Final_Project_Image_Captioning_pc3019

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0.0.1 Image Captioning

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Another objective of this project was to perform image captioning of the book cover images. The image captioning model was trained using the Flickr8K dataset. It is a dataset of 8,000 images where each image is mapped to 5 captions which describe the content of the image. The image embedding was implemented using Inception v3 which is a model pretrained on ImageNet. It accepts an input shape of 299x299x3 and creates an embedding vector of dimensions 256x1. The captions from the dataset are preprocessed before passing to the RNNs. Text preprocessing includes converting to lowercase, removing special characters, and more. “startseq” is added to the beginning of each caption. Similarly, “endseq” is added to the end of each caption. The word embedding technique used is GloVe. GloVe is an unsupervised learning algorithm to obtain the word vector representations. The GloVe embedding representation used in this project has 6 billion tokens and 200 features. To obtain the predicted image caption, the image is passed to the model with the input string “startseq”. Then the model predicts the next word and this word is appended to the input string. This repeats until “endseq” is reached or the maximum sentence length is reached.

[81]:

```
from time import time
import os
import glob
from tqdm import tqdm
import numpy as np
import tensorflow.keras as keras
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing import image
import string
import random
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.layers import add
from tensorflow.keras.models import Model
from pickle import dump,load
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.applications.inception_v3 import preprocess_input
from tensorflow.keras.applications.inception_v3 import InceptionV3
from tensorflow.keras.layers import Input,Dense,LSTM,Dropout,Embedding
from tensorflow.keras.utils import plot_model
```

[82]:

```
os.listdir('../input/flickr8k')
```

[82]:

```
['captions.txt', 'Images']
```

[ ]:

```

```

[83]:

```python
my_images = glob.glob('../input/flickr8k/Images/' +'*.jpg')
```

[84]:

```python
# Defining utility function which is used to load captions.txt
def loadFileUtil(file_name):
    f = open(file_name,'r')
    content = f.read()
    f.close()
    return content

captions = loadFileUtil('../input/flickr8k/captions.txt')
captions = captions.split('\n')
```

[85]:

```python
captions.pop(0)
```

[85]:

```
'image,caption'
```

[86]:

```python
captions.pop(-1)
```

[86]:

```
''
```

[87]:

```python
# Formatting the captions
my_images = []
for x in range(len(captions)):
    curr_img = captions[x].split(',')
    curr_img = curr_img[0]
    my_images.append(curr_img)

my_images= set(my_images)
```

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```

[88]:

```python
# Populating a dictionary where the image name is the key and captions are the␣
 ↪value
imgNameDict = {}
for curr_img in my_images:
    imgNameDict[curr_img] = []

for curr_image_caption in captions:
    curr_image_caption = curr_image_caption.split(',')
    curr_img,mycap = curr_image_caption[0],curr_image_caption[-1]
    imgNameDict[curr_img].append(mycap)
```

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[ ]:

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[ ]:

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[89]:

```
# Creating a translation table for punctuation removal
mytable = str.maketrans('', '', string.punctuation)
```

[90]:

```
for curr_img,captionList in imgNameDict.items():
    for x,curr_cap in enumerate(captionList):
        curr_cap = curr_cap.split()

        curr_cap = [y.lower() for y in curr_cap]

        curr_cap = [y.translate(mytable) for y in curr_cap]

        curr_cap = [y for y in curr_cap if len(y) >1]

        curr_cap = [y for y in curr_cap if y.isalpha()]

        captionList[x] = ' '.join(curr_cap)
```

[ ]:

```
```

[91]:

```
# Defining function to save the caption data
def saveCaptionData(caps,file_name):
    lines = []
    for img,capList in caps.items():
        for curr_cap in capList:
            lines.append(img + ',' + curr_cap)
        content = '\n'.join(lines)
        f =  open(file_name,'w')
        f.write(content)
        f.close()
```

[92]:

```
# Saving the cleaned captions
saveCaptionData(imgNameDict,'./cleanedCaptionData.txt')
```

[93]:

```
# Defining function to load the caption data
def loadCaptionData(file_name,image_path):
    myfile = loadFileUtil(file_name)
    myImageDict = {}
    my_images = glob.glob(image_path +'*.jpg')
    for idx,curr_image in enumerate(my_images):
        curr_image = curr_image.split('/')[-1]
        my_images[idx] = curr_image
        myImageDict[curr_image] = []
    for line in myfile.split('\n'):
        tokens = line.split(',')
        my_image= tokens[0]
        curr_cap=tokens[1:]
        if my_image in my_images:
            curr_cap = 'startseq ' + ' '.join(curr_cap) + ' endseq'
            myImageDict[my_image].append(curr_cap)
    return myImageDict

# Loading the cleaned caption data
imgNameDict = loadCaptionData('./cleanedCaptionData.txt','../input/flickr8k/
 ↪Images/')
```

[94]:

```
# Defining utility function to preprocess the image
def preprocessingUtil(myPath):
    curr_img = image.load_img(myPath,target_size=  (299,299))
    temp= image.img_to_array(curr_img)
    temp = np.expand_dims(temp,axis =0)
    temp = preprocess_input(temp)
    return temp
```

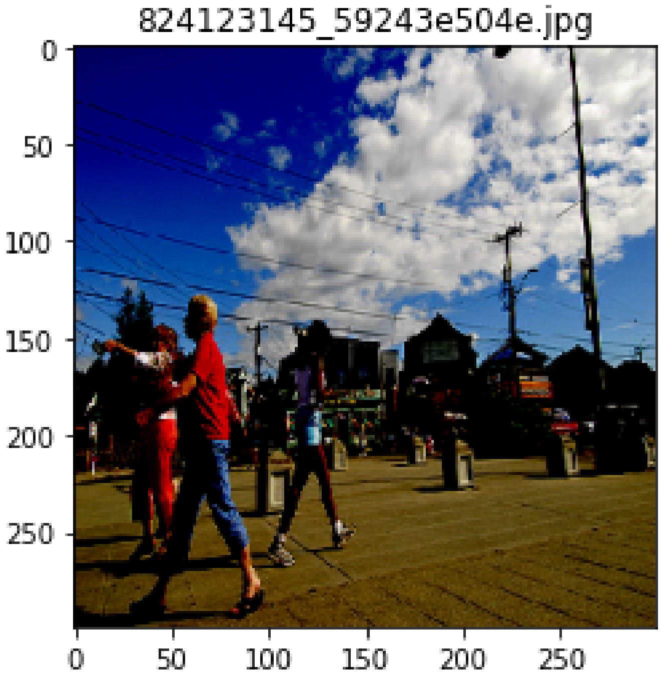
[95]:

```
random_image = random.choice(list(my_images))
temp2  = preprocessingUtil('../input/flickr8k/Images/' + random_image)
for cap in imgNameDict[random_image]:
    print(cap)
plt.imshow(temp2[0])
plt.title(random_image)
```

```
startseq people walk outside on wooden walkway endseq
startseq three woman walk on the sidewalk endseq
startseq two elderly women are walking past younger woman on public path endseq
startseq walkers on concrete boardwalk under blue sky endseq
startseq women walking beneath blue sky and powerlines endseq
```

[95]:

```
Text(0.5, 1.0, '824123145_59243e504e.jpg')
```



[96]:

```
# Loading the InceptionV3 model
mymodel = InceptionV3(weights = 'imagenet')
```

[ ]:

```

```

[97]:

```
# Removing the last layer
featExtractor = Model(mymodel.input,mymodel.layers[-2].output)
featExtractor.summary()
```

```
Model: "model_2"
________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_4 (InputLayer)            [(None, 299, 299, 3) 0

________________________________________________________________________________
__________________
conv2d_94 (Conv2D)              (None, 149, 149, 32) 864         input_4[0][0]

________________________________________________________________________________
__________________
batch_normalization_94 (BatchNo (None, 149, 149, 32) 96          conv2d_94[0][0]

________________________________________________________________________________
__________________
activation_94 (Activation)      (None, 149, 149, 32) 0
```

```
batch_normalization_94[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_95 (Conv2D)              (None, 147, 147, 32) 9216
activation_94[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_95 (BatchNo (None, 147, 147, 32) 96          conv2d_95[0][0]
--------------------------------------------------------------------------------
------------------
activation_95 (Activation)      (None, 147, 147, 32) 0
batch_normalization_95[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_96 (Conv2D)              (None, 147, 147, 64) 18432
activation_95[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_96 (BatchNo (None, 147, 147, 64) 192         conv2d_96[0][0]
--------------------------------------------------------------------------------
------------------
activation_96 (Activation)      (None, 147, 147, 64) 0
batch_normalization_96[0][0]
--------------------------------------------------------------------------------
------------------
max_pooling2d_4 (MaxPooling2D)  (None, 73, 73, 64)   0
activation_96[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_97 (Conv2D)              (None, 73, 73, 80)   5120
max_pooling2d_4[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_97 (BatchNo (None, 73, 73, 80)   240         conv2d_97[0][0]
--------------------------------------------------------------------------------
------------------
activation_97 (Activation)      (None, 73, 73, 80)   0
batch_normalization_97[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_98 (Conv2D)              (None, 71, 71, 192)  138240
activation_97[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_98 (BatchNo (None, 71, 71, 192)  576         conv2d_98[0][0]
--------------------------------------------------------------------------------
------------------
activation_98 (Activation)      (None, 71, 71, 192)  0
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batch_normalization_98[0][0]
--------------------------------------------------------------------------------
------------------
max_pooling2d_5 (MaxPooling2D)  (None, 35, 35, 192)  0
activation_98[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_102 (Conv2D)             (None, 35, 35, 64)   12288
max_pooling2d_5[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_102 (BatchN (None, 35, 35, 64)   192
conv2d_102[0][0]
--------------------------------------------------------------------------------
------------------
activation_102 (Activation)     (None, 35, 35, 64)   0
batch_normalization_102[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_100 (Conv2D)             (None, 35, 35, 48)   9216
max_pooling2d_5[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_103 (Conv2D)             (None, 35, 35, 96)   55296
activation_102[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_100 (BatchN (None, 35, 35, 48)   144
conv2d_100[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_103 (BatchN (None, 35, 35, 96)   288
conv2d_103[0][0]
--------------------------------------------------------------------------------
------------------
activation_100 (Activation)     (None, 35, 35, 48)   0
batch_normalization_100[0][0]
--------------------------------------------------------------------------------
------------------
activation_103 (Activation)     (None, 35, 35, 96)   0
batch_normalization_103[0][0]
--------------------------------------------------------------------------------
------------------
average_pooling2d_9 (AveragePoo (None, 35, 35, 192)  0
max_pooling2d_5[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_99 (Conv2D)              (None, 35, 35, 64)   12288
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max_pooling2d_5[0][0]

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------------------
conv2d_101 (Conv2D)             (None, 35, 35, 64)   76800
activation_100[0][0]

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------------------
conv2d_104 (Conv2D)             (None, 35, 35, 96)   82944
activation_103[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_105 (Conv2D)             (None, 35, 35, 32)   6144
average_pooling2d_9[0][0]

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------------------
batch_normalization_99 (BatchNo (None, 35, 35, 64)   192         conv2d_99[0][0]

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------------------
batch_normalization_101 (BatchN (None, 35, 35, 64)   192
conv2d_101[0][0]

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------------------
batch_normalization_104 (BatchN (None, 35, 35, 96)   288
conv2d_104[0][0]

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------------------
batch_normalization_105 (BatchN (None, 35, 35, 32)   96
conv2d_105[0][0]

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------------------
activation_99 (Activation)      (None, 35, 35, 64)   0
batch_normalization_99[0][0]

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------------------
activation_101 (Activation)     (None, 35, 35, 64)   0
batch_normalization_101[0][0]

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------------------
activation_104 (Activation)     (None, 35, 35, 96)   0
batch_normalization_104[0][0]

--------------------------------------------------------------------------------
------------------
activation_105 (Activation)     (None, 35, 35, 32)   0
batch_normalization_105[0][0]

--------------------------------------------------------------------------------
------------------
mixed0 (Concatenate)            (None, 35, 35, 256)  0
activation_99[0][0]
```

