Assignment 9: Text Classification with Deep Learning

Brendan Lim

CS4376.002

In [88]:
```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

import tensorflow as tf
from tensorflow.keras import layers, models, preprocessing
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report

import matplotlib.pyplot as plt

import os
from pathlib import Path

#code that came with kaggle
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))
```

```
/kaggle/input/news-headlines-dataset-for-sarcasm-detection/Sarcasm_Headlines_Dataset_v2.
json
/kaggle/input/news-headlines-dataset-for-sarcasm-detection/Sarcasm_Headlines_Dataset.jso
n
```

Sarcasm Headline Dataset

This sarcasm dataset takes headlines from the Onion (sarcastic) and the Huffington Post (serious) to determine whether a headline is sarcastic or not. The model must be able to predict between sarcastic and serious headlines, although I figure that it will veer more towards being able to predict the writing styles of the two news companies.

Citation:

1. Misra, Rishabh and Prahal Arora. "Sarcasm Detection using News Headlines Dataset." AI Open (2023).
2. Misra, Rishabh and Jigyasa Grover. "Sculpting Data for ML: The first act of Machine Learning." ISBN 9798585463570 (2021).

In [89]:
```
#read in json file using pandas
dataset_path = Path("/kaggle/input/news-headlines-dataset-for-sarcasm-detection/Sarcasm

json_df = pd.read_json(dataset_path, lines= True)
```

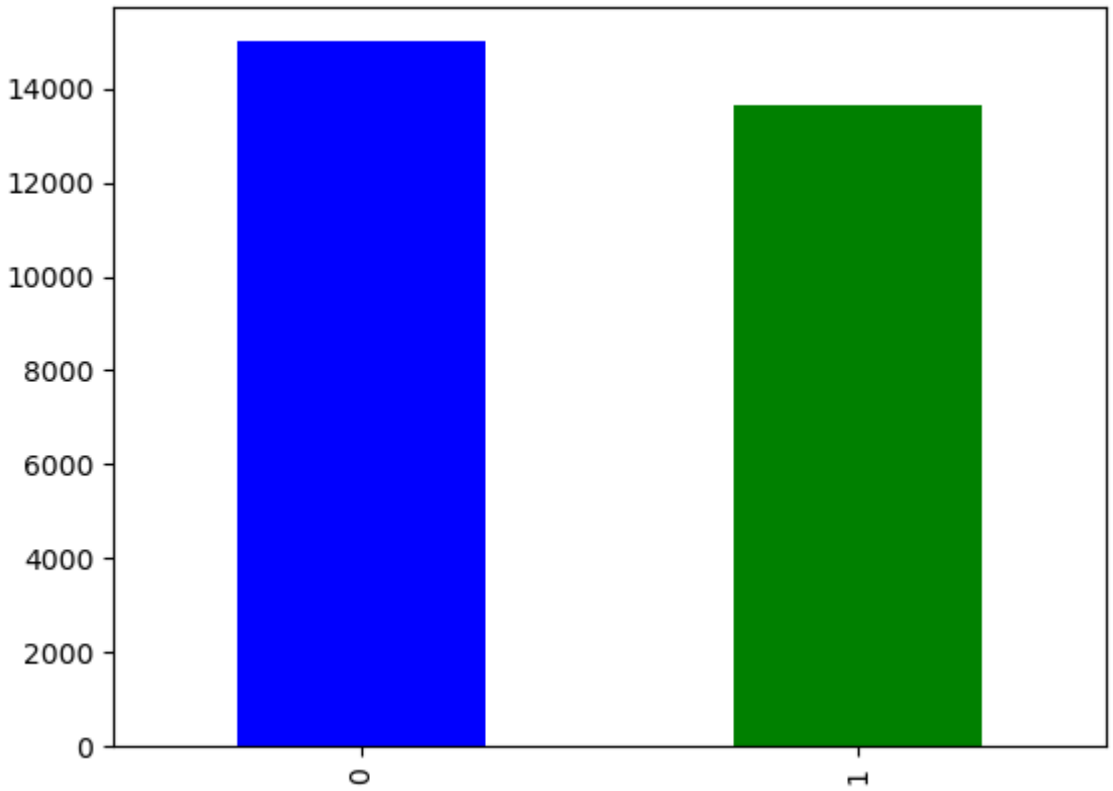
```
dataset = json_df[["headline", "is_sarcastic"]]
print(dataset)
```

```
                                                headline  is_sarcastic
0      thirtysomething scientists unveil doomsday clo...             1
1      dem rep. totally nails why congress is falling...             0
2      eat your veggies: 9 deliciously different recipes             0
3      inclement weather prevents liar from getting t...             1
4      mother comes pretty close to using word 'strea...             1
...                                                  ...           ...
28614      jews to celebrate rosh hashasha or something              1
28615  internal affairs investigator disappointed con...             1
28616  the most beautiful acceptance speech this week...             0
28617  mars probe destroyed by orbiting spielberg-gat...             1
28618                dad clarifies this not a food stop              1

[28619 rows x 2 columns]
```

