1. Read the parser.txt file containing the image id and the respective word for that image and take the first 10000 instances for training and testing of the model

In [1]:
```
from google.colab import drive
drive.mount('/content/drive')
```
```
Mounted at /content/drive
```

In [2]:
```
!cp "/content/drive/MyDrive/NITAIML/words.zip" "/content/words.zip"
!cp "/content/drive/MyDrive/NITAIML/parser.txt" "/content/parser.txt"
```

In [3]:
```
with open("/content/parser.txt","r") as file:
  lines=file.readlines()
len(lines)
```
Out[3]:
```
115320
```

In [4]:
```
import pandas as pd
columns_list=[]
max_col_lens=[]
for line in lines:
  cols=line.split(" ")
  max_col_len=len(cols)
  columns_list.append(cols)
  max_col_lens.append(max_col_len)
data_file=pd.DataFrame({"lines":columns_list,"max_col_len":max_col_lens})
data_file.head(3)
```
Out[4]:

	lines	max_col_len
0	[a01-000u-00-00, ok, 154, 408, 768, 27, 51, AT...	9
1	[a01-000u-00-01, ok, 154, 507, 766, 213, 48, N...	9
2	[a01-000u-00-02, ok, 154, 796, 764, 70, 50, TO...	9

In [5]:
```
data_file=data_file.loc[data_file.max_col_len==9,"lines"]
data_file.head(3)
```
Out[5]:
```
0    [a01-000u-00-00, ok, 154, 408, 768, 27, 51, AT...
1    [a01-000u-00-01, ok, 154, 507, 766, 213, 48, N...
2    [a01-000u-00-02, ok, 154, 796, 764, 70, 50, TO...
Name: lines, dtype: object
```

In [6]:
```
def get_data_file_cols(data_cols):
  c1,c2,c9=[],[],[]
  for i in data_cols:
    c1.append(i[0])
    c2.append(i[1])
    c9.append(i[8].replace("\n",""))
  dt=pd.DataFrame({"id":c1,"status":c2,"text":c9})
  return dt
df=get_data_file_cols(data_file)
df.head(1000).tail(5)
```
Out[6]:

	id	status	text
995	a01-020-04-04	ok	the
996	a01-020-04-05	ok	Africans
997	a01-020-04-06	ok	the
998	a01-020-04-07	ok	overall
999	a01-020-05-00	ok	majority

In [7]:
```
df.shape
```
Out[7]:
```
(115284, 3)
```

In [8]:
```
df=df.loc[df.status=="ok",:]
```

In [9]:
```
df.shape
```
Out[9]:
```
(96430, 3)
```

In [10]:
```
df.head(19045).tail(5)
```
Out[10]:

	id	status	text
21408	b06-049-07-03	ok	with
21409	b06-049-07-04	ok	the
21410	b06-049-07-05	ok	Tories
21411	b06-049-07-06	ok	.
21412	b06-049-07-07	ok	Many

1. Images can be of different shape thus resize all your images to have the same shape (for example = (128,32))
2. Currently, the pixel values are between 0 to 255, normalize the images so that the pixel values are in range 0 to 1

In [11]:
```
import os
from matplotlib import image
def getFileDF(path,files,file_names):
    for i in os.listdir(path):
        file_path=os.path.join(path,i)
        if os.path.isdir(file_path):
            getFileDF(file_path,files,file_names)

        else:

            dir_path=file_path.split("/")[:-1]
            file_name=file_path.split("/")[-1]
            file_name=file_name.split(".")[0]
            dir_path="/".join(dir_path)
            file_ext=file_path.split(".")[-1]
            files.append(file_path)
            file_names.append(file_name)
            #image_size.append(image.imread(file_path))
    return files,file_names
```

In [16]:
```
import shutil
shutil.rmtree("/content/words")
!unzip -q words.zip
files,file_names=getFileDF("/content/words",[],[])
```
```
warning [words.zip]:  76 extra bytes at beginning or within zipfile
  (attempting to process anyway)
error [words.zip]:  reported length of central directory is
  -76 bytes too long (Atari STZip zipfile?  J.H.Holm ZIPSPLIT 1.1
  zipfile?).  Compensating...
error:  expected central file header signature not found (file #116936).
  (please check that you have transferred or created the zipfile in the
  appropriate BINARY mode and that you have compiled UnZip properly)
```

In [17]:
```
import pandas as pd
image_df=pd.DataFrame({"files":files,"file_names":file_names})
image_df.head(2)
```
Out[17]:

	files	file_names
0	/content/words/a02/a02-042/a02-042-06-02.png	a02-042-06-02
1	/content/words/a02/a02-042/a02-042-05-01.png	a02-042-05-01

In [18]:
```
image_df.shape
```
Out[18]:
```
(115320, 2)
```

In [19]:
```
text_df=pd.DataFrame({"file_names":df["id"],"text":df["text"]})
text_df.head(2)
```
Out[19]:

	file_names	text
0	a01-000u-00-00	A
1	a01-000u-00-01	MOVE

In [20]:
```
text_df.shape
```
Out[20]:
```
(96430, 2)
```

In [21]:
```
data=pd.merge(text_df,image_df,on="file_names",how="left")
data.head(2)
```
Out[21]:

	file_names	text	files
0	a01-000u-00-00	A	/content/words/a01/a01-000u/a01-000u-00-00.png
1	a01-000u-00-01	MOVE	/content/words/a01/a01-000u/a01-000u-00-01.png

