In [0]:

```
import sqlite3
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

Loading Data file in Google Drive

In [0]:

```
# Install the PyDrive wrapper & import libraries.
!pip install -U -q PyDrive
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from google.colab import auth
from oauth2client.client import GoogleCredentials
```

In [0]:

```
# Authenticate and create the PyDrive client.
auth.authenticate_user()
gauth = GoogleAuth()
gauth.credentials = GoogleCredentials.get_application_default()
drive = GoogleDrive(gauth)
```

In [0]:

```
# Downloading a file based on its file ID
downloaded = drive.CreateFile({'id':'12rJAV6wO5I47FwxNHUUJLgrr7-LLPOsL'})
downloaded.GetContentFile('database.sqlite')
```

In [0]:

```
con = sqlite3.connect('database.sqlite')
```

In [156]:

```
filtered_data = pd.read_sql_query("""SELECT * FROM Reviews WHERE Score != 3""" , con)
# Getting data into a dataframe
#filtered_data = pd.read_csv('Reviews.csv')
def partition(x):
    if x>3:
        return 1
    else:
        return 0
actualScore = filtered_data['Score']
positiveNegative = actualScore.map(partition)
filtered_data['Score'] = positiveNegative
filtered_data.shape
filtered_data.head(3)
```

Out[156]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1	1	1303862400	Good Quality Dog Food
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0	0	1346976000	Not as Advertised

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1	1	1219017600	"Delight" says it all

In [0]:

```
sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')
```

In [158]:

```
final = sorted_data.drop_duplicates(subset={'UserId','ProfileName','Time','Text'},keep = 'first' ,inplace=False)
final.shape
```

Out[158]:

```
(364173, 10)
```

In [159]:

```
final = final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
final.shape
```

Out[159]:

```
(364171, 10)
```

In [160]:

```
final['Score'].value_counts()
```

Out[160]:

```
1    307061
0     57110
Name: Score, dtype: int64
```

Text Preprocessing

In [161]:

```
from nltk.corpus import stopwords
import nltk
nltk.download('stopwords')
stop = set(stopwords.words('english'))
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

In [0]:

```
from tqdm import tqdm
def cleanhtml(sentence):
    cleanr = re.compile('<.*?>')
    cleantext = re.sub(cleanr,'',sentence)
    return cleantext
#define function to clean the word of punctuation or special character
def cleanpunc(sentence):
    cleaned = re.sub(r'[?|!|\'|"|#]',r'',sentence)
    cleaned = re.sub(r'[.|,|)|(|\|/]',r' ',cleaned)
    return  cleaned
```

In [163]:

```
from nltk.stem import PorterStemmer
sno = nltk.stem.SnowballStemmer('english')
sno.stem('tasty')
```

Out[163]:

```
'tasti'
```

In [0]:

```
#Code for removing HTML tags , punctuations . Code for removing stopwords . Code for checking if w
ord is not alphanumeric and
# also greater than 2 . Code for stemmimg and also to convert them to lowercase letters
import re
i=0
str1=' '
final_string=[]
all_positive_words=[] # store words from +ve reviews here
all_negative_words=[] # store words from -ve reviews here.
s=''
for sent in final['Text'].values:
    filtered_sentence=[]
    #print(sent);
    sent=cleanhtml(sent) # remove HTMl tags
    for w in sent.split():
        for cleaned_words in cleanpunc(w).split():
            if((cleaned_words.isalpha()) & (len(cleaned_words)>2)):
                if(cleaned_words.lower() not in stop):
                    s=(sno.stem(cleaned_words.lower())).encode('utf8')
                    filtered_sentence.append(s)
                    if (final['Score'].values)[i] == 1:
                        all_positive_words.append(s) #list of all words used to describe positive r
eviews
                    if(final['Score'].values)[i] == 0:
                        all_negative_words.append(s) #list of all words used to describe negative r
eviews reviews
                else:
                    continue
            else:
                continue

    str1 = b" ".join(filtered_sentence) #final string of cleaned words


    final_string.append(str1)
    i+=1
```

In [165]:

```
#adding a column of CleanedText which displays the data after pre-processing of the review
final['CleanedText']=final_string
final['CleanedText']=final['CleanedText'].str.decode("utf-8")
#below the processed review can be seen in the CleanedText Column
print('Shape of final',final.shape)
final.head()
```

```
Shape of final (364171, 11)
```

Out[165]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Su
138706	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0	0	1	939340800	edu

