Assignment 3: Build a seq2seq model for machine translation.

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Task: Change LSTM model to Bidirectional LSTM Model and Translate English to Spanish

Due Date: Wednesday, April 19th, 11:59PM

In [1]:
```
!nvidia-smi
```

```
Thu Apr 20 13:06:43 2023
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 525.85.12    Driver Version: 525.85.12    CUDA Version: 12.0     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|                               |                      |               MIG M. |
|===============================+======================+======================|
|   0  Tesla T4            Off  | 00000000:00:04.0 Off |                    0 |
| N/A   42C    P8     9W /  70W |      0MiB / 15360MiB |      0%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                                  |
|  GPU   GI   CI        PID   Type   Process name                  GPU Memory |
|        ID   ID                                                   Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
```

0. You will do the following:

1. Read and run the code. Please make sure you have installed keras or tensorflow.Running the script on colab will speed up the training process and also prevent package loading issue.
2. Complete the code in Section 1.1, you may fill in your data directory.
3. Directly modify the code in Section 3. Change the current LSTM layer to a Bidirectional LSTM Model.

4. Training your model and translate English to Spanish in Section 4.2. You could try translating other languages.
5. Complete the code in Section 5.

Hint:

To implement `Bi-LSTM` , you will need the following code to build the encoder **in Section 3**. Do NOT use Bi-LSTM for the decoder. But there are other codes **you need to modify** to make it work.

In [2]:
```
# from keras.layers import Bidirectional, Concatenate

# encoder_bilstm = Bidirectional(LSTM(latent_dim, return_state=True,
#                                     dropout=0.5, name='encoder_lstm'))
# _, forward_h, forward_c, backward_h, backward_c = encoder_bilstm(encoder_inputs)

# state_h = Concatenate()([forward_h, backward_h])
# state_c = Concatenate()([forward_c, backward_c])
```

1. Data preparation (10 points)

1. Download spanish-english data from http://www.manythings.org/anki/
2. You may try to use other languages.
3. Unzip the .ZIP file.
4. Put the .TXT file (e.g., "deu.txt") in the directory "./Data/".
5. Fill in your data directory in section 1.1.

In [3]:
```
from nltk.translate.bleu_score import sentence_bleu, SmoothingFunction
import numpy as np
from keras.models import load_model
```

1.1. Load and clean text

In [4]:
```
import re
import string
from unicodedata import normalize
import numpy

# load doc into memory
```

```python
def load_doc(filename):
    # open the file as read only
    file = open(filename, mode='rt', encoding='utf-8')
    # read all text
    text = file.read()
    # close the file
    file.close()
    return text


# split a loaded document into sentences
def to_pairs(doc):
    lines = doc.strip().split('\n')
    pairs = [line.split('\t') for line in  lines]
    return pairs

def clean_data(lines):
    cleaned = list()
    # prepare regex for char filtering
    re_print = re.compile('[^%s]' % re.escape(string.printable))
    # prepare translation table for removing punctuation
    table = str.maketrans('', '', string.punctuation)
    for pair in lines:
        clean_pair = list()
        for line in pair:
            # normalize unicode characters
            line = normalize('NFD', line).encode('ascii', 'ignore')
            line = line.decode('UTF-8')
            # tokenize on white space
            line = line.split()
            # convert to lowercase
            line = [word.lower() for word in line]
            # remove punctuation from each token
            line = [word.translate(table) for word in line]
            # remove non-printable chars form each token
            line = [re_print.sub('', w) for w in line]
            # remove tokens with numbers in them
            line = [word for word in line if word.isalpha()]
            # store as string
            clean_pair.append(' '.join(line))
        cleaned.append(clean_pair)
    return numpy.array(cleaned)
```

Fill the following blanks:

In [5]:

```
# e.g., filename = 'Data/deu.txt'
filename = 'sample_data/spa.txt'

# e.g., n_train = 20000
n_train = 20000
```

In [6]:

```
# load dataset
doc = load_doc(filename)

# split into Language1-Language2 pairs
pairs = to_pairs(doc)

# clean sentences
clean_pairs = clean_data(pairs)[0:n_train, :]
```

In [7]:

```
for i in range(3000, 3010):
    print('[' + clean_pairs[i, 0] + '] => [' + clean_pairs[i, 1] + ']')
```

```
[were young] => [somos jovenes]
[weve eaten] => [hemos comido]
[what a bore] => [que aburrimiento]
[what a dope] => [que burro eres]
[what a dope] => [que burro]
[what a heel] => [que tipo tan arrastrado]
[what a jerk] => [que pendejo]
[what a jerk] => [que imbecil]
[what a jerk] => [que cretino]
[what a life] => [que vida]
```

