DL Assignment 2-Group 299

Question 1:

Image Captioning : Image Captioning is the process of generating textual description of an image. It uses both Natural Language Processing and Computer Vision to generate the captions. The dataset will be in the form [image → captions]. The dataset consists of input images and their corresponding output captions.

Encoder: The Convolutional Neural Network(CNN) can be thought of as an encoder. The input image is given to CNN to extract the features. The last hidden state of the CNN is connected to the Decoder.

Decoder: The Decoder is a Recurrent Neural Network(RNN) which does language modelling up to the word level. The first time step receives the encoded output from the encoder and also the vector.

Import Libraries/Dataset (0 mark) Import the required libraries Check the GPU available (recommended- use free GPU provided by Google Colab). Data Processing(1 mark) Read the pickle file (https://drive.google.com/file/d/1A8g74ohdb_5d2fPjc72yF7GxufE9GRcu/view?usp=sharing (https://drive.google.com/file/d/1A8g74ohdb_5d2fPjc72yF7GxufE9GRcu/view?usp=sharing)) (Links to an external site.) and convert the data into the correct format which could be used for ML model. Pickle file contains the image id and the text associated with the image.

Eg: '319847657_2c40e14113.jpg#0\tA girl in a purple shirt hold a pillow . Each image can have multiple captions. 319847657_2c40e14113.jpg -> image name #0 -> Caption ID \t -> separator between Image name and Image Caption A girl in a purple shirt hold a pillow . -> Image Caption

Corresponding image wrt image name can be found in the image dataset folder. Image dataset Folder : https://drive.google.com/file/d/1-mPKMpphaKqtT26ZzbR5hCHGedkNyAf1/view?usp=sharing (https://drive.google.com/file/d/1-mPKMpphaKqtT26ZzbR5hCHGedkNyAf1/view?usp=sharing) (Links to an external site.) Plot at least two samples and their captions (use matplotlib/seaborn/any other library). Bring the train and test data in the required format.

Model Building (4 mark) Use Pretrained Resnet-50 model trained on ImageNet dataset (available publicly on google) for image feature extraction. Create 5 layered LSTM layer model and other relevant layers for image caption generation. Add L1 regularization to all the LSTM layers. Add one layer of dropout at the appropriate position and give reasons. Choose the appropriate activation function for all the layers. Print the model summary.

Model Compilation (0.5 mark) Compile the model with the appropriate loss function. Use an appropriate optimizer. Give reasons for the choice of learning rate and its value. Model Training (1 mark) Train the model for an appropriate number of epochs. Print the train and validation loss for each epoch. Use the appropriate batch size. Plot the loss and accuracy history graphs for both train and validation set. Print the total time taken for training. Model Evaluation (1 mark)

Take a random image from google and generate caption for that image.

In [113]:

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import os
import random
import warnings
warnings.filterwarnings('ignore')

import matplotlib.image as img

#Import Necessary Libraries
from os import listdir
from pickle import dump, load
import pickle

from tqdm.notebook import tqdm
import tensorflow as tf
from tensorflow.keras.applications.resnet50 import ResNet50, preprocess_inp
from tensorflow.keras.preprocessing.image import load_img, img_to_array
from tensorflow.keras.models import Model
from tensorflow.keras.models import load_model
from tensorflow.keras.regularizers import L1L2

from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.utils import to_categorical, plot_model
from tensorflow.keras.layers import Input, Dense, LSTM, Embedding, Dropout,
from tensorflow.keras.optimizers import Adam, SGD
```

In [ ]:

```
random.seed(42)         # Initialize the random number generator.
np.random.seed(42)      # With the seed reset, the same set of
                        # numbers will appear every time.
#tf.set_random_seed(42)  # sets the graph-level random seed
tf.random.set_seed(42)
```

In [145]:

```
image_directory='../../../data/explore/image_caption_generator/Image_captio
img_caption_pkl=pd.read_pickle('../../../data/explore/image_caption_generat
```

Reading Image Captions

In [146]:

```

img_names, img_captionIds, img_captions=[], [], []
for row in img_caption_pkl:
    cnt_=sum([1  if char =='#' else 0 for char in row ])
    if cnt_>1:
        print(row, cnt_)
    row=row.split('#')
    img_name, img_caption=row[0], row[1]
    captionId, caption = img_caption.split('\t')
    img_names.append(img_name.split('.jpg')[0])
    img_captionIds.append(captionId)
    img_captions.append(caption)

image_captions=pd.DataFrame({'image':img_names, 'captionId':img_captionIds,
print(image_captions.shape)
image_captions.head(2)
```

```
2837799692_2f1c50722a.jpg#4     Closeup of football player # 25 . 2
3273625566_2454f1556b.jpg#4     A race dog have a muzzle and be wear strip
ed jersey # 8 . 2
2837799692_2f1c50722a.jpg#3     a university of Miami football player # 25
. 2
3147913471_322ea231d9.jpg#2     Florida man 's basketball player # 33 shoo
t basketball . 2
2833582518_074bef3ed6.jpg#4     A # 2 greyhound dog be run around a track
. 2
2769605231_dae8b30201.jpg#1     A black greyhound , with a green and white
jersey ( # 7 ) be run on a track . 2
(25000, 3)
```

Out[146]:

	image	captionId	caption
0	318667317_108c402140	4	A man in a black hoodie be hold a paper sign .
1	2072574835_febf0c5fb9	4	Three race dog be run out of the start gate on...

In [147]:

```
image_captions[image_captions['image']=='319847657_2c40e14113'].head()
```

Out[147]:

	image	captionId	caption
9948	319847657_2c40e14113	3	A woman be tug on a white sheet and laugh
16427	319847657_2c40e14113	1	A girl in a purple shirt be have pull someone ...

Observation: some image have more than 1 captions.

In [148]:

```
image_captions.drop_duplicates().shape
```

Out[148]:

```
(25000, 3)
```

In [149]:

```
image_captions.captionId.nunique(), image_captions.image.nunique(), image_c
```

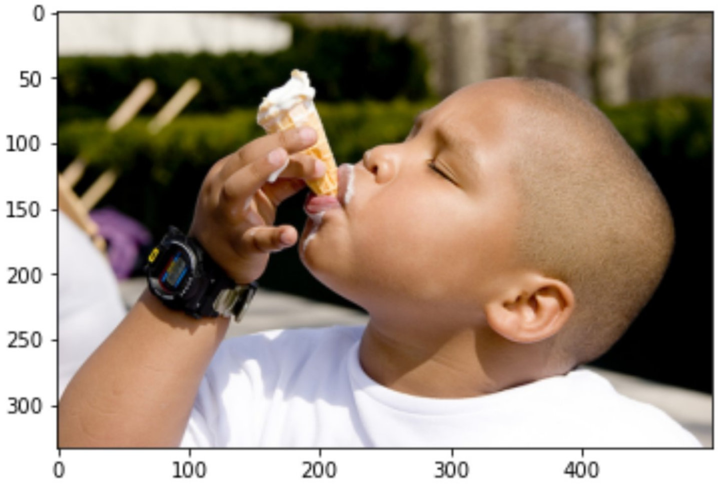
Out[149]:

```
(5, 8037, 24817)
```

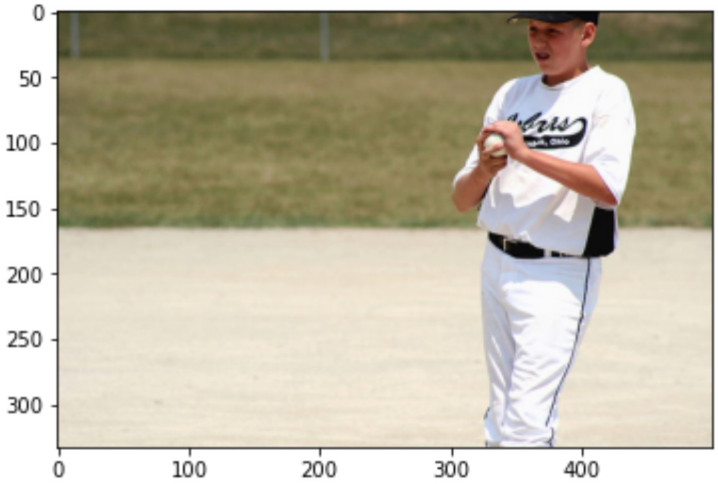
Ploting few images with its caption

In [152]:

```
# image_directory='Image_captioning_Dataset/Flicker8k_Dataset'
for image in random.sample(list(image_captions.image), 3):
    plt.figure()
    im = img.imread(image_directory + '/'+ image + '.jpg')
    plt.imshow(im)
    plt.show()
    print(f'Given Sequence are for this image are: \n')

    for caption in image_captions[image_captions['image']==image].caption.v
        print(caption)
#     print(image_captions[image_captions['image']==image].caption.iloc[0])
```

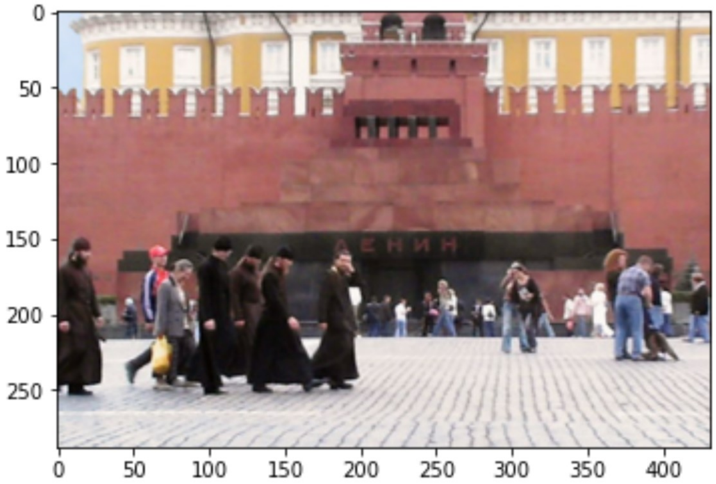


```
Given Sequence are for this image are:

A young boy wear a big watch eat an ice cream cone .
A young boy eat ice cream .
Little boy be eat the rest of an ice cream cone from the bottom up .
A boy with his eye close eat the bottom of an ice cream cone .
A boy be put the cone end of a melt ice cream cone in his mouth .
```



```
Given Sequence are for this image are:

A boy be wear a white baseball uniform and hold a baseball .
```

```
a boy in white play baseball .
Little leaguer get ready for pitch
A young Ohio baseball player contemplate his pitch .
A young boy be get ready to through a baseball
```



```
Given Sequence are for this image are:

A city square with a large red wall and person walk about .
```

Image Feature extraction

In [131]:

```
def image_feature_extraction(image_directory, model):
    '''
        extract image features from the given directory using pretrained mo
    '''
    model.layers.pop()
    model = Model(inputs=model.inputs, outputs=model.layers[-2].output)
    # summarize
    print(model.summary())
    # extract features from each photo
    features = dict()
    for name in tqdm(listdir(image_directory)):
        # load an image from file
        filename = image_directory + '/' + name
        image = load_img(filename, target_size=(224, 224))
        # convert the image pixels to a numpy array
        image = img_to_array(image)
        # reshape data for the model
        image = image.reshape((1, image.shape[0], image.shape[1], image.sha
        # prepare the image for the given model
        image = preprocess_input(image)
        # get features
        feature = model.predict(image, verbose=0)
        # get image id
        image_id = name.split('.')[0]
        # store feature
        features[image_id] = feature
#         print('>%s' % name)
    return features
```

In [16]:
```
resnet50=ResNet50()
# resnet50=load_model('../../../data/explore/image_caption_generator/resnet
image_features = image_feature_extraction(image_directory, resnet50)
print('Extracted Features: %d' % len(image_features))
# save to file
dump(image_features, open('../../../data/explore/image_caption_generator/ou
```

```
WARNING:tensorflow:No training configuration found in the save file, so th
e model was *not* compiled. Compile it manually.
Model: "functional_1"
__________________________________________________________________________
________________________
Layer (type)                    Output Shape         Param #     Connected
to
==========================================================================
========================
input_3 (InputLayer)            [(None, 224, 224, 3) 0
__________________________________________________________________________
________________________
conv1_pad (ZeroPadding2D)       (None, 230, 230, 3)  0           input_3
[0][0]
__________________________________________________________________________
________________________
conv1_conv (Conv2D)             (None, 112, 112, 64) 9472        conv1_pad
[0][0]
__________________________________________________________________________
```

In [31]:
```
# load features from pickle
with open(os.path.join('../../../data/explore/image_caption_generator/outpu
    image_features = load(f)
```

In [32]:
```
len(image_features), image_captions.image.nunique()
```

Out[32]:
```
(8091, 8037)
```

There are mismatch in the image available in image directory in comparision to captions. Let's remove image name from image_captions which are not available

In [74]:
```
image_captions=image_captions[image_captions['image'].isin(image_features.k
print(len(image_features), image_captions.image.nunique(), image_captions.s
```

```
8091 8036 (24996, 3)
```

Caption Preprocessing

Removing numbers, special character, addition spaces & changing all the word to lower case

Start and End Sequence has to be added to the tokens so that it's easier to identify the captions for the image as each of them are of different length

In [75]:
```
def caption_preprocessing(caption):
    # preprocessing steps
    # convert to lowercase, delete digits, special chars & additional space
    caption = caption.lower().replace('[^A-Za-z]', '').replace('\s+', ' ')
    # add start and end tags to the caption
    caption = 'startseq ' + " ".join([word for word in caption.split() if l
    return caption
image_captions['caption']=image_captions['caption'].apply(caption_preproces
image_captions['image_feature']=image_captions['image'].apply(lambda x: ima
image_captions.head()
```

Out[75]:

	image	captionId	caption	image_feature
0	318667317_108c402140	4	startseq man in black hoodie be hold paper sig...	[0.34249333, 0.36296466, 0.002094434, 0.805999...
1	2072574835_febf0c5fb9	4	startseq three race dog be run out of the star...	[0.34385532, 0.19550037, 0.6508237, 2.041569, ...
2	3083016677_5782bc337c	4	startseq two motorcycle with two rider each en...	[1.0154637, 4.204777, 0.43433255, 0.04175122, ...
3	95734038_2ab5783da7	0	startseq man on bike nest to river endseq	[0.67103887, 0.19373809, 0.27402854, 0.0329701...
4	241346146_f27759296d	1	startseq football player try tackle another pl...	[0.11336415, 2.6156332, 0.0, 1.4476278, 0.0714...

Tokenising the caption to convert text to numerical

In [76]:
```
image_captions_all=image_captions['caption'].values
print(len(image_captions_all))
image_captions_all[0:5]
```

```
24996
```

Out[76]:
```
array(['startseq man in black hoodie be hold paper sign endseq',
       'startseq three race dog be run out of the start gate on track ends
eq',
       'startseq two motorcycle with two rider each endseq',
       'startseq man on bike nest to river endseq',
       'startseq football player try tackle another player who have the ba
ll endseq'],
      dtype=object)
```

In [77]:
```
# tokenize the text
from tensorflow.keras.preprocessing.text import Tokenizer

tokenizer = Tokenizer()
tokenizer.fit_on_texts(image_captions_all)
vocab_size = len(tokenizer.word_index) + 1
print(vocab_size)
```

```
5340
```

In [78]:
```
# get maximum length of the caption available
max_len_caption = max([len(caption.split()) for caption in image_captions_a
max_len_caption
```

Out[78]:
```
31
```

In [81]:
```
image_captions['caption_token']=image_captions['caption'].apply(lambda x: t
```

In [82]:
```
image_captions.image.nunique()
```

Out[82]:
```
8036
```

In [83]:
```
image_captions.head(2)
```

Out[83]:

	image	captionId	caption	image_feature	caption_token
0	318667317_108c402140	4	startseq man in black hoodie be hold paper sig...	[0.34249333, 0.36296466, 0.002094434, 0.805999...	[1, 9, 3, 18, 795, 4, 38, 430, 188, 2]
1	2072574835_febf0c5fb9	4	startseq three race dog be run out of the star...	[0.34385532, 0.19550037, 0.6508237, 2.041569, ...	[1, 49, 101, 7, 4, 20, 88, 11, 6, 985, 796, 5,...

Splitting Train/Test Data

In [85]:
```
image_names = image_captions['image'].unique()
index = int(len(image_names) * 0.80)
image_names_train=image_names[:index]
image_names_test=image_names[index:]
image_captions_train = image_captions[image_captions['image'].isin(image_na
image_captions_test = image_captions[image_captions['image'].isin(image_nam
print(image_captions_train.shape, image_captions_test.shape)
```

```
(21000, 5) (3996, 5)
```

In [86]:
```
image_captions_train.head(2)
```

Out[86]:

	image	captionId	caption	image_feature	caption_token
0	318667317_108c402140	4	startseq man in black hoodie be hold paper sig...	[0.34249333, 0.36296466, 0.002094434, 0.805999...	[1, 9, 3, 18, 795, 4, 38, 430, 188, 2]
1	2072574835_febf0c5fb9	4	startseq three race dog be run out of the star...	[0.34385532, 0.19550037, 0.6508237, 2.041569, ...	[1, 49, 101, 7, 4, 20, 88, 11, 6, 985, 796, 5,...

In [89]:
```
dtexts=image_captions.caption_token.values
dimages=image_captions.image_feature.values
```

In [90]:

```
len(dimages[0])
```

Out[90]:

```
2048
```

Finding the Max & Min Lengh of caption

this will help us to do padding sequence in input /output of caption

In [91]:

```
maxlen = np.max([len(text) for text in dtexts])
minlen = np.min([len(text) for text in dtexts])
print("Min length of caption: {} and Max length of caption: {}".format(minl
```

```
Min length of caption: 2 and Max length of caption: 31
```

Processing the captions and images as per the model standard input type

The image embedding representations are concatenated with the first word of sentence ie. starseq and passed to the LSTM network The LSTM network starts generating words after each input thus forming a sentence at the end

In [122]:

```
def preprocessing(dtexts,dimages):
    N = len(dtexts)
    print("# captions/images = {}".format(N))

    assert(N==len(dimages)) # using assert to make sure that length of imag
    Xtext, Ximage, ytext = [],[],[]
    for text,image in zip(dtexts,dimages):
        # zip() is used to create a tuple of iteratable items
        for i in range(1,len(text)):
            in_text, out_text = text[:i], text[i]
            in_text = pad_sequences([in_text],maxlen=maxlen).flatten()# usi
            out_text = to_categorical(out_text,num_classes = vocab_size) #


            Xtext.append(in_text)
            Ximage.append(image)
            ytext.append(out_text)

    Xtext  = np.array(Xtext)
    Ximage = np.array(Ximage)
    ytext  = np.array(ytext)
    print(" {} {} {}".format(Xtext.shape,Ximage.shape,ytext.shape))
    return(Xtext,Ximage,ytext)


Xtext_train, Ximage_train, ytext_train = preprocessing(image_captions_train
Xtext_val,   Ximage_val,   ytext_val   = preprocessing(image_captions_test.
# pre-processing is not necessary for testing data
#Xtext_test,  Ximage_test,  ytext_test  = preprocessing(dt_test,di_test)
```

```
# captions/images = 21000
 (211644, 31) (211644, 2048) (211644, 5340)
# captions/images = 3996
 (40152, 31) (40152, 2048) (40152, 5340)
```

Model Building

In current implementation, output of 2nd last layer pretrained resnet50 is taken as input layer. we choose one Drop out layer, one Dense Layer(128) is added for the image features. For the captions, one Embedding layer (256 neuron), one drop out & 5 LSTM layer with l1 regularization is used. For the decoder, first add layer is used which add image feature tensors with captions tensor with equal shape & provide single tensor then another dense layer (256 neuron) is used with 'relu' activation function. At output, dense layer (vocab size) is used with 'sigmoid' activation function.

learning rate: The range of values to consider for the learning rate should be between 10^-6 to 1. A traditional default value for the learning rate is 0.1 or 0.01 which is a good starting point for any problem and this can be further optimize with Hyper parameter tuning. In this problem after several iteration & testing we are taking 0.001 as starting point as its convergence is faster.

Activation function: As this problem is related to sequence output problem, we choose sigmoid in the output layer and relu/tanh in the other layer. In addition we can also choose hidden layer activation function using hyper parameter tuning.

loss function: categorical_crossentropy is used as a loss function for this problem.

optimizer: Adam optimizer is used which generally prefer over others.

dropOut Layer: we have added two drop out layer, one at image feature to avoid taking all the essense of image. another is after embedding where we want to avoid text to go together & may lead to overfit.

In addition , variable learning rate with factor of 0.5 can be used if val_loss is not improving for 10 consecutive patience. Early Stopping criteria can used if val_loss is not improving for 50 patience but due to resource & time constraint, these area has not been explored much

In [123]:
```
# encoder model
#Image feature
img_input = Input(shape=(Ximage_train.shape[1],))
img_feature_layer1 = Dropout(0.4)(img_input)
img_feature_layer2 = Dense(128, activation='relu', name="ImageFeature")(img

# sequence feature layers
dim_embedding = 256
seq_input = Input(shape=(maxlen,))
seq_embedding = Embedding(vocab_size, dim_embedding, mask_zero=True)(seq_in
seq_dr_layer = Dropout(0.4)(seq_embedding)
seq_layer1 = LSTM(64, return_sequences=True, bias_regularizer=L1L2(l1=.01,
seq_layer2 = LSTM(32, return_sequences=True, bias_regularizer=L1L2(l1=.01,
seq_layer3 = LSTM(64, return_sequences=True, bias_regularizer=L1L2(l1=.01,
seq_layer4 = LSTM(64, return_sequences=True, bias_regularizer=L1L2(l1=.01,
seq_layer5 = LSTM(128, bias_regularizer=L1L2(l1=.01, l2=0))(seq_layer1)

# decoder model
print(vocab_size)

decoder1 = add([img_feature_layer2, seq_layer5])
decoder2 = Dense(256, activation='relu')(decoder1)
outputs = Dense(vocab_size, activation='softmax')(decoder2)

# model = Model(inputs=[img_input, seq_input], outputs=outputs)
```

```
5340
```

Model Compilation

In [124]:

```
adam=Adam(learning_rate=0.0005)
model.compile(loss='categorical_crossentropy', optimizer=adam, metrics=['ac
model.summary()
```

```
Model: "functional_11"
__________________________________________________________________________
________________________
Layer (type)                    Output Shape         Param #     Connected
to
==========================================================================
========================
input_14 (InputLayer)           [(None, 31)]         0
__________________________________________________________________________
________________________
embedding_5 (Embedding)         (None, 31, 256)      1367040     input_14
[0][0]
__________________________________________________________________________
________________________
input_13 (InputLayer)           [(None, 2048)]       0
__________________________________________________________________________
________________________
dropout_11 (Dropout)            (None, 31, 256)      0           embedding
_5[0][0]
__________________________________________________________________________
________________________
dropout_10 (Dropout)            (None, 2048)         0           input_13
[0][0]
__________________________________________________________________________
________________________
lstm_15 (LSTM)                  (None, 31, 64)       82176       dropout_1
1[0][0]
__________________________________________________________________________
________________________
ImageFeature (Dense)            (None, 128)          262272      dropout_1
0[0][0]
__________________________________________________________________________
________________________
lstm_19 (LSTM)                  (None, 128)          98816       lstm_15
[0][0]
__________________________________________________________________________
________________________
add_5 (Add)                     (None, 128)          0           ImageFeat
ure[0][0]
                                                                 lstm_19
[0][0]
__________________________________________________________________________
________________________
dense_10 (Dense)                (None, 256)          33024       add_5
[0][0]
__________________________________________________________________________
________________________
dense_11 (Dense)                (None, 5340)         1372380     dense_10
[0][0]
==========================================================================
========================
Total params: 3,215,708
Trainable params: 3,215,708
Non-trainable params: 0
__________________________________________________________________________
________________________
```

Model Training

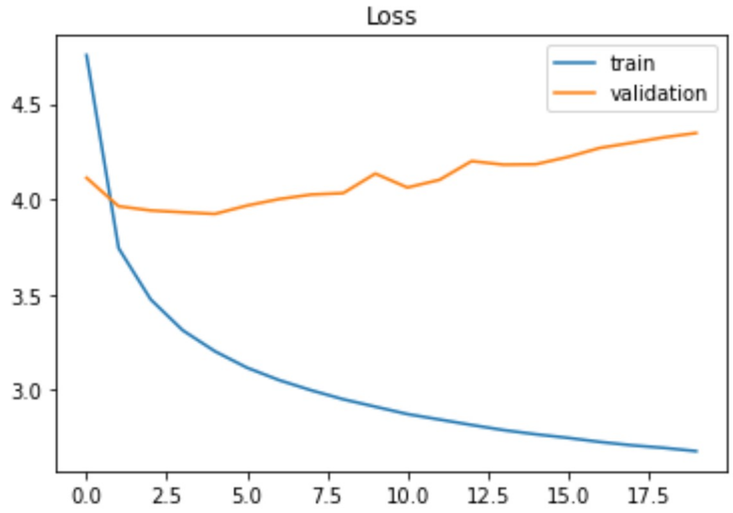
In [125]:

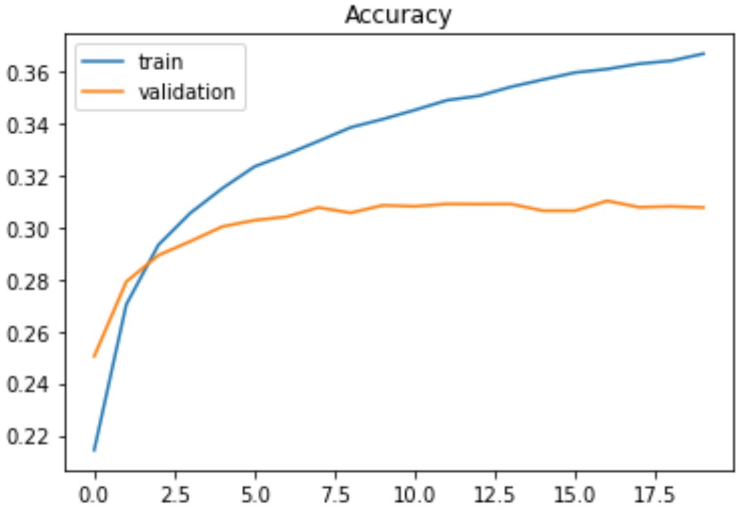
```
# fit model
import time
from keras.callbacks import TensorBoard

# tensorboard = TensorBoard(log_dir="log/{}".format(time()))
start_=time.time()
print(f'Model training is started at {start_}')
hist = model.fit([Ximage_train, Xtext_train], ytext_train, epochs=20, verbo
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_,
```

```
Model training is started at 1662838835.0287821
Epoch 1/20
6614/6614 - 2220s - loss: 4.7558 - accuracy: 0.2143 - val_loss: 4.1126 - v
al_accuracy: 0.2504
Epoch 2/20
6614/6614 - 2136s - loss: 3.7436 - accuracy: 0.2703 - val_loss: 3.9637 - v
al_accuracy: 0.2791
Epoch 3/20
6614/6614 - 2100s - loss: 3.4750 - accuracy: 0.2932 - val_loss: 3.9416 - v
al_accuracy: 0.2893
Epoch 4/20
6614/6614 - 2084s - loss: 3.3131 - accuracy: 0.3055 - val_loss: 3.9321 - v
al_accuracy: 0.2946
Epoch 5/20
6614/6614 - 2089s - loss: 3.2033 - accuracy: 0.3150 - val_loss: 3.9235 - v
al_accuracy: 0.3003
Epoch 6/20
6614/6614 - 2087s - loss: 3.1173 - accuracy: 0.3234 - val_loss: 3.9672 - v
al_accuracy: 0.3027
Epoch 7/20
6614/6614 - 2136s - loss: 3.0521 - accuracy: 0.3281 - val_loss: 4.0012 - v
al_accuracy: 0.3041
Epoch 8/20
6614/6614 - 2131s - loss: 2.9988 - accuracy: 0.3332 - val_loss: 4.0250 - v
al_accuracy: 0.3076
Epoch 9/20
6614/6614 - 2121s - loss: 2.9516 - accuracy: 0.3384 - val_loss: 4.0325 - v
al_accuracy: 0.3056
Epoch 10/20
6614/6614 - 2190s - loss: 2.9127 - accuracy: 0.3416 - val_loss: 4.1350 - v
al_accuracy: 0.3085
Epoch 11/20
6614/6614 - 2143s - loss: 2.8740 - accuracy: 0.3451 - val_loss: 4.0618 - v
al_accuracy: 0.3081
Epoch 12/20
6614/6614 - 2172s - loss: 2.8454 - accuracy: 0.3489 - val_loss: 4.1022 - v
al_accuracy: 0.3090
Epoch 13/20
6614/6614 - 2162s - loss: 2.8170 - accuracy: 0.3506 - val_loss: 4.2003 - v
al_accuracy: 0.3089
Epoch 14/20
6614/6614 - 2216s - loss: 2.7899 - accuracy: 0.3540 - val_loss: 4.1817 - v
al_accuracy: 0.3090
Epoch 15/20
```

```
6614/6614 - 2211s - loss: 2.7681 - accuracy: 0.3568 - val_loss: 4.1838 - v
al_accuracy: 0.3064
Epoch 16/20
6614/6614 - 2231s - loss: 2.7494 - accuracy: 0.3595 - val_loss: 4.2220 - v
al_accuracy: 0.3064
Epoch 17/20
6614/6614 - 2085s - loss: 2.7279 - accuracy: 0.3609 - val_loss: 4.2695 - v
al_accuracy: 0.3102
Epoch 18/20
6614/6614 - 2044s - loss: 2.7103 - accuracy: 0.3629 - val_loss: 4.2965 - v
al_accuracy: 0.3077
Epoch 19/20
6614/6614 - 2048s - loss: 2.6966 - accuracy: 0.3641 - val_loss: 4.3250 - v
al_accuracy: 0.3081
Epoch 20/20
6614/6614 - 2041s - loss: 2.6796 - accuracy: 0.3668 - val_loss: 4.3476 - v
al_accuracy: 0.3076
Model training is finished at 1662881499.849245 & it took 42665.0 sec
```

```
In [126]: plt.title(f'Loss')
          plt.plot(hist.history['loss'], label='train')
          plt.plot(hist.history['val_loss'], label='validation')
          plt.legend()
          plt.show()
          plt.title(f'Accuracy')
          plt.plot(hist.history['accuracy'], label='train')
          plt.plot(hist.history['val_accuracy'], label='validation')
          plt.legend()
          plt.show()
```





```
In [118]: # model=load_model('../../../data/explore/image_caption_generator/output/ls
```

```
In [127]: model.save('../../../data/explore/image_caption_generator/output/lstm_image
```

Prediction caption on new images downloaded from google

In [128]:

```
def tokenized_idx_to_word(idx, tokenizer):
    for word, index in tokenizer.word_index.items():
        if index==idx:
            return word
    return None

# generate caption for an image
def predict_caption(model, image_feature, tokenizer, max_length):
    # add start tag for generation process
    in_text = 'startseq'
    # iterate over the max length of sequencems
    for i in range(max_length):
        # encode input sequence
        sequence = tokenizer.texts_to_sequences([in_text])[0]
        # pad the sequence
        sequence = pad_sequences([sequence], max_length)
        # predict next word
        yhat = model.predict([image_feature, sequence], verbose=0)
        # get index with high probability
        yhat = np.argmax(yhat)
        # convert index to word
        word = tokenized_idx_to_word(yhat, tokenizer)
        # stop if word not found
        if word is None:
            break
        # append word as input for generating next word
        in_text += " " + word
        # stop if we reach end tag
        if word == 'endseq':
            break

    return in_text
# predict_caption(model, new_image_feature, tokenizer, maxlen)
```

In [136]:

```
image_prediction_dir='../../../data/explore/image_caption_generator/predict
new_image_feature=image_feature_extraction(image_prediction_dir, resnet50)
```

In [134]:

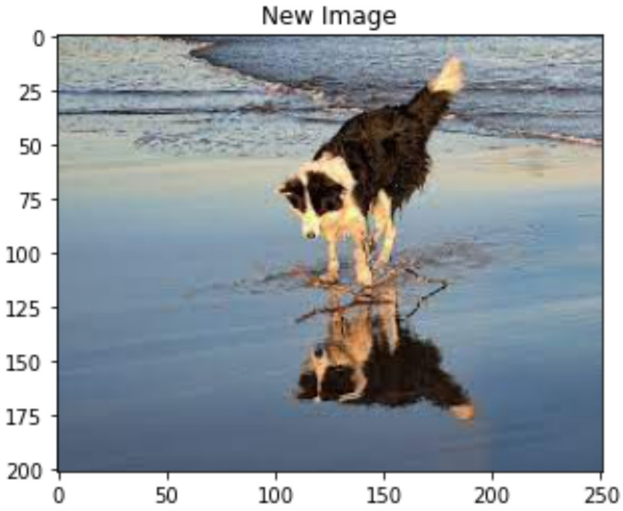
```
Image_caption_prediction=pd.DataFrame({'image':new_image_feature.keys(), 'i
Image_caption_prediction['image_feature']=Image_caption_prediction['image_f
Image_caption_prediction['caption']=Image_caption_prediction['image_feature
Image_caption_prediction
```

Out[134]:

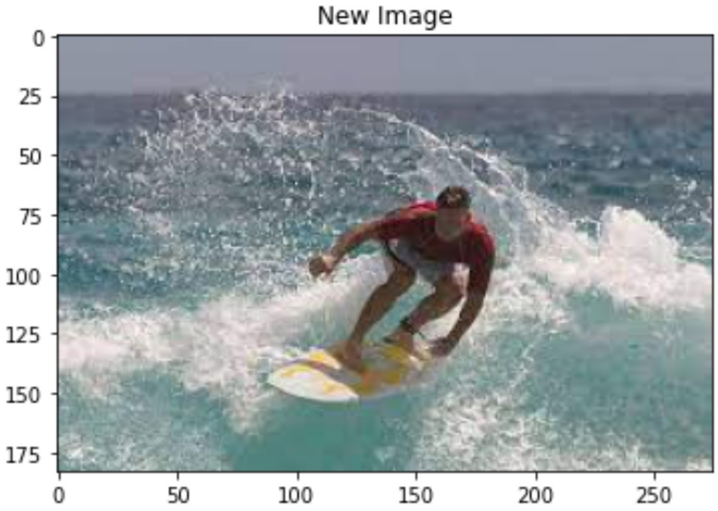
	image	image_feature	caption
0	dog	[[0.309161, 1.0375904, 1.2587302, 0.16566096, ...	startseq dog run along beach endseq
1	menInwater	[[0.6202339, 0.24474798, 0.4481918, 0.04732994...	startseq man in yellow wetsuit be surf on wave...

In [144]:

```
# image_directory='Image_captioning_Dataset/Flicker8k_Dataset'
for image in list(Image_caption_prediction.image):
    plt.figure()
    im = img.imread(image_prediction_dir + '/'+ image + '.jfif')
    plt.imshow(im)
    plt.title('New Image')
    plt.show()
    for caption in Image_caption_prediction[Image_caption_prediction['image
        print(f"output: {' '.join(caption.split()[1:-1])}")
#     print(image_captions[image_captions['image']==image].caption.iloc[0])
```



```
output: dog run along beach
```



```
output: man in yellow wetsuit be surf on wave
```

Conclusion

Based on current implementation and given data, model has been trained for 20 epoch and achieved accuracy of 30% for validation data.

From the loss curve, it has been observed that model is overfitting a bit which can be because of less data or model configuration.

We have predicted the caption for two new image & it seems good even with this model.

Model can be further tuned to increase its accuracy by optimizing its hyper parameters but with given resources & time constraint, it is fairly giving correct results.

We can also check bleu score to further validate the model if more data is given.

In [ ]: