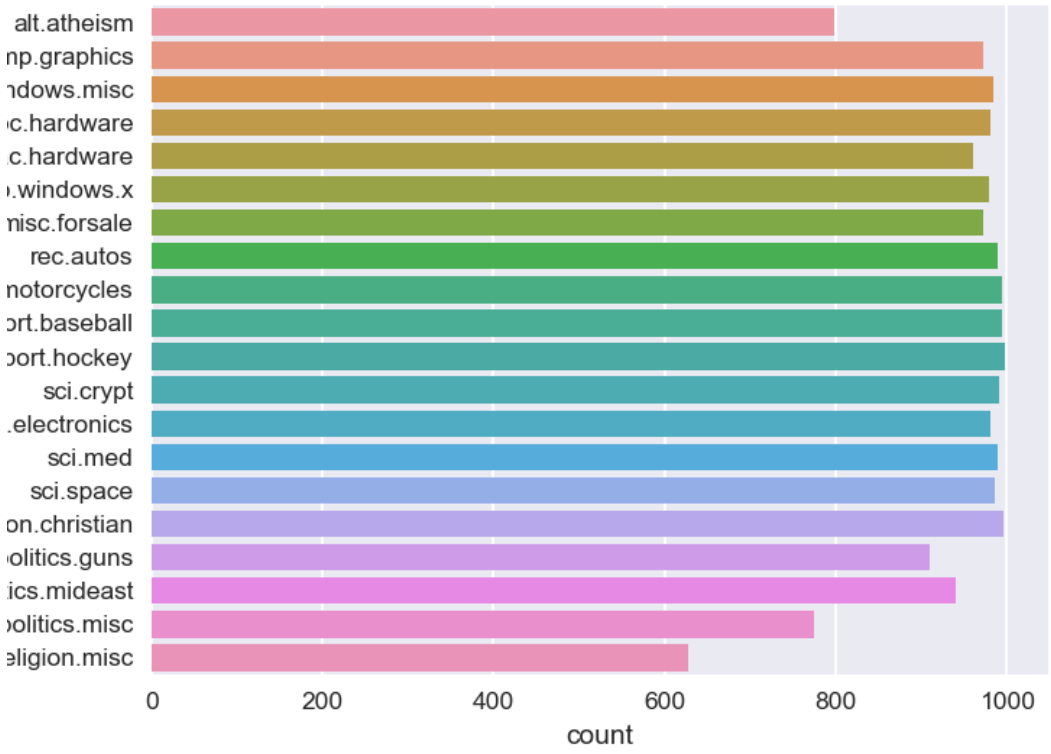
Text Classification:

Data

1. we have total of 20 types of documents(Text files) and total 18828 documents(text files).
2. You can download data from this link, in that you will get documents.rar folder.
If you unzip that, you will get total of 18828 documnets. document name is defined as'ClassLabel_DocumentNumberInThatLabel'.
so from document name, you can extract the label for that document.
4. Now our problem is to classify all the documents into any one of the class.
5. Below we provided count plot of all the labels in our data.

In [0]:
```
### count plot of all the class labels.
```



Assignment:

sample document

```
Subject: A word of advice
From: jcopelan@nyx.cs.du.edu (The One and Only)

In article < 65882@mimsy.umd.edu > mangoe@cs.umd.edu (Charley
Wingate) writes:
>
>I've said 100 times that there is no "alternative" that should
think you
>might have caught on by now.  And there is no "alternative", but
the point
>is, "rationality" isn't an alternative either.  The problems of
metaphysical
>and religious knowledge are unsolvable-- or I should say, humans
cannot
>solve them.

How does that saying go: Those who say it can't be done shouldn't
interrupt
those who are doing it.

Jim
--
Have you washed your brain today?
```

Preprocessing:

useful links: http://www.pyregex.com/

1. Find all emails in the document and then get the text after the "@". and then split those texts by '.'
after that remove the words whose length is less than or equal to 2 and also remove'com' word and then combine those words by space.
In one doc, if we have 2 or more mails, get all.
Eg:[test@dm1.d.com, test2@dm2.dm3.com]-->[dm1.d.com, dm3.dm4.com]-->[dm1,d,com,dm2,dm3,com]-->[dm1,dm2,dm3]-->"dm1 dm2 dm3"
append all those into one list/array. (This will give length of 18828 sentences i.e one list for each of the document).
Some sample output was shown below.

> In the above sample document there are emails [jcopelan@nyx.cs.du.edu, 65882@mimsy.umd.edu, mangoe@cs.umd.edu]

preprocessing:
[jcopelan@nyx.cs.du.edu, 65882@mimsy.umd.edu, mangoe@cs.umd.edu] ==> [nyx cs du edu mimsy umd edu cs umd edu] ==>
[nyx edu mimsy umd edu umd edu]

2. Replace all the emails by space in the original text.

In [0]:
```
# we have collected all emails and preprocessed them, this is sample output
```

```
preprocessed_email
```

Out[0]:
```
array(['juliet caltech edu',
       'coding bchs edu newsgate sps mot austlcm sps mot austlcm sps mot com  dna
bchs edu',
       'batman bmd trw', ..., 'rbdc wsnc org dscomsa desy zeus  desy',
       'rbdc wsnc org morrow stanford edu pangea Stanford EDU',
       'rbdc wsnc org apollo apollo'], dtype=object)
```

In [0]:
```
len(preprocessed_email)
```

Out[0]:
```
18828
```

3. Get subject of the text i.e. get the total lines where "Subject:" occur and remove
the word which are before the ":" remove the newlines, tabs, punctuations, any special chars.
Eg: if we have sentance like "Subject: Re: Gospel Dating @ \r\r\n" --> You have to get "Gospel Dating"
Save all this data into another list/array.

4. After you store it in the list, Replace those sentances in original text by space.

5. Delete all the sentances where sentence starts with **"Write to:"** or **"From:"**.
> In the above sample document check the 2nd line, we should remove that

6. Delete all the tags like "< anyword >"
> In the above sample document check the 4nd line, we should remove that "< 65882@mimsy.umd.edu >"

7. Delete all the data which are present in the brackets.
In many text data, we observed that, they maintained the explanation of sentence
or translation of sentence to another language in brackets so remove all those.
Eg: "AAIC-The course that gets you HIRED(AAIC - Der Kurs, der Sie anstellt)" --> "AAIC-The course that gets you HIRED"

> In the above sample document check the 4nd line, we should remove that "(Charley Wingate)"

8. Remove all the newlines('\n'), tabs('\t'), "-", "\".

9. Remove all the words which ends with ":".
Eg: "Anyword:"
> In the above sample document check the 4nd line, we should remove that "writes:"

10. Decontractions, replace words like below to full words.
please check the donors choose preprocessing for this
Eg: can't -> can not, 's -> is, i've -> i have, i'm -> i am, you're -> you are, i'll --> i will

There is no order to do point 6 to 10. but you have to get final output correctly

11. Do chunking on the text you have after above preprocessing.
Text chunking, also referred to as shallow parsing, is a task that follows Part-Of-Speech Tagging and that adds more structure to the sentence.
So it combines the some phrases, named entities into single word.
So after that combine all those phrases/named entities by separating "_".
And remove the phrases/named entities if that is a "Person".
You can use **nltk.ne_chunk** to get these.
Below we have given one example. please go through it.

useful links:
https://www.nltk.org/book/ch07.html
https://stackoverflow.com/a/31837224/4084039
http://www.nltk.org/howto/tree.html
https://stackoverflow.com/a/44294377/4084039

In [0]:
```
#i am living in the New York
print("i am living in the New York -->", list(chunks))
print(" ")
print("-"*50)
print(" ")
#My name is Srikanth Varma
print("My name is Srikanth Varma -->", list(chunks1))
```

```
i am living in the New York --> [('i', 'NN'), ('am', 'VBP'), ('living', 'VBG'),
('in', 'IN'), ('the', 'DT'), Tree('GPE', [('New', 'NNP'), ('York', 'NNP')])]

--------------------------------------------------

My name is Srikanth Varma --> [('My', 'PRP$'), ('name', 'NN'), ('is', 'VBZ'), Tree
('PERSON', [('Srikanth', 'NNP'), ('Varma', 'NNP')])]
```

We did chunking for above two lines and then We got one list where each word is mapped to a
POS(parts of speech) and also if you see "New York" and "Srikanth Varma",
they got combined and represented as a tree and "New York" was referred as "GPE" and "Srikanth Varma" was referred as "PERSON".
so now you have to Combine the "New York" with "_" i.e "New_York" and remove the "Srikanth Varma" from the above sentence because it is a person.

