Movie Reviews Classification

Problem Statement II

Classify movie reviews as positive or negative using the text of the review.

This is an example of a binary—or two-class—classification, an important kind of machine learning problem. Use the IMDB Dataset that contains the text of 50,000 movie reviews from the Internet Movie Database . These are split into 25,000 reviews for training and 25,000 reviews for testing. The training and testing sets are balanced. Source -The IMDB dataset is available on imdb reviews or on TensorFlow datasets. You are free to use it with a python based platform of your choice (e.g. Keras/TF, Pytorch, Pycharm etc) in a python environment. We expect that you include the required visualizations, comments and results as part of your python code. The solution MUST use a deep learning method and demonstrate near-SOTA accuracy.

In [1]:
```
## Imports

import tensorflow as tf
import tensorflow_datasets as tfds
import tensorflow_hub as hub
import matplotlib.pyplot as plt
```

In [2]:
```
# tensorflow version used
tf.__version__
```

Out[2]:
```
'2.5.0'
```

In [3]:
```
train_data, validation_data, test_data = tfds.load(name="imdb_reviews",
            split=('train[:60%]', 'train[60%:]', 'test'), as_supervised=True)
```

Data Size

In [4]:
```
print('Training Data size   :: ', len(train_data))
print('Validation Data size :: ', len(validation_data))
print('Testing Data size    :: ', len(test_data))
```

```
Training Data size   ::  15000
Validation Data size ::  10000
Testing Data size    ::  25000
```

Following is Sample batch of 3 reviews

In [5]:
```
train_examples_batch, train_labels_batch = next(iter(train_data.batch(3)))
```

In [6]:
```
train_examples_batch
```

Out[6]:
```
<tf.Tensor: shape=(3,), dtype=string, numpy=
array([b"This was an absolutely terrible movie. Don't be lured in by Christopher Walken
or Michael Ironside. Both are great actors, but this must simply be their worst role in
history. Even their great acting could not redeem this movie's ridiculous storyline. Thi
s movie is an early nineties US propaganda piece. The most pathetic scenes were those wh
en the Columbian rebels were making their cases for revolutions. Maria Conchita Alonso a
ppeared phony, and her pseudo-love affair with Walken was nothing but a pathetic emotion
al plug in a movie that was devoid of any real meaning. I am disappointed that there are
movies like this, ruining actor's like Christopher Walken's good name. I could barely si
t through it.",
       b'I have been known to fall asleep during films, but this is usually due to a com
bination of things including, really tired, being warm and comfortable on the sette and
having just eaten a lot. However on this occasion I fell asleep because the film was rub
bish. The plot development was constant. Constantly slow and boring. Things seemed to ha
ppen, but with no explanation of what was causing them or why. I admit, I may have misse
d part of the film, but i watched the majority of it and everything just seemed to happe
n of its own accord without any real concern for anything else. I cant recommend this fi
lm at all.',
       b'Mann photographs the Alberta Rocky Mountains in a superb fashion, and Jimmy Ste
wart and Walter Brennan give enjoyable performances as they always seem to do. <br /><br
/>But come on Hollywood - a Mountie telling the people of Dawson City, Yukon to elect th
emselves a marshal (yes a marshal!) and to enforce the law themselves, then gunfighters
battling it out on the streets for control of the town? <br /><br />Nothing even remotel
y resembling that happened on the Canadian side of the border during the Klondike gold r
ush. Mr. Mann and company appear to have mistaken Dawson City for Deadwood, the Canadian
North for the American Wild West.<br /><br />Canadian viewers be prepared for a Reefer M
adness type of enjoyable howl with this ludicrous plot, or, to shake your head in disgus
t.'],
      dtype=object)>
```

Following are labels for reviews

0 - Review is negative

1 - Review is positive

In [7]:
```
train_labels_batch
```

Out[7]:
```
<tf.Tensor: shape=(3,), dtype=int64, numpy=array([0, 0, 0], dtype=int64)>
```

Using gnews-swivel-20dim

Token based text embedding trained on English Google News 130GB corpus.

