dir /fname,dst=dir / fname)
```

we call the function and give it as parameters the name of our 3 directories (train,validation,test) and the dictionary that contains the data for each set ,for the train set for example ,it will create a subdirectory inside memotion_small called train,and 5 sub_directories with the name of the five classes ,for each class it copies the images according to their names drawn from the dictionary to the specified directory holding that class name .

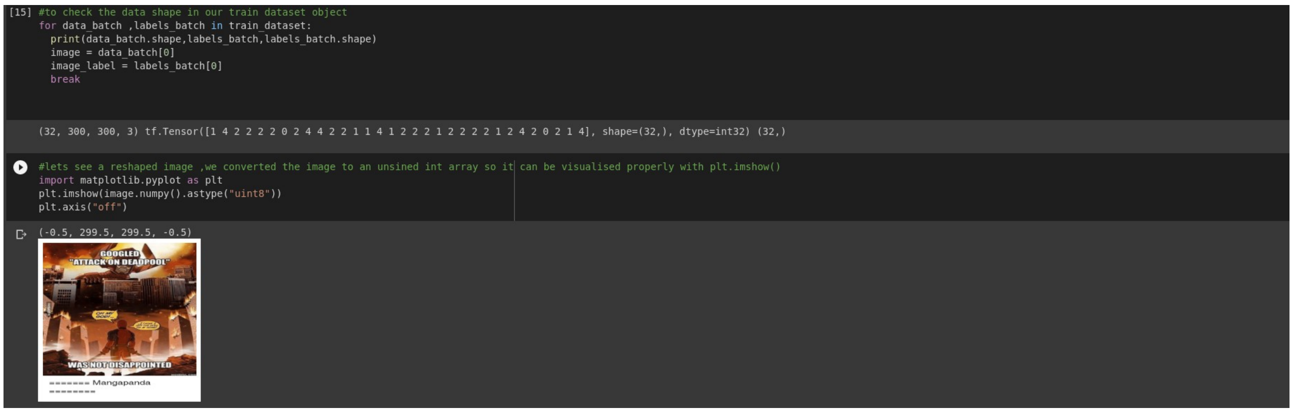
5th Step :

Since our directories are ready and each one contains the correct data ,we can now use the dataset object by using the **image_dataset_from_directory** class as discussed before it will list all the subdirectories assuming that each (train,validation,test) contains correct subdirectories with correct data ,it will then assign classes to those subdirectories ,ordered list of integers as the subdirectories order .



```
#image_dataset_from_directory will list subdirectories and assume that each directory belongs to a class ,so as directroies are listed as
#(negative,neutral,positive,very_negative,very_positive) classes will be (0,1,2,3,4) accordingly

from tensorflow.keras.utils import image_dataset_from_directory

shape = (300,300)

train_dataset = image_dataset_from_directory(new_base_dir /"train",
                                             image_size = shape,batch_size = 32)      # train_dataset will be an iterable that holds the training data as 32 batches with(300,300) shape ,and their corrosponding lat

validation_dataset = image_dataset_from_directory(new_base_dir / "validation",
                                                  image_size = shape,batch_size = 32)
test_dataset = image_dataset_from_directory(new_base_dir / "test",
                                            image_size = shape,batch_size = 32)
```

We can check for instance the shape of tensors that the image_dataset_from_directory returns ,it returns an iterable that we can loop on its elements .

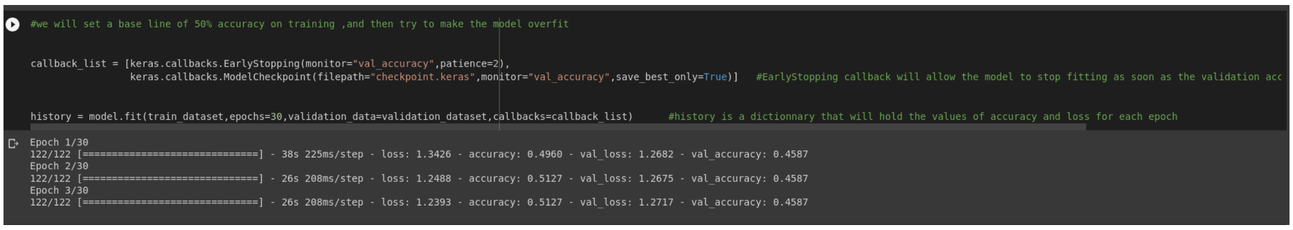


```
[15] #to check the data shape in our train dataset object
     for data_batch ,labels_batch in train_dataset:
       print(data_batch.shape,labels_batch,labels_batch.shape)
       image = data_batch[0]
       image_label = labels_batch[0]
       break

     (32, 300, 300, 3) tf.Tensor([1 4 2 2 2 2 0 2 4 4 2 2 1 1 4 1 2 2 2 1 2 2 2 2 1 2 4 2 0 2 1 4], shape=(32,), dtype=int32) (32,)

     #lets see a reshaped image ,we converted the image to an unsined int array so it can be visualised properly with plt.imshow()
     import matplotlib.pyplot as plt
     plt.imshow(image.numpy().astype("uint8"))
     plt.axis("off")

     (-0.5, 299.5, 299.5, -0.5)
```

The shape of the data is (32,300,300,3) which is a batch of 32 samples of (300,300) 3 channel images

6th Step :

Now we are ready to fit our model ,at first sight we can only fit the data ,see if the model fit and try different number of epochs and batch sizes ,to remove the need of waiting till the end of fit each time to check the accuracy and loss on train and validation we can simply use keras callbacks ,EarlyStopping ,specify which metric to monitor and the number of epochs where to interrupt the fit if there are no change or improvements .
We can also use ModelCheckpoint callback to save the best version of the model obtained .

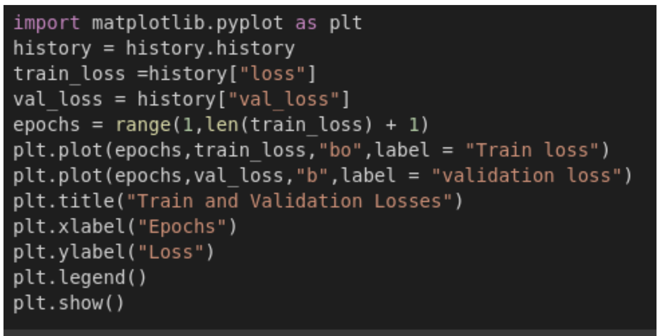