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Su
138688	150506	0006641040	A2IW4PEEKO2R0U	Tracy	1	1	1	1194739200	boo t
138689	150507	0006641040	A1S4A3IQ2MU7V4	sally sue "sally sue"	1	1	1	1191456000	sc
138690	150508	0006641040	AZGXZ2UUK6X	Catherine Hallberg " (Kate)"	1	1	1	1076025600	rhy
138691	150509	0006641040	A3CMRKGE0P909G	Teresa	3	4	1	1018396800	le

In [0]:

```
##Sorting data according to Time in ascending order for Time Based Splitting
time_sorted_data = final.sort_values('Time', axis=0, ascending=True, inplace=False, kind='quicksort
', na_position='last')

x = time_sorted_data['CleanedText'].values
y = time_sorted_data['Score']
```

In [167]:

```
# Finding all words in the vocabulary
from sklearn.feature_extraction.text import CountVectorizer
count_vect = CountVectorizer()
count_vect.fit(x)

vocabulary = count_vect.get_feature_names()
print('No. of words in the Vocabulary : ',len(vocabulary))
```

```
No. of words in the Vocabulary :  98496
```

In [0]:

```
# Storing all words in the dictionary (words as keys and index as values)
Dictionary = dict()
ind = 0
for sent in x:
  for word in sent.split():
    Dictionary.setdefault(word,[])
    Dictionary[word].append(ind)
    ind += 1
```

In [0]:

```
# Getting frequency for each word of vocabulary and storing it in a list
freq = []
for w in vocabulary:
  freq.append(len(Dictionary[w]))
```

In [0]:

```
# Getting Index for each word in the vocabulary
inc_index =np.argsort(np.array(freq))[::-1]
```

In [0]:

```
# Allocating ranks to words of vocabulary in decreasing order of frequency and storing words in a
dictionary
word_rank = dict()
rank = 1
for i in inc_index:
  word_rank[vocabulary[i]] = rank
  rank +=1
```

In [0]:

```
# Converting full data into imdb format
data = []
for sent in x:
  row = []
  for word in sent.split():
    if(len(word)>1):
      row.append(word_rank[word])
  data.append(row)
```

In [0]:

```
# Splitting the data into 50-50 train_data and test_data
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(data, y, test_size=0.5, random_state=42)
```

In [0]:

```
# Importing libraries
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import LSTM
from keras.layers.embeddings import Embedding
from keras.preprocessing import sequence
from keras.layers import Dropout
# fix random seed for reproducibility
np.random.seed(7)
```

In [175]:

```
# truncate and/or pad input sequences
max_review_length = 100
X_train = sequence.pad_sequences(X_train, maxlen=max_review_length)
X_test = sequence.pad_sequences(X_test, maxlen=max_review_length)

print(X_train.shape)
print(X_train[1])
```

```
(182085, 100)
[   0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    5   14  385 3432   61
    9 1245  290  938  343   81  998   96  530   90   49   13  953 1251
  812  601]
```

In [0]:

```
def plt_dynamic(x, vy, ty, ax, colors=['b']):
    ax.plot(x, vy, 'b', label="Validation Loss")
    ax.plot(x, ty, 'r', label="Train Loss")
    plt.legend()
    plt.grid()
    fig.canvas.draw()
```

(1) RNN with 1 LSTM layer

In [177]:

```
# create the model
embedding_vecor_length = 32
model = Sequential()
model.add(Embedding(len(vocabulary), embedding_vecor_length, input_length=max_review_length))
model.add(LSTM(100))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
print(model.summary())
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
embedding_6 (Embedding)      (None, 100, 32)           3151872   
_________________________________________________________________
lstm_7 (LSTM)                (None, 100)               53200     
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 101       
=================================================================
Total params: 3,205,173
Trainable params: 3,205,173
Non-trainable params: 0
_________________________________________________________________
None
```

In [0]:

```
# Compiling the model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
```