In [22]:
```
data.shape
```
Out[22]:
```
(96430, 3)
```

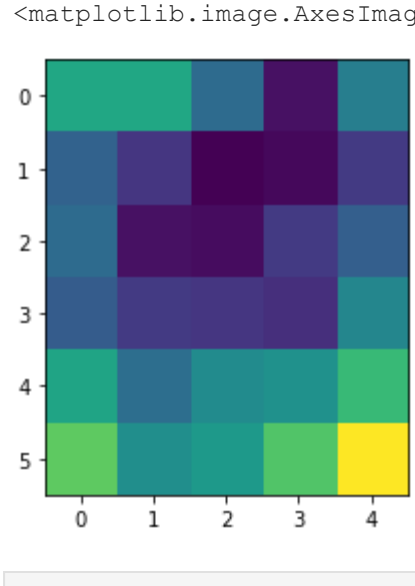
In [23]:
```
X=data.loc[:9999,["files","text"]].copy()
print("X Shape: ",X.shape)
```
```
X Shape:  (10000, 2)
```

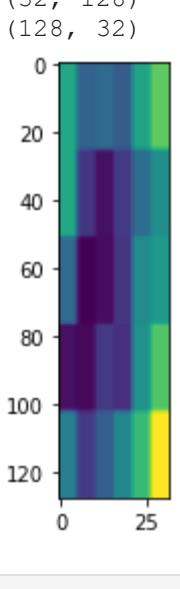
In [24]:
```
X=X.reset_index()
X.head(2)
```
Out[24]:

	index	files	text
0	0	/content/words/a01/a01-000u/a01-000u-00-00.png	A
1	1	/content/words/a01/a01-000u/a01-000u-00-01.png	MOVE

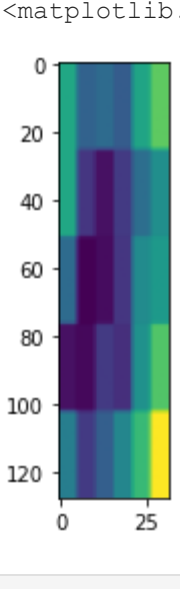
In [25]:
```
X.drop(["index"],axis=1,inplace=True)
```

In [26]:
```
X.head(7010).tail(5)
X=X.loc[:,:]
```

In [30]:
```
import matplotlib.image as image
import numpy as np
import matplotlib.pyplot as plt
import cv2
img=image.imread("/content/words/b01/b01-049/b01-049-01-07.png",format="RGB")
print(img.shape)
plt.imshow(img)
```
```
(6, 5)
```
Out[30]:
```
<matplotlib.image.AxesImage at 0x7fd9d1ee6dd0>
```


In [31]:
```
img=cv2.resize(img,(128,32),interpolation=cv2.INTER_AREA)
print(img.shape)
#img=cv2.cvtColor(img,cv2.COLOR_RGB2GRAY)
img=np.transpose(img)
plt.imshow(img)
print(img.shape)
```
```
(32, 128)
(128, 32)
```


In [32]:
```
image.imsave("/content/images_test.png",img)
```

In [33]:
```
img=image.imread("/content/images_test.png")
plt.imshow(img)
```
Out[33]:
```
<matplotlib.image.AxesImage at 0x7fd9d229d2d0>
```


In [34]:
```
def transform(image):
    image=cv2.resize(image,(128,32),interpolation=cv2.INTER_AREA)
    #image=cv2.cvtColor(image,cv2.COLOR_RGB2GRAY)
    image=np.transpose(image)
    return image
```

In [36]:
```
new_files=[]
import shutil
#shutil.rmtree("/kaggle/working/new_words")
for i in X.files:
  try:
    img=image.imread(i)
    img=transform(img)
    new_file=i.split("/")[-1]
    if os.path.isdir("/content/new_words"):
        pass
    else:
        os.mkdir("/content/new_words")
    new_path="/content/new_words/"+new_file
    new_files.append(new_path)
    image.imsave(new_path,img)
  except:
    print(i)
```
```
/content/words/a01/a01-117/a01-117-05-02.png
```

In [ ]:
```
#X.loc[X.files=="/content/words/r06/r06-022/r06-022-03-05.png",:]
```

In [37]:
```
X.loc[X.files=="/content/words/a01/a01-117/a01-117-05-02.png",:]
```
Out[37]:

	files	text
3588	/content/words/a01/a01-117/a01-117-05-02.png	Powell

In [38]:
```
X.drop([3588],axis=0,inplace=True)
```

In [39]:
```
X.shape
```
Out[39]:
```
(9999, 2)
```

In [40]:
```
print(new_files[0],X.files.head(1))
```
```
/content/new_words/a01-000u-00-00.png 0    /content/words/a01/a01-000u/a01-000u-00-00.png
Name: files, dtype: object
```

In [41]:
```
X=X.reset_index()
X.head(2)
```
Out[41]:

	index	files	text
0	0	/content/words/a01/a01-000u/a01-000u-00-00.png	A
1	1	/content/words/a01/a01-000u/a01-000u-00-01.png	MOVE

In [42]:
```
X.drop(["index"],axis=1,inplace=True)
print(X.shape)
X.head(3)
```
```
(9999, 2)
```
Out[42]:

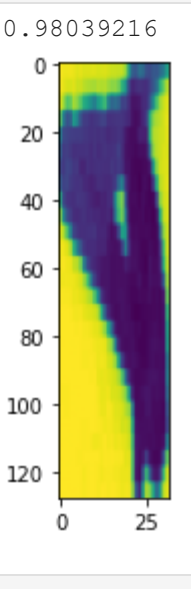
	files	text
0	/content/words/a01/a01-000u/a01-000u-00-00.png	A
1	/content/words/a01/a01-000u/a01-000u-00-01.png	MOVE
2	/content/words/a01/a01-000u/a01-000u-00-02.png	to