In [8]:

```
input_texts = clean_pairs[:, 0]
target_texts = ['\t' + text + '\n' for text in clean_pairs[:, 1]]

print('Length of input_texts:  ' + str(input_texts.shape))
print('Length of target_texts: ' + str(input_texts.shape))
```

```
Length of input_texts:  (20000,)
Length of target_texts: (20000,)
```

In [9]:

```
max_encoder_seq_length = max(len(line) for line in input_texts)
max_decoder_seq_length = max(len(line) for line in target_texts)
```

```
print('max length of input  sentences: %d' % (max_encoder_seq_length))
print('max length of target sentences: %d' % (max_decoder_seq_length))
```

```
max length of input  sentences: 18
max length of target sentences: 48
```

Remark: To this end, you have two lists of sentences: input_texts and target_texts

2. Text processing

2.1. Convert texts to sequences

- Input: A list of n sentences (with max length t).
- It is represented by a $n \times t$ matrix after the tokenization and zero-padding.

In [10]:

```
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences

# encode and pad sequences
def text2sequences(max_len, lines):
    tokenizer = Tokenizer(char_level=True, filters='')
    tokenizer.fit_on_texts(lines)
    seqs = tokenizer.texts_to_sequences(lines)
    seqs_pad = pad_sequences(seqs, maxlen=max_len, padding='post')
    return seqs_pad, tokenizer.word_index


encoder_input_seq, input_token_index = text2sequences(max_encoder_seq_length,
                                                      input_texts)
decoder_input_seq, target_token_index = text2sequences(max_decoder_seq_length,
                                                       target_texts)

print('shape of encoder_input_seq: ' + str(encoder_input_seq.shape))
print('shape of input_token_index: ' + str(len(input_token_index)))
print('shape of decoder_input_seq: ' + str(decoder_input_seq.shape))
print('shape of target_token_index: ' + str(len(target_token_index)))
```

```
shape of encoder_input_seq: (20000, 18)
shape of input_token_index: 27
shape of decoder_input_seq: (20000, 48)
shape of target_token_index: 29
```

In [11]:
```
num_encoder_tokens = len(input_token_index) + 1
num_decoder_tokens = len(target_token_index) + 1

print('num_encoder_tokens: ' + str(num_encoder_tokens))
print('num_decoder_tokens: ' + str(num_decoder_tokens))
```

```
num_encoder_tokens: 28
num_decoder_tokens: 30
```

Remark: To this end, the input language and target language texts are converted to 2 matrices.

- Their number of rows are both n_train.
- Their number of columns are respective max_encoder_seq_length and max_decoder_seq_length.

The followings print a sentence and its representation as a sequence.

In [12]:
```
target_texts[100]
```

Out[12]:
```
'\tsali\n'
```

In [13]:
```
decoder_input_seq[100, :]
```

Out[13]:
```
array([ 6,  5,  4, 12, 11,  7,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
        0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
        0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0],
      dtype=int32)
```

2.2. One-hot encode

- Input: A list of n sentences (with max length t).
- It is represented by a $n \times t$ matrix after the tokenization and zero-padding.
- It is represented by a $n \times t \times v$ tensor (t is the number of unique chars) after the one-hot encoding.

In [14]:
```
from tensorflow.keras.utils import to_categorical

# one hot encode target sequence
def onehot_encode(sequences, max_len, vocab_size):
    n = len(sequences)
    data = numpy.zeros((n, max_len, vocab_size))
```

```
    for i in range(n):
        data[i, :, :] = to_categorical(sequences[i], num_classes=vocab_size)
    return data

encoder_input_data = onehot_encode(encoder_input_seq, max_encoder_seq_length, num_encoder_tokens)
decoder_input_data = onehot_encode(decoder_input_seq, max_decoder_seq_length, num_decoder_tokens)

decoder_target_seq = numpy.zeros(decoder_input_seq.shape)
decoder_target_seq[:, 0:-1] = decoder_input_seq[:, 1:]
decoder_target_data = onehot_encode(decoder_target_seq,
                                    max_decoder_seq_length,
                                    num_decoder_tokens)

print(encoder_input_data.shape)
print(decoder_input_data.shape)
```

```
(20000, 18, 28)
(20000, 48, 30)
```

3. Build the networks (for training) (20 points)

- In this section, we have already implemented the LSTM model for you. You can run the code and see what the code is doing.
- **You need to change the existing LSTM model to a Bidirectional LSTM model. Just modify the network structrue and do not change the training cell in section 3.4.**
- Build encoder, decoder, and connect the two modules to get "model".
- Fit the model on the bilingual data to train the parameters in the encoder and decoder.

