Project 2nd : Toxic comment classsification

Problem statement:

In the world full of internet everybody has liberty to write and give their opinion at any social medial platform. people usually choose to write their opinion on website"s comment section and thread section but many times it has observed that rather than giving constructive advise people use this opportunity to bully or abuse others and start fighting with each other in the threads and comment section where they sometimes even give threat and insult each other .To specifically identify and restrict these type of comments internet companies are working very hardly and this competition was also held on similar topic.

The resources used in this project

1.) https://arxiv.org/pdf/1810.04805.pdf

2.) https://huggingface.co/transformers/model_doc/bert.html

1.) Importing all the important libraries

In [4]:

```
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd
import tensorflow as tf
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.callbacks import ModelCheckpoint
from tqdm import *
from sklearn.model_selection import train_test_split
from sklearn.model_selection import KFold
from sklearn.model_selection import StratifiedKFold
from sklearn.utils import shuffle
from transformers import BertTokenizer, TFBertModel , TFBertForSequenceClassification
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.metrics import AUC
import os
from googletrans import *
from wordcloud import WordCloud , STOPWORDS
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.testing is deprecated. Use the functions in the pub
lic API at pandas.testing instead.
  import pandas.util.testing as tm
```

3.) Loading the data

In [6]:

```
data = pd.read_csv("/gdrive/My Drive/Colab Notebooks/jigsaw-toxic-comment-classification-challenge/train.csv")
test_data =  pd.read_csv("/gdrive/My Drive/Colab Notebooks/jigsaw-toxic-comment-classification-challenge/test.csv")
test_data.head()
```

Out[6]:

	id	comment_text
0	00001cee341fdb12	Yo bitch Ja Rule is more succesful then you'll...
1	0000247867823ef7	== From RfC == \n\n The title is fine as it is...
2	00013b17ad220c46	" \n\n == Sources == \n\n * Zawe Ashton on Lap...
3	00017563c3f7919a	:If you have a look back at the source, the in...
4	00017695ad8997eb	I don't anonymously edit articles at all.

In [7]:

```
test_labels = pd.read_csv("/gdrive/My Drive/Colab Notebooks/jigsaw-toxic-comment-classification-challenge/test_labels.csv")
test_labels.head()
```

Out[7]:

	id	toxic	severe_toxic	obscene	threat	insult	identity_hate
0	00001cee341fdb12	-1	-1	-1	-1	-1	-1
1	0000247867823ef7	-1	-1	-1	-1	-1	-1
2	00013b17ad220c46	-1	-1	-1	-1	-1	-1
3	00017563c3f7919a	-1	-1	-1	-1	-1	-1
4	00017695ad8997eb	-1	-1	-1	-1	-1	-1

In [8]:

```
test_data = test_data.merge(  test_labels ,  how='right')
test_data_new = test_data[test_data["toxic"]!= -1].reset_index(drop=True)
test_data_new.head()
```

Out[8]:

	id	comment_text	toxic	severe_toxic	obscene	threat	insult	identity_hate
0	0001ea8717f6de06	Thank you for understanding. I think very high...	0	0	0	0	0	0
1	000247e83dcc1211	:Dear god this site is horrible.	0	0	0	0	0	0
2	0002f87b16116a7f	"::: Somebody will invariably try to add Relig...	0	0	0	0	0	0
3	0003e1cccfd5a40a	" \n\n It says it right there that it IS a typ...	0	0	0	0	0	0
4	00059ace3e3e9a53	" \n\n == Before adding a new product to the l...	0	0	0	0	0	0

3.) check the null values in the data frames

In [9]:

```
print("comment_text null value   =",sum(pd.isnull(data['comment_text'])))
print("toxic comment null values =" ,sum(pd.isnull(data['toxic'])))
print("sever toxic null values   =" , sum(pd.isnull(data['severe_toxic'])))
print("obscene null values       =" , sum(pd.isnull(data['obscene'])))
print("threat null values        =" ,sum(pd.isnull(data['threat'])))
print("insult null values        =" ,sum(pd.isnull(data['insult'])))
print("identity null values      ="  ,sum(pd.isnull(data['identity_hate'])))
```

```
comment_text null value   = 0
toxic comment null values = 0
sever toxic null values   = 0
obscene null values       = 0
threat null values        = 0
insult null values        = 0
identity null values      = 0
```

In [10]:

```
print("comment_text null value   =",sum(pd.isnull(test_data_new['comment_text'])))
print("toxic comment null values =" ,sum(pd.isnull(test_data_new['toxic'])))
print("sever toxic null values   =" , sum(pd.isnull(test_data_new['severe_toxic'])))
print("obscene null values       =" , sum(pd.isnull(test_data_new['obscene'])))
print("threat null values        =" ,sum(pd.isnull(test_data_new['threat'])))
print("insult null values        =" ,sum(pd.isnull(test_data_new['insult'])))
print("identity null values      ="  ,sum(pd.isnull(test_data_new['identity_hate'])))
```

```
comment_text null value   = 0
toxic comment null values = 0
sever toxic null values   = 0
obscene null values       = 0
threat null values        = 0
insult null values        = 0
identity null values      = 0
```

4.) Visualizing data

In [75]:

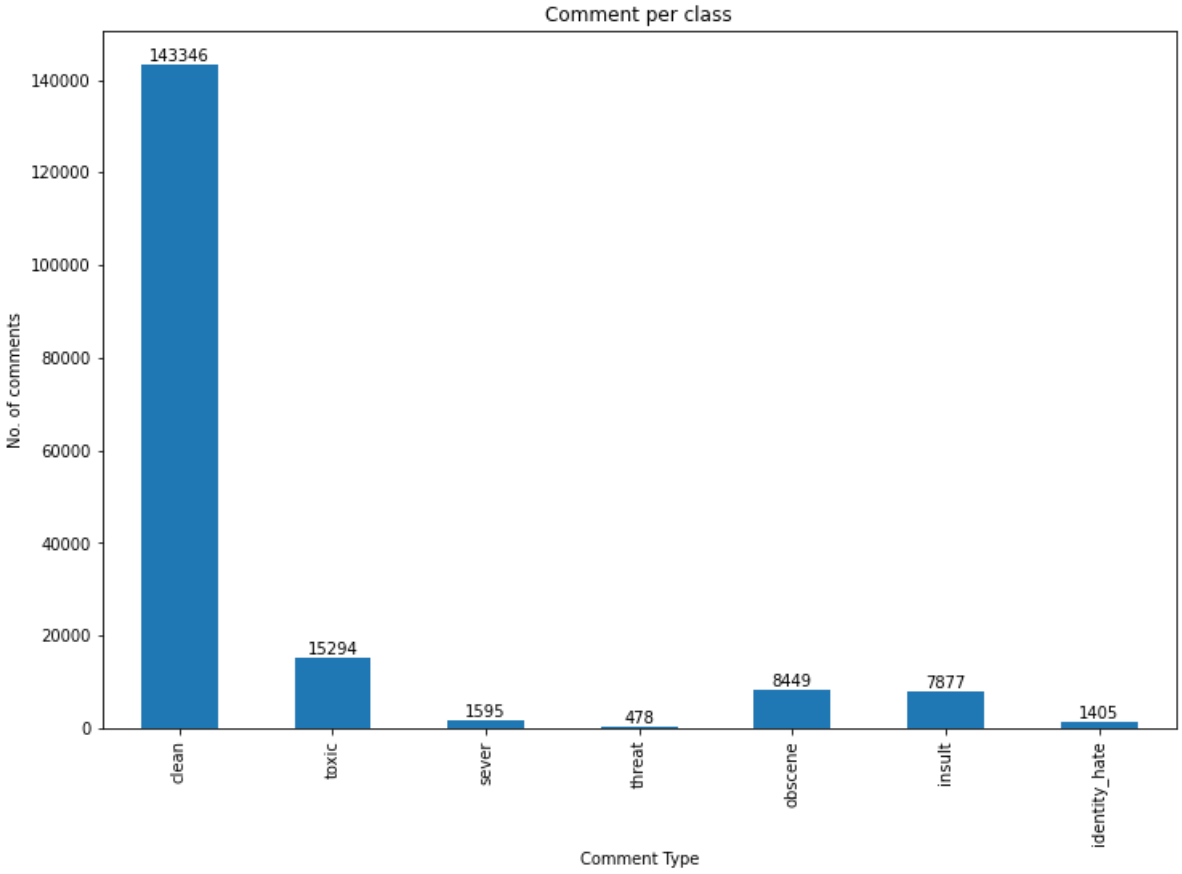
```
#https://stackoverflow.com/questions/28931224/adding-value-labels-on-a-matplotlib-bar-chart

clean = len(data[(data["toxic"]==0) & (data["severe_toxic"]==0) & (data["obscene"]==0) & (data["threat"]==0) &(data["insult"]==0) & (data["identity_ha
te"]==0)])
toxic = len(data[data["toxic"]==1])
sever =  len(data[data["severe_toxic"]==1])
threat = len(data[data["threat"]==1])
obscene = len(data[data["obscene"]==1])
insult = len(data[data["insult"]==1])
identity_hate = len(data[data["identity_hate"]==1])
fr = [clean , toxic , sever , threat ,obscene , insult , identity_hate]

freq_series = pd.Series(fr)
x_labels = ["clean" , "toxic" , "sever" , "threat" ,"obscene" , "insult" , "identity_hate"]
plt.figure(figsize=(12, 8))
ax = freq_series.plot(kind='bar')
ax.set_title('Comment per class')
ax.set_xlabel("Comment Type")
ax.set_ylabel('No. of comments')
ax.set_xticklabels(x_labels)
rects = ax.patches


for rect , label in zip(rects , fr):
    height = rect.get_height()
    ax.text(rect.get_x() + rect.get_width() / 2, height + 5, label,
            ha='center', va='bottom')

plt.show()
```



observation:

1.) The data is highly imbalanced in nature and some of the points are very less like threat and identity hate.