In [90]:
```
dataset['is_sarcastic'].value_counts().plot(kind='bar', color = ["b",'g'])
```

Out[90]: <AxesSubplot:>



In [91]:
```
#divide into train/valid/test
train_split = 0.8
test_split = 0.2
#validation will be 25% of training dataset, or 20% of whole dataset
valid_split = 0.25


x_train, x_test, y_train, y_test = train_test_split(dataset.headline, dataset.is_sarcas
x_train, x_valid, y_train, y_valid = train_test_split(x_train, y_train, test_size= vali

print(x_train.shape)
```

```
print(x_valid.shape)
print(x_test.shape)
```

```
(17171,)
(5724,)
(5724,)
```

In [92]:

```
#articles headlines are expected to have higher diversity of speech
text_vect_layer = tf.keras.layers.TextVectorization(
    max_tokens = 10000,
    output_mode = 'int',
    output_sequence_length=50
)
text_vect_layer.adapt(x_train)
```

Simple Sequential Model

The simple sequential did not perform very well, even after being given many different variations of dense neural layers. I tried using different activation functions, but that did not seem to have a significant effect. This model seems to be the stepping stone between ML neural networks and the deep learnign models we've discussed earlier.

In [120…

```
seq_model = models.Sequential()
seq_model.add(tf.keras.Input(shape=(1,), dtype=tf.string))
seq_model.add(text_vect_layer)
seq_model.add(layers.Dense(30, activation='relu'))
seq_model.add(layers.Dense(30, activation='relu'))
seq_model.add(layers.Dense(1, activation='sigmoid'))

seq_model.summary()

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

```
Model: "sequential_29"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 text_vectorization_3 (TextV  (None, 50)               0
 ectorization)

 dense_42 (Dense)            (None, 30)                1530

 dense_43 (Dense)            (None, 30)                930

 dense_44 (Dense)            (None, 1)                 31

=================================================================
Total params: 2,491
Trainable params: 2,491
Non-trainable params: 0
_________________________________________________________________
```

In [121…

```
history = seq_model.fit(
    x_train,
    y_train,
    epochs = 10,
    batch_size = 256,
    validation_data=((x_valid, y_valid))
)
```

```
Epoch 1/10
68/68 [==============================] - 1s 8ms/step - loss: 110.4009 - accuracy: 0.5004
- val_loss: 35.0019 - val_accuracy: 0.5262
Epoch 2/10
68/68 [==============================] - 0s 5ms/step - loss: 30.9152 - accuracy: 0.5239
- val_loss: 23.0225 - val_accuracy: 0.5143
Epoch 3/10
68/68 [==============================] - 0s 6ms/step - loss: 21.9473 - accuracy: 0.5215
- val_loss: 18.2069 - val_accuracy: 0.5101
Epoch 4/10
68/68 [==============================] - 0s 5ms/step - loss: 17.5716 - accuracy: 0.5247
- val_loss: 15.1931 - val_accuracy: 0.5147
Epoch 5/10
68/68 [==============================] - 0s 4ms/step - loss: 14.6262 - accuracy: 0.5275
- val_loss: 13.1573 - val_accuracy: 0.5203
Epoch 6/10
68/68 [==============================] - 0s 4ms/step - loss: 12.1413 - accuracy: 0.5304
- val_loss: 11.1731 - val_accuracy: 0.5114
Epoch 7/10
68/68 [==============================] - 0s 5ms/step - loss: 10.3357 - accuracy: 0.5292
- val_loss: 9.3746 - val_accuracy: 0.5236
Epoch 8/10
68/68 [==============================] - 0s 5ms/step - loss: 9.0609 - accuracy: 0.5339 -
val_loss: 8.4005 - val_accuracy: 0.5245
Epoch 9/10
68/68 [==============================] - 0s 6ms/step - loss: 7.9575 - accuracy: 0.5346 -
val_loss: 7.3633 - val_accuracy: 0.5327
Epoch 10/10
68/68 [==============================] - 0s 4ms/step - loss: 7.0928 - accuracy: 0.5366 -
val_loss: 6.9588 - val_accuracy: 0.5280
```

In [115…
```
#predict on test data
pred = seq_model.predict(x_test)
```

```
179/179 [==============================] - 0s 2ms/step
```

In [116…
```
bool_pred = np.where(pred < 0.5, 0, 1)
print(pred[:10])
print(bool_pred[:10])

print(classification_report(y_test, bool_pred))
```

```
[[1.0000000e+00]
 [6.9303697e-01]
 [9.9301457e-01]
 [1.0000000e+00]
 [1.0534343e-05]
 [9.8170125e-01]
 [1.0000000e+00]
 [9.4150776e-01]
 [1.0000000e+00]
 [6.7488298e-05]]
[[1]
 [1]
 [1]
 [1]
 [0]
 [1]
 [1]
 [1]
 [1]
 [0]]
              precision    recall  f1-score   support

           0       0.55      0.51      0.53      3035
           1       0.49      0.52      0.51      2689

    accuracy                           0.52      5724
   macro avg       0.52      0.52      0.52      5724
weighted avg       0.52      0.52      0.52      5724
```

Convolutional Neural Network

I've only ever used CNNs for things like images, so I was curious to see how a 1D CNN works.

Something interesting is that the test accuracy was near 100%, while the validation and test accuracy were very nearly the same at ~80%, showing an example of overfitting. I am surprised that nearly any CNN model I threw the dataset at was able to get a good starting accuracy, especially comparing it to other neural networks, which require a decent amount of fine tuning before getting good results.

I think I would have to read up more on how to choose filter/kernel size so that I can design better models ratehr than just doing trial-and-error.

In [97]:
```
cnn_model = models.Sequential()
cnn_model.add(tf.keras.Input(shape=(1,), dtype=tf.string))
cnn_model.add(text_vect_layer)
#10000 vocab size and 50 input length
cnn_model.add(layers.Embedding(10000,64,input_length = 50))
cnn_model.add(layers.Conv1D(64,7, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.Conv1D(32,3, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.GlobalMaxPooling1D())
cnn_model.add(layers.Dense(1))
cnn_model.summary()
```

```
Model: "sequential_21"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 text_vectorization_3 (TextV  (None, 50)               0
 ectorization)

 embedding_17 (Embedding)    (None, 50, 64)            640000

 conv1d_34 (Conv1D)          (None, 44, 64)            28736

 max_pooling1d_31 (MaxPoolin  (None, 8, 64)            0
 g1D)

 conv1d_35 (Conv1D)          (None, 6, 32)             6176

 max_pooling1d_32 (MaxPoolin  (None, 1, 32)            0
 g1D)

 global_max_pooling1d_10 (Gl  (None, 32)               0
 obalMaxPooling1D)

 dense_26 (Dense)            (None, 1)                 33

=================================================================
Total params: 674,945
Trainable params: 674,945
Non-trainable params: 0
_________________________________________________________________
```

In [98]:
```
#model definition
cnn_model.compile(
    optimizer = "adam",
    loss="binary_crossentropy",
    metrics= ['accuracy']
)
```

In [99]:
```
#training the model
history = cnn_model.fit(
    x_train,
    y_train,
    epochs = 20,
    batch_size = 256,
```

```
    validation_data=((x_valid, y_valid))
)
```

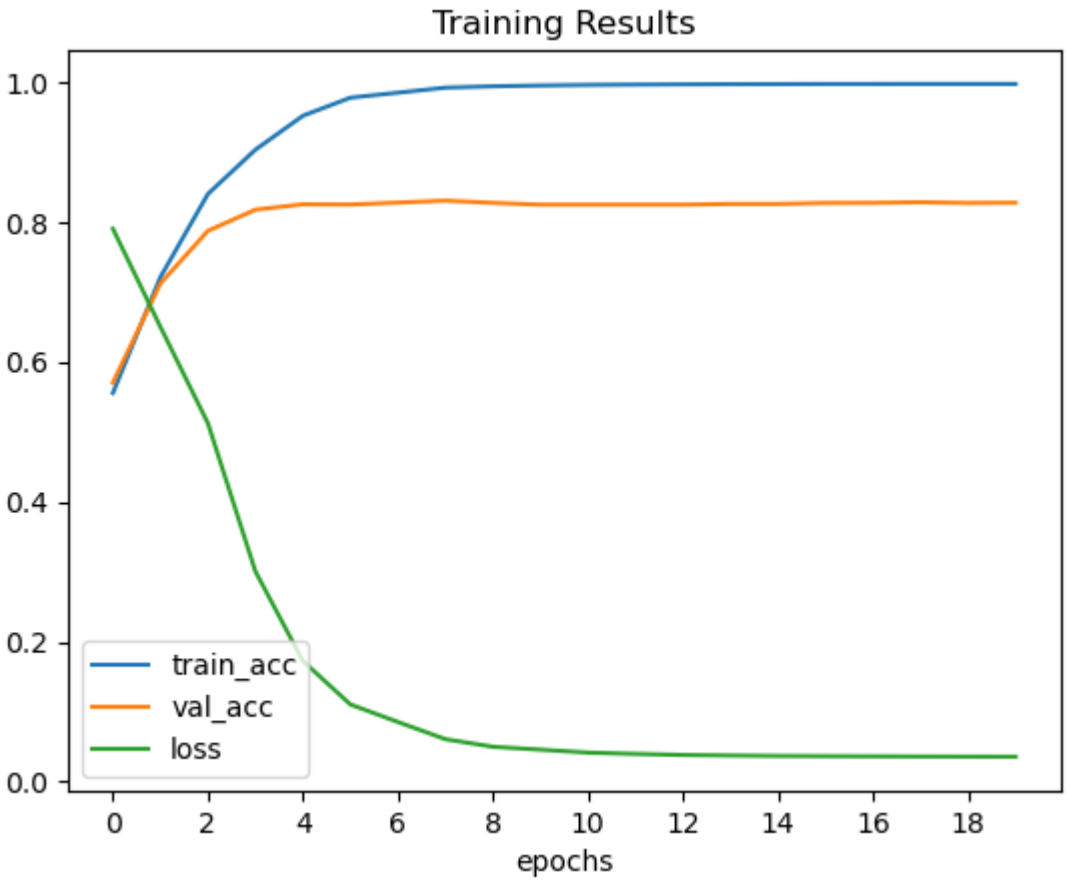
```
Epoch 1/20
68/68 [==============================] - 5s 50ms/step - loss: 0.7903 - accuracy: 0.5556
- val_loss: 0.6822 - val_accuracy: 0.5704
Epoch 2/20
68/68 [==============================] - 3s 41ms/step - loss: 0.6502 - accuracy: 0.7212
- val_loss: 0.6377 - val_accuracy: 0.7121
Epoch 3/20
68/68 [==============================] - 3s 42ms/step - loss: 0.5124 - accuracy: 0.8401
- val_loss: 0.4888 - val_accuracy: 0.7874
Epoch 4/20
68/68 [==============================] - 3s 43ms/step - loss: 0.3006 - accuracy: 0.9033
- val_loss: 0.5187 - val_accuracy: 0.8176
Epoch 5/20
68/68 [==============================] - 3s 41ms/step - loss: 0.1725 - accuracy: 0.9518
- val_loss: 0.5863 - val_accuracy: 0.8253
Epoch 6/20
68/68 [==============================] - 3s 41ms/step - loss: 0.1104 - accuracy: 0.9777
- val_loss: 0.8005 - val_accuracy: 0.8249
Epoch 7/20
68/68 [==============================] - 3s 42ms/step - loss: 0.0854 - accuracy: 0.9848
- val_loss: 0.8318 - val_accuracy: 0.8277
Epoch 8/20
68/68 [==============================] - 3s 43ms/step - loss: 0.0608 - accuracy: 0.9920
- val_loss: 0.8836 - val_accuracy: 0.8305
Epoch 9/20
68/68 [==============================] - 3s 41ms/step - loss: 0.0500 - accuracy: 0.9939
- val_loss: 0.9395 - val_accuracy: 0.8274
Epoch 10/20
68/68 [==============================] - 3s 42ms/step - loss: 0.0458 - accuracy: 0.9951
- val_loss: 0.9523 - val_accuracy: 0.8248
Epoch 11/20
68/68 [==============================] - 3s 41ms/step - loss: 0.0416 - accuracy: 0.9959
- val_loss: 0.9817 - val_accuracy: 0.8248
Epoch 12/20
68/68 [==============================] - 3s 47ms/step - loss: 0.0398 - accuracy: 0.9964
- val_loss: 0.9901 - val_accuracy: 0.8248
Epoch 13/20
68/68 [==============================] - 3s 42ms/step - loss: 0.0382 - accuracy: 0.9967
- val_loss: 1.0106 - val_accuracy: 0.8248
Epoch 14/20
68/68 [==============================] - 3s 41ms/step - loss: 0.0375 - accuracy: 0.9970
- val_loss: 1.0629 - val_accuracy: 0.8258
Epoch 15/20
68/68 [==============================] - 3s 41ms/step - loss: 0.0369 - accuracy: 0.9971
- val_loss: 1.0742 - val_accuracy: 0.8258
Epoch 16/20
68/68 [==============================] - 3s 43ms/step - loss: 0.0365 - accuracy: 0.9973
- val_loss: 1.0815 - val_accuracy: 0.8272
Epoch 17/20
68/68 [==============================] - 3s 41ms/step - loss: 0.0363 - accuracy: 0.9973
- val_loss: 1.1005 - val_accuracy: 0.8274
Epoch 18/20
68/68 [==============================] - 3s 41ms/step - loss: 0.0361 - accuracy: 0.9973
- val_loss: 1.1039 - val_accuracy: 0.8283
Epoch 19/20
68/68 [==============================] - 3s 42ms/step - loss: 0.0359 - accuracy: 0.9973
- val_loss: 1.1090 - val_accuracy: 0.8272
```

```
Epoch 20/20
68/68 [==============================] - 3s 42ms/step - loss: 0.0358 - accuracy: 0.9973
- val_loss: 1.1325 - val_accuracy: 0.8276
```

In [100…

```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.plot(history.history['loss'])
plt.title("Training Results")
plt.xlabel('epochs')
plt.xticks(np.arange(0, 20, 2))
plt.legend(['train_acc', 'val_acc', 'loss'], loc = 'lower left')

plt.show()
```



In [101…

```
pred = cnn_model.predict(x_test)
```

```
179/179 [==============================] - 1s 3ms/step
```

In [102…

```
print(pred.shape)
bool_pred = np.where(pred < 0.5, 0, 1)
new_bool_pred = bool_pred.reshape((y_test.shape[0],1))
new_y_test = y_test.values.reshape((y_test.shape[0],1))
print(new_bool_pred.shape)
print(new_y_test.shape)
print(classification_report(new_y_test, new_bool_pred))
```

```
(5724, 1)
(5724, 1)
(5724, 1)
```

```
              precision    recall  f1-score   support

           0       0.84      0.84      0.84      3035
           1       0.82      0.82      0.82      2689

    accuracy                           0.83      5724
   macro avg       0.83      0.83      0.83      5724
weighted avg       0.83      0.83      0.83      5724
```

Trying out different embedding approaches

Trying out a 128, 32, and 16 dimensional vector for embedding. They do not seem to produce noticeably better results. The model seems to overfit either way and have 80% accuracy for the validation and test sets.

In [103…

```
#128
cnn_model = models.Sequential()
cnn_model.add(tf.keras.Input(shape=(1,), dtype=tf.string))
cnn_model.add(text_vect_layer)
#10000 vocab size and 50 input length
cnn_model.add(layers.Embedding(10000,128,input_length = 50))
cnn_model.add(layers.Conv1D(64,7, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.Conv1D(32,3, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.GlobalMaxPooling1D())
cnn_model.add(layers.Dense(1))

cnn_model.summary()

cnn_model.compile(
    optimizer = "adam",
    loss="binary_crossentropy",
    metrics= ['accuracy']
)

history = cnn_model.fit(
    x_train,
    y_train,
    epochs = 10,
    batch_size = 256,
    validation_data=((x_valid, y_valid))
)

pred = cnn_model.predict(x_test)
bool_pred = np.where(pred < 0.5, 0, 1)
new_bool_pred = bool_pred.reshape((y_test.shape[0],1))
new_y_test = y_test.values.reshape((y_test.shape[0],1))
print(classification_report(new_y_test, new_bool_pred))
```

```
Model: "sequential_22"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 text_vectorization_3 (TextV  (None, 50)               0
```

```
 ectorization)

 embedding_18 (Embedding)    (None, 50, 128)           1280000

 conv1d_36 (Conv1D)          (None, 44, 64)            57408

 max_pooling1d_33 (MaxPoolin  (None, 8, 64)            0
 g1D)

 conv1d_37 (Conv1D)          (None, 6, 32)             6176

 max_pooling1d_34 (MaxPoolin  (None, 1, 32)            0
 g1D)

 global_max_pooling1d_11 (Gl  (None, 32)               0
 obalMaxPooling1D)

 dense_27 (Dense)            (None, 1)                 33

=================================================================
Total params: 1,343,617
Trainable params: 1,343,617
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
68/68 [==============================] - 6s 77ms/step - loss: 4.3288 - accuracy: 0.5214
- val_loss: 0.6864 - val_accuracy: 0.5196
Epoch 2/10
68/68 [==============================] - 5s 70ms/step - loss: 0.5836 - accuracy: 0.7538
- val_loss: 0.4800 - val_accuracy: 0.7802
Epoch 3/10
68/68 [==============================] - 5s 70ms/step - loss: 0.3244 - accuracy: 0.8789
- val_loss: 0.5268 - val_accuracy: 0.8085
Epoch 4/10
68/68 [==============================] - 5s 71ms/step - loss: 0.2072 - accuracy: 0.9493
- val_loss: 0.7160 - val_accuracy: 0.8297
Epoch 5/10
68/68 [==============================] - 5s 70ms/step - loss: 0.1536 - accuracy: 0.9715
- val_loss: 0.8629 - val_accuracy: 0.8265
Epoch 6/10
68/68 [==============================] - 5s 71ms/step - loss: 0.0923 - accuracy: 0.9864
- val_loss: 0.9990 - val_accuracy: 0.8256
Epoch 7/10
68/68 [==============================] - 5s 70ms/step - loss: 0.0761 - accuracy: 0.9904
- val_loss: 1.0438 - val_accuracy: 0.8202
Epoch 8/10
68/68 [==============================] - 5s 77ms/step - loss: 0.0608 - accuracy: 0.9931
- val_loss: 1.0081 - val_accuracy: 0.8211
Epoch 9/10
68/68 [==============================] - 5s 70ms/step - loss: 0.0498 - accuracy: 0.9951
- val_loss: 1.0436 - val_accuracy: 0.8215
Epoch 10/10
68/68 [==============================] - 5s 70ms/step - loss: 0.0461 - accuracy: 0.9954
- val_loss: 1.1950 - val_accuracy: 0.8239
179/179 [==============================] - 1s 4ms/step
              precision    recall  f1-score   support

           0       0.84      0.85      0.84      3035
           1       0.82      0.82      0.82      2689
```

```
    accuracy                           0.83      5724
   macro avg       0.83      0.83      0.83      5724
weighted avg       0.83      0.83      0.83      5724
```

In [104…

```
#32
cnn_model = models.Sequential()
cnn_model.add(tf.keras.Input(shape=(1,), dtype=tf.string))
cnn_model.add(text_vect_layer)
#10000 vocab size and 50 input length
cnn_model.add(layers.Embedding(10000,32,input_length = 50))
cnn_model.add(layers.Conv1D(32,2, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.Conv1D(16,2, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.GlobalMaxPooling1D())
cnn_model.add(layers.Dense(1))

cnn_model.summary()

cnn_model.compile(
    optimizer = "adam",
    loss="binary_crossentropy",
    metrics= ['accuracy']
)

history = cnn_model.fit(
    x_train,
    y_train,
    epochs = 10,
    batch_size = 256,
    validation_data=((x_valid, y_valid))
)

pred = cnn_model.predict(x_test)
bool_pred = np.where(pred < 0.5, 0, 1)
new_bool_pred = bool_pred.reshape((y_test.shape[0],1))
print(classification_report(new_y_test, new_bool_pred))
```

```
Model: "sequential_23"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 text_vectorization_3 (TextV  (None, 50)               0
 ectorization)

 embedding_19 (Embedding)    (None, 50, 32)            320000

 conv1d_38 (Conv1D)          (None, 49, 32)            2080

 max_pooling1d_35 (MaxPoolin  (None, 9, 32)            0
 g1D)

 conv1d_39 (Conv1D)          (None, 8, 16)             1040

 max_pooling1d_36 (MaxPoolin  (None, 1, 16)            0
 g1D)

 global_max_pooling1d_12 (Gl  (None, 16)               0
```

```
 obalMaxPooling1D)

 dense_28 (Dense)            (None, 1)                 17

=================================================================
Total params: 323,137
Trainable params: 323,137
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
68/68 [==============================] - 2s 20ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 2/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 3/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 4/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 5/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 6/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 7/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 8/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 9/10
68/68 [==============================] - 1s 16ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
Epoch 10/10
68/68 [==============================] - 1s 17ms/step - loss: 7.3617 - accuracy: 0.5227
- val_loss: 7.4107 - val_accuracy: 0.5196
179/179 [==============================] - 1s 2ms/step
              precision    recall  f1-score   support

           0       0.53      1.00      0.69      3035
           1       0.00      0.00      0.00      2689

    accuracy                           0.53      5724
   macro avg       0.27      0.50      0.35      5724
weighted avg       0.28      0.53      0.37      5724

/opt/conda/lib/python3.7/site-packages/sklearn/metrics/_classification.py:1318: Undefine
dMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/conda/lib/python3.7/site-packages/sklearn/metrics/_classification.py:1318: Undefine
dMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/conda/lib/python3.7/site-packages/sklearn/metrics/_classification.py:1318: Undefine
dMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
```

```
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [105…

```
#16
cnn_model = models.Sequential()
cnn_model.add(tf.keras.Input(shape=(1,), dtype=tf.string))
cnn_model.add(text_vect_layer)
#10000 vocab size and 50 input length
cnn_model.add(layers.Embedding(10000,16,input_length = 50))
cnn_model.add(layers.Conv1D(64,7, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.Conv1D(32,3, activation = 'relu'))
cnn_model.add(layers.MaxPooling1D(5))
cnn_model.add(layers.GlobalMaxPooling1D())
cnn_model.add(layers.Dense(1))

cnn_model.summary()

cnn_model.compile(
    optimizer = "adam",
    loss="binary_crossentropy",
    metrics= ['accuracy']
)

history = cnn_model.fit(
    x_train,
    y_train,
    epochs = 10,
    batch_size = 256,
    validation_data=((x_valid, y_valid))
)

pred = cnn_model.predict(x_test)
bool_pred = np.where(pred < 0.5, 0, 1)
new_bool_pred = bool_pred.reshape((y_test.shape[0],1))
print(classification_report(new_y_test, new_bool_pred))
```

```
Model: "sequential_24"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 text_vectorization_3 (TextV  (None, 50)               0
 ectorization)

 embedding_20 (Embedding)    (None, 50, 16)            160000

 conv1d_40 (Conv1D)          (None, 44, 64)            7232

 max_pooling1d_37 (MaxPoolin  (None, 8, 64)            0
 g1D)

 conv1d_41 (Conv1D)          (None, 6, 32)             6176

 max_pooling1d_38 (MaxPoolin  (None, 1, 32)            0
 g1D)

 global_max_pooling1d_13 (Gl  (None, 32)               0
 obalMaxPooling1D)
```

```
 dense_29 (Dense)            (None, 1)                 33

=================================================================
Total params: 173,441
Trainable params: 173,441
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
68/68 [==============================] - 3s 25ms/step - loss: 0.8474 - accuracy: 0.5506
- val_loss: 0.6712 - val_accuracy: 0.6244
Epoch 2/10
68/68 [==============================] - 2s 25ms/step - loss: 0.6209 - accuracy: 0.7064
- val_loss: 0.5796 - val_accuracy: 0.6964
Epoch 3/10
68/68 [==============================] - 2s 22ms/step - loss: 0.4226 - accuracy: 0.8264
- val_loss: 0.4980 - val_accuracy: 0.7956
Epoch 4/10
68/68 [==============================] - 2s 24ms/step - loss: 0.2765 - accuracy: 0.9037
- val_loss: 0.5727 - val_accuracy: 0.8104
Epoch 5/10
68/68 [==============================] - 2s 22ms/step - loss: 0.2699 - accuracy: 0.9355
- val_loss: 0.5742 - val_accuracy: 0.8139
Epoch 6/10
68/68 [==============================] - 1s 21ms/step - loss: 0.1604 - accuracy: 0.9583
- val_loss: 0.7745 - val_accuracy: 0.8124
Epoch 7/10
68/68 [==============================] - 1s 22ms/step - loss: 0.1157 - accuracy: 0.9730
- val_loss: 0.8664 - val_accuracy: 0.8127
Epoch 8/10
68/68 [==============================] - 1s 21ms/step - loss: 0.0904 - accuracy: 0.9812
- val_loss: 1.0608 - val_accuracy: 0.8115
Epoch 9/10
68/68 [==============================] - 1s 22ms/step - loss: 0.0719 - accuracy: 0.9878
- val_loss: 1.2308 - val_accuracy: 0.8082
Epoch 10/10
68/68 [==============================] - 1s 22ms/step - loss: 0.0615 - accuracy: 0.9907
- val_loss: 1.2759 - val_accuracy: 0.8036
179/179 [==============================] - 1s 3ms/step
              precision    recall  f1-score   support

           0       0.81      0.83      0.82      3035
           1       0.80      0.78      0.79      2689

    accuracy                           0.80      5724
   macro avg       0.80      0.80      0.80      5724
weighted avg       0.80      0.80      0.80      5724
```

Trying out the model on current headlines

The Onion is not the only source of news satire nowadays and the Huffington Post is not the only source of news. Here I tested some headlines from various sarcastic and serious news networks.

It seems that this model is not very good at determining satire from other news websites. This should be improved by adding more headlines from different sites, thereby incorporating more writing styles into the model.

In [106…

```
serious_headlines = [
    ["sudan fighting: army says foreign nationals to be evacuated"],#bbc
    ["oklahoma man saves wife from being sucked away by tornado"],#bbc
    ["nfl suspensions expose the league's problem with sports gambling"] #NYT
]

satire_headlines = [
    ["not just for crimes: the 5 most polite acts ever committed in international water
    ["9 names to consider before naming your child aiden"],#hard times
    ["places you've left your water bottle, and whether you can get it back"] #the new
]

print(cnn_model.predict(serious_headlines))
print(cnn_model.predict(satire_headlines))
```

```
1/1 [==============================] - 0s 45ms/step
[[-0.08028802]
 [ 3.2397485 ]
 [-0.05846712]]
1/1 [==============================] - 0s 48ms/step
[[ 0.04883295]
 [ 1.5674242 ]
 [-0.23062049]]
```