3.1. Encoder network

- Input: one-hot encode of the input language
- Return:

  -- output (all the hidden states $h_1, \cdots, h_t$) are always discarded

  -- the final hidden state h_t

  -- the final conveyor belt c_t

In [15]:

```
from tensorflow.keras.layers import Input, LSTM,Bidirectional, Concatenate
from tensorflow.keras.models import Model

latent_dim = 256

# inputs of the encoder network
encoder_inputs = Input(shape=(None, num_encoder_tokens),
                       name='encoder_inputs')

# set the LSTM layer
#encoder_lstm = LSTM(latent_dim, return_state=True,
#                     dropout=0.5, name='encoder_lstm')
#_, state_h, state_c = encoder_lstm(encoder_inputs)

#------------------------------------------
# set the Bidirectional LSTM layer

encoder_bilstm = Bidirectional(LSTM(latent_dim, return_state=True, dropout=0.5, name='encoder_lstm'))
_, forward_h, forward_c, backward_h, backward_c = encoder_bilstm(encoder_inputs)

state_h = Concatenate()([forward_h, backward_h])
state_c = Concatenate()([forward_c, backward_c])

#---------------------------------------------

# build the encoder network model
encoder_model = Model(inputs=encoder_inputs,
                      outputs=[state_h, state_c],
                      name='encoder')
```

Print a summary and save the encoder network structure to "./encoder.pdf"

In [16]:

```
from IPython.display import SVG
from keras.utils.vis_utils import model_to_dot, plot_model

SVG(model_to_dot(encoder_model, show_shapes=False).create(prog='dot', format='svg'))

plot_model(
    model=encoder_model, show_shapes=False,
    to_file='encoder.pdf'
)
```

```
encoder_model.summary()
```

```
Model: "encoder"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to                     
==================================================================================================
 encoder_inputs (InputLayer)    [(None, None, 28)]   0           []                               
                                                                                                  
 bidirectional (Bidirectional)  [(None, 512),        583680      ['encoder_inputs[0][0]']         
                                 (None, 256),                                                     
                                 (None, 256),                                                     
                                 (None, 256),                                                     
                                 (None, 256)]                                                     
                                                                                                  
 concatenate (Concatenate)      (None, 512)          0           ['bidirectional[0][1]',          
                                                                  'bidirectional[0][3]']          
                                                                                                  
 concatenate_1 (Concatenate)    (None, 512)          0           ['bidirectional[0][2]',          
                                                                  'bidirectional[0][4]']          
                                                                                                  
==================================================================================================
Total params: 583,680
Trainable params: 583,680
Non-trainable params: 0
__________________________________________________________________________________________________
```

3.2. Decoder network

- Inputs:

  -- one-hot encode of the target language

  -- The initial hidden state h_t

  -- The initial conveyor belt c_t

- Return:

  -- output (all the hidden states) $h_1, \cdots, h_t$

  -- the final hidden state h_t (discarded in the training and used in the prediction)

-- the final conveyor belt c_t (discarded in the training and used in the prediction)

In [17]:

```
# here we need to change the shape as  we used bidirection encoder
from tensorflow.keras.layers import Input, LSTM, Dense
from tensorflow.keras.models import Model

# inputs of the decoder network

decoder_input_h = Input(shape=(latent_dim * 2,), name='decoder_input_h')
decoder_input_c = Input(shape=(latent_dim * 2,), name='decoder_input_c')
decoder_input_x = Input(shape=(None, num_decoder_tokens), name='decoder_input_x')

# set the LSTM layer
decoder_lstm = LSTM(latent_dim * 2, return_sequences=True,
                    return_state=True, dropout=0.5, name='decoder_lstm')
decoder_lstm_outputs, state_h, state_c = decoder_lstm(decoder_input_x,
                                                       initial_state=[decoder_input_h, decoder_input_c])

# set the dense layer
decoder_dense = Dense(num_decoder_tokens, activation='softmax', name='decoder_dense')
decoder_outputs = decoder_dense(decoder_lstm_outputs)

# build the decoder network model
decoder_model = Model(inputs=[decoder_input_x, decoder_input_h, decoder_input_c],
                      outputs=[decoder_outputs, state_h, state_c],
                      name='decoder')
```

Print a summary and save the encoder network structure to "./decoder.pdf"