In [8]:
```
pretrained_model = "https://tfhub.dev/google/tf2-preview/gnews-swivel-20dim/1"
hub_layer = hub.KerasLayer(pretrained_model, input_shape=[], dtype=tf.string, trainable
```

In [9]:
```
train_examples_batch[:2]
```

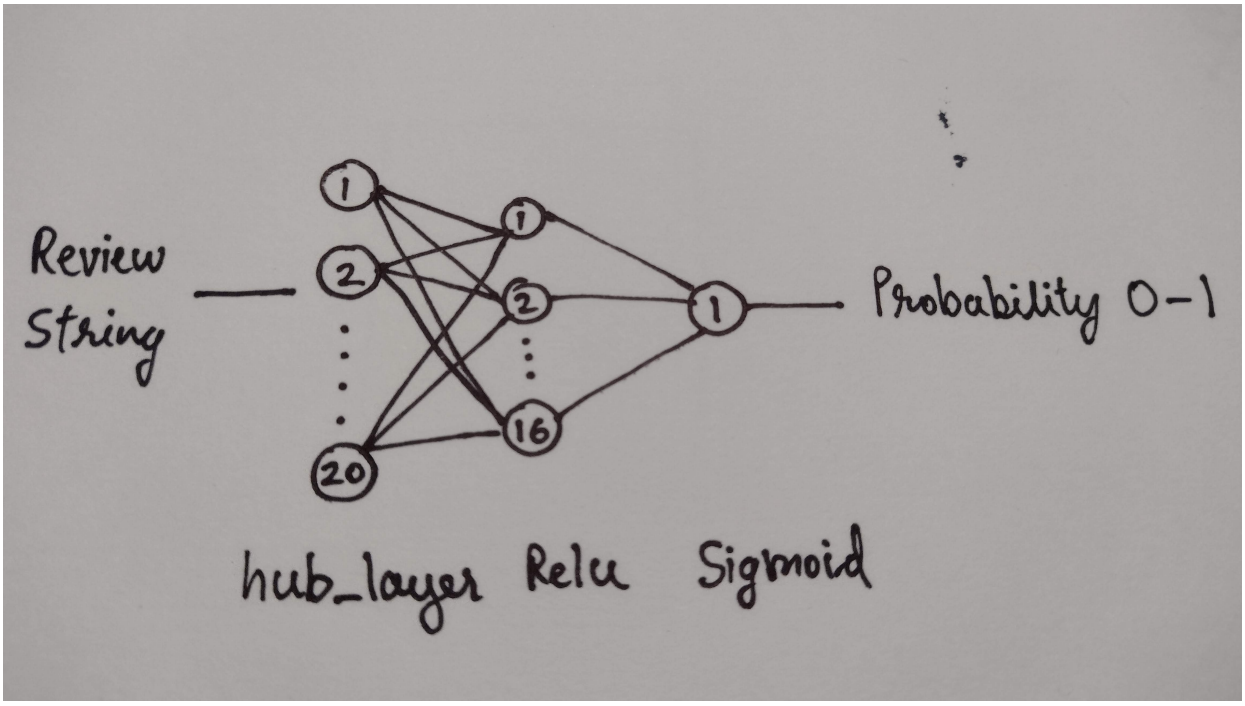
Out[9]:
```
<tf.Tensor: shape=(2,), dtype=string, numpy=
array([b"This was an absolutely terrible movie. Don't be lured in by Christopher Walken
or Michael Ironside. Both are great actors, but this must simply be their worst role in
history. Even their great acting could not redeem this movie's ridiculous storyline. Thi
s movie is an early nineties US propaganda piece. The most pathetic scenes were those wh
en the Columbian rebels were making their cases for revolutions. Maria Conchita Alonso a
ppeared phony, and her pseudo-love affair with Walken was nothing but a pathetic emotion
al plug in a movie that was devoid of any real meaning. I am disappointed that there are
```

```
movies like this, ruining actor's like Christopher Walken's good name. I could barely si
t through it.",
       b'I have been known to fall asleep during films, but this is usually due to a com
bination of things including, really tired, being warm and comfortable on the sette and
having just eaten a lot. However on this occasion I fell asleep because the film was rub
bish. The plot development was constant. Constantly slow and boring. Things seemed to ha
ppen, but with no explanation of what was causing them or why. I admit, I may have misse
d part of the film, but i watched the majority of it and everything just seemed to happe
n of its own accord without any real concern for anything else. I cant recommend this fi
lm at all.'],
      dtype=object)>
```