In [43]:
```
X=pd.concat([X,pd.Series(new_files)],axis=1)
X.head(3)
```
Out[43]:

	files	text	0
0	/content/words/a01/a01-000u/a01-000u-00-00.png	A	/content/new_words/a01-000u-00-00.png
1	/content/words/a01/a01-000u/a01-000u-00-01.png	MOVE	/content/new_words/a01-000u-00-01.png
2	/content/words/a01/a01-000u/a01-000u-00-02.png	to	/content/new_words/a01-000u-00-02.png

In [44]:
```
X.columns=["files","text","new_files"]
X.drop(["files"],axis=1,inplace=True)
X.head(3)
```
Out[44]:

	text	new_files
0	A	/content/new_words/a01-000u-00-00.png
1	MOVE	/content/new_words/a01-000u-00-01.png
2	to	/content/new_words/a01-000u-00-02.png

In [45]:
```
img=image.imread("/content/new_words/a01-000u-00-00.png")
print(img[0,0,0])
plt.imshow(img)
plt.show()
```
```
0.98039216
```


In [46]:
```
X.head(2)
```
Out[46]:

	text	new_files
0	A	/content/new_words/a01-000u-00-00.png
1	MOVE	/content/new_words/a01-000u-00-01.png

In [47]:
```
X.tail(5)
```
Out[47]:

	text	new_files
9994	debate	/content/new_words/a05-053-08-00.png
9995	,	/content/new_words/a05-053-08-01.png
9996	said	/content/new_words/a05-053-08-02.png
9997	the	/content/new_words/a05-053-08-03.png
9998	Government	/content/new_words/a05-053-08-04.png

1. Create a list of all characters and use the character's index to encode the actual words into digits

In [48]:
```
char_list="ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789 ,;.!?:'\"/\|_@#&*+-=()"
char_tokens=[char for char in char_list]
def get_token_text(text,char_token):
  tokens=[token for token in text]
  token_ids=[char_tokens.index(token) for token in tokens]
  token_text=",".join([str(tkn) for tkn in token_ids])
  max_len=len(token_ids)
  return token_text,max_len
```

In [49]:
```
token_list=[]
max_lens=[]
for i in X.text:
  token_text,max_len=get_token_text(i,char_tokens)
  token_list.append(token_text)
  max_lens.append(max_len)
tokenization_data=pd.DataFrame({"tokens":token_list,"max_len":max_lens})
tokenization_data.head(3)
```
Out[49]:

	tokens	max_len
0	0	1
1	12,14,21,4	4
2	45,40	2

In [50]:
```
X.text.head(3)
```
Out[50]:
```
0       A
1    MOVE
2      to
Name: text, dtype: object
```

In [51]:
```
X.text.tail(4)
```
Out[51]:
```
9995             ,
9996          said
9997           the
9998    Government
Name: text, dtype: object
```

In [52]:
```
tokenization_data.tail(4)
```
Out[52]:

	tokens	max_len
9995	63	1
9996	44,26,34,29	4
9997	45,33,30	3
9998	6,40,47,30,43,39,38,30,39,45	10

In [53]:
```
max_length=tokenization_data.max_len.max()
```

In [54]:
```
max_length
```
Out[54]:
```
16
```

In [55]:
```
X.loc[tokenization_data.max_len==16,"text"]
```
Out[55]:
```
1495    unconstitutional
2558    once-and-for-all
2624    once-and-for-all
Name: text, dtype: object
```

In [56]:
```
X.loc[[1495,2558,2624],:]
```
Out[56]:

	text	new_files
1495	unconstitutional	/content/new_words/a01-038-10-01.png
2558	once-and-for-all	/content/new_words/a01-072u-02-03.png
2624	once-and-for-all	/content/new_words/a01-072x-02-00.png

1. Pad all the words to have a similar length

In [57]:
```
def get_padded_data(token_list,max_len):
  tokens=token_list.split(",")
  len_tokens=len(tokens)
  padding=[99 for i in range(max_len-len_tokens)]
  tokens.extend(padding)
  token_text=",".join([str(token) for token in tokens])
  return token_text
```

In [58]:
```
tokens_padded=[get_padded_data(token,max_length+1) for token in tokenization_data.tokens]
tokenization_data=pd.concat([tokenization_data,pd.Series(tokens_padded),X.text],axis=1)
tokenization_data.head(1004).tail(5)
```
Out[58]:

	tokens	max_len	0	text
999	26,43,30	3	26,43,30,99,99,99,99,99,99,99,99,99,99,99,9...	are
1000	44,30,30,36,34,39,32	7	44,30,30,36,34,39,32,99,99,99,99,99,99,99,9...	seeking
1001	65	1	65,99,99,99,99,99,99,99,99,99,99,99,99,99,9...	.
1002	0,31,43,34,28,26,39	7	0,31,43,34,28,26,39,99,99,99,99,99,99,99,99,99,99	African
1003	29,30,37,30,32,26,45,30,44	9	29,30,37,30,32,26,45,30,44,99,99,99,99,99,9...	delegates