In [18]:

```
from IPython.display import SVG
from keras.utils.vis_utils import model_to_dot, plot_model

SVG(model_to_dot(decoder_model, show_shapes=False).create(prog='dot', format='svg'))

plot_model(
    model=decoder_model, show_shapes=False,
    to_file='decoder.pdf'
)

decoder_model.summary()
```

```
Model: "decoder"
_________________________________________________________________
```

```
 Layer (type)                Output Shape         Param #     Connected to
==================================================================================================
 decoder_input_x (InputLayer)   [(None, None, 30)]   0           []

 decoder_input_h (InputLayer)   [(None, 512)]        0           []

 decoder_input_c (InputLayer)   [(None, 512)]        0           []

 decoder_lstm (LSTM)            [(None, None, 512),  1112064     ['decoder_input_x[0][0]',
                                 (None, 512),                     'decoder_input_h[0][0]',
                                 (None, 512)]                     'decoder_input_c[0][0]']

 decoder_dense (Dense)          (None, None, 30)     15390       ['decoder_lstm[0][0]']

==================================================================================================
Total params: 1,127,454
Trainable params: 1,127,454
Non-trainable params: 0
__________________________________________________________________________________________________
```

3.3. Connect the encoder and decoder

In [19]:

```python
# input layers
encoder_input_x = Input(shape=(None, num_encoder_tokens), name='encoder_input_x')
decoder_input_x = Input(shape=(None, num_decoder_tokens), name='decoder_input_x')

# connect encoder to decoder
encoder_final_states = encoder_model([encoder_input_x])
decoder_lstm_output, _, _ = decoder_lstm(decoder_input_x, initial_state=encoder_final_states)
decoder_pred = decoder_dense(decoder_lstm_output)

model = Model(inputs=[encoder_input_x, decoder_input_x],
              outputs=decoder_pred,
              name='model_training')
```

In [20]:

```python
from IPython.display import SVG
from keras.utils.vis_utils import model_to_dot, plot_model

SVG(model_to_dot(model, show_shapes=False).create(prog='dot', format='svg'))

plot_model(
    model=model, show_shapes=False,
    to_file='model_training.pdf'
```

```
)

model.summary()
```

```
Model: "model_training"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 encoder_input_x (InputLayer)   [(None, None, 28)]   0           []

 decoder_input_x (InputLayer)   [(None, None, 30)]   0           []

 encoder (Functional)           [(None, 512),        583680      ['encoder_input_x[0][0]']
                                 (None, 512)]

 decoder_lstm (LSTM)            [(None, None, 512),  1112064     ['decoder_input_x[0][0]',
                                 (None, 512),                     'encoder[0][0]',
                                 (None, 512)]                     'encoder[0][1]']

 decoder_dense (Dense)          (None, None, 30)     15390       ['decoder_lstm[1][0]']

==================================================================================================
Total params: 1,711,134
Trainable params: 1,711,134
Non-trainable params: 0
__________________________________________________________________________________________________
```

3.4. Fit the model on the bilingual dataset

- encoder_input_data: one-hot encode of the input language
- decoder_input_data: one-hot encode of the input language
- decoder_target_data: labels (left shift of decoder_input_data)
- tune the hyper-parameters
- stop when the validation loss stop decreasing.

In [21]:

```
print('shape of encoder_input_data' + str(encoder_input_data.shape))
print('shape of decoder_input_data' + str(decoder_input_data.shape))
print('shape of decoder_target_data' + str(decoder_target_data.shape))
```

```
shape of encoder_input_data(20000, 18, 28)
shape of decoder_input_data(20000, 48, 30)
shape of decoder_target_data(20000, 48, 30)
```