In [28]:

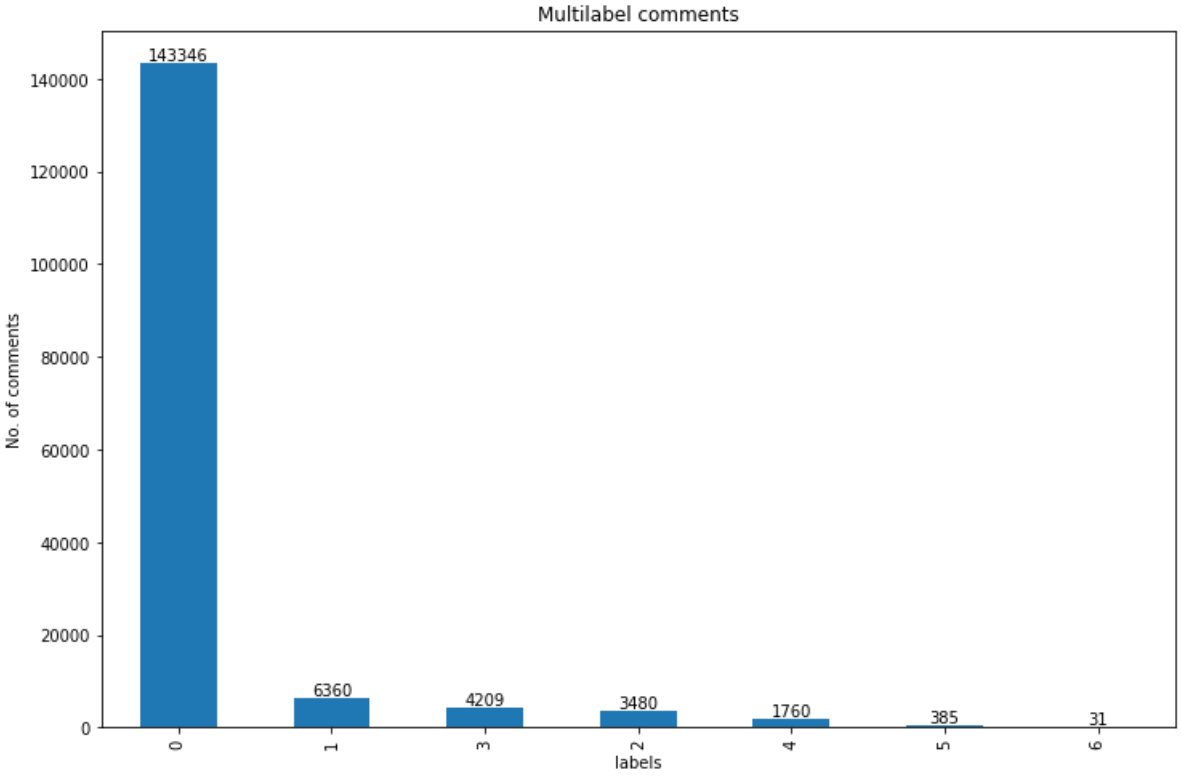
```
x = data[["toxic" , "severe_toxic"  ,"obscene" , "threat" , "insult" , "identity_hate"]].sum(axis = 1).value_counts()#it written a dictionary
key = x.keys()
value = x.values

fr = pd.Series(value)
plt.figure(figsize=(12, 8))
```

```
ax = fr.plot(kind='bar')
ax.set_title('Multilabel comments')
ax.set_xlabel("labels")
ax.set_ylabel('No. of comments')
ax.set_xticklabels(key)
rects = ax.patches


for rect , label in zip(rects , fr):
    height = rect.get_height()
    ax.text(rect.get_x() + rect.get_width() / 2, height + 5, label,
            ha='center', va='bottom')

plt.show()
```



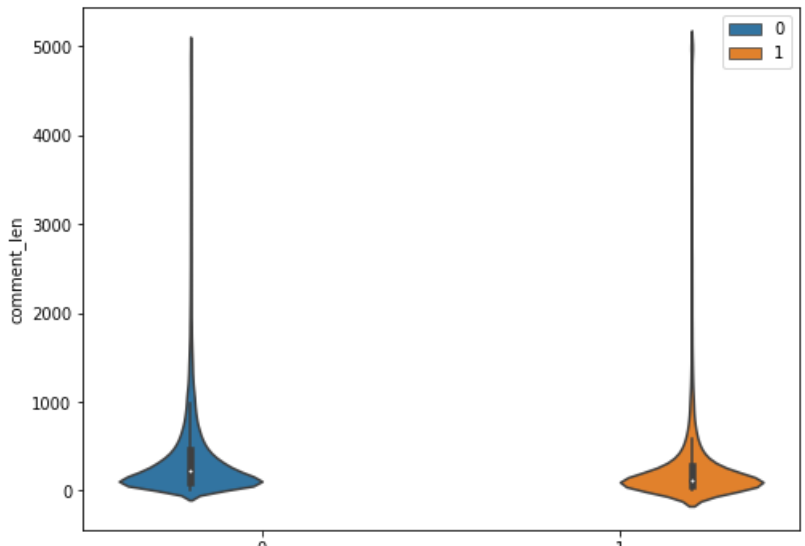
Observation:

1.) Most of the labels are sigle labeled in the data set.