```
#we will set a base line of 50% accuracy on training ,and then try to make the model overfit


callback_list = [keras.callbacks.EarlyStopping(monitor="val_accuracy",patience=2),
                 keras.callbacks.ModelCheckpoint(filepath="checkpoint.keras",monitor="val_accuracy",save_best_only=True)]   #EarlyStopping callback will allow the model to stop fitting as soon as the validation acc


history = model.fit(train_dataset,epochs=30,validation_data=validation_dataset,callbacks=callback_list)      #history is a dictionnary that will hold the values of accuracy and loss for each epoch
```

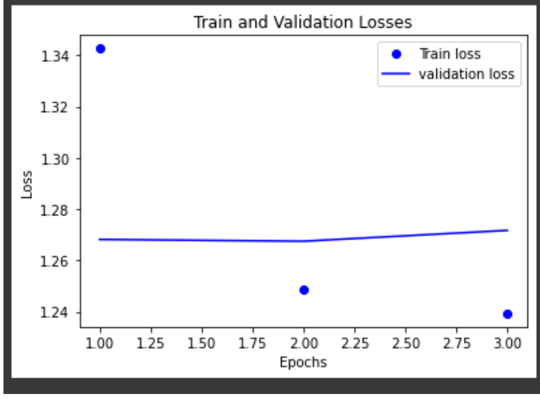
```
Epoch 1/30
122/122 [==============================] - 38s 225ms/step - loss: 1.3426 - accuracy: 0.4960 - val_loss: 1.2682 - val_accuracy: 0.4587
Epoch 2/30
122/122 [==============================] - 26s 208ms/step - loss: 1.2488 - accuracy: 0.5127 - val_loss: 1.2675 - val_accuracy: 0.4587
Epoch 3/30
122/122 [==============================] - 26s 208ms/step - loss: 1.2393 - accuracy: 0.5127 - val_loss: 1.2717 - val_accuracy: 0.4587
```

7th Step :

To be able to plot metrics versus epochs the fit method returns and object that has an attribute called history that records metrics during each epoch ,we can use it to plot the accuracy and loss for both train and validation .

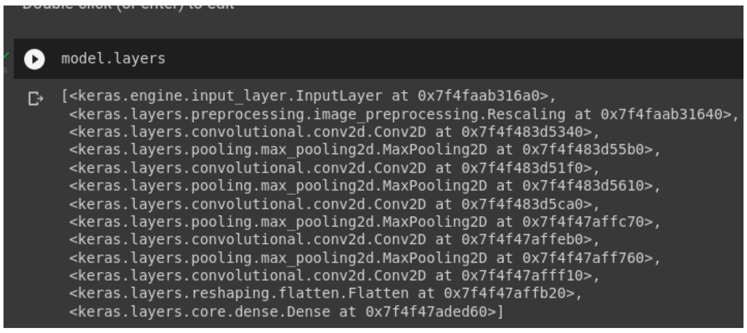


```
import matplotlib.pyplot as plt
history = history.history
train_loss =history["loss"]
val_loss = history["val_loss"]
epochs = range(1,len(train_loss) + 1)
plt.plot(epochs,train_loss,"bo",label = "Train loss")
plt.plot(epochs,val_loss,"b",label = "validation loss")
plt.title("Train and Validation Losses")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.show()
```



Now that the accuracy of train is very low ,we can think of increasing the number of layers ,which means giving the model more degrees of freedom ,adding layers will allow the model to learn more complex representation on the way and can help it (a big theoretical maybe) learn a better representation of the data ,this will never happen mainly because looking at the images can say that data is very noisy meaning that each class related to an image doesn't really hold any clear visual representation with respect to other images ,so likely the model won't be able to learn any good representations of those data ,and since images contains text ,where text is more related to the classes ,maybe we can use a multi input model and make it learn to link images to text ,this what we tried but didn't work due to the labels of both classes ,I try to make it work nevertheless .

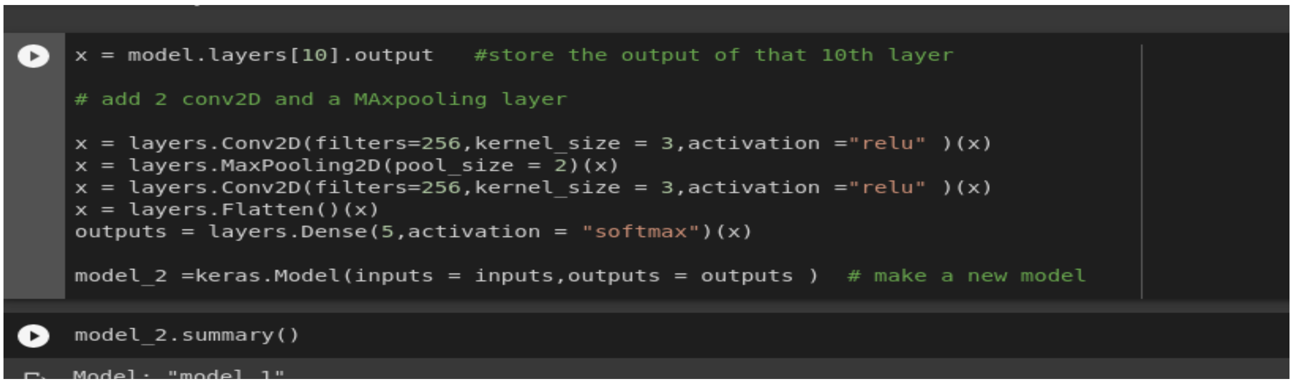
We can list the layers of our model



```
model.layers
```

```
[<keras.engine.input_layer.InputLayer at 0x7f4faab316a0>,
 <keras.layers.preprocessing.image_preprocessing.Rescaling at 0x7f4faab31640>,
 <keras.layers.convolutional.conv2d.Conv2D at 0x7f4f483d5340>,
 <keras.layers.pooling.max_pooling2d.MaxPooling2D at 0x7f4f483d55b0>,
 <keras.layers.convolutional.conv2d.Conv2D at 0x7f4f483d51f0>,
 <keras.layers.pooling.max_pooling2d.MaxPooling2D at 0x7f4f483d5610>,
 <keras.layers.convolutional.conv2d.Conv2D at 0x7f4f483d5ca0>,
 <keras.layers.pooling.max_pooling2d.MaxPooling2D at 0x7f4f47affc70>,
 <keras.layers.convolutional.conv2d.Conv2D at 0x7f4f47affeb0>,
 <keras.layers.pooling.max_pooling2d.MaxPooling2D at 0x7f4f47aff760>,
 <keras.layers.convolutional.conv2d.Conv2D at 0x7f4f47afff10>,
 <keras.layers.reshaping.flatten.Flatten at 0x7f4f47affb20>,
 <keras.layers.core.dense.Dense at 0x7f4f47aded60>]
```

We can see that the index of the layer just before flatten ,is 10
so we can use the output of this layer and use it as the input for the new layers that we will add to the model ,here 2 conv2D layers with a maxpooling in between ,since maxpooling halves the shape by 2 ,we just used one layer ,so we don't need to change the input shape .

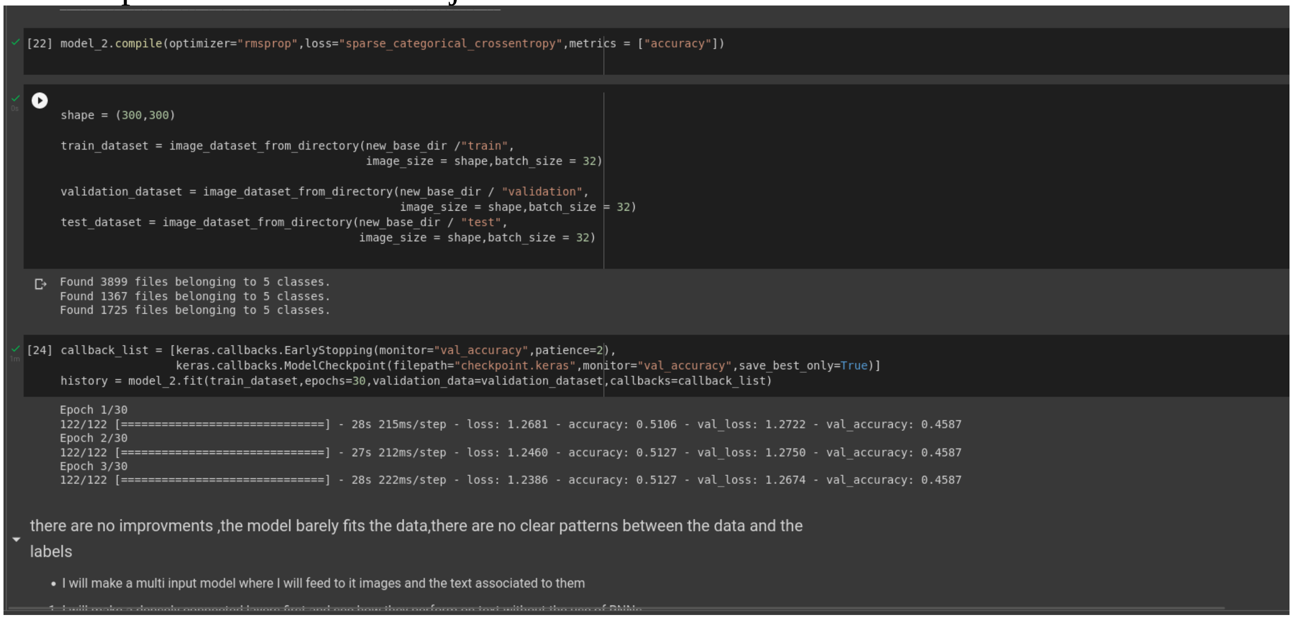