In [59]:
```
tokenization_data.columns=["tokens","max_len","padded_tokens","text"]
tokenization_data.head(4)
```
Out[59]:

	tokens	max_len	padded_tokens	text
0	0	1	0,99,99,99,99,99,99,99,99,99,99,99,99,99,99,99,99	A
1	12,14,21,4	4	12,14,21,4,99,99,99,99,99,99,99,99,99,99,99,99,99	MOVE
2	45,40	2	45,40,99,99,99,99,99,99,99,99,99,99,99,99,99,9...	to
3	44,45,40,41	4	44,45,40,41,99,99,99,99,99,99,99,99,99,99,99,9...	stop

In [60]:
```
tokenization_data.loc[0,"padded_tokens"]
```
Out[60]:
```
'0,99,99,99,99,99,99,99,99,99,99,99,99,99,99,99,99'
```

1. Split your dataset for training and testing

In [61]:
```
from sklearn.model_selection import train_test_split
x_values=X.new_files[:]
y_values=tokenization_data.loc[:,["max_len","padded_tokens","text"]]

x_train,x_test,y_train,y_test=train_test_split(x_values,y_values,test_size=0.20,random_state=100)
x_test,x_final_test,y_test,y_final_test=train_test_split(x_test,y_test,test_size=0.50,random_state=100)
print(" Train shapes X",x_train.shape, " Y: ",y_train.shape)
print(" Test shapes X",x_test.shape, " Y : ",y_test.shape)
print(" Test shapes X",x_final_test.shape, " Y : ",y_final_test.shape)
```
```
 Train shapes X (7999,)  Y:  (7999, 3)
 Test shapes X (1000,)  Y :  (1000, 3)
 Test shapes X (1000,)  Y :  (1000, 3)
```

In [62]:
```
import numpy as np
import cv2
def get_images_matrix(files):
  arr=[]
  for i,file in enumerate(files):
    img=image.imread(file,format="RGB")
    img = cv2.cvtColor(img, cv2.COLOR_RGB2GRAY)
    img=img/255
    if i==0:
      print(img.shape)
      arr.append(np.reshape(img,(32,128,1)))
    else:
      if i%5000==0:
        print(i," files processed..")
      arr.append(np.reshape(img,(32,128,1)))
  return arr
x_test_arr=get_images_matrix(x_test)
```
```
(128, 32)
```

In [63]:
```
del x_test
```

In [64]:
```
print(len(x_test_arr))
print(x_test_arr[0][0,0,0])
```
```
1000
0.5254901960784314
```

In [65]:
```
x_train_arr=get_images_matrix(x_train)
```
```
(128, 32)
5000  files processed..
```

In [66]:
```
del x_train
```

In [67]:
```
x_final_test_arr=get_images_matrix(x_final_test)
```
```
(128, 32)
```

In [68]:
```
del x_final_test
```

In [69]:
```
print(len(x_train_arr))
print(x_train_arr[0][0,0,0])
```
```
7999
0.8431372549019608
```

In [70]:
```
y_train.head(3)
```
Out[70]:

	max_len	padded_tokens	text
9387	3	26,39,29,99,99,99,99,99,99,99,99,99,99,99,99,9...	and
7538	3	31,40,43,99,99,99,99,99,99,99,99,99,99,99,99,9...	for
6949	10	4,47,30,43,50,45,33,34,39,32,99,99,99,99,99,99,99	Everything

In [71]:
```
y_test.head(3)
```
Out[71]:

	max_len	padded_tokens	text
6615	3	45,48,40,99,99,99,99,99,99,99,99,99,99,99,99,9...	two
4704	3	33,34,38,99,99,99,99,99,99,99,99,99,99,99,99,9...	him
9843	12	13,26,45,34,40,39,26,37,34,44,45,44,99,99,99,9...	Nationalists

In [72]:
```
y_train=y_train.reset_index()
y_train.drop(["index"],axis=1,inplace=True)
y_test=y_test.reset_index()
y_test.drop(["index"],axis=1,inplace=True)
y_final_test=y_final_test.reset_index()
y_final_test.drop(["index"],axis=1,inplace=True)
```

In [73]:
```
y_train.head(3)
```
Out[73]:

	max_len	padded_tokens	text
0	3	26,39,29,99,99,99,99,99,99,99,99,99,99,99,99,9...	and
1	3	31,40,43,99,99,99,99,99,99,99,99,99,99,99,99,9...	for
2	10	4,47,30,43,50,45,33,34,39,32,99,99,99,99,99,99,99	Everything

In [74]:
```
len(x_train_arr)
```
Out[74]:
```
7999
```

1. Create a model for training: Marks: 30

a) Add several CNN layers to extract the sequence of features

b) Add Bi-LSTM layers to propagate through the sequence

c) Add a dense layer (output layer) with total number of neurons as (total number of characters + 1) and the activation as softmax.

In [77]:
```
!pip install tensorflow_addons
```
```
Collecting tensorflow_addons
  Downloading tensorflow_addons-0.16.1-cp37-cp37m-manylinux_2_12_x86_64.manylinux2010_x86_64.whl (1.1 MB)
     |████████████████████████████████| 1.1 MB 5.1 MB/s
Requirement already satisfied: typeguard>=2.7 in /usr/local/lib/python3.7/dist-packages (from tensorflow_addon
s) (2.7.1)
Installing collected packages: tensorflow-addons
Successfully installed tensorflow-addons-0.16.1
```

In [78]:
```
from tensorflow.keras.layers import Dense, Flatten,Input,Conv2D,MaxPool2D,Dropout,BatchNormalization
from tensorflow.keras.layers import LSTM,Bidirectional,Lambda,Flatten
from tensorflow.keras.models import Model
from tensorflow_addons.layers import GroupNormalization
```