In [179]:

```
# Fitting the data to the model
history = model.fit(X_train, Y_train, nb_epoch=10, batch_size=512 ,verbose=1,validation_data=(X_tes
t, Y_test))
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:1: UserWarning: The `nb_epoch`
argument in `fit` has been renamed `epochs`.
  """Entry point for launching an IPython kernel.
```

```
Train on 182085 samples, validate on 182086 samples
Epoch 1/10
182085/182085 [==============================] - 103s 567us/step - loss: 0.2638 - acc: 0.8979 - va
l_loss: 0.2029 - val_acc: 0.9216
Epoch 2/10
182085/182085 [==============================] - 102s 559us/step - loss: 0.1817 - acc: 0.9304 - va
l_loss: 0.1987 - val_acc: 0.9216
Epoch 3/10
182085/182085 [==============================] - 103s 563us/step - loss: 0.1644 - acc: 0.9371 - va
l_loss: 0.1986 - val_acc: 0.9215
Epoch 4/10
182085/182085 [==============================] - 103s 567us/step - loss: 0.1526 - acc: 0.9416 - va
l_loss: 0.2079 - val_acc: 0.9200
Epoch 5/10
182085/182085 [==============================] - 104s 572us/step - loss: 0.1413 - acc: 0.9463 - va
l_loss: 0.2029 - val_acc: 0.9206
Epoch 6/10
182085/182085 [==============================] - 103s 567us/step - loss: 0.1301 - acc: 0.9510 - va
l_loss: 0.2126 - val_acc: 0.9207
Epoch 7/10
182085/182085 [==============================] - 103s 563us/step - loss: 0.1179 - acc: 0.9556 - va
l_loss: 0.2175 - val_acc: 0.9184
Epoch 8/10
182085/182085 [==============================] - 102s 562us/step - loss: 0.1080 - acc: 0.9596 - va
l_loss: 0.2278 - val_acc: 0.9174
Epoch 9/10
182085/182085 [==============================] - 103s 567us/step - loss: 0.0982 - acc: 0.9638 - va
l_loss: 0.2529 - val_acc: 0.9175
Epoch 10/10
182085/182085 [==============================] - 103s 564us/step - loss: 0.0897 - acc: 0.9673 - va
l_loss: 0.2653 - val_acc: 0.9151
```

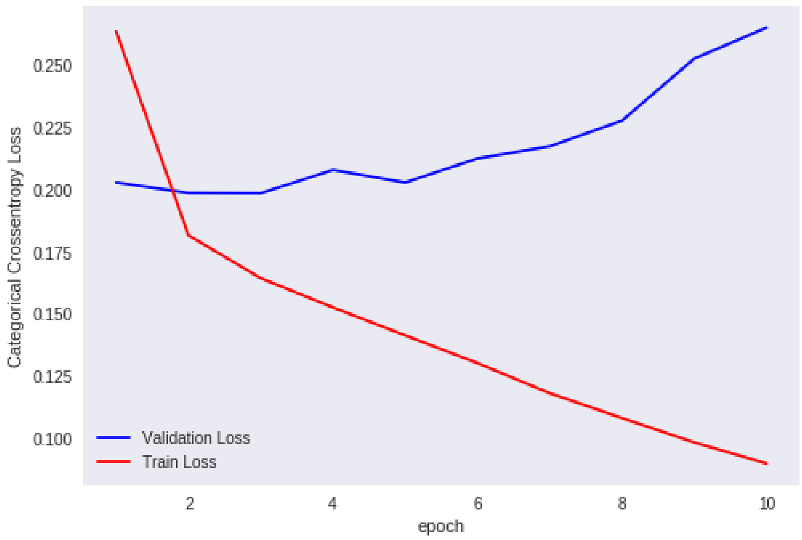
In [180]:

```
score = model.evaluate(X_test, Y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
epochs = 10

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,epochs+1))
vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```

```
Test loss: 0.26529355157468715
Test accuracy: 0.9150730973276364
```



(2) RNN with 2 LSTM layer

In [185]:

```
# create the model
embedding_vecor_length = 32
model = Sequential()
model.add(Embedding(len(vocabulary), embedding_vecor_length, input_length=max_review_length))
# Adding first LSTM layer
model.add(LSTM(100,return_sequences=True, dropout=0.4, recurrent_dropout=0.4))

# Adding second LSTM layer
model.add(LSTM(100, dropout=0.4, recurrent_dropout=0.4))

model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
print(model.summary())
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-
packages/keras/backend/tensorflow_backend.py:3445: calling dropout (from
tensorflow.python.ops.nn_ops) with keep_prob is deprecated and will be removed in a future
version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.

_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
embedding_11 (Embedding)     (None, 100, 32)           3151872   
_________________________________________________________________
lstm_13 (LSTM)               (None, 100, 100)          53200     
_________________________________________________________________
lstm_14 (LSTM)               (None, 100)               80400     
```

```
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 101       
=================================================================
Total params: 3,285,573
Trainable params: 3,285,573
Non-trainable params: 0
_________________________________________________________________
None
```

In [0]:

```
# Compiling the model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
```

In [187]:

```
# Fitting the data to the model
history = model.fit(X_train, Y_train, nb_epoch=10, batch_size=512 ,verbose=1,validation_data=(X_tes
t, Y_test))
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:1: UserWarning: The `nb_epoch`
argument in `fit` has been renamed `epochs`.
  """Entry point for launching an IPython kernel.
```