```
x = model.layers[10].output   #store the output of that 10th layer

# add 2 conv2D and a MAxpooling layer

x = layers.Conv2D(filters=256,kernel_size = 3,activation ="relu" )(x)
x = layers.MaxPooling2D(pool_size = 2)(x)
x = layers.Conv2D(filters=256,kernel_size = 3,activation ="relu" )(x)
x = layers.Flatten()(x)
outputs = layers.Dense(5,activation = "softmax")(x)

model_2 =keras.Model(inputs = inputs,outputs = outputs )  # make a new model
```

```
model_2.summary()
```

8th Step :

we compile and fit the model just as before



```
[22] model_2.compile(optimizer="rmsprop",loss="sparse_categorical_crossentropy",metrics = ["accuracy"])
```

```
shape = (300,300)

train_dataset = image_dataset_from_directory(new_base_dir /"train",
                                             image_size = shape,batch_size = 32)

validation_dataset = image_dataset_from_directory(new_base_dir / "validation",
                                                  image_size = shape,batch_size = 32)
test_dataset = image_dataset_from_directory(new_base_dir / "test",
                                            image_size = shape,batch_size = 32)
```

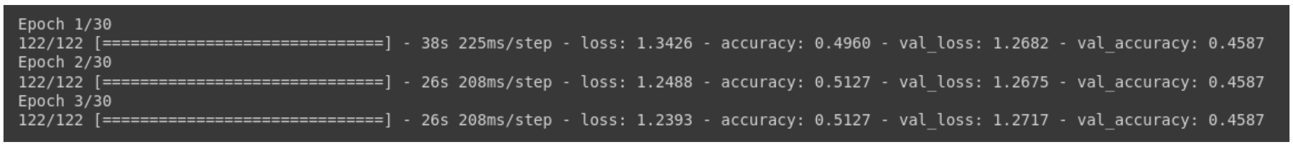
```
Found 3899 files belonging to 5 classes.
Found 1367 files belonging to 5 classes.
Found 1725 files belonging to 5 classes.
```

```
[24] callback_list = [keras.callbacks.EarlyStopping(monitor="val_accuracy",patience=2),
                     keras.callbacks.ModelCheckpoint(filepath="checkpoint.keras",monitor="val_accuracy",save_best_only=True)]
     history = model_2.fit(train_dataset,epochs=30,validation_data=validation_dataset,callbacks=callback_list)
```

```
Epoch 1/30
122/122 [==============================] - 28s 215ms/step - loss: 1.2681 - accuracy: 0.5106 - val_loss: 1.2722 - val_accuracy: 0.4587
Epoch 2/30
122/122 [==============================] - 27s 212ms/step - loss: 1.2460 - accuracy: 0.5127 - val_loss: 1.2750 - val_accuracy: 0.4587
Epoch 3/30
122/122 [==============================] - 28s 222ms/step - loss: 1.2386 - accuracy: 0.5127 - val_loss: 1.2674 - val_accuracy: 0.4587
```

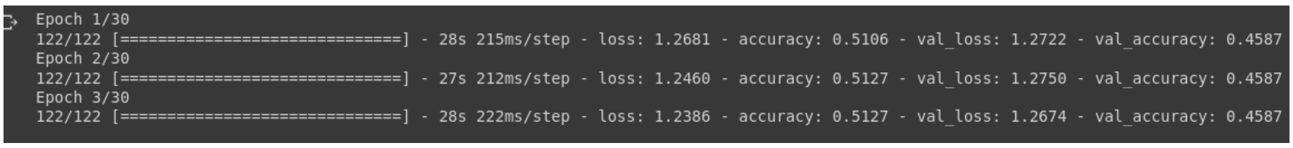
there are no improvments ,the model barely fits the data,there are no clear patterns between the data and the labels

- I will make a multi input model where I will feed to it images and the text associated to them we can see that the accuracy of training was improved for the first epoch but the values are the same as the old model so there are no improvements



```
Epoch 1/30
122/122 [==============================] - 38s 225ms/step - loss: 1.3426 - accuracy: 0.4960 - val_loss: 1.2682 - val_accuracy: 0.4587
Epoch 2/30
122/122 [==============================] - 26s 208ms/step - loss: 1.2488 - accuracy: 0.5127 - val_loss: 1.2675 - val_accuracy: 0.4587
Epoch 3/30
122/122 [==============================] - 26s 208ms/step - loss: 1.2393 - accuracy: 0.5127 - val_loss: 1.2717 - val_accuracy: 0.4587
```

Figure 1: old model



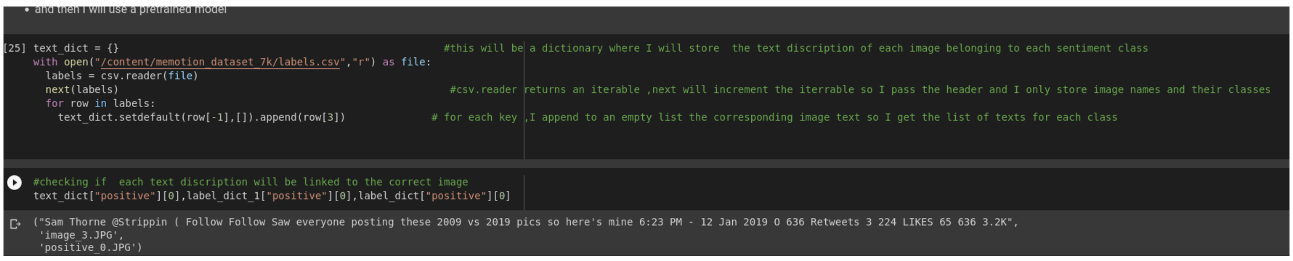
```
Epoch 1/30
122/122 [==============================] - 28s 215ms/step - loss: 1.2681 - accuracy: 0.5106 - val_loss: 1.2722 - val_accuracy: 0.4587
Epoch 2/30
122/122 [==============================] - 27s 212ms/step - loss: 1.2460 - accuracy: 0.5127 - val_loss: 1.2750 - val_accuracy: 0.4587
Epoch 3/30
122/122 [==============================] - 28s 222ms/step - loss: 1.2386 - accuracy: 0.5127 - val_loss: 1.2674 - val_accuracy: 0.4587
```

Figure 2: model with added layers

9th Step :

Now we will make a new model to process text instead of a CNN model ,the model will be a simple sequential model ,

as what we did with images ,instead of recording the names of images belonging to each class ,I will record the text belonging to each class ,letting in mind that I need to maintain the same index for the text and images so I keep the same labels (having in mind that I will use the multi input model in future)



• and then I will use a pretrained model