In [79]:
```
import tensorflow as tf
from tensorflow.keras import backend as k
input_layer=Input(shape=(32,128,1))
layer=Conv2D(filters=32,kernel_size=(3,3),padding="same",activation="relu")(input_layer)
layer=MaxPool2D(pool_size=(2,2),padding="same")(layer)
layer=GroupNormalization(4)(layer)
layer=Conv2D(filters=32,kernel_size=(3,3),padding="same",activation="relu")(layer)
layer=MaxPool2D(pool_size=(2,2),padding="same")(layer)
layer=GroupNormalization(4)(layer)
layer=tf.keras.layers.Reshape(target_shape=((32, 256)))(layer)
layer=Dense(32,activation="relu")(layer)
layer=Dropout(0.4)(layer)
layer=Bidirectional(LSTM(100,return_sequences=True,dropout=0.5))(layer)
layer=GroupNormalization(5)(layer)
output_layer=Dense(len(char_tokens)+1,activation='softmax')(layer)
```

In [80]:
```
len(char_tokens)
```
Out[80]:
```
84
```

1. The output sequence from the output layer will be fed to the CTC layer.

In [81]:
```
labels = Input(name='label', shape=(max_length+1), dtype='float32')
input_length = Input(name='input_length', shape=(1), dtype='int64')
label_length = Input(name='label_length', shape=(1), dtype='int64')


def ctc_lambda_func(args):
  y_pred, labels, label_length,input_length = args
  return k.ctc_batch_cost(labels, y_pred, input_length, label_length)
loss = Lambda(ctc_lambda_func, output_shape=(1,), name='ctc')([output_layer, labels, label_length,input_length]
```

In [82]:
```
model = Model(inputs=[input_layer, labels, label_length,input_length], outputs=loss)
model.summary()
```
```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 32, 128, 1)  0           []
                                ]

 conv2d (Conv2D)                (None, 32, 128, 32)  320         ['input_1[0][0]']

 max_pooling2d (MaxPooling2D)   (None, 16, 64, 32)   0           ['conv2d[0][0]']

 group_normalization (GroupNorm  (None, 16, 64, 32)  64          ['max_pooling2d[0][0]']
 alization)

 conv2d_1 (Conv2D)              (None, 16, 64, 32)   9248        ['group_normalization[0][0]']

 max_pooling2d_1 (MaxPooling2D)  (None, 8, 32, 32)   0           ['conv2d_1[0][0]']

 group_normalization_1 (GroupNo  (None, 8, 32, 32)   64          ['max_pooling2d_1[0][0]']
 rmalization)

 reshape (Reshape)              (None, 32, 256)      0           ['group_normalization_1[0][0]']

 dense (Dense)                  (None, 32, 32)       8224        ['reshape[0][0]']

 dropout (Dropout)              (None, 32, 32)       0           ['dense[0][0]']

 bidirectional (Bidirectional)  (None, 32, 200)      106400      ['dropout[0][0]']

 group_normalization_2 (GroupNo  (None, 32, 200)     400         ['bidirectional[0][0]']
 rmalization)

 dense_1 (Dense)                (None, 32, 85)       17085       ['group_normalization_2[0][0]']

 label (InputLayer)             [(None, 17)]         0           []

 label_length (InputLayer)      [(None, 1)]          0           []

 input_length (InputLayer)      [(None, 1)]          0           []

 ctc (Lambda)                   (None, 1)            0           ['dense_1[0][0]',
                                                                  'label[0][0]',
                                                                  'label_length[0][0]',
                                                                  'input_length[0][0]']

==================================================================================================
Total params: 141,805
Trainable params: 141,805
Non-trainable params: 0
__________________________________________________________________________________________________
```

In [83]:
```
model.compile(loss={'ctc': lambda y_true, y_pred: y_pred}, optimizer ="adam")

labels_train=np.zeros((y_train.shape[0],max_length+1))
labels_test=np.zeros((y_test.shape[0],max_length+1))
for i,_ in enumerate(y_train.padded_tokens):
    temp=np.array( y_train.padded_tokens[i].split(","))
    labels_train[i, :] =temp


for i ,_ in enumerate(y_test.padded_tokens):
    temp=np.array( y_test.padded_tokens[i].split(","))
    labels_test[i, :] =temp
```

In [84]:
```
print(labels_train.shape)
print(labels_train[0])
print(y_train.padded_tokens[0])
```
```
(7999, 17)
[26. 39. 29. 99. 99. 99. 99. 99. 99. 99. 99. 99. 99. 99. 99. 99. 99.]
26,39,29,99,99,99,99,99,99,99,99,99,99,99,99,99,99
```

In [85]:
```python
class TextImageGenerator:

    def __init__(self, images,text_padded,
                 img_w,
                 img_h,
                 batch_size,
                 i_len,
                 max_text_len
                 ):
        self.img_h = img_h
        self.img_w = img_w
        self.batch_size = batch_size
        self.max_text_len = max_text_len
        #self.samples = data
        self.images=images
        self.text_padded=text_padded
        self.n = len(self.text_padded)
        self.i_len = i_len
        self.indexes = list(range(self.n))
        self.cur_index = 0

    def build_data(self):
        self.imgs = np.zeros((self.n, self.img_h, self.img_w,1))
        self.texts = []
        for i,  (text, img) in enumerate(zip(self.text_padded,self.images)):
            self.imgs[i, :, :,:] = img
            self.texts.append(text)

    def next_sample(self):
        self.cur_index += 1
        if self.cur_index >= self.n:
            self.cur_index = 0
            np.random.shuffle(self.indexes)
        return self.imgs[self.indexes[self.cur_index]], self.texts[self.indexes[self.cur_index]]

    def next_batch(self):
        while True:

            # width and height are backwards from typical Keras convention
            # because width is the time dimension when it gets fed into the RNN
            X_data = np.zeros([self.batch_size, self.img_h, self.img_w, 1])
            Y_data = np.zeros([self.batch_size, self.max_text_len])
            input_length_i = np.ones((self.batch_size, 1)) * self.i_len
            label_length_i = np.ones((self.batch_size, 1)) * self.max_text_len

            for i in range(self.batch_size):
                img, text = self.next_sample()
                X_data[i] = img
                Y_data[i, :] = text
            inputs = [X_data, Y_data, input_length_i, label_length_i]
            outputs = np.zeros([self.batch_size])
            yield (inputs, outputs)
```

In [86]:
```python
batch_size = 32
input_length = len(char_tokens)+1
img_w = 128
img_h = 32
train_data = TextImageGenerator(x_train_arr,labels_train, img_w, img_h, batch_size, input_length, max_length+1)
train_data.build_data()
```

In [87]:
```python
max_length
```

Out[87]: 16

In [88]:
```python
y_train[:9]
```

Out[88]:

	max_len	padded_tokens	text
0	3	26,39,29,99,99,99,99,99,99,99,99,99,99,99,99,9...	and
1	3	31,40,43,99,99,99,99,99,99,99,99,99,99,99,99,9...	for
2	10	4,47,30,43,50,45,33,34,39,32,99,99,99,99,99,99	Everything
3	7	18,30,39,26,45,40,43,99,99,99,99,99,99,99,99,9...	Senator
4	3	45,33,30,99,99,99,99,99,99,99,99,99,99,99,99,9...	the
5	9	31,34,39,26,39,28,34,39,32,99,99,99,99,99,99,9...	financing
6	3	18,34,43,99,99,99,99,99,99,99,99,99,99,99,99,9...	Sir
7	1	65,99,99,99,99,99,99,99,99,99,99,99,99,99,99,9...	.
8	1	80,99,99,99,99,99,99,99,99,99,99,99,99,99,99,9...	-

In [89]:
```python
labels_train[8]
```

Out[89]:
```
array([80., 99., 99., 99., 99., 99., 99., 99., 99., 99., 99., 99., 99.,
       99., 99., 99., 99.])
```

In [90]:
```python
train_data.n
```

Out[90]: 7999

In [91]:
```python
val_data = TextImageGenerator(x_test_arr,labels_test, img_w, img_h, batch_size, input_length, max_length+1)
val_data.build_data()
```

In [92]:
```python
y_train.padded_tokens[0]
```

Out[92]: '26,39,29,99,99,99,99,99,99,99,99,99,99,99,99,99,99'

In [92]:

In [92]:

In [93]:
```python
from tensorflow.keras.callbacks import Callback
from tensorflow.keras.callbacks import EarlyStopping

earlystop = EarlyStopping(monitor='val_loss', min_delta=0.0001, patience=10, verbose=0, mode='min')
history=model.fit(train_data.next_batch(),epochs=100,steps_per_epoch=train_data.n/batch_size,
                  validation_data=val_data.next_batch(),
                  validation_steps=val_data.n/batch_size, callbacks=[earlystop])
```

```
Epoch 1/100
249/249 [==============================] - 42s 101ms/step - loss: 16.5280 - val_loss: 15.5578
Epoch 2/100
249/249 [==============================] - 18s 71ms/step - loss: 14.7548 - val_loss: 14.4796
Epoch 3/100
249/249 [==============================] - 18s 71ms/step - loss: 14.0016 - val_loss: 13.7748
Epoch 4/100
249/249 [==============================] - 17s 70ms/step - loss: 13.3103 - val_loss: 12.7242
Epoch 5/100
249/249 [==============================] - 20s 80ms/step - loss: 12.6906 - val_loss: 12.3868
Epoch 6/100
249/249 [==============================] - 18s 72ms/step - loss: 12.2519 - val_loss: 12.3436
Epoch 7/100
249/249 [==============================] - 18s 71ms/step - loss: 11.7377 - val_loss: 11.3116
Epoch 8/100
249/249 [==============================] - 18s 71ms/step - loss: 11.4223 - val_loss: 11.1774
Epoch 9/100
249/249 [==============================] - 18s 72ms/step - loss: 11.0820 - val_loss: 10.9919
Epoch 10/100
249/249 [==============================] - 19s 75ms/step - loss: 10.8459 - val_loss: 10.5128
Epoch 11/100
249/249 [==============================] - 18s 72ms/step - loss: 10.6181 - val_loss: 10.4838
Epoch 12/100
249/249 [==============================] - 18s 71ms/step - loss: 10.3871 - val_loss: 10.7753
Epoch 13/100
249/249 [==============================] - 18s 72ms/step - loss: 10.2257 - val_loss: 10.1251
Epoch 14/100
249/249 [==============================] - 18s 72ms/step - loss: 9.9956 - val_loss: 9.8818
Epoch 15/100
249/249 [==============================] - 18s 72ms/step - loss: 9.8374 - val_loss: 10.2212
Epoch 16/100
249/249 [==============================] - 18s 72ms/step - loss: 9.7487 - val_loss: 10.0331
Epoch 17/100
249/249 [==============================] - 18s 71ms/step - loss: 9.5709 - val_loss: 9.5355
Epoch 18/100
249/249 [==============================] - 18s 71ms/step - loss: 9.4766 - val_loss: 9.4663
Epoch 19/100
249/249 [==============================] - 18s 71ms/step - loss: 9.3127 - val_loss: 9.5733
Epoch 20/100
249/249 [==============================] - 18s 71ms/step - loss: 9.2661 - val_loss: 9.0936
Epoch 21/100
249/249 [==============================] - 18s 71ms/step - loss: 9.1210 - val_loss: 9.1082
Epoch 22/100
249/249 [==============================] - 18s 72ms/step - loss: 9.0111 - val_loss: 9.3717
Epoch 23/100
249/249 [==============================] - 18s 71ms/step - loss: 8.8916 - val_loss: 8.9817
Epoch 24/100
249/249 [==============================] - 19s 76ms/step - loss: 8.8021 - val_loss: 9.1990
Epoch 25/100
249/249 [==============================] - 18s 72ms/step - loss: 8.7411 - val_loss: 9.0488
Epoch 26/100
249/249 [==============================] - 18s 72ms/step - loss: 8.6006 - val_loss: 9.1091
Epoch 27/100
249/249 [==============================] - 18s 71ms/step - loss: 8.5134 - val_loss: 8.9412
Epoch 28/100
249/249 [==============================] - 17s 69ms/step - loss: 8.4859 - val_loss: 8.5239
Epoch 29/100
249/249 [==============================] - 17s 69ms/step - loss: 8.3526 - val_loss: 8.8924
Epoch 30/100
249/249 [==============================] - 17s 70ms/step - loss: 8.3334 - val_loss: 8.6191
Epoch 31/100
249/249 [==============================] - 17s 69ms/step - loss: 8.2656 - val_loss: 8.7196
Epoch 32/100
249/249 [==============================] - 17s 70ms/step - loss: 8.2060 - val_loss: 8.5879
Epoch 33/100
249/249 [==============================] - 17s 69ms/step - loss: 8.0581 - val_loss: 8.5886
Epoch 34/100
249/249 [==============================] - 17s 70ms/step - loss: 8.0363 - val_loss: 8.1916
Epoch 35/100
249/249 [==============================] - 17s 70ms/step - loss: 7.9193 - val_loss: 8.7115
Epoch 36/100
249/249 [==============================] - 17s 70ms/step - loss: 7.8402 - val_loss: 8.5535
Epoch 37/100
249/249 [==============================] - 17s 70ms/step - loss: 7.8606 - val_loss: 8.5411
Epoch 38/100
249/249 [==============================] - 17s 70ms/step - loss: 7.7254 - val_loss: 8.5559
Epoch 39/100
249/249 [==============================] - 18s 70ms/step - loss: 7.7162 - val_loss: 8.2342
Epoch 40/100
249/249 [==============================] - 18s 70ms/step - loss: 7.6233 - val_loss: 8.2358
Epoch 41/100
249/249 [==============================] - 17s 70ms/step - loss: 7.5673 - val_loss: 8.3327
Epoch 42/100
249/249 [==============================] - 18s 70ms/step - loss: 7.4965 - val_loss: 8.0981
Epoch 43/100
249/249 [==============================] - 17s 69ms/step - loss: 7.4751 - val_loss: 8.1816
Epoch 44/100
249/249 [==============================] - 17s 69ms/step - loss: 7.4554 - val_loss: 8.2271
Epoch 45/100
249/249 [==============================] - 17s 69ms/step - loss: 7.4448 - val_loss: 8.2839
Epoch 46/100
249/249 [==============================] - 18s 71ms/step - loss: 7.3616 - val_loss: 7.9069
Epoch 47/100
249/249 [==============================] - 17s 69ms/step - loss: 7.1998 - val_loss: 8.0731
Epoch 48/100
249/249 [==============================] - 17s 69ms/step - loss: 7.2288 - val_loss: 7.9102
Epoch 49/100
249/249 [==============================] - 17s 69ms/step - loss: 7.1379 - val_loss: 8.0231
Epoch 50/100
249/249 [==============================] - 18s 72ms/step - loss: 7.1315 - val_loss: 7.9174
Epoch 51/100
249/249 [==============================] - 18s 71ms/step - loss: 7.0536 - val_loss: 7.7934
Epoch 52/100
249/249 [==============================] - 18s 71ms/step - loss: 7.0365 - val_loss: 7.9462
Epoch 53/100
249/249 [==============================] - 17s 70ms/step - loss: 7.0536 - val_loss: 8.0103
Epoch 54/100
249/249 [==============================] - 17s 70ms/step - loss: 6.9686 - val_loss: 7.8159
Epoch 55/100
249/249 [==============================] - 17s 69ms/step - loss: 6.8511 - val_loss: 8.0268
Epoch 56/100
249/249 [==============================] - 17s 69ms/step - loss: 6.8849 - val_loss: 7.9564
Epoch 57/100
249/249 [==============================] - 17s 69ms/step - loss: 6.8244 - val_loss: 8.1330
Epoch 58/100
249/249 [==============================] - 17s 69ms/step - loss: 6.8040 - val_loss: 7.7198
Epoch 59/100
249/249 [==============================] - 17s 69ms/step - loss: 6.7629 - val_loss: 8.1653
Epoch 60/100
249/249 [==============================] - 17s 70ms/step - loss: 6.7450 - val_loss: 7.7726
Epoch 61/100
249/249 [==============================] - 17s 70ms/step - loss: 6.6500 - val_loss: 8.3236
Epoch 62/100
249/249 [==============================] - 17s 69ms/step - loss: 6.6498 - val_loss: 7.7122
Epoch 63/100
249/249 [==============================] - 18s 70ms/step - loss: 6.6188 - val_loss: 7.5635
Epoch 64/100
249/249 [==============================] - 17s 69ms/step - loss: 6.4933 - val_loss: 7.8785
Epoch 65/100
249/249 [==============================] - 17s 70ms/step - loss: 6.5819 - val_loss: 7.8639
Epoch 66/100
249/249 [==============================] - 17s 70ms/step - loss: 6.5147 - val_loss: 7.4945
Epoch 67/100
249/249 [==============================] - 17s 69ms/step - loss: 6.4630 - val_loss: 7.8019
Epoch 68/100
249/249 [==============================] - 17s 69ms/step - loss: 6.3918 - val_loss: 7.6180
Epoch 69/100
249/249 [==============================] - 17s 69ms/step - loss: 6.4347 - val_loss: 7.9210
Epoch 70/100
249/249 [==============================] - 17s 69ms/step - loss: 6.3618 - val_loss: 7.7096
Epoch 71/100
249/249 [==============================] - 18s 70ms/step - loss: 6.3559 - val_loss: 7.6328
Epoch 72/100
249/249 [==============================] - 17s 70ms/step - loss: 6.2862 - val_loss: 7.7569
Epoch 73/100
249/249 [==============================] - 18s 72ms/step - loss: 6.2793 - val_loss: 7.6934
Epoch 74/100
249/249 [==============================] - 18s 72ms/step - loss: 6.2727 - val_loss: 7.8156
Epoch 75/100
249/249 [==============================] - 18s 73ms/step - loss: 6.2157 - val_loss: 7.6609
Epoch 76/100
249/249 [==============================] - 18s 73ms/step - loss: 6.1744 - val_loss: 7.8448
```

In [94]:
```python
model.save("/content/model1.h5",overwrite=True,include_optimizer=True)
```

In [95]:
```python
test_arr=x_final_test_arr
```

In [96]:
```python
test_arr=np.array(test_arr)
```

In [97]:
```python
test_arr.shape
```

Out[97]: (1000, 32, 128, 1)

In [98]:
```python
model2=Model(inputs=[input_layer],outputs=[output_layer])
model2.summary()
```

```
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 32, 128, 1)]      0

 conv2d (Conv2D)             (None, 32, 128, 32)       320

 max_pooling2d (MaxPooling2D  (None, 16, 64, 32)       0
 )

 group_normalization (GroupN  (None, 16, 64, 32)       64
 ormalization)

 conv2d_1 (Conv2D)           (None, 16, 64, 32)        9248

 max_pooling2d_1 (MaxPooling  (None, 8, 32, 32)        0
 2D)

 group_normalization_1 (Grou  (None, 8, 32, 32)        64
 pNormalization)

 reshape (Reshape)           (None, 32, 256)           0

 dense (Dense)               (None, 32, 32)            8224

 dropout (Dropout)           (None, 32, 32)            0

 bidirectional (Bidirectiona  (None, 32, 200)          106400
 l)

 group_normalization_2 (Grou  (None, 32, 200)          400
 pNormalization)

 dense_1 (Dense)             (None, 32, 85)            17085

=================================================================
Total params: 141,805
Trainable params: 141,805
Non-trainable params: 0
_________________________________________________________________
```

In [99]:
```python
test_arr.shape
```

Out[99]: (1000, 32, 128, 1)

In [101…
```python
model2.load_weights("/content/model1.h5")
```

In [104…
```python
prediction=model2.predict(x=test_arr,verbose=1)
```

```
32/32 [==============================] - 2s 17ms/step
```

In [105…
```python
prediction.shape
```

Out[105… (1000, 32, 85)

In [106…
```python
# use CTC decoder
decoded = k.ctc_decode(prediction,input_length=np.ones(prediction.shape[0]) * prediction.shape[1],greedy=True)[
output = k.get_value(decoded)
```

In [107…
```python
print(output.shape)
print(output[0])
```

```
(1000, 32)
[29 45 12 45 65 30 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1]
```

In [108…
```python
y_final_test.head(2)
```

Out[108…

	max_len	padded_tokens	text
0	4	29,30,26,37,99,99,99,99,99,99,99,99,99,99,99,9...	deal
1	1	65,99,99,99,99,99,99,99,99,99,99,99,99,99,99,9...	.

In [114…
```python
word_more=0
for i, word in enumerate(output[4:]):
    plt.imshow(test_arr[i+4,:,:,:].reshape(32,128), cmap=plt.cm.gray)
    plt.show()
    text= y_final_test.padded_tokens[i+4].split(",")
    print("original text =  '",end="")
    for letter in text:
        if (int(letter) != 99) :
            print(char_tokens[int(letter)], end = '')
    print("' ",end="")
    print("predicted text = '", end = '')
    for letter in word:
        if (int(letter) != 99) & (int(letter) != -1):
            print(char_tokens[int(letter)], end = '')
        else:
          break
    print("' ",end="")
    if word_more==5:
      break
    else:
      word_more+=1
```

original text = 'a' predicted text = 'arf.P'

original text = 'and' predicted text = 'pode'

original text = 'of' predicted text = 'of'

original text = 'the' predicted text = 'the.6o'

original text = 'party' predicted text = 'prtys'

original text = 'not' predicted text = 'notfe'

In [ ]: