SPAM SMS - CLASSIFICATION AND TOPIC MODELLING

1. SMS Classification

Reference:

https://machinelearningmastery.com/deep-learning-for-nlp/ (https://machinelearningmastery.com/deep-learning-for-nlp/)

https://machinelearningmastery.com/clean-text-machine-learning-python/?fbclid=IwAR1Zu4lFlGkdW7bdEZz01sLEo2VNj-7yhKN92ZLOqlTfeBQWC8XSiNkCpks (https://machinelearningmastery.com/clean-text-machine-learning-python/?fbclid=IwAR1Zu4lFlGkdW7bdEZz01sLEo2VNj-7yhKN92ZLOqlTfeBQWC8XSiNkCpks)

https://machinelearningmastery.com/develop-n-gram-multichannel-convolutional-neural-network-sentiment-analysis/?fbclid=IwAR2KthsKRrP9eZ_ezZQEse_5bwWJ8pH1r9DvXtv5UtCTRpvanuE6BbKtehU (https://machinelearningmastery.com/develop-n-gram-multichannel-convolutional-neural-network-sentiment-analysis/?fbclid=IwAR2KthsKRrP9eZ_ezZQEse_5bwWJ8pH1r9DvXtv5UtCTRpvanuE6BbKtehU)

About Dataset:

"The SMS Spam Collection is a set of SMS tagged messages that have been collected for SMS Spam research. It contains one set of SMS messages in English of 5,574 messages, tagged acording being ham (legitimate) or spam".

The files contain one message per line. Each line is composed by two columns: v1 contains the label (ham or spam) and v2 contains the raw text.

https://www.kaggle.com/uciml/sms-spam-collection-dataset (https://www.kaggle.com/uciml/sms-spam-collection-dataset)

Library and Data

In [1]:
```
import tensorflow as tf
```

In [118]:
```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix,f1_score

import string
import re
from nltk.corpus import stopwords

from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import Flatten
from keras.layers import Embedding
from keras.layers.convolutional import Conv1D
from keras.layers.convolutional import MaxPooling1D
from keras.utils  import to_categorical
from keras.layers import Input
from keras.layers import Dropout
from keras.layers.merge import concatenate
from keras.models import Model
from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import KFold
```

In [4]:
```
mydf = pd.read_csv('spam.csv',
                   encoding = "latin-1")
mydf = mydf.iloc[:,0:2]
```

Cleaning / Processing Text

In [5]:
```
### turn a doc into clean tokens
def clean_doc(doc):
    # split into tokens by white space
    tokens = doc.split()
    # prepare regex for char filtering
    re_punc = re.compile('[%s]' % re.escape(string.punctuation))
    # remove punctuation from each word
    tokens = [re_punc.sub('', w) for w in tokens]
    # remove remaining tokens that are not alphabetic
    tokens = [word for word in tokens if word.isalpha()]
    # filter out stop words
    stop_words = set(stopwords.words('english'))
    tokens = [w for w in tokens if not w in stop_words]
    # filter out short tokens
    tokens = [word for word in tokens if len(word) > 1]
    return tokens
```

In [6]:
```
#### fit a tokenizer
def create_tokenizer(lines):
    tokenizer = Tokenizer()
    tokenizer.fit_on_texts(lines)
    return tokenizer
```

In [7]:
```
import nltk
nltk.download('stopwords')
# Using the stopwords.
from nltk.corpus import stopwords
# Initialize the stopwords
stop_words = stopwords.words('english')
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\ADMIN\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

In [8]:
```
mydf['clean_text']=mydf['Text'].apply(lambda row : clean_doc(row))

mydf['Text_len'] = mydf['Text'].apply(lambda x: len(x) - x.count(" "))

mydf.drop("Text", axis=1, inplace=True)
```

In [9]:
```
X_train,X_test,y_train,y_test = train_test_split(mydf,mydf['Label'],test_size
=.15)
```

In [10]:
```
print(y_train.value_counts())
print(y_test.value_counts())
```

```
ham     4103
spam     633
Name: Label, dtype: int64
ham     722
spam    114
Name: Label, dtype: int64
```

In [11]:
```
max_length_train = mydf['clean_text'].apply(lambda x: len(x)).max()

train_docs = X_train['clean_text']

tokenizer_train = create_tokenizer(train_docs)

encoded_train = tokenizer_train.texts_to_sequences(train_docs)

padded_train = pad_sequences(encoded_train, maxlen=max_length_train, padding=
'post')

padded_train_df = pd.DataFrame(padded_train)
```

In [12]:
```
max_length_test = mydf['clean_text'].apply(lambda x: len(x)).max()

test_docs = X_test['clean_text']

encoded_test = tokenizer_train.texts_to_sequences(test_docs)

padded_test = pad_sequences(encoded_test, maxlen=max_length_test, padding='pos
t')

padded_test_df = pd.DataFrame(padded_test)
```

Model 1 - CNN With Embedding Layer

In [13]:
```
# define the model
def define_model(vocab_size, max_length):
    model = Sequential()
    model.add(Embedding(vocab_size, 100, input_length=max_length))
    model.add(Conv1D(filters=32, kernel_size=8, activation='relu'))
    model.add(MaxPooling1D(pool_size=2))
    model.add(Flatten())
    model.add(Dense(10, activation='relu'))
    model.add(Dense(1, activation='sigmoid'))
    # compile network
    model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accu
racy'])
    # summarize defined model
    model.summary()
    return model
```

In [14]:
```
y_train[y_train == 'ham'] = 0
y_train[y_train == 'spam'] = 1
to_categorical(y_train)
```

Out[14]:
```
array([[1., 0.],
       [1., 0.],
       [1., 0.],
       ...,
       [1., 0.],
       [1., 0.],
       [1., 0.]], dtype=float32)
```

In [15]:
```
y_test[y_test == 'ham'] = 0
y_test[y_test == 'spam'] = 1
to_categorical(y_test)
```

Out[15]:
```
array([[0., 1.],
       [1., 0.],
       [1., 0.],
       ...,
       [1., 0.],
       [1., 0.],
       [1., 0.]], dtype=float32)
```

In [16]:
```
max_length = mydf['clean_text'].apply(lambda x: len(x)).max()
max_length
```

Out[16]: 81

In [17]:
```
# define vocabulary size
vocab_size = len(tokenizer_train.word_index) + 1
print('Vocabulary size: %d' % vocab_size)
```

```
Vocabulary size: 7507
```

In [18]:
```
modelCNN = define_model(vocab_size, max_length)
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_1 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_1 (Dense)              (None, 10)                11850
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________
```

In [19]:
```
modelCNN.fit(padded_train_df, y_train, epochs=10, verbose=2)
```

```
C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "

Epoch 1/10
 - 3s - loss: 0.2844 - accuracy: 0.8752
Epoch 2/10
 - 3s - loss: 0.1174 - accuracy: 0.9842
Epoch 3/10
 - 3s - loss: 0.0940 - accuracy: 0.9937
Epoch 4/10
 - 3s - loss: 0.0820 - accuracy: 0.9975
Epoch 5/10
 - 3s - loss: 0.0740 - accuracy: 0.9983
Epoch 6/10
 - 3s - loss: 0.0671 - accuracy: 0.9985
Epoch 7/10
 - 3s - loss: 0.0622 - accuracy: 0.9985
Epoch 8/10
 - 3s - loss: 0.0559 - accuracy: 0.9989
Epoch 9/10
 - 3s - loss: 0.0524 - accuracy: 0.9987
Epoch 10/10
 - 3s - loss: 0.0470 - accuracy: 0.9994
```

Out[19]:
```
<keras.callbacks.callbacks.History at 0x1b3abfe83c8>
```

In [20]:
```
# evaluate model on train dataset
_, acc_train = modelCNN.evaluate(padded_train_df, y_train, verbose=0)
print('Train Accuracy: %f' % (acc_train*100))
```

```
Train Accuracy: 99.957770
```

In [21]:
```
# evaluate model on test dataset
_, acc_test = modelCNN.evaluate(padded_test_df, y_test, verbose=0)
print('Test Accuracy: %f' % (acc_test*100))
```

```
Test Accuracy: 98.923445
```

In [22]:
```
predict_test = np.round(modelCNN.predict(padded_test_df)).astype(int)
predict_test = predict_test.flatten()
predict_test = pd.Series(predict_test)
```

In [23]:
```
confusion_matrix(y_test.astype(int), predict_test)
tn, fp, fn, tp =confusion_matrix(y_test.astype(int), predict_test).ravel()
```

In [24]:
```
f1 = f1_score(y_test.astype(int), predict_test)
print('Test F1 Score: %f' % (f1*100))
```

```
Test F1 Score: 95.890411
```

Model 1 is CNN With Embedding Layer.

Model 1 has 100% Accuracy on Trainset and 98.9% Accuracy on Testset.

The Dataset is Imbalanced so F1-Score of Model 1 on Testset is 96.0%.

Tuning Model 1

Tuning Parameters Batch_Size and Epochs for Model 1 for Better Deep Learning model performance

In [25]:
```
# define the model
def define_model1():
    model = Sequential()
    model.add(Embedding(vocab_size, 100, input_length=max_length))
    model.add(Conv1D(filters=32, kernel_size=8, activation='relu'))
    model.add(MaxPooling1D(pool_size=2))
    model.add(Flatten())
    model.add(Dense(10, activation='relu'))
    model.add(Dense(1, activation='sigmoid'))
    # compile network
    model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accu
racy'])
    # summarize defined model
    model.summary()
    return model
```

In [26]:
```
# Create a KerasClassifier
model1 = KerasClassifier(build_fn = define_model1)
```

In [30]:
```
# Define the parameters to try out
params1 = {
            'batch_size': [6,10,14,18],
            'epochs': [2,4,6,8,10]
          }
```

In [31]:
```
random_search1 = RandomizedSearchCV(model1, param_distributions = params1, cv
= KFold(5))
```

In [32]:
```
random_search1.fit(padded_train_df, y_train, verbose = 1)
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_2 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_2 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_2 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_2 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_3 (Dense)              (None, 10)                11850
_________________________________________________________________
dense_4 (Dense)              (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.1986 - acc
uracy: 0.9205
Epoch 2/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0289 - acc
uracy: 0.9926
Epoch 3/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0059 - acc
uracy: 0.9989
Epoch 4/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0033 - acc
uracy: 0.9992
Epoch 5/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0020 - acc
uracy: 0.9995
Epoch 6/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0018 - acc
uracy: 0.9997
Epoch 7/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0016 - acc
uracy: 0.9995
Epoch 8/8
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0012 - acc
uracy: 0.9997
948/948 [==============================] - 0s 189us/step
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_3 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_3 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_3 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_3 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_5 (Dense)              (None, 10)                11850
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.2247 - acc
uracy: 0.9232
Epoch 2/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0743 - acc
uracy: 0.9913
Epoch 3/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0146 - acc
uracy: 0.9968
Epoch 4/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0059 - acc
uracy: 0.9987
Epoch 5/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0033 - acc
uracy: 0.9995
Epoch 6/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0036 - acc
uracy: 0.9992
Epoch 7/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0028 - acc
uracy: 0.9995
Epoch 8/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0014 - acc
uracy: 0.9997
947/947 [==============================] - 0s 167us/step
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_4 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_4 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_4 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_4 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_7 (Dense)              (None, 10)                11850
_________________________________________________________________
dense_8 (Dense)              (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.2218 - acc
uracy: 0.9219
Epoch 2/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.1051 - acc
uracy: 0.9900
Epoch 3/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0569 - acc
uracy: 0.9952
Epoch 4/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0108 - acc
uracy: 0.9971
Epoch 5/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0032 - acc
uracy: 0.9995
Epoch 6/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0020 - acc
uracy: 0.9997
Epoch 7/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0017 - acc
uracy: 0.9997
Epoch 8/8
3789/3789 [==============================] - 6s 1ms/step - loss: 0.0018 - acc
uracy: 0.9995
947/947 [==============================] - 0s 211us/step
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_5 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_5 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_5 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_5 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_9 (Dense)              (None, 10)                11850
_________________________________________________________________
dense_10 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.2241 - acc
uracy: 0.9155
Epoch 2/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0998 - acc
uracy: 0.9934
Epoch 3/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0777 - acc
uracy: 0.9979
Epoch 4/8
3789/3789 [==============================] - ETA: 0s - loss: 0.0670 - accurac
y: 0.99 - 5s 1ms/step - loss: 0.0667 - accuracy: 0.9987
Epoch 5/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0436 - acc
uracy: 0.9997
Epoch 6/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0017 - acc
uracy: 0.9997 ETA: 3s - loss: 1.728
Epoch 7/8
3789/3789 [==============================] - 5s 1ms/step - loss: 9.0033e-04 -
accuracy: 0.9997
Epoch 8/8
3789/3789 [==============================] - 5s 1ms/step - loss: 1.7885e-04 -
accuracy: 1.0000
947/947 [==============================] - 0s 167us/step
Model: "sequential_6"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_6 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_6 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_6 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_6 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_11 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_12 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.1719 - acc
uracy: 0.9393
Epoch 2/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0243 - acc
uracy: 0.9923
Epoch 3/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0081 - acc
uracy: 0.9984
Epoch 4/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0033 - acc
uracy: 0.9995
Epoch 5/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0028 - acc
uracy: 0.9995
Epoch 6/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0022 - acc
uracy: 0.9997
Epoch 7/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0025 - acc
uracy: 0.9997
Epoch 8/8
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0021 - acc
uracy: 0.9997
947/947 [==============================] - 0s 169us/step
Model: "sequential_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_7 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_7 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_7 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_7 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_13 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_14 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.2560 - acc
uracy: 0.8989
Epoch 2/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.1112 - acc
uracy: 0.9865
Epoch 3/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0857 - acc
uracy: 0.9950
Epoch 4/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0743 - acc
uracy: 0.9971
Epoch 5/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0653 - acc
uracy: 0.9974
Epoch 6/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0583 - acc
uracy: 0.9987
Epoch 7/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0512 - acc
uracy: 0.9989
Epoch 8/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0462 - acc
uracy: 0.9989
Epoch 9/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0408 - acc
uracy: 0.9992
Epoch 10/10
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0371 - acc
uracy: 0.9992
948/948 [==============================] - 0s 108us/step
Model: "sequential_8"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_8 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_8 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_8 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_8 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_15 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_16 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2329 - acc
uracy: 0.9158
Epoch 2/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1074 - acc
uracy: 0.9889
Epoch 3/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0860 - acc
uracy: 0.9955
Epoch 4/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0747 - acc
uracy: 0.9976
Epoch 5/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0655 - acc
uracy: 0.9982
Epoch 6/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0583 - acc
uracy: 0.9984
Epoch 7/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0517 - acc
uracy: 0.9984
Epoch 8/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0466 - acc
uracy: 0.9984
Epoch 9/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0115 - acc
uracy: 0.9976
Epoch 10/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0030 - acc
uracy: 0.9995
947/947 [==============================] - 0s 126us/step
Model: "sequential_9"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_9 (Embedding)      (None, 81, 100)           750700
_________________________________________________________________
conv1d_9 (Conv1D)            (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_9 (MaxPooling1 (None, 37, 32)            0
_________________________________________________________________
flatten_9 (Flatten)          (None, 1184)              0
_________________________________________________________________
dense_17 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_18 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2342 - acc
uracy: 0.9148
Epoch 2/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1044 - acc
uracy: 0.9905
Epoch 3/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0839 - acc
uracy: 0.9952
Epoch 4/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0720 - acc
uracy: 0.9971
Epoch 5/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0645 - acc
uracy: 0.9979
Epoch 6/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0554 - acc
uracy: 0.9987
Epoch 7/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0488 - acc
uracy: 0.9992
Epoch 8/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0438 - acc
uracy: 0.9992
Epoch 9/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0388 - acc
uracy: 0.9995
Epoch 10/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0361 - acc
uracy: 0.9987
947/947 [==============================] - 0s 110us/step
Model: "sequential_10"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_10 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_10 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_10 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_10 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_19 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_20 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2343 - acc
uracy: 0.9150
Epoch 2/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1018 - acc
uracy: 0.9892
Epoch 3/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0285 - acc
uracy: 0.9955
Epoch 4/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0041 - acc
uracy: 0.9992
Epoch 5/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0023 - acc
uracy: 0.9995
Epoch 6/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0018 - acc
uracy: 0.9997
Epoch 7/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0013 - acc
uracy: 0.9997
Epoch 8/10
3789/3789 [==============================] - 4s 1ms/step - loss: 9.8121e-04 -
accuracy: 0.9997
Epoch 9/10
3789/3789 [==============================] - 4s 1ms/step - loss: 3.2913e-04 -
accuracy: 0.9997
Epoch 10/10
3789/3789 [==============================] - 4s 1ms/step - loss: 8.2907e-04 -
accuracy: 0.9997
947/947 [==============================] - 0s 118us/step
Model: "sequential_11"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_11 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_11 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_11 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_11 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_21 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_22 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2347 - acc
uracy: 0.9129TA: 0s - loss: 0.2
Epoch 2/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1075 - acc
uracy: 0.9910: 0s - loss: 0.104
Epoch 3/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0858 - acc
uracy: 0.9950
Epoch 4/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0718 - acc
uracy: 0.9974
Epoch 5/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0635 - acc
uracy: 0.9979: 1s - ETA: 0s - loss: 0.0648 - accuracy
Epoch 6/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0569 - acc
uracy: 0.9984
Epoch 7/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0510 - acc
uracy: 0.9984
Epoch 8/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0453 - acc
uracy: 0.9989
Epoch 9/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0404 - acc
uracy: 0.9989
Epoch 10/10
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0372 - acc
uracy: 0.9989
947/947 [==============================] - 0s 115us/step
Model: "sequential_12"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_12 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_12 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_12 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_12 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_23 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_24 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.2055 - acc
uracy: 0.9340
Epoch 2/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0947 - acc
uracy: 0.9916
Epoch 3/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0701 - acc
uracy: 0.9968
Epoch 4/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0581 - acc
uracy: 0.9984
Epoch 5/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0478 - acc
uracy: 0.9987
Epoch 6/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0397 - acc
uracy: 0.9989
Epoch 7/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0066 - acc
uracy: 0.9989
Epoch 8/10
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0032 - acc
uracy: 0.9989
Epoch 9/10
3788/3788 [==============================] - 7s 2ms/step - loss: 9.7931e-04 -
accuracy: 0.9997 - loss: 0.001
Epoch 10/10
3788/3788 [==============================] - 6s 2ms/step - loss: 0.0016 - acc
uracy: 0.9995
948/948 [==============================] - 0s 190us/step
Model: "sequential_13"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_13 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_13 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_13 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_13 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_25 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_26 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.2118 - acc
uracy: 0.9293
Epoch 2/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0965 - acc
uracy: 0.9910
Epoch 3/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0734 - acc
uracy: 0.9963
Epoch 4/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0479 - acc
uracy: 0.9974
Epoch 5/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0105 - acc
uracy: 0.9974
Epoch 6/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0018 - acc
uracy: 0.9995
Epoch 7/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0021 - acc
uracy: 0.9995
Epoch 8/10
3789/3789 [==============================] - 6s 2ms/step - loss: 9.1156e-04 -
accuracy: 0.9995
Epoch 9/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0013 - acc
uracy: 0.9997
Epoch 10/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0010 - acc
uracy: 0.9992
947/947 [==============================] - 0s 189us/step
Model: "sequential_14"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_14 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_14 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_14 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_14 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_27 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_28 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.1847 - acc
uracy: 0.9369
Epoch 2/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0258 - acc
uracy: 0.9931
Epoch 3/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0081 - acc
uracy: 0.9982
Epoch 4/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0041 - acc
uracy: 0.9995
Epoch 5/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0032 - acc
uracy: 0.9995
Epoch 6/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0023 - acc
uracy: 0.9992
Epoch 7/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0015 - acc
uracy: 0.9995
Epoch 8/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0014 - acc
uracy: 0.9997
Epoch 9/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0013 - acc
uracy: 0.9997
Epoch 10/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0013 - acc
uracy: 0.9997
947/947 [==============================] - 0s 182us/step
Model: "sequential_15"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_15 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_15 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_15 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_15 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_29 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_30 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 7s 2ms/step - loss: 0.1869 - acc
uracy: 0.9375: 0s - loss: 0.1890 - accuracy:
Epoch 2/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0246 - acc
uracy: 0.9934
Epoch 3/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0047 - acc
uracy: 0.9987
Epoch 4/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0018 - acc
uracy: 0.9997
Epoch 5/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0017 - acc
uracy: 0.9995
Epoch 6/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0012 - acc
uracy: 0.9997
Epoch 7/10
3789/3789 [==============================] - 6s 2ms/step - loss: 7.2206e-05 -
accuracy: 1.0000
Epoch 8/10
3789/3789 [==============================] - 6s 2ms/step - loss: 6.0084e-05 -
accuracy: 1.0000
Epoch 9/10
3789/3789 [==============================] - 6s 2ms/step - loss: 3.5437e-05 -
accuracy: 1.0000
Epoch 10/10
3789/3789 [==============================] - 6s 2ms/step - loss: 2.4943e-05 -
accuracy: 1.0000
947/947 [==============================] - 0s 193us/step
Model: "sequential_16"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_16 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_16 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_16 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_16 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_31 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_32 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.1889 - acc
uracy: 0.9274
Epoch 2/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0292 - acc
uracy: 0.9918
Epoch 3/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0058 - acc
uracy: 0.9987
Epoch 4/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0029 - acc
uracy: 0.9997
Epoch 5/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0024 - acc
uracy: 0.9997
Epoch 6/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0023 - acc
uracy: 0.9997
Epoch 7/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0019 - acc
uracy: 0.9997
Epoch 8/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0023 - acc
uracy: 0.9997
Epoch 9/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0016 - acc
uracy: 0.9997
Epoch 10/10
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0015 - acc
uracy: 0.9997
947/947 [==============================] - 0s 217us/step
Model: "sequential_17"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_17 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_17 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_17 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_17 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_33 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_34 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3788/3788 [==============================] - 7s 2ms/step - loss: 0.1800 - acc
uracy: 0.9345
Epoch 2/4
3788/3788 [==============================] - 6s 2ms/step - loss: 0.0216 - acc
uracy: 0.9939
Epoch 3/4
3788/3788 [==============================] - 6s 2ms/step - loss: 0.0055 - acc
uracy: 0.9989
Epoch 4/4
3788/3788 [==============================] - 6s 2ms/step - loss: 0.0038 - acc
uracy: 0.9995
948/948 [==============================] - 0s 188us/step
Model: "sequential_18"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_18 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_18 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_18 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_18 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_35 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_36 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 7s 2ms/step - loss: 0.2134 - acc
uracy: 0.9256
Epoch 2/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0984 - acc
uracy: 0.9905
Epoch 3/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0784 - acc
uracy: 0.9952
Epoch 4/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0603 - acc
uracy: 0.9979
947/947 [==============================] - 0s 185us/step
Model: "sequential_19"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_19 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_19 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_19 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_19 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_37 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_38 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.1950 - acc
uracy: 0.9396
Epoch 2/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0961 - acc
uracy: 0.9908
Epoch 3/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0713 - acc
uracy: 0.9971
Epoch 4/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0570 - acc
uracy: 0.9984
947/947 [==============================] - 0s 220us/step
Model: "sequential_20"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_20 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_20 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_20 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_20 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_39 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_40 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.2247 - acc
uracy: 0.9169
Epoch 2/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0984 - acc
uracy: 0.9905: 0s - loss: 0.1015 - accuracy:  - ETA: 0s - loss: 0.1009
Epoch 3/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0754 - acc
uracy: 0.9950
Epoch 4/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0623 - acc
uracy: 0.9974
947/947 [==============================] - 0s 186us/step
Model: "sequential_21"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_21 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_21 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_21 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_21 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_41 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_42 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 7s 2ms/step - loss: 0.1678 - acc
uracy: 0.9364
Epoch 2/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0242 - acc
uracy: 0.9937
Epoch 3/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0057 - acc
uracy: 0.9989
Epoch 4/4
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0023 - acc
uracy: 0.9995
947/947 [==============================] - 0s 188us/step
Model: "sequential_22"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_22 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_22 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_22 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_22 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_43 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_44 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/2
3788/3788 [==============================] - 6s 2ms/step - loss: 0.1684 - acc
uracy: 0.9446
Epoch 2/2
3788/3788 [==============================] - 6s 2ms/step - loss: 0.0271 - acc
uracy: 0.9918
948/948 [==============================] - 0s 186us/step
Model: "sequential_23"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_23 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_23 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_23 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_23 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_45 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_46 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/2
3789/3789 [==============================] - 6s 2ms/step - loss: 0.2245 - acc
uracy: 0.9240
Epoch 2/2
3789/3789 [==============================] - 6s 2ms/step - loss: 0.1025 - acc
uracy: 0.9900
947/947 [==============================] - 0s 217us/step
Model: "sequential_24"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_24 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_24 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_24 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_24 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_47 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_48 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/2
3789/3789 [==============================] - 7s 2ms/step - loss: 0.1968 - acc