In [10]:
```
hub_layer(train_examples_batch[:2])
```

Out[10]:
```
<tf.Tensor: shape=(2, 20), dtype=float32, numpy=
array([[ 1.765786  , -3.882232  ,  3.9134233 , -1.5557289 , -3.3362343 ,
        -1.7357955 , -1.9954445 ,  1.2989551 ,  5.081598  , -1.1041286 ,
        -2.0503852 , -0.72675157, -0.65675956,  0.24436149, -3.7208383 ,
         2.0954835 ,  2.2969332 , -2.0689783 , -2.9489717 , -1.1315987 ],
       [ 1.8804485 , -2.5852382 ,  3.4066997 ,  1.0982676 , -4.056685  ,
        -4.891284  , -2.785554  ,  1.3874227 ,  3.8476458 , -0.9256538 ,
        -1.896706  ,  1.2113281 ,  0.11474707,  0.76209456, -4.8791065 ,
         2.906149  ,  4.7087674 , -2.3652055 , -3.5015898 , -1.6390051 ]],
      dtype=float32)>
```

Keras Sequential Model



In [11]:
```
model = tf.keras.Sequential()

# neural network layers
model.add(hub_layer)
model.add(tf.keras.layers.Dense(16,activation="relu"))
model.add(tf.keras.layers.Dense(1,activation="sigmoid"))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
keras_layer (KerasLayer)     (None, 20)                400020
_________________________________________________________________
dense (Dense)                (None, 16)                336
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 17
=================================================================
Total params: 400,373
Trainable params: 400,373
Non-trainable params: 0
_________________________________________________________________
```

Configuring the model

In [12]:

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

Training the Model with 40 Epochs

In [13]:

```
history = model.fit(train_data.shuffle(10000).batch(512),
          epochs=40,
          validation_data=validation_data.batch(512),
          verbose=1)
```

```
Epoch 1/40
30/30 [==============================] - 4s 96ms/step - loss: 0.7071 - accuracy: 0.6209
- val_loss: 0.6565 - val_accuracy: 0.6441
Epoch 2/40
30/30 [==============================] - 3s 83ms/step - loss: 0.6079 - accuracy: 0.6822
- val_loss: 0.5874 - val_accuracy: 0.6974
Epoch 3/40
30/30 [==============================] - 3s 83ms/step - loss: 0.5552 - accuracy: 0.7224
- val_loss: 0.5475 - val_accuracy: 0.7346
Epoch 4/40
30/30 [==============================] - 2s 80ms/step - loss: 0.5184 - accuracy: 0.7548
- val_loss: 0.5184 - val_accuracy: 0.7578
Epoch 5/40
30/30 [==============================] - 2s 81ms/step - loss: 0.4871 - accuracy: 0.7779
- val_loss: 0.4906 - val_accuracy: 0.7782
Epoch 6/40
30/30 [==============================] - 2s 80ms/step - loss: 0.4564 - accuracy: 0.7999
- val_loss: 0.4659 - val_accuracy: 0.7952
Epoch 7/40
30/30 [==============================] - 2s 80ms/step - loss: 0.4273 - accuracy: 0.8174
- val_loss: 0.4426 - val_accuracy: 0.8080
Epoch 8/40
30/30 [==============================] - 2s 81ms/step - loss: 0.3994 - accuracy: 0.8307
- val_loss: 0.4221 - val_accuracy: 0.8149
Epoch 9/40
30/30 [==============================] - 2s 82ms/step - loss: 0.3723 - accuracy: 0.8460
- val_loss: 0.4007 - val_accuracy: 0.8267
Epoch 10/40
30/30 [==============================] - 3s 85ms/step - loss: 0.3467 - accuracy: 0.8611
- val_loss: 0.3833 - val_accuracy: 0.8348
Epoch 11/40
30/30 [==============================] - 3s 98ms/step - loss: 0.3225 - accuracy: 0.8745
```

```
- val_loss: 0.3679 - val_accuracy: 0.8419
Epoch 12/40
30/30 [==============================] - 3s 101ms/step - loss: 0.3013 - accuracy: 0.8851
- val_loss: 0.3556 - val_accuracy: 0.8439
Epoch 13/40
30/30 [==============================] - 4s 130ms/step - loss: 0.2795 - accuracy: 0.8946
- val_loss: 0.3423 - val_accuracy: 0.8513
Epoch 14/40
30/30 [==============================] - 3s 112ms/step - loss: 0.2595 - accuracy: 0.9046
- val_loss: 0.3331 - val_accuracy: 0.8569
Epoch 15/40
30/30 [==============================] - 3s 115ms/step - loss: 0.2425 - accuracy: 0.9111
- val_loss: 0.3254 - val_accuracy: 0.8592
Epoch 16/40
30/30 [==============================] - 3s 115ms/step - loss: 0.2254 - accuracy: 0.9181
- val_loss: 0.3195 - val_accuracy: 0.8635
Epoch 17/40
30/30 [==============================] - 3s 106ms/step - loss: 0.2109 - accuracy: 0.9237
- val_loss: 0.3148 - val_accuracy: 0.8659
Epoch 18/40
30/30 [==============================] - 3s 94ms/step - loss: 0.1966 - accuracy: 0.9304
- val_loss: 0.3124 - val_accuracy: 0.8676
Epoch 19/40
30/30 [==============================] - 3s 96ms/step - loss: 0.1837 - accuracy: 0.9361
- val_loss: 0.3100 - val_accuracy: 0.8684
Epoch 20/40
30/30 [==============================] - 3s 97ms/step - loss: 0.1714 - accuracy: 0.9421
- val_loss: 0.3097 - val_accuracy: 0.8700
Epoch 21/40
30/30 [==============================] - 3s 99ms/step - loss: 0.1602 - accuracy: 0.9462
- val_loss: 0.3100 - val_accuracy: 0.8688
Epoch 22/40
30/30 [==============================] - 3s 94ms/step - loss: 0.1499 - accuracy: 0.9510
- val_loss: 0.3118 - val_accuracy: 0.8708
Epoch 23/40
30/30 [==============================] - 3s 99ms/step - loss: 0.1388 - accuracy: 0.9567
- val_loss: 0.3153 - val_accuracy: 0.8713
Epoch 24/40
30/30 [==============================] - 2s 82ms/step - loss: 0.1302 - accuracy: 0.9591
- val_loss: 0.3155 - val_accuracy: 0.8712
Epoch 25/40
30/30 [==============================] - 2s 81ms/step - loss: 0.1201 - accuracy: 0.9641
- val_loss: 0.3179 - val_accuracy: 0.8718
Epoch 26/40
30/30 [==============================] - 2s 82ms/step - loss: 0.1127 - accuracy: 0.9664
- val_loss: 0.3237 - val_accuracy: 0.8703
Epoch 27/40
30/30 [==============================] - 2s 80ms/step - loss: 0.1047 - accuracy: 0.9708
- val_loss: 0.3261 - val_accuracy: 0.8739
Epoch 28/40
30/30 [==============================] - 2s 80ms/step - loss: 0.0975 - accuracy: 0.9734
- val_loss: 0.3314 - val_accuracy: 0.8722
Epoch 29/40
30/30 [==============================] - 2s 81ms/step - loss: 0.0899 - accuracy: 0.9759
- val_loss: 0.3385 - val_accuracy: 0.8715
Epoch 30/40
30/30 [==============================] - 3s 85ms/step - loss: 0.0834 - accuracy: 0.9787
- val_loss: 0.3437 - val_accuracy: 0.8724
Epoch 31/40
30/30 [==============================] - 2s 81ms/step - loss: 0.0770 - accuracy: 0.9803
- val_loss: 0.3504 - val_accuracy: 0.8706
Epoch 32/40
30/30 [==============================] - 3s 84ms/step - loss: 0.0714 - accuracy: 0.9823
- val_loss: 0.3573 - val_accuracy: 0.8693
Epoch 33/40
```

```
30/30 [==============================] - 2s 82ms/step - loss: 0.0662 - accuracy: 0.9840
- val_loss: 0.3652 - val_accuracy: 0.8677
Epoch 34/40
30/30 [==============================] - 2s 81ms/step - loss: 0.0609 - accuracy: 0.9870
- val_loss: 0.3747 - val_accuracy: 0.8666
Epoch 35/40
30/30 [==============================] - 2s 82ms/step - loss: 0.0563 - accuracy: 0.9885
- val_loss: 0.3816 - val_accuracy: 0.8672
Epoch 36/40
30/30 [==============================] - 2s 83ms/step - loss: 0.0517 - accuracy: 0.9905
- val_loss: 0.3901 - val_accuracy: 0.8656
Epoch 37/40
30/30 [==============================] - 2s 82ms/step - loss: 0.0477 - accuracy: 0.9918
- val_loss: 0.3983 - val_accuracy: 0.8642
Epoch 38/40
30/30 [==============================] - 3s 84ms/step - loss: 0.0440 - accuracy: 0.9931
- val_loss: 0.4081 - val_accuracy: 0.8631
Epoch 39/40
30/30 [==============================] - 2s 82ms/step - loss: 0.0407 - accuracy: 0.9937
- val_loss: 0.4158 - val_accuracy: 0.8633
Epoch 40/40
30/30 [==============================] - 2s 79ms/step - loss: 0.0372 - accuracy: 0.9955
- val_loss: 0.4257 - val_accuracy: 0.8612
```