```
Train on 182085 samples, validate on 182086 samples
Epoch 1/10
182085/182085 [==============================] - 226s 1ms/step - loss: 0.2745 - acc: 0.8943 - val_
loss: 0.2053 - val_acc: 0.9204
Epoch 2/10
182085/182085 [==============================] - 224s 1ms/step - loss: 0.1935 - acc: 0.9250 - val_
loss: 0.1981 - val_acc: 0.9217
Epoch 3/10
182085/182085 [==============================] - 224s 1ms/step - loss: 0.1770 - acc: 0.9323 - val_
loss: 0.2011 - val_acc: 0.9225
Epoch 4/10
182085/182085 [==============================] - 225s 1ms/step - loss: 0.1667 - acc: 0.9363 - val_
loss: 0.1987 - val_acc: 0.9236
Epoch 5/10
182085/182085 [==============================] - 224s 1ms/step - loss: 0.1574 - acc: 0.9399 - val_
loss: 0.2026 - val_acc: 0.9226
Epoch 6/10
182085/182085 [==============================] - 224s 1ms/step - loss: 0.1503 - acc: 0.9429 - val_
loss: 0.2020 - val_acc: 0.9221
Epoch 7/10
182085/182085 [==============================] - 223s 1ms/step - loss: 0.1444 - acc: 0.9452 - val_
loss: 0.2065 - val_acc: 0.9218
Epoch 8/10
182085/182085 [==============================] - 220s 1ms/step - loss: 0.1385 - acc: 0.9473 - val_
loss: 0.2087 - val_acc: 0.9219
Epoch 9/10
182085/182085 [==============================] - 221s 1ms/step - loss: 0.1334 - acc: 0.9498 - val_
loss: 0.2100 - val_acc: 0.9219
Epoch 10/10
182085/182085 [==============================] - 223s 1ms/step - loss: 0.1270 - acc: 0.9523 - val_
loss: 0.2194 - val_acc: 0.9203
```

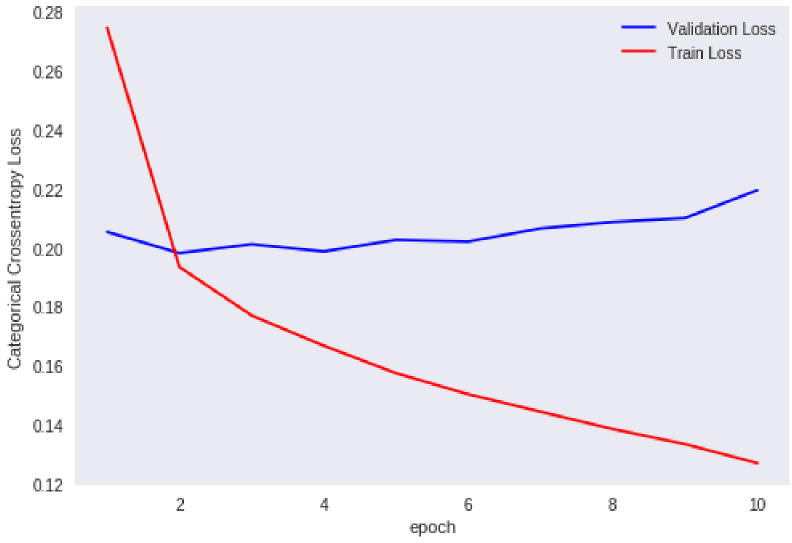
In [189]:

```
score = model.evaluate(X_test, Y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])

fig,ax = plt.subplots(1,1)
ax.set_xlabel('epoch') ; ax.set_ylabel('Categorical Crossentropy Loss')

# list of epoch numbers
x = list(range(1,epochs+1))
vy = history.history['val_loss']
ty = history.history['loss']
plt_dynamic(x, vy, ty, ax)
```

```
Test loss: 0.21942285291394065
Test accuracy: 0.920268444581132
```



Conclusion:

In [190]:

```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["MOdel","Test AUC","Test Loss"]

x.add_row([" RNN with 1 LSTM layer","91.5%","0.26529355157468715"])
x.add_row(["RNN with 2 LSTM layer","92%","0.21942285291394065"])



print(x)
```

```
+------------------------+----------+---------------------+
|         MOdel          | Test AUC |      Test Loss      |
+------------------------+----------+---------------------+
|  RNN with 1 LSTM layer |  91.5%   | 0.26529355157468715 |
| RNN with 2 LSTM layer  |   92%    | 0.21942285291394065 |
+------------------------+----------+---------------------+
```

1) As number of layers increases accuracy increases. 2) As number of layers increases loss decreases.3) By observing error plots, in both plots as number of epoch increases model is overfitting. 4) As number of layer increases computation time increases.

In [0]: