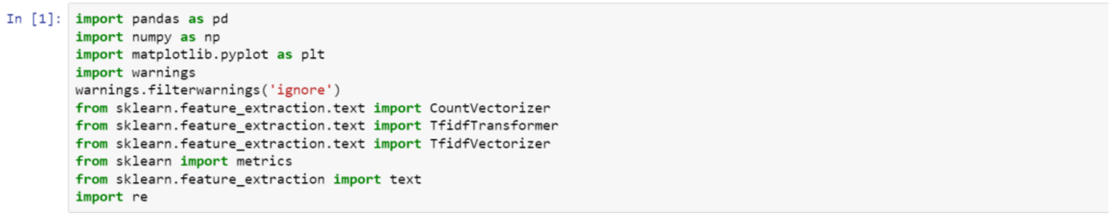
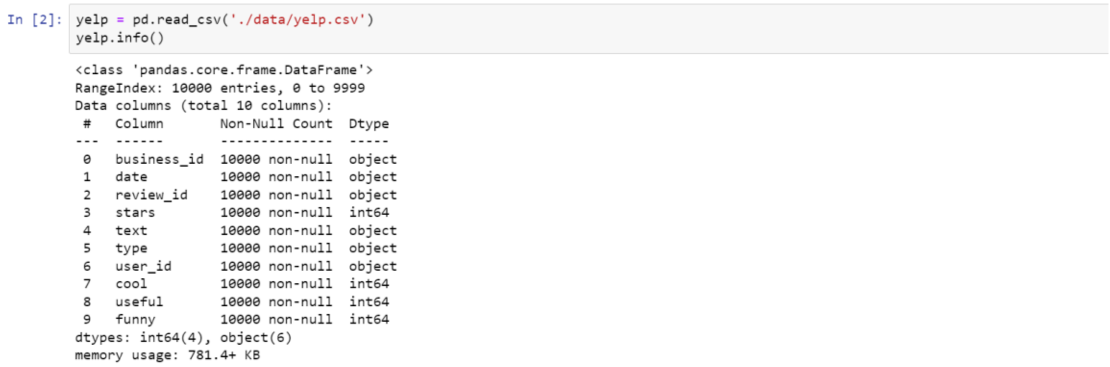
- [1]：import packages



```
In [1]:
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings('ignore')
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn import metrics
from sklearn.feature_extraction import text
import re
```

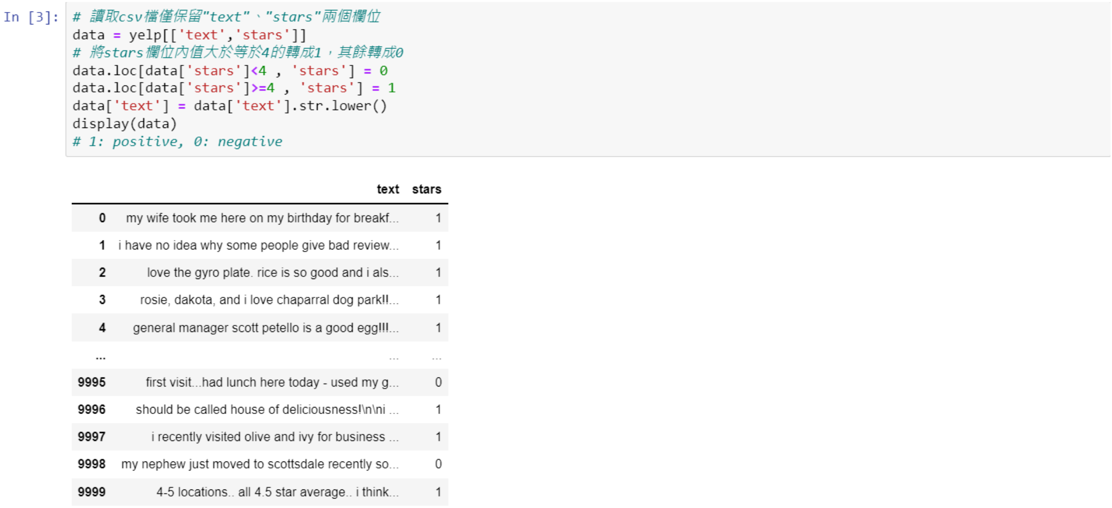
- [2]：load yelp.csv，查看 yelp 資料，沒有缺值



```
In [2]:
yelp = pd.read_csv('./data/yelp.csv')
yelp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 10 columns):
 #   Column       Non-Null Count  Dtype 
---  ------       --------------  ----- 
 0   business_id  10000 non-null  object
 1   date         10000 non-null  object
 2   review_id    10000 non-null  object
 3   stars        10000 non-null  int64 
 4   text         10000 non-null  object
 5   type         10000 non-null  object
 6   user_id      10000 non-null  object
 7   cool         10000 non-null  int64 
 8   useful       10000 non-null  int64 
 9   funny        10000 non-null  int64 
dtypes: int64(4), object(6)
memory usage: 781.4+ KB
```

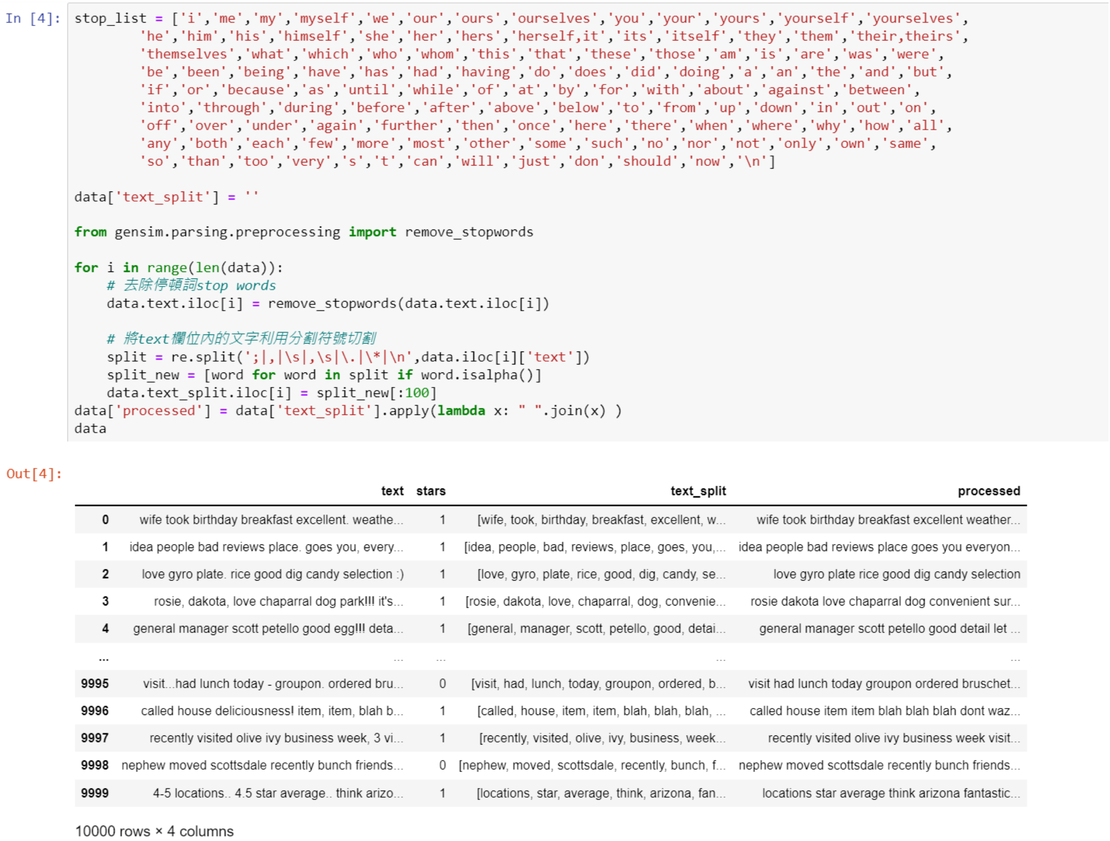
- [3]：yelp.csv 只保留 text 和 stars 兩個欄位，存為 data。並將 stars 欄位內值大於等於 4 的轉成 1，小於 4 轉成 0。並將 text 中的文字全部轉成小寫。



```
In [3]:
# 讀取csv檔僅保留"text"、"stars"兩個欄位
data = yelp[['text','stars']]
# 將stars欄位內值大於等於4的轉成1，其餘轉成0
data.loc[data['stars']<4 , 'stars'] = 0
data.loc[data['stars']>=4 , 'stars'] = 1
data['text'] = data['text'].str.lower()
display(data)
# 1: positive, 0: negative
```

	text	stars
0	my wife took me here on my birthday for breakf...	1
1	i have no idea why some people give bad review...	1
2	love the gyro plate. rice is so good and i als...	1
3	rosie, dakota, and i love chaparral dog park!!...	1
4	general manager scott petello is a good egg!!!...	1
...	...	...
9995	first visit...had lunch here today - used my g...	0
9996	should be called house of deliciousness!\n\ni ...	1
9997	i recently visited olive and ivy for business ...	1
9998	my nephew just moved to scottsdale recently so...	0
9999	4-5 locations.. all 4.5 star average.. i think...	1

- [4]： 自己建立 stop list。並用 gensim 內建的 remove_stopwords 移除 stop words，經過 re.split 分割，確定分割單位內皆為字母(isalpha)後存入 data[‘text_split’]。(只存每則評論前 100 個分割單字，因為評論包含單字數的中位數是 83)



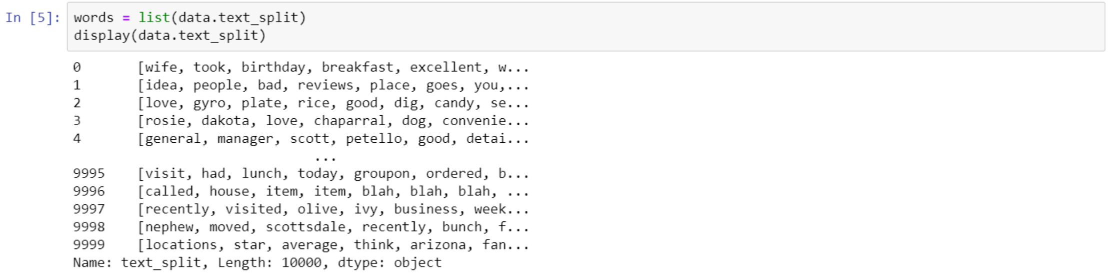
In [4]:
```
stop_list = ['i','me','my','myself','we','our','ours','ourselves','you','your','yours','yourself','yourselves',
        'he','him','his','himself','she','her','hers','herself,it','its','itself','they','them','their,theirs',
        'themselves','what','which','who','whom','this','that','these','those','am','is','are','was','were',
        'be','been','being','have','has','had','having','do','does','did','doing','a','an','the','and','but',
        'if','or','because','as','until','while','of','at','by','for','with','about','against','between',
        'into','through','during','before','after','above','below','to','from','up','down','in','out','on',
        'off','over','under','again','further','then','once','here','there','when','where','why','how','all',
        'any','both','each','few','more','most','other','some','such','no','nor','not','only','own','same',
        'so','than','too','very','s','t','can','will','just','don','should','now','\n']

data['text_split'] = ''

from gensim.parsing.preprocessing import remove_stopwords

for i in range(len(data)):
    # 去除停頓詞stop words
    data.text.iloc[i] = remove_stopwords(data.text.iloc[i])

    # 將text欄位內的文字利用分割符號切割
    split = re.split(';|,|\s|,\s|\.|\*|\n',data.iloc[i]['text'])
    split_new = [word for word in split if word.isalpha()]
    data.text_split.iloc[i] = split_new[:100]
data['processed'] = data['text_split'].apply(lambda x: " ".join(x) )
data
```

Out[4]:

	text	stars	text_split	processed
0	wife took birthday breakfast excellent. weathe...	1	[wife, took, birthday, breakfast, excellent, w...	wife took birthday breakfast excellent weather...
1	idea people bad reviews place. goes you, every...	1	[idea, people, bad, reviews, place, goes, you,...	idea people bad reviews place goes you everyon...
2	love gyro plate. rice good dig candy selection :)	1	[love, gyro, plate, rice, good, dig, candy, se...	love gyro plate rice good dig candy selection
3	rosie, dakota, love chaparral dog park!!! it's...	1	[rosie, dakota, love, chaparral, dog, convenie...	rosie dakota love chaparral dog convenient sur...
4	general manager scott petello good egg!!! deta...	1	[general, manager, scott, petello, good, detai...	general manager scott petello good detail let ...
...	...	...	...	...
9995	visit...had lunch today - groupon. ordered bru...	0	[visit, had, lunch, today, groupon, ordered, b...	visit had lunch today groupon ordered bruschet...
9996	called house deliciousness! item, item, blah b...	1	[called, house, item, item, blah, blah, blah, ...	called house item item blah blah blah dont waz...
9997	recently visited olive ivy business week, 3 vi...	1	[recently, visited, olive, ivy, business, week...	recently visited olive ivy business week visit...
9998	nephew moved scottsdale recently bunch friends...	0	[nephew, moved, scottsdale, recently, bunch, f...	nephew moved scottsdale recently bunch friends...
9999	4-5 locations.. 4.5 star average.. think arizo...	1	[locations, star, average, think, arizona, fan...	locations star average think arizona fantastic...

10000 rows × 4 columns

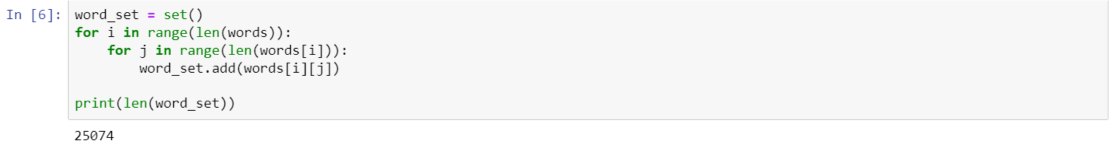
- [5]：data[‘text_split’]轉為 list 型態，並存為 words。



In [5]:
```
words = list(data.text_split)
display(data.text_split)
```

```
0       [wife, took, birthday, breakfast, excellent, w...
1       [idea, people, bad, reviews, place, goes, you,...
2       [love, gyro, plate, rice, good, dig, candy, se...
3       [rosie, dakota, love, chaparral, dog, convenie...
4       [general, manager, scott, petello, good, detai...
                              ...
9995    [visit, had, lunch, today, groupon, ordered, b...
9996    [called, house, item, item, blah, blah, blah, ...
9997    [recently, visited, olive, ivy, business, week...
9998    [nephew, moved, scottsdale, recently, bunch, f...
9999    [locations, star, average, think, arizona, fan...
Name: text_split, Length: 10000, dtype: object
```

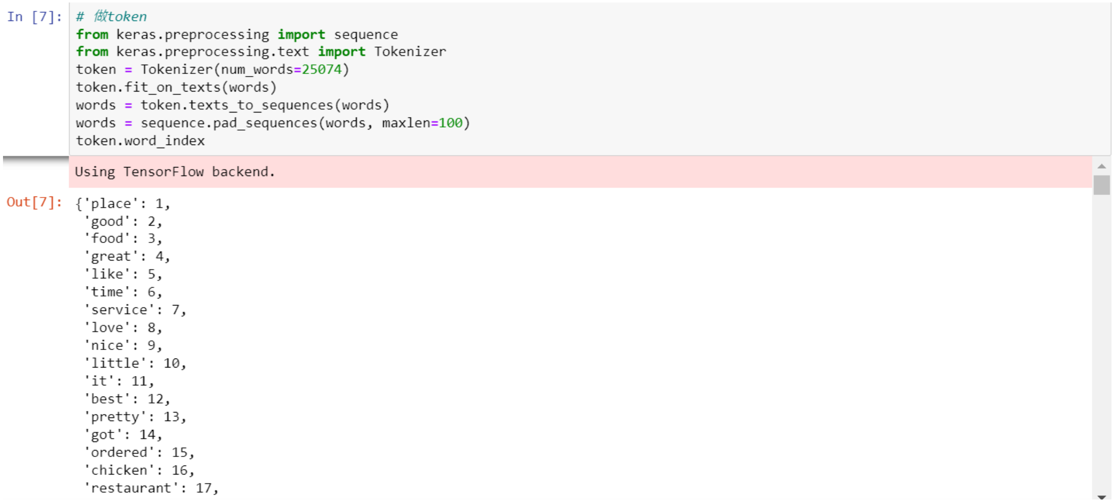
- [6]：檢查 words 的評論中，出現過的單字數(不重複)，即為 token 字典數。(共有 25074 個單字，1~25074)



In [6]:
```
word_set = set()
for i in range(len(words)):
    for j in range(len(words[i])):
        word_set.add(words[i][j])

print(len(word_set))
```

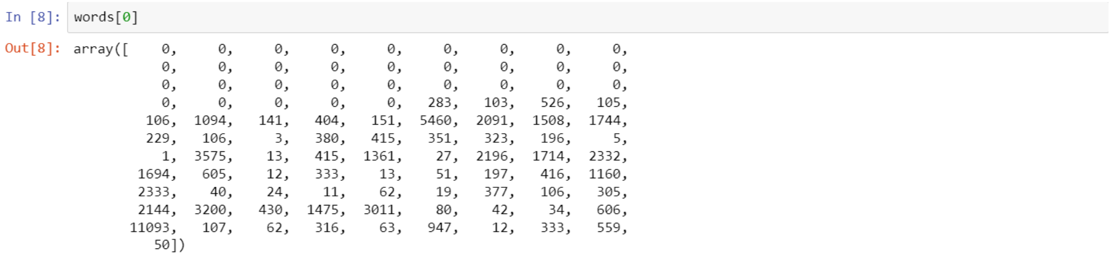
```
25074
```

- [7]：做 token，將 words 中每個單字 mapping 到正整數編號，並做 padding (sequence.pad_sequences)將每則評論補到 100 個字(加入 0)



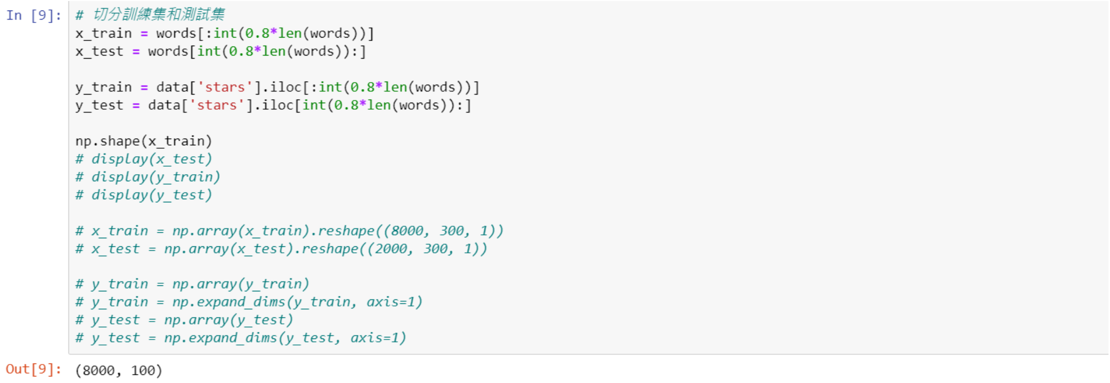
```
In [7]: # 做token
        from keras.preprocessing import sequence
        from keras.preprocessing.text import Tokenizer
        token = Tokenizer(num_words=25074)
        token.fit_on_texts(words)
        words = token.texts_to_sequences(words)
        words = sequence.pad_sequences(words, maxlen=100)
        token.word_index

        Using TensorFlow backend.

Out[7]: {'place': 1,
         'good': 2,
         'food': 3,
         'great': 4,
         'like': 5,
         'time': 6,
         'service': 7,
         'love': 8,
         'nice': 9,
         'little': 10,
         'it': 11,
         'best': 12,
         'pretty': 13,
         'got': 14,
         'ordered': 15,
         'chicken': 16,
         'restaurant': 17,
```