```
[25] text_dict = {}                                                          #this will be a dictionary where I will store  the text discription of each image belonging to each sentiment class
     with open("/content/memotion_dataset_7k/labels.csv","r") as file:
       labels = csv.reader(file)
       next(labels)                                                          #csv.reader returns an iterable ,next will increment the iterrable so I pass the header and I only store image names and their classes
       for row in labels:
         text_dict.setdefault(row[-1],[]).append(row[3])                   # for each key ,I append to an empty list the corresponding image text so I get the list of texts for each class
```

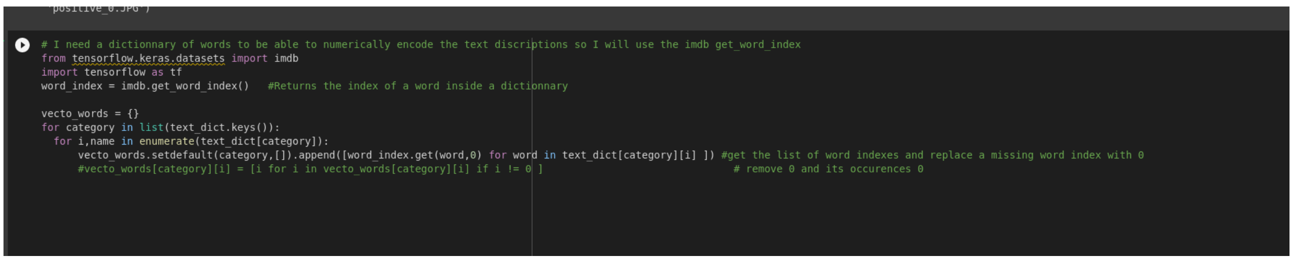
```
#checking if  each text discription will be linked to the correct image
text_dict["positive"][0],label_dict_1["positive"][0],label_dict["positive"][0]
```

```
("Sam Thorne @Strippin ( Follow Follow Saw everyone posting these 2009 vs 2019 pics so here's mine 6:23 PM - 12 Jan 2019 O 636 Retweets 3 224 LIKES 65 636 3.2K",
 'image_3.JPG',
 'positive_0.JPG')
```

the text descriptions are in the 4th column   of the csv file ,classes are in the final column (index -1, and 3) so for each class as a key I append to an empty list the corresponding class ,that empty list is the value of the text_dict dictionary .

now we need to decode the text into integers with the help of a dictionary ,We though that we could use a dictionary from the imdb example that is prebuilt in keras .
So for each word we store the index of the corresponding word if its exists if it doesn’t I replace it with 0 instead ,this could not be practical because 0 could alter the text meaning and bias the model,but it what I though about using .

Just as before,for each class ,I add to an empty list a list that contains the integers for

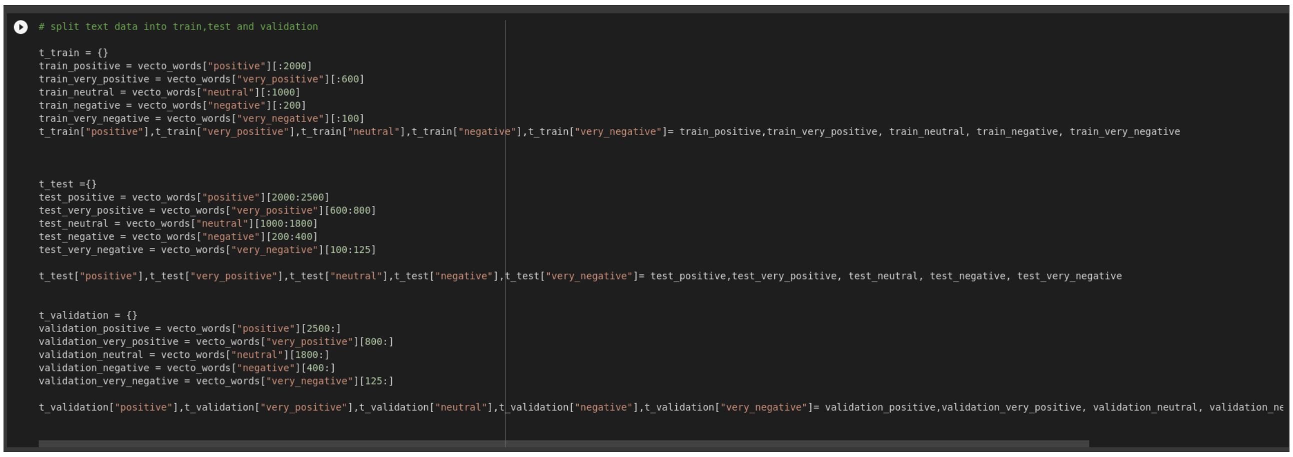


```
  'positive_0.JPG')

# I need a dictionnary of words to be able to numerically encode the text discriptions so I will use the imdb get_word_index
from tensorflow.keras.datasets import imdb
import tensorflow as tf
word_index = imdb.get_word_index()   #Returns the index of a word inside a dictionnary

vecto_words = {}
for category in list(text_dict.keys()):
  for i,name in enumerate(text_dict[category]):
      vecto_words.setdefault(category,[]).append([word_index.get(word,0) for word in text_dict[category][i] ]) #get the list of word indexes and replace a missing word index with 0
      #vecto_words[category][i] = [i for i in vecto_words[category][i] if i != 0 ]                                # remove 0 and its occurences 0
```

each text ,the role of get word method is will return the index of the word if it exist ,or it will return 0 if not

10th Step :

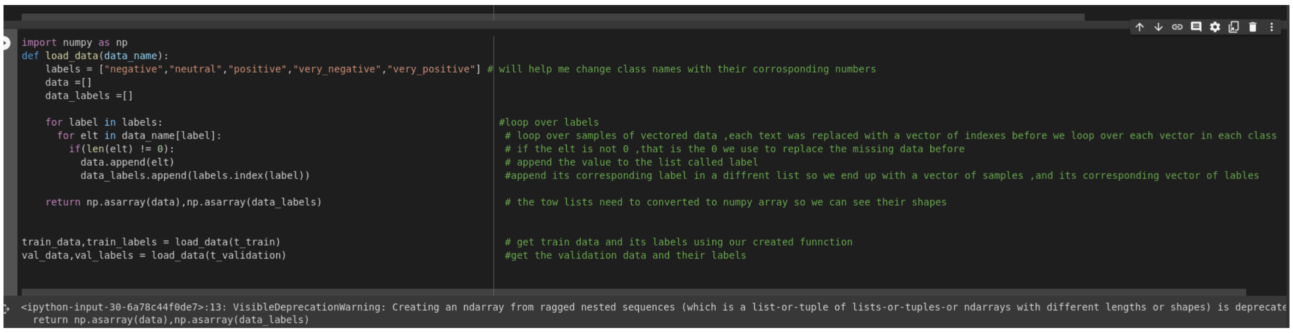
Now that we have numbers instead of words ,we prepare the train ,test and validation the same way we did with images



```
# split text data into train,test and validation

t_train = {}
train_positive = vecto_words["positive"][:2000]
train_very_positive = vecto_words["very_positive"][:600]
train_neutral = vecto_words["neutral"][:1000]
train_negative = vecto_words["negative"][:200]
train_very_negative = vecto_words["very_negative"][:100]
t_train["positive"],t_train["very_positive"],t_train["neutral"],t_train["negative"],t_train["very_negative"]= train_positive,train_very_positive, train_neutral, train_negative, train_very_negative



t_test ={}
test_positive = vecto_words["positive"][2000:2500]
test_very_positive = vecto_words["very_positive"][600:800]
test_neutral = vecto_words["neutral"][1000:1800]
test_negative = vecto_words["negative"][200:400]
test_very_negative = vecto_words["very_negative"][100:125]

t_test["positive"],t_test["very_positive"],t_test["neutral"],t_test["negative"],t_test["very_negative"]= test_positive,test_very_positive, test_neutral, test_negative, test_very_negative


t_validation = {}
validation_positive = vecto_words["positive"][2500:]
validation_very_positive = vecto_words["very_positive"][800:]
validation_neutral = vecto_words["neutral"][1800:]
validation_negative = vecto_words["negative"][400:]
validation_very_negative = vecto_words["very_negative"][125:]

t_validation["positive"],t_validation["very_positive"],t_validation["neutral"],t_validation["negative"],t_validation["very_negative"]= validation_positive,validation_very_positive, validation_neutral, validation_ne
```

11th Step :

the data is stored in a dictionary and to be able to use it to train a model it should be in the form of tensors ,so we defined a function that transforms the data ,for each vector belonging to each class ,store the vector on a list and its corresponding class in separate list ,we used the same labels as in the CNN section ,hoping that later I can



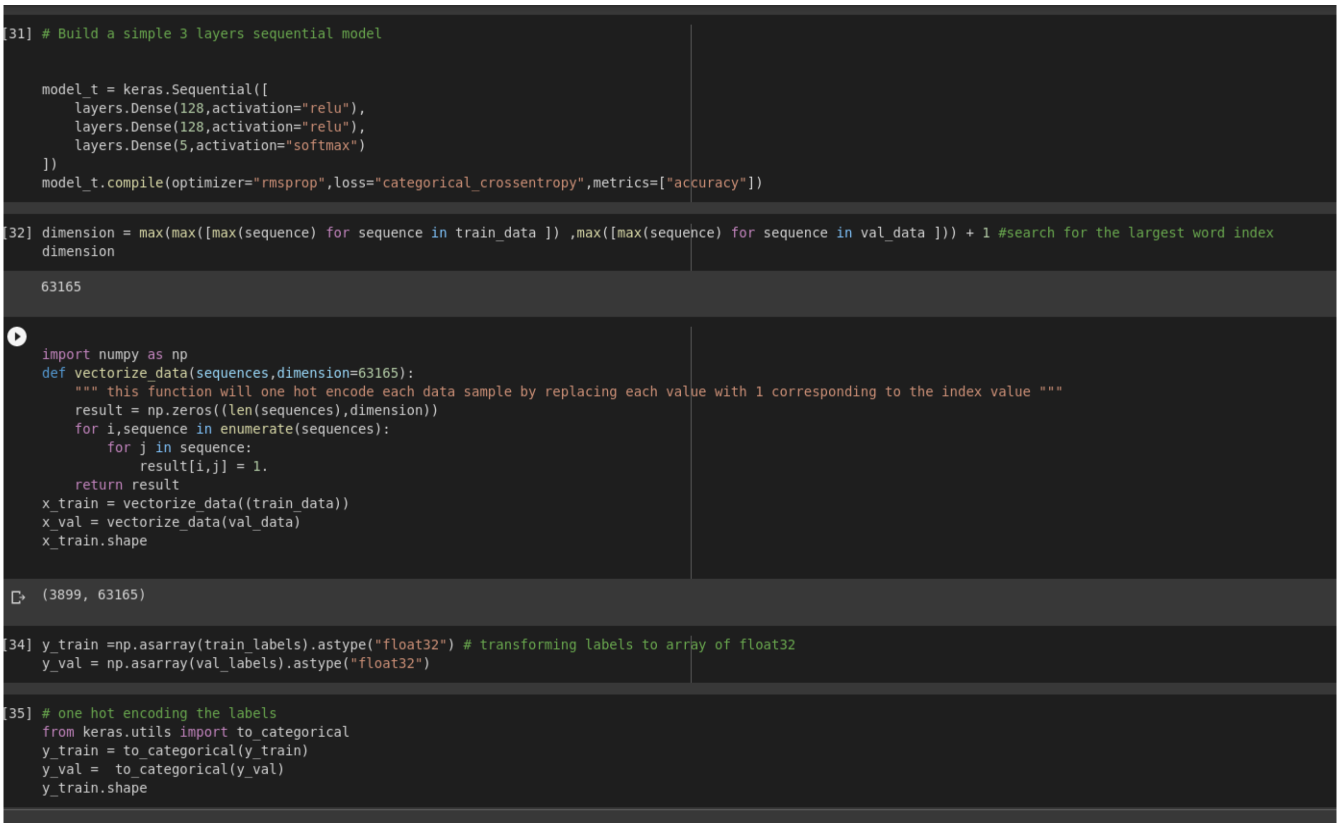
```
import numpy as np
def load_data(data_name):
    labels = ["negative","neutral","positive","very_negative","very_positive"] # will help me change class names with their corrosponding numbers
    data =[]
    data_labels =[]

    for label in labels:                                                        #loop over labels
      for elt in data_name[label]:                                               # loop over samples of vectored data ,each text was replaced with a vector of indexes before we loop over each vector in each class
        if(len(elt) != 0):                                                       # if the elt is not 0 ,that is the 0 we use to replace the missing data before
          data.append(elt)                                                       # append the value to the list called label
          data_labels.append(labels.index(label))                                #append its corresponding label in a diffrent list so we end up with a vector of samples ,and its corresponding vector of lables

    return np.asarray(data),np.asarray(data_labels)                              # the tow lists need to converted to numpy array so we can see their shapes


train_data,train_labels = load_data(t_train)                                     # get train data and its labels using our created funnction
val_data,val_labels = load_data(t_validation)                                    #get the validation data and their labels
```