13. Replace all the digits with space i.e delete all the digits.
> In the above sample document, the 6th line have digit 100, so we have to remove that.

14. After doing above points, we observed there might be few word's like
"_word_" (i.e starting and ending with the _), "_word" (i.e starting with the _),
"word_" (i.e ending with the _) remove the _ from these type of words.

15. We also observed some words like **"OneLetter_word"- eg: d_berlin,**
"TwoLetters_word" - eg: dr_berlin , in these words we remove the "OneLetter_" (d_berlin ==> berlin) and
"TwoLetters_" (de_berlin ==> berlin). i.e remove the words which are length less than or equal to 2 after spliiting those words by "_".

16. Convert all the words into lower case and lowe case
and remove the words which are greater than or equal to 15 or less than or equal to 2.

17. replace all the words except "A-Za-z_" with space.

18. Now You got Preprocessed Text, email, subject. create a dataframe with those.
Below are the columns of the df.

In [0]:
```
data.columns
```

```
Index(['text', 'class', 'preprocessed_text', 'preprocessed_subject',
       'preprocessed_emails'],
      dtype='object')
```

In [0]:
```
data.iloc[400]
```

```
text                   From: arc1@ukc.ac.uk (Tony Curtis)\r\r\r\nSubj...
class                                                        alt.atheism
preprocessed_text      said re is article if followed the quoting rig...
preprocessed_subject                                christian morality is
preprocessed_emails                                   ukc mac macalstr edu
Name: 567, dtype: object
```

To get above mentioned data frame --> Try to Write Total Preprocessing steps in One Function Named Preprocess as below.

In [1]:
```
import tensorflow as tf
import numpy as np
import pandas as pd
import re
import nltk
```

```
import os
from tqdm import tqdm
from sklearn.model_selection import train_test_split
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.layers import Dense,Input,Activation, Dropout, Embedding, Con
from tensorflow.keras.models import Model
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping
from tensorflow.keras.utils import plot_model
import datetime
```

In [2]:
```
path = "documents/"
```

In [3]:
```
#https://www.geeksforgeeks.org/extracting-email-addresses-using-regular-expressions
def preprocess(Input_Text):
    """Do all the Preprocessing as shown above and
    return a tuple contain preprocess_email,preprocess_subject,preprocess_text for
    #Email
    preprocessed_email = []
    e_mail_list = re.findall(r'\S+@\S+', Input_Text)
    for e_mail in e_mail_list:
        e_mail_second_part = e_mail.split('@')[1]
        e_mail_remove_dot = e_mail_second_part.split('.')
        for i in e_mail_remove_dot:
            if len(i)<=2:
                e_mail_remove_dot.remove(i)
        if 'com' in e_mail_remove_dot:
            e_mail_remove_dot.remove(r'com')
        if 'com>' in e_mail_remove_dot:
            e_mail_remove_dot.remove(r'com>')   #sometimes .com ends with the chara
        e_mail_final = '_'.join(e_mail_remove_dot)
        e_mail_final = re.sub(r'>', '',e_mail_final)   #sometimes email address end
        preprocessed_email.append(e_mail_final)
    Input_Text = re.sub(r'\S+@\S+', ' ' , Input_Text)

    #Subject
    subject_list = re.findall(r'Subject:.*', Input_Text)   #Subject ends with a new

    subject_list = str(subject_list).split(':')[-1]
    subject_list = re.sub(r'\\.?', ' ', subject_list)
    preprocessed_subject = re.sub(r'[^A-Za-z0-9]',' ', subject_list)
    preprocessed_subject = re.sub(r' +',' ',preprocessed_subject)   # Removing extr
    preprocessed_subject = preprocessed_subject.lower()

    Input_Text = re.sub(r'Subject:.*', ' ', Input_Text)

    #Removing certain parts of text

    Input_Text = re.sub(r'From:.*', ' ', Input_Text)        # Removing the sentence

    Input_Text = re.sub(r'Write to:.*', ' ', Input_Text)     # Removing the sentenc


    Input_Text = re.sub(r'<.*?>', ' ', Input_Text)
```

```
Input_Text = re.sub(r'\(.*?\)', ' ', Input_Text)


Input_Text = re.sub(r'\s.*?:', ' ', Input_Text)

#Decontraction code taken from Donor Choose dataset code
Input_Text = re.sub(r"won't", "will not", Input_Text)
Input_Text = re.sub(r"can\'t", "can not", Input_Text)
Input_Text = re.sub(r"n\'t", " not", Input_Text)
Input_Text = re.sub(r"\'re", " are", Input_Text)
Input_Text = re.sub(r"\'s", " is", Input_Text)
Input_Text = re.sub(r"\'d", " would", Input_Text)
Input_Text = re.sub(r"\'ll", " will", Input_Text)
Input_Text = re.sub(r"\'t", " not", Input_Text)
Input_Text = re.sub(r"\'ve", " have", Input_Text)
Input_Text = re.sub(r"\'m", " am", Input_Text)

Input_Text = re.sub(r'[\n\t\-\\]',' ',Input_Text)

#Chunking
#Code is taken from https://classroom.appliedroots.com/v2/faqs/amO3NN9p/
words = nltk.word_tokenize(Input_Text)

tagged = nltk.pos_tag(words)
chunks = list(nltk.ne_chunk(tagged))

person = []

for chunk in chunks:
    if hasattr(chunk, 'label'):
        if chunk.label() == 'PERSON':
            if type(chunk) is nltk.Tree:
                t = ' '.join(c[0] for c in chunk.leaves())
                person.append(t)
        if chunk.label() == 'GPE':
            if type(chunk) is nltk.Tree:
                p = ' '.join(c[0] for c in chunk.leaves())
                changed = '_'.join(c[0] for c in chunk.leaves())
                Input_Text = Input_Text.replace(p,changed)

person = sorted(person, key = len, reverse = True)
for i in range(len(person)):
    Input_Text = Input_Text.replace(person[i],' ')    # Removing the larger nam
                                                      # mentioned twice as full
                                                      # time as just last_name,
                                                      # last_name will be delet
                                                      # first_name and if this
                                                      # will not be deleted

#Removing digits
Input_Text = re.sub(r'\d',' ', Input_Text)

#Removing words like _word, word_, _word_
Input_Text = re.sub(r'\s_[A-Za-z]+\s', ' ', Input_Text)
Input_Text = re.sub(r'\s_[A-Za-z]+_\s', ' ', Input_Text)
```

```
    Input_Text = re.sub(r'\s[A-Za-z]+_\s', ' ', Input_Text)

    #Removing words like d_berline and de_berlin
    oneletter_word = re.findall(r'\b[A-Za-z]_[A-Za-z]+', Input_Text)            # \
    twoletter_word = re.findall(r'\b[A-Za-z][A-Za-z]_[A-Za-z]+', Input_Text)
    for i in oneletter_word:
        Input_Text = re.sub(i,i.split('_')[1], Input_Text)
    for i in twoletter_word:
        Input_Text = re.sub(i,i.split('_')[1], Input_Text)

    Input_Text= Input_Text.lower()

    #https://stackoverflow.com/questions/24332025/remove-words-of-length-less-than-
    Input_Text = re.sub(r'\b\w{1,2}\b', '', Input_Text)
    Input_Text = re.sub(r'\b\w{15,}\b', '', Input_Text)
    preprocessed_text = re.sub(r'[^A-Za-z_\s]','', Input_Text)

    #Remove extra spaces
    preprocessed_text = re.sub(r' +',' ',preprocessed_text)

    return (preprocessed_email,preprocessed_subject,preprocessed_text)
```

In [4]:

```
with open(path+'alt.atheism_49960.txt',encoding = 'ISO-8859-1') as f:
    text = f.read()
    print(preprocess(text))
```

(['mantis_uk', 'netcom', 'mantis_uk'], ' atheist resources ', ' atheismresources r
esources december atheist resources addresses atheist organizations usa freedom fr
om religion foundation fish bumper stickers and assorted other atheist paraphernal
ia are available from the freedom from religion foundation the evolution designs e
volution designs sell the fish fish symbol like the ones stick their cars but with
feet and the word written inside the deluxe moulded plastic fish postpaid the peop
le the san francisco bay area can get from try mailing for net people who directly
the price per fish american atheist press aap publish various atheist books critiq
ues the bible lists the bible handbook and american atheist press isbn edition bib
le contradictions the bible contradicts itself aap based the king version the bibl
e austin prometheus books sell books including holy horrors prometheus books afric
an americans for humanism organization promoting black secular humanism and uncove
ring the history black freethought they publish quarterly newsletter aah examiner
united kingdom rationalist press association national secular society street hollo
way road london london british humanist association south place ethical society la
mb conduit passage conway hall london red lion square london fax the national secu
lar society publish the freethinker monthly magazine founded germany ibka bund der
und berlin germany miz materialien und zur zeit politisches journal der und ibka m
iz vertrieb postfach berlin germany ibdk ucherdienst der hannover germany books fi
ction thomas disch the claus compromise short story the ultimate proof that exists
all characters and events are fictitious any similarity living dead gods well walt
er miller canticle for leibowitz one gem this post atomic doomsday novel the monks
who spent their lives copying blueprints from saint leibowitz filling the sheets p
aper with ink and leaving white lines and letters edgar pangborn davy post atomic
doomsday novel set clerical states the church for example forbids that anyone prod
uce describe use any substance containing atoms philip dick wrote many philosophic
al and thought provoking short stories and novels his stories are bizarre times bu
t very approachable wrote mainly but wrote about people truth and religion rather
than technology although often believed that had met some sort fallible alien deit
y summons group craftsmen and women remote planet raise giant cathedral from benea
th the oceans when the deity begins demand faith from the earthers pot healer unab
le comply polished ironic and amusing novel maze death noteworthy for its descript
ion technology based religion valis the schizophrenic hero searches for the hidden
mysteries gnostic ity after reality fired into his brain pink laser beam unknown b
ut possibly divine origin accompanied his dogmatic and dismissively atheist friend
and assorted other odd characters the divine invasion invades making young woman p
regnant she returns from another star system unfortunately she terminally ill and
must assisted dead man whose brain wired hour easy listening music margaret atwood
the handmaid story based the premise that the congress mysteriously assassinated a
nd quickly take charge the nation set right again the book the diary woman life sh
e tries live under the new theocracy women right own property revoked and their ba
nk accounts are closed sinful luxuries are outlawed and the radio only used for re
adings from the bible crimes are punished doctors who performed legal abortions th
e old world are hunted down and hanged writing style difficult get used first but
the tale grows more and more chilling goes various authors the bible this somewhat
dull and rambling work has often been criticized however probably worth reading on
ly that you will know what all the fuss about exists many different versions make
sure you get the one true version books non fiction peter rosa vicars christ altho
ugh seems even catholic this very enlighting history papal immoralities adulteries
fallacies etc gottes erste dunkle seite des michael martin philosophical justifica
tion philadelphia usa detailed and scholarly justification atheism contains outsta
nding appendix defining terminology and usage this tendentious area argues both fo
r negative atheism the non belief the existence god and also for positive atheism
the belief the non existence god includes great refutations the most challenging a
rguments for god particular attention paid refuting contempory theists such and sw
inburne pages isbn the case against ity comprehensive critique ity which considers

```
the best contemporary defences ity and demonstrates that they are unsupportable an
d incoherent pages isbn james turner the johns hopkins university press baltimore
usa subtitled the origins unbelief america examines the way which unbelief became
mainstream alternative world view focusses the period and while considering france
and britain the emphasis american and particularly new_england developments neithe
r religious history secularization atheism rather the intellectual history the fat
e single idea the belief that exists pages isbn george seldes the great thoughts n
ew_york usa dictionary quotations different kind concentrating statements and writ
ings which explicitly implicitly present the person philosophy and world view incl
udes obscure opinions from many people for some popular observations traces the wa
y which various people expressed and twisted the idea over the centuries quite num
ber the quotations are derived from cardiff what religion and views religion pages
isbn richard swinburne the existence oxford this book the second volume trilogy th
at began with the coherence theism and was concluded with and this work swinburne
attempts construct series inductive arguments for the existence his arguments whic
h are somewhat tendentious and rely upon the imputation late century western value
s and aesthetics which supposedly simple can conceived were decisively rejected th
e miracle theism the revised edition the existence swinburne includes appendix whi
ch makes somewhat incoherent attempt rebut mackie the miracle theism oxford this v
olume contains comprehensive review the principal arguments for and against the ex
istence ranges from the classical philosophical positions descartes anselm through
the moral arguments newman kant and the recent restatements the classical theses a
nd swinburne also addresses those positions which push the concept beyond the real
m the rational such those kierkegaard and well replacements for such axiarchism th
e book delight read less formalistic and better written than works and refreshingl
y direct when compared with the hand waving swinburne haught illustrated history r
eligious murder and madness prometheus books looks religious persecution from anci
ent times the present day and not only library congress catalog card number norm a
llen anthology see the listing for african americans for humanism above gordon ste
in anthology atheism and rationalism prometheus books anthology covering wide rang
e subjects including the devil and morality and the history freethought comprehens
ive bibliography edmund cohen the mind the bible believer prometheus books study w
hy people become and what effect has them net resources there small mail based arc
hive server mantis which carries archives old altatheismmoderated articles and ass
orted other files for more information send mail saying help send atheismindex and
will mail back reply mathew ')
```

Code checking:

After Writing preprocess function. call that functoin with the input text of 'alt.atheism_49960' doc and print the output of the preprocess function

This will help us to evaluate faster, based on the output we can suggest you if there are any changes.

In [5]:
```
if not os.path.isfile('preprocessed_data.csv'):
    preprocessed_email_list = []
    preprocessed_subject_list = []
    preprocessed_text_list = []
    text_list = []
    class_label = []
    doc_num=[]
```

```
    for file in tqdm(os.listdir(path)):
        label, _ = file.split('_')
        class_label.append(label)
        with open(path+file,encoding = 'ISO-8859-1') as f:
            text = f.read()
            text_list.append(text)
            email , subject , pre_text = preprocess(text)
            preprocessed_email_list.append(email)
            preprocessed_subject_list.append(subject)
            preprocessed_text_list.append(pre_text)

    #https://stackoverflow.com/questions/30522724/take-multiple-lists-into-datafram

    data = pd.DataFrame({'text':text_list,'class':class_label,'processed_email': pr
                         'processed_subject': preprocessed_subject_list, 'processed
    data.to_csv('preprocessed_data.csv', index = False)
else:
    print('preprocessed_data.csv already exists')
```

```
preprocessed_data.csv already exists
```

In [6]:
```
data = pd.read_csv('preprocessed_data.csv')
```

In [7]:
```
data.head()
```

Out[7]:

	text	class	processed_email	processed_subject	processe
0	From: mathew <mathew@mantis.co.uk>\nSubject: A...	alt.atheism	['mantis_uk', 'netcom', 'mantis_uk']	atheist resources	atheismres resources dec ath
1	From: mathew <mathew@mantis.co.uk>\nSubject: A...	alt.atheism	['mantis_uk', 'mantis_uk', 'mantis_uk']	introduction to atheism	atheismintroc introductic e
2	From: I3150101@dbstu1.rz.tu-bs.de (Benedikt Ro...	alt.atheism	['dbstu1_tu-bs', 'mimsy_umd_edu', 'umd_edu']	gospel dating	article v quite differ nec
3	From: mathew <mathew@mantis.co.uk>\nSubject: R...	alt.atheism	['mantis_uk', 'kepler_unh_edu']	university violating separation of church state	recently ra been order none
4	From: strom@Watson.Ibm.Com (Rob Strom)\nSubjec...	alt.atheism	['Watson_Ibm_Com', 'harder_ccr-p_ida_org,', 'h...	soc motss et al princeton axes matching funds...	howev economic te and pc

In [8]:
```
data.shape
```

Out[8]:
```
(18828, 5)
```

In [9]:
```
data.columns
```

Out[9]:
```
Index(['text', 'class', 'processed_email', 'processed_subject',
       'processed_text'],
      dtype='object')
```

After writing Preprocess function, call the function for each of the document(18828 docs) and then create a dataframe as mentioned above.

Training The models to Classify:

1. Combine "preprocessed_text", "preprocessed_subject", "preprocessed_emails" into one column. use that column to model.

2. Now Split the data into Train and test. use 25% for test also do a stratify split.

3. Analyze your text data and pad the sequnce if required.
Sequnce length is not restricted, you can use anything of your choice.
you need to give the reasoning

4. Do Tokenizer i.e convert text into numbers. please be careful while doing it.
if you are using tf.keras "Tokenizer" API, it removes the "_", but we need that.

5. code the model's (Model-1, Model-2) as discussed below
and try to optimize that models.

