```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
!pip install rouge-score
```

```
Collecting rouge-score
  Downloading rouge_score-0.1.2.tar.gz (17 kB)
  Preparing metadata (setup.py) ... done
Requirement already satisfied: absl-py in /usr/local/lib/python3.10/dist-packages (from rouge-score) (1.4.0)
Requirement already satisfied: nltk in /usr/local/lib/python3.10/dist-packages (from rouge-score) (3.8.1)
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (from rouge-score) (1.26.4)
Requirement already satisfied: six>=1.14.0 in /usr/local/lib/python3.10/dist-packages (from rouge-score) (1.16.0)
Requirement already satisfied: click in /usr/local/lib/python3.10/dist-packages (from nltk->rouge-score) (8.1.7)
Requirement already satisfied: joblib in /usr/local/lib/python3.10/dist-packages (from nltk->rouge-score) (1.4.2)
Requirement already satisfied: regex>=2021.8.3 in /usr/local/lib/python3.10/dist-packages (from nltk->rouge-score) (2024.5.15)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from nltk->rouge-score) (4.66.5)
Building wheels for collected packages: rouge-score
  Building wheel for rouge-score (setup.py) ... done
  Created wheel for rouge-score: filename=rouge_score-0.1.2-py3-none-any.whl size=24935 sha256=fe6e3c7369463c8d25c7176698bf081b7395
  Stored in directory: /root/.cache/pip/wheels/5f/dd/89/461065a73be61a532ff8599a28e9beef17985c9e9c31e541b4
Successfully built rouge-score
Installing collected packages: rouge-score
Successfully installed rouge-score-0.1.2
```

```
#importing all required libraries
import os
import re
import csv
import nltk
import keras
import string
import pickle
import numpy as np
import pandas as pd
import seaborn as sns
import tensorflow as tf
from nltk.tag import pos_tag
from keras.layers import Layer
from nltk import word_tokenize
import matplotlib.pyplot as plt
from nltk.corpus import stopwords
from nltk.corpus import stopwords
from keras.utils import plot_model
from keras.layers import Concatenate
from rouge_score import rouge_scorer
from nltk.tokenize import word_tokenize
from tensorflow.keras import Input, Model
from tensorflow.keras import backend as K
from wordcloud import STOPWORDS, WordCloud
from tensorflow.keras.models import load_model
from nltk.stem.wordnet import WordNetLemmatizer
from nltk.corpus import twitter_samples, stopwords
from sklearn.model_selection import train_test_split
from keras.models import Sequential, model_from_json
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau
from tensorflow.keras.layers import LSTM, Bidirectional, Dense, Embedding, TimeDistributed
```

```
logger = tf.get_logger()
K.clear_session()
import warnings
warnings.filterwarnings('ignore')
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
True
```

```
nltk.download('all')
```

```
[nltk_data] Downloading collection 'all'
[nltk_data]    |
[nltk_data]    | Downloading package abc to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/abc.zip.
[nltk_data]    | Downloading package alpino to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/alpino.zip.
[nltk_data]    | Downloading package averaged_perceptron_tagger to
```

```
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping taggers/averaged_perceptron_tagger.zip.
[nltk_data]    | Downloading package averaged_perceptron_tagger_eng to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping
[nltk_data]    |       taggers/averaged_perceptron_tagger_eng.zip.
[nltk_data]    | Downloading package averaged_perceptron_tagger_ru to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping
[nltk_data]    |       taggers/averaged_perceptron_tagger_ru.zip.
[nltk_data]    | Downloading package averaged_perceptron_tagger_rus to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping
[nltk_data]    |       taggers/averaged_perceptron_tagger_rus.zip.
[nltk_data]    | Downloading package basque_grammars to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping grammars/basque_grammars.zip.
[nltk_data]    | Downloading package bcp47 to /root/nltk_data...
[nltk_data]    | Downloading package biocreative_ppi to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping corpora/biocreative_ppi.zip.
[nltk_data]    | Downloading package bllip_wsj_no_aux to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping models/bllip_wsj_no_aux.zip.
[nltk_data]    | Downloading package book_grammars to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping grammars/book_grammars.zip.
[nltk_data]    | Downloading package brown to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/brown.zip.
[nltk_data]    | Downloading package brown_tei to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/brown_tei.zip.
[nltk_data]    | Downloading package cess_cat to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/cess_cat.zip.
[nltk_data]    | Downloading package cess_esp to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/cess_esp.zip.
[nltk_data]    | Downloading package chat80 to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/chat80.zip.
[nltk_data]    | Downloading package city_database to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping corpora/city_database.zip.
[nltk_data]    | Downloading package cmudict to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/cmudict.zip.
[nltk_data]    | Downloading package comparative_sentences to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping corpora/comparative_sentences.zip.
[nltk_data]    | Downloading package comtrans to /root/nltk_data...
[nltk_data]    | Downloading package conll2000 to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/conll2000.zip.
[nltk_data]    | Downloading package conll2002 to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/conll2002.zip.
[nltk_data]    | Downloading package conll2007 to /root/nltk_data...
```

```
dataframe = pd.read_csv('/content/drive/MyDrive/news_abstractive_text_summarization/Data/train.csv', nrows=11000)
dataframe.drop('id',axis='columns',inplace=True)
dataframe
```

	article	highlights
0	By . Associated Press . PUBLISHED: . 14:11 EST...	Bishop John Folda, of North Dakota, is taking ...
1	(CNN) -- Ralph Mata was an internal affairs li...	Criminal complaint: Cop used his role to help ...
2	A drunk driver who killed a young woman in a h...	Craig Eccleston-Todd, 27, had drunk at least t...
3	(CNN) -- With a breezy sweep of his pen Presid...	Nina dos Santos says Europe must be ready to a...
4	Fleetwood are the only team still to have a 10...	Fleetwood top of League One after 2-0 win at S...
...	...	...
10995	By . Leon Watson . PUBLISHED: . 08:15 EST, 31 ...	Meeting between statesmen will take place in M...
10996	(CNN) -- The parents of an American journalist...	Marc and Debra Tice: "We urge you, whoever you...
10997	Police chased the bus for 30 minutes through c...	Police chased the bus for 30 minutes through c...
10998	(CNN) -- Inspired by Psalm 103 verse 11 -- "Fo...	A golf course in Casey, Illinois hopes to soon...
10999	Gareth Southgate will stay loyal to the group ...	England's U21 side progressed to the Euro 2015...

11000 rows × 2 columns

```
dataframe.columns
```

```
Index(['article', 'highlights'], dtype='object')
```

```
dataframe.isna().sum()
```

	0
article	0
highlights	0

dtype: int64

```
contractions = {
"ain't": "am not",
"aren't": "are not",
"can't": "cannot",
"can't've": "cannot have",
"'cause": "because",
"could've": "could have",
"couldn't": "could not",
"couldn't've": "could not have",
"didn't": "did not",
"doesn't": "does not",
"don't": "do not",
"hadn't": "had not",
"hadn't've": "had not have",
"hasn't": "has not",
"haven't": "have not",
"he'd": "he would",
"he'd've": "he would have",
"he'll": "he will",
"he's": "he is",
"how'd": "how did",
"how'll": "how will",
"how's": "how is",
"i'd": "i would",
"i'll": "i will",
"i'm": "i am",
"i've": "i have",
"isn't": "is not",
"it'd": "it would",
"it'll": "it will",
"it's": "it is",
"let's": "let us",
"ma'am": "madam",
"mayn't": "may not",
"might've": "might have",
"mightn't": "might not",
"must've": "must have",
"mustn't": "must not",
"needn't": "need not",
"oughtn't": "ought not",
"shan't": "shall not",
"sha'n't": "shall not",
"she'd": "she would",
"she'll": "she will",
"she's": "she is",
"should've": "should have",
"shouldn't": "should not",
"that'd": "that would",
"that's": "that is",
"there'd": "there had",
"there's": "there is",
"they'd": "they would",
"they'll": "they will",
"they're": "they are",
"they've": "they have",
"wasn't": "was not",
"we'd": "we would",
"we'll": "we will",
"we're": "we are",
"we've": "we have",
"weren't": "were not",
"what'll": "what will",
"what're": "what are",
"what's": "what is",
"what've": "what have",
"where'd": "where did",
"where's": "where is",
"who'll": "who will",
"who's": "who is",
"won't": "will not",
"wouldn't": "would not",
"you'd": "you would",
"you'll": "you will",
"you're": "you are"
}
```

```
def clean_text(text, remove_stopwords=True):
    text = text.lower()
    text = text.split()
    tmp = []
    for word in text:
        if word in contractions:
            tmp.append(contractions[word])
        else:
            tmp.append(word)
    text = ' '.join(tmp)

    text = re.sub(r'https?:\/\/.*[\r\n]*', '', text, flags=re.MULTILINE)
    text = re.sub(r'\<a href', ' ', text)
    text = re.sub(r'&amp;', '', text)
    text = re.sub(r'[_"\-;%()|+&=*%.,!?:#$@\[\]/]', ' ', text)
    text = re.sub(r'<br />', ' ', text)
    text = re.sub(r'\'', ' ', text)

    if remove_stopwords:
        text = text.split()
        stops = set(stopwords.words('english'))
        text = [w for w in text if w not in stops]
        text = ' '.join(text)

    return text
```

```
clean_summaries = []
for summary in dataframe.highlights:
    clean_summaries.append(clean_text(summary, remove_stopwords=False))
print('Cleaning Summaries Complete')

clean_texts = []
for text in dataframe.article:
    clean_texts.append(clean_text(text))
print('Cleaning Texts Complete')
del dataframe
```

```
Cleaning Summaries Complete
Cleaning Texts Complete
```

```
dataframe1 = pd.DataFrame()
dataframe1['text'] = clean_texts[:]
dataframe1['summary'] = clean_summaries[:]
dataframe1['summary'].replace('', np.nan, inplace=True)
dataframe1.dropna(axis=0, inplace=True)
```

```
start_token = '<sostok>'
end_token = '<eostok>'
dataframe1.summary = dataframe1.summary.apply(lambda x: f'{start_token} {x} {end_token}')
dataframe1.head()
```

	text	summary
0	associated press published 14 11 est 25 octobe...	<sostok> bishop john folda of north dakota i...
1	cnn ralph mata internal affairs lieutenant mia...	<sostok> criminal complaint cop used his role...
2	drunk driver killed young woman head crash che...	<sostok> craig eccleston todd 27 had drunk a...
3	cnn breezy sweep pen president vladimir putin ...	<sostok> nina dos santos says europe must be r...
4	fleetwood team still 100 record sky bet league...	<sostok> fleetwood top of league one after 2 0...

```
print(dataframe1.shape)
```

```
(11000, 2)
```

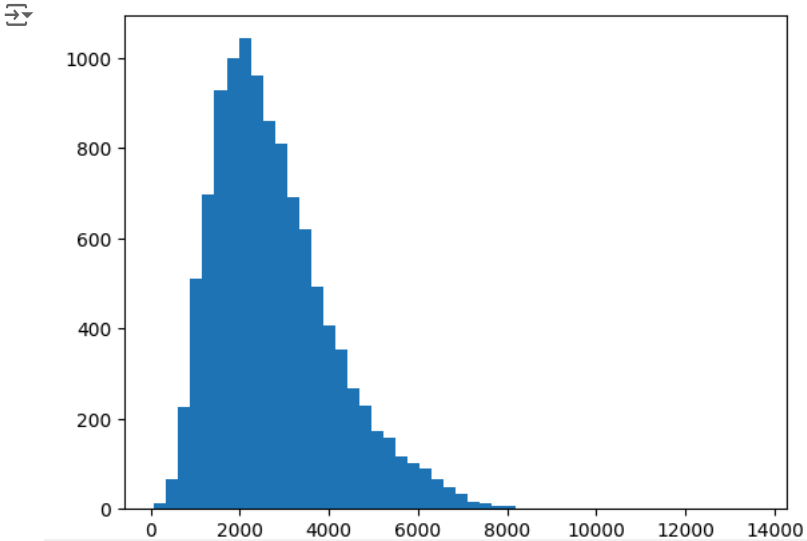
```
#original text
dataframe1['text'][0]
```

```
'associated press published 14 11 est 25 october 2013 updated 15 36 est 25 october 2013 bishop fargo catholic diocese north dakota exposed potentially hundreds church members fargo grand forks jamestown hepatitis virus late september early october state health department issued advisory exposure anyone attended five churches took communion bishop john folda pictured fargo catholic diocese north dakota exposed potentially hundreds church members fargo grand forks jamestown hepatitis state immunization program manager molly howell says risk low officials feel important alert people possible exposure diocese announced monday bishop john folda taking
```

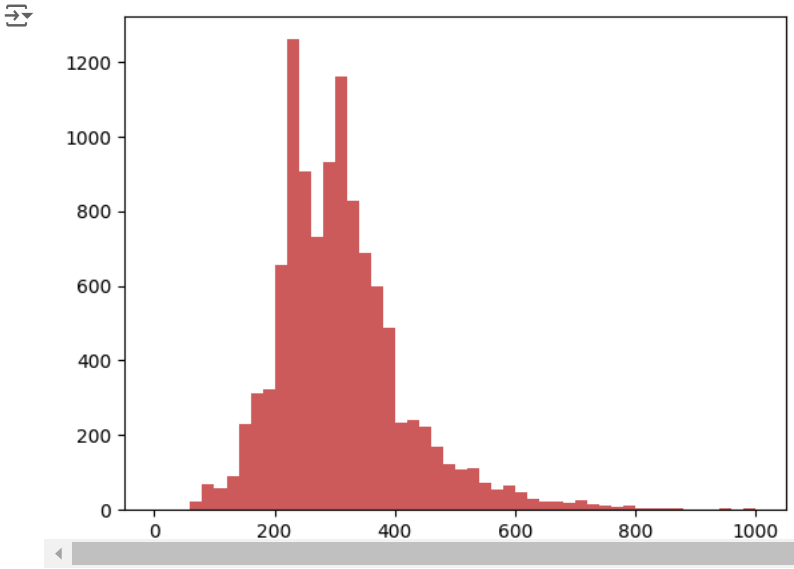
```
#text summary
dataframe1['summary'][0]
```

```
'<sostok> bishop john folda  of north dakota  is taking time off after being diagnosed   he contracted the infection through contam
```

```
text_lengths = []
for text in dataframe1['text']:
 text_lengths.append(len(text))
plt.hist(text_lengths, bins=50)
plt.show()
```




```
summary_lengths = []
for summary_text in dataframe1['summary']:
 summary_lengths.append(len(summary_text))
plt.hist(summary_lengths, bins=50,range=(0,1000),color='indianred')
plt.show()
```




```
X_train,X_test,y_train,y_test = train_test_split(dataframe1['text'], dataframe1['summary'], test_size=0.2)
X_train,X_val,y_train,y_val = train_test_split(X_train, y_train, test_size=0.2)
```

Tokenization of Original Text

```
t_max_features = 110788
s_max_features = 36188
```

```
x_tokenizer = Tokenizer(num_words = t_max_features)
x_tokenizer.fit_on_texts(list(np.array((dataframe1['text']))))
max_text_len = 800
# one-hot-encoding
x_train_sequence = x_tokenizer.texts_to_sequences(np.array(X_train))
x_val_sequence = x_tokenizer.texts_to_sequences(np.array(X_val))
x_test_sequence = x_tokenizer.texts_to_sequences(np.array(X_test))
# padding upto max_text_len
x_train_padded = pad_sequences(x_train_sequence, maxlen=max_text_len, padding='post')
x_val_padded = pad_sequences(x_val_sequence, maxlen=max_text_len, padding='post')
x_test_padded = pad_sequences(x_test_sequence, maxlen=max_text_len, padding='post')
# if you're not using num_words parameter in Tokenizer then use this
x_vocab_size = len(x_tokenizer.word_index) + 1
print(x_vocab_size)
```

```
110788
```

```
pickle.dump(x_tokenizer,open('/content/drive/MyDrive/news_abstractive_text_summarization/Models/x_tokenizer.pkl', 'wb'))
```

Tokenization for Summary

```
y_tokenizer = Tokenizer(num_words = s_max_features)
y_tokenizer.fit_on_texts(list(np.array(dataframe1['summary'])))
max_summary_len = 150
# one-hot-encoding
y_train_sequence = y_tokenizer.texts_to_sequences(np.array(y_train))
y_val_sequence = y_tokenizer.texts_to_sequences(np.array(y_val))
y_test_sequence = y_tokenizer.texts_to_sequences(np.array(y_test))
# padding upto max_summary_len
y_train_padded = pad_sequences(y_train_sequence, maxlen=max_summary_len, padding='post')
y_val_padded = pad_sequences(y_val_sequence, maxlen=max_summary_len, padding='post')
y_test_padded = pad_sequences(y_test_sequence, maxlen=max_summary_len, padding='post')
# if you're not using num_words parameter in Tokenizer then use this
y_vocab_size = len(y_tokenizer.word_index) + 1
print(y_vocab_size)
embed_dim = 300
```

```
36188
```

```
pickle.dump(y_tokenizer,open('/content/drive/MyDrive/news_abstractive_text_summarization/Models/y_tokenizer.pkl', 'wb'))
```

```
epoch_num = 30 #30
```