uracy: 0.9390
Epoch 2/2
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0970 - acc
uracy: 0.9897: 0s - loss: 0.0956 - accu
947/947 [==============================] - 0s 201us/step
Model: "sequential_25"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_25 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_25 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_25 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_25 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_49 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_50 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/2
3789/3789 [==============================] - 7s 2ms/step - loss: 0.2038 - acc
uracy: 0.9324
Epoch 2/2
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0952 - acc
uracy: 0.9910
947/947 [==============================] - 0s 201us/step
Model: "sequential_26"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_26 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_26 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_26 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_26 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_51 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_52 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/2
3789/3789 [==============================] - 7s 2ms/step - loss: 0.2043 - acc
uracy: 0.9314
Epoch 2/2
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0994 - acc
uracy: 0.9902
947/947 [==============================] - 0s 195us/step
Model: "sequential_27"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_27 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_27 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_27 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_27 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_53 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_54 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3788/3788 [==============================] - 10s 3ms/step - loss: 0.1949 - ac
curacy: 0.9414
Epoch 2/4
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0883 - ac
curacy: 0.9902
Epoch 3/4
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0632 - ac
curacy: 0.9963
Epoch 4/4
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0489 - ac
curacy: 0.9976
948/948 [==============================] - 0s 233us/step
Model: "sequential_28"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_28 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_28 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_28 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_28 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_55 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_56 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.1982 - ac
curacy: 0.9385
Epoch 2/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0885 - ac
curacy: 0.9910
Epoch 3/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0618 - ac
curacy: 0.9968
Epoch 4/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0491 - ac
curacy: 0.9958
947/947 [==============================] - 0s 239us/step
Model: "sequential_29"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_29 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_29 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_29 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_29 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_57 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_58 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.1994 - ac
curacy: 0.9404
Epoch 2/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0577 - ac
curacy: 0.9923
Epoch 3/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0109 - ac
curacy: 0.9968
Epoch 4/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0033 - ac
curacy: 0.9992
947/947 [==============================] - 0s 220us/step
Model: "sequential_30"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_30 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_30 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_30 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_30 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_59 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_60 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 11s 3ms/step - loss: 0.1320 - ac
curacy: 0.9554
Epoch 2/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0167 - ac
curacy: 0.9963
Epoch 3/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0046 - ac
curacy: 0.9989
Epoch 4/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0026 - ac
curacy: 0.9995
947/947 [==============================] - 0s 226us/step
Model: "sequential_31"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_31 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_31 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_31 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_31 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_61 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_62 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.1557 - ac
curacy: 0.9448
Epoch 2/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0222 - ac
curacy: 0.9926
Epoch 3/4
3789/3789 [==============================] - 11s 3ms/step - loss: 0.0085 - ac
curacy: 0.9976
Epoch 4/4
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0027 - ac
curacy: 0.9997
947/947 [==============================] - 0s 240us/step
Model: "sequential_32"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_32 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_32 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_32 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_32 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_63 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_64 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.1726 - acc
uracy: 0.9388
Epoch 2/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0270 - acc
uracy: 0.9918
Epoch 3/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0061 - acc
uracy: 0.9987
Epoch 4/8
3788/3788 [==============================] - 6s 2ms/step - loss: 0.0039 - acc
uracy: 0.9995
Epoch 5/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0024 - acc
uracy: 0.9995
Epoch 6/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0016 - acc
uracy: 0.9995
Epoch 7/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0014 - acc
uracy: 0.9997
Epoch 8/8
3788/3788 [==============================] - 7s 2ms/step - loss: 0.0014 - acc
uracy: 0.9995
948/948 [==============================] - 0s 204us/step
Model: "sequential_33"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_33 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_33 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_33 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_33 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_65 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_66 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.1808 - acc
uracy: 0.9319
Epoch 2/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0228 - acc
uracy: 0.9942
Epoch 3/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0073 - acc
uracy: 0.9989
Epoch 4/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0042 - acc
uracy: 0.9992
Epoch 5/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0026 - acc
uracy: 0.9995
Epoch 6/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0019 - acc
uracy: 0.9995
Epoch 7/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0015 - acc
uracy: 0.9995
Epoch 8/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0011 - acc
uracy: 0.9995
947/947 [==============================] - 0s 192us/step
Model: "sequential_34"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_34 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_34 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_34 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_34 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_67 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_68 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.2332 - acc
uracy: 0.9155
Epoch 2/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.1011 - acc
uracy: 0.9892
Epoch 3/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0170 - acc
uracy: 0.9955
Epoch 4/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0050 - acc
uracy: 0.9989
Epoch 5/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0034 - acc
uracy: 0.9995
Epoch 6/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0019 - acc
uracy: 0.9995
Epoch 7/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0018 - acc
uracy: 0.9997
Epoch 8/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0012 - acc
uracy: 0.9997
947/947 [==============================] - 0s 208us/step
Model: "sequential_35"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_35 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_35 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_35 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_35 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_69 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_70 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.1985 - acc
uracy: 0.9327
Epoch 2/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0967 - acc
uracy: 0.9916
Epoch 3/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0707 - acc
uracy: 0.9971
Epoch 4/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0574 - acc
uracy: 0.9984
Epoch 5/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0517 - acc
uracy: 0.9968
Epoch 6/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0248 - acc
uracy: 0.9984
Epoch 7/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0016 - acc
uracy: 0.9995
Epoch 8/8
3789/3789 [==============================] - 6s 2ms/step - loss: 2.1771e-04 -
accuracy: 1.0000
947/947 [==============================] - 0s 190us/step
Model: "sequential_36"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_36 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_36 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_36 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_36 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_71 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_72 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.2104 - acc
uracy: 0.9303
Epoch 2/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0987 - acc
uracy: 0.9897
Epoch 3/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0740 - acc
uracy: 0.9963
Epoch 4/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0594 - acc
uracy: 0.9971
Epoch 5/8
3789/3789 [==============================] - 7s 2ms/step - loss: 0.0486 - acc
uracy: 0.9989
Epoch 6/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0415 - acc
uracy: 0.9987: 0s - loss: 0.0416 - accuracy: 0.
Epoch 7/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0110 - acc
uracy: 0.9984
Epoch 8/8
3789/3789 [==============================] - 6s 2ms/step - loss: 0.0028 - acc
uracy: 0.9997
947/947 [==============================] - 0s 188us/step
Model: "sequential_37"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_37 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_37 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_37 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_37 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_73 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_74 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3788/3788 [==============================] - 4s 1ms/step - loss: 0.2248 - acc
uracy: 0.9190
Epoch 2/4
3788/3788 [==============================] - 4s 1ms/step - loss: 0.1066 - acc
uracy: 0.9884
Epoch 3/4
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0823 - acc
uracy: 0.9960
Epoch 4/4
3788/3788 [==============================] - 4s 1ms/step - loss: 0.0714 - acc
uracy: 0.9968
948/948 [==============================] - 0s 112us/step
Model: "sequential_38"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_38 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_38 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_38 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_38 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_75 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_76 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2406 - acc
uracy: 0.9055
Epoch 2/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1080 - acc
uracy: 0.9913: 0s - loss: 0.110
Epoch 3/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0854 - acc
uracy: 0.9963
Epoch 4/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0742 - acc
uracy: 0.9971
947/947 [==============================] - 0s 111us/step
Model: "sequential_39"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_39 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_39 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_39 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_39 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_77 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_78 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2730 - acc
uracy: 0.8841
Epoch 2/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1172 - acc
uracy: 0.9857
Epoch 3/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0903 - acc
uracy: 0.9955
Epoch 4/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0781 - acc