6. For every model use predefined Glove vectors.
Don't train any word vectors while Training the model.

7. Use "categorical_crossentropy" as Loss.

8. Use **Accuracy and Micro Avgeraged F1 score** as your as Key metrics to evaluate your model.

9. Use Tensorboard to plot the loss and Metrics based on the epoches.

10. Please save your best model weights in to **'best_model_L.h5' (L = 1 or 2)**.

11. You are free to choose any Activation function, learning rate, optimizer.
But have to use the same architecture which we are giving below.

12. You can add some layer to our architecture but you **deletion** of layer is not acceptable.

13. Try to use **Early Stopping** technique or any of the callback techniques that you did in the previous assignments.

14. For Every model save your model to image (Plot the model) with shapes
and inlcude those images in the notebook markdown cell,

upload those imgages to Classroom. You can use "plot_model" please refer this if you don't know how to plot the model with shapes.

In [10]:
```
data['final_text'] = data['processed_email'].astype(str) +" "+ data['processed_subj
                     + " "+ data['processed_text'].astype(str)
```

In [11]:
```
data.head()
```

Out[11]:

	text	class	processed_email	processed_subject	processe
0	From: mathew <mathew@mantis.co.uk>\nSubject: A...	alt.atheism	['mantis_uk', 'netcom', 'mantis_uk']	atheist resources	atheismres resources dec ath
1	From: mathew <mathew@mantis.co.uk>\nSubject: A...	alt.atheism	['mantis_uk', 'mantis_uk', 'mantis_uk']	introduction to atheism	atheismintroc introductic e
2	From: I3150101@dbstu1.rz.tu-bs.de (Benedikt Ro...	alt.atheism	['dbstu1_tu-bs', 'mimsy_umd_edu', 'umd_edu']	gospel dating	article v quite differ nec
3	From: mathew <mathew@mantis.co.uk>\nSubject: R...	alt.atheism	['mantis_uk', 'kepler_unh_edu']	university violating separation of church state	recently ra been order none
4	From: strom@Watson.Ibm.Com (Rob Strom)\nSubjec...	alt.atheism	['Watson_Ibm_Com', 'harder_ccr-p_ida_org,', 'h...	soc motss et al princeton axes matching funds...	howev economic te and pc

In [12]:
```
X = data['final_text']
y = data['class']
```

In [13]:
```
x_train, x_test, y_train, y_test = train_test_split(X , y, test_size = 0.25 , strat
```

In [14]:
```
#https://machinelearningknowledge.ai/keras-tokenizer-tutorial-with-examples-for-fit
tokenizer = Tokenizer(filters='!"#$%&()*+,-./:;<=>?@[\\]^`{|}~\t\n')  # Removed '_'
tokenizer.fit_on_texts(x_train)
train_sequences = tokenizer.texts_to_sequences(x_train)
test_sequences = tokenizer.texts_to_sequences(x_test)
```

In [15]:
```
length = []
for i in train_sequences:
    length.append(len(i))
print('95 percent of data has sequence length lesser than',np.percentile(length,95))
```

```
95 percent of data has sequence length lesser than 503.0
```

So we can pad the data with max length 502

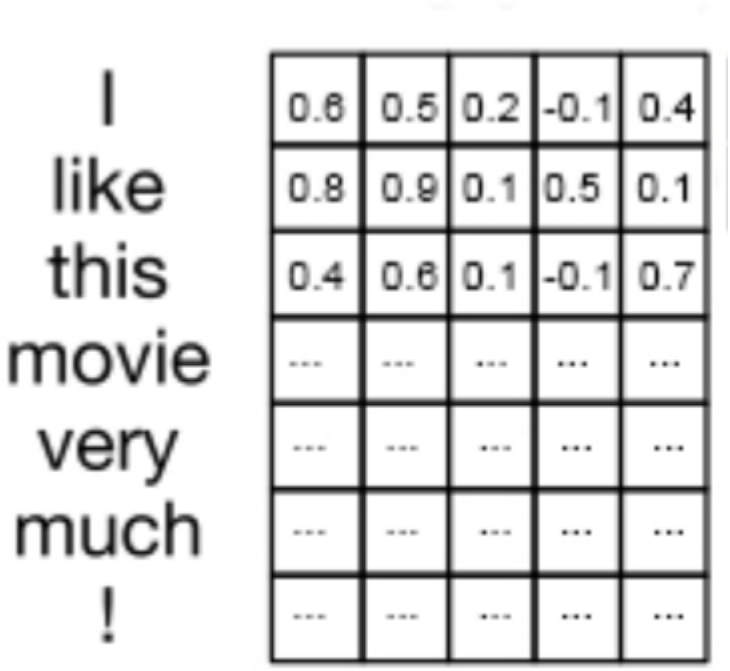
In [16]:
```
#https://medium.com/@canerkilinc/padding-for-nlp-7dd8598c916a
padded_train_sequences=pad_sequences(train_sequences,padding="post",truncating="pos
padded_test_sequences=pad_sequences(test_sequences,padding="post",truncating="post"
```

In [17]:
```
num_class_labels = LabelEncoder()      # to_categorical method needs the input to b
num_class_labels.fit(y_train)          # LabelEncoder to convert our classes into n
y_train = num_class_labels.transform(y_train)
y_test = num_class_labels.transform(y_test)

Y_train = tf.keras.utils.to_categorical(y_train, num_classes=20)
Y_test = tf.keras.utils.to_categorical(y_test, num_classes=20)
```

In [18]:
```
vocab = tokenizer.word_index
#https://datascience.stackexchange.com/questions/93651/reason-for-adding-1-to-word-
vocab_size = len(vocab)+1 # word_index starts with index 1. Last word in word_index
                          # Normally index always starts at zero. So, to access the
                          # we need to specify vocab_size = len(vocab) + 1
```

Model-1: Using 1D convolutions with word embeddings

Encoding of the Text --> For a given text data create a Matrix with Embedding layer as shown Below.
In the example we have considered d = 5, but in this assignment we will get d = dimension of Word vectors we are using.
i.e if we have maximum of 350 words in a sentence and embedding of 300 dim word vector,
we result in 350*300 dimensional matrix for each sentance as output after embedding layer



Ref: https://i.imgur.com/kiVQuk1.png

Reference:
https://stackoverflow.com/a/43399308/4084039
https://missinglink.ai/guides/keras/keras-conv1d-working-1d-

convolutional-neural-networks-keras/

How EMBEDDING LAYER WORKS

Go through this blog, if you have any doubt on using predefined Embedding values in Embedding layer - https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/

In [19]:
```
#https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/

embeddings_index = dict()
f = open('glove.6B.300d.txt', encoding ='utf-8')
for line in f:
    values = line.split()
    word = values[0]
    coefs = np.asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
f.close()
print('Loaded %s word vectors.' % len(embeddings_index))
```

```
Loaded 400000 word vectors.
```

In [20]:
```
embedding_matrix = np.zeros((vocab_size, 300))  # We used 300d glove word embedding
for word, i in vocab.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector
```

ref: 'https://i.imgur.com/fv1GvFJ.png'

```
1. all are Conv1D layers with any number of filter and filter
sizes, there is no restriction on this.

2. use concatenate layer is to concatenate all the
filters/channels.

3. You can use any pool size and stride for maxpooling layer.

4. Don't use more than 16 filters in one Conv layer becuase it will
```

increase the no of params.
(Only recommendation if you have less computing power)

5. You can use any number of layers after the Flatten Layer.

In [30]:
```
input_layer = Input(shape=(len(padded_train_sequences[0]),))
embedding_layer = Embedding(input_dim = vocab_size, output_dim = 300, weights = [em
                            input_length=len(padded_train_sequences[0]), trainable=


conv1 = Conv1D(16, 3, activation = 'relu', kernel_initializer='HeUniform') (embeddi
conv2 = Conv1D(16, 4, activation = 'relu', kernel_initializer='HeUniform') (embeddi
conv3 = Conv1D(16, 5, activation = 'relu', kernel_initializer='HeUniform') (embeddi

concatenate1 = Concatenate(axis=1)([conv1,conv2,conv3])

maxpool1 = MaxPool1D(2) (concatenate1)

conv4 = Conv1D(16, 6, activation = 'relu', kernel_initializer='HeUniform') (maxpool
conv5 = Conv1D(16, 7, activation = 'relu', kernel_initializer='HeUniform') (maxpool
conv6 = Conv1D(16, 8, activation = 'relu', kernel_initializer='HeUniform') (maxpool

concatenate2 = Concatenate(axis=1)([conv4,conv5,conv6])

maxpool2 = MaxPool1D(2) (concatenate2)

conv7 = Conv1D(16, 3, activation = 'relu', kernel_initializer='HeUniform') (maxpool

flatten = Flatten() (conv7)

dropout = Dropout(0.5) (flatten)

dense1 = Dense(128,activation='relu', kernel_initializer='HeUniform')(dropout)
dense2 = Dense(256,activation='relu', kernel_initializer='HeUniform')(dense1)

output = Dense(20,activation='softmax')(dense2)

model_one = Model(inputs=input_layer,outputs=output)
model_one.summary()
```

```
Model: "model"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            [(None, 502)]        0
__________________________________________________________________________________________________
embedding (Embedding)           (None, 502, 300)     27780300    input_1[0][0]
__________________________________________________________________________________________________
conv1d (Conv1D)                 (None, 500, 16)      14416       embedding[0][0]
__________________________________________________________________________________________________
conv1d_1 (Conv1D)               (None, 499, 16)      19216       embedding[0][0]
__________________________________________________________________________________________________
conv1d_2 (Conv1D)               (None, 498, 16)      24016       embedding[0][0]
__________________________________________________________________________________________________
concatenate (Concatenate)       (None, 1497, 16)     0           conv1d[0][0]
                                                                 conv1d_1[0][0]
                                                                 conv1d_2[0][0]
__________________________________________________________________________________________________
max_pooling1d (MaxPooling1D)    (None, 748, 16)      0           concatenate[0][0]
__________________________________________________________________________________________________
conv1d_3 (Conv1D)               (None, 743, 16)      1552        max_pooling1d[0]
[0]
__________________________________________________________________________________________________
conv1d_4 (Conv1D)               (None, 742, 16)      1808        max_pooling1d[0]
[0]
__________________________________________________________________________________________________
conv1d_5 (Conv1D)               (None, 741, 16)      2064        max_pooling1d[0]
[0]
__________________________________________________________________________________________________
concatenate_1 (Concatenate)     (None, 2226, 16)     0           conv1d_3[0][0]
                                                                 conv1d_4[0][0]
                                                                 conv1d_5[0][0]
```

```
__________________________________________________________________________________________________
max_pooling1d_1 (MaxPooling1D)  (None, 1113, 16)     0           concatenate_1[0][0]
__________________________________________________________________________________________________
conv1d_6 (Conv1D)               (None, 1111, 16)     784         max_pooling1d_1[0][0]
__________________________________________________________________________________________________
flatten (Flatten)               (None, 17776)        0           conv1d_6[0][0]
__________________________________________________________________________________________________
dropout (Dropout)               (None, 17776)        0           flatten[0][0]
__________________________________________________________________________________________________
dense (Dense)                   (None, 128)          2275456     dropout[0][0]
__________________________________________________________________________________________________
dense_1 (Dense)                 (None, 256)          33024       dense[0][0]
__________________________________________________________________________________________________
dense_2 (Dense)                 (None, 20)           5140        dense_1[0][0]
==================================================================================================
Total params: 30,157,776
Trainable params: 2,377,476
Non-trainable params: 27,780,300
__________________________________________________________________________________________________
```

In [31]:
```
%load_ext tensorboard
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```

In [32]:
```
filepath="model_save/best_model_one.hdf5"
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1,

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0.01, patience=2, verbo

tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir= ("logs/fits/"+dateti
                       ,histogram_freq=1,write_graph=True)

call_back_list = [ earlystop, checkpoint, tensorboard_callback]
```

In [33]:
```
model_one.compile(optimizer='adam', loss='categorical_crossentropy',metrics=['accur

model_one.fit(padded_train_sequences,Y_train,epochs=25, validation_data=(padded_tes
```

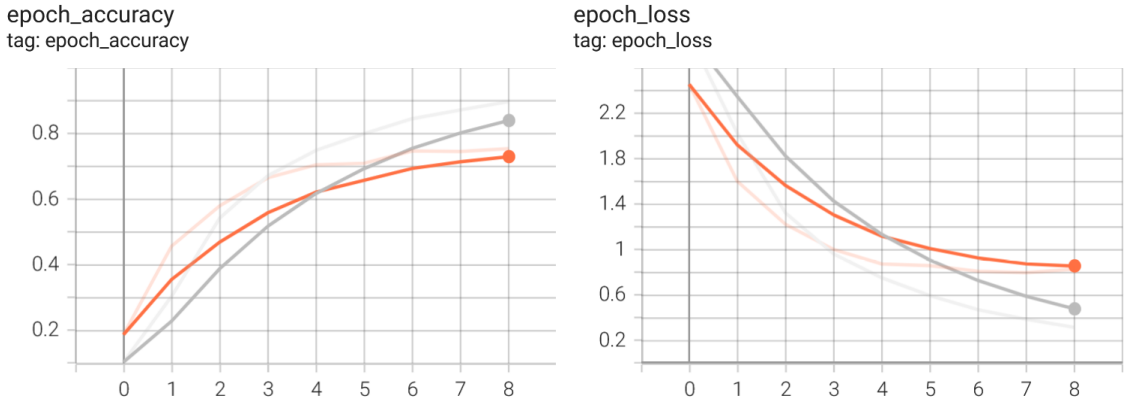
```
Epoch 1/25
28/28 [==============================] - 7s 220ms/step - loss: 2.8887 - accuracy:
0.1045 - val_loss: 2.4559 - val_accuracy: 0.1882

Epoch 00001: val_accuracy improved from -inf to 0.18823, saving model to model_sav
e\best_model_one.hdf5
Epoch 2/25
28/28 [==============================] - 5s 167ms/step - loss: 2.0236 - accuracy:
0.3047 - val_loss: 1.6005 - val_accuracy: 0.4572

Epoch 00002: val_accuracy improved from 0.18823 to 0.45719, saving model to model_
save\best_model_one.hdf5
Epoch 3/25
28/28 [==============================] - 5s 166ms/step - loss: 1.3221 - accuracy:
0.5427 - val_loss: 1.2220 - val_accuracy: 0.5798

Epoch 00003: val_accuracy improved from 0.45719 to 0.57977, saving model to model_
save\best_model_one.hdf5
Epoch 4/25
28/28 [==============================] - 5s 166ms/step - loss: 0.9597 - accuracy:
0.6714 - val_loss: 0.9995 - val_accuracy: 0.6652

Epoch 00004: val_accuracy improved from 0.57977 to 0.66518, saving model to model_
save\best_model_one.hdf5
Epoch 5/25
28/28 [==============================] - 5s 166ms/step - loss: 0.7498 - accuracy:
0.7485 - val_loss: 0.8722 - val_accuracy: 0.7045

Epoch 00005: val_accuracy improved from 0.66518 to 0.70448, saving model to model_
save\best_model_one.hdf5
Epoch 6/25
28/28 [==============================] - 5s 167ms/step - loss: 0.5936 - accuracy:
0.7992 - val_loss: 0.8576 - val_accuracy: 0.7092

Epoch 00006: val_accuracy improved from 0.70448 to 0.70916, saving model to model_
save\best_model_one.hdf5
Epoch 7/25
28/28 [==============================] - 5s 167ms/step - loss: 0.4690 - accuracy:
0.8448 - val_loss: 0.8082 - val_accuracy: 0.7465

Epoch 00007: val_accuracy improved from 0.70916 to 0.74655, saving model to model_
save\best_model_one.hdf5
Epoch 8/25
28/28 [==============================] - 5s 166ms/step - loss: 0.3851 - accuracy:
0.8715 - val_loss: 0.7958 - val_accuracy: 0.7448

Epoch 00008: val_accuracy did not improve from 0.74655
Epoch 9/25
28/28 [==============================] - 5s 168ms/step - loss: 0.3133 - accuracy:
0.8967 - val_loss: 0.8258 - val_accuracy: 0.7538