```
<ipython-input-30-6a78c44f0de7>:13: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecate
  return np.asarray(data),np.asarray(data_labels)
```

use them both to tra11th Step :in a multi input model

12th Step:

we can now define a sequential model ,before feeding the data to this model we should convert it to a tensor that contains only 0s and 1s ,so we used a function that takes each data vector and replace each index of that vector by 1 in that position index ,for making such a tensor we need to search for the max index available in the train an validation data because that will be used as the second axis dimension for our tensor ,we finally get a tensor with (number of samples ,dimension) shape ,for each sample we have a vector that contains 0 and 1s ,and its label ,we could also hot encode the labels ,for this we used to_categorical



```
[31] # Build a simple 3 layers sequential model


     model_t = keras.Sequential([
         layers.Dense(128,activation="relu"),
         layers.Dense(128,activation="relu"),
         layers.Dense(5,activation="softmax")
     ])
     model_t.compile(optimizer="rmsprop",loss="categorical_crossentropy",metrics=["accuracy"])
```

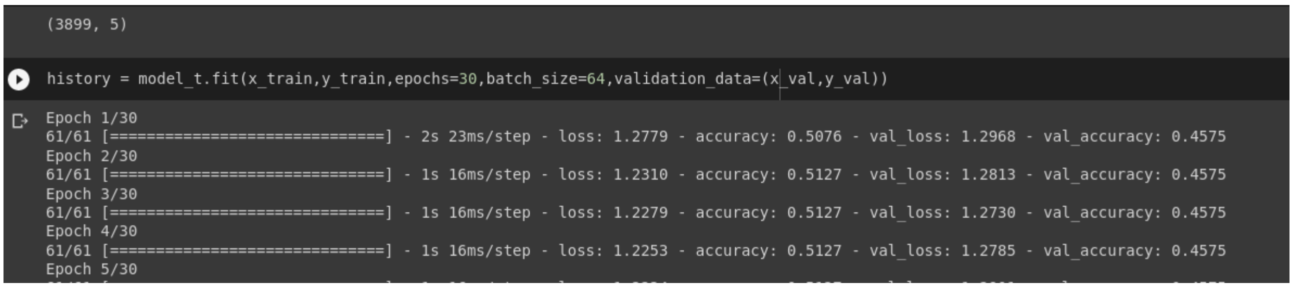
```
[32] dimension = max(max([max(sequence) for sequence in train_data ]) ,max([max(sequence) for sequence in val_data ])) + 1 #search for the largest word index
     dimension

     63165
```

```
     import numpy as np
     def vectorize_data(sequences,dimension=63165):
         """ this function will one hot encode each data sample by replacing each value with 1 corresponding to the index value """
         result = np.zeros((len(sequences),dimension))
         for i,sequence in enumerate(sequences):
             for j in sequence:
                 result[i,j] = 1.
         return result
     x_train = vectorize_data((train_data))
     x_val = vectorize_data(val_data)
     x_train.shape

     (3899, 63165)
```

```
[34] y_train =np.asarray(train_labels).astype("float32") # transforming labels to array of float32
     y_val = np.asarray(val_labels).astype("float32")
```

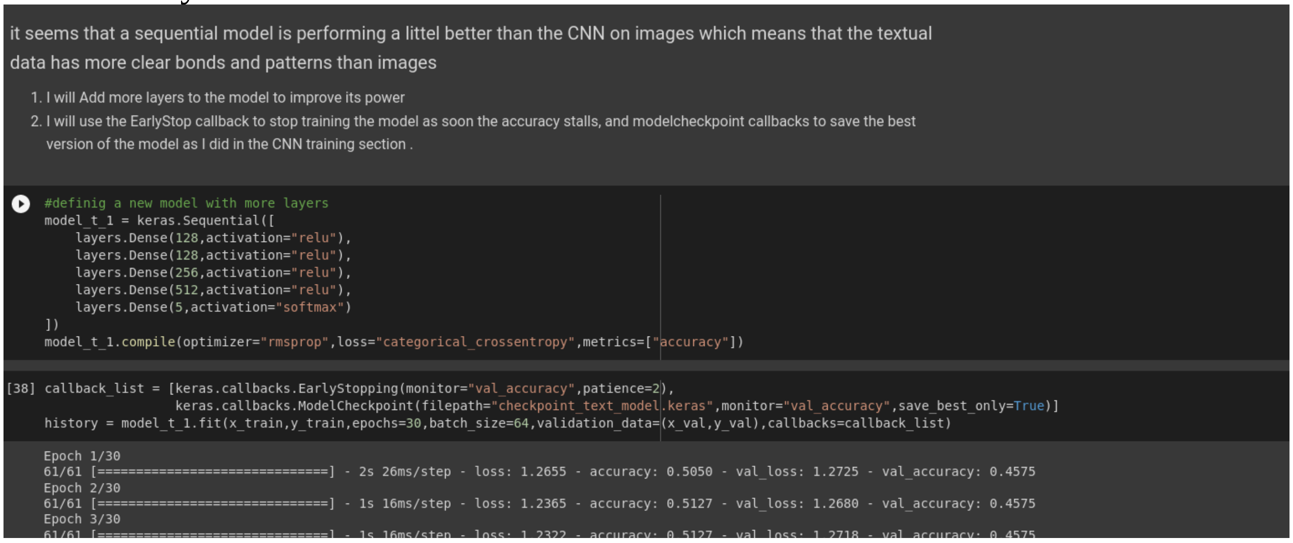
```
[35] # one hot encoding the labels
     from keras.utils import to_categorical
     y_train = to_categorical(y_train)
     y_val =  to_categorical(y_val)
     y_train.shape
```

we fit then our model



```
(3899, 5)

history = model_t.fit(x_train,y_train,epochs=30,batch_size=64,validation_data=(x_val,y_val))