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activation_101[0][0]
activation_104[0][0]
activation_105[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_109 (Conv2D)             (None, 35, 35, 64)   16384       mixed0[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_109 (BatchN (None, 35, 35, 64)   192
conv2d_109[0][0]
--------------------------------------------------------------------------------
------------------
activation_109 (Activation)     (None, 35, 35, 64)   0
batch_normalization_109[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_107 (Conv2D)             (None, 35, 35, 48)   12288       mixed0[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_110 (Conv2D)             (None, 35, 35, 96)   55296
activation_109[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_107 (BatchN (None, 35, 35, 48)   144
conv2d_107[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_110 (BatchN (None, 35, 35, 96)   288
conv2d_110[0][0]
--------------------------------------------------------------------------------
------------------
activation_107 (Activation)     (None, 35, 35, 48)   0
batch_normalization_107[0][0]
--------------------------------------------------------------------------------
------------------
activation_110 (Activation)     (None, 35, 35, 96)   0
batch_normalization_110[0][0]
--------------------------------------------------------------------------------
------------------
average_pooling2d_10 (AveragePo (None, 35, 35, 256)  0           mixed0[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_106 (Conv2D)             (None, 35, 35, 64)   16384       mixed0[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_108 (Conv2D)             (None, 35, 35, 64)   76800
activation_107[0][0]
--------------------------------------------------------------------------------
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__________________
conv2d_111 (Conv2D)             (None, 35, 35, 96)   82944
activation_110[0][0]
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__________________
conv2d_112 (Conv2D)             (None, 35, 35, 64)   16384
average_pooling2d_10[0][0]
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__________________
batch_normalization_106 (BatchN (None, 35, 35, 64)   192
conv2d_106[0][0]
________________________________________________________________________________
__________________
batch_normalization_108 (BatchN (None, 35, 35, 64)   192
conv2d_108[0][0]
________________________________________________________________________________
__________________
batch_normalization_111 (BatchN (None, 35, 35, 96)   288
conv2d_111[0][0]
________________________________________________________________________________
__________________
batch_normalization_112 (BatchN (None, 35, 35, 64)   192
conv2d_112[0][0]
________________________________________________________________________________
__________________
activation_106 (Activation)     (None, 35, 35, 64)   0
batch_normalization_106[0][0]
________________________________________________________________________________
__________________
activation_108 (Activation)     (None, 35, 35, 64)   0
batch_normalization_108[0][0]
________________________________________________________________________________
__________________
activation_111 (Activation)     (None, 35, 35, 96)   0
batch_normalization_111[0][0]
________________________________________________________________________________
__________________
activation_112 (Activation)     (None, 35, 35, 64)   0
batch_normalization_112[0][0]
________________________________________________________________________________
__________________
mixed1 (Concatenate)            (None, 35, 35, 288)  0
activation_106[0][0]
activation_108[0][0]
activation_111[0][0]
activation_112[0][0]
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```

```
conv2d_116 (Conv2D)             (None, 35, 35, 64)   18432       mixed1[0][0]

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------------------
batch_normalization_116 (BatchN (None, 35, 35, 64)   192
conv2d_116[0][0]

--------------------------------------------------------------------------------
------------------
activation_116 (Activation)     (None, 35, 35, 64)   0
batch_normalization_116[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_114 (Conv2D)             (None, 35, 35, 48)   13824       mixed1[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_117 (Conv2D)             (None, 35, 35, 96)   55296
activation_116[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_114 (BatchN (None, 35, 35, 48)   144
conv2d_114[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_117 (BatchN (None, 35, 35, 96)   288
conv2d_117[0][0]

--------------------------------------------------------------------------------
------------------
activation_114 (Activation)     (None, 35, 35, 48)   0
batch_normalization_114[0][0]

--------------------------------------------------------------------------------
------------------
activation_117 (Activation)     (None, 35, 35, 96)   0
batch_normalization_117[0][0]

--------------------------------------------------------------------------------
------------------
average_pooling2d_11 (AveragePo (None, 35, 35, 288)  0           mixed1[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_113 (Conv2D)             (None, 35, 35, 64)   18432       mixed1[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_115 (Conv2D)             (None, 35, 35, 64)   76800
activation_114[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_118 (Conv2D)             (None, 35, 35, 96)   82944
activation_117[0][0]

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```
conv2d_119 (Conv2D)             (None, 35, 35, 64)   18432
average_pooling2d_11[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_113 (BatchN (None, 35, 35, 64)   192
conv2d_113[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_115 (BatchN (None, 35, 35, 64)   192
conv2d_115[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_118 (BatchN (None, 35, 35, 96)   288
conv2d_118[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_119 (BatchN (None, 35, 35, 64)   192
conv2d_119[0][0]
--------------------------------------------------------------------------------
------------------
activation_113 (Activation)     (None, 35, 35, 64)   0
batch_normalization_113[0][0]
--------------------------------------------------------------------------------
------------------
activation_115 (Activation)     (None, 35, 35, 64)   0
batch_normalization_115[0][0]
--------------------------------------------------------------------------------
------------------
activation_118 (Activation)     (None, 35, 35, 96)   0
batch_normalization_118[0][0]
--------------------------------------------------------------------------------
------------------
activation_119 (Activation)     (None, 35, 35, 64)   0
batch_normalization_119[0][0]
--------------------------------------------------------------------------------
------------------
mixed2 (Concatenate)            (None, 35, 35, 288)  0
activation_113[0][0]
activation_115[0][0]
activation_118[0][0]
activation_119[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_121 (Conv2D)             (None, 35, 35, 64)   18432       mixed2[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_121 (BatchN (None, 35, 35, 64)   192
conv2d_121[0][0]
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--------------------------------------------------------------------------------
------------------
activation_121 (Activation)     (None, 35, 35, 64)   0
batch_normalization_121[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_122 (Conv2D)             (None, 35, 35, 96)   55296
activation_121[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_122 (BatchN (None, 35, 35, 96)   288
conv2d_122[0][0]
--------------------------------------------------------------------------------
------------------
activation_122 (Activation)     (None, 35, 35, 96)   0
batch_normalization_122[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_120 (Conv2D)             (None, 17, 17, 384)  995328      mixed2[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_123 (Conv2D)             (None, 17, 17, 96)   82944
activation_122[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_120 (BatchN (None, 17, 17, 384)  1152
conv2d_120[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_123 (BatchN (None, 17, 17, 96)   288
conv2d_123[0][0]
--------------------------------------------------------------------------------
------------------
activation_120 (Activation)     (None, 17, 17, 384)  0
batch_normalization_120[0][0]
--------------------------------------------------------------------------------
------------------
activation_123 (Activation)     (None, 17, 17, 96)   0
batch_normalization_123[0][0]
--------------------------------------------------------------------------------
------------------
max_pooling2d_6 (MaxPooling2D)  (None, 17, 17, 288)  0           mixed2[0][0]
--------------------------------------------------------------------------------
------------------
mixed3 (Concatenate)            (None, 17, 17, 768)  0
activation_120[0][0]
activation_123[0][0]
max_pooling2d_6[0][0]
```

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------------------
conv2d_128 (Conv2D)             (None, 17, 17, 128)  98304       mixed3[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_128 (BatchN (None, 17, 17, 128)  384
conv2d_128[0][0]
--------------------------------------------------------------------------------
------------------
activation_128 (Activation)     (None, 17, 17, 128)  0
batch_normalization_128[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_129 (Conv2D)             (None, 17, 17, 128)  114688
activation_128[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_129 (BatchN (None, 17, 17, 128)  384
conv2d_129[0][0]
--------------------------------------------------------------------------------
------------------
activation_129 (Activation)     (None, 17, 17, 128)  0
batch_normalization_129[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_125 (Conv2D)             (None, 17, 17, 128)  98304       mixed3[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_130 (Conv2D)             (None, 17, 17, 128)  114688
activation_129[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_125 (BatchN (None, 17, 17, 128)  384
conv2d_125[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_130 (BatchN (None, 17, 17, 128)  384
conv2d_130[0][0]
--------------------------------------------------------------------------------
------------------
activation_125 (Activation)     (None, 17, 17, 128)  0
batch_normalization_125[0][0]
--------------------------------------------------------------------------------
------------------
activation_130 (Activation)     (None, 17, 17, 128)  0
batch_normalization_130[0][0]
--------------------------------------------------------------------------------
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```

```
conv2d_126 (Conv2D)             (None, 17, 17, 128)  114688
activation_125[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_131 (Conv2D)             (None, 17, 17, 128)  114688
activation_130[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_126 (BatchN (None, 17, 17, 128)  384
conv2d_126[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_131 (BatchN (None, 17, 17, 128)  384
conv2d_131[0][0]
--------------------------------------------------------------------------------
------------------
activation_126 (Activation)     (None, 17, 17, 128)  0
batch_normalization_126[0][0]
--------------------------------------------------------------------------------
------------------
activation_131 (Activation)     (None, 17, 17, 128)  0
batch_normalization_131[0][0]
--------------------------------------------------------------------------------
------------------
average_pooling2d_12 (AveragePo (None, 17, 17, 768)  0           mixed3[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_124 (Conv2D)             (None, 17, 17, 192)  147456      mixed3[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_127 (Conv2D)             (None, 17, 17, 192)  172032
activation_126[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_132 (Conv2D)             (None, 17, 17, 192)  172032
activation_131[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_133 (Conv2D)             (None, 17, 17, 192)  147456
average_pooling2d_12[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_124 (BatchN (None, 17, 17, 192)  576
conv2d_124[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_127 (BatchN (None, 17, 17, 192)  576
conv2d_127[0][0]
```

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--------------------------------------------------------------------------------
------------------
batch_normalization_132 (BatchN (None, 17, 17, 192)  576
conv2d_132[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_133 (BatchN (None, 17, 17, 192)  576
conv2d_133[0][0]

--------------------------------------------------------------------------------
------------------
activation_124 (Activation)     (None, 17, 17, 192)  0
batch_normalization_124[0][0]

--------------------------------------------------------------------------------
------------------
activation_127 (Activation)     (None, 17, 17, 192)  0
batch_normalization_127[0][0]

--------------------------------------------------------------------------------
------------------
activation_132 (Activation)     (None, 17, 17, 192)  0
batch_normalization_132[0][0]

--------------------------------------------------------------------------------
------------------
activation_133 (Activation)     (None, 17, 17, 192)  0
batch_normalization_133[0][0]

--------------------------------------------------------------------------------
------------------
mixed4 (Concatenate)            (None, 17, 17, 768)  0
activation_124[0][0]
activation_127[0][0]
activation_132[0][0]
activation_133[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_138 (Conv2D)             (None, 17, 17, 160)  122880      mixed4[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_138 (BatchN (None, 17, 17, 160)  480
conv2d_138[0][0]

--------------------------------------------------------------------------------
------------------
activation_138 (Activation)     (None, 17, 17, 160)  0
batch_normalization_138[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_139 (Conv2D)             (None, 17, 17, 160)  179200
activation_138[0][0]

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```

```
batch_normalization_139 (BatchN (None, 17, 17, 160)  480
conv2d_139[0][0]
________________________________________________________________________________
__________________
activation_139 (Activation)     (None, 17, 17, 160)  0
batch_normalization_139[0][0]
________________________________________________________________________________
__________________
conv2d_135 (Conv2D)             (None, 17, 17, 160)  122880      mixed4[0][0]
________________________________________________________________________________
__________________
conv2d_140 (Conv2D)             (None, 17, 17, 160)  179200
activation_139[0][0]
________________________________________________________________________________
__________________
batch_normalization_135 (BatchN (None, 17, 17, 160)  480
conv2d_135[0][0]
________________________________________________________________________________
__________________
batch_normalization_140 (BatchN (None, 17, 17, 160)  480
conv2d_140[0][0]
________________________________________________________________________________
__________________
activation_135 (Activation)     (None, 17, 17, 160)  0
batch_normalization_135[0][0]
________________________________________________________________________________
__________________
activation_140 (Activation)     (None, 17, 17, 160)  0
batch_normalization_140[0][0]
________________________________________________________________________________
__________________
conv2d_136 (Conv2D)             (None, 17, 17, 160)  179200
activation_135[0][0]
________________________________________________________________________________
__________________
conv2d_141 (Conv2D)             (None, 17, 17, 160)  179200
activation_140[0][0]
________________________________________________________________________________
__________________
batch_normalization_136 (BatchN (None, 17, 17, 160)  480
conv2d_136[0][0]
________________________________________________________________________________
__________________
batch_normalization_141 (BatchN (None, 17, 17, 160)  480
conv2d_141[0][0]
________________________________________________________________________________
__________________
activation_136 (Activation)     (None, 17, 17, 160)  0
```

```
batch_normalization_136[0][0]

---------------------------------------------------------------------------------
-----------------
activation_141 (Activation)     (None, 17, 17, 160)  0
batch_normalization_141[0][0]

---------------------------------------------------------------------------------
-----------------
average_pooling2d_13 (AveragePo (None, 17, 17, 768)  0           mixed4[0][0]

---------------------------------------------------------------------------------
-----------------
conv2d_134 (Conv2D)             (None, 17, 17, 192)  147456      mixed4[0][0]

---------------------------------------------------------------------------------
-----------------
conv2d_137 (Conv2D)             (None, 17, 17, 192)  215040
activation_136[0][0]

---------------------------------------------------------------------------------
-----------------
conv2d_142 (Conv2D)             (None, 17, 17, 192)  215040
activation_141[0][0]

---------------------------------------------------------------------------------
-----------------
conv2d_143 (Conv2D)             (None, 17, 17, 192)  147456
average_pooling2d_13[0][0]

---------------------------------------------------------------------------------
-----------------
batch_normalization_134 (BatchN (None, 17, 17, 192)  576
conv2d_134[0][0]

---------------------------------------------------------------------------------
-----------------
batch_normalization_137 (BatchN (None, 17, 17, 192)  576
conv2d_137[0][0]

---------------------------------------------------------------------------------
-----------------
batch_normalization_142 (BatchN (None, 17, 17, 192)  576
conv2d_142[0][0]

---------------------------------------------------------------------------------
-----------------
batch_normalization_143 (BatchN (None, 17, 17, 192)  576
conv2d_143[0][0]

---------------------------------------------------------------------------------
-----------------
activation_134 (Activation)     (None, 17, 17, 192)  0
batch_normalization_134[0][0]

---------------------------------------------------------------------------------
-----------------
activation_137 (Activation)     (None, 17, 17, 192)  0
batch_normalization_137[0][0]

---------------------------------------------------------------------------------
```

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------------------
activation_142 (Activation)     (None, 17, 17, 192)  0
batch_normalization_142[0][0]
--------------------------------------------------------------------------------
------------------
activation_143 (Activation)     (None, 17, 17, 192)  0
batch_normalization_143[0][0]
--------------------------------------------------------------------------------
------------------
mixed5 (Concatenate)            (None, 17, 17, 768)  0
activation_134[0][0]
activation_137[0][0]
activation_142[0][0]
activation_143[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_148 (Conv2D)             (None, 17, 17, 160)  122880      mixed5[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_148 (BatchN (None, 17, 17, 160)  480
conv2d_148[0][0]
--------------------------------------------------------------------------------
------------------
activation_148 (Activation)     (None, 17, 17, 160)  0
batch_normalization_148[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_149 (Conv2D)             (None, 17, 17, 160)  179200
activation_148[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_149 (BatchN (None, 17, 17, 160)  480
conv2d_149[0][0]
--------------------------------------------------------------------------------
------------------
activation_149 (Activation)     (None, 17, 17, 160)  0
batch_normalization_149[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_145 (Conv2D)             (None, 17, 17, 160)  122880      mixed5[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_150 (Conv2D)             (None, 17, 17, 160)  179200
activation_149[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_145 (BatchN (None, 17, 17, 160)  480
conv2d_145[0][0]
```

```
--------------------------------------------------------------------------------
------------------
batch_normalization_150 (BatchN (None, 17, 17, 160)  480
conv2d_150[0][0]

--------------------------------------------------------------------------------
------------------
activation_145 (Activation)     (None, 17, 17, 160)  0
batch_normalization_145[0][0]

--------------------------------------------------------------------------------
------------------
activation_150 (Activation)     (None, 17, 17, 160)  0
batch_normalization_150[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_146 (Conv2D)             (None, 17, 17, 160)  179200
activation_145[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_151 (Conv2D)             (None, 17, 17, 160)  179200
activation_150[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_146 (BatchN (None, 17, 17, 160)  480
conv2d_146[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_151 (BatchN (None, 17, 17, 160)  480
conv2d_151[0][0]

--------------------------------------------------------------------------------
------------------
activation_146 (Activation)     (None, 17, 17, 160)  0
batch_normalization_146[0][0]

--------------------------------------------------------------------------------
------------------
activation_151 (Activation)     (None, 17, 17, 160)  0
batch_normalization_151[0][0]

--------------------------------------------------------------------------------
------------------
average_pooling2d_14 (AveragePo (None, 17, 17, 768)  0           mixed5[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_144 (Conv2D)             (None, 17, 17, 192)  147456      mixed5[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_147 (Conv2D)             (None, 17, 17, 192)  215040
activation_146[0][0]

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------------------
```

```
conv2d_152 (Conv2D)             (None, 17, 17, 192)  215040
activation_151[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_153 (Conv2D)             (None, 17, 17, 192)  147456
average_pooling2d_14[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_144 (BatchN (None, 17, 17, 192)  576
conv2d_144[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_147 (BatchN (None, 17, 17, 192)  576
conv2d_147[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_152 (BatchN (None, 17, 17, 192)  576
conv2d_152[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_153 (BatchN (None, 17, 17, 192)  576
conv2d_153[0][0]
--------------------------------------------------------------------------------
------------------
activation_144 (Activation)     (None, 17, 17, 192)  0
batch_normalization_144[0][0]
--------------------------------------------------------------------------------
------------------
activation_147 (Activation)     (None, 17, 17, 192)  0
batch_normalization_147[0][0]
--------------------------------------------------------------------------------
------------------
activation_152 (Activation)     (None, 17, 17, 192)  0
batch_normalization_152[0][0]
--------------------------------------------------------------------------------
------------------
activation_153 (Activation)     (None, 17, 17, 192)  0
batch_normalization_153[0][0]
--------------------------------------------------------------------------------
------------------
mixed6 (Concatenate)            (None, 17, 17, 768)  0
activation_144[0][0]
activation_147[0][0]
activation_152[0][0]
activation_153[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_158 (Conv2D)             (None, 17, 17, 192)  147456      mixed6[0][0]
```

```
--------------------------------------------------------------------------------
------------------
batch_normalization_158 (BatchN (None, 17, 17, 192)  576
conv2d_158[0][0]

--------------------------------------------------------------------------------
------------------
activation_158 (Activation)     (None, 17, 17, 192)  0
batch_normalization_158[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_159 (Conv2D)             (None, 17, 17, 192)  258048
activation_158[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_159 (BatchN (None, 17, 17, 192)  576
conv2d_159[0][0]

--------------------------------------------------------------------------------
------------------
activation_159 (Activation)     (None, 17, 17, 192)  0
batch_normalization_159[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_155 (Conv2D)             (None, 17, 17, 192)  147456      mixed6[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_160 (Conv2D)             (None, 17, 17, 192)  258048
activation_159[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_155 (BatchN (None, 17, 17, 192)  576
conv2d_155[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_160 (BatchN (None, 17, 17, 192)  576
conv2d_160[0][0]

--------------------------------------------------------------------------------
------------------
activation_155 (Activation)     (None, 17, 17, 192)  0
batch_normalization_155[0][0]

--------------------------------------------------------------------------------
------------------
activation_160 (Activation)     (None, 17, 17, 192)  0
batch_normalization_160[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_156 (Conv2D)             (None, 17, 17, 192)  258048
activation_155[0][0]

--------------------------------------------------------------------------------
```

```
------------------
conv2d_161 (Conv2D)             (None, 17, 17, 192)  258048
activation_160[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_156 (BatchN (None, 17, 17, 192)  576
conv2d_156[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_161 (BatchN (None, 17, 17, 192)  576
conv2d_161[0][0]
--------------------------------------------------------------------------------
------------------
activation_156 (Activation)     (None, 17, 17, 192)  0
batch_normalization_156[0][0]
--------------------------------------------------------------------------------
------------------
activation_161 (Activation)     (None, 17, 17, 192)  0
batch_normalization_161[0][0]
--------------------------------------------------------------------------------
------------------
average_pooling2d_15 (AveragePo (None, 17, 17, 768)  0           mixed6[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_154 (Conv2D)             (None, 17, 17, 192)  147456      mixed6[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_157 (Conv2D)             (None, 17, 17, 192)  258048
activation_156[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_162 (Conv2D)             (None, 17, 17, 192)  258048
activation_161[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_163 (Conv2D)             (None, 17, 17, 192)  147456
average_pooling2d_15[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_154 (BatchN (None, 17, 17, 192)  576
conv2d_154[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_157 (BatchN (None, 17, 17, 192)  576
conv2d_157[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_162 (BatchN (None, 17, 17, 192)  576
conv2d_162[0][0]
________________________________________________________________________________
__________________
batch_normalization_163 (BatchN (None, 17, 17, 192)  576
conv2d_163[0][0]
________________________________________________________________________________
__________________
activation_154 (Activation)     (None, 17, 17, 192)  0
batch_normalization_154[0][0]
________________________________________________________________________________
__________________
activation_157 (Activation)     (None, 17, 17, 192)  0
batch_normalization_157[0][0]
________________________________________________________________________________
__________________
activation_162 (Activation)     (None, 17, 17, 192)  0
batch_normalization_162[0][0]
________________________________________________________________________________
__________________
activation_163 (Activation)     (None, 17, 17, 192)  0
batch_normalization_163[0][0]
________________________________________________________________________________
__________________
mixed7 (Concatenate)            (None, 17, 17, 768)  0
activation_154[0][0]
activation_157[0][0]
activation_162[0][0]
activation_163[0][0]
________________________________________________________________________________
__________________
conv2d_166 (Conv2D)             (None, 17, 17, 192)  147456      mixed7[0][0]
________________________________________________________________________________
__________________
batch_normalization_166 (BatchN (None, 17, 17, 192)  576
conv2d_166[0][0]
________________________________________________________________________________
__________________
activation_166 (Activation)     (None, 17, 17, 192)  0
batch_normalization_166[0][0]
________________________________________________________________________________
__________________
conv2d_167 (Conv2D)             (None, 17, 17, 192)  258048
activation_166[0][0]
________________________________________________________________________________
__________________
batch_normalization_167 (BatchN (None, 17, 17, 192)  576
conv2d_167[0][0]
________________________________________________________________________________
```

```
------------------
activation_167 (Activation)     (None, 17, 17, 192)  0
batch_normalization_167[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_164 (Conv2D)             (None, 17, 17, 192)  147456      mixed7[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_168 (Conv2D)             (None, 17, 17, 192)  258048
activation_167[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_164 (BatchN (None, 17, 17, 192)  576
conv2d_164[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_168 (BatchN (None, 17, 17, 192)  576
conv2d_168[0][0]

--------------------------------------------------------------------------------
------------------
activation_164 (Activation)     (None, 17, 17, 192)  0
batch_normalization_164[0][0]

--------------------------------------------------------------------------------
------------------
activation_168 (Activation)     (None, 17, 17, 192)  0
batch_normalization_168[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_165 (Conv2D)             (None, 8, 8, 320)    552960
activation_164[0][0]

--------------------------------------------------------------------------------
------------------
conv2d_169 (Conv2D)             (None, 8, 8, 192)    331776
activation_168[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_165 (BatchN (None, 8, 8, 320)    960
conv2d_165[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_169 (BatchN (None, 8, 8, 192)    576
conv2d_169[0][0]

--------------------------------------------------------------------------------
------------------
activation_165 (Activation)     (None, 8, 8, 320)    0
batch_normalization_165[0][0]

--------------------------------------------------------------------------------
------------------
```

```
activation_169 (Activation)     (None, 8, 8, 192)    0
batch_normalization_169[0][0]
________________________________________________________________________________
__________________
max_pooling2d_7 (MaxPooling2D)  (None, 8, 8, 768)    0           mixed7[0][0]
________________________________________________________________________________
__________________
mixed8 (Concatenate)            (None, 8, 8, 1280)   0
activation_165[0][0]
activation_169[0][0]
max_pooling2d_7[0][0]
________________________________________________________________________________
__________________
conv2d_174 (Conv2D)             (None, 8, 8, 448)    573440      mixed8[0][0]
________________________________________________________________________________
__________________
batch_normalization_174 (BatchN (None, 8, 8, 448)    1344
conv2d_174[0][0]
________________________________________________________________________________
__________________
activation_174 (Activation)     (None, 8, 8, 448)    0
batch_normalization_174[0][0]
________________________________________________________________________________
__________________
conv2d_171 (Conv2D)             (None, 8, 8, 384)    491520      mixed8[0][0]
________________________________________________________________________________
__________________
conv2d_175 (Conv2D)             (None, 8, 8, 384)    1548288
activation_174[0][0]
________________________________________________________________________________
__________________
batch_normalization_171 (BatchN (None, 8, 8, 384)    1152
conv2d_171[0][0]
________________________________________________________________________________
__________________
batch_normalization_175 (BatchN (None, 8, 8, 384)    1152
conv2d_175[0][0]
________________________________________________________________________________
__________________
activation_171 (Activation)     (None, 8, 8, 384)    0
batch_normalization_171[0][0]
________________________________________________________________________________
__________________
activation_175 (Activation)     (None, 8, 8, 384)    0
batch_normalization_175[0][0]
________________________________________________________________________________
__________________
conv2d_172 (Conv2D)             (None, 8, 8, 384)    442368
```

```
activation_171[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_173 (Conv2D)             (None, 8, 8, 384)    442368
activation_171[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_176 (Conv2D)             (None, 8, 8, 384)    442368
activation_175[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_177 (Conv2D)             (None, 8, 8, 384)    442368
activation_175[0][0]
--------------------------------------------------------------------------------
------------------
average_pooling2d_16 (AveragePo (None, 8, 8, 1280)   0           mixed8[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_170 (Conv2D)             (None, 8, 8, 320)    409600      mixed8[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_172 (BatchN (None, 8, 8, 384)    1152
conv2d_172[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_173 (BatchN (None, 8, 8, 384)    1152
conv2d_173[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_176 (BatchN (None, 8, 8, 384)    1152
conv2d_176[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_177 (BatchN (None, 8, 8, 384)    1152
conv2d_177[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_178 (Conv2D)             (None, 8, 8, 192)    245760
average_pooling2d_16[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_170 (BatchN (None, 8, 8, 320)    960
conv2d_170[0][0]
--------------------------------------------------------------------------------
------------------
activation_172 (Activation)     (None, 8, 8, 384)    0
batch_normalization_172[0][0]
--------------------------------------------------------------------------------
```

```
------------------
activation_173 (Activation)     (None, 8, 8, 384)    0
batch_normalization_173[0][0]

--------------------------------------------------------------------------------
------------------
activation_176 (Activation)     (None, 8, 8, 384)    0
batch_normalization_176[0][0]

--------------------------------------------------------------------------------
------------------
activation_177 (Activation)     (None, 8, 8, 384)    0
batch_normalization_177[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_178 (BatchN (None, 8, 8, 192)    576
conv2d_178[0][0]

--------------------------------------------------------------------------------
------------------
activation_170 (Activation)     (None, 8, 8, 320)    0
batch_normalization_170[0][0]

--------------------------------------------------------------------------------
------------------
mixed9_0 (Concatenate)          (None, 8, 8, 768)    0
activation_172[0][0]
activation_173[0][0]

--------------------------------------------------------------------------------
------------------
concatenate_2 (Concatenate)     (None, 8, 8, 768)    0
activation_176[0][0]
activation_177[0][0]

--------------------------------------------------------------------------------
------------------
activation_178 (Activation)     (None, 8, 8, 192)    0
batch_normalization_178[0][0]

--------------------------------------------------------------------------------
------------------
mixed9 (Concatenate)            (None, 8, 8, 2048)   0
activation_170[0][0]
                                                                 mixed9_0[0][0]
concatenate_2[0][0]
activation_178[0][0]

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------------------
conv2d_183 (Conv2D)             (None, 8, 8, 448)    917504      mixed9[0][0]

--------------------------------------------------------------------------------
------------------
batch_normalization_183 (BatchN (None, 8, 8, 448)    1344
conv2d_183[0][0]

--------------------------------------------------------------------------------
```

```
------------------
activation_183 (Activation)     (None, 8, 8, 448)    0
batch_normalization_183[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_180 (Conv2D)             (None, 8, 8, 384)    786432      mixed9[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_184 (Conv2D)             (None, 8, 8, 384)    1548288
activation_183[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_180 (BatchN (None, 8, 8, 384)    1152
conv2d_180[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_184 (BatchN (None, 8, 8, 384)    1152
conv2d_184[0][0]
--------------------------------------------------------------------------------
------------------
activation_180 (Activation)     (None, 8, 8, 384)    0
batch_normalization_180[0][0]
--------------------------------------------------------------------------------
------------------
activation_184 (Activation)     (None, 8, 8, 384)    0
batch_normalization_184[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_181 (Conv2D)             (None, 8, 8, 384)    442368
activation_180[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_182 (Conv2D)             (None, 8, 8, 384)    442368
activation_180[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_185 (Conv2D)             (None, 8, 8, 384)    442368
activation_184[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_186 (Conv2D)             (None, 8, 8, 384)    442368
activation_184[0][0]
--------------------------------------------------------------------------------
------------------
average_pooling2d_17 (AveragePo (None, 8, 8, 2048)   0           mixed9[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_179 (Conv2D)             (None, 8, 8, 320)    655360      mixed9[0][0]
```

```
--------------------------------------------------------------------------------
------------------
batch_normalization_181 (BatchN (None, 8, 8, 384)    1152
conv2d_181[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_182 (BatchN (None, 8, 8, 384)    1152
conv2d_182[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_185 (BatchN (None, 8, 8, 384)    1152
conv2d_185[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_186 (BatchN (None, 8, 8, 384)    1152
conv2d_186[0][0]
--------------------------------------------------------------------------------
------------------
conv2d_187 (Conv2D)             (None, 8, 8, 192)    393216
average_pooling2d_17[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_179 (BatchN (None, 8, 8, 320)    960
conv2d_179[0][0]
--------------------------------------------------------------------------------
------------------
activation_181 (Activation)     (None, 8, 8, 384)    0
batch_normalization_181[0][0]
--------------------------------------------------------------------------------
------------------
activation_182 (Activation)     (None, 8, 8, 384)    0
batch_normalization_182[0][0]
--------------------------------------------------------------------------------
------------------
activation_185 (Activation)     (None, 8, 8, 384)    0
batch_normalization_185[0][0]
--------------------------------------------------------------------------------
------------------
activation_186 (Activation)     (None, 8, 8, 384)    0
batch_normalization_186[0][0]
--------------------------------------------------------------------------------
------------------
batch_normalization_187 (BatchN (None, 8, 8, 192)    576
conv2d_187[0][0]
--------------------------------------------------------------------------------
------------------
activation_179 (Activation)     (None, 8, 8, 320)    0
batch_normalization_179[0][0]
```

```
--------------------------------------------------------------------------------
------------------
mixed9_1 (Concatenate)          (None, 8, 8, 768)    0
activation_181[0][0]
activation_182[0][0]

--------------------------------------------------------------------------------
------------------
concatenate_3 (Concatenate)     (None, 8, 8, 768)    0
activation_185[0][0]
activation_186[0][0]

--------------------------------------------------------------------------------
------------------
activation_187 (Activation)     (None, 8, 8, 192)    0
batch_normalization_187[0][0]

--------------------------------------------------------------------------------
------------------
mixed10 (Concatenate)           (None, 8, 8, 2048)   0
activation_179[0][0]
                                                                 mixed9_1[0][0]

concatenate_3[0][0]
activation_187[0][0]

--------------------------------------------------------------------------------
------------------
avg_pool (GlobalAveragePooling2 (None, 2048)         0           mixed10[0][0]
================================================================================
==================
Total params: 21,802,784
Trainable params: 21,768,352
Non-trainable params: 34,432

--------------------------------------------------------------------------------
------------------
```

[98]:

```python
# Performing image embedding with featExtractor
def encodeData(curr_image,featExtractor):
    curr_image = preprocessingUtil(curr_image)
    featVector = featExtractor.predict(curr_image)
    featVector = np.ravel(featVector)
    return featVector
```

[108]:

```python
# Dividing the data into training, validation, and testing data
AllData = list(my_images)
trainingData = AllData[:6000]
validationData = AllData[6000:7000]
TestingData = AllData[7000:]
print(f'Number of training images {len(trainingData)}')
print(f'Number of testing images {len(TestingData)}')
print(f'Number of validation images {len(validationData)}')
```

```
Number of training images 6000
Number of testing images 1091
Number of validation images 1000
```

[109]:

```
trainingEnc = {}
validationEnc = {}
testingEnc = {}
```

[110]:

```
# Encoding the training data
for x in range(1,len(trainingData)):
    myloc = '../input/flickr8k/Images/' + trainingData[x]
    trainingEnc[trainingData[x]] = encodeData(myloc,featExtractor)
```

[111]:

```
# Storing the encoded training images
with open('./training_images_enc.pkl','wb') as pickEnc:
    dump(trainingEnc,pickEnc)
```

[112]:

```
# Similarly we encode and store the validation and testing data
for curr_img in tqdm(validationData):
    validationEnc[curr_img] = encodeData('../input/flickr8k/Images/' +␣
 ↪curr_img,featExtractor)
```

```
100%|          | 1000/1000 [01:07<00:00, 14.88it/s]
```

[113]:

```
with open('./validation_images_enc.pkl','wb') as pickEnc:
    dump(validationEnc,pickEnc)
```

[114]:

```
for curr_img in tqdm(TestingData):
    testingEnc[curr_img] = encodeData('../input/flickr8k/Images/' +␣
 ↪curr_img,featExtractor)
```

```
100%|          | 1091/1091 [01:12<00:00, 15.00it/s]
```

[115]:

```
with open('./testing_images_enc.pkl','wb') as pickEnc:
    dump(testingEnc,pickEnc)
```

[116]:

```
!cp ./testing_images_enc.pkl /content/drive/MyDrive
```

```
cp: cannot create regular file '/content/drive/MyDrive': No such file or
directory
```

[117]:

```
# Loading the features
featTrain = load(open('./training_images_enc.pkl','rb'))

featValid = load(open('./validation_images_enc.pkl','rb'))

featTest = load(open('./testing_images_enc.pkl','rb'))
print(f'The number of training features {len(featTrain)}')
print(f'The number of testing features {len(featTest)}')
print(f'The number of validation features {len(featValid)}')
```

```
The number of training features 5999
The number of testing features 1091
The number of validation features 1000
```

[118]:
```
# Creating separate lists for storing the training, testing, and validation captions
allCaptionsTrain = []
allCaptionsVal = []
allCaptionsTest = []
for x in range(1,len(trainingData)):
    curr_img=trainingData[x]
    captions = imgNameDict[curr_img]
    for mycap in captions:
        allCaptionsTrain.append(mycap)
print(f'Number of all training captions {len(allCaptionsTrain)}')
```

```
Number of all training captions 29995
```

[119]:
```
for curr_img in validationData:
    captions = imgNameDict[curr_img]
    for mycap in captions:
        allCaptionsVal.append(mycap)
print(f'Number of all validation captions {len(allCaptionsVal)}')
```

```
Number of all validation captions 5000
```

[120]:
```
for img in TestingData:
    captions = imgNameDict[img]
    for mycap in captions:
        allCaptionsTest.append(mycap)
print(f'Number of all test captions {len(allCaptionsTest)}')
```

```
Number of all test captions 5455
```

[121]:
```
wc = {}
for mysentence in allCaptionsTrain:
    for curr_word in mysentence.split(' '):
        wc[curr_word] = wc.get(curr_word,0) + 1

myvocab = [curr_word for curr_word in wc if wc[curr_word] >= 10]
```

[122]:
```
id_word = {}
word_id = {}
idx = 1
for curr_word in myvocab:
    word_id[curr_word] = idx
    id_word[idx] = curr_word
    idx +=1
```

[123]:

```
with open('./word_id.pkl','wb') as word_id1:
    dump(word_id,word_id1)
```

[124]:

```
with open('./id_word.pkl','wb') as id_word1:
    dump(id_word,id_word1)
```

[125]:

```
vocabSize = len(id_word) +1
vocabSize
```

[125]:

```
1621
```

[126]:

```
trainDict = {}
for x in range(1,len(trainingData)):
    my_image=trainingData[x]
    trainDict[my_image] = imgNameDict[my_image]
```

[127]:

```
# Defining function to find maximum length of captions
def maxFun(imageCaptions):
    lines = to_lines(imageCaptions)
    return max(len(line.split()) for line in lines)

# Defining function which accepts dictionary of clean captions as input
# Returns captions list
def to_lines(imageCaptions):
    allCaptions = []
    for x in imageCaptions.keys():
        [allCaptions.append(mycap) for mycap in imageCaptions[x]]
    return allCaptions

maxLength = maxFun(trainDict)
print(f'The captions maximum length is {maxLength}')
```

```
The captions maximum length is 30
```

[128]:

```
# Loading GloVe
embeddingsIndex = {}
myfile = open('../input/glove6b/glove.6B.200d.txt',encoding = 'utf-8')

for x in tqdm(myfile):
    vals = x.split()
    curr_word = vals[0]
    coefficients = np.asarray(vals[1:],dtype = 'float32')
    embeddingsIndex[curr_word] = coefficients

myfile.close()
print('Number of word vectors is %s' % len(embeddingsIndex))
```

```
400000it [00:18, 21609.09it/s]

Number of word vectors is 400000
```

[129]:

```
embedDim = 200
```

[130]:

```
# Creating the embedding matrix
embedMat = np.zeros((vocabSize,embedDim))
print(f'The embedding matrix dimensions are {embedMat.shape}')
```

```
The embedding matrix dimensions are (1621, 200)
```

[131]:

```
for curr_word,idx in word_id.items():
    embedVec = embeddingsIndex.get(curr_word)
    if embedVec is not None:
        embedMat[idx] = embedVec
```

[ ]:

[ ]:

[132]:

```
# Building the model
inp1 = Input(shape = (2048,))
fe1 = Dropout(0.5)(inp1)
fe2 = Dense(256,activation = 'relu')(fe1)
inp2 = Input(shape = (maxLength,))
se1 = Embedding(vocabSize,embedDim,mask_zero = True)(inp2)
se2 = Dropout(0.5)(se1)
se3 = LSTM(256)(se2)
dec1 = add([fe2,se3])
dec2 = Dense(256,activation = 'relu')(dec1)
out = Dense(vocabSize,activation = 'softmax')(dec2)
```

[133]:

```
mymodel2 = Model(inputs = [inp1,inp2],outputs = out)
mymodel2.summary()
```

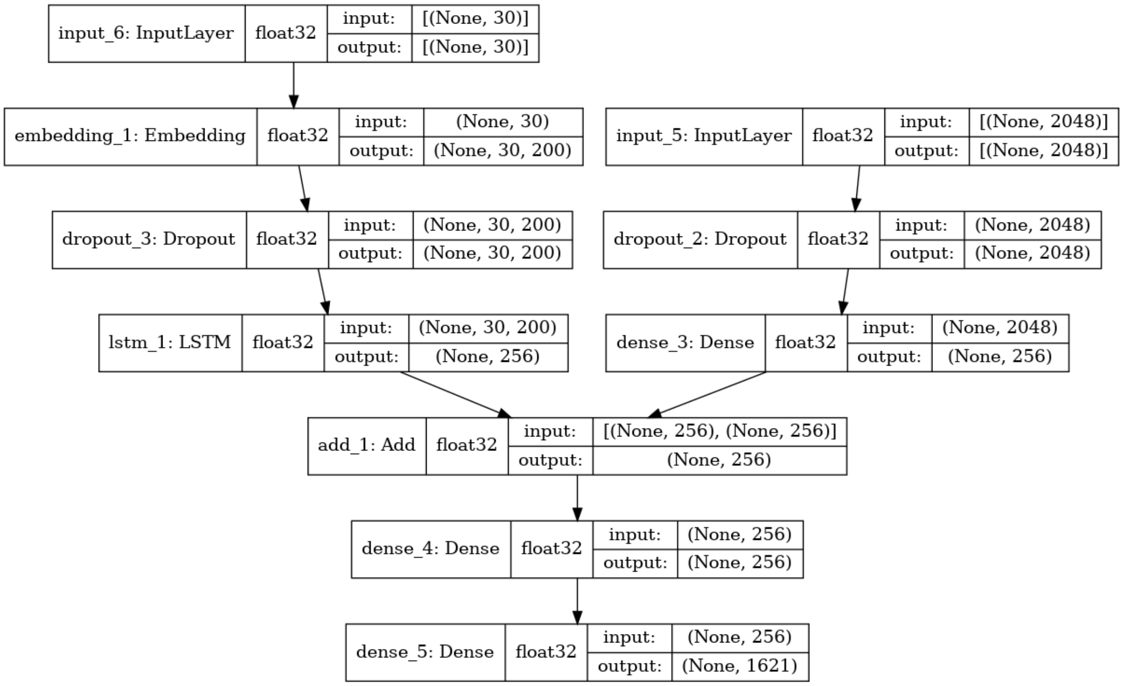
```
Model: "model_3"
________________________________________________________________________________
__________________
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_6 (InputLayer)            [(None, 30)]         0
________________________________________________________________________________
__________________
input_5 (InputLayer)            [(None, 2048)]       0
________________________________________________________________________________
__________________
```

```
embedding_1 (Embedding)         (None, 30, 200)      324200      input_6[0][0]

--------------------------------------------------------------------------------
------------------
dropout_2 (Dropout)             (None, 2048)         0           input_5[0][0]

--------------------------------------------------------------------------------
------------------
dropout_3 (Dropout)             (None, 30, 200)      0
embedding_1[0][0]

--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                 (None, 256)          524544      dropout_2[0][0]

--------------------------------------------------------------------------------
------------------
lstm_1 (LSTM)                   (None, 256)          467968      dropout_3[0][0]

--------------------------------------------------------------------------------
------------------
add_1 (Add)                     (None, 256)          0           dense_3[0][0]
                                                                 lstm_1[0][0]

--------------------------------------------------------------------------------
------------------
dense_4 (Dense)                 (None, 256)          65792       add_1[0][0]

--------------------------------------------------------------------------------
------------------
dense_5 (Dense)                 (None, 1621)         416597      dense_4[0][0]
================================================================================
==================
Total params: 1,799,101
Trainable params: 1,799,101
Non-trainable params: 0

--------------------------------------------------------------------------------
------------------
```

[134]:

```
# Displaying the model layers
plot_model(mymodel2,
           to_file='mymodel2.png',
           show_layer_names=True,
           show_dtype=True,
           show_shapes=True
           )
```

[134]:



[135]:
```
print(f'Embedding Matrix Shape {embedMat.shape}')
embedWeight = mymodel2.layers[2].get_weights()
print(f'Embedding Weight Shape {embedWeight[0].shape}')
mymodel2.layers[2].set_weights([embedMat])
mymodel2.layers[2].trainable = False
```

```
Embedding Matrix Shape (1621, 200)
Embedding Weight Shape (1621, 200)
```

[136]:
```
mymodel2.summary()
```

```
Model: "model_3"

--------------------------------------------------------------------------------
------------------
Layer (type)                    Output Shape         Param #     Connected to
================================================================================
==================
input_6 (InputLayer)            [(None, 30)]         0

--------------------------------------------------------------------------------
------------------
input_5 (InputLayer)            [(None, 2048)]       0

--------------------------------------------------------------------------------
------------------
embedding_1 (Embedding)         (None, 30, 200)      324200      input_6[0][0]

--------------------------------------------------------------------------------
------------------
```

```
dropout_2 (Dropout)             (None, 2048)         0           input_5[0][0]
--------------------------------------------------------------------------------
------------------
dropout_3 (Dropout)             (None, 30, 200)      0
embedding_1[0][0]
--------------------------------------------------------------------------------
------------------
dense_3 (Dense)                 (None, 256)          524544      dropout_2[0][0]
--------------------------------------------------------------------------------
------------------
lstm_1 (LSTM)                   (None, 256)          467968      dropout_3[0][0]
--------------------------------------------------------------------------------
------------------
add_1 (Add)                     (None, 256)          0           dense_3[0][0]
                                                                 lstm_1[0][0]
--------------------------------------------------------------------------------
------------------
dense_4 (Dense)                 (None, 256)          65792       add_1[0][0]
--------------------------------------------------------------------------------
------------------
dense_5 (Dense)                 (None, 1621)         416597      dense_4[0][0]
================================================================================
==================
Total params: 1,799,101
Trainable params: 1,474,901
Non-trainable params: 324,200
--------------------------------------------------------------------------------
------------------
```

[137]:

```
mymodel2.compile(optimizer = 'adam',loss = 'categorical_crossentropy')
```

[138]:

```
epochs = 10
steps = len(trainDict)//6

mymodel2.optimizer.lr = 1e-4
```

[ ]:

```

```

[139]:

```
def data_generator(trainDict,featTrain,word_id,maxLength,pics_p_batch):
    y=[]
    n = 0
    X1 =[]
    X2=[]

    while True:
        for curr_image,captionsList in trainDict.items():
            n+=1
            myfeatVect = featTrain[curr_image]
            for mycap in captionsList:
                encoded_cap = [word_id[word] for word in mycap.split(' ') if␣
↪word in word_id]
                for idx in range(1,len(encoded_cap)):
                    in_seq = encoded_cap[:idx]
                    out_seq = encoded_cap[idx]
                    in_seq = pad_sequences([in_seq],maxlen = maxLength)[0]
                    out_seq = to_categorical([out_seq],num_classes =␣
↪vocabSize)[0]
                    y.append(out_seq)
                    X1.append(myfeatVect)
                    X2.append(in_seq)

            if n == pics_p_batch:
                X1,X2,y = np.array(X1),np.array(X2),np.array(y)
                yield [X1,X2],y
                y=[]
                n=0
                X1 =[]
                X2=[]
```

```
[140]: '3448855727_f16dea7b03.jpg' in featTrain
```

```
[140]: True
```

```
[141]: for curr_epoch in range(epochs):
           genvar = data_generator(trainDict, featTrain, word_id, maxLength, 6)
           mymodel2.fit_generator(genvar, epochs=1, steps_per_epoch=steps, verbose=1)
```

```
/opt/conda/lib/python3.7/site-
packages/tensorflow/python/keras/engine/training.py:1844: UserWarning:
`Model.fit_generator` is deprecated and will be removed in a future version.
Please use `Model.fit`, which supports generators.
  warnings.warn('`Model.fit_generator` is deprecated and '
```

```
999/999 [==============================] - 113s 109ms/step - loss: 5.5713
999/999 [==============================] - 111s 111ms/step - loss: 4.4140
999/999 [==============================] - 117s 117ms/step - loss: 4.0736
999/999 [==============================] - 108s 108ms/step - loss: 3.8797
999/999 [==============================] - 110s 110ms/step - loss: 3.7496
999/999 [==============================] - 117s 118ms/step - loss: 3.6473
999/999 [==============================] - 108s 108ms/step - loss: 3.5669
999/999 [==============================] - 107s 107ms/step - loss: 3.4978
999/999 [==============================] - 117s 117ms/step - loss: 3.4407
999/999 [==============================] - 115s 115ms/step - loss: 3.3863
```

[142]:
```
# Saving the model
mymodel2.save('model_flickr8k')

# Saving the model weights
mymodel2.save_weights('./model_flickr8k.h5')
```

[ ]:
```

```

[143]:
```
!zip -r model_flickr8k.zip model_flickr8k
```

```
updating: model_flickr8k/ (stored 0%)
updating: model_flickr8k/saved_model.pb (deflated 90%)
updating: model_flickr8k/variables/ (stored 0%)
updating: model_flickr8k/variables/variables.data-00000-of-00001 (deflated 7%)
updating: model_flickr8k/variables/variables.index (deflated 64%)
updating: model_flickr8k/assets/ (stored 0%)
```

[144]:
```
#To obtain the predicted image caption, the image is passed to the model with␣
 ↪the input string "startseq".
# Then the model predicts the next word and this word is appended to the input␣
 ↪string. This repeats until
# "endseq" is reached or the maximum sentence length is reached.

def greedy_search(featVect,verbose = 0):
    in_text ='startseq'
    for i in range(maxLength):
        sequence = [word_id[x] for x in in_text.split() if x in word_id]
        sequence = pad_sequences([sequence],maxlen = maxLength)
        yhat = mymodel2.predict([featVect,sequence],verbose = verbose) #␣
 ↪[(1,2048),(1,31)]
        yhat = np.argmax(yhat)
        curr_word = id_word[yhat]
        in_text += ' ' + curr_word
        if curr_word == 'endseq':
            break
    res = in_text.split()
    res = res[1:-1]
    res = ' '.join(res)
    return res


img = random.choice(TestingData)
featVect = featTest[img].reshape((1,2048))
print(f'feature_vector: {featVect.shape}')
final = greedy_search(featVect,1)
final
```

```
feature_vector: (1, 2048)
```

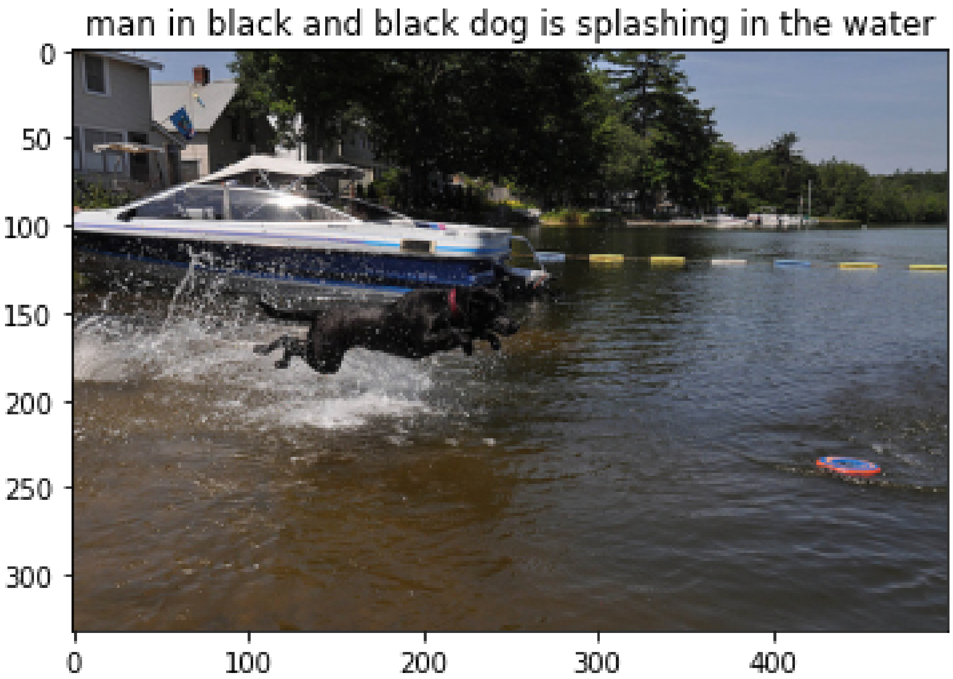
```
1/1 [==============================] - 1s 1s/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 23ms/step
```

[144]:

```
'woman wearing red shirt and glasses and glasses'
```

[145]:

```python
img = random.choice(TestingData)
feature_vector = featTest[img].reshape((1,2048))
x = plt.imread('../input/flickr8k/Images/' + img)
plt.imshow(x)
plt.title(greedy_search(feature_vector,0))
plt.show()
```



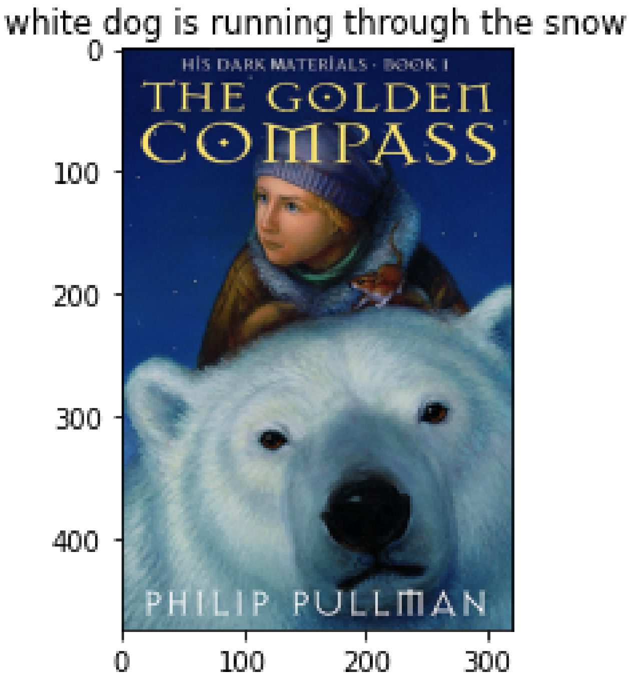
[146]:

```python
# Performing image captioning for a single sample image from the dataset
img = 'fantasy20.jpg'
testingEnc[img] = encodeData('../input/sampleimage/' + img,featExtractor)
```

[147]:

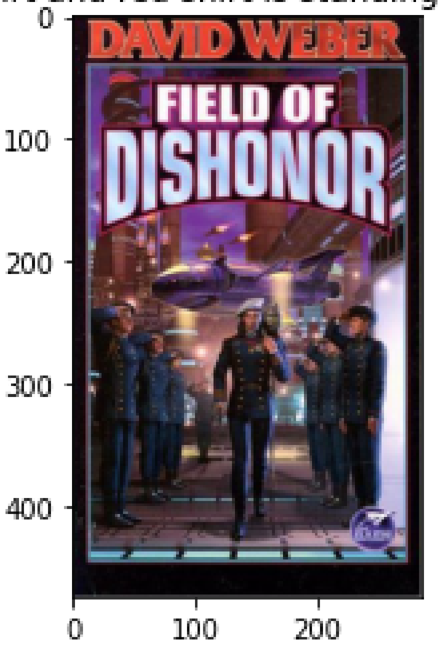
```python
feature_vector = testingEnc[img].reshape((1,2048))
x = plt.imread('../input/sampleimage/fantasy20.jpg')
```

```
plt.imshow(x)
plt.title(greedy_search(feature_vector,0))
plt.show()
```

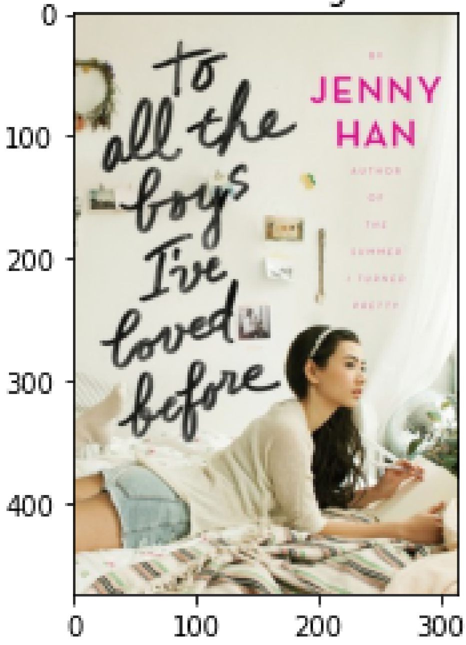


[148]:
```
# Performing image captioning for several sample images from the dataset
for myfile in os.listdir('../input/sampleimage/'):
    img = myfile
    encoded_data = encodeData('../input/sampleimage/' + img,featExtractor)
    feature_vector = encoded_data.reshape((1,2048))
    x = plt.imread('../input/sampleimage/'+img)
    plt.imshow(x)
    plt.title(greedy_search(feature_vector,0))
    plt.show()
```

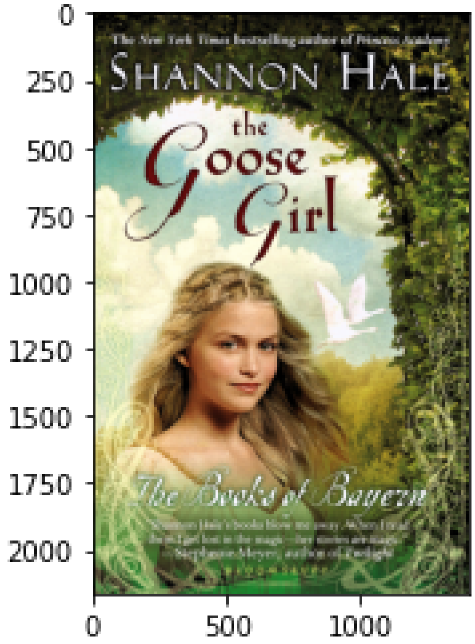
man in red shirt and red shirt is standing in front of crowd



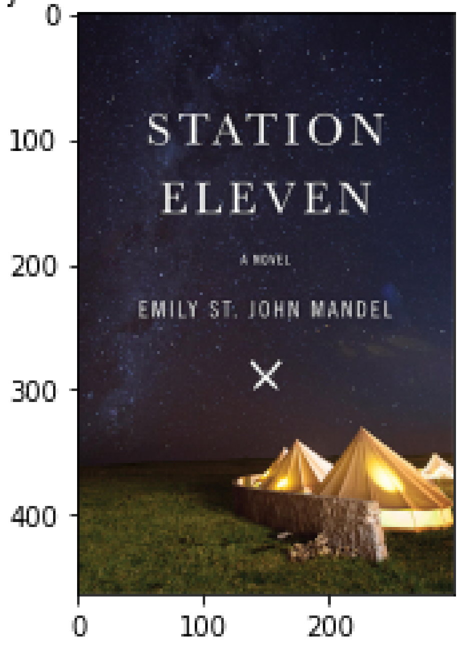
two women are sitting on the floor


to all the boys I've loved before
BY
JENNY HAN
AUTHOR OF THE SUMMER I TURNED PRETTY
0
100
200
300
400
0
100
200
300

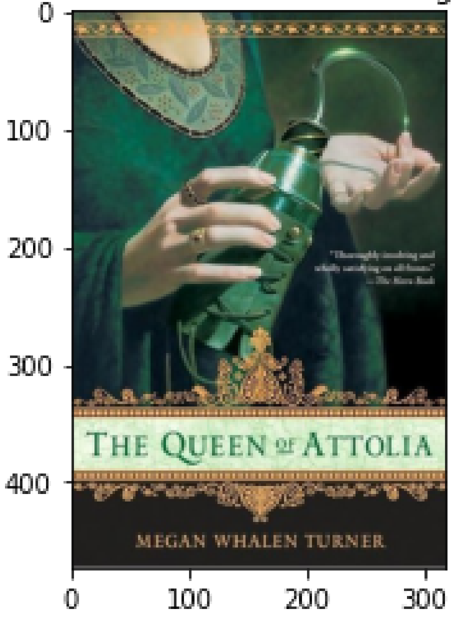
woman in red shirt and white shirt is sitting on the sidewalk



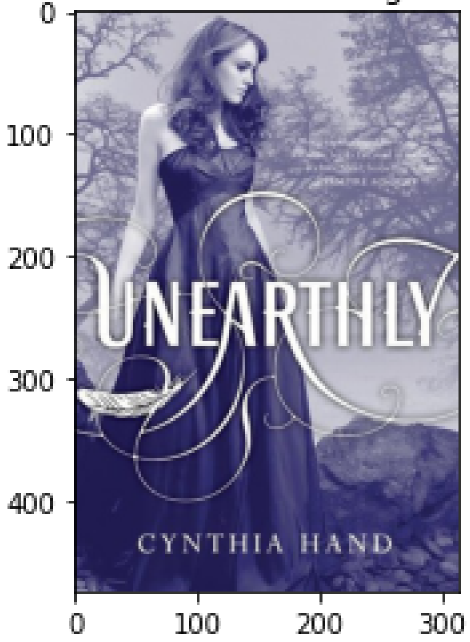
man in red jacket and white hat is sitting on the beach



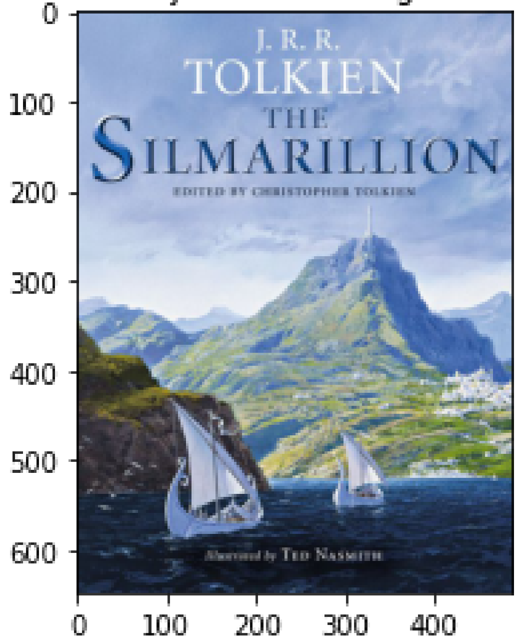
woman in black shirt and black shirt is standing in front of the camera



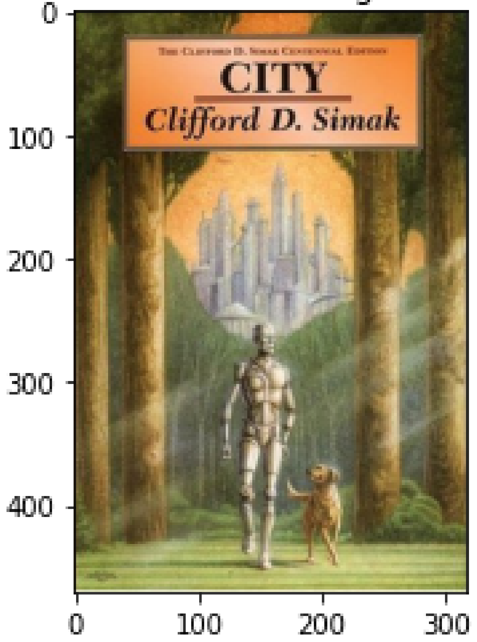
woman in black dress is sitting on the beach



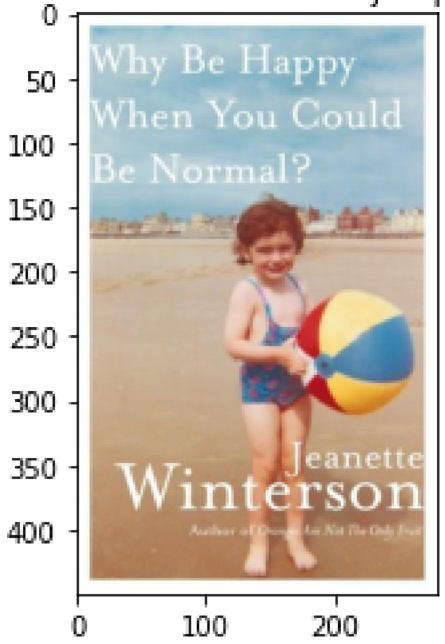
man in white jacket is sitting on the beach



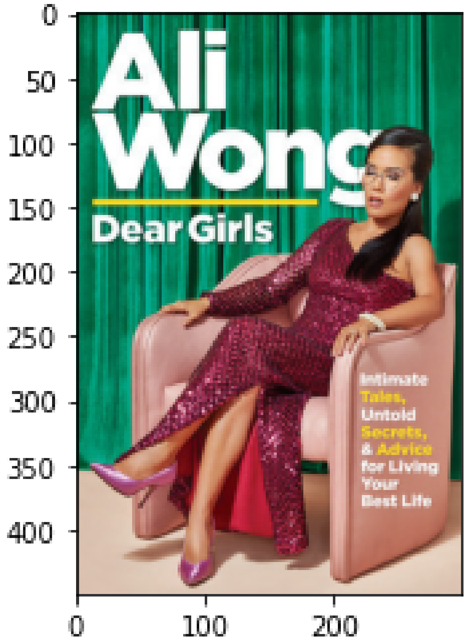
man and woman are sitting on the ground



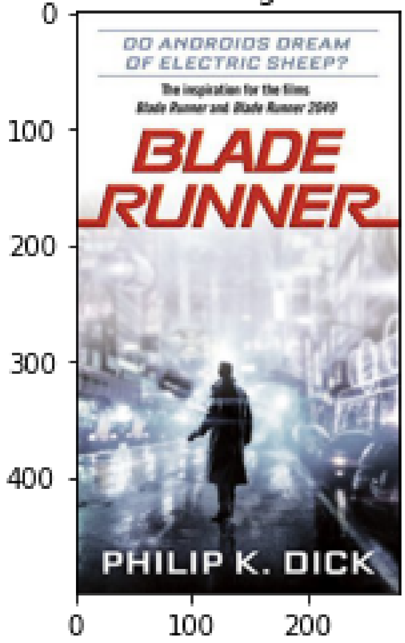
woman in black and white shirt is jumping into the air



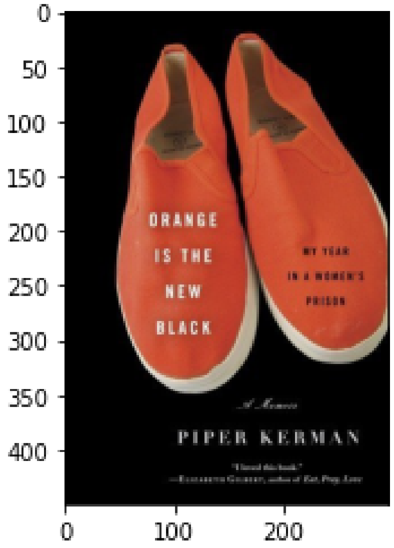
woman in black dress and white shirt is sitting on the street



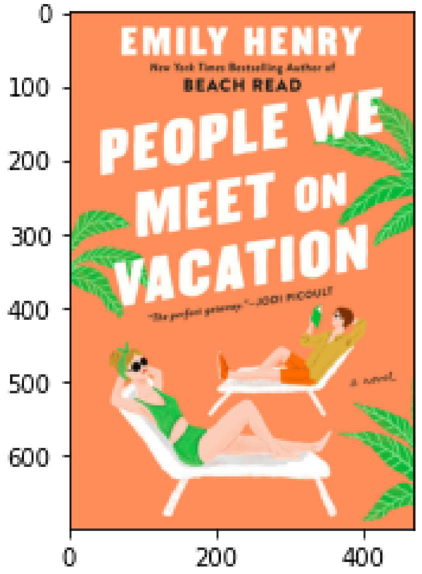
man in red shirt is standing in front of the camera



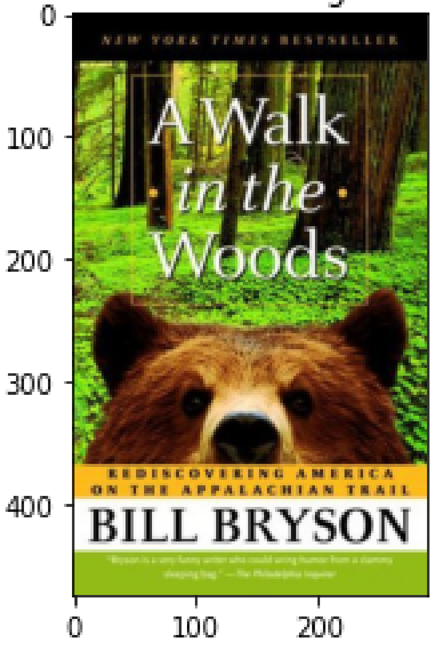
woman wearing red shirt and black shirt and white shirt is sitting on the ground



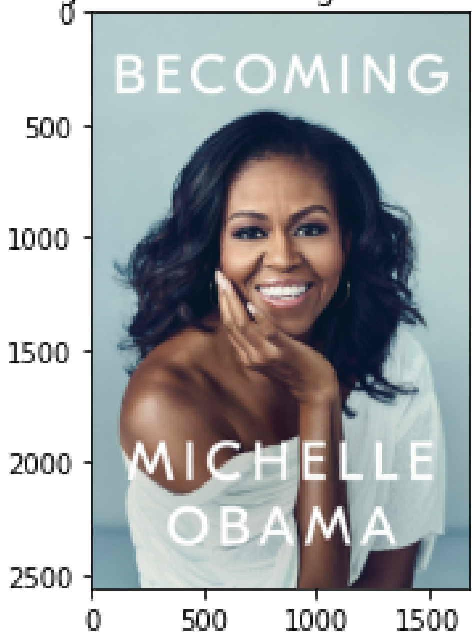
woman wearing red shirt and white shirt and white shirt is holding her head


EMILY HENRY
New York Times Bestselling Author of
BEACH READ
PEOPLE WE MEET ON VACATION
"The perfect getaway."—JODI PICOULT
a novel
0
100
200
300
400
500
600
0
200
400

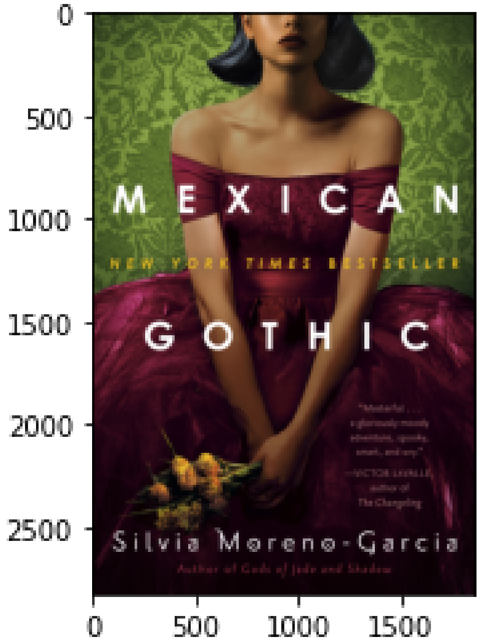
man in red shirt is sitting on the grass

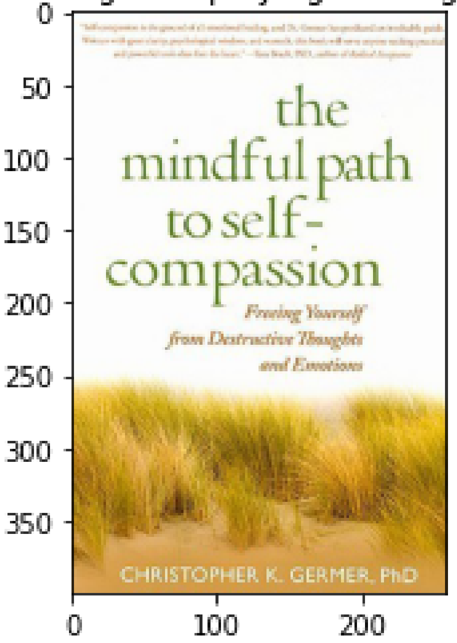

NEW YORK TIMES BESTSELLER
A Walk in the Woods
REDISCOVERING AMERICA ON THE APPALACHIAN TRAIL
BILL BRYSON
0
100
200
300
400
0
100
200

woman wearing sunglasses and sunglasses is sitting on the camera

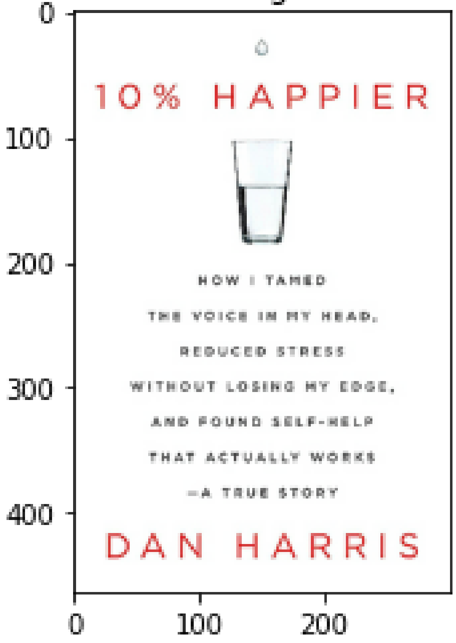


woman in black dress and black hat and woman in black dress

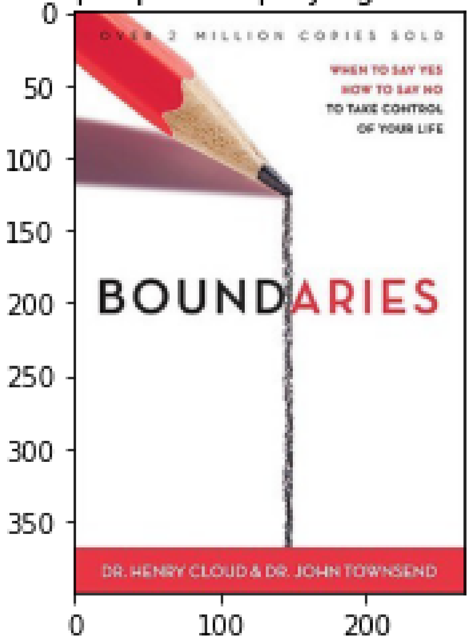



0
50
100
150
200
250
300
350
the mindful path to self-compassion
Freeing Yourself from Destructive Thoughts and Emotions
CHRISTOPHER K. GERMER, PhD
0
100
200

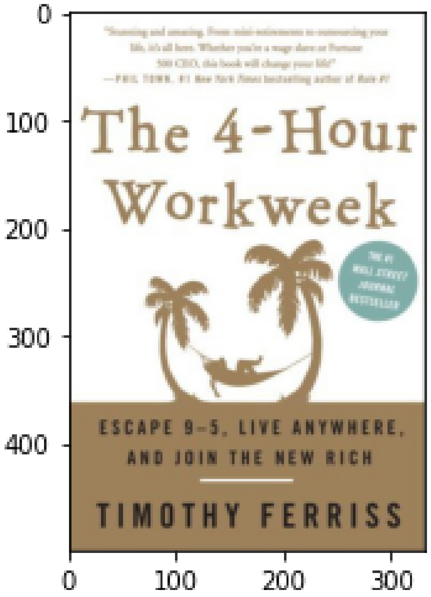
two dogs are playing in the grass


0
100
200
300
400
10% HAPPIER
HOW I TAMED THE VOICE IN MY HEAD, REDUCED STRESS WITHOUT LOSING MY EDGE, AND FOUND SELF-HELP THAT ACTUALLY WORKS —A TRUE STORY
DAN HARRIS
0
100
200

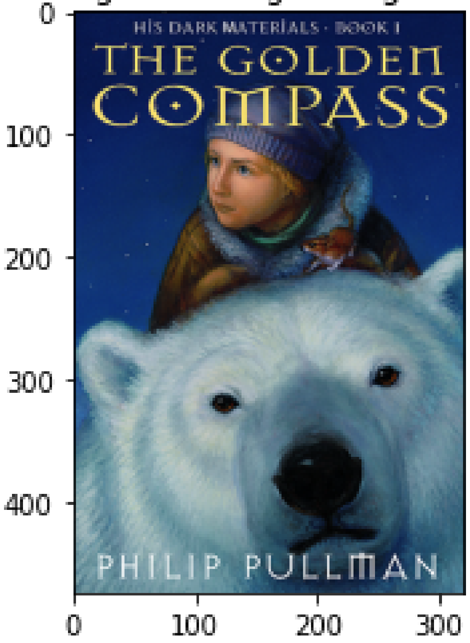
man wearing black shirt and sunglasses is sitting on the camera two people are playing in the air



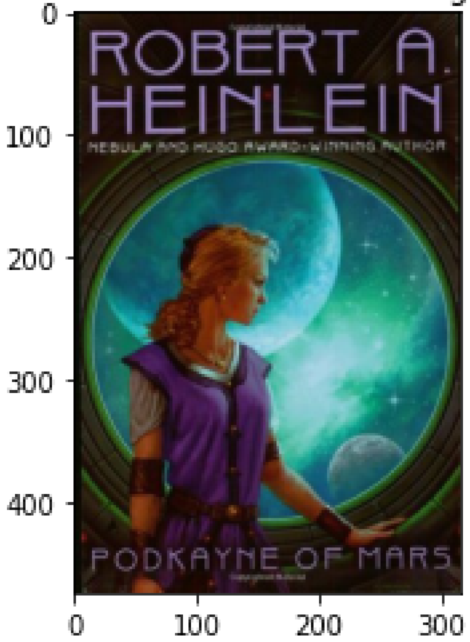
man in black shirt and black shirt and white shirt is sitting on the ground



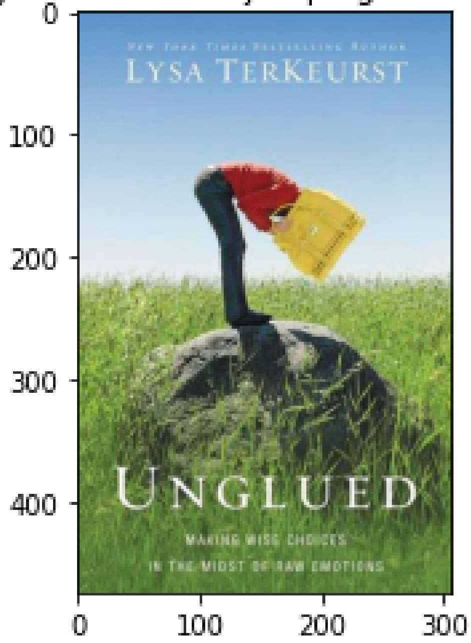
white dog is running through the snow



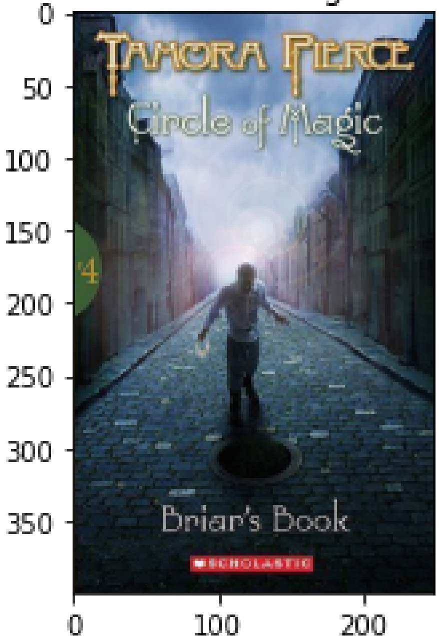
man in red shirt and red shirt is sitting on the street



boy in red shirt is jumping over the air



man in red shirt is standing on the sidewalk



woman wearing red shirt and sunglasses and white shirt and white shirt and white shirt and white shirt and white shirt and white shirt and white shirt and white