Epoch 00009: val_accuracy improved from 0.74655 to 0.75377, saving model to model_
save\best_model_one.hdf5
Epoch 00009: early stopping
```

Out[33]: <keras.callbacks.History at 0x1bf9b0265e0>

Our final validation accuracy is 75.37% after 9 epochs

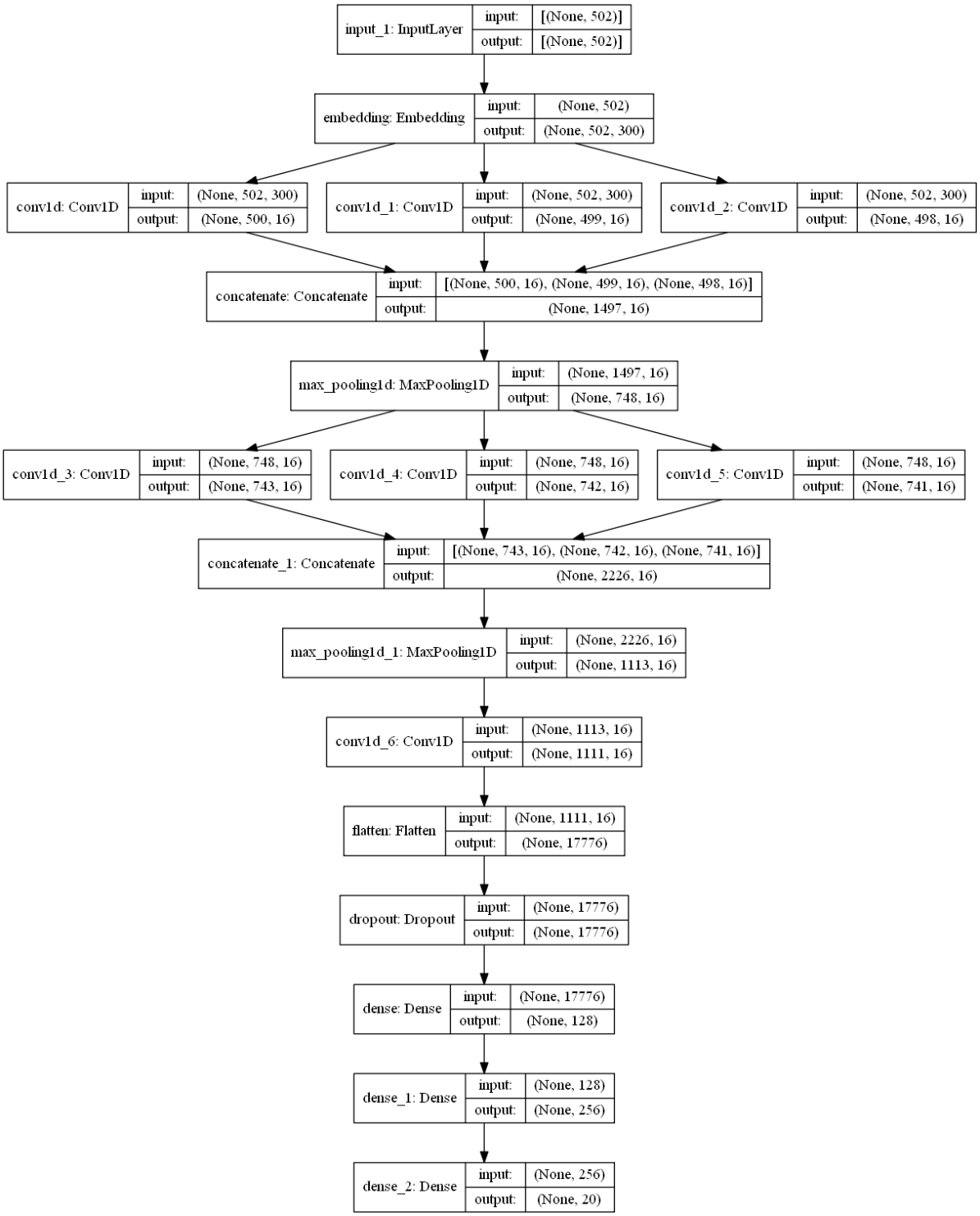
In [34]:
```
%tensorboard --logdir logs/fits
```

Model one Accuracy and loss in Tensorboard

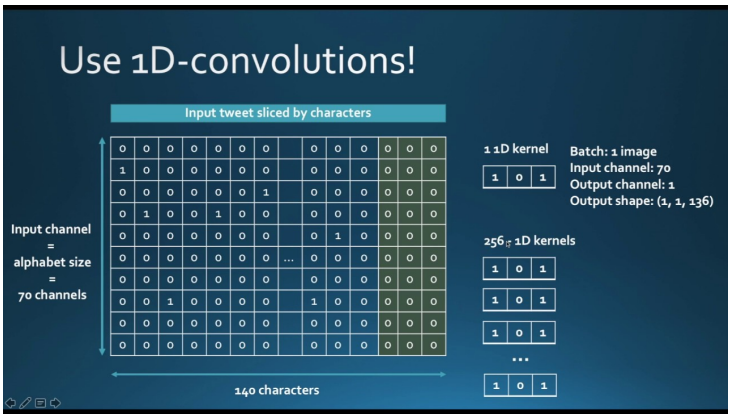


In [35]:
```
plot_model(model_one, to_file='model_one.png', show_shapes=True)
```

Out[35]:

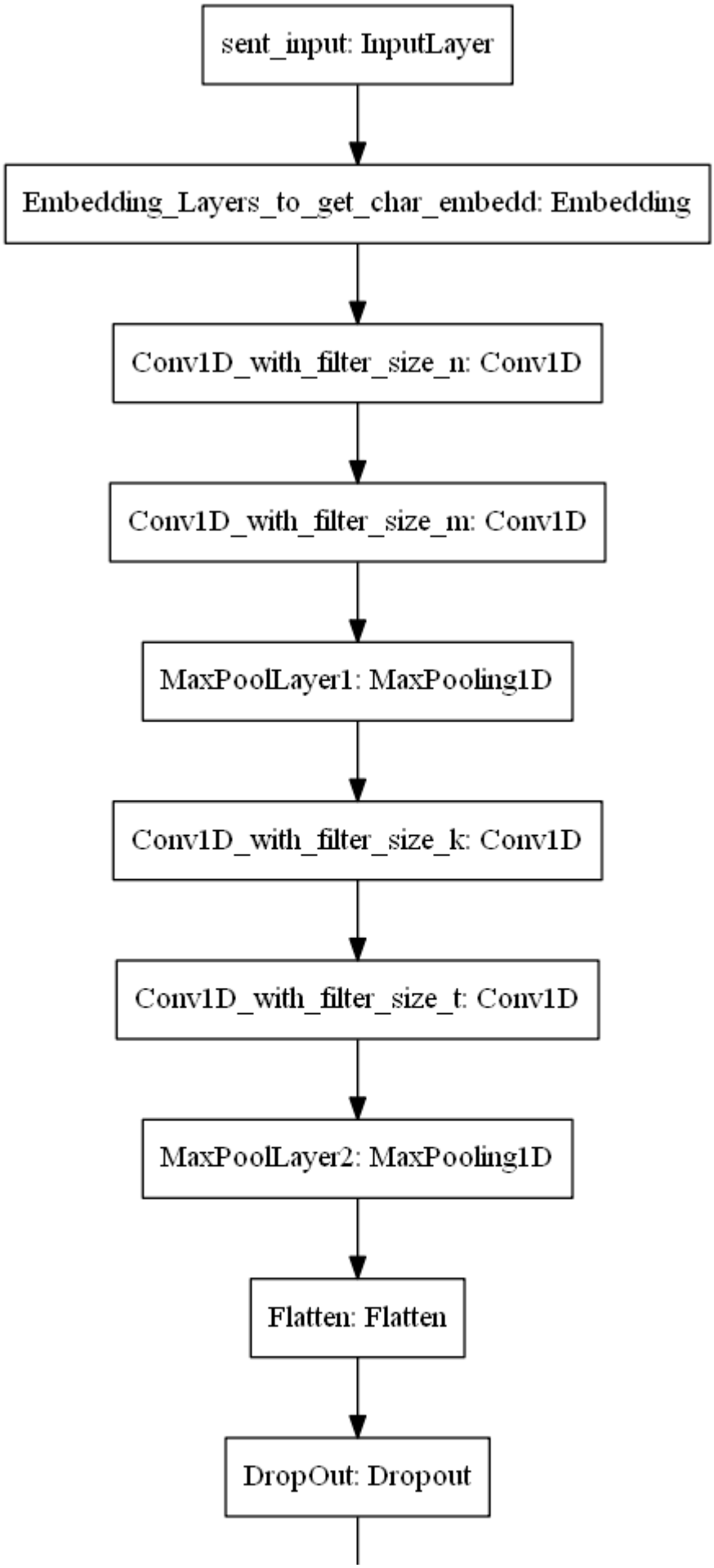


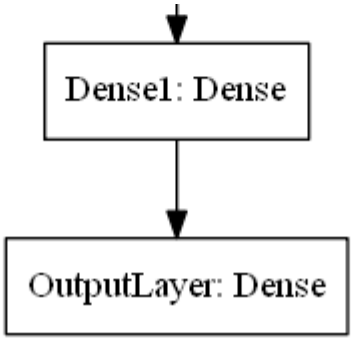
Model-2 : Using 1D convolutions with character embedding



Here are the some papers based on Char-CNN

1. Xiang Zhang, Junbo Zhao, Yann LeCun. Character-level Convolutional Networks for Text Classification.NIPS 2015
2. Yoon Kim, Yacine Jernite, David Sontag, Alexander M. Rush. Character-Aware Neural Language Models. AAAI 2016
3. Shaojie Bai, J. Zico Kolter, Vladlen Koltun. An Empirical Evaluation of Generic Convolutional and Recurrent Networks for Sequence Modeling
4. Use the pratrained char embeddings https://github.com/minimaxir/char-embeddings/blob/master/glove.840B.300d-char.txt


sent_input: InputLayer
Embedding_Layers_to_get_char_embedd: Embedding
Conv1D_with_filter_size_n: Conv1D
Conv1D_with_filter_size_m: Conv1D
MaxPoolLayer1: MaxPooling1D
Conv1D_with_filter_size_k: Conv1D
Conv1D_with_filter_size_t: Conv1D
MaxPoolLayer2: MaxPooling1D
Flatten: Flatten
DropOut: Dropout



In [36]:
```
#https://machinelearningknowledge.ai/keras-tokenizer-tutorial-with-examples-for-fit
tokenizer = Tokenizer(char_level = True, filters='!"#$%&()*+,-./:;<=>?@[\\]^`{|}~\t
tokenizer.fit_on_texts(x_train)
train_sequences = tokenizer.texts_to_sequences(x_train)
test_sequences = tokenizer.texts_to_sequences(x_test)
```

In [72]:
```
length = []
for i in train_sequences:
    length.append(len(i))
max_length = int(np.percentile(length,95))
print('95 percent of data has sequence length lesser than',max_length)
```

