A_14 (2)

June 4, 2019

In [1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")


import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os
import xgboost as xgb


import numpy
```

```
        from keras.datasets import imdb
        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
```

```
Using TensorFlow backend.
```

```
In [2]: from google.colab import drive
        drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6

Enter your authorization code:
ůůůůůůůůůů
Mounted at /content/drive
```

```
In [3]: # using SQLite Table to read data.
        con = sqlite3.connect('drive/My Drive/database.sqlite')

        # filtering only positive and negative reviews i.e.
        # not taking into consideration those reviews with Score=3
        # SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 500000 data points
        # you can change the number to any other number based on your computing power

        # filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 5
        # for tsne assignment you can take 5k data points

        filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 100

        # Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negativ
        def partition(x):
            if x < 3:
                return 0
            return 1

        #changing reviews with score less than 3 to be positive and vice-versa
        actualScore = filtered_data['Score']
        positiveNegative = actualScore.map(partition)
        filtered_data['Score'] = positiveNegative
        print("Number of data points in our data", filtered_data.shape)
        filtered_data.head(3)
```

```
Number of data points in our data (10000, 10)
```

```
Out[3]:    Id  ...                                                Text
        0   1  ...  I have bought several of the Vitality canned d...
        1   2  ...  Product arrived labeled as Jumbo Salted Peanut...
        2   3  ...  This is a confection that has been around a fe...

        [3 rows x 10 columns]
```

```
In [0]: display = pd.read_sql_query("""
        SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
        FROM Reviews
        GROUP BY UserId
        HAVING COUNT(*)>1
        """, con)
```

```
In [5]: print(display.shape)
        display.head()

(80668, 7)
```

```
Out[5]:                 UserId  ... COUNT(*)
        0  #oc-R115TNMSPFT9I7  ...        2
        1  #oc-R11D9D7SHXIJB9  ...        3
        2  #oc-R11DNU2NBKQ23Z  ...        2
        3  #oc-R11O5J5ZVQE25C  ...        3
        4  #oc-R12KPBODL2B5ZD  ...        2

        [5 rows x 7 columns]
```

```
In [6]: display[display['UserId']=='AZY10LLTJ71NX']
```

```
Out[6]:               UserId  ... COUNT(*)
        80638  AZY10LLTJ71NX  ...        5

        [1 rows x 7 columns]
```

```
In [7]: display['COUNT(*)'].sum()

Out[7]: 393063
```

1 [2] Exploratory Data Analysis

1.1 [2.1] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

```
In [8]: display= pd.read_sql_query("""
        SELECT *
        FROM Reviews
        WHERE Score != 3 AND UserId="AR5J8UI46CURR"
        ORDER BY ProductID
        """, con)
        display.head()
```

```
Out[8]:        Id  ...                                                Text
        0   78445  ...  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
        1  138317  ...  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
        2  138277  ...  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
        3   73791  ...  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
        4  155049  ...  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...

        [5 rows x 10 columns]
```

As it can be seen above that same user has multiple reviews with same values for HelpfulnessNumerator, HelpfulnessDenominator, Score, Time, Summary and Text and on doing analysis it was found that ProductId=B000HDOPZG was Loacker Quadratini Vanilla Wafer Cookies, 8.82-Ounce Packages (Pack of 8) ProductId=B000HDL1RQ was Loacker Quadratini Lemon Wafer Cookies, 8.82-Ounce Packages (Pack of 8) and so on

It was inferred after analysis that reviews with same parameters other than ProductId belonged to the same product just having different flavour or quantity. Hence in order to reduce redundancy it was decided to eliminate the rows having same parameters.

The method used for the same was that we first sort the data according to ProductId and then just keep the first similar product review and delelte the others. for eg. in the above just the review for ProductId=B000HDL1RQ remains. This method ensures that there is only one representative for each product and deduplication without sorting would lead to possibility of different representatives still existing for the same product.

```
In [0]: #Sorting data according to ProductId in ascending order
        sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=Fals
```

```
In [10]: #Deduplication of entries
         final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep=
         final.shape
```

```
Out[10]: (9564, 10)
```

```
In [11]: #Checking to see how much % of data still remains
         (final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

```
Out[11]: 95.64
```

Observation:- It was also seen that in two rows given below the value of HelpfulnessNumerator is greater than HelpfulnessDenominator which is not practically possible hence these two rows too are removed from calcualtions

```
In [12]: display= pd.read_sql_query("""
         SELECT *
         FROM Reviews
         WHERE Score != 3 AND Id=44737 OR Id=64422
         ORDER BY ProductID
         """, con)

         display.head()
```

```
Out[12]:       Id  ...                                                Text
         0  64422  ...  My son loves spaghetti so I didn't hesitate or...
         1  44737  ...  It was almost a 'love at first bite' - the per...

         [2 rows x 10 columns]
```

```
In [0]: final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

```
In [14]: #Before starting the next phase of preprocessing lets see the number of entries left
         print(final.shape)

         #How many positive and negative reviews are present in our dataset?
         final['Score'].value_counts()
```

```
(9564, 10)


Out[14]: 1    7976
         0    1588
         Name: Score, dtype: int64
```

```
In [15]: final.columns
```

```
Out[15]: Index(['Id', 'ProductId', 'UserId', 'ProfileName', 'HelpfulnessNumerator',
                'HelpfulnessDenominator', 'Score', 'Time', 'Summary', 'Text'],
               dtype='object')
```

```
In [0]: X = final['Text']
        y = final['Score'][:]
```

```
In [17]: X.shape
```

```
Out[17]: (9564,)
```

```
In [18]: X_train = X[:7000 ]
         X_test = X[7001:]

         y_train = y[:7000]
         y_test = y[7001:]

         print(X_train.shape, y_train.shape)
         print(X_test.shape, y_test.shape)
```

```
(7000,) (7000,)
(2563,) (2563,)
```

In [0]:
```python
from keras.preprocessing.text import Tokenizer

tokenizer = Tokenizer(num_words = 10000)
tokenizer.fit_on_texts(X_train)

X_train = tokenizer.texts_to_sequences(X_train)
X_test = tokenizer.texts_to_sequences(X_test)
```

In [20]:
```python
## Zero Padding
max_review_length = 600

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])
```

```
(7000, 600)
[   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    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    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    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    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    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    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    0    0    0  321    8   10   47
    1  192   35    8  373   11  217    9  357  355   59  257 6126 2655
 9706 4308 3975 5315 9707    9    9    1 6126 9708    3 9709 3976   19
 7320    7  547  900 2655 9710  251 2439   16   63  181 2256]
```

2 Single layer LSTM Model

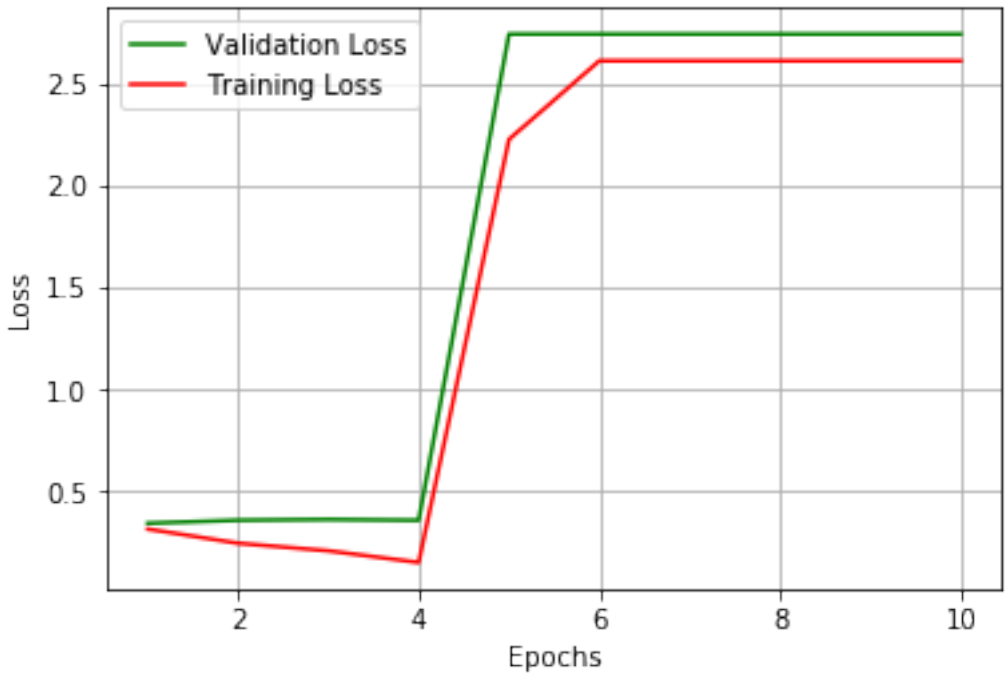
```
In [21]: top_words = 5000
         embedding_vecor_length = 32
         model = Sequential()
         model.add(Embedding(top_words+1, embedding_vecor_length, input_length=max_review_leng
         model.add(LSTM(100))
         model.add(Dense(1, activation='sigmoid'))
         model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
         print(model.summary())
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/python/framework/op_
Instructions for updating:
Colocations handled automatically by placer.
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 600, 32)           160032
_________________________________________________________________
lstm_1 (LSTM)                (None, 100)               53200
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 101
=================================================================
Total params: 213,333
Trainable params: 213,333
Non-trainable params: 0
_________________________________________________________________
None
```

```
In [22]: history = model.fit(X_train, y_train, batch_size = 128, epochs = 10, verbose = 1, vali
         # Final evaluation of the model
         scores = model.evaluate(X_test, y_test, verbose=1)
         print("Accuracy: %.2f%%" % (scores[1]*100))
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow/python/ops/math_ops.p
Instructions for updating:
Use tf.cast instead.
Train on 7000 samples, validate on 2563 samples
Epoch 1/10
7000/7000 [==============================] - 55s 8ms/step - loss: 2.0669 - acc: 0.8319 - val_lo
Epoch 2/10
7000/7000 [==============================] - 53s 8ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 3/10
7000/7000 [==============================] - 52s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 4/10
7000/7000 [==============================] - 52s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 5/10
7000/7000 [==============================] - 51s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 6/10
7000/7000 [==============================] - 51s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 7/10
7000/7000 [==============================] - 51s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 8/10
7000/7000 [==============================] - 51s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 9/10
7000/7000 [==============================] - 51s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
Epoch 10/10
7000/7000 [==============================] - 51s 7ms/step - loss: 2.6123 - acc: 0.8361 - val_lo
2563/2563 [==============================] - 24s 9ms/step
Accuracy: 82.72%
```

```
In [0]: fig,ax = plt.subplots(1,1)
        ax.set_xlabel('Epochs') ; ax.set_ylabel('Loss')

        # list of epoch numbers
        list_of_epoch = list(range(1,10+1))

        train_loss = history.history['loss']
        val_loss = history.history['val_loss']

        ax.plot(list_of_epoch, val_loss, 'g', label="Validation Loss")
        ax.plot(list_of_epoch, train_loss, 'r', label="Training Loss")
        plt.legend()
        plt.grid()
        plt.show();
```



---

3 2-Layer LSTM model

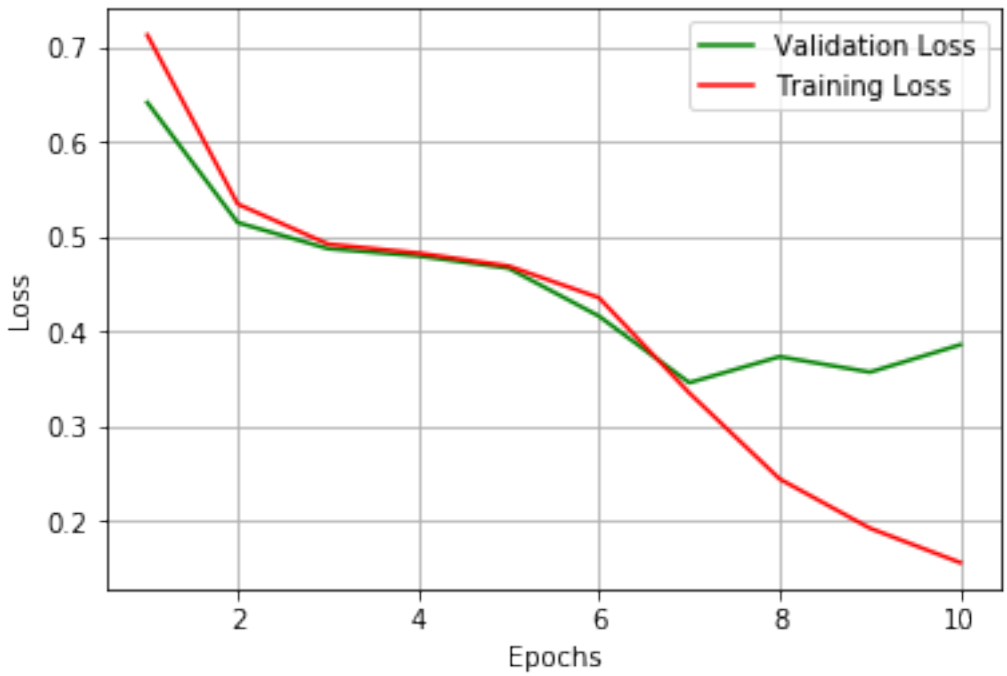
```
In [0]: from keras.layers import Dense, Dropout, Flatten
        from keras.layers.normalization import BatchNormalization
        from keras import regularizers

        embedding_vecor_length = 32
        top_words = 50000

        model = Sequential()
        model.add(Embedding(top_words+1, embedding_vecor_length, input_length=max_review_lengt
        model.add(LSTM(32, return_sequences=True, kernel_initializer = 'random_uniform',W_regu
        model.add(Dropout(0.5))
        model.add(LSTM(32,W_regularizer=regularizers.l2(0.001)))
        model.add(Dropout(0.5))

        model.add(Dense(1, activation='sigmoid'))

        model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
        print(model.summary())
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:10: UserWarning: Update your `LSTM
  # Remove the CWD from sys.path while we load stuff.
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: UserWarning: Update your `LSTM
  if sys.path[0] == '':


_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_8 (Embedding)      (None, 600, 32)           1600032
_________________________________________________________________
lstm_12 (LSTM)               (None, 600, 32)           8320
_________________________________________________________________
dropout_11 (Dropout)         (None, 600, 32)           0
_________________________________________________________________
lstm_13 (LSTM)               (None, 32)                8320
_________________________________________________________________
dropout_12 (Dropout)         (None, 32)                0
_________________________________________________________________
dense_7 (Dense)              (None, 1)                 33
=================================================================
Total params: 1,616,705
Trainable params: 1,616,705
Non-trainable params: 0
_________________________________________________________________
None


In [0]: history = model.fit(X_train, y_train,
                            nb_epoch=10,
                            batch_size=512,
                           validation_data=(X_test, y_test))
        # Final evaluation of the model
        scores = model.evaluate(X_test, y_test, verbose=1)
        print("Accuracy: %.2f%%" % (scores[1]*100))

/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:4: UserWarning: The `nb_epoch` arg
  after removing the cwd from sys.path.


Train on 7000 samples, validate on 2563 samples
Epoch 1/10
7000/7000 [==============================] - 30s 4ms/step - loss: 0.7131 - acc: 0.8147 - val_lo
Epoch 2/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.5347 - acc: 0.8361 - val_lo
Epoch 3/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.4924 - acc: 0.8361 - val_lo
Epoch 4/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.4829 - acc: 0.8361 - val_lo
Epoch 5/10
7000/7000 [==============================] - 27s 4ms/step - loss: 0.4692 - acc: 0.8361 - val_lo
```

```
Epoch 6/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.4358 - acc: 0.8361 - val_lo
Epoch 7/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.3352 - acc: 0.8604 - val_lo
Epoch 8/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.2444 - acc: 0.9227 - val_lo
Epoch 9/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.1924 - acc: 0.9467 - val_lo
Epoch 10/10
7000/7000 [==============================] - 26s 4ms/step - loss: 0.1561 - acc: 0.9593 - val_lo
2563/2563 [==============================] - 49s 19ms/step
Accuracy: 86.73%
```

```
In [0]: fig,ax = plt.subplots(1,1)
        ax.set_xlabel('Epochs') ; ax.set_ylabel('Loss')

        # list of epoch numbers
        list_of_epoch = list(range(1,10+1))

        train_loss = history.history['loss']
        val_loss = history.history['val_loss']

        ax.plot(list_of_epoch, val_loss, 'g', label="Validation Loss")
        ax.plot(list_of_epoch, train_loss, 'r', label="Training Loss")
        plt.legend()
        plt.grid()
        plt.show();
```



4 2 layer LSTM Model with Dropout = 0.8

```
In [24]: from keras.layers import Dense, Dropout, Flatten
         from keras.layers.normalization import BatchNormalization
         from keras import regularizers

         embedding_vecor_length = 32
         top_words = 50000

         model = Sequential()
         model.add(Embedding(top_words+1, embedding_vecor_length, input_length=max_review_leng
         model.add(LSTM(32, return_sequences=True, kernel_initializer = 'random_uniform',W_reg
         model.add(Dropout(0.8))
         model.add(LSTM(32,W_regularizer=regularizers.l2(0.001)))
         model.add(Dropout(0.8))

         model.add(Dense(1, activation='sigmoid'))

         model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
         print(model.summary())
```

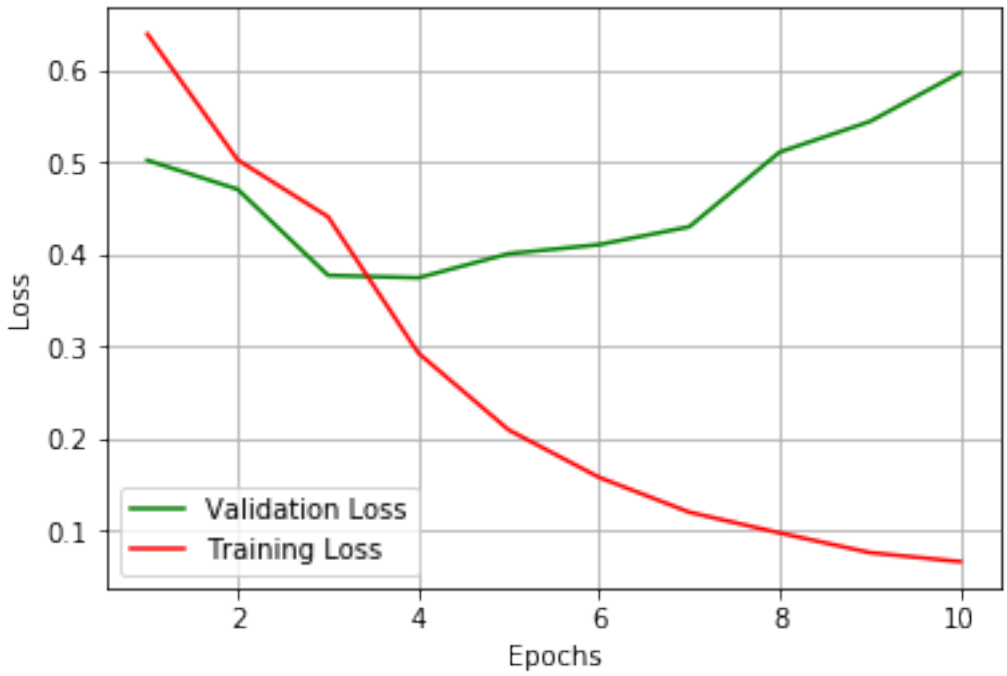
```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tensorflow_backen
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_prob`.


/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:10: UserWarning: Update your `LST
  # Remove the CWD from sys.path while we load stuff.
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: UserWarning: Update your `LST
  if sys.path[0] == '':


_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_2 (Embedding)      (None, 600, 32)           1600032
_________________________________________________________________
lstm_2 (LSTM)                (None, 600, 32)           8320
_________________________________________________________________
dropout_1 (Dropout)          (None, 600, 32)           0
_________________________________________________________________
lstm_3 (LSTM)                (None, 32)                8320
_________________________________________________________________
dropout_2 (Dropout)          (None, 32)                0
_________________________________________________________________
```

```
dense_2 (Dense)              (None, 1)                 33
=================================================================
Total params: 1,616,705
Trainable params: 1,616,705
Non-trainable params: 0
_________________________________________________________________
None
```

```
In [25]: history = model.fit(X_train, y_train, batch_size = 256, epochs = 10, verbose = 1, vali
         # Final evaluation of the model
         scores = model.evaluate(X_test, y_test, verbose=1)
         print("Accuracy: %.2f%%" % (scores[1]*100))

Train on 7000 samples, validate on 2563 samples
Epoch 1/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.6392 - acc: 0.8211 - val_lo
Epoch 2/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.5024 - acc: 0.8353 - val_lo
Epoch 3/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.4407 - acc: 0.8367 - val_lo
Epoch 4/10
7000/7000 [==============================] - 51s 7ms/step - loss: 0.2926 - acc: 0.8991 - val_lo
Epoch 5/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.2092 - acc: 0.9364 - val_lo
Epoch 6/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.1577 - acc: 0.9616 - val_lo
Epoch 7/10
7000/7000 [==============================] - 51s 7ms/step - loss: 0.1198 - acc: 0.9746 - val_lo
Epoch 8/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.0972 - acc: 0.9810 - val_lo
Epoch 9/10
7000/7000 [==============================] - 52s 7ms/step - loss: 0.0758 - acc: 0.9876 - val_lo
Epoch 10/10
7000/7000 [==============================] - 51s 7ms/step - loss: 0.0660 - acc: 0.9907 - val_lo
2563/2563 [==============================] - 49s 19ms/step
Accuracy: 85.76%
```

```
In [26]: fig,ax = plt.subplots(1,1)
         ax.set_xlabel('Epochs') ; ax.set_ylabel('Loss')

         # list of epoch numbers
         list_of_epoch = list(range(1,10+1))

         train_loss = history.history['loss']
         val_loss = history.history['val_loss']
```

```
ax.plot(list_of_epoch, val_loss, 'g', label="Validation Loss")
ax.plot(list_of_epoch, train_loss, 'r', label="Training Loss")
plt.legend()
plt.grid()
plt.show();
```



5 2 layer LSTM Model with Dropout = 0.2

In [27]:
```
from keras.layers import Dense, Dropout, Flatten
from keras.layers.normalization import BatchNormalization
from keras import regularizers

embedding_vecor_length = 32
top_words = 50000

model = Sequential()
model.add(Embedding(top_words+1, embedding_vecor_length, input_length=max_review_leng
model.add(LSTM(32, return_sequences=True, kernel_initializer = 'random_uniform',W_reg
model.add(Dropout(0.2))
model.add(LSTM(32,W_regularizer=regularizers.l2(0.001)))
model.add(Dropout(0.2))

model.add(Dense(1, activation='sigmoid'))
```

```
        model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
        print(model.summary())
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:10: UserWarning: Update your `LSTM
  # Remove the CWD from sys.path while we load stuff.
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: UserWarning: Update your `LSTM
  if sys.path[0] == '':
```

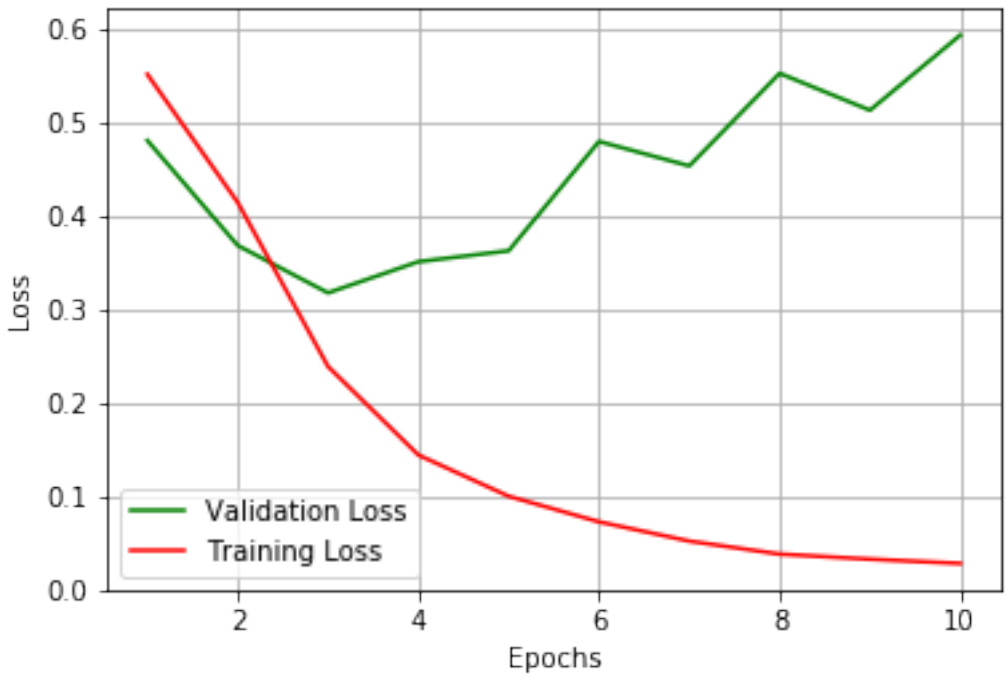
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_3 (Embedding)      (None, 600, 32)           1600032
_________________________________________________________________
lstm_4 (LSTM)                (None, 600, 32)           8320
_________________________________________________________________
dropout_3 (Dropout)          (None, 600, 32)           0
_________________________________________________________________
lstm_5 (LSTM)                (None, 32)                8320
_________________________________________________________________
dropout_4 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 33
=================================================================
Total params: 1,616,705
Trainable params: 1,616,705
Non-trainable params: 0
_________________________________________________________________
None
```

```
In [28]: history = model.fit(X_train, y_train, batch_size = 128, epochs = 10, verbose = 1, vali
         # Final evaluation of the model
         scores = model.evaluate(X_test, y_test, verbose=1)
         print("Accuracy: %.2f%%" % (scores[1]*100))
```

```
Train on 7000 samples, validate on 2563 samples
Epoch 1/10
7000/7000 [==============================] - 103s 15ms/step - loss: 0.5513 - acc: 0.8297 - val_
Epoch 2/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.4146 - acc: 0.8397 - val_
Epoch 3/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.2395 - acc: 0.9153 - val_
Epoch 4/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.1450 - acc: 0.9574 - val_
Epoch 5/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.1009 - acc: 0.9733 - val_
Epoch 6/10
7000/7000 [==============================] - 101s 14ms/step - loss: 0.0737 - acc: 0.9829 - val_
```

```
Epoch 7/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.0531 - acc: 0.9900 - val
Epoch 8/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.0392 - acc: 0.9950 - val
Epoch 9/10
7000/7000 [==============================] - 102s 15ms/step - loss: 0.0338 - acc: 0.9950 - val
Epoch 10/10
7000/7000 [==============================] - 101s 14ms/step - loss: 0.0292 - acc: 0.9963 - val
2563/2563 [==============================] - 49s 19ms/step
Accuracy: 87.36%
```

```
In [29]: fig,ax = plt.subplots(1,1)
         ax.set_xlabel('Epochs') ; ax.set_ylabel('Loss')

         # list of epoch numbers
         list_of_epoch = list(range(1,10+1))

         train_loss = history.history['loss']
         val_loss = history.history['val_loss']

         ax.plot(list_of_epoch, val_loss, 'g', label="Validation Loss")
         ax.plot(list_of_epoch, train_loss, 'r', label="Training Loss")
         plt.legend()
         plt.grid()
         plt.show();
```



6 3 layer LSTM Model with Dropout = 0.8

```
In [37]: from keras.layers import Dense, Dropout, Flatten
         from keras.layers.normalization import BatchNormalization
         from keras import regularizers

         embedding_vecor_length = 32
         top_words = 50000

         model = Sequential()
         model.add(Embedding(top_words+1, embedding_vecor_length, input_length=max_review_leng
         model.add(LSTM(32, return_sequences=True, kernel_initializer = 'random_uniform',W_reg
         model.add(Dropout(0.8))
         model.add(LSTM(64,W_regularizer=regularizers.l2(0.001),return_sequences = True))
         model.add(Dropout(0.8))
         model.add(LSTM(32,W_regularizer=regularizers.l2(0.001), return_sequences = False))
         model.add(Dropout(0.8))
         model.add(Dense(1, activation='sigmoid'))

         model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
         print(model.summary())
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:10: UserWarning: Update your `LSTM
  # Remove the CWD from sys.path while we load stuff.
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: UserWarning: Update your `LSTM
  if sys.path[0] == '':
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:14: UserWarning: Update your `LSTM
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_8 (Embedding)      (None, 600, 32)           1600032
_________________________________________________________________
lstm_18 (LSTM)               (None, 600, 32)           8320
_________________________________________________________________
dropout_13 (Dropout)         (None, 600, 32)           0
_________________________________________________________________
lstm_19 (LSTM)               (None, 600, 64)           24832
_________________________________________________________________
dropout_14 (Dropout)         (None, 600, 64)           0
_________________________________________________________________
lstm_20 (LSTM)               (None, 32)                12416
_________________________________________________________________
dropout_15 (Dropout)         (None, 32)                0
```

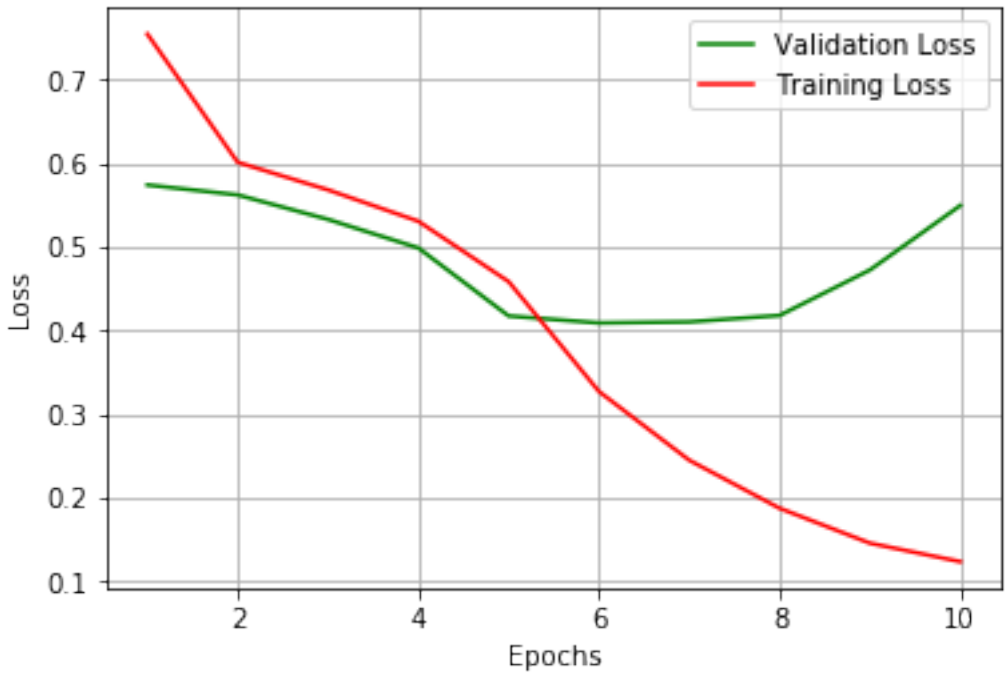
```
_________________________________________________________________
dense_4 (Dense)              (None, 1)                 33
=================================================================
Total params: 1,645,633
Trainable params: 1,645,633
Non-trainable params: 0
_________________________________________________________________
None
```

```
In [38]: history = model.fit(X_train, y_train, batch_size = 512, epochs = 10, verbose = 1, vali
         # Final evaluation of the model
         scores = model.evaluate(X_test, y_test, verbose=1)
         print("Accuracy: %.2f%%" % (scores[1]*100))
```

```
Train on 7000 samples, validate on 2563 samples
Epoch 1/10
7000/7000 [==============================] - 43s 6ms/step - loss: 0.7540 - acc: 0.8094 - val_lo
Epoch 2/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.6007 - acc: 0.8337 - val_lo
Epoch 3/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.5677 - acc: 0.8354 - val_lo
Epoch 4/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.5303 - acc: 0.8361 - val_lo
Epoch 5/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.4581 - acc: 0.8470 - val_lo
Epoch 6/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.3268 - acc: 0.8976 - val_lo
Epoch 7/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.2447 - acc: 0.9347 - val_lo
Epoch 8/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.1873 - acc: 0.9600 - val_lo
Epoch 9/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.1455 - acc: 0.9729 - val_lo
Epoch 10/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.1235 - acc: 0.9813 - val_lo
2563/2563 [==============================] - 73s 28ms/step
Accuracy: 87.12%
```

```
In [39]: fig,ax = plt.subplots(1,1)
         ax.set_xlabel('Epochs') ; ax.set_ylabel('Loss')

         # list of epoch numbers
         list_of_epoch = list(range(1,10+1))

         train_loss = history.history['loss']
         val_loss = history.history['val_loss']
```

```
ax.plot(list_of_epoch, val_loss, 'g', label="Validation Loss")
ax.plot(list_of_epoch, train_loss, 'r', label="Training Loss")
plt.legend()
plt.grid()
plt.show();
```



7 3 layer LSTM Model with Dropout = 0.5

```
In [40]: from keras.layers import Dense, Dropout, Flatten
         from keras.layers.normalization import BatchNormalization
         from keras import regularizers

         embedding_vecor_length = 32
         top_words = 50000

         model = Sequential()
         model.add(Embedding(top_words+1, embedding_vecor_length, input_length=max_review_lengt
         model.add(LSTM(32, return_sequences=True, kernel_initializer = 'random_uniform',W_regu
         model.add(Dropout(0.5))
         model.add(LSTM(64,W_regularizer=regularizers.l2(0.001),return_sequences = True))
         model.add(Dropout(0.5))
         model.add(LSTM(128,W_regularizer=regularizers.l2(0.001), return_sequences = False))
         model.add(Dropout(0.5))
```

```
        model.add(Dense(1, activation='sigmoid'))

        model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
        print(model.summary())
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:10: UserWarning: Update your `LSTM
  # Remove the CWD from sys.path while we load stuff.
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:12: UserWarning: Update your `LSTM
  if sys.path[0] == '':
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:14: UserWarning: Update your `LSTM
```

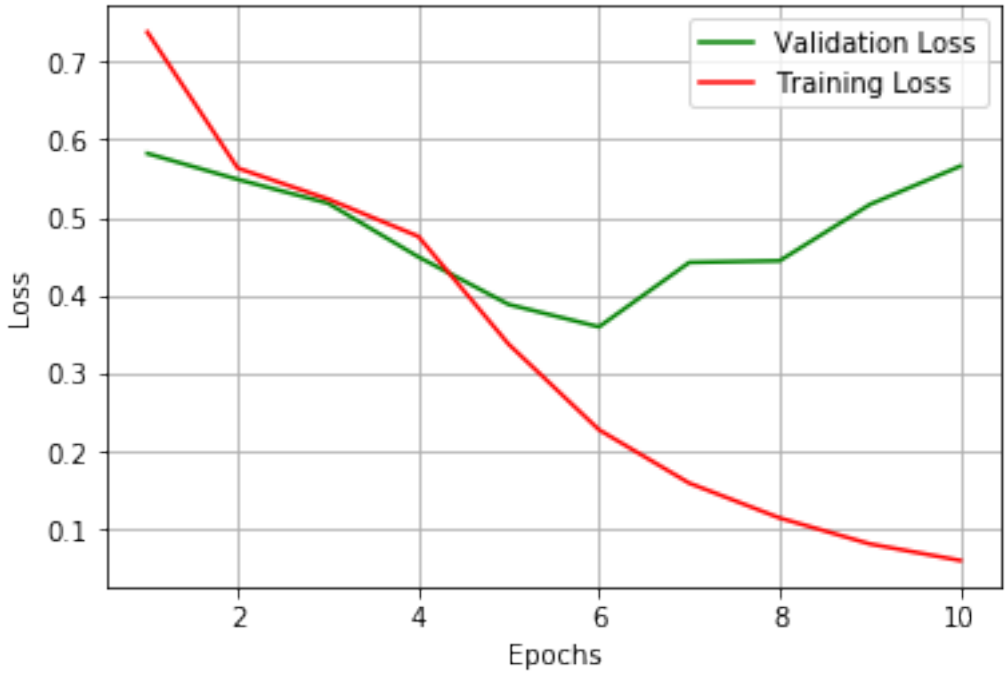
```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_9 (Embedding)      (None, 600, 32)           1600032
_________________________________________________________________
lstm_21 (LSTM)               (None, 600, 32)           8320
_________________________________________________________________
dropout_16 (Dropout)         (None, 600, 32)           0
_________________________________________________________________
lstm_22 (LSTM)               (None, 600, 64)           24832
_________________________________________________________________
dropout_17 (Dropout)         (None, 600, 64)           0
_________________________________________________________________
lstm_23 (LSTM)               (None, 128)               98816
_________________________________________________________________
dropout_18 (Dropout)         (None, 128)               0
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 129
=================================================================
Total params: 1,732,129
Trainable params: 1,732,129
Non-trainable params: 0
_________________________________________________________________
None
```

```
In [41]: history = model.fit(X_train, y_train, batch_size = 512, epochs = 10, verbose = 1, vali
         # Final evaluation of the model
         scores = model.evaluate(X_test, y_test, verbose=1)
         print("Accuracy: %.2f%%" % (scores[1]*100))
```

```
Train on 7000 samples, validate on 2563 samples
Epoch 1/10
7000/7000 [==============================] - 43s 6ms/step - loss: 0.7378 - acc: 0.8134 - val_lo
Epoch 2/10
7000/7000 [==============================] - 40s 6ms/step - loss: 0.5635 - acc: 0.8361 - val_lo
```

```
Epoch 3/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.5239 - acc: 0.8361 - val_lo
Epoch 4/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.4761 - acc: 0.8361 - val_lo
Epoch 5/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.3379 - acc: 0.8741 - val_lo
Epoch 6/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.2283 - acc: 0.9211 - val_lo
Epoch 7/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.1599 - acc: 0.9521 - val_lo
Epoch 8/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.1153 - acc: 0.9706 - val_lo
Epoch 9/10
7000/7000 [==============================] - 39s 6ms/step - loss: 0.0820 - acc: 0.9824 - val_lo
Epoch 10/10
7000/7000 [==============================] - 40s 6ms/step - loss: 0.0608 - acc: 0.9903 - val_lo
2563/2563 [==============================] - 73s 29ms/step
Accuracy: 86.62%
```

```
In [42]: fig,ax = plt.subplots(1,1)
         ax.set_xlabel('Epochs') ; ax.set_ylabel('Loss')

         # list of epoch numbers
         list_of_epoch = list(range(1,10+1))

         train_loss = history.history['loss']
         val_loss = history.history['val_loss']

         ax.plot(list_of_epoch, val_loss, 'g', label="Validation Loss")
         ax.plot(list_of_epoch, train_loss, 'r', label="Training Loss")
         plt.legend()
         plt.grid()
         plt.show();
```



---

8 Conclusion

- The data points used for training in this notebook is about 10k due to limited computing power.Accuracy can be further improved using more number of training data points.L2 regularization is useful to prevent overfitting in the 2 Layers LSTM model.

```
In [45]: from prettytable import PrettyTable

         x = PrettyTable()

         x.field_names = ["Numer of Layers","Dropout", "Accuracy"]

         x.add_row(["1","NO", '82.72%'])
         x.add_row(["2",0.5, '86.73%'])
         x.add_row(["2",0.8, '85.76%'])
         x.add_row(["2",0.2, '87.36%'])
         x.add_row(["3",0.8, '87.12%'])
         x.add_row(["3",0.5, '86.62%'])
```

```
print(x)
```

```
+-----------------+---------+----------+
| Numer of Layers | Dropout | Accuracy |
+-----------------+---------+----------+
|        1        |    NO   |  82.72%  |
|        2        |   0.5   |  86.73%  |
|        2        |   0.8   |  85.76%  |
|        2        |   0.2   |  87.36%  |
|        3        |   0.8   |  87.12%  |
|        3        |   0.5   |  86.62%  |
+-----------------+---------+----------+
```