uracy: 0.9966
947/947 [==============================] - 0s 107us/step
Model: "sequential_40"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_40 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_40 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_40 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_40 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_79 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_80 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2240 - acc
uracy: 0.9184
Epoch 2/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1007 - acc
uracy: 0.9916
Epoch 3/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0815 - acc
uracy: 0.9963
Epoch 4/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0706 - acc
uracy: 0.9974
947/947 [==============================] - 0s 107us/step
Model: "sequential_41"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_41 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_41 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_41 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_41 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_81 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_82 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.2456 - acc
uracy: 0.9055
Epoch 2/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.1104 - acc
uracy: 0.9900
Epoch 3/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0849 - acc
uracy: 0.9968
Epoch 4/4
3789/3789 [==============================] - 4s 1ms/step - loss: 0.0722 - acc
uracy: 0.9984
947/947 [==============================] - 0s 108us/step
Model: "sequential_42"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_42 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_42 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_42 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_42 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_83 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_84 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/6
3788/3788 [==============================] - 5s 1ms/step - loss: 0.2047 - acc
uracy: 0.9187
Epoch 2/6
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0304 - acc
uracy: 0.9929
Epoch 3/6
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0070 - acc
uracy: 0.9987
Epoch 4/6
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0040 - acc
uracy: 0.9995
Epoch 5/6
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0038 - acc
uracy: 0.9995
Epoch 6/6
3788/3788 [==============================] - 5s 1ms/step - loss: 0.0022 - acc
uracy: 0.9995
948/948 [==============================] - 0s 182us/step
Model: "sequential_43"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_43 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_43 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_43 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_43 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_85 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_86 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/6
3789/3789 [==============================] - 6s 2ms/step - loss: 0.1729 - acc
uracy: 0.9388
Epoch 2/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0260 - acc
uracy: 0.9923
Epoch 3/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0076 - acc
uracy: 0.9987
Epoch 4/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0047 - acc
uracy: 0.9989
Epoch 5/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0033 - acc
uracy: 0.9995
Epoch 6/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0020 - acc
uracy: 0.9995
947/947 [==============================] - 0s 214us/step
Model: "sequential_44"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_44 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_44 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_44 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_44 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_87 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_88 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/6
3789/3789 [==============================] - 6s 1ms/step - loss: 0.2364 - acc
uracy: 0.9076
Epoch 2/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0460 - acc
uracy: 0.9897
Epoch 3/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0099 - acc
uracy: 0.9974
Epoch 4/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0043 - acc
uracy: 0.9992
Epoch 5/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0032 - acc
uracy: 0.9995
Epoch 6/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0021 - acc
uracy: 0.9995
947/947 [==============================] - 0s 186us/step
Model: "sequential_45"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_45 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_45 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_45 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_45 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_89 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_90 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.2309 - acc
uracy: 0.9169
Epoch 2/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.1025 - acc
uracy: 0.9900
Epoch 3/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0798 - acc
uracy: 0.9960
Epoch 4/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0212 - acc
uracy: 0.9976
Epoch 5/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0048 - acc
uracy: 0.9989
Epoch 6/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0017 - acc
uracy: 0.9995
947/947 [==============================] - 0s 177us/step
Model: "sequential_46"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_46 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_46 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_46 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_46 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_91 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_92 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.1782 - acc
uracy: 0.9385: 0s - loss: 0.1887 - ac
Epoch 2/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0265 - acc
uracy: 0.9923
Epoch 3/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0084 - acc
uracy: 0.9979
Epoch 4/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0040 - acc
uracy: 0.9992
Epoch 5/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0022 - acc
uracy: 0.9997
Epoch 6/6
3789/3789 [==============================] - 5s 1ms/step - loss: 0.0021 - acc
uracy: 0.9997
947/947 [==============================] - 0s 176us/step
Model: "sequential_47"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_47 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_47 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_47 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_47 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_93 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_94 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.1902 - ac
curacy: 0.9435
Epoch 2/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0892 - ac
curacy: 0.9908
Epoch 3/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0643 - ac
curacy: 0.9947
Epoch 4/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0473 - ac
curacy: 0.9971
Epoch 5/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0383 - ac
curacy: 0.9971
Epoch 6/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0283 - ac
curacy: 0.9979
Epoch 7/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0125 - ac
curacy: 0.9958
Epoch 8/8
3788/3788 [==============================] - 10s 3ms/step - loss: 0.0019 - ac
curacy: 0.9995
948/948 [==============================] - 0s 235us/step
Model: "sequential_48"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_48 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_48 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_48 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_48 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_95 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_96 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.1955 - ac
curacy: 0.9364
Epoch 2/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0293 - ac
curacy: 0.9918
Epoch 3/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0060 - ac
curacy: 0.9989
Epoch 4/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0038 - ac
curacy: 0.9989
Epoch 5/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0025 - ac
curacy: 0.9995
Epoch 6/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0018 - ac
curacy: 0.9992
Epoch 7/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0021 - ac
curacy: 0.9992
Epoch 8/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0031 - ac
curacy: 0.9992
947/947 [==============================] - 0s 286us/step
Model: "sequential_49"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_49 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_49 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_49 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_49 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_97 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_98 (Dense)             (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 11s 3ms/step - loss: 0.1971 - ac
curacy: 0.9388
Epoch 2/8
3789/3789 [==============================] - 11s 3ms/step - loss: 0.0918 - ac
curacy: 0.9894
Epoch 3/8
3789/3789 [==============================] - 11s 3ms/step - loss: 0.0645 - ac
curacy: 0.9952
Epoch 4/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0492 - ac
curacy: 0.9971
Epoch 5/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0375 - ac
curacy: 0.9971
Epoch 6/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0078 - ac
curacy: 0.9968
Epoch 7/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0025 - ac
curacy: 0.9989 0s - loss: 0.0026 - accu
Epoch 8/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0011 - ac
curacy: 0.9997
947/947 [==============================] - 0s 237us/step
Model: "sequential_50"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_50 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_50 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_50 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_50 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_99 (Dense)             (None, 10)                11850
_________________________________________________________________
dense_100 (Dense)            (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.1946 - ac
curacy: 0.9422
Epoch 2/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0879 - ac
curacy: 0.9908
Epoch 3/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0618 - ac
curacy: 0.9966
Epoch 4/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0477 - ac
curacy: 0.9968
Epoch 5/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0393 - ac
curacy: 0.9968
Epoch 6/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0272 - ac
curacy: 0.9971
Epoch 7/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0112 - ac
curacy: 0.9968
Epoch 8/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0017 - ac
curacy: 0.9995
947/947 [==============================] - 0s 232us/step
Model: "sequential_51"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_51 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_51 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_51 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_51 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_101 (Dense)            (None, 10)                11850
_________________________________________________________________
dense_102 (Dense)            (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.1491 - ac
curacy: 0.9470
Epoch 2/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0204 - ac
curacy: 0.9934
Epoch 3/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0043 - ac
curacy: 0.9989
Epoch 4/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0024 - ac
curacy: 0.9997
Epoch 5/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0016 - ac
curacy: 0.9997
Epoch 6/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0018 - ac
curacy: 0.9997
Epoch 7/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0016 - ac
curacy: 0.9997
Epoch 8/8
3789/3789 [==============================] - 10s 3ms/step - loss: 0.0032 - ac
curacy: 0.9992
947/947 [==============================] - 0s 235us/step
Model: "sequential_52"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_52 (Embedding)     (None, 81, 100)           750700
_________________________________________________________________
conv1d_52 (Conv1D)           (None, 74, 32)            25632
_________________________________________________________________
max_pooling1d_52 (MaxPooling (None, 37, 32)            0
_________________________________________________________________
flatten_52 (Flatten)         (None, 1184)              0
_________________________________________________________________
dense_103 (Dense)            (None, 10)                11850
_________________________________________________________________
dense_104 (Dense)            (None, 1)                 11
=================================================================
Total params: 788,193
Trainable params: 788,193
Non-trainable params: 0
_________________________________________________________________

C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "
```

```
Epoch 1/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.1953 - acc
uracy: 0.9379
Epoch 2/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0888 - acc
uracy: 0.9924
Epoch 3/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0672 - acc
uracy: 0.9966: 0s - loss:
Epoch 4/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0538 - acc
uracy: 0.9975
Epoch 5/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0078 - acc
uracy: 0.9983
Epoch 6/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0021 - acc
uracy: 0.9992
Epoch 7/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0028 - acc
uracy: 0.9994
Epoch 8/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0016 - acc
uracy: 0.9994
Epoch 9/10
4736/4736 [==============================] - 8s 2ms/step - loss: 9.5305e-04 -
accuracy: 0.9998
Epoch 10/10
4736/4736 [==============================] - 8s 2ms/step - loss: 0.0012 - acc
uracy: 0.9998
```

Out[32]:
```
RandomizedSearchCV(cv=KFold(n_splits=5, random_state=None, shuffle=False),
                   error_score=nan,
                   estimator=<keras.wrappers.scikit_learn.KerasClassifier obj
ect at 0x000001B3AC1F5D08>,
                   iid='deprecated', n_iter=10, n_jobs=None,
                   param_distributions={'batch_size': [6, 10, 14, 18],
                                        'epochs': [2, 4, 6, 8, 10]},
                   pre_dispatch='2*n_jobs', random_state=None, refit=True,
                   return_train_score=False, scoring=None, verbose=0)
```

In [39]:
```
random_search1.best_params_
```

Out[39]:
```
{'epochs': 10, 'batch_size': 10}
```

After tuning, the Best Parameters of Model are epochs=10,batch_size=10

In [40]:
```
modelCNN.fit(padded_train_df, y_train, epochs=10,batch_size=10, verbose=2)
```

```
Epoch 1/10
 - 8s - loss: 0.0113 - accuracy: 0.9992
Epoch 2/10
 - 8s - loss: 0.0023 - accuracy: 0.9994
Epoch 3/10
 - 8s - loss: 0.0011 - accuracy: 0.9996
Epoch 4/10
 - 8s - loss: 0.0015 - accuracy: 0.9996
Epoch 5/10
 - 8s - loss: 0.0013 - accuracy: 0.9996
Epoch 6/10
 - 8s - loss: 8.0348e-04 - accuracy: 0.9996
Epoch 7/10
 - 8s - loss: 0.0014 - accuracy: 0.9996
Epoch 8/10
 - 8s - loss: 0.0011 - accuracy: 0.9996
Epoch 9/10
 - 8s - loss: 7.5628e-04 - accuracy: 0.9998
Epoch 10/10
 - 8s - loss: 8.5526e-04 - accuracy: 0.9998
```

Out[40]:
```
<keras.callbacks.callbacks.History at 0x1b3c6c14c08>
```

In [41]:
```
# evaluate model on test dataset
_, acc_test_tune = modelCNN.evaluate(padded_test_df, y_test, verbose=0)
print('Test Accuracy: %f' % (acc_test_tune*100))
```

```
Test Accuracy: 98.205739
```

In [43]:
```
predict_test_tune = np.round(modelCNN.predict(padded_test_df)).astype(int)
```

In [44]:
```
predict_test_tune = predict_test_tune.flatten()
predict_test_tune = pd.Series(predict_test_tune)
```

In [45]:
```
f1_tune = f1_score(y_test.astype(int), predict_test_tune)
print('Test F1 Score: %f' % (f1_tune*100))
```

```
Test F1 Score: 93.023256
```

Model 1 CNN With Embedding Layer with Tuning Paramter (aka. Parameterized Model 1)

Parameterized Model 1 has 100% Accuracy on Trainset and 98.2% Accuracy on Testset. Slightly lower than Model 1 on Testset.

The Dataset is Imbalanced so F1-Score of Parameterized Model 1 on Testset is 93.0%.

Model 2 - Multi-Channel CNN With Embedding Layer

In [46]:
```
# define the model
def define_model_multi(length, vocab_size):
    # channel 1
    inputs1 = Input(shape=(length,))
    embedding1 = Embedding(vocab_size, 100)(inputs1)
    conv1 = Conv1D(filters=32, kernel_size=4, activation='relu')(embedding1)
    drop1 = Dropout(0.5)(conv1)
    pool1 = MaxPooling1D(pool_size=2)(drop1)
    flat1 = Flatten()(pool1)
    # channel 2
    inputs2 = Input(shape=(length,))
    embedding2 = Embedding(vocab_size, 100)(inputs2)
    conv2 = Conv1D(filters=32, kernel_size=6, activation='relu')(embedding2)
    drop2 = Dropout(0.5)(conv2)
    pool2 = MaxPooling1D(pool_size=2)(drop2)
    flat2 = Flatten()(pool2)
    # channel 3
    inputs3 = Input(shape=(length,))
    embedding3 = Embedding(vocab_size, 100)(inputs3)
    conv3 = Conv1D(filters=32, kernel_size=8, activation='relu')(embedding3)
    drop3 = Dropout(0.5)(conv3)
    pool3 = MaxPooling1D(pool_size=2)(drop3)
    flat3 = Flatten()(pool3)
    # merge
    merged = concatenate([flat1, flat2, flat3])
    # interpretation
    dense1 = Dense(10, activation='relu')(merged)
    outputs = Dense(1, activation='sigmoid')(dense1)
    model = Model(inputs=[inputs1, inputs2, inputs3], outputs=outputs)
    # compile
    model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accu
racy'])
    # summarize
    model.summary()
    return model
```

In [47]:
```
# define model Train Multi-Channel-CNN With Embedding Layer
modelMultiCNN = define_model_multi(max_length,vocab_size)
```

```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_1 (InputLayer)            (None, 81)           0
__________________________________________________________________________________________________
input_2 (InputLayer)            (None, 81)           0
__________________________________________________________________________________________________
input_3 (InputLayer)            (None, 81)           0
__________________________________________________________________________________________________
embedding_53 (Embedding)        (None, 81, 100)      750700      input_1[0]
[0]
__________________________________________________________________________________________________
embedding_54 (Embedding)        (None, 81, 100)      750700      input_2[0]
[0]
__________________________________________________________________________________________________
embedding_55 (Embedding)        (None, 81, 100)      750700      input_3[0]
[0]
__________________________________________________________________________________________________
conv1d_53 (Conv1D)              (None, 78, 32)       12832       embedding_53
[0][0]
__________________________________________________________________________________________________
conv1d_54 (Conv1D)              (None, 76, 32)       19232       embedding_54
[0][0]
__________________________________________________________________________________________________
conv1d_55 (Conv1D)              (None, 74, 32)       25632       embedding_55
[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 78, 32)       0           conv1d_53[0]
[0]
__________________________________________________________________________________________________
dropout_2 (Dropout)             (None, 76, 32)       0           conv1d_54[0]
[0]
__________________________________________________________________________________________________
dropout_3 (Dropout)             (None, 74, 32)       0           conv1d_55[0]
[0]
__________________________________________________________________________________________________
max_pooling1d_53 (MaxPooling1D) (None, 39, 32)       0           dropout_1[0]
[0]
__________________________________________________________________________________________________
max_pooling1d_54 (MaxPooling1D) (None, 38, 32)       0           dropout_2[0]
[0]
```

```
__________________________________________________________________________________
_____________________
max_pooling1d_55 (MaxPooling1D) (None, 37, 32)       0           dropout_3[0]
[0]
__________________________________________________________________________________
_____________________
flatten_53 (Flatten)            (None, 1248)         0           max_pooling1
d_53[0][0]
__________________________________________________________________________________
_____________________
flatten_54 (Flatten)            (None, 1216)         0           max_pooling1
d_54[0][0]
__________________________________________________________________________________
_____________________
flatten_55 (Flatten)            (None, 1184)         0           max_pooling1
d_55[0][0]
__________________________________________________________________________________
_____________________
concatenate_1 (Concatenate)     (None, 3648)         0           flatten_53
[0][0]
                                                                 flatten_54
[0][0]
                                                                 flatten_55
[0][0]
__________________________________________________________________________________
_____________________
dense_105 (Dense)               (None, 10)           36490       concatenate_
1[0][0]
__________________________________________________________________________________
_____________________
dense_106 (Dense)               (None, 1)            11          dense_105[0]
[0]
==================================================================================
====================
Total params: 2,346,297
Trainable params: 2,346,297
Non-trainable params: 0
__________________________________________________________________________________
_____________________
```

Using the Best Parameters (epochs=10, batch_size=10) that I have tuned with 1-Channel for 3-Channel CNN.

In [48]:
```
modelMultiCNN.fit([padded_train_df,padded_train_df,padded_train_df], y_train,
                  epochs=10, batch_size=10, verbose=2)
```

```
C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\tensorflow_core\pytho
n\framework\indexed_slices.py:433: UserWarning: Converting sparse IndexedSlic
es to a dense Tensor of unknown shape. This may consume a large amount of mem
ory.
  "Converting sparse IndexedSlices to a dense Tensor of unknown shape. "

Epoch 1/10
 - 17s - loss: 0.1887 - accuracy: 0.9481
Epoch 2/10
 - 17s - loss: 0.0894 - accuracy: 0.9907
Epoch 3/10
 - 17s - loss: 0.0649 - accuracy: 0.9956
Epoch 4/10
 - 17s - loss: 0.0522 - accuracy: 0.9962
Epoch 5/10
 - 17s - loss: 0.0434 - accuracy: 0.9975
Epoch 6/10
 - 17s - loss: 0.0130 - accuracy: 0.9983
Epoch 7/10
 - 17s - loss: 0.0044 - accuracy: 0.9989
Epoch 8/10
 - 17s - loss: 0.0016 - accuracy: 0.9998
Epoch 9/10
 - 17s - loss: 0.0019 - accuracy: 0.9994
Epoch 10/10
 - 17s - loss: 0.0011 - accuracy: 0.9998
```

Out[48]:
```
<keras.callbacks.callbacks.History at 0x1b3adff8488>
```

In [49]:
```
# evaluate model on test dataset
_, acc_test_2 = modelMultiCNN.evaluate([padded_test_df,padded_test_df,padded_t
est_df],
                                       y_test, verbose=0)

print('Test Accuracy: %f' % (acc_test_2*100))
```

```
Test Accuracy: 99.162680
```

In [50]:
```
predict_test2 = np.round(modelMultiCNN.predict([padded_test_df,padded_test_df,
padded_test_df])).astype(int)
predict_test2 = predict_test2.flatten()
predict_test2 = pd.Series(predict_test2)
```

In [51]:
```
f1_2 = f1_score(y_test.astype(int), predict_test2)
print('Test F1 Score: %f' % (f1_2*100))
```

```
Test F1 Score: 96.832579
```

Model 2 Multi-Channel CNN With Embedding Layer.

Model 2 has 100% Accuracy on Trainset and 99.2% Accuracy on Testset. This is the best among 3 models.

The Dataset is Imbalanced so F1-Score of Model 2 on Testset is 96.8%.

In [53]:
```
tf.keras.backend.clear_session()
```

Conclusion

The Dataset is trained on 85% of messages and then being tested for the remaining 15% of messages (836 messagees).

Processing Steps: Cleaning Text -> Tokenize Text -> texts_to_sequences -> Padding Sequences -> Train Model.

3 Models are trained: CNN With Embedding Layer,Parameterized CNN With Embedding Layer ,Multi-Channel CNN With Embedding Layer.

Multi-Channel CNN With Embedding Layer is the best model with 99.2% Accuracy on Testset with F1-Score on Testset is 96.8%

2. Topic Modelling

In [64]:
```
mydf = pd.read_csv('spam.csv',
                   encoding = "latin-1")
mydf = mydf.iloc[:,0:2]
```

In [87]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
import nltk

from sklearn.decomposition import TruncatedSVD
from sklearn.cluster import KMeans
from sklearn.pipeline import make_pipeline

from sklearn.decomposition import LatentDirichletAllocation


from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
```

Step-by-Step Cleaning Text

In [65]:
```
def remove_punctuation(s):
    s1 = re.sub(r'[^\w\s]','',s)
    return s1
```

In [66]:
```
def remove_nonAlphabet(s):
    s1 = re.sub("[^a-zA-Z]+", " ", s)
    return s1
```

In [67]:
```
def tokenize(text):
    tokens=re.split('\W+',text)
    return tokens
```

In [68]:
```
def remove_stopwords(text):
    clean_text=[word for word in text if word not in nltk.corpus.stopwords.wor
ds('english')]
    return clean_text
```

In [69]:
```
ps = nltk.PorterStemmer()

def stemming(tokenized_text):
    stemmed_text=[ps.stem(word) for word in tokenized_text]
    return stemmed_text
```

In [70]:
```
def get_final_text(text):
    final_text=" ".join([word for word in text])
    return final_text
```

In [71]:
```
def word_count(string):
    tokens = string.split()
    n_tokens = len(tokens)
    return n_tokens
```

In [72]:
```
mydf['CleanText_RemovePunctuation'] = mydf['Text'].apply(lambda row : remove_p
unctuation(row))

mydf['CleanText_NonAlphabet'] = mydf['CleanText_RemovePunctuation'].apply(lamb
da row : remove_nonAlphabet(row))

mydf['CleanText_Tokenzied'] = mydf['CleanText_NonAlphabet'].apply(lambda row :
tokenize(row.lower()))

mydf['CleanText_RemoveStopword'] = mydf['CleanText_Tokenzied'].apply(lambda ro
w : remove_stopwords(row))

mydf['stemmed_text']=  mydf['CleanText_RemoveStopword'].apply(lambda row : ste
mming(row))

mydf['final_clean_text']=  mydf['stemmed_text'].apply(lambda row : get_final_t
ext(row))
```

In [73]:
```
final_df = mydf[['Text', 'final_clean_text']]
```

In [77]:
```
final_df['Text_len'] = final_df['Text'].apply(lambda row: word_count(row))
final_df['final_clean_text_len'] = final_df['final_clean_text'].apply(lambda r
ow: word_count(row))
```

```
C:\Users\ADMIN\anaconda3\envs\AlexEnv\lib\site-packages\ipykernel_launcher.p
y:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/s
table/user_guide/indexing.html#returning-a-view-versus-a-copy
  """Entry point for launching an IPython kernel.
```

In [78]:
```
final_df.head(10)
```

Out[78]:

	Text	final_clean_text	Text_len	final_clean_text_len
0	Go until jurong point, crazy.. Available only ...	go jurong point crazi avail bugi n great world...	20	16
1	Ok lar... Joking wif u oni...	ok lar joke wif u oni	6	6
2	Free entry in 2 a wkly comp to win FA Cup fina...	free entri wkli comp win fa cup final tkt st m...	28	19
3	U dun say so early hor... U c already then say...	u dun say earli hor u c alreadi say	11	9
4	Nah I don't think he goes to usf, he lives aro...	nah dont think goe usf live around though	13	8
5	FreeMsg Hey there darling it's been 3 week's n...	freemsg hey darl week word back id like fun st...	32	17
6	Even my brother is not like to speak with me. ...	even brother like speak treat like aid patent	16	8
7	As per your request 'Melle Melle (Oru Minnamin...	per request mell mell oru minnaminungint nurun...	26	15
8	WINNER!! As a valued network customer you have...	winner valu network custom select receivea pri...	26	15
9	Had your mobile 11 months or more? U R entitle...	mobil month u r entitl updat latest colour mob...	29	16

Create a TfidfVectorizer

In [79]:
```
documents = final_df['final_clean_text']
```

In [82]:
```
# Create a TfidfVectorizer: tfidf
tfidf = TfidfVectorizer()
```

In [84]:
```
# Apply fit_transform to document: csr_mat
csr_mat = tfidf.fit_transform(documents)
```

Dimensionality Reduction with SVD

In [90]:
```
# Create a TruncatedSVD instance: svd
svd = TruncatedSVD(n_components=50)
```

In [91]:
```
# Fit the pipeline to articles
svd.fit(csr_mat)
```

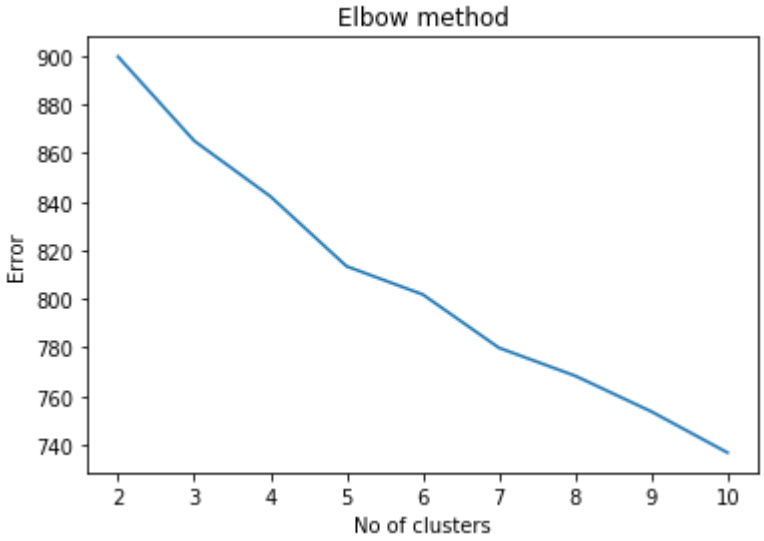
Out[91]:
```
TruncatedSVD(algorithm='randomized', n_components=50, n_iter=5,
             random_state=None, tol=0.0)
```

In [92]:
```
csr_mat_svd = svd.transform(csr_mat)
```

Kmeans

In [93]:
```
Error =[]
for i in range(2, 11):
    kmeans = KMeans(n_clusters = i).fit(csr_mat_svd)
    kmeans.fit(csr_mat_svd)
    Error.append(kmeans.inertia_)
```

In [94]:
```
plt.plot(range(2, 11), Error)
plt.title('Elbow method')
plt.xlabel('No of clusters')
plt.ylabel('Error')
plt.show()
```



In [137]:
```
kmeans = KMeans(n_clusters = 2).fit(csr_mat_svd)
kmeans.fit(csr_mat_svd)
```

Out[137]:
```
KMeans(algorithm='auto', copy_x=True, init='k-means++', max_iter=300,
       n_clusters=2, n_init=10, n_jobs=None, precompute_distances='auto',
       random_state=None, tol=0.0001, verbose=0)
```

In [138]:
```
kmeans_label = kmeans.predict(csr_mat_svd)
```

In [139]:
```
pd.value_counts(kmeans_label)
```

Out[139]:
```
1    5377
0     195
dtype: int64
```

In [142]:
```
print("Top terms per cluster:")
order_centroids = kmeans.cluster_centers_.argsort()[:, ::-1]
terms = tfidf.get_feature_names()
for i in range(2):
    print("Cluster %d:" % i),
    for ind in order_centroids[i, :20]:
        print(' %s' % terms[ind]),
    print
```

```
Top terms per cluster:
Cluster 0:
 aah
 aa
 aaniy
 aaooooright
 abbey
 aathiwher
 academ
 abdomen
 accident
 access
 abouta
 abt
 absenc
 abroad
 abeg
 absolut
 aburo
 accommodationvouch
 abil
 acid
Cluster 1:
 aa
 ab
 abil
 accident
 abus
 abel
 aaooooright
 aberdeen
 abnorm
 accommodationvouch
 accomod
 accid
 accentur
 account
 abroad
 accordingli
 accumul
 accommod
 abta
 absolut
```

Latent Dirichlet Allocation (LDA)

https://medium.com/analytics-vidhya/topic-modelling-using-latent-dirichlet-allocation-in-scikit-learn-7daf770406c4 (https://medium.com/analytics-vidhya/topic-modelling-using-latent-dirichlet-allocation-in-scikit-learn-7daf770406c4)

In [113]:
```
# train a LDA Model
lda_model = LatentDirichletAllocation(n_components=5, max_iter=20)

X_topics = lda_model.fit_transform(csr_mat)
```

In [114]:
```
for index, topic in enumerate(lda_model.components_):
    print(f'Top 5 words for Topic #{index}')
    print([tfidf.get_feature_names()[i] for i in topic.argsort()[-5:]])
    print('\n')
```

```
Top 5 words for Topic #0
['collect', 'go', 'ur', 'call', 'im']


Top 5 words for Topic #1
['claim', 'repli', 'mobil', 'free', 'call']


Top 5 words for Topic #2
['come', 'wat', 'go', 'lor', 'ok']


Top 5 words for Topic #3
['get', 'later', 'sorri', 'call', 'ill']


Top 5 words for Topic #4
['love', 'im', 'get', 'go', 'home']
```

Tuning Paramters for LDA

In [129]:
```
lda_params = {
                'n_components' : [2,3,4,5,6,7],
                'learning_decay': [.4,.6,.8,1.0],
                'max_iter' : [5,10,20,30]
            }
```

In [130]:
```
lda = LatentDirichletAllocation()
```

In [131]:
```
model_lda = GridSearchCV(lda, param_grid=lda_params)
```

In [132]:
```
model_lda.fit(csr_mat)
```

Out[132]:
```
GridSearchCV(cv=None, error_score=nan,
             estimator=LatentDirichletAllocation(batch_size=128,
                                                 doc_topic_prior=None,
                                                 evaluate_every=-1,
                                                 learning_decay=0.7,
                                                 learning_method='batch',
                                                 learning_offset=10.0,
                                                 max_doc_update_iter=100,
                                                 max_iter=10,
                                                 mean_change_tol=0.001,
                                                 n_components=10, n_jobs=Non
e,
                                                 perp_tol=0.1,
                                                 random_state=None,
                                                 topic_word_prior=None,
                                                 total_samples=1000000.0,
                                                 verbose=0),
             iid='deprecated', n_jobs=None,
             param_grid={'learning_decay': [0.4, 0.6, 0.8, 1.0],
                         'max_iter': [5, 10, 20, 30],
                         'n_components': [2, 3, 4, 5, 6, 7]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring=None, verbose=0)
```

In [133]:
```
model_lda.best_params_
```

Out[133]:
```
{'learning_decay': 0.4, 'max_iter': 20, 'n_components': 2}
```

In [134]:
```
# train a LDA Model
lda_model_tune = LatentDirichletAllocation(n_components=2,learning_decay=0.4,
max_iter=20)
```

In [135]:
```
X_topics_tune = lda_model_tune.fit_transform(csr_mat)
```

In [136]:
```
for index, topic in enumerate(lda_model_tune.components_):
    print(f'Top 20 words for Topic #{index}')
    print([tfidf.get_feature_names()[i] for i in topic.argsort()[-30:]])
    print('\n')
```

```
Top 20 words for Topic #0
['know', 'today', 'miss', 'prize', 'week', 'claim', 'get', 'min', 'ye', 'grea
t', 'day', 'number', 'pl', 'mobil', 'txt', 'repli', 'hi', 'good', 'stop', 'me
ssag', 'new', 'dear', 'phone', 'love', 'pleas', 'ur', 'send', 'text', 'free',
'call']


Top 20 words for Topic #1
['tell', 'take', 'think', 'say', 'ask', 'work', 'da', 'oh', 'wat', 'one', 'kn
ow', 'meet', 'need', 'want', 'ltgt', 'still', 'dont', 'lor', 'got', 'later',
'home', 'sorri', 'like', 'time', 'get', 'ill', 'come', 'go', 'im', 'ok']
```

Topic 1 is most likely to be "spam" topic. Topic 2 is most likely "ham" topic.