Predicting 3 simple review sentences

In [14]:

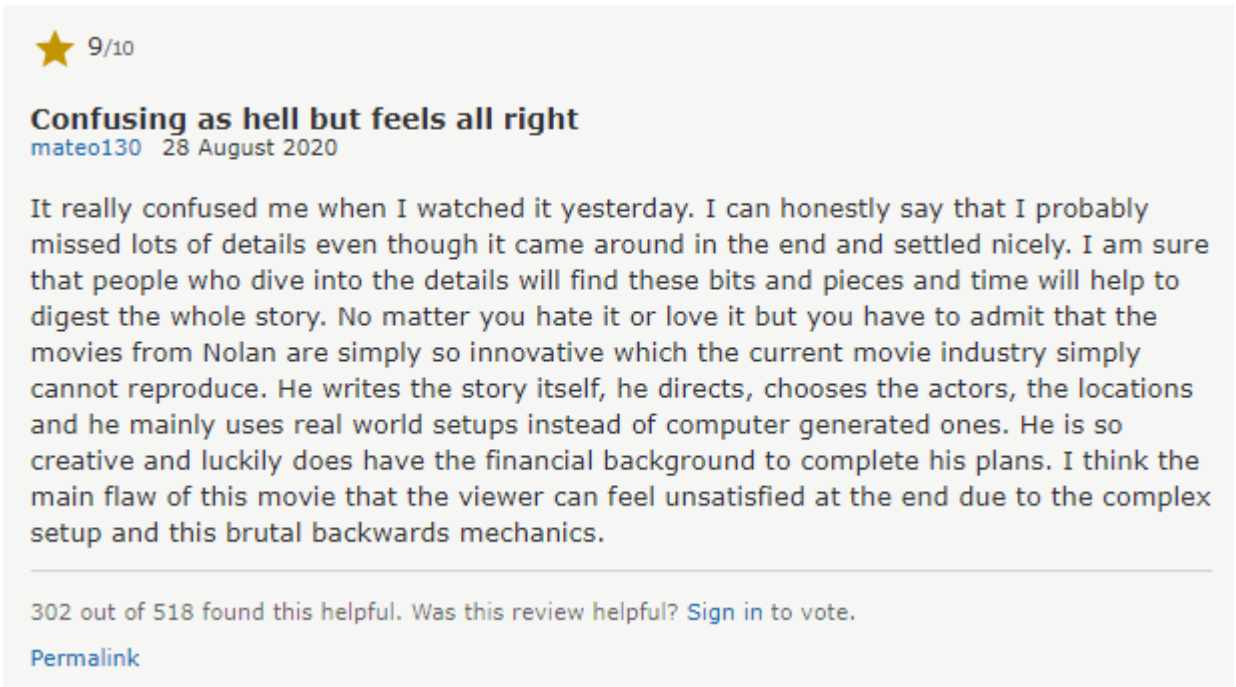
```
model.predict(["This is the worst movie I have ever seen",
               "An excellent movie that I enjoyed a lot",
               "how can one make such a horrible movie? there is no story, acting direct
```

Out[14]:

```
array([[2.1716893e-02],
       [9.9997926e-01],
       [2.9364228e-04]], dtype=float32)
```

Predicting reviews outside the dataset

9 Star review of movie Tenet



9/10

Confusing as hell but feels all right

mateo130 28 August 2020

It really confused me when I watched it yesterday. I can honestly say that I probably missed lots of details even though it came around in the end and settled nicely. I am sure that people who dive into the details will find these bits and pieces and time will help to digest the whole story. No matter you hate it or love it but you have to admit that the movies from Nolan are simply so innovative which the current movie industry simply cannot reproduce. He writes the story itself, he directs, chooses the actors, the locations and he mainly uses real world setups instead of computer generated ones. He is so creative and luckily does have the financial background to complete his plans. I think the main flaw of this movie that the viewer can feel unsatisfied at the end due to the complex setup and this brutal backwards mechanics.

302 out of 518 found this helpful. Was this review helpful? Sign in to vote.

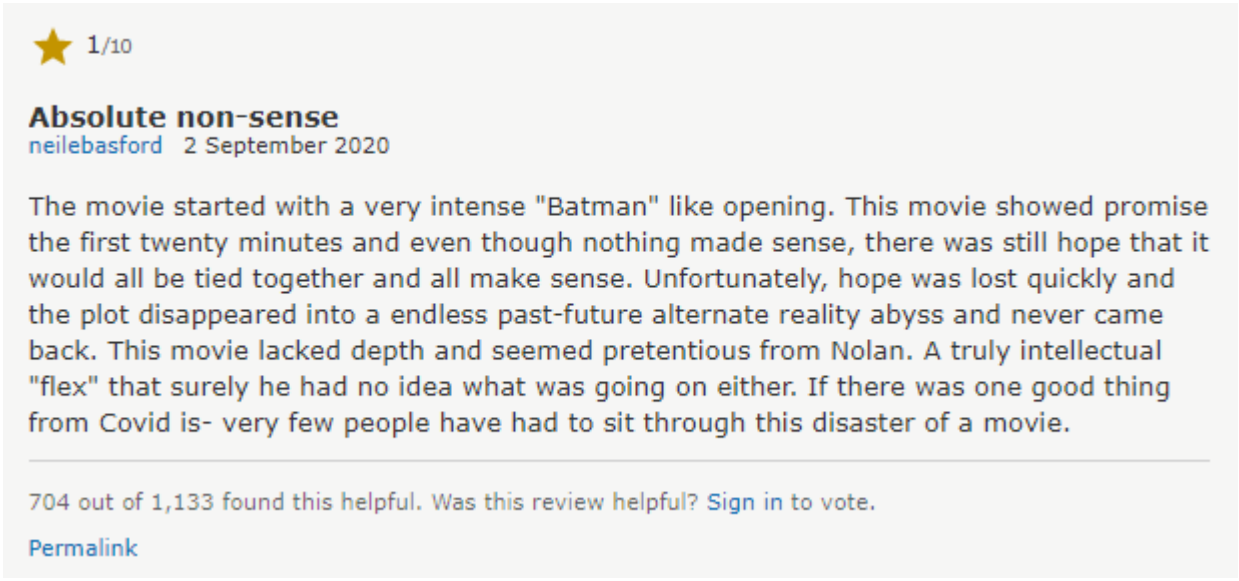
Permalink

Predicted value is about 0.9 i.e. review is positive just as the user rating.

In [15]:
```
model.predict(["""It really confused me when I watched it yesterday. I can honestly say
               details even though it came around in the end and settled nicely. I am
               details will find these bits and pieces and time will help to digest th
               it or love it but you have to admit that the movies from Nolan are simp
               movie industry simply cannot reproduce. He writes the story itself, he
               locations and he mainly uses real world setups instead of computer gene
               luckily does have the financial background to complete his plans. I thi
               the viewer can feel unsatisfied at the end due to the complex setup and
```

Out[15]:
```
array([[0.9794344]], dtype=float32)
```

1 Star review of movie Tenet



★ 1/10

Absolute non-sense
neilebasford 2 September 2020

The movie started with a very intense "Batman" like opening. This movie showed promise the first twenty minutes and even though nothing made sense, there was still hope that it would all be tied together and all make sense. Unfortunately, hope was lost quickly and the plot disappeared into a endless past-future alternate reality abyss and never came back. This movie lacked depth and seemed pretentious from Nolan. A truly intellectual "flex" that surely he had no idea what was going on either. If there was one good thing from Covid is- very few people have had to sit through this disaster of a movie.

704 out of 1,133 found this helpful. Was this review helpful? Sign in to vote.

Permalink

Predicted value is about 0.01 i.e. review is negative just as the user rating.

In [16]:
```
model.predict(["""The movie started with a very intense "Batman" like opening. This mov
               minutes and even though nothing made sense, there was still hope that i
               all make sense. Unfortunately, hope was lost quickly and the plot disap
               alternate reality abyss and never came back. This movie lacked depth an
               A truly intellectual "flex" that surely he had no idea what was going o
               thing from Covid is- very few people have had to sit through this disas
```

Out[16]:
```
array([[0.02783105]], dtype=float32)
```

In [17]:
```
history_dict = history.history
history_dict.keys()
```

Out[17]:
```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

Plotting Model Accuracy and Loss

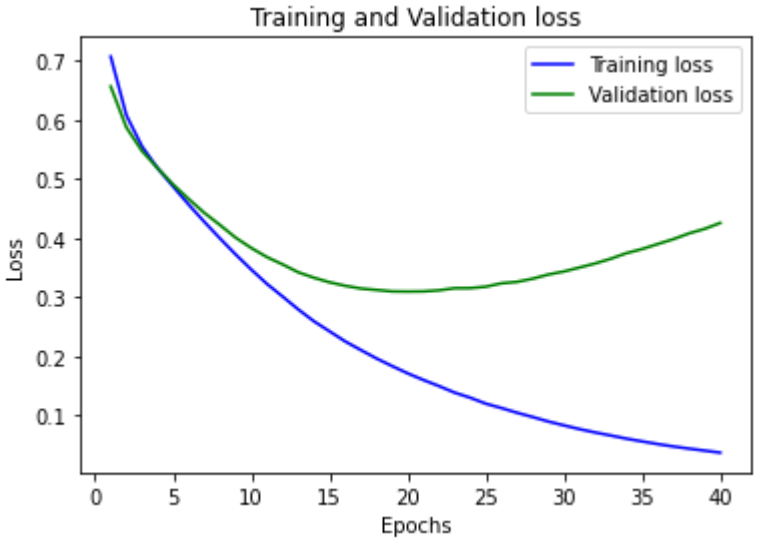
In [18]:
```
# Plotting Training and Validation Loss
```

```
acc = history_dict['accuracy']
val_acc = history_dict['val_accuracy']
loss = history_dict['loss']
val_loss = history_dict['val_loss']

epochs = range(1, len(acc) + 1)


plt.plot(epochs, loss, 'b', label='Training loss')
plt.plot(epochs, val_loss, 'g', label='Validation loss')
plt.title('Training and Validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



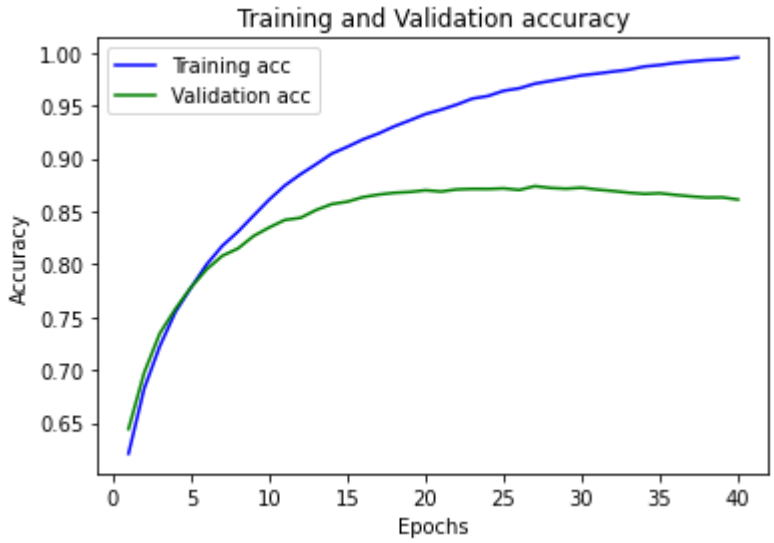
In [19]:

```
# Plotting Training and Validation Accuracy

plt.clf()

plt.plot(epochs, acc, 'b', label='Training acc')
plt.plot(epochs, val_acc, 'g', label='Validation acc')
plt.title('Training and Validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
```



Model Analysis

1. The input string is a review string that in converted into a 20 shape array of numbers generated by hub_layer. This string if further passed to ReLU layer and then to Sigmoid layer for output.
2. The output of the neural network is probability where output near 0 signifies input string is a negative review and near 1 signifies input string is a positive review.
3. This model was able to reach an accuracy of 87%.
4. Analyzing the validation accuracy and loss plots, The model has an increase in accuracy and decrease in losses till Epoch 20. After epoch 20, It flattens in accuracy and increases in the losses.

References

1. https://tfhub.dev/google/tf2-preview/gnews-swivel-20dim/1
2. https://www.tensorflow.org/api_docs/python/tf/nn/embedding_lookup_sparse
3. https://paperswithcode.com/sota/sentiment-analysis-on-imdb
4. https://www.kaggle.com/arunkumarramanan/awesome-ml-and-text-classification-movie-reviews

In [ ]: