```
import glob
from PIL import Image
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import pickle
from tqdm import tqdm
import pandas as pd
from keras.preprocessing import sequence
from keras.models import Sequential
from keras.layers import LSTM, Embedding, TimeDistributed, Dense, RepeatVector, Merge, Act
from keras.optimizers import Adam, RMSprop
from keras.layers.wrappers import Bidirectional
from keras.applications.inception_v3 import InceptionV3
from keras.preprocessing import image
import nltk
```

```
Using TensorFlow backend.
```

```
token = 'Flickr8k_text/Flickr8k.token.txt'
```

```
captions = open(token, 'r').read().strip().split('\n')
```

Creating a dictionary containing all the captions of the images

```
d = {}
for i, row in enumerate(captions):
    row = row.split('\t')
    row[0] = row[0][:len(row[0])-2]
    if row[0] in d:
        d[row[0]].append(row[1])
    else:
        d[row[0]] = [row[1]]
```

```
d['1000268201_693b08cb0e.jpg']
```

```
['A child in a pink dress is climbing up a set of stairs in an entry way .',
 'A girl going into a wooden building .',
 'A little girl climbing into a wooden playhouse .',
 'A little girl climbing the stairs to her playhouse .',
 'A little girl in a pink dress going into a wooden cabin .']
```

```
images = 'Flickr8k_Dataset/Flicker8k_Dataset/'
```

```
# Contains all the images
img = glob.glob(images+'*.jpg')
```

```
img[:5]
```

```
img[:5]
```

```
['Flickr8k_Dataset/Flicker8k_Dataset/17273391_55cfc7d3d4.jpg',
 'Flickr8k_Dataset/Flicker8k_Dataset/2890075175_4bd32b201a.jpg',
 'Flickr8k_Dataset/Flicker8k_Dataset/3356642567_f1d92cb81b.jpg',
 'Flickr8k_Dataset/Flicker8k_Dataset/186890605_ddff5b694e.jpg',
 'Flickr8k_Dataset/Flicker8k_Dataset/2773682293_3b712e47ff.jpg']
```

```
train_images_file = 'Flickr8k_text/Flickr_8k.trainImages.txt'
```

```
train_images = set(open(train_images_file, 'r').read().strip().split('\n'))
```

```
def split_data(l):
    temp = []
    for i in img:
        if i[len(images):] in l:
            temp.append(i)
    return temp
```

```
# Getting the training images from all the images
train_img = split_data(train_images)
len(train_img)
```

```
6000
```

```
val_images_file = 'Flickr8k_text/Flickr_8k.devImages.txt'
val_images = set(open(val_images_file, 'r').read().strip().split('\n'))
```

```
# Getting the validation images from all the images
val_img = split_data(val_images)
len(val_img)
```

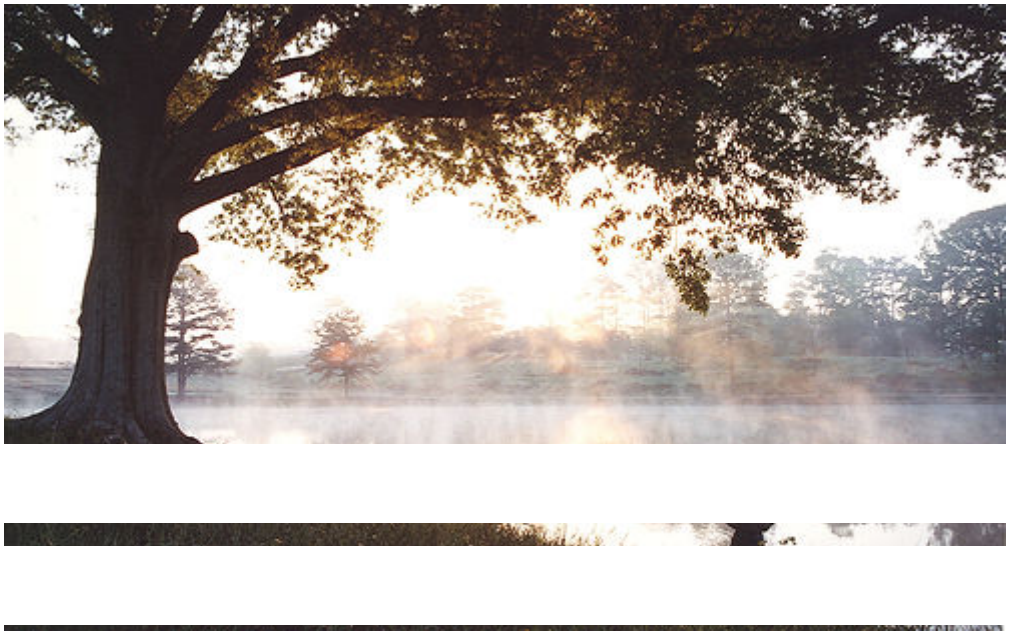
```
1000
```

```
test_images_file = 'Flickr8k_text/Flickr_8k.testImages.txt'
test_images = set(open(test_images_file, 'r').read().strip().split('\n'))
```

```
# Getting the testing images from all the images
test_img = split_data(test_images)
len(test_img)
```

```
1000
```

```
Image.open(train_img[0])
```



We will feed these images to VGG-16 to get the encoded images. Hence we need to preprocess the images as the authors of VGG-16 did. The last layer of VGG-16 is the softmax classifier(FC layer with 1000 hidden neurons) which returns the probability of a class. This layer should be removed so as to get a feature representation of an image. We will use the last Dense layer(4096 hidden neurons) after popping the classifier layer. Hence the shape of the encoded image will be (1, 4096)

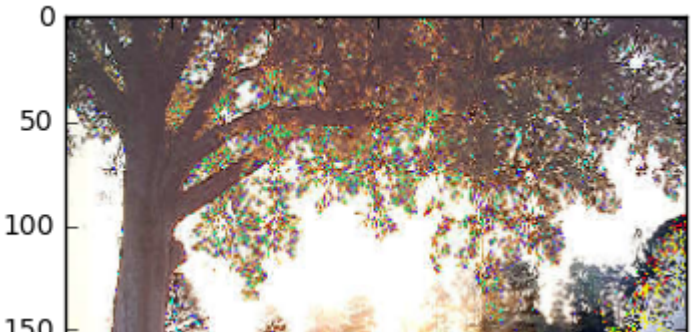
```
def preprocess_input(x):
    x /= 255.
    x -= 0.5
    x *= 2.
    return x


def preprocess(image_path):
    img = image.load_img(image_path, target_size=(299, 299))
    x = image.img_to_array(img)
    x = np.expand_dims(x, axis=0)

    x = preprocess_input(x)
    return x


plt.imshow(np.squeeze(preprocess(train_img[0])))
```

```
<matplotlib.image.AxesImage at 0x7f24a426a438>
```




```
model = InceptionV3(weights='imagenet')
```


```
from keras.models import Model

new_input = model.input
hidden_layer = model.layers[-2].output

model_new = Model(new_input, hidden_layer)
```

```
tryi = model_new.predict(preprocess(train_img[0]))
```

```
tryi.shape
```

```
(1, 2048)
```

```
def encode(image):
    image = preprocess(image)
    temp_enc = model_new.predict(image)
    temp_enc = np.reshape(temp_enc, temp_enc.shape[1])
    return temp_enc


encoding_train = {}
for img in tqdm(train_img):
    encoding_train[img[len(images):]] = encode(img)


with open("encoded_images_inceptionV3.p", "wb") as encoded_pickle:
    pickle.dump(encoding_train, encoded_pickle)


encoding_train = pickle.load(open('encoded_images_inceptionV3.p', 'rb'))


encoding_train['3556792157_d09d42bef7.jpg'].shape
```

```
(2048,)
```

```
encoding_test = {}
for img in tqdm(test_img):
    encoding_test[img[len(images):]] = encode(img)
```

```
 100%|██████████| 1000/1000 [18:50<00:00,  1.10s/it]
```

```
with open("encoded_images_test_inceptionV3.p", "wb") as encoded_pickle:
    pickle.dump(encoding_test, encoded_pickle)
```

```
encoding_test = pickle.load(open('encoded_images_test_inceptionV3.p', 'rb'))
```

```
encoding_test[test_img[0][len(images):]].shape
```

```
 (2048,)
```

```
train_d = {}
for i in train_img:
    if i[len(images):] in d:
        train_d[i] = d[i[len(images):]]
```

```
len(train_d)
```

```
 6000
```

```
train_d[images+'3556792157_d09d42bef7.jpg']
```

```
 ['A bunch of children sitting in chairs and standing on wooden floors .',
  'A group of children sit , stand , and kneel along a wall .',
  'A group of children sitting on folding chairs and playing .',
  'a young group of children sitting in a row against the wall .',
  'The kids talking while sitting on a row of chairs along the wall .']
```

```
val_d = {}
for i in val_img:
    if i[len(images):] in d:
        val_d[i] = d[i[len(images):]]
```

```
len(val_d)
```

```
 1000
```

```
test_d = {}
for i in test_img:
    if i[len(images):] in d:
        test_d[i] = d[i[len(images):]]
```

```
len(test_d)
```

```
1000
```

Calculating the unique words in the vocabulary.

```
caps = []
for key, val in train_d.items():
    for i in val:
        caps.append('<start> ' + i + ' <end>')
```

```
words = [i.split() for i in caps]
```

```
unique = []
for i in words:
    unique.extend(i)
```

```
unique = list(set(unique))
```

```
# with open("unique.p", "wb") as pickle_d:
#     pickle.dump(unique, pickle_d)
```

```
unique = pickle.load(open('unique.p', 'rb'))
```

```
len(unique)
```

```
8256
```

Mapping the unique words to indices and vice-versa

```
word2idx = {val:index for index, val in enumerate(unique)}
```

```
word2idx['<start>']
```

```
5553
```

```
idx2word = {index:val for index, val in enumerate(unique)}
```

```
idx2word[5553]
```

```
'<start>'
```

Calculating the maximum length among all the captions

```
max_len = 0
for c in caps:
    c = c.split()
    if len(c) > max_len:
        max_len = len(c)
max_len
```

```
40
```

```
len(unique), max_len
```

```
(8256, 40)
```

```
vocab_size = len(unique)
```

```
vocab_size
```

```
8256
```

Adding and to all the captions to indicate the starting and ending of a sentence. This will be used while we predict the caption of an image

```
f = open('flickr8k_training_dataset.txt', 'w')
f.write("image_id\tcaptions\n")
```

```
18
```

```
for key, val in train_d.items():
    for i in val:
        f.write(key[len(images):] + "\t" + "<start> " + i +" <end>" + "\n")

f.close()
```

```
df = pd.read_csv('flickr8k_training_dataset.txt', delimiter='\t')
```

```
len(df)
```

```
30000
```

```
c = [i for i in df['captions']]
len(c)
```

```
30000
```

```
imgs = [i for i in df['image_id']]
```

```
a = c[-1]
a, imgs[-1]
```

```
('<start> Two rafts overturn in a river . <end>', '3421928157_69a325366f.jpg')
```

```
for i in a.split():
    print (i, "=>", word2idx[i])
```

```
<start> => 5553
Two => 2666
rafts => 4606
overturn => 3779
in => 8156
a => 32
river => 1816
. => 7023
<end> => 5232
```

```
samples_per_epoch = 0
for ca in caps:
    samples_per_epoch += len(ca.split())-1
```

```
samples_per_epoch
```

```
383454
```

Generator

We will use the encoding of an image and use a start word to predict the next word. After that, we will again use the same image and use the predicted word to predict the next word. So, the image will be used at every iteration for the entire caption. This is how we will generate the caption for an image. Hence, we need to create a custom generator for that.

The CS231n lecture by Andrej Karpathy explains this concept very clearly and beautifully. Link for the lecture:- https://youtu.be/cO0a0QYmFm8?t=32m25s

```
def data_generator(batch_size = 32):
```

```
partial_caps = []
next_words = []
images = []

df = pd.read_csv('flickr8k_training_dataset.txt', delimiter='\t')
df = df.sample(frac=1)
iter = df.iterrows()
c = []
imgs = []
for i in range(df.shape[0]):
    x = next(iter)
    c.append(x[1][1])
    imgs.append(x[1][0])


count = 0
while True:
    for j, text in enumerate(c):
        current_image = encoding_train[imgs[j]]
        for i in range(len(text.split())-1):
            count+=1

            partial = [word2idx[txt] for txt in text.split()[:i+1]]
            partial_caps.append(partial)

            # Initializing with zeros to create a one-hot encoding matrix
            # This is what we have to predict
            # Hence initializing it with vocab_size length
            n = np.zeros(vocab_size)
            # Setting the next word to 1 in the one-hot encoded matrix
            n[word2idx[text.split()[i+1]]] = 1
            next_words.append(n)

            images.append(current_image)

            if count>=batch_size:
                next_words = np.asarray(next_words)
                images = np.asarray(images)
                partial_caps = sequence.pad_sequences(partial_caps, maxlen=max_len
                yield [[images, partial_caps], next_words]
                partial_caps = []
                next_words = []
                images = []
                count = 0
```

Let's create the model

```
embedding_size = 300
```

Input dimension is 4096 since we will feed it the encoded version of the image.

```
image_model = Sequential([
        Dense(embedding_size, input_shape=(2048,), activation='relu'),
        RepeatVector(max_len)
    ])
```

Since we are going to predict the next word using the previous words(length of previous words changes with every iteration over the caption), we have to set return_sequences = True.

```
caption_model = Sequential([
        Embedding(vocab_size, embedding_size, input_length=max_len),
        LSTM(256, return_sequences=True),
        TimeDistributed(Dense(300))
    ])
```

Merging the models and creating a softmax classifier

```
final_model = Sequential([
        Merge([image_model, caption_model], mode='concat', concat_axis=1),
        Bidirectional(LSTM(256, return_sequences=False)),
        Dense(vocab_size),
        Activation('softmax')
    ])
```

```
final_model.compile(loss='categorical_crossentropy', optimizer=RMSprop(), metrics=['accura
```

```
final_model.summary()
```

```
_________________________________________________________________________________
Layer (type)                 Output Shape              Param #     Connected to
=================================================================================
dense_1 (Dense)              (None, 300)               614700
_________________________________________________________________________________
repeatvector_1 (RepeatVector)(None, 40, 300)           0
_________________________________________________________________________________
embedding_1 (Embedding)      (None, 40, 300)           2476800
_________________________________________________________________________________
lstm_1 (LSTM)                (None, 40, 256)           570368
_________________________________________________________________________________
timedistributed_1 (TimeDistribut (None, 40, 300)       77100
_________________________________________________________________________________
bidirectional_1 (Bidirectional)  (None, 512)           1140736     merge_1[0][0]
_________________________________________________________________________________
dense_3 (Dense)              (None, 8256)              4235328     bidirectional_1[0]
_________________________________________________________________________________
activation_1 (Activation)    (None, 8256)              0           dense_3[0][0]
=================================================================================
Total params: 9,115,032
Trainable params: 9,115,032
Non-trainable params: 0
_________________________________________________________________________________
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
971s - loss: 4.0727 - acc: 0.3072
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0e02cdb38>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
958s - loss: 3.4351 - acc: 0.3855
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0dc4c76a0>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
959s - loss: 3.3411 - acc: 0.4033
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0e035fcf8>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
959s - loss: 3.3024 - acc: 0.4138
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0dc4d6eb8>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
958s - loss: 3.2991 - acc: 0.4214
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0dc4df358>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
959s - loss: 3.2920 - acc: 0.4288
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0dc0f0a20>
```

```
final_model.optimizer.lr = 1e-4
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
958s - loss: 3.2612 - acc: 0.4302
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0dc4fbbe0>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
958s - loss: 3.2604 - acc: 0.4357
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7fd0dc0f8048>
```

```
final_model.save_weights('time_inceptionV3_7_loss_3.2604.h5')
```

```
final_model.load_weights('time_inceptionV3_7_loss_3.2604.h5')
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
1017s - loss: 3.2368 - acc: 0.4399
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7f76384cd518>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
993s - loss: 3.2185 - acc: 0.4458
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7f76326d5518>
```

```
final_model.save_weights('time_inceptionV3_3.21_loss.h5')
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
993s - loss: 3.2044 - acc: 0.4505
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7f76326d58d0>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
992s - loss: 3.1809 - acc: 0.4539
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7f7632723f28>
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
992s - loss: 3.1510 - acc: 0.4589
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7f763272fb70>
```

```
final_model.save_weights('time_inceptionV3_3.15_loss.h5')
```

```
final_model.fit_generator(data_generator(batch_size=128), samples_per_epoch=samples_per_ep
                          verbose=2)
```

```
Epoch 1/1
992s - loss: 3.1449 - acc: 0.4643
/usr/local/lib/python3.5/site-packages/keras/engine/training.py:1573: UserWarning: Ep
  warnings.warn('Epoch comprised more than '
<keras.callbacks.History at 0x7f7632732a90>
```

```
final_model.load_weights('time_inceptionV3_1.5987_loss.h5')
```

Predict funtion

```
def predict_captions(image):
    start_word = ["<start>"]
```

```
    start_word = ["<start>"]
    while True:
        par_caps = [word2idx[i] for i in start_word]
        par_caps = sequence.pad_sequences([par_caps], maxlen=max_len, padding='post')
        e = encoding_test[image[len(images):]]
        preds = final_model.predict([np.array([e]), np.array(par_caps)])
        word_pred = idx2word[np.argmax(preds[0])]
        start_word.append(word_pred)

        if word_pred == "<end>" or len(start_word) > max_len:
            break

    return ' '.join(start_word[1:-1])


def beam_search_predictions(image, beam_index = 3):
    start = [word2idx["<start>"]]

    start_word = [[start, 0.0]]

    while len(start_word[0][0]) < max_len:
        temp = []
        for s in start_word:
            par_caps = sequence.pad_sequences([s[0]], maxlen=max_len, padding='post')
            e = encoding_test[image[len(images):]]
            preds = final_model.predict([np.array([e]), np.array(par_caps)])

            word_preds = np.argsort(preds[0])[-beam_index:]

            # Getting the top <beam_index>(n) predictions and creating a
            # new list so as to put them via the model again
            for w in word_preds:
                next_cap, prob = s[0][:], s[1]
                next_cap.append(w)
                prob += preds[0][w]
                temp.append([next_cap, prob])

        start_word = temp
        # Sorting according to the probabilities
        start_word = sorted(start_word, reverse=False, key=lambda l: l[1])
        # Getting the top words
        start_word = start_word[-beam_index:]

    start_word = start_word[-1][0]
    intermediate_caption = [idx2word[i] for i in start_word]

    final_caption = []

    for i in intermediate_caption:
        if i != '<end>':
            final_caption.append(i)
        else:
            break

    final_caption = ' '.join(final_caption[1:])
    return final_caption
```

```
try_image = test_img[0]
Image.open(try_image)
```


```
print ('Normal Max search:', predict_captions(try_image))
print ('Beam Search, k=3:', beam_search_predictions(try_image, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(try_image, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(try_image, beam_index=7))
```

```
Normal Max search: Three men in white uniforms playing basketball .
Beam Search, k=3: Three men in white uniforms playing basketball .
Beam Search, k=5: Three men in white uniforms playing basketball .
Beam Search, k=7: Three men in white uniforms playing basketball .
```

```
try_image2 = test_img[7]
Image.open(try_image2)
```

```
print ('Normal Max search:', predict_captions(try_image2))
print ('Beam Search, k=3:', beam_search_predictions(try_image2, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(try_image2, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(try_image2, beam_index=7))
```

```
Normal Max search: A snowboarder flies through the air after midair from a mountain
Beam Search, k=3: A skier is performing a trick high in the air over a snowy area .
Beam Search, k=5: A downhill skier races near trees .
Beam Search, k=7: This person is snowboarding off a ramp .
```

```
try_image3 = test_img[851]
Image.open(try_image3)
```

```
print ('Normal Max search:', predict_captions(try_image3))
print ('Beam Search, k=3:', beam_search_predictions(try_image3, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(try_image3, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(try_image3, beam_index=7))
```

```
Normal Max search: A man and a woman are standing in front of a building
Beam Search, k=3: A man and a woman are standing in front of a white building .
Beam Search, k=5: A man and a woman are standing in front of a white building .
Beam Search, k=7: A bunch of people at park .
```

```
try_image4 = 'Flickr8k_Dataset/Flicker8k_Dataset/136552115_6dc3e7231c.jpg'
print ('Normal Max search:', predict_captions(try_image4))
print ('Beam Search, k=3:', beam_search_predictions(try_image4, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(try_image4, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(try_image4, beam_index=7))
Image.open(try_image4)
```

```
Normal Max search: A person on a bike is coming up through the mud .
Beam Search, k=3: A guy is doing a trick on a bike .
Beam Search, k=5: A mountain biker jumps a rock on a mountain .
Beam Search, k=7: A mountain biker is riding on a line back at bushes .
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/1674612291_7154c5ab61.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Normal Max search: A dog is jumping in the air to catch something .
Beam Search, k=3: A brown dog is jumping in the air .
Beam Search, k=5: A dog is jumping in the air to catch something .
Beam Search, k=7: A dog in a harness holds a stick in his mouth while standing in the
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/384577800_fc325af410.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Normal Max search: A tan dog runs through the snow .
Beam Search, k=3: A tan dog runs through the snow .
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/3631986552_944ea208fc.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Normal Max search: A man is riding a surfboard
Beam Search, k=3: A man rides a wave on a surfboard .
Beam Search, k=5: A man rides a surfboard as a wave makes a splash .
Beam Search, k=7: A man rides a surfboard as a wave makes a splash .
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/3320032226_63390d74a6.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Normal Max search: A little girl in a red coat plays in snow .
Beam Search, k=3: A little kid plays in the snow in a brown jacket and red shorts on
Beam Search, k=5: Little girl in red coat going down a hill .
Beam Search, k=7: Little girl in red coat going down a hill .
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/3316725440_9ccd9b5417.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

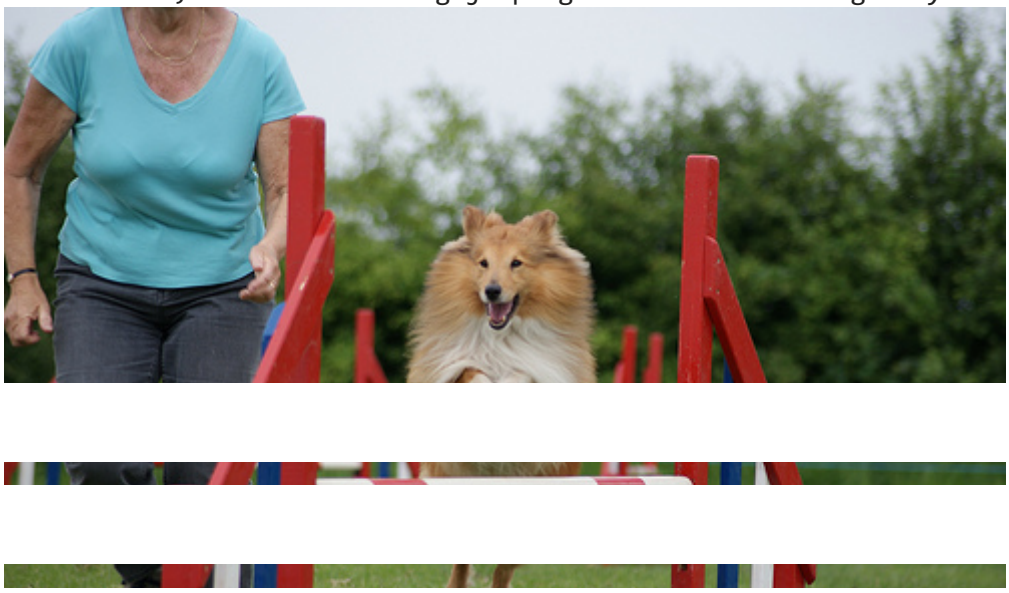
```
Normal Max search: A man rides a bicycle on a trail down a river .
Beam Search, k=3: A man is riding a bicycle on a trail through some trees .
Beam Search, k=5: A man rides a mountain bike down a slope in the woods .
Beam Search, k=7: A man rides a bicycle on a trail down a river .
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/2306674172_dc07c7f847.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Normal Max search: A skateboarder in the air in front of a red slide .
Beam Search, k=3: A skateboarder in the air in front of a blue building .
Beam Search, k=5: A skateboarder in the air in front of a blue building .
Beam Search, k=7: A male skateboarder is skating in a skate park .
```

```
im = 'Flickr8k_Dataset/Flicker8k_Dataset/2542662402_d781dd7f7c.jpg'
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Normal Max search: A small dog jumping an obstacle in a grassy field .
Beam Search, k=3: A small dog jumping an obstacle in a grassy field .
Beam Search, k=5: A small dog jumping an obstacle in a grassy field .
Beam Search, k=7: A small dog jumping an obstacle in a grassy field .
```



```
im = test_img[int(np.random.randint(0, 1000, size=1))]
print (im)
print ('Normal Max search:', predict_captions(im))
print ('Beam Search, k=3:', beam_search_predictions(im, beam_index=3))
print ('Beam Search, k=5:', beam_search_predictions(im, beam_index=5))
print ('Beam Search, k=7:', beam_search_predictions(im, beam_index=7))
Image.open(im)
```

```
Flickr8k_Dataset/Flicker8k_Dataset/3123351642_3794f2f601.jpg
Normal Max search: A snowboarder is riding down the ramp next to a hill .
Beam Search, k=3: A person on a snowboard jumps over a cliff in the snow .
Beam Search, k=5: A person on a snowboard jumps over a cliff in the snow .
Beam Search, k=7: A person on a snowboard jumps over a cliff in the snow .
```