- [8]：檢查 padding 結果，可以看到前面會用 0 將整個評論補到長度為 100



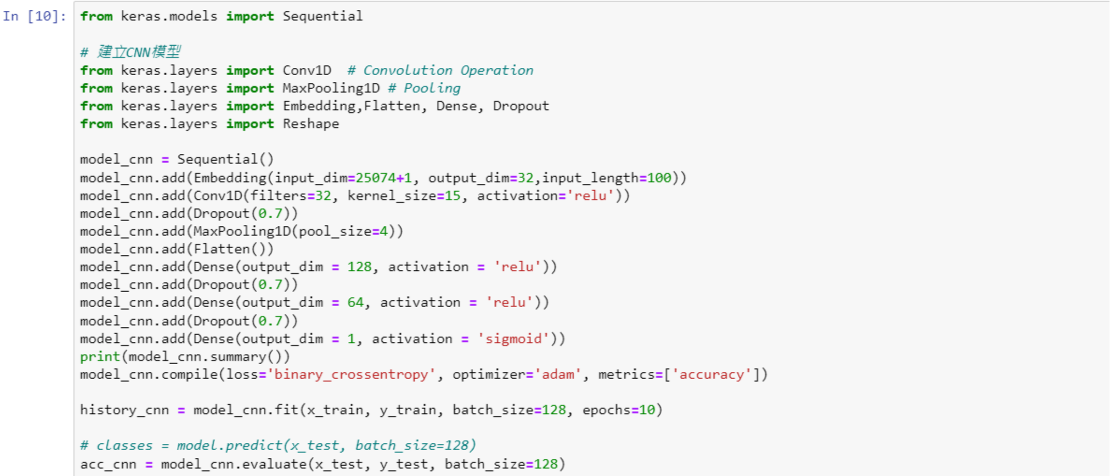
```
In [8]: words[0]

Out[8]: array([    0,     0,     0,     0,     0,     0,     0,     0,     0,
                   0,     0,     0,     0,     0,     0,     0,     0,     0,
                   0,     0,     0,     0,     0,     0,     0,     0,     0,
                   0,     0,     0,     0,     0,   283,   103,   526,   105,
                 106,  1094,   141,   404,   151,  5460,  2091,  1508,  1744,
                 229,   106,     3,   380,   415,   351,   323,   196,     5,
                   1,  3575,    13,   415,  1361,    27,  2196,  1714,  2332,
                1694,   605,    12,   333,    13,    51,   197,   416,  1160,
                2333,    40,    24,    11,    62,    19,   377,   106,   305,
                2144,  3200,   430,  1475,  3011,    80,    42,    34,   606,
               11093,   107,    62,   316,    63,   947,    12,   333,   559,
                  50])
```

- [9]：切分訓練集和測試集



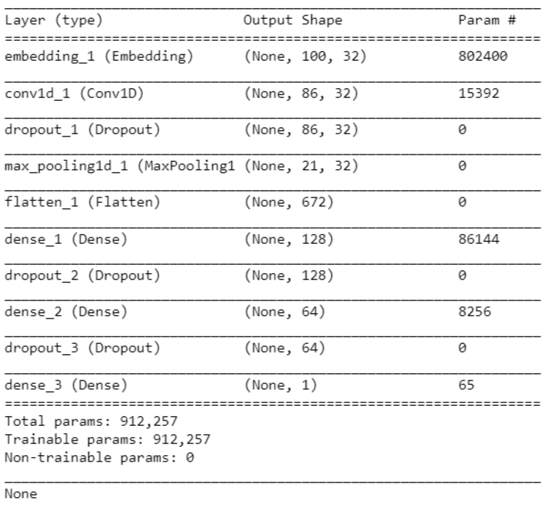
```
In [9]: # 切分訓練集和測試集
        x_train = words[:int(0.8*len(words))]
        x_test = words[int(0.8*len(words)):]

        y_train = data['stars'].iloc[:int(0.8*len(words))]
        y_test = data['stars'].iloc[int(0.8*len(words)):]

        np.shape(x_train)
        # display(x_test)
        # display(y_train)
        # display(y_test)

        # x_train = np.array(x_train).reshape((8000, 300, 1))
        # x_test = np.array(x_test).reshape((2000, 300, 1))

        # y_train = np.array(y_train)
        # y_train = np.expand_dims(y_train, axis=1)
        # y_test = np.array(y_test)
        # y_test = np.expand_dims(y_test, axis=1)

Out[9]: (8000, 100)
```

- [10]：用 keras 建立 CNN 模型，使用 Embedding 將每則評論轉成 32 維的 Embedding，接著使用 Conv1D 進行卷積，加入 Dropout ratio=0.7 過濾掉部分神經元資訊以避免 overfitting，再接著進行 MaxPooling, Flatten 等，最後加入三層 Dense，用 sigmoid 將輸出轉為 0/1 的預測結果(因為 label 是 0/1)



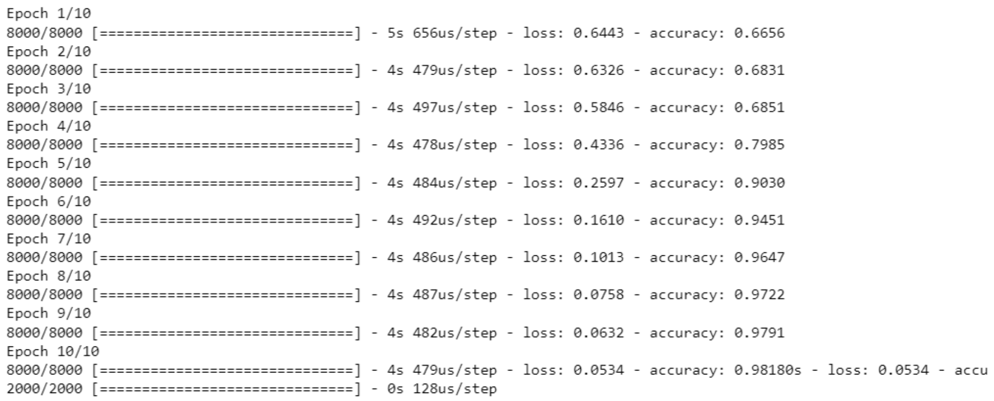
```
In [10]: from keras.models import Sequential

         # 建立CNN模型
         from keras.layers import Conv1D  # Convolution Operation
         from keras.layers import MaxPooling1D # Pooling
         from keras.layers import Embedding,Flatten, Dense, Dropout
         from keras.layers import Reshape

         model_cnn = Sequential()
         model_cnn.add(Embedding(input_dim=25074+1, output_dim=32,input_length=100))
         model_cnn.add(Conv1D(filters=32, kernel_size=15, activation='relu'))
         model_cnn.add(Dropout(0.7))
         model_cnn.add(MaxPooling1D(pool_size=4))
         model_cnn.add(Flatten())
         model_cnn.add(Dense(output_dim = 128, activation = 'relu'))
         model_cnn.add(Dropout(0.7))
         model_cnn.add(Dense(output_dim = 64, activation = 'relu'))
         model_cnn.add(Dropout(0.7))
         model_cnn.add(Dense(output_dim = 1, activation = 'sigmoid'))
         print(model_cnn.summary())
         model_cnn.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])

         history_cnn = model_cnn.fit(x_train, y_train, batch_size=128, epochs=10)

         # classes = model.predict(x_test, batch_size=128)
         acc_cnn = model_cnn.evaluate(x_test, y_test, batch_size=128)
```

- [10]：參數計算如下，
  ①embedding_1：802400(Param) = 25075(25074+1, token 字數加上 padding 編號 0)*32(embedding_size)
  ②conv1d_1：15392(Param) = 32(filters)*[32*15(link weight, embedding_size*kernel_size)+1(bias)]
  ③dense_1：86144(Param) = 672(Flatten output)*128(dense output)+128(bias)

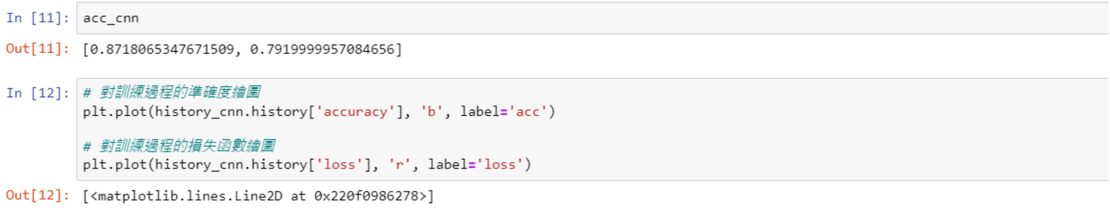


```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 100, 32)           802400
_________________________________________________________________
conv1d_1 (Conv1D)            (None, 86, 32)            15392
_________________________________________________________________
dropout_1 (Dropout)          (None, 86, 32)            0
_________________________________________________________________
max_pooling1d_1 (MaxPooling1 (None, 21, 32)            0
_________________________________________________________________
flatten_1 (Flatten)          (None, 672)               0
_________________________________________________________________
dense_1 (Dense)              (None, 128)               86144
_________________________________________________________________
dropout_2 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_2 (Dense)              (None, 64)                8256
_________________________________________________________________
dropout_3 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 65
=================================================================
Total params: 912,257
Trainable params: 912,257
Non-trainable params: 0
_________________________________________________________________
None
```

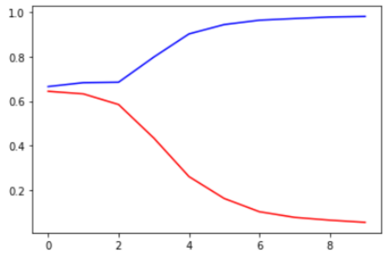
- [10]：訓練結果，accuracy 上升至 0.98，loss 和 acc 變化如圖[12]。



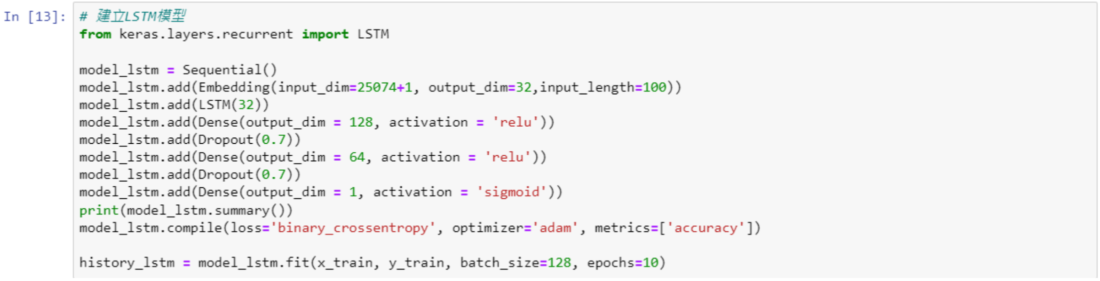
```
Epoch 1/10
8000/8000 [==============================] - 5s 656us/step - loss: 0.6443 - accuracy: 0.6656
Epoch 2/10
8000/8000 [==============================] - 4s 479us/step - loss: 0.6326 - accuracy: 0.6831
Epoch 3/10
8000/8000 [==============================] - 4s 497us/step - loss: 0.5846 - accuracy: 0.6851
Epoch 4/10
8000/8000 [==============================] - 4s 478us/step - loss: 0.4336 - accuracy: 0.7985
Epoch 5/10
8000/8000 [==============================] - 4s 484us/step - loss: 0.2597 - accuracy: 0.9030
Epoch 6/10
8000/8000 [==============================] - 4s 492us/step - loss: 0.1610 - accuracy: 0.9451
Epoch 7/10
8000/8000 [==============================] - 4s 486us/step - loss: 0.1013 - accuracy: 0.9647
Epoch 8/10
8000/8000 [==============================] - 4s 487us/step - loss: 0.0758 - accuracy: 0.9722
Epoch 9/10
8000/8000 [==============================] - 4s 482us/step - loss: 0.0632 - accuracy: 0.9791
Epoch 10/10
8000/8000 [==============================] - 4s 479us/step - loss: 0.0534 - accuracy: 0.98180s - loss: 0.0534 - accu
2000/2000 [==============================] - 0s 128us/step
```



```
In [11]: acc_cnn

Out[11]: [0.8718065347671509, 0.7919999957084656]

In [12]: # 對訓練過程的準確度繪圖
         plt.plot(history_cnn.history['accuracy'], 'b', label='acc')

         # 對訓練過程的損失函數繪圖
         plt.plot(history_cnn.history['loss'], 'r', label='loss')

Out[12]: [<matplotlib.lines.Line2D at 0x220f0986278>]
```

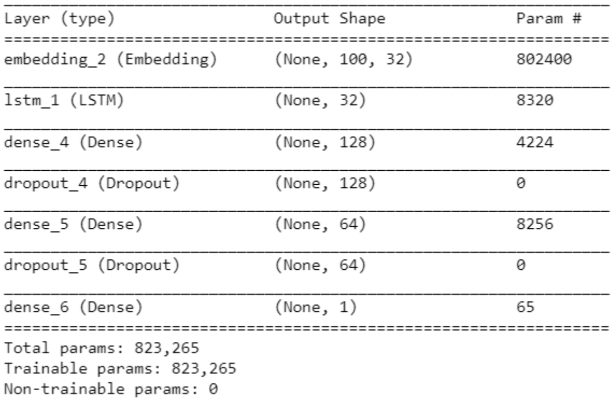


- [13]：建立 LSTM 模型(大致如 CNN 模型，使用 32 LSTM units)



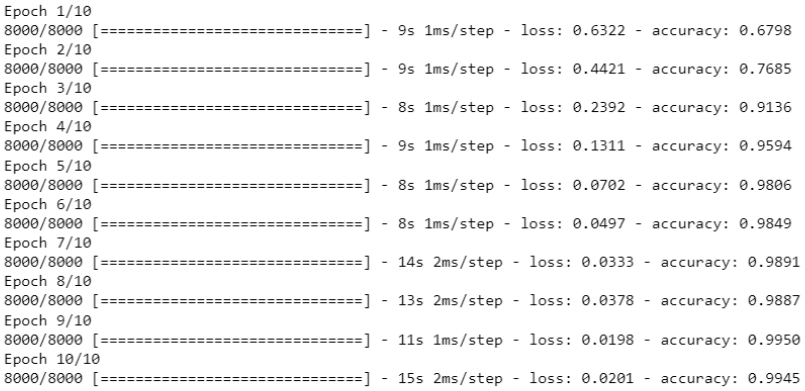
```
In [13]: # 建立LSTM模型
         from keras.layers.recurrent import LSTM

         model_lstm = Sequential()
         model_lstm.add(Embedding(input_dim=25074+1, output_dim=32,input_length=100))
         model_lstm.add(LSTM(32))
         model_lstm.add(Dense(output_dim = 128, activation = 'relu'))
         model_lstm.add(Dropout(0.7))
         model_lstm.add(Dense(output_dim = 64, activation = 'relu'))
         model_lstm.add(Dropout(0.7))
         model_lstm.add(Dense(output_dim = 1, activation = 'sigmoid'))
         print(model_lstm.summary())
         model_lstm.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])

         history_lstm = model_lstm.fit(x_train, y_train, batch_size=128, epochs=10)
```

- [13]：參數計算如下，
①embedding_2：802400(Param) = 25075(25074+1, token 字數加上 padding 編號 0)*32(embedding_size)
②lstm_1：8320(Param) = 4(gates)*[32(input)*32(LSTM units)+32(previous hidden unit)*32(LSTM units)+32(bias for each LSTM units)]
③dense_4：4224(Param) = 32(lstm_1 output)*128(dense output)+128(bias)

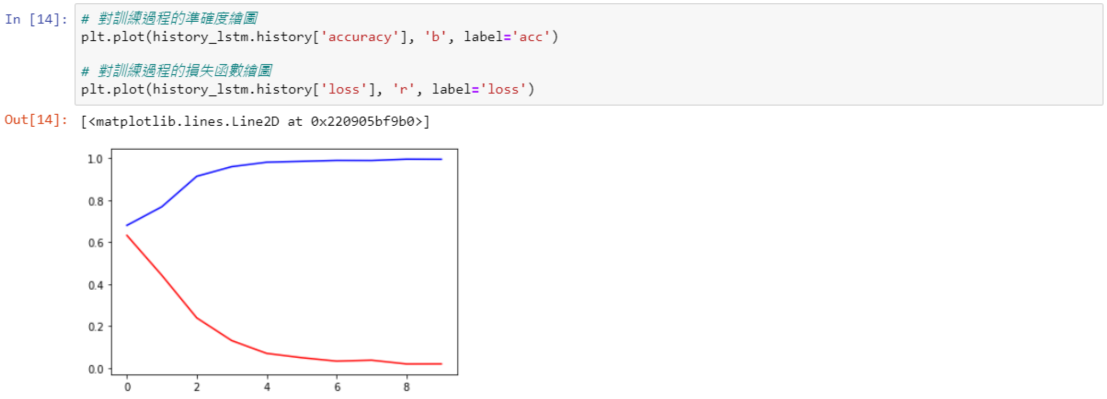


```
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
embedding_2 (Embedding)      (None, 100, 32)           802400    
_________________________________________________________________
lstm_1 (LSTM)                (None, 32)                8320      
_________________________________________________________________
dense_4 (Dense)              (None, 128)               4224      
_________________________________________________________________
dropout_4 (Dropout)          (None, 128)               0         
_________________________________________________________________
dense_5 (Dense)              (None, 64)                8256      
_________________________________________________________________
dropout_5 (Dropout)          (None, 64)                0         
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 65        
=================================================================
Total params: 823,265
Trainable params: 823,265
Non-trainable params: 0
```

- [13]：訓練結果，accuracy 上升至 0.99，loss 和 acc 變化如圖[14]。



```
Epoch 1/10
8000/8000 [==============================] - 9s 1ms/step - loss: 0.6322 - accuracy: 0.6798
Epoch 2/10
8000/8000 [==============================] - 9s 1ms/step - loss: 0.4421 - accuracy: 0.7685
Epoch 3/10
8000/8000 [==============================] - 8s 1ms/step - loss: 0.2392 - accuracy: 0.9136
Epoch 4/10
8000/8000 [==============================] - 9s 1ms/step - loss: 0.1311 - accuracy: 0.9594
Epoch 5/10
8000/8000 [==============================] - 8s 1ms/step - loss: 0.0702 - accuracy: 0.9806
Epoch 6/10
8000/8000 [==============================] - 8s 1ms/step - loss: 0.0497 - accuracy: 0.9849
Epoch 7/10
8000/8000 [==============================] - 14s 2ms/step - loss: 0.0333 - accuracy: 0.9891
Epoch 8/10
8000/8000 [==============================] - 13s 2ms/step - loss: 0.0378 - accuracy: 0.9887
Epoch 9/10
8000/8000 [==============================] - 11s 1ms/step - loss: 0.0198 - accuracy: 0.9950
Epoch 10/10
8000/8000 [==============================] - 15s 2ms/step - loss: 0.0201 - accuracy: 0.9945
```



```
In [14]: # 對訓練過程的準確度繪圖
         plt.plot(history_lstm.history['accuracy'], 'b', label='acc')

         # 對訓練過程的損失函數繪圖
         plt.plot(history_lstm.history['loss'], 'r', label='loss')

Out[14]: [<matplotlib.lines.Line2D at 0x220905bf9b0>]
```