Epoch 1/30
61/61 [==============================] - 2s 23ms/step - loss: 1.2779 - accuracy: 0.5076 - val_loss: 1.2968 - val_accuracy: 0.4575
Epoch 2/30
61/61 [==============================] - 1s 16ms/step - loss: 1.2310 - accuracy: 0.5127 - val_loss: 1.2813 - val_accuracy: 0.4575
Epoch 3/30
61/61 [==============================] - 1s 16ms/step - loss: 1.2279 - accuracy: 0.5127 - val_loss: 1.2730 - val_accuracy: 0.4575
Epoch 4/30
61/61 [==============================] - 1s 16ms/step - loss: 1.2253 - accuracy: 0.5127 - val_loss: 1.2785 - val_accuracy: 0.4575
Epoch 5/30
```

add more layers to see if we can make him over fits and use callbacks



it seems that a sequential model is performing a littel better than the CNN on images which means that the textual data has more clear bonds and patterns than images

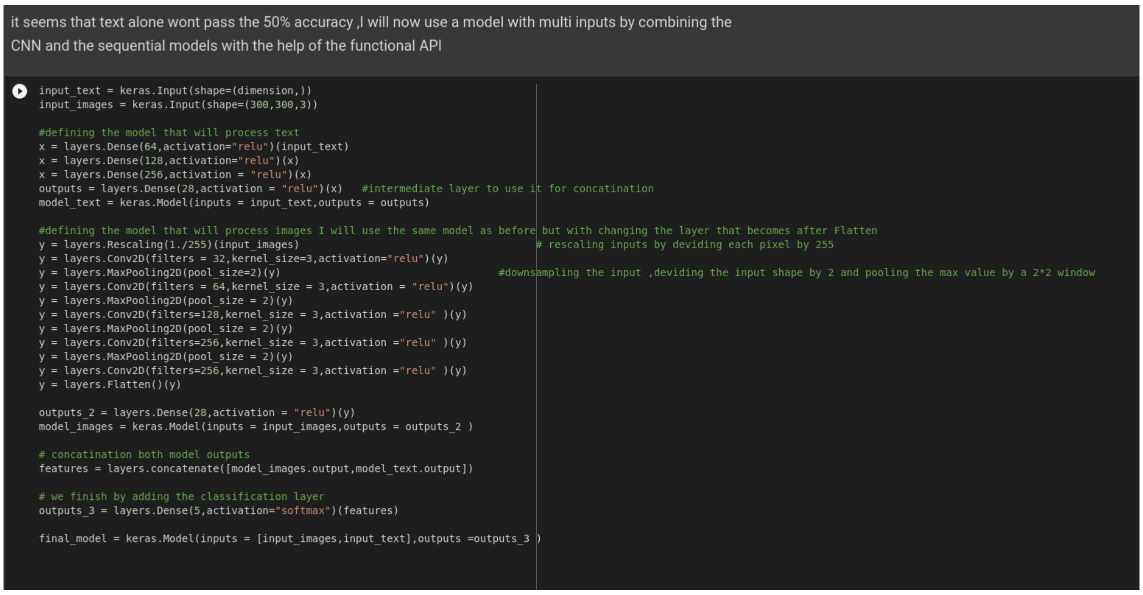
1. I will Add more layers to the model to improve its power
2. I will use the EarlyStop callback to stop training the model as soon the accuracy stalls, and modelcheckpoint callbacks to save the best version of the model as I did in the CNN training section .

```
#definig a new model with more layers
model_t_1 = keras.Sequential([
    layers.Dense(128,activation="relu"),
    layers.Dense(128,activation="relu"),
    layers.Dense(256,activation="relu"),
    layers.Dense(512,activation="relu"),
    layers.Dense(5,activation="softmax")
])
model_t_1.compile(optimizer="rmsprop",loss="categorical_crossentropy",metrics=["accuracy"])
```

```
[38] callback_list = [keras.callbacks.EarlyStopping(monitor="val_accuracy",patience=2),
                      keras.callbacks.ModelCheckpoint(filepath="checkpoint_text_model.keras",monitor="val_accuracy",save_best_only=True)]
     history = model_t_1.fit(x_train,y_train,epochs=30,batch_size=64,validation_data=(x_val,y_val),callbacks=callback_list)

     Epoch 1/30
     61/61 [==============================] - 2s 26ms/step - loss: 1.2655 - accuracy: 0.5050 - val_loss: 1.2725 - val_accuracy: 0.4575
     Epoch 2/30
     61/61 [==============================] - 1s 16ms/step - loss: 1.2365 - accuracy: 0.5127 - val_loss: 1.2680 - val_accuracy: 0.4575
     Epoch 3/30
     61/61 [==============================] - 1s 16ms/step - loss: 1.2322 - accuracy: 0.5127 - val_loss: 1.2718 - val_accuracy: 0.4575
```

3th Step :

since the text and images seems to hold the same results I hough of using a multiinput model with the help of the functional api but it didn’t work due to an error because of data labeling ,one coming from dataset objects and the others from a tensor ,nonetheless Ill try to make it work and see what it gives

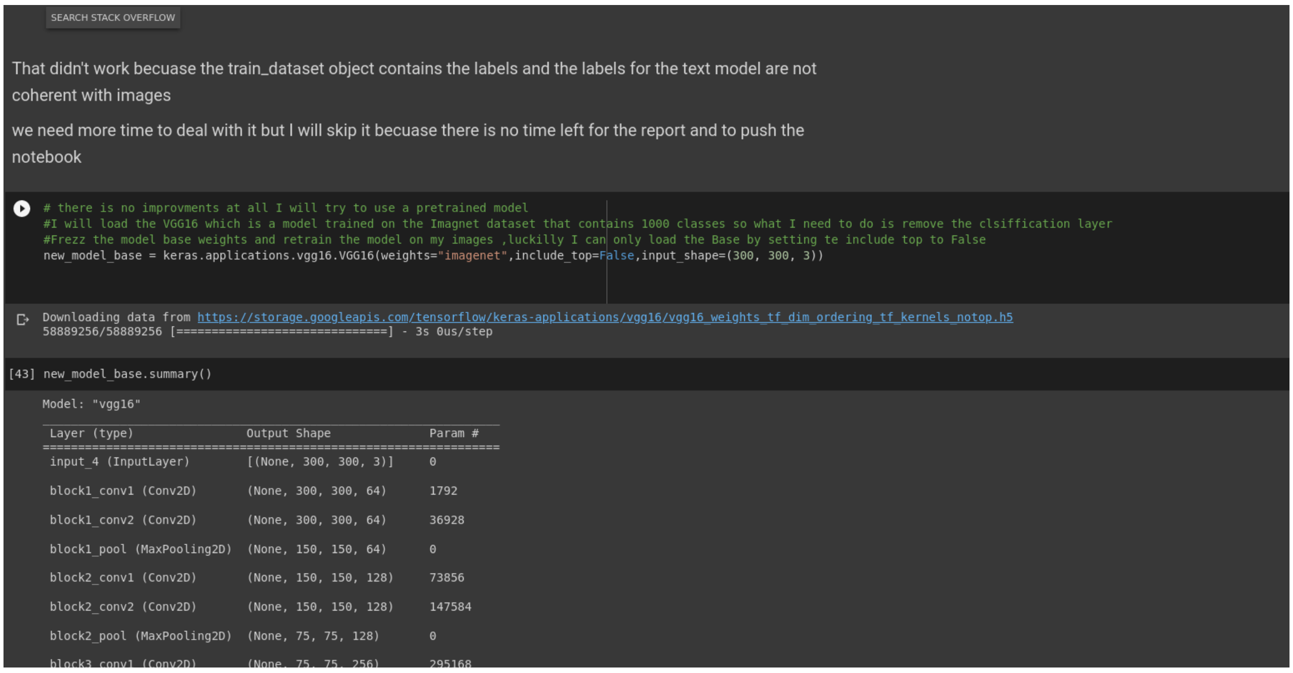


it seems that text alone wont pass the 50% accuracy ,I will now use a model with multi inputs by combining the CNN and the sequential models with the help of the functional API

```
input_text = keras.Input(shape=(dimension,))
input_images = keras.Input(shape=(300,300,3))

#defining the model that will process text
x = layers.Dense(64,activation="relu")(input_text)
x = layers.Dense(128,activation="relu")(x)
x = layers.Dense(256,activation = "relu")(x)
outputs = layers.Dense(28,activation = "relu")(x)   #intermediate layer to use it for concatination
model_text = keras.Model(inputs = input_text,outputs = outputs)

#defining the model that will process images I will use the same model as before but with changing the layer that becomes after Flatten
y = layers.Rescaling(1./255)(input_images)                                           # rescaling inputs by deviding each pixel by 255
y = layers.Conv2D(filters = 32,kernel_size=3,activation="relu")(y)
y = layers.MaxPooling2D(pool_size=2)(y)                                        #downsampling the input ,deviding the input shape by 2 and pooling the max value by a 2*2 window
y = layers.Conv2D(filters = 64,kernel_size = 3,activation = "relu")(y)
y = layers.MaxPooling2D(pool_size = 2)(y)
y = layers.Conv2D(filters=128,kernel_size = 3,activation ="relu" )(y)
y = layers.MaxPooling2D(pool_size = 2)(y)
y = layers.Conv2D(filters=256,kernel_size = 3,activation ="relu" )(y)
y = layers.MaxPooling2D(pool_size = 2)(y)
y = layers.Conv2D(filters=256,kernel_size = 3,activation ="relu" )(y)
y = layers.Flatten()(y)

outputs_2 = layers.Dense(28,activation = "relu")(y)
model_images = keras.Model(inputs = input_images,outputs = outputs_2 )

# concatination both model outputs
features = layers.concatenate([model_images.output,model_text.output])

# we finish by adding the classification layer
outputs_3 = layers.Dense(5,activation="softmax")(features)

final_model = keras.Model(inputs = [input_images,input_text],outputs =outputs_3 )
```

Final Step:

the final step was to use a pretrained model ,we could use Xception ,ResNet ,Densnet ,VGG19 or others ,we tried to use VGG16 a pretrained model on the ImageNet dataset with 1000 classes ,the first thing after importing the model base ,without the classification layer is to ,use its base to predict on the train and validation data,and record that output in list ,that will be used later as an input to a classifier that we create for our needs ,5 class classification ,,this is exactly as freezing the weights and training the classification layer



That didn't work becuase the train_dataset object contains the labels and the labels for the text model are not coherent with images

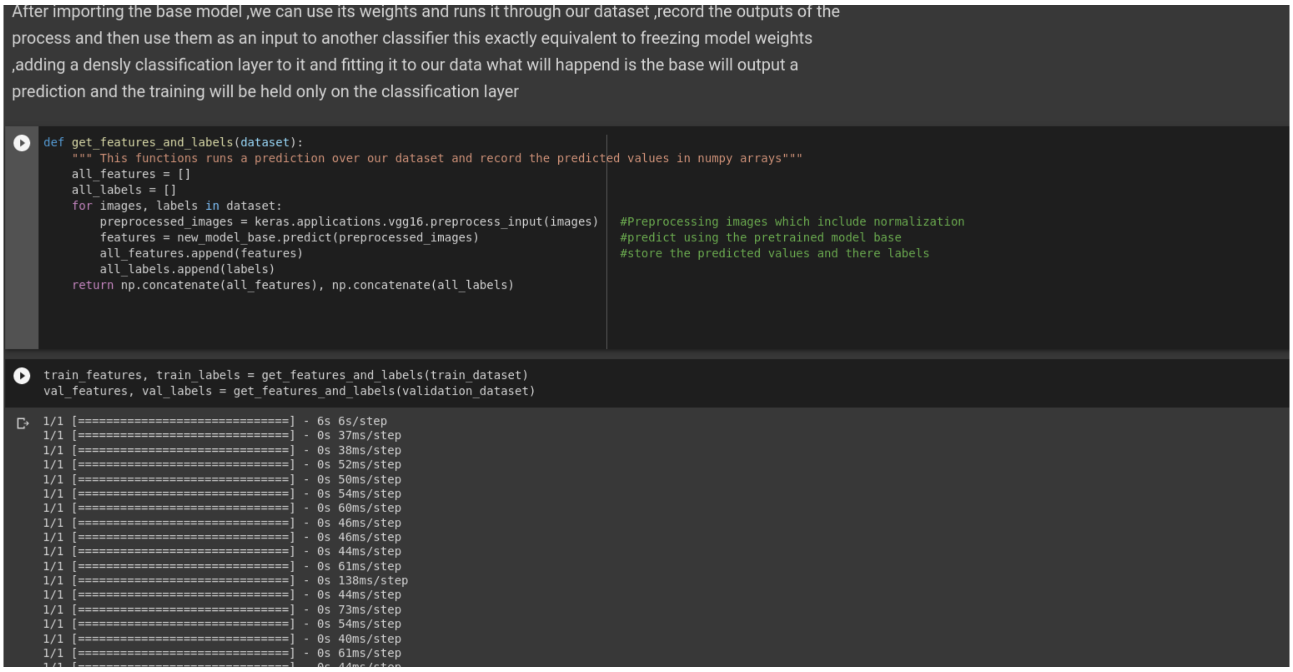
we need more time to deal with it but I will skip it becuase there is no time left for the report and to push the notebook

```
# there is no improvments at all I will try to use a pretrained model
#I will load the VGG16 which is a model trained on the Imagnet dataset that contains 1000 classes so what I need to do is remove the clsiffication layer
#Frezz the model base weights and retrain the model on my images ,luckilly I can only load the Base by setting te include top to False
new_model_base = keras.applications.vgg16.VGG16(weights="imagenet",include_top=False,input_shape=(300, 300, 3))
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58889256/58889256 [==============================] - 3s 0us/step
```

```
[43] new_model_base.summary()
```

```
Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_4 (InputLayer)        [(None, 300, 300, 3)]     0

 block1_conv1 (Conv2D)       (None, 300, 300, 64)      1792

 block1_conv2 (Conv2D)       (None, 300, 300, 64)      36928

 block1_pool (MaxPooling2D)  (None, 150, 150, 64)      0

 block2_conv1 (Conv2D)       (None, 150, 150, 128)     73856

 block2_conv2 (Conv2D)       (None, 150, 150, 128)     147584

 block2_pool (MaxPooling2D)  (None, 75, 75, 128)       0

 block3_conv1 (Conv2D)       (None, 75, 75, 256)       295168
```



After importing the base model ,we can use its weights and runs it through our dataset ,record the outputs of the process and then use them as an input to another classifier this exactly equivalent to freezing model weights ,adding a densly classification layer to it and fitting it to our data what will happend is the base will output a prediction and the training will be held only on the classification layer

```python
def get_features_and_labels(dataset):
    """ This functions runs a prediction over our dataset and record the predicted values in numpy arrays"""
    all_features = []
    all_labels = []
    for images, labels in dataset:
        preprocessed_images = keras.applications.vgg16.preprocess_input(images)   #Preprocessing images which include normalization
        features = new_model_base.predict(preprocessed_images)                     #predict using the pretrained model base
        all_features.append(features)                                              #store the predicted values and there labels
        all_labels.append(labels)
    return np.concatenate(all_features), np.concatenate(all_labels)
```

```python
train_features, train_labels = get_features_and_labels(train_dataset)
val_features, val_labels = get_features_and_labels(validation_dataset)
```

```
1/1 [==============================] - 6s 6s/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 52ms/step
1/1 [==============================] - 0s 50ms/step
1/1 [==============================] - 0s 54ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 46ms/step
1/1 [==============================] - 0s 46ms/step
1/1 [==============================] - 0s 44ms/step
1/1 [==============================] - 0s 61ms/step
1/1 [==============================] - 0s 138ms/step
1/1 [==============================] - 0s 44ms/step
1/1 [==============================] - 0s 73ms/step
1/1 [==============================] - 0s 54ms/step
1/1 [==============================] - 0s 40ms/step
1/1 [==============================] - 0s 61ms/step
```