In [21]:

```

```

In [22]:

```
model.compile(optimizer='rmsprop', loss='categorical_crossentropy')

model.fit([encoder_input_data, decoder_input_data],  # training data
          decoder_target_data,                       # labels (left shift of the target sequences)
          batch_size=64, epochs=50, validation_split=0.2)

model.save_weights('seq2seq_weights.h5')
model.save('seq2seq.h5')
```

```
Epoch 1/50
250/250 [==============================] - 16s 21ms/step - loss: 1.0972 - val_loss: 1.1133
Epoch 2/50
250/250 [==============================] - 4s 17ms/step - loss: 0.9066 - val_loss: 0.9611
Epoch 3/50
250/250 [==============================] - 4s 16ms/step - loss: 0.8499 - val_loss: 0.9046
Epoch 4/50
250/250 [==============================] - 4s 16ms/step - loss: 0.8292 - val_loss: 0.8764
Epoch 5/50
250/250 [==============================] - 4s 17ms/step - loss: 0.8153 - val_loss: 0.8713
Epoch 6/50
250/250 [==============================] - 4s 16ms/step - loss: 0.8031 - val_loss: 0.8366
Epoch 7/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7912 - val_loss: 0.8223
Epoch 8/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7816 - val_loss: 0.8172
Epoch 9/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7724 - val_loss: 0.7937
Epoch 10/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7630 - val_loss: 0.7906
Epoch 11/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7544 - val_loss: 0.7696
Epoch 12/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7468 - val_loss: 0.7645
Epoch 13/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7395 - val_loss: 0.7438
Epoch 14/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7309 - val_loss: 0.7369
```

```
Epoch 15/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7240 - val_loss: 0.7270
Epoch 16/50
250/250 [==============================] - 4s 18ms/step - loss: 0.7170 - val_loss: 0.7205
Epoch 17/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7086 - val_loss: 0.7108
Epoch 18/50
250/250 [==============================] - 4s 17ms/step - loss: 0.7033 - val_loss: 0.7008
Epoch 19/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6964 - val_loss: 0.6887
Epoch 20/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6905 - val_loss: 0.6885
Epoch 21/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6855 - val_loss: 0.6776
Epoch 22/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6794 - val_loss: 0.6682
Epoch 23/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6727 - val_loss: 0.6638
Epoch 24/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6702 - val_loss: 0.6589
Epoch 25/50
250/250 [==============================] - 5s 19ms/step - loss: 0.6649 - val_loss: 0.6521
Epoch 26/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6596 - val_loss: 0.6455
Epoch 27/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6544 - val_loss: 0.6408
Epoch 28/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6492 - val_loss: 0.6418
Epoch 29/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6450 - val_loss: 0.6325
Epoch 30/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6405 - val_loss: 0.6286
Epoch 31/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6369 - val_loss: 0.6220
Epoch 32/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6300 - val_loss: 0.6156
Epoch 33/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6257 - val_loss: 0.6166
Epoch 34/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6232 - val_loss: 0.6098
Epoch 35/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6199 - val_loss: 0.6063
Epoch 36/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6161 - val_loss: 0.6053
Epoch 37/50
```

```
250/250 [==============================] - 4s 17ms/step - loss: 0.6099 - val_loss: 0.5961
Epoch 38/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6074 - val_loss: 0.5916
Epoch 39/50
250/250 [==============================] - 4s 18ms/step - loss: 0.6042 - val_loss: 0.5897
Epoch 40/50
250/250 [==============================] - 4s 17ms/step - loss: 0.6011 - val_loss: 0.5902
Epoch 41/50
250/250 [==============================] - 4s 17ms/step - loss: 0.5965 - val_loss: 0.5868
Epoch 42/50
250/250 [==============================] - 5s 18ms/step - loss: 0.5909 - val_loss: 0.5807
Epoch 43/50
250/250 [==============================] - 4s 17ms/step - loss: 0.5914 - val_loss: 0.5805
Epoch 44/50
250/250 [==============================] - 4s 18ms/step - loss: 0.5863 - val_loss: 0.5791
Epoch 45/50
250/250 [==============================] - 5s 18ms/step - loss: 0.5806 - val_loss: 0.5767
Epoch 46/50
250/250 [==============================] - 4s 18ms/step - loss: 0.5785 - val_loss: 0.5736
Epoch 47/50
250/250 [==============================] - 5s 18ms/step - loss: 0.5761 - val_loss: 0.5691
Epoch 48/50
250/250 [==============================] - 4s 18ms/step - loss: 0.5726 - val_loss: 0.5656
Epoch 49/50
250/250 [==============================] - 4s 17ms/step - loss: 0.5706 - val_loss: 0.5633
Epoch 50/50
250/250 [==============================] - 5s 18ms/step - loss: 0.5677 - val_loss: 0.5674
```

In [23]:

```

```

4. Make predictions

- In this section, you need to complete section 4.2 to translate English to the target language.

4.1. Translate English to XXX

1. Encoder read a sentence (source language) and output its final states, h_t and c_t.
2. Take the [star] sign "\t" and the final state h_t and c_t as input and run the decoder.
3. Get the new states and predicted probability distribution.
4. sample a char from the predicted probability distribution

5. take the sampled char and the new states as input and repeat the process (stop if reach the [stop] sign "\n").

In [24]:
```
# Reverse-lookup token index to decode sequences back to something readable.
reverse_input_char_index = dict((i, char) for char, i in input_token_index.items())
reverse_target_char_index = dict((i, char) for char, i in target_token_index.items())
```

In [25]:
```
def decode_sequence(input_seq):
    states_value = encoder_model.predict(input_seq)

    target_seq = numpy.zeros((1, 1, num_decoder_tokens))
    target_seq[0, 0, target_token_index['\t']] = 1.

    stop_condition = False
    decoded_sentence = ''
    while not stop_condition:
        output_tokens, h, c = decoder_model.predict([target_seq] + states_value)

        # this line of code is greedy selection
        # try to use multinomial sampling instead (with temperature)
        sampled_token_index = numpy.argmax(output_tokens[0, -1, :])

        sampled_char = reverse_target_char_index[sampled_token_index]
        decoded_sentence += sampled_char

        if (sampled_char == '\n' or
           len(decoded_sentence) > max_decoder_seq_length):
            stop_condition = True

        target_seq = numpy.zeros((1, 1, num_decoder_tokens))
        target_seq[0, 0, sampled_token_index] = 1.

        states_value = [h, c]

    return decoded_sentence
```

In [26]:
```
for seq_index in range(2100, 2120):
    # Take one sequence (part of the training set)
    # for trying out decoding.
    input_seq = encoder_input_data[seq_index: seq_index + 1]
    decoded_sentence = decode_sequence(input_seq)
    print('-')
    print('English:       ', input_texts[seq_index])
```

```
    print('Spanish (true): ', target_texts[seq_index][1:-1])
    print('Spanish (pred): ', decoded_sentence[0:-1])
```

```
1/1 [==============================] - 1s 732ms/step
1/1 [==============================] - 0s 380ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 33ms/step
-
English:         dont smoke
Spanish (true):  no fumeis
Spanish (pred):  no se preguntes
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 25ms/step
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1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
-
English:         dont smoke
Spanish (true):  no fumais
Spanish (pred):  no se preguntes
```

```
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
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1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 25ms/step
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1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
-
English:        dont speak
Spanish (true):  no hables
Spanish (pred):  no seas triste
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 29ms/step
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1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 24ms/step
-
English:        dont worry
Spanish (true):  no te preocupes
Spanish (pred):  no se preguntes
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
```

```
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
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1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 26ms/step
-
English:         dont worry
Spanish (true):  no os preocupeis
Spanish (pred):  no se preguntes
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 24ms/step
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1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 32ms/step
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1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 42ms/step
1/1 [==============================] - 0s 42ms/step
1/1 [==============================] - 0s 47ms/step
-
English:         dont worry
Spanish (true):  no se preocupen
Spanish (pred):  no se preguntes
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 49ms/step
```

```
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 20ms/step
-
English:        finish this
Spanish (true):  termine esto
Spanish (pred):  lermina esto
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 24ms/step
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1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
-
English:        finish this
Spanish (true):  termina esto
Spanish (pred):  lermina esto
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
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1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
-
English:        finish this
```

```
Spanish (true):  termina esto
Spanish (pred):  lermina esto
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
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1/1 [==============================] - 0s 43ms/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 25ms/step
-
English:         finish this
Spanish (true):  terminen esto
Spanish (pred):  lermina esto
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 22ms/step
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1/1 [==============================] - 0s 23ms/step
-
English:         finish this
Spanish (true):  terminad esto
Spanish (pred):  lermina esto
1/1 [==============================] - 0s 24ms/step
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1/1 [==============================] - 0s 28ms/step
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1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
-
English:        flip a coin
Spanish (true):  lanza una moneda
Spanish (pred):  sigue un cantante
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 24ms/step
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1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 22ms/step
-
English:        flip a coin
Spanish (true):  tira una moneda al aire
Spanish (pred):  sigue un cantante
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 23ms/step
```

```
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 20ms/step
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1/1 [==============================] - 0s 29ms/step
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1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
-
English:         forgive tom
Spanish (true):  disculpe a tom
Spanish (pred):  desplemate a tom
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 25ms/step
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1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
-
English:         forgive tom
Spanish (true):  disculpa a tom
Spanish (pred):  desplemate a tom
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
```

```
1/1 [==============================] - 0s 36ms/step
1/1 [==============================] - 0s 33ms/step
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1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 42ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 33ms/step
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 33ms/step
-
English:        get dressed
Spanish (true):  vistete
Spanish (pred):  abate a sor revor
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 31ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 30ms/step
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1/1 [==============================] - 0s 19ms/step
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1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
-
English:        get dressed
Spanish (true):  vestite
Spanish (pred):  abate a sor revor
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 27ms/step
```

```
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 29ms/step
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1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
-
English:        get in here
Spanish (true):  entra aqui
Spanish (pred):  abre la cara
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 22ms/step
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1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 22ms/step
-
English:        get serious
Spanish (true):  ponte serio
Spanish (pred):  comemos a las dercas
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 20ms/step
```

```
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 26ms/step
-
English:        get started
Spanish (true):  empieza
Spanish (pred):  dejamos a las
```

4.2. Translate an English sentence to the target language （20 points）

1. Tokenization
2. One-hot encode
3. Translate

In [27]:

```
input_sentence = 'I love you'

input_sequence, _ = text2sequences(max_encoder_seq_length, [input_sentence])

input_x = onehot_encode(input_sequence, max_encoder_seq_length, num_encoder_tokens)
print(input_x.shape)

translated_sentence = decode_sequence(input_x)


print('source sentence is: ' + input_sentence)
print('translated sentence is: ' + translated_sentence)
```

```
(1, 18, 28)
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
```

```
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
source sentence is: I love you
translated sentence is: esta es mi cala
```

In [27]:

```

```

5. Evaluate the translation using BLEU score

- We have already translated from English to target language, but how can we evaluate the performance of our model quantitatively?
- In this section, you need to re-train the model we built in secton 3 and then evaluate the bleu score on testing dataset.

Reference:

https://machinelearningmastery.com/calculate-bleu-score-for-text-python/

https://en.wikipedia.org/wiki/BLEU

Hint:

- Randomly partition the dataset to training, validation, and test.
- Evaluate the BLEU score using the test set. Report the average.
- You may use packages to calculate bleu score, e.g., sentence_bleu() from nltk package.

5.1. Partition the dataset to training, validation, and test. Build new token index. (10 points)

1. You may try to load more data/lines from text file.
2. Convert text to sequences and build token index using training data.

3. One-hot encode your training and validation text sequences.

In [28]:

```
from nltk.translate.bleu_score import sentence_bleu, SmoothingFunction
from keras.optimizers import RMSprop
from keras.callbacks import EarlyStopping
import numpy as np
```

In [29]:

```
# chatgpt
filename = 'sample_data/spa.txt'
num_samples = 30000  # change this to load more samples
doc = load_doc(filename)

# split into Language1-Language2 pairs
pairs = to_pairs(doc)

clean_pairs = clean_data(pairs)[0:num_samples, :]

input_texts = clean_pairs[:, 0]
target_texts = ['\t' + text + '\n' for text in clean_pairs[:, 1]]

#Randomly partition the dataset to training, validation, and test.
index = np.random.permutation(30000)

# 98% for training and remaining 2% for testing
train_indices = index[0:int(30000*.98)]
test_indices = index[int(30000*.98):int(30000)]


# split into input and target for both train and test
train_input = input_texts[train_indices]
train_target = numpy.asarray(target_texts)[train_indices]


test_input = input_texts[test_indices]
test_target = numpy.asarray(target_texts)[test_indices]



# converting into tokens
max_encoder_seq_length = max(len(line) for line in input_texts)
max_decoder_seq_length = max(len(line) for line in target_texts)

encoder_input_seq, input_token_index = text2sequences(max_encoder_seq_length,
```

```
                                                      train_input)
decoder_input_seq, target_token_index = text2sequences(max_decoder_seq_length,
                                                       train_target)



print('shape of encoder_input_seq: ' + str(encoder_input_seq.shape))
print('shape of input_token_index: ' + str(len(input_token_index)))
print('shape of decoder_input_seq: ' + str(decoder_input_seq.shape))
print('shape of target_token_index: ' + str(len(target_token_index)))




##num_encoder_tokens = len(input_token_index)
#num_decoder_tokens = len(target_token_index)

encoder_input_data = onehot_encode(encoder_input_seq, max_encoder_seq_length, num_encoder_tokens)
decoder_input_data = onehot_encode(decoder_input_seq, max_decoder_seq_length, num_decoder_tokens)

decoder_target_seq = numpy.zeros(decoder_input_seq.shape)
decoder_target_seq[:, 0:-1] = decoder_input_seq[:, 1:]
decoder_target_data = onehot_encode(decoder_target_seq,
                                    max_decoder_seq_length,
                                    num_decoder_tokens)
```

```
shape of encoder_input_seq: (29400, 20)
shape of input_token_index: 27
shape of decoder_input_seq: (29400, 68)
shape of target_token_index: 29
```

In [30]:

```
print(encoder_input_data.shape)
print(decoder_input_data.shape)
```

```
(29400, 20, 28)
(29400, 68, 30)
```

5.2 Retrain your previous Bidirectional LSTM model with training and validation data and tune the parameters (learning rate, optimizer, etc) based on validation score. (25 points)

1. Use the model structure in section 3 to train a new model with new training and validation datasets.
2. Based on validation BLEU score or loss to tune parameters.

In [31]:
```
#5.2

#updating optimizer here and batch size to make it faster
model.load_weights('seq2seq_weights.h5')
model.compile(optimizer='adam', loss='categorical_crossentropy')
model.fit([encoder_input_data, decoder_input_data],  # training data
          decoder_target_data,                       # labels
          batch_size=100, epochs=50)

#save the newly trained model
model.save('seq2seq_new.h5')
```

```
Epoch 1/50
294/294 [==============================] - 16s 31ms/step - loss: 0.5525
Epoch 2/50
294/294 [==============================] - 8s 29ms/step - loss: 0.5071
Epoch 3/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4905
Epoch 4/50
294/294 [==============================] - 9s 29ms/step - loss: 0.4778
Epoch 5/50
294/294 [==============================] - 9s 29ms/step - loss: 0.4692
Epoch 6/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4591
Epoch 7/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4518
Epoch 8/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4457
Epoch 9/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4397
Epoch 10/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4347
Epoch 11/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4291
Epoch 12/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4236
Epoch 13/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4176
Epoch 14/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4154
Epoch 15/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4115
Epoch 16/50
294/294 [==============================] - 8s 28ms/step - loss: 0.4064
```

```
Epoch 17/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4029
Epoch 18/50
294/294 [==============================] - 8s 29ms/step - loss: 0.4001
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294/294 [==============================] - 8s 28ms/step - loss: 0.3956
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294/294 [==============================] - 8s 29ms/step - loss: 0.3931
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294/294 [==============================] - 8s 29ms/step - loss: 0.3896
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Epoch 39/50
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294/294 [==============================] - 8s 28ms/step - loss: 0.3407
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Epoch 47/50
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294/294 [==============================] - 8s 28ms/step - loss: 0.3372
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294/294 [==============================] - 8s 28ms/step - loss: 0.3360
Epoch 50/50
294/294 [==============================] - 8s 28ms/step - loss: 0.3340
```

5.3 Evaluate the BLEU score using the test set. (15 points)

1. Use trained model above to calculate the BLEU score with testing dataset.
2. A reasonable should be 0.1-0.3. The higher, the better.

In [32]:

```
from nltk.translate.bleu_score import sentence_bleu
from nltk.translate.bleu_score import SmoothingFunction
smoothIt = SmoothingFunction().method2
```

In [37]:

```
#initialize belu score and failed count as 0
belu_score=0
failed_count=0

bleu_list = []
for n in range(len(test_input)):

  text = test_input[n]
  target = test_target[n]
```

```
    input = [text]

    encoder_input_seq,l= text2sequences(max_encoder_seq_length,input)
    input_x = onehot_encode(encoder_input_seq, max_encoder_seq_length, num_encoder_tokens)

    #After experiemntation, using try,
    # except since test data new keywords which dont have decoded words during training

    try:
      translated_sentence = decode_sequence(input_x)
    except KeyError as err:
      failed_count=failed_count+1
      continue
    score = sentence_bleu(target, translated_sentence, smoothing_function = smoothIt)

    print(score)
    bleu_list.append(score)
```

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Streaming output truncated to the last 5000 lines.
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1/1 [==============================] - 0s 44ms/step
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1/1 [==============================] - 0s 39ms/step
1/1 [==============================] - 0s 49ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 38ms/step
0.128831879819136
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 47ms/step
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1/1 [==============================] - 0s 46ms/step
1/1 [==============================] - 0s 35ms/step
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1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 41ms/step
1/1 [==============================] - 0s 34ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 28ms/step
0.14498922073576034
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0.05515883843922034
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0.0645777692487244
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1/1 [==============================] - 0s 42ms/step
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1/1 [==============================] - 0s 31ms/step
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0.11835664479450718
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1/1 [==============================] - 0s 32ms/step
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1/1 [==============================] - 0s 30ms/step
0.10363232116621422
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1/1 [==============================] - 0s 65ms/step
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1/1 [==============================] - 0s 33ms/step
0.08744821970182538
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 43ms/step
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0.11002068284361832
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1/1 [==============================] - 0s 53ms/step
1/1 [==============================] - 0s 44ms/step
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0.2125450426268808
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1/1 [==============================] - 0s 32ms/step
0.08312218488523596
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1/1 [==============================] - 0s 31ms/step
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1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 28ms/step
0.19304869754804482
```

In [43]:

```
print('BLEU score is:',np.sum(bleu_list)/546) # removed the failedcount(54) while finding the average belu scor
```

```
BLEU score is: 0.10676064826553622
```