```
95 percent of data has sequence length lesser than 3222
```

So we can pad the data with max length 3222

In [73]:
```
#https://medium.com/@canerkilinc/padding-for-nlp-7dd8598c916a
padded_train_sequences=pad_sequences(train_sequences,padding="post",truncating="pos
padded_test_sequences=pad_sequences(test_sequences,padding="post",truncating="post"
```

In [74]:
```
vocab = tokenizer.word_index
#https://datascience.stackexchange.com/questions/93651/reason-for-adding-1-to-word-
vocab_size = len(vocab)+1 # word_index starts with index 1. Last word in word_index
                          # Normally index always starts at zero. So, to access the
                          # we need to specify vocab_size = len(vocab) + 1
```

In [75]:
```
#https://machinelearningmastery.com/use-word-embedding-layers-deep-learning-keras/

embeddings_index = dict()
f = open('glove.840B.300d-char.txt', encoding ='utf-8')
for line in f:
    values = line.split()
    word = values[0]
    coefs = np.asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
f.close()
print('Loaded %s word vectors.' % len(embeddings_index))
```

```
Loaded 94 word vectors.
```

In [76]:
```
embedding_matrix = np.zeros((vocab_size, 300))  # We used 300d glove word embedding
for word, i in vocab.items():
    embedding_vector = embeddings_index.get(word)
```

```
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector
```

In [102…

```
input_layer_2 = Input(shape=(max_length,))
embedding_layer = Embedding(input_dim = vocab_size, output_dim = 300, weights = [em
                            input_length=max_length, trainable=False) (input_layer_


conv1 = Conv1D(16, 3, activation = 'relu', kernel_initializer='HeUniform') (embeddi
conv2 = Conv1D(16, 4, activation = 'relu', kernel_initializer='HeUniform') (conv1)

maxpool1 = MaxPool1D(2) (conv2)

conv3 = Conv1D(16, 5, activation = 'relu', kernel_initializer='HeUniform') (maxpool
conv4 = Conv1D(16, 6, activation = 'relu', kernel_initializer='HeUniform') (conv3)

maxpool2 = MaxPool1D(2) (conv4)

flatten = Flatten() (maxpool2)

dropout = Dropout(0.5) (flatten)

dense1 = Dense(128,activation='relu', kernel_initializer='HeUniform')(dropout)
dense2 = Dense(256,activation='relu', kernel_initializer='HeUniform')(dense1)

output_2 = Dense(20,activation='softmax')(dense2)

model_two = Model(inputs=input_layer_2,outputs=output_2)
model_two.summary()
```

```
Model: "model_10"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_13 (InputLayer)        [(None, 3222)]            0
_________________________________________________________________
embedding_9 (Embedding)      (None, 3222, 300)         21000
_________________________________________________________________
conv1d_44 (Conv1D)           (None, 3220, 16)          14416
_________________________________________________________________
conv1d_45 (Conv1D)           (None, 3217, 16)          1040
_________________________________________________________________
max_pooling1d_20 (MaxPooling (None, 1608, 16)          0
_________________________________________________________________
conv1d_46 (Conv1D)           (None, 1604, 16)          1296
_________________________________________________________________
conv1d_47 (Conv1D)           (None, 1599, 16)          1552
_________________________________________________________________
max_pooling1d_21 (MaxPooling (None, 799, 16)           0
_________________________________________________________________
flatten_10 (Flatten)         (None, 12784)             0
_________________________________________________________________
dropout_10 (Dropout)         (None, 12784)             0
_________________________________________________________________
dense_30 (Dense)             (None, 128)               1636480
_________________________________________________________________
dense_31 (Dense)             (None, 256)               33024
_________________________________________________________________
dense_32 (Dense)             (None, 20)                5140
=================================================================
Total params: 1,713,948
Trainable params: 1,692,948
Non-trainable params: 21,000
_________________________________________________________________
```

In [103…

```
filepath="model_save/best_model_two.hdf5"
checkpoint = ModelCheckpoint(filepath=filepath, monitor='val_accuracy',  verbose=1,

earlystop = EarlyStopping(monitor='val_accuracy', min_delta=0.005, patience=2, verb

tensorboard_callback = tf.keras.callbacks.TensorBoard(log_dir= ("logs/fits/"+dateti
                       ,histogram_freq=1,write_graph=True)

call_back_list = [ earlystop, checkpoint, tensorboard_callback]
```

In [104…

```
model_two.compile(optimizer='adam', loss='categorical_crossentropy',metrics=['accur

model_two.fit(padded_train_sequences,Y_train,epochs=25, validation_data=(padded_tes
```

```
Epoch 1/25
111/111 [==============================] - 11s 92ms/step - loss: 2.9385 - accurac
y: 0.0778 - val_loss: 2.9182 - val_accuracy: 0.0877

Epoch 00001: val_accuracy improved from -inf to 0.08774, saving model to model_sav
e\best_model_two.hdf5
Epoch 2/25
111/111 [==============================] - 9s 80ms/step - loss: 2.9008 - accuracy:
0.0960 - val_loss: 2.8761 - val_accuracy: 0.1001

Epoch 00002: val_accuracy improved from 0.08774 to 0.10006, saving model to model_
save\best_model_two.hdf5
Epoch 3/25
111/111 [==============================] - 9s 78ms/step - loss: 2.8001 - accuracy:
0.1321 - val_loss: 2.8465 - val_accuracy: 0.1181

Epoch 00003: val_accuracy improved from 0.10006 to 0.11812, saving model to model_
save\best_model_two.hdf5
Epoch 4/25
111/111 [==============================] - 9s 79ms/step - loss: 2.6405 - accuracy:
0.1870 - val_loss: 2.9022 - val_accuracy: 0.1139

Epoch 00004: val_accuracy did not improve from 0.11812
Epoch 5/25
111/111 [==============================] - 9s 79ms/step - loss: 2.3992 - accuracy:
0.2627 - val_loss: 3.0002 - val_accuracy: 0.1156

Epoch 00005: val_accuracy did not improve from 0.11812
Epoch 00005: early stopping
```

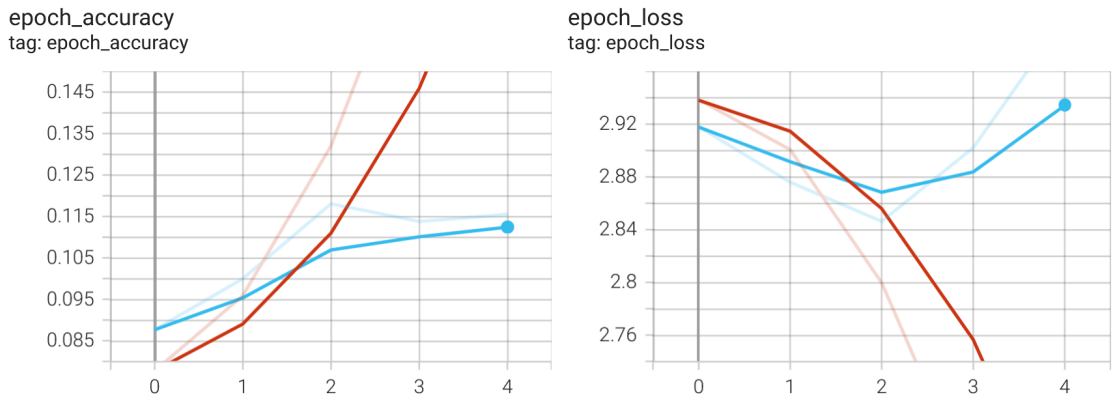
Out[104]: `<keras.callbacks.History at 0x1be0f260430>`

Our final validation accuracy is 11.81% after 5 epochs

Model Two Accuracy and loss in Tensorboard

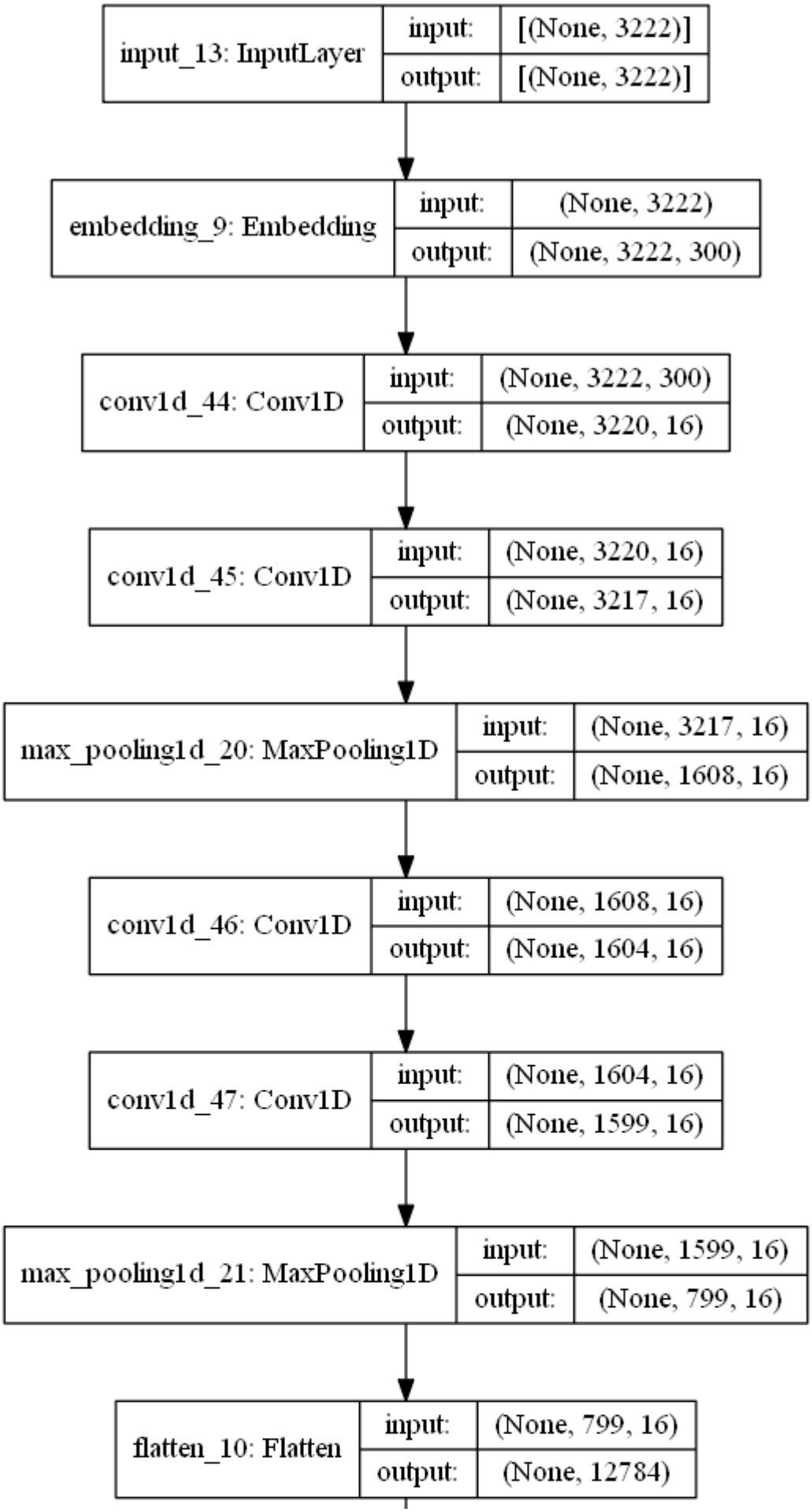
In [109…
```
!tensorboard --logdir logs/fits
```

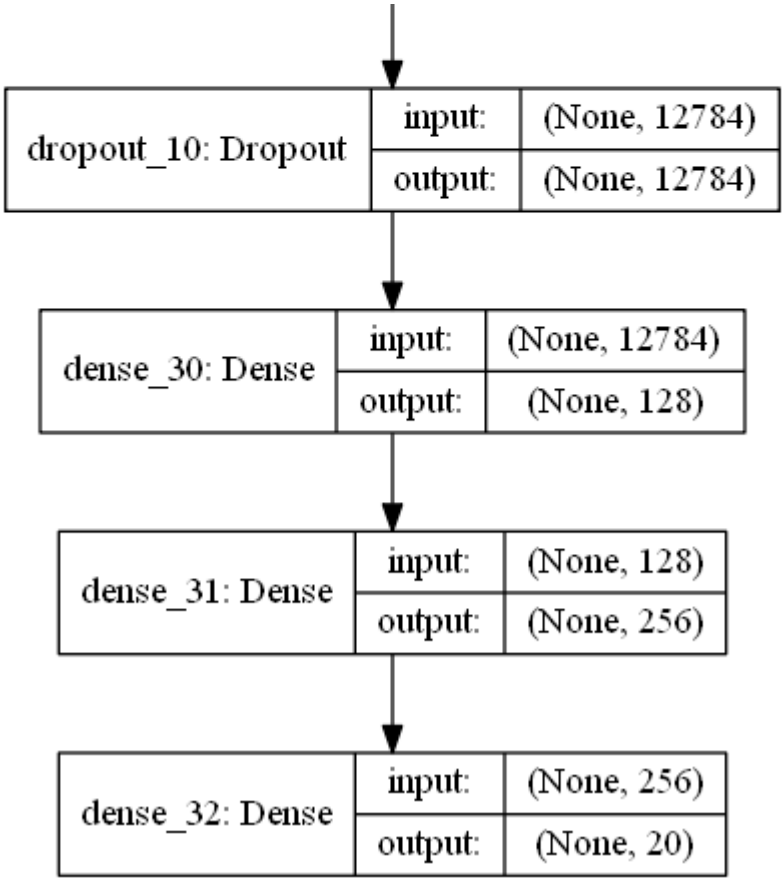
```
^C
```



In [105…
```
plot_model(model_two, to_file='model_two.png', show_shapes=True)
```

Out[105]:


input_13: InputLayer
input: [(None, 3222)]
output: [(None, 3222)]
embedding_9: Embedding
input: (None, 3222)
output: (None, 3222, 300)
conv1d_44: Conv1D
input: (None, 3222, 300)
output: (None, 3220, 16)
conv1d_45: Conv1D
input: (None, 3220, 16)
output: (None, 3217, 16)
max_pooling1d_20: MaxPooling1D
input: (None, 3217, 16)
output: (None, 1608, 16)
conv1d_46: Conv1D
input: (None, 1608, 16)
output: (None, 1604, 16)
conv1d_47: Conv1D
input: (None, 1604, 16)
output: (None, 1599, 16)
max_pooling1d_21: MaxPooling1D
input: (None, 1599, 16)
output: (None, 799, 16)
flatten_10: Flatten
input: (None, 799, 16)
output: (None, 12784)


dropout_10: Dropout
input: (None, 12784)
output: (None, 12784)
dense_30: Dense
input: (None, 12784)
output: (None, 128)
dense_31: Dense
input: (None, 128)
output: (None, 256)
dense_32: Dense
input: (None, 256)
output: (None, 20)