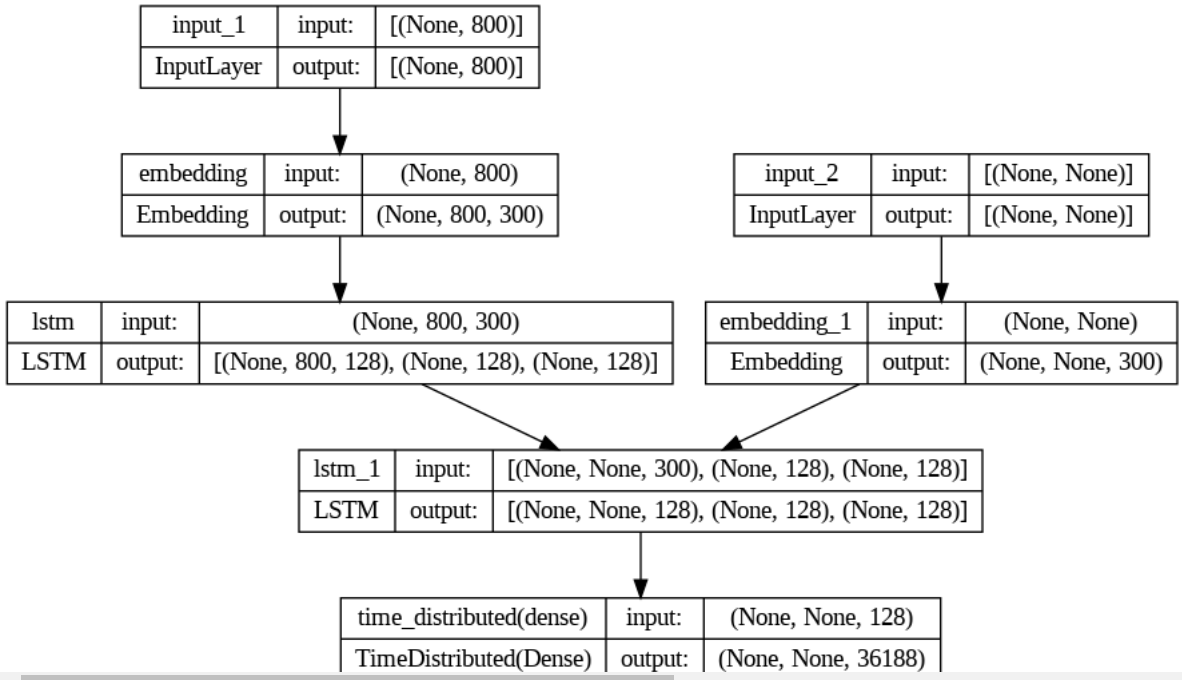
Model1 :- LSTM without Embedding

```
latent_dim = 128
# Encoder
enc_input = Input(shape=(max_text_len, ))
enc_embed = Embedding(t_max_features, embed_dim, input_length=max_text_len, trainable=False)(enc_input)
h_lstm = LSTM(latent_dim, return_sequences=True, return_state=True)
h_out, enc_h, enc_c = h_lstm(enc_embed)
#Decoder
dec_input = Input(shape=(None, ))
dec_embed = Embedding(s_max_features, embed_dim, trainable=False)(dec_input)
dec_lstm = LSTM(latent_dim, return_sequences=True, return_state=True, dropout=0.3, recurrent_dropout=0.2)
dec_outputs, _, _ = dec_lstm(dec_embed, initial_state=[enc_h, enc_c])

dec_dense = TimeDistributed(Dense(s_max_features, activation='softmax'))
dec_output = dec_dense(dec_outputs)

model = Model([enc_input, dec_input], dec_output)
model.summary()

plot_model(
    model,
    to_file='./seq2seq_encoder_decoder.png',
    show_shapes=True,
    show_layer_names=True,
    rankdir='TB',
    expand_nested=False,
    dpi=96)
```

```
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel a
Model: "model"
```

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, 800)]	0	[]
input_2 (InputLayer)	[(None, None)]	0	[]
embedding (Embedding)	(None, 800, 300)	3323640	['input_1[0][0]']
embedding_1 (Embedding)	(None, None, 300)	1085640	['input_2[0][0]']
lstm (LSTM)	[(None, 800, 128), (None, 128), (None, 128)]	219648	['embedding[0][0]']
lstm_1 (LSTM)	[(None, None, 128), (None, 128), (None, 128)]	219648	['embedding_1[0][0]', 'lstm[0][1]', 'lstm[0][2]']
time_distributed (TimeDistributed)	(None, None, 36188)	4668252	['lstm_1[0][0]']

```
Total params: 49200348 (187.68 MB)
Trainable params: 5107548 (19.48 MB)
Non-trainable params: 44092800 (168.20 MB)
```




```
model.compile(loss='sparse_categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])

model.fit([x_train_padded, y_train_padded[:, :-1]], y_train_padded.reshape(y_train_padded.shape[0],
          y_train_padded.shape[1], 1)[:, 1:],
          epochs=epoch_num,
          batch_size=32,
          verbose=1,
          validation_data=([x_val_padded, y_val_padded[:, :-1]], y_val_padded.reshape(y_val_padded.shape[0],
          y_val_padded.shape[1], 1)[:, 1:]))
```

```
Epoch 1/20
220/220 [==============================] - 120s 507ms/step - loss: 3.8026 - accuracy: 0.6604 - val_loss: 2.6851 - val_accuracy: 0.67
Epoch 2/20
220/220 [==============================] - 111s 506ms/step - loss: 2.6554 - accuracy: 0.6706 - val_loss: 2.6186 - val_accuracy: 0.67
Epoch 3/20
220/220 [==============================] - 112s 509ms/step - loss: 2.6109 - accuracy: 0.6748 - val_loss: 2.5949 - val_accuracy: 0.67
Epoch 4/20
220/220 [==============================] - 111s 503ms/step - loss: 2.5934 - accuracy: 0.6759 - val_loss: 2.5874 - val_accuracy: 0.67
Epoch 5/20
220/220 [==============================] - 111s 503ms/step - loss: 2.5860 - accuracy: 0.6762 - val_loss: 2.5862 - val_accuracy: 0.67
Epoch 6/20
220/220 [==============================] - 110s 502ms/step - loss: 2.5815 - accuracy: 0.6764 - val_loss: 2.5835 - val_accuracy: 0.67
Epoch 7/20
220/220 [==============================] - 112s 508ms/step - loss: 2.5779 - accuracy: 0.6767 - val_loss: 2.5819 - val_accuracy: 0.67
Epoch 8/20
220/220 [==============================] - 111s 506ms/step - loss: 2.5746 - accuracy: 0.6770 - val_loss: 2.5803 - val_accuracy: 0.67
```

```
Epoch 9/20
220/220 [==============================] - 111s 503ms/step - loss: 2.5709 - accuracy: 0.6776 - val_loss: 2.5778 - val_accuracy: 0.68
Epoch 10/20
220/220 [==============================] - 111s 502ms/step - loss: 2.5665 - accuracy: 0.6780 - val_loss: 2.5743 - val_accuracy: 0.68
Epoch 11/20
220/220 [==============================] - 109s 496ms/step - loss: 2.5618 - accuracy: 0.6786 - val_loss: 2.5711 - val_accuracy: 0.68
Epoch 12/20
220/220 [==============================] - 109s 498ms/step - loss: 2.5570 - accuracy: 0.6790 - val_loss: 2.5670 - val_accuracy: 0.68
Epoch 13/20
220/220 [==============================] - 110s 502ms/step - loss: 2.5523 - accuracy: 0.6793 - val_loss: 2.5639 - val_accuracy: 0.68
Epoch 14/20
220/220 [==============================] - 109s 496ms/step - loss: 2.5477 - accuracy: 0.6794 - val_loss: 2.5608 - val_accuracy: 0.68
Epoch 15/20
220/220 [==============================] - 112s 508ms/step - loss: 2.5435 - accuracy: 0.6796 - val_loss: 2.5601 - val_accuracy: 0.68
Epoch 16/20
220/220 [==============================] - 111s 505ms/step - loss: 2.5393 - accuracy: 0.6797 - val_loss: 2.5549 - val_accuracy: 0.68
Epoch 17/20
220/220 [==============================] - 109s 498ms/step - loss: 2.5350 - accuracy: 0.6798 - val_loss: 2.5515 - val_accuracy: 0.68
Epoch 18/20
220/220 [==============================] - 110s 499ms/step - loss: 2.5313 - accuracy: 0.6800 - val_loss: 2.5482 - val_accuracy: 0.68
Epoch 19/20
220/220 [==============================] - 111s 505ms/step - loss: 2.5273 - accuracy: 0.6804 - val_loss: 2.5454 - val_accuracy: 0.68
Epoch 20/20
220/220 [==============================] - 111s 505ms/step - loss: 2.5236 - accuracy: 0.6806 - val_loss: 2.5426 - val_accuracy: 0.68
<keras.src.callbacks.History at 0x79753ceb7610>
```

```
enc_model = Model(inputs=enc_input, outputs=[enc_h, enc_c])

dec_init_state_h = Input(shape=(latent_dim, ))
dec_init_state_c = Input(shape=(latent_dim, ))
decoder_hidden_state_input = Input(shape=(max_text_len, latent_dim))

dec_out, dec_h, dec_c = dec_lstm(dec_embed, initial_state=[dec_init_state_h, dec_init_state_c])
dec_final = dec_dense(dec_out)

dec_model = Model([dec_input]+[dec_init_state_h, dec_init_state_c], [dec_final]+[dec_h, dec_c])
```

```
def generate_summary(input_seq):
    h, c = enc_model.predict(input_seq)

    next_token = np.zeros((1, 1))
    next_token[0, 0] = y_tokenizer.word_index['sostok']
    output_seq = ''

    stop = False
    count = 0

    while not stop:
        if count > 100:
            break
        decoder_out, state_h, state_c = dec_model.predict([next_token]+[h, c])
        token_idx = np.argmax(decoder_out[0, -1, :])

        if token_idx == y_tokenizer.word_index['eostok']:
            stop = True
        elif token_idx > 0 and token_idx != y_tokenizer.word_index['sostok']:
            token = y_tokenizer.index_word[token_idx]
            output_seq = output_seq + ' ' + token

        next_token = np.zeros((1, 1))
        next_token[0, 0] = token_idx
        h, c = state_h, state_c
        count += 1

    return output_seq
```

```
test_inputs = [clean_text(sent) for sent in X_test]
test_inputs = x_tokenizer.texts_to_sequences(list(test_inputs))
test_inputs = pad_sequences(test_inputs, maxlen=max_text_len, padding='post')
```

```
X_test.reset_index(drop=True,inplace=True)
y_test.reset_index(drop=True,inplace=True)
```

```
hyps = []
with open('/content/drive/MyDrive/news_abstractive_text_summarization/output_file/result1.csv', 'w') as f:
    writer = csv.writer(f)
    writer.writerow(['Article', 'Original Summary', 'Model Output'])
    for i in range(10):
        our_summ = generate_summary(test_inputs[i].reshape(1, max_text_len))
        hyps.append(our_summ)
        writer.writerow([X_test[i], y_test[i], our_summ])
```

```
1/1 [==============================] - 0s 347ms/step
1/1 [==============================] - 0s 218ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 24ms/step
```

```
pred_df = pd.read_csv('/content/drive/MyDrive/news_abstractive_text_summarization/output_file/result1.csv')
org_summary = pred_df['Original Summary']
pred_summary =  pred_df['Model Output']
```

```
scorer = rouge_scorer.RougeScorer(['rouge1'])
results = {'precision': [], 'recall': [], 'fmeasure': []}
for (h, r) in zip(org_summary, pred_summary):
  # computing the ROUGE
  score = scorer.score(h, r)
  # separating the measurements
  precision, recall, fmeasure = score['rouge1']
  # add them to the proper list in the dictionary
  results['precision'].append(precision)
  results['recall'].append(recall)
  results['fmeasure'].append(fmeasure)
result = pd.DataFrame(results)
result
```

	precision	recall	fmeasure
0	0.057143	0.035088	0.043478
1	0.171429	0.150000	0.160000
2	0.157895	0.084507	0.110092
3	0.057143	0.028571	0.038095
4	0.114286	0.045455	0.065041
5	0.105263	0.097561	0.101266
6	0.200000	0.125000	0.153846
7	0.028571	0.026316	0.027397
8	0.085714	0.078947	0.082192
9	0.000000	0.000000	0.000000

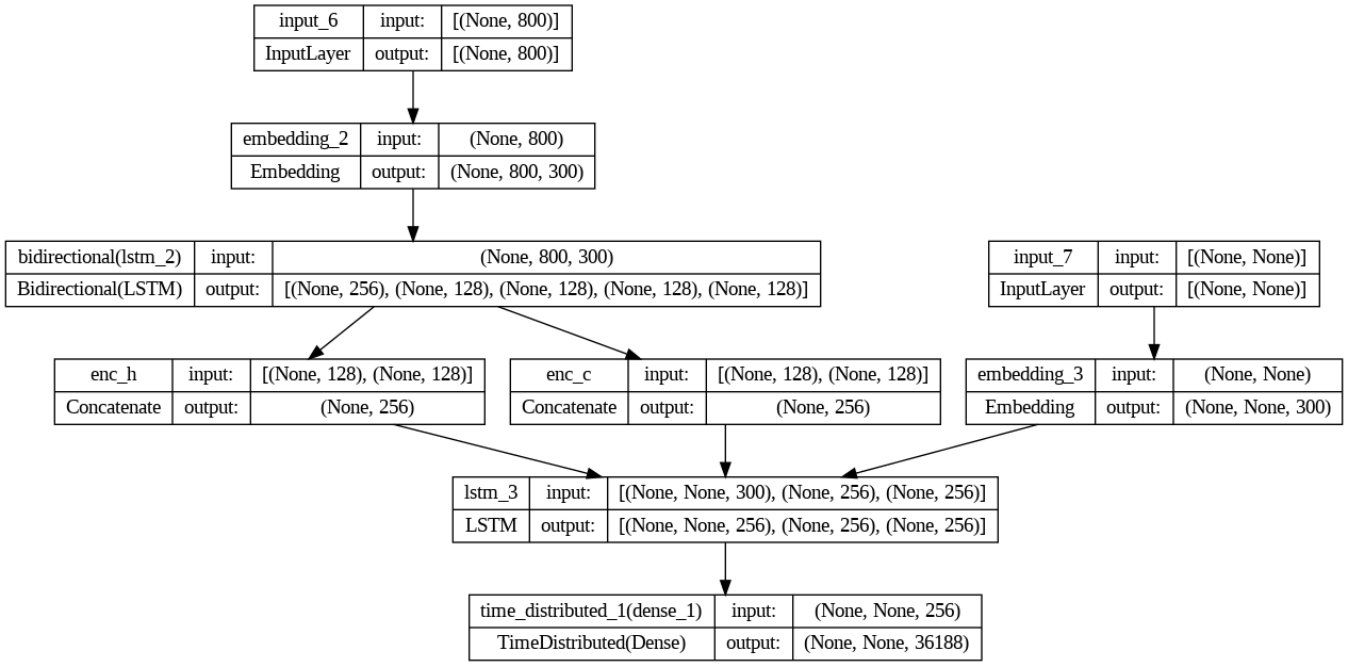
Model2 :- BILSTM without Embedding

```
latent_dim = 128
# Encoder
enc_input = Input(shape=(max_text_len, ))
enc_embed = Embedding(t_max_features, embed_dim, input_length=max_text_len, trainable=True)(enc_input)
enc_lstm = Bidirectional(LSTM(latent_dim, return_state=True))
enc_output, enc_fh, enc_fc, enc_bh, enc_bc = enc_lstm(enc_embed)
enc_h = Concatenate(axis=-1, name='enc_h')([enc_fh, enc_bh])
enc_c = Concatenate(axis=-1, name='enc_c')([enc_fc, enc_bc])
#Decoder
dec_input = Input(shape=(None, ))
dec_embed = Embedding(s_max_features, embed_dim, trainable=True)(dec_input)
dec_lstm = LSTM(latent_dim*2, return_sequences=True, return_state=True, dropout=0.3, recurrent_dropout=0.2)
dec_outputs, _, _ = dec_lstm(dec_embed, initial_state=[enc_h, enc_c])

dec_dense = TimeDistributed(Dense(s_max_features, activation='softmax'))
dec_output = dec_dense(dec_outputs)

model = Model([enc_input, dec_input], dec_output)
model.summary()

plot_model(
    model,
    to_file='./seq2seq_encoder_decoder.png',
    show_shapes=True,
    show_layer_names=True,
    rankdir='TB',
    expand_nested=False,
    dpi=96)
```

```
WARNING:tensorflow:Layer lstm_3 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as f
Model: "model_3"
```

Layer (type)	Output Shape	Param #	Connected to
input_6 (InputLayer)	[(None, 800)]	0	[]
embedding_2 (Embedding)	(None, 800, 300)	3323640	['input_6[0][0]']
input_7 (InputLayer)	[(None, None)]	0	[]
bidirectional (Bidirectional)	[(None, 256), (None, 128), (None, 128), (None, 128), (None, 128)]	439296	['embedding_2[0][0]']
embedding_3 (Embedding)	(None, None, 300)	1085640	['input_7[0][0]']
enc_h (Concatenate)	(None, 256)	0	['bidirectional[0][1]', 'bidirectional[0][3]']
enc_c (Concatenate)	(None, 256)	0	['bidirectional[0][2]', 'bidirectional[0][4]']
lstm_3 (LSTM)	[(None, None, 256), (None, 256), (None, 256)]	570368	['embedding_3[0][0]', 'enc_h[0][0]', 'enc_c[0][0]']
time_distributed_1 (TimeDistributed)	(None, None, 36188)	9300316	['lstm_3[0][0]']

```
Total params: 54402780 (207.53 MB)
Trainable params: 54402780 (207.53 MB)
Non-trainable params: 0 (0.00 Byte)
```




```
model.compile(loss='sparse_categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])

model.fit([x_train_padded, y_train_padded[:, :-1]], y_train_padded.reshape(y_train_padded.shape[0],
          y_train_padded.shape[1], 1)[:, 1:],
          epochs=epoch_num,
          batch_size=32,
          verbose=1,
          validation_data=([x_val_padded, y_val_padded[:, :-1]], y_val_padded.reshape(y_val_padded.shape[0],
          y_val_padded.shape[1], 1)[:, 1:]))
```

```
Epoch 1/20
220/220 [==============================] - 186s 809ms/step - loss: 3.2422 - accuracy: 0.6644 - val_loss: 2.6101 - val_accuracy: 0.67
```

```
Epoch 2/20
220/220 [==============================] - 163s 740ms/step - loss: 2.6039 - accuracy: 0.6759 - val_loss: 2.5910 - val_accuracy: 0.67
Epoch 3/20
220/220 [==============================] - 155s 703ms/step - loss: 2.5819 - accuracy: 0.6781 - val_loss: 2.5658 - val_accuracy: 0.68
Epoch 4/20
220/220 [==============================] - 156s 708ms/step - loss: 2.5537 - accuracy: 0.6800 - val_loss: 2.5472 - val_accuracy: 0.68
Epoch 5/20
220/220 [==============================] - 150s 680ms/step - loss: 2.5342 - accuracy: 0.6809 - val_loss: 2.5357 - val_accuracy: 0.68
Epoch 6/20
220/220 [==============================] - 147s 667ms/step - loss: 2.5205 - accuracy: 0.6816 - val_loss: 2.5273 - val_accuracy: 0.68
Epoch 7/20
220/220 [==============================] - 145s 660ms/step - loss: 2.5093 - accuracy: 0.6820 - val_loss: 2.5183 - val_accuracy: 0.68
Epoch 8/20
220/220 [==============================] - 145s 660ms/step - loss: 2.4987 - accuracy: 0.6828 - val_loss: 2.5112 - val_accuracy: 0.68
Epoch 9/20
220/220 [==============================] - 145s 658ms/step - loss: 2.4887 - accuracy: 0.6836 - val_loss: 2.5049 - val_accuracy: 0.68
Epoch 10/20
220/220 [==============================] - 143s 650ms/step - loss: 2.4781 - accuracy: 0.6844 - val_loss: 2.4963 - val_accuracy: 0.68
Epoch 11/20
220/220 [==============================] - 144s 654ms/step - loss: 2.4675 - accuracy: 0.6853 - val_loss: 2.4908 - val_accuracy: 0.68
Epoch 12/20
220/220 [==============================] - 141s 643ms/step - loss: 2.4565 - accuracy: 0.6863 - val_loss: 2.4801 - val_accuracy: 0.68
Epoch 13/20
220/220 [==============================] - 141s 640ms/step - loss: 2.4448 - accuracy: 0.6871 - val_loss: 2.4699 - val_accuracy: 0.68
Epoch 14/20
220/220 [==============================] - 138s 629ms/step - loss: 2.4331 - accuracy: 0.6878 - val_loss: 2.4663 - val_accuracy: 0.68
Epoch 15/20
220/220 [==============================] - 137s 625ms/step - loss: 2.4223 - accuracy: 0.6888 - val_loss: 2.4563 - val_accuracy: 0.69
Epoch 16/20
220/220 [==============================] - 137s 623ms/step - loss: 2.4114 - accuracy: 0.6897 - val_loss: 2.4466 - val_accuracy: 0.69
Epoch 17/20
220/220 [==============================] - 138s 625ms/step - loss: 2.4008 - accuracy: 0.6907 - val_loss: 2.4423 - val_accuracy: 0.69
Epoch 18/20
220/220 [==============================] - 137s 620ms/step - loss: 2.3901 - accuracy: 0.6918 - val_loss: 2.4311 - val_accuracy: 0.69
Epoch 19/20
220/220 [==============================] - 151s 686ms/step - loss: 2.3802 - accuracy: 0.6925 - val_loss: 2.4253 - val_accuracy: 0.69
Epoch 20/20
220/220 [==============================] - 140s 635ms/step - loss: 2.3706 - accuracy: 0.6933 - val_loss: 2.4203 - val_accuracy: 0.69
<keras.src.callbacks.History at 0x7974e71b4f40>
```

```
enc_model = Model(inputs=enc_input, outputs=[enc_h, enc_c])

dec_init_state_h = Input(shape=(latent_dim*2, ))
dec_init_state_c = Input(shape=(latent_dim*2, ))

dec_out, dec_h, dec_c = dec_lstm(dec_embed, initial_state=[dec_init_state_h, dec_init_state_c])
dec_final = dec_dense(dec_out)

dec_model = Model([dec_input]+[dec_init_state_h, dec_init_state_c], [dec_final]+[dec_h, dec_c])
```

```
def generate_summary(input_seq):
    h, c = enc_model.predict(input_seq)

    next_token = np.zeros((1, 1))
    next_token[0, 0] = y_tokenizer.word_index['sostok']
    output_seq = ''

    stop = False
    count = 0

    while not stop:
        if count > 100:
            break
        decoder_out, state_h, state_c = dec_model.predict([next_token]+[h, c])
        token_idx = np.argmax(decoder_out[0, -1, :])

        if token_idx == y_tokenizer.word_index['eostok']:
            stop = True
        elif token_idx > 0 and token_idx != y_tokenizer.word_index['sostok']:
            token = y_tokenizer.index_word[token_idx]
            output_seq = output_seq + ' ' + token

        next_token = np.zeros((1, 1))
        next_token[0, 0] = token_idx
        h, c = state_h, state_c
        count += 1

    return output_seq
```

```
test_inputs = [clean_text(sent) for sent in X_test]
test_inputs = x_tokenizer.texts_to_sequences(list(test_inputs))
test_inputs = pad_sequences(test_inputs, maxlen=max_text_len, padding='post')
```

```
X_test.reset_index(drop=True,inplace=True)
y_test.reset_index(drop=True,inplace=True)
```

```
hyps = []
with open('/content/drive/MyDrive/news_abstractive_text_summarization/output_file/result2.csv', 'w') as f:
    writer = csv.writer(f)
    writer.writerow(['Article', 'Original Summary', 'Model Output'])
    for i in range(10):
        our_summ = generate_summary(test_inputs[i].reshape(1, max_text_len))
        hyps.append(our_summ)
        writer.writerow([X_test[i], y_test[i], our_summ])
```

```
1/1 [==============================] - 1s 646ms/step
1/1 [==============================] - 0s 237ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 43ms/step
1/1 [==============================] - 0s 71ms/step
1/1 [==============================] - 0s 48ms/step
1/1 [==============================] - 0s 40ms/step
1/1 [==============================] - 0s 49ms/step
1/1 [==============================] - 0s 43ms/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 42ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 41ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 41ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 29ms/step
```

```
pred_df = pd.read_csv('/content/drive/MyDrive/news_abstractive_text_summarization/output_file/result2.csv')
org_summary = pred_df['Original Summary']
pred_summary =  pred_df['Model Output']
```

```
scorer = rouge_scorer.RougeScorer(['rouge1'])
results = {'precision': [], 'recall': [], 'fmeasure': []}
for (h, r) in zip(org_summary, pred_summary):
  # computing the ROUGE
  score = scorer.score(h, r)
  # separating the measurements
  precision, recall, fmeasure = score['rouge1']
  # add them to the proper list in the dictionary
  results['precision'].append(precision)
  results['recall'].append(recall)
  results['fmeasure'].append(fmeasure)
result = pd.DataFrame(results)
result
```

	precision	recall	fmeasure
0	0.089109	0.157895	0.113924
1	0.079208	0.200000	0.113475
2	0.118812	0.169014	0.139535
3	0.069307	0.100000	0.081871
4	0.108911	0.125000	0.116402
5	0.059406	0.146341	0.084507
6	0.118812	0.214286	0.152866
7	0.039604	0.105263	0.057554
8	0.019802	0.052632	0.028777
9	0.029703	0.069767	0.041667

Model3 :- LSTM + Attention with GloVe Embedding

```
embeding_index = {}
embed_dim = 300
with open('/content/drive/MyDrive/news_abstractive_text_summarization/glove.6B.300d.txt') as f:
    for line in f:
        values = line.split()
        word = values[0]
        coefs = np.asarray(values[1:], dtype='float32')
        embeding_index[word] = coefs
```

```
t_embed = np.zeros((t_max_features, embed_dim))
for word, i in x_tokenizer.word_index.items():
    vec = embeding_index.get(word)
    if i < t_max_features and vec is not None:
        t_embed[i] = vec
```

```
s_embed = np.zeros((s_max_features, embed_dim))
for word, i in y_tokenizer.word_index.items():
    vec = embeding_index.get(word)
    if i < s_max_features and vec is not None:
        s_embed[i] = vec
```

```
del embeding_index
```

```
class AttentionLayer(tf.keras.layers.Layer):

    def __init__(self, **kwargs):
        super(AttentionLayer, self).__init__(**kwargs)

    def build(self, input_shape):
        assert isinstance(input_shape, list)
        # Create a trainable weight variable for this layer.
        print(input_shape)
        self.W_a = self.add_weight(name='W_a',
                                   shape=tf.TensorShape((input_shape[0][2], input_shape[0][2])),
                                   initializer='uniform',
                                   trainable=True)
        self.U_a = self.add_weight(name='U_a',
                                   shape=tf.TensorShape((input_shape[1][2], input_shape[0][2])),
                                   initializer='uniform',
                                   trainable=True)
        self.V_a = self.add_weight(name='V_a',
                                   shape=tf.TensorShape((input_shape[0][2], 1)),
                                   initializer='uniform',
                                   trainable=True)

        super(AttentionLayer, self).build(input_shape)  # Be sure to call this at the end

    def call(self, inputs):
        """
        inputs: [encoder_output_sequence, decoder_output_sequence]
        """
        assert type(inputs) == list
        encoder_out_seq, decoder_out_seq = inputs

        logger.debug(f"encoder_out_seq.shape = {encoder_out_seq.shape}")
        logger.debug(f"decoder_out_seq.shape = {decoder_out_seq.shape}")

        def energy_step(inputs, states):
            """ Step function for computing energy for a single decoder state
            inputs: (batchsize * 1 * de_in_dim)
            states: (batchsize * 1 * de_latent_dim)
            """

            logger.debug("Running energy computation step")

            if not isinstance(states, (list, tuple)):
                raise TypeError(f"States must be an iterable. Got {states} of type {type(states)}")

            encoder_full_seq = states[-1]

            """ Computing S.Wa where S=[s0, s1, ..., si]"""
            # <= batch size * en_seq_len * latent_dim
            W_a_dot_s = K.dot(encoder_full_seq, self.W_a)

            """ Computing hj.Ua """
            U_a_dot_h = K.expand_dims(K.dot(inputs, self.U_a), 1)  # <= batch_size, 1, latent_dim

            logger.debug(f"U_a_dot_h.shape = {U_a_dot_h.shape}")

            """ tanh(S.Wa + hj.Ua) """
            # <= batch_size*en_seq_len, latent_dim
            Ws_plus_Uh = K.tanh(W_a_dot_s + U_a_dot_h)

            logger.debug(f"Ws_plus_Uh.shape = {Ws_plus_Uh.shape}")

            """ softmax(va.tanh(S.Wa + hj.Ua)) """
            # <= batch_size, en_seq_len
            e_i = K.squeeze(K.dot(Ws_plus_Uh, self.V_a), axis=-1)
            # <= batch_size, en_seq_len
            e_i = K.softmax(e_i)

            logger.debug(f"ei.shape = {e_i.shape}")

            return e_i, [e_i]

        def context_step(inputs, states):
            """ Step function for computing ci using ei """

            logger.debug("Running attention vector computation step")

            if not isinstance(states, (list, tuple)):
                raise TypeError(f"States must be an iterable. Got {states} of type {type(states)}")

            encoder_full_seq = states[-1]
```

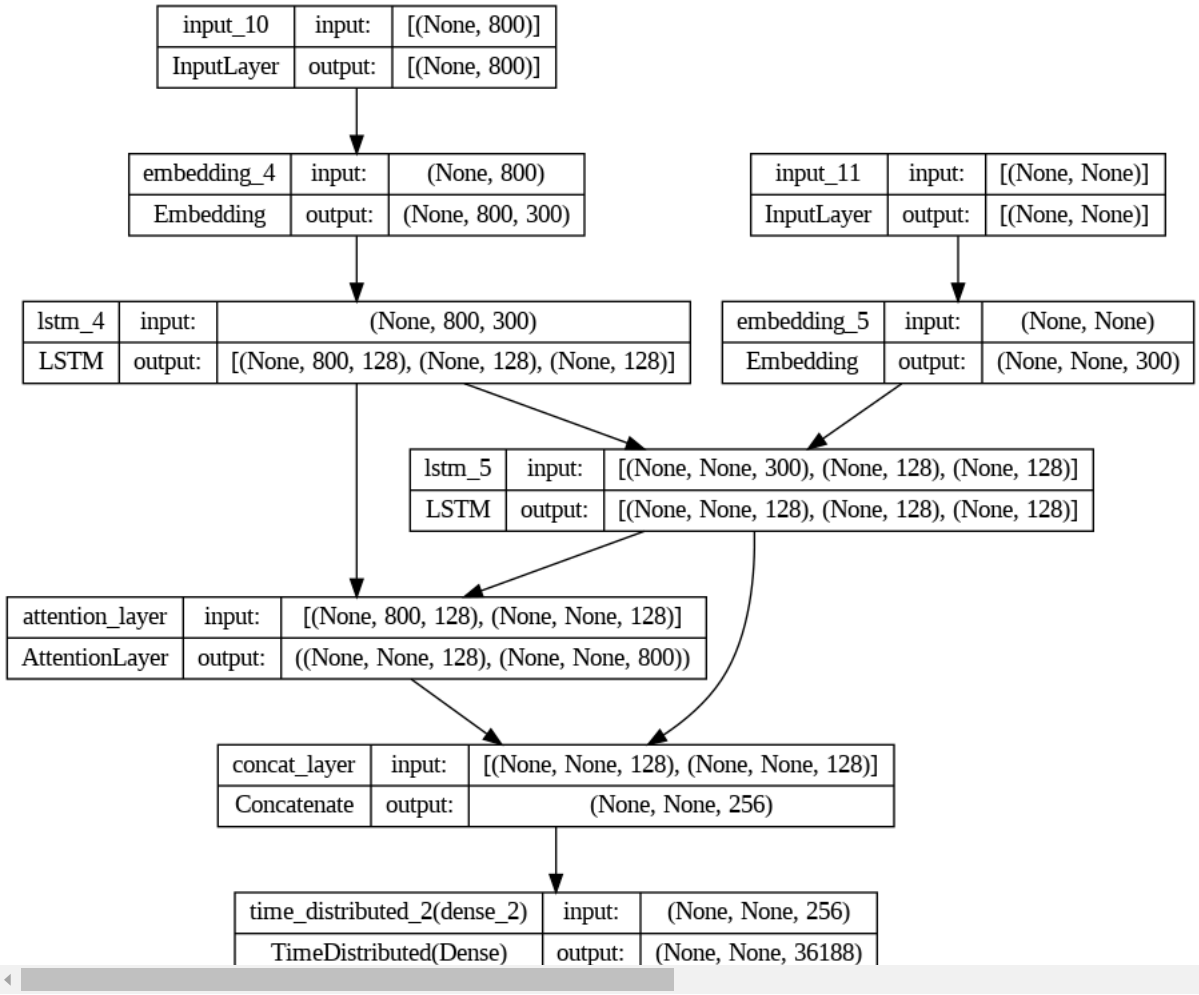
```
            # <= batch_size, hidden_size
            c_i = K.sum(encoder_full_seq * K.expand_dims(inputs, -1), axis=1)

            logger.debug(f"ci.shape = {c_i.shape}")

            return c_i, [c_i]

        # we don't maintain states between steps when computing attention
        # attention is stateless, so we're passing a fake state for RNN step function
        fake_state_c = K.sum(encoder_out_seq, axis=1)
        fake_state_e = K.sum(encoder_out_seq, axis=2)  # <= (batch_size, enc_seq_len, latent_dim

        """ Computing energy outputs """
        # e_outputs => (batch_size, de_seq_len, en_seq_len)
        last_out, e_outputs, _ = K.rnn(
            energy_step, decoder_out_seq, [fake_state_e], constants=[encoder_out_seq]
        )

        """ Computing context vectors """
        last_out, c_outputs, _ = K.rnn(
            context_step, e_outputs, [fake_state_c], constants=[encoder_out_seq]
        )

        return c_outputs, e_outputs

    def compute_output_shape(self, input_shape):
        """ Outputs produced by the layer """
        return [
            tf.TensorShape((input_shape[1][0], input_shape[1][1], input_shape[1][2])),
            tf.TensorShape((input_shape[1][0], input_shape[1][1], input_shape[0][1]))
        ]
```

```
latent_dim = 128
# Encoder
enc_input = Input(shape=(max_text_len, ))
enc_embed = Embedding(t_max_features, embed_dim, input_length=max_text_len, weights=[t_embed], trainable=False)(enc_input)
h_lstm = LSTM(latent_dim, return_sequences=True, return_state=True)
h_out, enc_h, enc_c = h_lstm(enc_embed)
#Decoder
dec_input = Input(shape=(None, ))
dec_embed = Embedding(s_max_features, embed_dim, trainable=False)(dec_input)
dec_lstm = LSTM(latent_dim, return_sequences=True, return_state=True, dropout=0.3, recurrent_dropout=0.2)
dec_outputs, _, _ = dec_lstm(dec_embed, initial_state=[enc_h, enc_c])

# Attention layer
attn_layer = AttentionLayer(name='attention_layer')
attn_out, attn_states = attn_layer([h_out, dec_outputs])

# Concat attention input and decoder LSTM output
decoder_concat_input = Concatenate(axis=-1, name='concat_layer')([dec_outputs, attn_out])

dec_dense = TimeDistributed(Dense(s_max_features, activation='softmax'))
dec_output = dec_dense(decoder_concat_input)

model = Model([enc_input, dec_input], dec_output)
model.summary()

plot_model(
    model,
    to_file='./seq2seq_encoder_decoder.png',
    show_shapes=True,
    show_layer_names=True,
    rankdir='TB',
    expand_nested=False,
    dpi=96)
```

```
WARNING:tensorflow:Layer lstm_5 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel a
[TensorShape([None, 800, 128]), TensorShape([None, None, 128])]
Model: "model_6"
```

Layer (type)	Output Shape	Param #	Connected to
input_10 (InputLayer)	[(None, 800)]	0	[]
input_11 (InputLayer)	[(None, None)]	0	[]
embedding_4 (Embedding)	(None, 800, 300)	3323640	['input_10[0][0]']
embedding_5 (Embedding)	(None, None, 300)	1085640	['input_11[0][0]']
lstm_4 (LSTM)	[(None, 800, 128), (None, 128), (None, 128)]	219648	['embedding_4[0][0]']
lstm_5 (LSTM)	[(None, None, 128), (None, 128), (None, 128)]	219648	['embedding_5[0][0]', 'lstm_4[0][1]', 'lstm_4[0][2]']
attention_layer (Attention Layer)	((None, None, 128), (None, None, 800))	32896	['lstm_4[0][0]', 'lstm_5[0][0]']
concat_layer (Concatenate)	(None, None, 256)	0	['lstm_5[0][0]', 'attention_layer[0][0]']
time_distributed_2 (TimeDistributed)	(None, None, 36188)	9300316	['concat_layer[0][0]']

```
Total params: 53865308 (205.48 MB)
Trainable params: 9772508 (37.28 MB)
Non-trainable params: 44092800 (168.20 MB)
```



```
model.compile(loss='sparse_categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])

model.fit([x_train_padded, y_train_padded[:, :-1]], y_train_padded.reshape(y_train_padded.shape[0],
          y_train_padded.shape[1], 1)[:, 1:],
          epochs=epoch_num,
          batch_size=32,
          verbose=1,
          validation_data=([x_val_padded, y_val_padded[:, :-1]], y_val_padded.reshape(y_val_padded.shape[0],
          y_val_padded.shape[1], 1)[:, 1:]
          ) )
```

```
Epoch 1/20
220/220 [==============================] - 214s 939ms/step - loss: 3.2698 - accuracy: 0.6625 - val_loss: 2.6436 - val_accuracy: 0.67
Epoch 2/20
220/220 [==============================] - 207s 940ms/step - loss: 2.6275 - accuracy: 0.6729 - val_loss: 2.6014 - val_accuracy: 0.67
Epoch 3/20
220/220 [==============================] - 211s 961ms/step - loss: 2.5965 - accuracy: 0.6757 - val_loss: 2.5894 - val_accuracy: 0.67
Epoch 4/20
220/220 [==============================] - 206s 935ms/step - loss: 2.5857 - accuracy: 0.6762 - val_loss: 2.5857 - val_accuracy: 0.67
Epoch 5/20
220/220 [==============================] - 210s 955ms/step - loss: 2.5801 - accuracy: 0.6763 - val_loss: 2.5872 - val_accuracy: 0.67
Epoch 6/20
220/220 [==============================] - 206s 939ms/step - loss: 2.5759 - accuracy: 0.6766 - val_loss: 2.5860 - val_accuracy: 0.67
Epoch 7/20
220/220 [==============================] - 210s 955ms/step - loss: 2.5721 - accuracy: 0.6769 - val_loss: 2.5838 - val_accuracy: 0.67
Epoch 8/20
220/220 [==============================] - 210s 954ms/step - loss: 2.5681 - accuracy: 0.6774 - val_loss: 2.5829 - val_accuracy: 0.67
Epoch 9/20
220/220 [==============================] - 206s 936ms/step - loss: 2.5634 - accuracy: 0.6778 - val_loss: 2.5785 - val_accuracy: 0.68
Epoch 10/20
220/220 [==============================] - 205s 933ms/step - loss: 2.5580 - accuracy: 0.6784 - val_loss: 2.5767 - val_accuracy: 0.68
Epoch 11/20
220/220 [==============================] - 208s 945ms/step - loss: 2.5523 - accuracy: 0.6790 - val_loss: 2.5732 - val_accuracy: 0.68
Epoch 12/20
220/220 [==============================] - 206s 937ms/step - loss: 2.5469 - accuracy: 0.6793 - val_loss: 2.5706 - val_accuracy: 0.68
Epoch 13/20
220/220 [==============================] - 212s 962ms/step - loss: 2.5414 - accuracy: 0.6796 - val_loss: 2.5671 - val_accuracy: 0.68
Epoch 14/20
220/220 [==============================] - 211s 959ms/step - loss: 2.5359 - accuracy: 0.6800 - val_loss: 2.5617 - val_accuracy: 0.68
Epoch 15/20
220/220 [==============================] - 205s 933ms/step - loss: 2.5309 - accuracy: 0.6800 - val_loss: 2.5609 - val_accuracy: 0.68
Epoch 16/20
220/220 [==============================] - 211s 960ms/step - loss: 2.5259 - accuracy: 0.6802 - val_loss: 2.5567 - val_accuracy: 0.68
Epoch 17/20
220/220 [==============================] - 205s 933ms/step - loss: 2.5210 - accuracy: 0.6806 - val_loss: 2.5530 - val_accuracy: 0.68
Epoch 18/20
220/220 [==============================] - 204s 930ms/step - loss: 2.5161 - accuracy: 0.6810 - val_loss: 2.5502 - val_accuracy: 0.68
Epoch 19/20
220/220 [==============================] - 210s 956ms/step - loss: 2.5114 - accuracy: 0.6813 - val_loss: 2.5482 - val_accuracy: 0.68
Epoch 20/20
220/220 [==============================] - 210s 955ms/step - loss: 2.5067 - accuracy: 0.6815 - val_loss: 2.5450 - val_accuracy: 0.68
<keras.src.callbacks.History at 0x7975316448b0>
```

```
enc_model = Model(inputs=enc_input, outputs=[h_out, enc_h, enc_c])

dec_init_state_h = Input(shape=(latent_dim, ))
dec_init_state_c = Input(shape=(latent_dim, ))
decoder_hidden_state_input = Input(shape=(max_text_len,latent_dim))

# Get the embeddings of the decoder sequence

dec_out2, dec_h, dec_c = dec_lstm(dec_embed, initial_state=[dec_init_state_h, dec_init_state_c])

#attention inference
attn_out_inf, attn_states_inf = attn_layer([decoder_hidden_state_input, dec_out2])
decoder_inf_concat = Concatenate(axis=-1, name='concat')([dec_out2, attn_out_inf])


dec_final = dec_dense(decoder_inf_concat)

dec_model = Model([dec_input]+[decoder_hidden_state_input,dec_init_state_h, dec_init_state_c], [dec_final]+[dec_h, dec_c])
```

```
def generate_summary(input_seq):
    e_out, h, c = enc_model.predict(input_seq)

    next_token = np.zeros((1, 1))
    next_token[0, 0] = y_tokenizer.word_index['sostok']
    output_seq = ''

    stop = False
    count = 0

    while not stop:
        if count > 100:
            break
        decoder_out, state_h, state_c = dec_model.predict([next_token]+[e_out, h, c])
        token_idx = np.argmax(decoder_out[0, -1, :])

        if token_idx == y_tokenizer.word_index['eostok']:
            stop = True
        elif token_idx > 0 and token_idx != y_tokenizer.word_index['sostok']:
            token = y_tokenizer.index_word[token_idx]
            output_seq = output_seq + ' ' + token

        next_token = np.zeros((1, 1))
        next_token[0, 0] = token_idx
        h, c = state_h, state_c
        count += 1

    return output_seq
```

```
test_inputs = [clean_text(sent) for sent in X_test]
test_inputs = x_tokenizer.texts_to_sequences(list(test_inputs))
test_inputs = pad_sequences(test_inputs, maxlen=max_text_len, padding='post')
```

```
X_test.reset_index(drop=True,inplace=True)
y_test.reset_index(drop=True,inplace=True)
```

```
test_inputs[1].reshape(1, max_text_len).shape
```

```
(1, 800)
```

```
hyps = []
with open('/content/drive/MyDrive/news_abstractive_text_summarization/output_file/result3.csv', 'w') as f:
    writer = csv.writer(f)
    writer.writerow(['Article', 'Original Summary', 'Model Output'])
    for i in range(10):
        our_summ = generate_summary(test_inputs[i].reshape(1, max_text_len))
        hyps.append(our_summ)
        writer.writerow([X_test[i], y_test[i], our_summ])
```

```
1/1 [==============================] - 0s 348ms/step
1/1 [==============================] - 1s 626ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 44ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 42ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 40ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 43ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 21ms/step
```

```
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
```

```
pred_df = pd.read_csv('/content/drive/MyDrive/news_abstractive_text_summarization/output_file/result3.csv')
org_summary = pred_df['Original Summary']
pred_summary =  pred_df['Model Output']
```

```
scorer = rouge_scorer.RougeScorer(['rouge1'])
results = {'precision': [], 'recall': [], 'fmeasure': []}
for (h, r) in zip(org_summary, pred_summary):
  # computing the ROUGE
  score = scorer.score(h, r)
  # separating the measurements
  precision, recall, fmeasure = score['rouge1']
  # add them to the proper list in the dictionary
  results['precision'].append(precision)
  results['recall'].append(recall)
  results['fmeasure'].append(fmeasure)
result = pd.DataFrame(results)
result
```

	precision	recall	fmeasure
0	0.04000	0.035088	0.037383
1	0.12000	0.150000	0.133333
2	0.12000	0.084507	0.099174
3	0.04000	0.028571	0.033333
4	0.08000	0.045455	0.057971
5	0.08000	0.097561	0.087912
6	0.14000	0.125000	0.132075
7	0.02000	0.026316	0.022727
8	0.06383	0.078947	0.070588
9	0.00000	0.000000	0.000000

Model4 :- BILSTM + Attention with GloVe Embedding

```
embeding_index = {}
embed_dim = 300
with open('/content/drive/MyDrive/news_abstractive_text_summarization/glove.6B.300d.txt') as f:
    for line in f:
        values = line.split()
        word = values[0]
        coefs = np.asarray(values[1:], dtype='float32')
        embeding_index[word] = coefs
```

```
t_embed = np.zeros((t_max_features, embed_dim))
for word, i in x_tokenizer.word_index.items():
    vec = embeding_index.get(word)
    if i < t_max_features and vec is not None:
        t_embed[i] = vec
```

```
s_embed = np.zeros((s_max_features, embed_dim))
for word, i in y_tokenizer.word_index.items():
    vec = embeding_index.get(word)
    if i < s_max_features and vec is not None:
        s_embed[i] = vec
```

```
del embeding_index
```

```
class AttentionLayer(tf.keras.layers.Layer):

    def __init__(self, **kwargs):
        super(AttentionLayer, self).__init__(**kwargs)

    def build(self, input_shape):
        assert isinstance(input_shape, list)
        # Create a trainable weight variable for this layer.
        print(input_shape)
        self.W_a = self.add_weight(name='W_a',
                                   shape=tf.TensorShape((input_shape[0][2], input_shape[0][2])),
                                   initializer='uniform',
                                   trainable=True)
        self.U_a = self.add_weight(name='U_a',
                                   shape=tf.TensorShape((input_shape[1][2], input_shape[0][2])),
                                   initializer='uniform',
                                   trainable=True)
        self.V_a = self.add_weight(name='V_a',
                                   shape=tf.TensorShape((input_shape[0][2], 1)),
                                   initializer='uniform',
                                   trainable=True)

        super(AttentionLayer, self).build(input_shape)  # Be sure to call this at the end

    def call(self, inputs):
        """
        inputs: [encoder_output_sequence, decoder_output_sequence]
        """
        assert type(inputs) == list
        encoder_out_seq, decoder_out_seq = inputs

        logger.debug(f"encoder_out_seq.shape = {encoder_out_seq.shape}")
        logger.debug(f"decoder_out_seq.shape = {decoder_out_seq.shape}")

        def energy_step(inputs, states):
            """ Step function for computing energy for a single decoder state
            inputs: (batchsize * 1 * de_in_dim)
            states: (batchsize * 1 * de_latent_dim)
            """

            logger.debug("Running energy computation step")

            if not isinstance(states, (list, tuple)):
                raise TypeError(f"States must be an iterable. Got {states} of type {type(states)}")

            encoder_full_seq = states[-1]

            """ Computing S.Wa where S=[s0, s1, ..., si]"""
            # <= batch size * en_seq_len * latent_dim
            W_a_dot_s = K.dot(encoder_full_seq, self.W_a)

            """ Computing hj.Ua """
            U_a_dot_h = K.expand_dims(K.dot(inputs, self.U_a), 1)  # <= batch_size, 1, latent_dim

            logger.debug(f"U_a_dot_h.shape = {U_a_dot_h.shape}")

            """ tanh(S.Wa + hj.Ua) """
            # <= batch_size*en_seq_len, latent_dim
            Ws_plus_Uh = K.tanh(W_a_dot_s + U_a_dot_h)

            logger.debug(f"Ws_plus_Uh.shape = {Ws_plus_Uh.shape}")

            """ softmax(va.tanh(S.Wa + hj.Ua)) """
            # <= batch_size, en_seq_len
            e_i = K.squeeze(K.dot(Ws_plus_Uh, self.V_a), axis=-1)
            # <= batch_size, en_seq_len
            e_i = K.softmax(e_i)

            logger.debug(f"ei.shape = {e_i.shape}")

            return e_i, [e_i]

        def context_step(inputs, states):
            """ Step function for computing ci using ei """

            logger.debug("Running attention vector computation step")

            if not isinstance(states, (list, tuple)):
                raise TypeError(f"States must be an iterable. Got {states} of type {type(states)}")

            encoder_full_seq = states[-1]
```

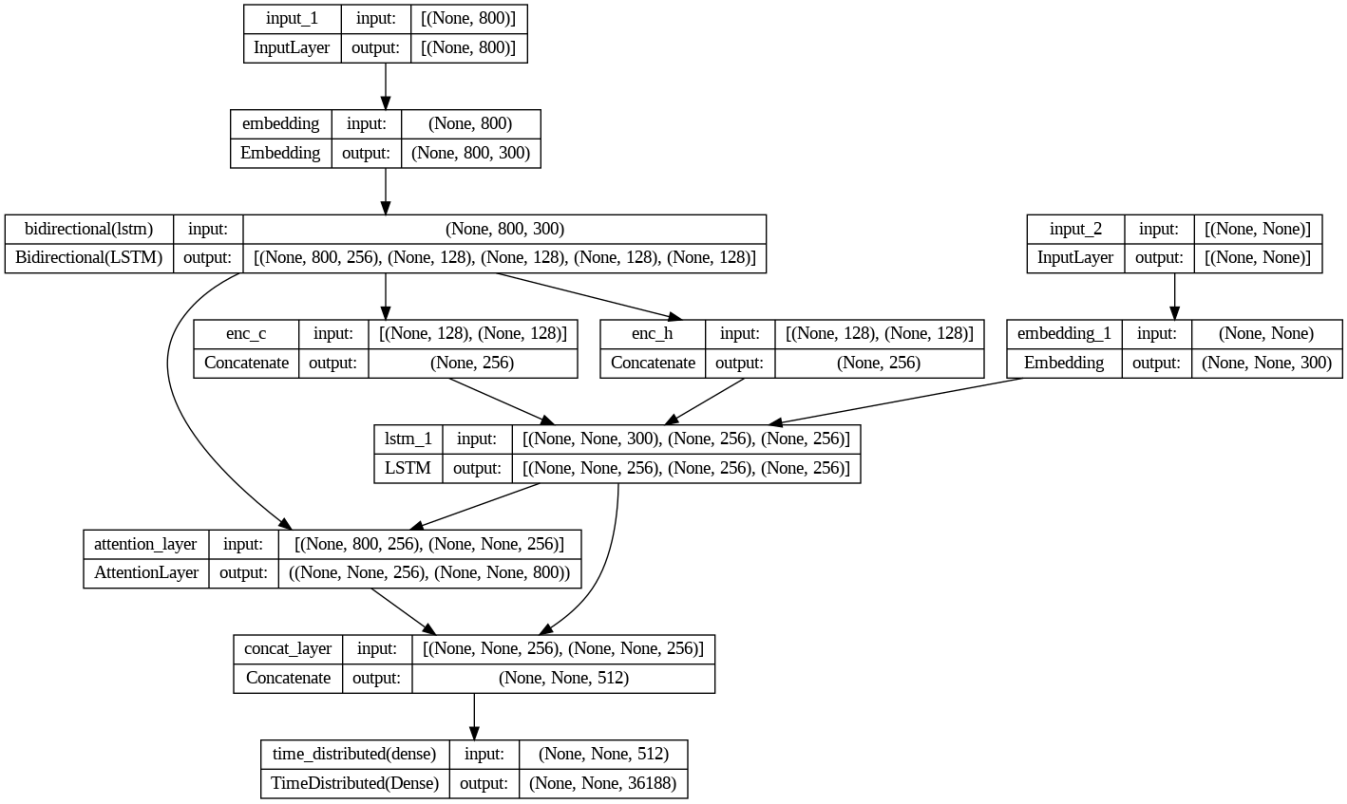
```
            # <= batch_size, hidden_size
            c_i = K.sum(encoder_full_seq * K.expand_dims(inputs, -1), axis=1)

            logger.debug(f"ci.shape = {c_i.shape}")

            return c_i, [c_i]

        # we don't maintain states between steps when computing attention
        # attention is stateless, so we're passing a fake state for RNN step function
        fake_state_c = K.sum(encoder_out_seq, axis=1)
        fake_state_e = K.sum(encoder_out_seq, axis=2)  # <= (batch_size, enc_seq_len, latent_dim

        """ Computing energy outputs """
        # e_outputs => (batch_size, de_seq_len, en_seq_len)
        last_out, e_outputs, _ = K.rnn(
            energy_step, decoder_out_seq, [fake_state_e], constants=[encoder_out_seq]
        )

        """ Computing context vectors """
        last_out, c_outputs, _ = K.rnn(
            context_step, e_outputs, [fake_state_c], constants=[encoder_out_seq]
        )

        return c_outputs, e_outputs

    def compute_output_shape(self, input_shape):
        """ Outputs produced by the layer """
        return [
            tf.TensorShape((input_shape[1][0], input_shape[1][1], input_shape[1][2])),
            tf.TensorShape((input_shape[1][0], input_shape[1][1], input_shape[0][1]))
        ]
```

```
latent_dim = 128
# Encoder
enc_input = Input(shape=(max_text_len, ))
enc_embed = Embedding(t_max_features, embed_dim, input_length=max_text_len, weights=[t_embed], trainable=False)(enc_input)
enc_lstm = Bidirectional(LSTM(latent_dim, return_sequences=True, return_state=True))
enc_output, enc_fh, enc_fc, enc_bh, enc_bc = enc_lstm(enc_embed)
enc_h = Concatenate(axis=-1, name='enc_h')([enc_fh, enc_bh])
enc_c = Concatenate(axis=-1, name='enc_c')([enc_fc, enc_bc])
#Decoder
dec_input = Input(shape=(None, ))
dec_embed = Embedding(s_max_features, embed_dim, weights=[s_embed], trainable=True)(dec_input)
dec_lstm = LSTM(latent_dim*2, return_sequences=True, return_state=True, dropout=0.3, recurrent_dropout=0.2)
dec_outputs, _, _ = dec_lstm(dec_embed, initial_state=[enc_h, enc_c])

# Attention layer
attn_layer = AttentionLayer(name='attention_layer')
attn_out, attn_states = attn_layer([enc_output, dec_outputs])

# Concat attention input and decoder LSTM output
decoder_concat_input = Concatenate(axis=-1, name='concat_layer')([dec_outputs, attn_out])

dec_dense = TimeDistributed(Dense(s_max_features, activation='softmax'))
dec_output = dec_dense(decoder_concat_input)

model = Model([enc_input, dec_input], dec_output)
model.summary()

plot_model(
    model,
    to_file='./seq2seq_encoder_decoder.png',
    show_shapes=True,
    show_layer_names=True,
    rankdir='TB',
    expand_nested=False,
    dpi=96)
```

```
WARNING:tensorflow:Layer lstm_1 will not use cuDNN kernels since it doesn't meet the criteria. It will use a generic GPU kernel as f
[TensorShape([None, 800, 256]), TensorShape([None, None, 256])]
Model: "model"
```

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, 800)]	0	[]
embedding (Embedding)	(None, 800, 300)	3323640	['input_1[0][0]']
input_2 (InputLayer)	[(None, None)]	0	[]
bidirectional (Bidirectional)	[(None, 800, 256), (None, 128), (None, 128), (None, 128), (None, 128)]	439296	['embedding[0][0]']
embedding_1 (Embedding)	(None, None, 300)	1085640	['input_2[0][0]']
enc_h (Concatenate)	(None, 256)	0	['bidirectional[0][1]', 'bidirectional[0][3]']
enc_c (Concatenate)	(None, 256)	0	['bidirectional[0][2]', 'bidirectional[0][4]']
lstm_1 (LSTM)	[(None, None, 256), (None, 256), (None, 256)]	570368	['embedding_1[0][0]', 'enc_h[0][0]', 'enc_c[0][0]']
attention_layer (AttentionLayer)	((None, None, 256), (None, None, 800))	131328	['bidirectional[0][0]', 'lstm_1[0][0]']
concat_layer (Concatenate)	(None, None, 512)	0	['lstm_1[0][0]', 'attention_layer[0][0]']
time_distributed (TimeDistributed)	(None, None, 36188)	18564444	['concat_layer[0][0]']

```
Total params: 63798236 (243.37 MB)
Trainable params: 30561836 (116.58 MB)
Non-trainable params: 33236400 (126.79 MB)
```



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