2.) Only 31 points are there which has all the three labesl.

In [46]:

```
data["comment_len"] = [len(i) for i in data.comment_text.values]
plt.figure(figsize=(8,6))
ax = sns.violinplot(x="toxic", y="comment_len", data=data , hue = "toxic")
plt.legend()
plt.show()
```



toxic

Observation:

1.) Boht the toxic and clean comments have equal lengths in the distribution.

2.) The 75percentile clean comments have lenght nearly equal to the 200-250 words.

3.) The 75percentile toxic comments have lenght nearly equal to the 200-250 words.

5.) Visualizing word cloud of each column:

In [29]:

```
toxic_data = data[data["toxic"]==1]
```

In [30]:

```
#https://stackoverflow.com/questions/16645799/how-to-create-a-word-cloud-from-a-corpus-in-python
str1 = ''.join(toxic_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black', max_words=2000,
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud.recolor(colormap= 'summer' , random_state=2534), alpha=0.98)
#plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

In [27]:

```
toxic_data = data[data["severe_toxic"]==1]
```

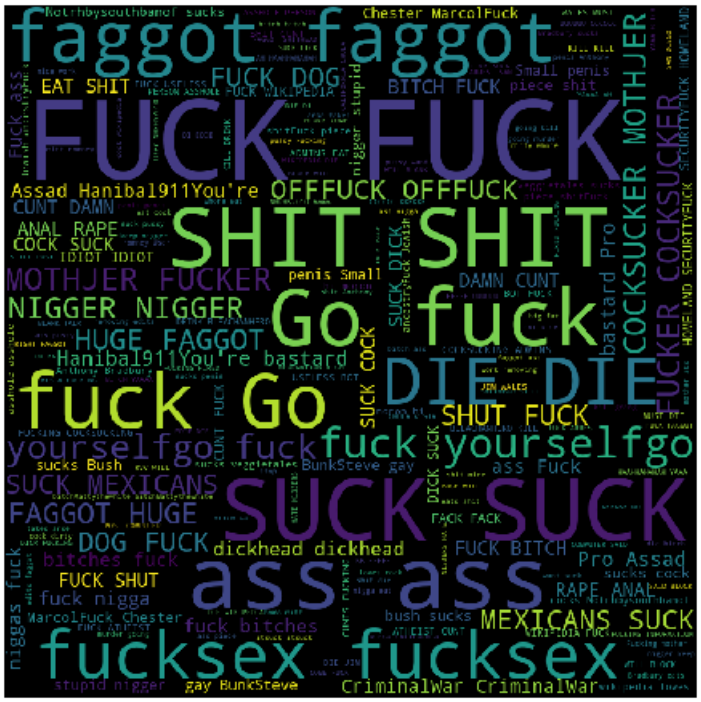
In [28]:

```
str1 = ''.join(toxic_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
```

```
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



In [25]:

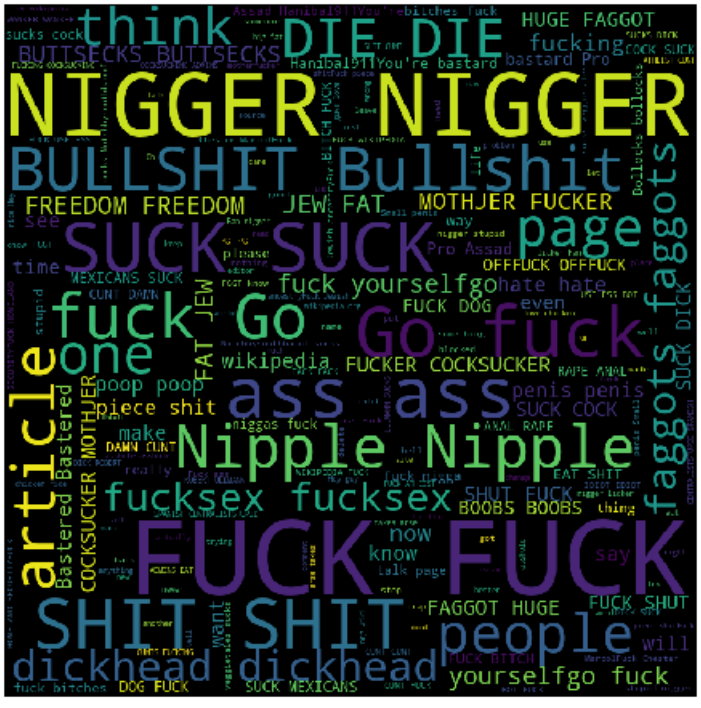
```
toxic_data = data[data["obscene"]==1]
```

In [26]:

```
str1 = ''.join(toxic_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```



In [23]:

```
toxic_data = data[data["threat"]==1]
```

In [24]:

```
str1 = ''.join(toxic_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

In [21]:

```
toxic_data = data[data["insult"]==1]
```

In [22]:

```
str1 = ''.join(toxic_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

In [19]:

```
toxic_data = data[data["identity_hate"]==1]
```

In [20]:

```
str1 = ''.join(toxic_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)

plt.show()
```

In [14]:

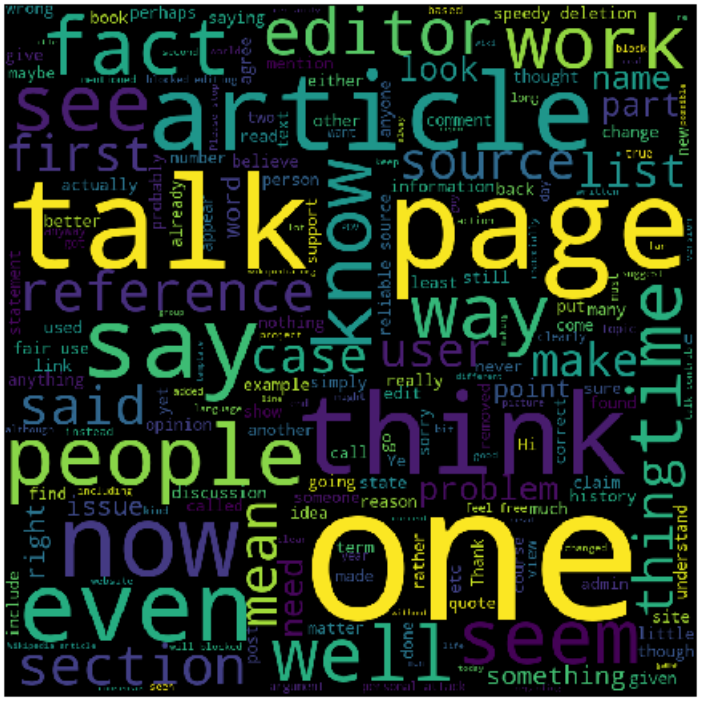
```
clean_data = data[(data["toxic"]==0)&(data["severe_toxic"]==0)&(data["obscene"]==0)&(data["insult"]==0)&(data["threat"]==0)&(data["identity_hate"]==0)]
```

In [18]:

```
str1 = ''.join(clean_data['comment_text'])
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = STOPWORDS).generate(str1)

# plot the WordCloud image
plt.figure(figsize = (6, 6), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
```

```
plt.show()
```



Observation:

1.) Most of the words in toxic are very abusive in nature.

2.) On the other hand clean comments have all the constructive and positive approch.

6.) Extending the data set.

We saw a new way of extending the data set . This idea was proposed by the (Pavel Ostyakov) https://www.kaggle.com/c/jigsaw-toxic-comment-classification-challenge/discussion/48038, in this we can leverage the idea of google translator. The example of this is given below.

In [26]:

```
translator = Translator()
encode = translator.translate(data.comment_text.values[0] , dest='fr').text
decode = translator.translate(encode , dest='en').text
print(data.comment_text.values[0])
print(decode)
```

Explanation
Why the edits made under my username Hardcore Metallica Fan were reverted? They weren't vandalisms, just closure on some GAs after I voted at New York Dolls FAC. And please don't remove the template from the talk page since I'm retired now.89.205.38.27
Explanation
Why have the changes made under my Hardcore Metallica Fan username been canceled? They were not vandalism, just the closing of some GAs af ter having voted in the FAC of New York Dolls. And don't delete the template from the talk page, because I'm now retired.

In [ ]:

```
translator = Translator()

train_es = []
train_de = []
train_fr = []

for i in range(len(data.comment_text.values)):
    encode_es = translator.translate(data.comment_text.values[0] , dest='es').text
    decode_es = translator.translate(encode_es , dest='en').text
    train_es.append(decode_es)

    encode_de = translator.translate(data.comment_text.values[0] , dest='de').text
    decode_de = translator.translate(encode_de , dest='en').text
    train_de.append(decode_de)

    encode_fr = translator.translate(data.comment_text.values[0] , dest='fr').text
    decode_fr = translator.translate(encode_fr , dest='en')
    train_fr.append(decode_fr)
```

In [16]:

```
train_es =  pd.read_csv("/gdrive/My Drive/Colab Notebooks/train_es.csv")
train_de =  pd.read_csv("/gdrive/My Drive/Colab Notebooks/train_de.csv")
train_fr =  pd.read_csv("/gdrive/My Drive/Colab Notebooks/train_fr.csv")
print(len(train_es))
print(len(train_de))
print(len(train_fr))
```

```
159571
159571
159571
```

7.) Creating the new data set with higher no. of data points

In [17]:

```
new_train =  pd.concat([data ,train_fr  ,train_es ,train_de , test_data_new])
new_train = shuffle(new_train)
print(len(new_train))
```

```
702262
```

In [23]:

```
train_comment = new_train["comment_text"].values
test_comment  = test_data["comment_text"].values
```

8.) Loading the bert tokenizer and encoding the text in input format

In [20]:

```
tokenizer = BertTokenizer.from_pretrained('bert-base-cased')
```

In [34]:

```
padded_ids_train = []
mask_ids_train = []

for i in tqdm(range(len(train_comment))):
    encoding = tokenizer.encode_plus(train_comment[i]  , max_length = 128 , pad_to_max_length = True  ,do_lower_case = False)
    input_ids , attention_id = encoding["input_ids"] , encoding["attention_mask"]
  #if len(input_ids) < max_len:
    #padded_ = [0]*((max_len) - len(input_ids))
    padded_ids_train.append(input_ids)
  #padded_ids.extend(padded_)
    mask_ids_train.append(attention_id)
```

```
100%|██████████| 702262/702262 [12:02<00:00, 971.62it/s]
```

In [21]:

```
padded_ids_test = []
mask_ids_test = []

for i in tqdm(range(len(test_comment))):
    encoding = tokenizer.encode_plus(test_comment[i]  , max_length = 128 , pad_to_max_length = True , do_lower_case = False )
    input_ids , attention_id = encoding["input_ids"] , encoding["attention_mask"]
  #if len(input_ids) < max_len:
    #padded_ = [0]*((max_len) - len(input_ids))
    padded_ids_test.append(input_ids)
  #padded_ids.extend(padded_)
    mask_ids_test.append(attention_id)
```

```
100%|██████████| 153164/153164 [02:37<00:00, 974.24it/s]
```

In [ ]:

```
#train_array = np.array(new_df["toxic"].values)
```

```
#train_array = np.array(new_df["toxic"].values)
y_train = new_train.drop(["id" ,"comment_text"] , axis=1)

#test_array = np.array(test_data_new["toxic"].values)
```

In [35]:

```
train_id = np.array(padded_ids_train)
train_mask = np.array(mask_ids_train)

test_id = np.array(padded_ids_test)
test_mask = np.array(mask_ids_test)

print(train_id.shape , test_id.shape)
print(train_mask.shape , test_mask.shape)
```

```
(702262, 128) (153164, 128)
(702262, 128) (153164, 128)
```

Model 1.)

Architecture:

In [36]:

```
input_1 = tf.keras.Input(shape = (128) , dtype=np.int32)

input_2 = tf.keras.Input(shape = (128) , dtype=np.int32)

model = TFBertForSequenceClassification.from_pretrained('bert-base-uncased')

output  = model([input_1 , input_2] , training = True )

answer = tf.keras.layers.Dense(6 , activation = tf.nn.sigmoid )(output[0])

model = tf.keras.Model(inputs = [input_1, input_2 ] , outputs = [answer])
```

In [37]:

```
model.summary()
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================================
input_3 (InputLayer)         [(None, 128)]             0
__________________________________________________________________________________________________
input_4 (InputLayer)         [(None, 128)]             0
__________________________________________________________________________________________________
tf_bert_for_sequence_classifica ((None, 2),)          109483778   input_3[0][0]
                                                                  input_4[0][0]
__________________________________________________________________________________________________
dense_2 (Dense)              (None, 6)                 18          tf_bert_for_sequence_classificati
==================================================================================================
Total params: 109,483,796
Trainable params: 109,483,796
Non-trainable params: 0
__________________________________________________________________________________________________
```

In [46]:

```
%load_ext tensorboard
```

In [ ]:

```
!rm -rf /gdrive/My Drive/logs/
```

Creating path for saving the model and tensorboard

In [ ]:

```
log_dir = "/gdrive/My Drive/logs/"
```

```
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1)
filepath = "/gdrive/My Drive/final_model.h5"
checkpoint = ModelCheckpoint(filepath=filepath,
                             monitor='val_auc',
                             verbose=1,
                             save_best_only=True , mode = "max" , save_weights_only = True)
```

In [38]:

```
auc_score = AUC(multi_label=True)
model.compile(optimizer = Adam(lr = 3e-5),
              loss = tf.keras.losses.binary_crossentropy,
            metrics = [ auc_score])
```

In [ ]:

```
model.fit([train_id , train_mask] , y_train,
          validation_split = 0.1 , batch_size = 32,
          epochs=4, callbacks = [tensorboard_callback , checkpoint]
)
```

In [39]:

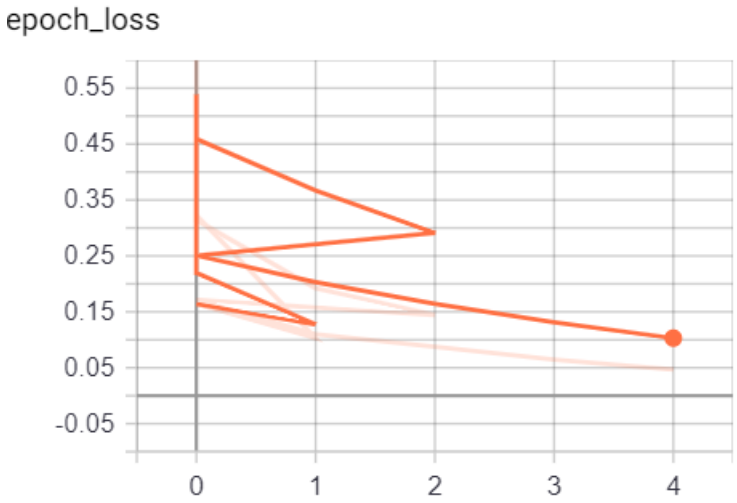
```
%tensorboard --logdir "/gdrive/My Drive/logs"
```

Train loss:

In [3]:

```
from IPython.display import Image
Image(filename="C:\\Users\\my pc\\Pictures\\Screenshots\\Model_1 train loss.PNG")
```

Out[3]:

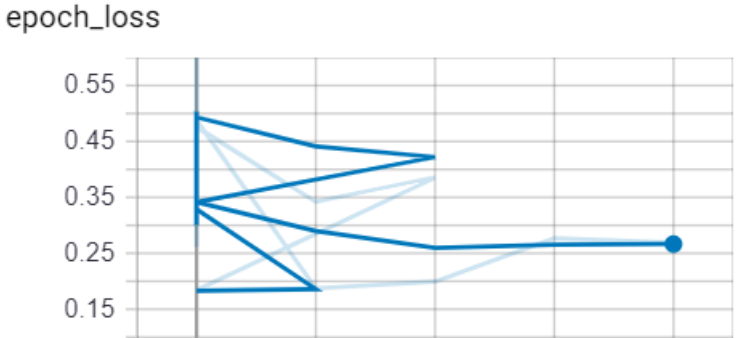


CV loss:

In [6]:

```
Image(filename="C:\\Users\\my pc\\Pictures\\Screenshots\\Model_1 val loss.PNG")
```

Out[6]:



Model prediction and saving the output

In [ ]:

```
a = model.predict([test_id , test_mask])
sub = pd.DataFrame(a , columns=['toxic', 'severe_toxic', 'obscene', 'threat', 'insult', 'identity_hate'])
sub["id"] = test_data["id"].values
sub.head()
```

Out[ ]:

	toxic	severe_toxic	obscene	threat	insult	identity_hate	id
0	0.996859	0.249085	0.988158	0.020886	0.978657	0.226216	00001cee341fdb12
1	0.000981	0.000043	0.000692	0.000128	0.000117	0.000079	0000247867823ef7
2	0.015035	0.000207	0.003353	0.000754	0.002331	0.000990	00013b17ad220c46
3	0.000158	0.000004	0.000095	0.000014	0.000013	0.000004	00017563c3f7919a
4	0.000236	0.000008	0.000170	0.000023	0.000025	0.000007	00017695ad8997eb

In [ ]:

```
result = sub[["id",'toxic', 'severe_toxic', 'obscene', 'threat', 'insult', 'identity_hate']]
result.to_csv("/gdrive/My Drive/ninth_submission.csv" ,index=False)
result.tail()
```

Out[ ]:

	id	toxic	severe_toxic	obscene	threat	insult	identity_hate
153159	fffcd0960ee309b5	0.496643	0.001046	0.182512	0.000676	0.031268	0.001175
153160	fffd7a9a6eb32c16	0.000931	0.000030	0.000584	0.000143	0.000087	0.000072
153161	fffda9e8d6fafa9e	0.000181	0.000004	0.000116	0.000018	0.000012	0.000005
153162	fffe8f1340a79fc2	0.000768	0.000047	0.000810	0.000115	0.000069	0.000082
153163	ffffce3fb183ee80	0.620240	0.004997	0.381507	0.002538	0.113429	0.006729

Modle 2.)

Architecture :

In [41]:

```
def creat_model():

    input_1 = tf.keras.Input(shape = (128) , dtype=np.int32)

    input_2 = tf.keras.Input(shape = (128) , dtype=np.int32)

    model = TFBertModel.from_pretrained('bert-base-uncased')

    output , pooled_out  = model([input_1 , input_2] , training = True )

    x = tf.reshape(pooled_out , (-1 , pooled_out.shape[1]))

    dense_1 = tf.keras.layers.Dense(768   , activation= tf.nn.relu)(x)

    drop_1 = tf.keras.layers.Dropout(0.1)(dense_1)

    answer = tf.keras.layers.Dense(6 , activation = tf.nn.sigmoid)(drop_1)

    model = tf.keras.Model(inputs = [input_1, input_2 ] , outputs = [answer])

    return model
```

In [42]:

```
model = creat_model()
model.summary()
```

```
Model: "model_2"
__________________________________________________________________________________________________
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================================
input_5 (InputLayer)         [(None, 128)]             0
__________________________________________________________________________________________________
input_6 (InputLayer)         [(None, 128)]             0
__________________________________________________________________________________________________
tf_bert_model_1 (TFBertModel)   ((None, 128, 768), ( 109482240   input_5[0][0]
                                                                 input_6[0][0]
__________________________________________________________________________________________________
tf_op_layer_Reshape_1 (TensorFl [(None, 768)]        0           tf_bert_model_1[0][1]
__________________________________________________________________________________________________
dense_3 (Dense)              (None, 768)               590592      tf_op_layer_Reshape_1[0][0]
__________________________________________________________________________________________________
dropout_113 (Dropout)        (None, 768)               0           dense_3[0][0]
__________________________________________________________________________________________________
dense_4 (Dense)              (None, 6)                 4614        dropout_113[0][0]
==================================================================================================
Total params: 110,077,446
Trainable params: 110,077,446
Non-trainable params: 0
__________________________________________________________________________________________________
```

Creating path for saving the model and tensorboard

In [ ]:

```
log_dir = "/gdrive/My Drive/logs/"
tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir, histogram_freq=1)
filepath = "/gdrive/My Drive/final_model3.h5"
checkpoint = ModelCheckpoint(filepath=filepath,
                             monitor='val_auc',
                             verbose=1,
                             save_best_only=True , mode = "max" , save_weights_only = True)
```

In [43]:

```
auc_score = AUC(multi_label=True)
model.compile(optimizer = Adam(lr = 3e-5),
              loss = tf.keras.losses.binary_crossentropy,
            metrics = [ auc_score])
```

In [ ]:

```
model.fit([train_id , train_mask] , y_train,
          validation_split = 0.1 , batch_size = 32,
          epochs=4, callbacks = [tensorboard_callback , checkpoint]
)
```

Model prediction and saving the output

In [ ]:

```
b = model.predict([test_id , test_mask])
sub = pd.DataFrame(b , columns=['toxic', 'severe_toxic', 'obscene', 'threat', 'insult', 'identity_hate'])
sub["id"] = test_data["id"].values
result = sub[["id",'toxic', 'severe_toxic', 'obscene', 'threat', 'insult', 'identity_hate']]
result.to_csv("/gdrive/My Drive/13th_submission.csv" ,index=False)
```

In [ ]:

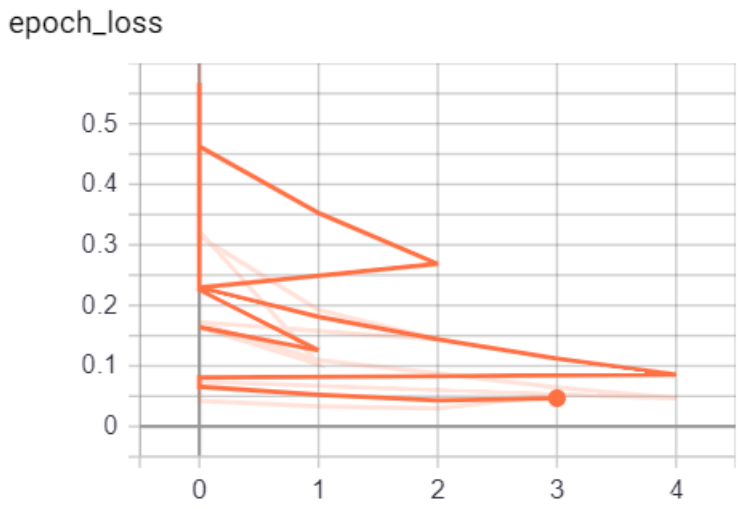
```
%tensorboard --logdir "/gdrive/My Drive/logs"
```

Train loss:

In [5]:

```
Image(filename="C:\\Users\\my pc\\Pictures\\Screenshots\\Model_2 train loss.PNG")
```

Out[5]:

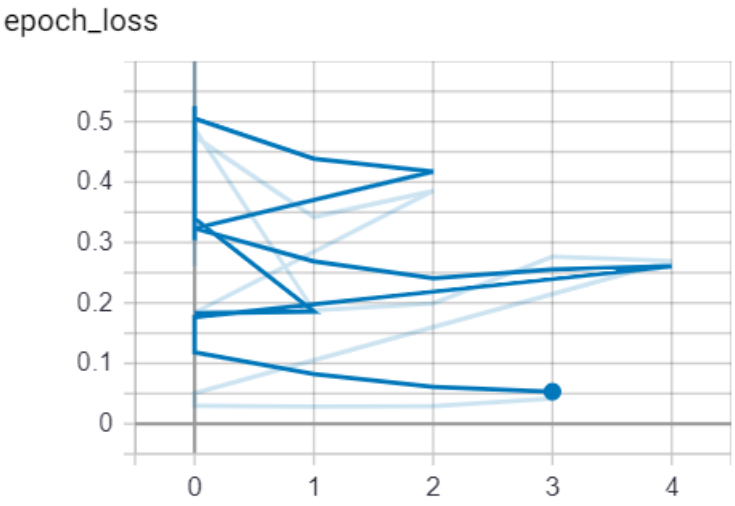


CV loss:

In [4]:

```
Image(filename="C:\\Users\\my pc\\Pictures\\Screenshots\\Model_2 val loss.PNG")
```

Out[4]:



Final result:

In [8]:

```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Model name", "Private_score", "public_score"]
x.add_row(["Model_1"           , 0.98139, 0.98209 ])
x.add_row(["Model_2"           , 0.98951, 0.98931 ])
x.add_row(["Model_1 + Model_2" , 0.98971, 0.98993 ])

print(x)
```

```
+------------------+--------------+--------------+
|    Model name    | Private_score | public_score |
+------------------+--------------+--------------+
|     Model_1      |    0.98139   |   0.98209    |
|     Model_2      |    0.98951   |   0.98931    |
| Model_1 + Model_2 |    0.98971   |   0.98993    |
+------------------+--------------+--------------+
```