Image_Captioning

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Team Members * **Saurabh Mishra - 64** * **Vaibhav Singh - 67** * **Virag Dosani - 77**

1 Image Captioning with Visual Attention

Given an image like the example below, our goal is to generate a caption such as "**Dog playing with a ball**".

2 Introduction

Automatically generating captions of an image is a task very close to the heart of scene understanding — one of the primary goals of computer vision. Not only must caption generation models be powerful enough to solve the computer vision challenges of determining which objects are in an image, but they must also be capable of capturing and expressing their relationships in a natural language.

[1]:
```
!pip install -q tqdm
!pip install -q wandb
!wandb login 984196dfc7bc6ae6093fed3667fd5da413300d29
```

```
     |                | 1.4MB 3.4MB/s
     |                | 112kB 40.5MB/s
     |                | 102kB 8.3MB/s
     |                | 102kB 10.4MB/s
     |                | 460kB 35.6MB/s
     |                | 71kB 7.0MB/s
     |                | 71kB 6.7MB/s
  Building wheel for gql (setup.py) … done
  Building wheel for subprocess32 (setup.py) … done
  Building wheel for watchdog (setup.py) … done
  Building wheel for graphql-core (setup.py) … done
  Building wheel for pathtools (setup.py) … done
wandb: Appending key for api.wandb.ai to your netrc file:
/root/.netrc
Successfully logged in to Weights & Biases!
```

[2]:
```
!pip install -q kaggle
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle/
!chmod 600 ~/.kaggle/kaggle.json
!kaggle datasets download -d thanakomsn/glove6b300dtxt
!unzip /content/glove6b300dtxt.zip
!rm -rf /content/glove6b300dtxt.zip
```

```
Downloading glove6b300dtxt.zip to /content
 99% 382M/386M [00:05<00:00, 73.2MB/s]
100% 386M/386M [00:05<00:00, 72.3MB/s]
Archive:  /content/glove6b300dtxt.zip
  inflating: glove.6B.300d.txt
```

[3]:
```
import wandb
wandb.init(project="image-captioning-test")
```

```
<IPython.core.display.HTML object>
```

[3]: W&B Run: https://app.wandb.ai/veb-101/image-captioning-test/runs/14dmbbj2

[0]:
```
import tensorflow as tf

import matplotlib.pyplot as plt

from sklearn.model_selection import train_test_split
from sklearn.utils import shuffle

import re
import numpy as np
import os
import time
import json
from PIL import Image
import pickle
from tqdm import tqdm
import matplotlib.image as mpimg
```

3 Step1: Downloading and preparing the MS-COCO dataset

[5]:
```
# downloading caption annotation files
annotation_folder = '/annotations/'
if not os.path.exists(os.path.abspath('.') + annotation_folder):
    annotation_zip = tf.keras.utils.get_file('captions.zip',
                                             cache_subdir=os.path.abspath('.'),
                                             origin = 'http://images.
 ↪cocodataset.org/annotations/annotations_trainval2014.zip',
                                             extract = True)
    annotation_file = os.path.dirname(annotation_zip)+'/annotations/
 ↪captions_train2014.json'
    os.remove(annotation_zip)
else:
    annotation_file = r"/content/annotations/captions_train2014.json"


# downloading image files
image_folder = '/train2014/'
if not os.path.exists(os.path.abspath('.') + image_folder):
    image_zip = tf.keras.utils.get_file('train2014.zip',
```

```
                                          cache_subdir=os.path.abspath('.'),
                                          origin = 'http://images.cocodataset.org/
↪zips/train2014.zip',
                                          extract = True)
    PATH = os.path.dirname(image_zip) + image_folder
    os.remove(image_zip)
else:
    PATH = os.path.abspath('.') + image_folder
```

```
Downloading data from
http://images.cocodataset.org/annotations/annotations_trainval2014.zip
252878848/252872794 [==============================] - 3s 0us/step
Downloading data from http://images.cocodataset.org/zips/train2014.zip
13510574080/13510573713 [==============================] - 333s 0us/step
```

[0]:
```
with open(annotation_file, 'r') as f:
    annotations = json.load(f)

# storing each captions and image name
all_captions = []
all_img_name_vector = []

for annot in annotations['annotations']:
    caption = '<start> ' + annot['caption'] + ' <end>'
    image_id = annot['image_id']
    full_coco_image_path = PATH + 'COCO_train2014_' + '%012d.jpg' % (image_id)

    all_img_name_vector.append(full_coco_image_path)
    all_captions.append(caption)

train_captions, img_name_vector = shuffle(all_captions,
                                          all_img_name_vector,
                                          random_state=42)
```

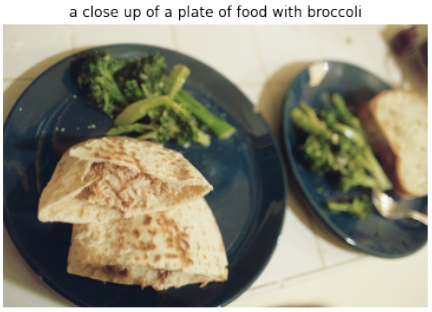
[0]:
```
# Select the first 50000 captions from the shuffled set
num_examples = 45000
train_captions = train_captions[:num_examples]
img_name_vector = img_name_vector[:num_examples]
```

[8]:
```
len(train_captions), len(img_name_vector), len(all_captions)
```

[8]:
```
(45000, 45000, 414113)
```

[9]:
```
# Demo Images

plt.figure(figsize=(18, 15))
for i in range(4):
```

```
    plt.subplot(3, 2, i+1)
    caption_id = np.random.choice(range(len(train_captions)))
    image = mpimg.imread(img_name_vector[caption_id])
    caption = train_captions[caption_id].replace("<start>", '').
↪replace("<end>", '')
    caption.strip()
    plt.title(caption)
    plt.imshow(image)
    plt.axis("off")
```



4 Step 2: Image and caption preparation

4.1 Step2a: Defining an Image feature extractor (InceptionV3)

[0]:
```
def load_image(image_path):
    img = tf.io.read_file(image_path)
    img = tf.image.decode_jpeg(img, channels=3)
    img = tf.image.resize(img, (299, 299))
    img = tf.keras.applications.inception_v3.preprocess_input(img)
    return img, image_path
```

4.2 Step 2b: Initialize and loading InceptionV3 with the pretrained Imagenet weights

[11]:
```
image_model = tf.keras.applications.InceptionV3(include_top=False,␣
 ↪weights='imagenet')
new_input = image_model.input
hidden_layer = image_model.layers[-1].output

image_features_extract_model = tf.keras.Model(new_input, hidden_layer)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applicatio
ns/inception_v3/inception_v3_weights_tf_dim_ordering_tf_kernels_notop.h5
87916544/87910968 [==============================] - 1s 0us/step
```

4.3 Step2c: Caching the features extracted from InceptionV3

[12]:
```
encode_train = sorted(set(img_name_vector))
print(len(encode_train))

# extracting features from images
image_dataset = tf.data.Dataset.from_tensor_slices(encode_train)
image_dataset = image_dataset.map(
    load_image, num_parallel_calls=tf.data.experimental.AUTOTUNE).batch(16)

# caching
for img, path in tqdm(image_dataset):
    batch_features = image_features_extract_model(img)
    # temp = batch_features.shape
    batch_features = tf.reshape(batch_features,
                                (batch_features.shape[0], -1, batch_features.
 ↪shape[3]))

    for bf, p in zip(batch_features, path):
        path_of_feature = p.numpy().decode("utf-8")
        np.save(path_of_feature, bf.numpy())
```

```
36168
```

```
2261it [10:19,  3.65it/s]
```

[0]:
```
# temp, batch_features.shape
```

4.4 Step 2d: Caption tokenization and preprocessing

[0]:
```
# train_captions[:2], img_name_vector[:2]
```

[0]:
```
# Find the maximum length of any caption in our dataset
def calc_max_length(tensor):
    return max(len(t) for t in tensor)
```

[0]:
```
# Choosing all words in the embedding
top_k = 7500
tokenizer = tf.keras.preprocessing.text.Tokenizer(num_words=top_k,
                                                  oov_token="<unk>",
                                                  filters='!"#$%&()*+.,-/:;=?
 ↪@[\]^_`{|}~ ')
tokenizer.fit_on_texts(train_captions)
```

[16]:
```
tokenizer.word_index['<pad>'] = 0
tokenizer.index_word[0] = '<pad>'

word_index = {}
k = 0
for i, j in tokenizer.word_index.items():
    if k < top_k:
        word_index[i] = j
        k += 1

print(len(tokenizer.word_index))
print(len(word_index))
```

```
9741
7500
```

[0]:
```
# Create the tokenized vectors
train_seqs = tokenizer.texts_to_sequences(train_captions)
# train_seqs[:2]

# Pad each vector to the max_length of the captions
cap_vector = tf.keras.preprocessing.sequence.pad_sequences(train_seqs,␣
 ↪padding='post')
# cap_vector[:2]

# Calculates the max_length, which is used to store the attention weights
max_length = calc_max_length(train_seqs)
# max_length
```

[0]:
```
import csv
def create_csv(file, dict):
    with open(file, 'w') as csvfile:
        writer = csv.writer(csvfile)
        for key in dict.keys():
            writer.writerow([key,dict[key]])
```

```
create_csv('idx2word.csv', tokenizer.index_word)
```

5 Step 3: Dataset preparation

5.1 Step 3a: Splitting data in train and validation set

[19]:
```
# Create training and validation sets using an 80-20 split
img_name_train, img_name_val, cap_train, cap_val =␣
↪train_test_split(img_name_vector,
                                                                cap_vector,
                                                                test_size=0.
↪2,
                                                               ␣
↪shuffle=True,
                                                               ␣
↪random_state=47)

len(img_name_train), len(cap_train), len(img_name_val), len(cap_val)
```

[19]:
```
(36000, 36000, 9000, 9000)
```

[0]:
```
# word embedding initialization

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

5.2 Step 3b: Creating dataset pipeline

[0]:
```
# imp constants used later
EPOCHS = 20
BATCH_SIZE = 64
BUFFER_SIZE = 1000
embedding_dim = 300
units = 512
vocab_size = len(word_index) + 1
# num_steps = len(img_name_train)
```

[0]:
```
# Shape of the vector extracted from InceptionV3 is (64, 2048)
# These two variables represent that vector shape
features_shape = 2048
attention_features_shape = 64
```

[0]:
```
# !rm -rf /content/glove.6B.300d.txt
embeddings_matrix = np.zeros((vocab_size, embedding_dim));
for word, i in word_index.items():
    embedding_vector = embeddings_index.get(word);
    if embedding_vector is not None:
        embeddings_matrix[i] = embedding_vector;
```

[25]:
```
len(embeddings_matrix), len(embeddings_matrix[0])
```

[25]:
```
(7501, 300)
```

[0]:
```
config = wandb.config
config.CNN = "InceptionV3"
config.CNN_out_shape = "8x8x2048"
config.optimizer = "Adam-default"
config.captions = num_examples
config.vocab_size = vocab_size
config.BATCH_SIZE = BATCH_SIZE
config.embedding_dim = embedding_dim
config.Decoder = "LSTM"
config.EPOCHS = EPOCHS
config.img_size = "299x299"
```

[0]:
```
def map_func(img_name, cap):
    img_tensor = np.load(img_name.decode('utf-8') + '.npy')
    return img_tensor, cap
```

[0]:
```
def createDataset(img_name, cap):
    dataset = tf.data.Dataset.from_tensor_slices((img_name, cap))
    # Use map to load the numpy files in parallel
    dataset = dataset.map(lambda item1, item2: tf.numpy_function(
            map_func, [item1, item2], [tf.float32, tf.int32]),
            num_parallel_calls=tf.data.experimental.AUTOTUNE)


    # Shuffle and batch
    dataset = dataset.shuffle(BUFFER_SIZE).batch(BATCH_SIZE)
    dataset = dataset.prefetch(buffer_size=tf.data.experimental.AUTOTUNE)
    return dataset
```

[0]:
```
train_dataset = createDataset(img_name_train, cap_train)
valid_dataset = createDataset(img_name_val, cap_val)
```

6 Step 4: Model Definition

6.1 Step 4a: *Bahdanau's Attention*

$score(s_t, h_i) = v_a^T tanh(W_a[s_t : h_i])$

$\alpha_{t,i} = \frac{exp(score(s_{t-1}, h_i))}{\sum_{i'=1}^{n} exp(score(s_{t-1}, h_{i'}))}$

$ContextVector_t = \sum_{i=1}^{n} \alpha_{t,i} h_i$

α = ***attention weights***

s_t = ***previous state output***

h_i = ***image feature 'i'***

[0]:
```
class SoftAttention(tf.keras.Model):

    def __init__(self, units):
        super().__init__()
        self.W1 = tf.keras.layers.Dense(units)
        self.W2 = tf.keras.layers.Dense(units)
        self.V = tf.keras.layers.Dense(1)

    def call(self, features, hidden):
        hidden_with_time_axis = tf.expand_dims(hidden, 1)
        score = tf.nn.tanh(self.W1(features) + self.W2(hidden_with_time_axis))
        attention_weights = tf.nn.softmax(self.V(score), axis=1)
        context_vector = attention_weights * features
        context_vector = tf.reduce_sum(context_vector, axis=1)
        return context_vector, attention_weights
```

6.2 Step 4b: CNN Encoder

This encoder maps the input feature of size ***(64, 2048)*** to dimesion ***(64, 300)*** using a fully connected layer and applies a **relu** activation on the output.

[0]:
```
class CNN_Encoder(tf.keras.Model):

    def __init__(self, embedding_dim):
        super().__init__()
        self.fc = tf.keras.layers.Dense(embedding_dim)

    def call(self, x):
        x = self.fc(x)
        x = tf.nn.relu(x)
        return x
```

6.3 Step 4c: Long short-term memory Decoder

LSTM as used in paper by Recurrent Neural Network Regularization

h_{t-1} = ***previous state output***

Ey_{t-1} = ***Word Embedding of previous state output (used as this state's input)***

$\hat{z}_t$ = ***Context Vector*** t ***from Attention unit***

[0]:
```
class RNN_Decoder(tf.keras.Model):
    def __init__(self, attention, embedding_dim, units, vocab_size):
        super().__init__()
        self.units = units

        self.embedding = tf.keras.layers.Embedding(vocab_size, embedding_dim,␣
↪input_length=max_length,
                                                   weights=[embeddings_matrix],␣
↪trainable=False)
        self.lstm = tf.keras.layers.LSTM(self.units,
                                         return_sequences=True,
                                         return_state=True,
                                         recurrent_initializer='glorot_uniform')
        self.gru = tf.keras.layers.GRU(self.units,
                                       return_sequences=True,
                                       return_state=True,
                                       recurrent_initializer='glorot_uniform')

        self.fc1 = tf.keras.layers.Dense(self.units)
        self.fc2 = tf.keras.layers.Dense(vocab_size)

        # need to change here
        self.attention = attention

    def call(self, x, features, hidden, dec="lstm"):
        context_vector, attention_weights = self.attention(features, hidden)
        x = self.embedding(x)
        x = tf.concat([tf.expand_dims(context_vector, 1), x], axis=-1)
        if dec == "lstm":
            lstm1, hidden_state_op, state_cell = self.lstm(x)
            x = self.fc1(hidden_state_op)
            x = self.fc2(x)
            return x, hidden_state_op, attention_weights
        elif dec == "gru":
            hidden_state_op, state = self.gru(x)
            x = self.fc1(hidden_state_op)
            x = tf.reshape(x, (-1, x.shape[2]))
            x = self.fc2(x)
            return x, state, attention_weights

    def reset_state(self, batch_size):
        return tf.zeros((batch_size, self.units))
```

6.4 Step 4d: Defining optimizer and checkpoints

[0]:
```
optimizer = tf.keras.optimizers.Adam()
loss_object = tf.keras.losses.SparseCategoricalCrossentropy(
    from_logits=True, reduction='none')

def loss_function(real, pred):
    mask = tf.math.logical_not(tf.math.equal(real, 0))
    loss_ = loss_object(real, pred)
    mask = tf.cast(mask, dtype=loss_.dtype)
    loss_ *= mask
    return tf.reduce_mean(loss_)
```

[0]:
```
import shutil
try:
    shutil.rmtree("checkpoints")
except:
    pass
```

[0]:
```
start_epoch = 0
```

[0]:
```
# checkpoint
checkpoint_path = "./checkpoints/train"
ckpt = tf.train.Checkpoint(encoder=encoder,
                           attention=attention,
                           decoder=decoder,
                           optimizer = optimizer)
ckpt_manager = tf.train.CheckpointManager(ckpt, checkpoint_path, max_to_keep=2)
```

[0]:
```
# # for restoring latest checkpoint
if ckpt_manager.latest_checkpoint:
    start_epoch = int(ckpt_manager.latest_checkpoint.split('-')[-1])
    ckpt.restore(ckpt_manager.latest_checkpoint)
```

7 Step 5: Evalution, attention plot and caption generation

[0]:
```
def evaluate(image, encoder=None, decoder=None):
    attention_plot = np.zeros((max_length, attention_features_shape))

    hidden = decoder.reset_state(batch_size=1)

    temp_input = tf.expand_dims(load_image(image)[0], 0)
    img_tensor_val = image_features_extract_model(temp_input)
    img_tensor_val = tf.reshape(img_tensor_val, (img_tensor_val.shape[0], -1,␣
 ↪img_tensor_val.shape[3]))
```

```
    features = encoder(img_tensor_val)

    dec_input = tf.expand_dims([tokenizer.word_index['<start>']], 0)
    result = []

    for i in range(max_length):
        predictions, hidden, attention_weights = decoder(dec_input, features,␣
↪hidden)
        attention_plot[i] = tf.reshape(attention_weights, (-1, )).numpy()

        predicted_id = tf.random.categorical(predictions, 1)[0][0].numpy()
        result.append(tokenizer.index_word[predicted_id])

        if tokenizer.index_word[predicted_id] == '<end>':
            return result, attention_plot

        dec_input = tf.expand_dims([predicted_id], 0)

    attention_plot = attention_plot[:len(result), :]
    return result, attention_plot
```

[0]:
```
def plot_attention(image, result, attention_plot):
    temp_image = np.array(Image.open(image))

    fig = plt.figure(figsize=(15, 12))

    len_result = len(result)
    for l in range(len_result):
        temp_att = np.resize(attention_plot[l], (8, 8))
        ax = fig.add_subplot(len_result//2, len_result//2, l+1)
        ax.set_title(result[l])
        img = ax.imshow(temp_image)
        ax.axis("off")
        ax.imshow(temp_att, cmap='gray', alpha=0.6, extent=img.get_extent())

    plt.tight_layout()
    plt.show()
```

[0]:
```
def predict(id=None, name=None, encoder=encoder, decoder=decoder):

    # captions on the validation set
    if id == None and name==None:
        rid = np.random.randint(0, len(img_name_val))
    else:
        rid = id

    if rid:
```

```
        real_caption = ' '.join([tokenizer.index_word[i] for i in cap_val[rid]␣
↪if i not in [0]])
        print ('Real Caption:', real_caption)



    if name == None:
        image = img_name_val[rid]
    else:
        image = name
        rid=None

    result, attention_plot = evaluate(image, encoder=encoder, decoder=decoder)
    print ('Prediction Caption:', ' '.join(result))
    print(rid, image)
    plot_attention(image, result, attention_plot)
    plt.figure(figsize=(12, 10))
    img = mpimg.imread(image)
    plt.imshow(img)
    plt.axis("off")
```

8 Saving Weights

[0]:
```
import shutil

try:
    shutil.rmtree("/content/Attention")
    shutil.rmtree("/content/Decoder")
    shutil.rmtree("/content/Encoder")
except:
    pass
```

[0]:
```
# SAVING
## ENCODER
from google.colab import files

def save():
    encoder.save_weights("./Encoder/encoder_weights", save_format='tf')

    ## Attention
    attention.save_weights("./Attention/attention_weights", save_format='tf')

    ## Decoder
    decoder.save_weights("./Decoder/decoder_weights", save_format='tf')

    # DOWNLOADING WEIGHTS
```

```
!zip -rq Attention.zip ./Attention
!zip -rq Encoder.zip ./Encoder
!zip -rq Decoder.zip ./Decoder

!zip -rq all.zip Attention.zip Encoder.zip Decoder.zip
!rm -rf Attention.zip Decoder.zip Encoder.zip


shutil.rmtree("/content/Attention")
shutil.rmtree("/content/Decoder")
shutil.rmtree("/content/Encoder")

# files.download('all.zip')
# !rm -rf all.zip
```

9 Step 6: Training

- You extract the features stored in the respective `.npy` files and then pass those features through the encoder.
- The encoder output, hidden state(initialized to 0) and the decoder input (which is the start token) is passed to the decoder.
- The decoder returns the predictions and the decoder hidden state.
- The decoder hidden state is then passed back into the model and the predictions are used to calculate the loss.
- Use teacher forcing to decide the next input to the decoder.
- Teacher forcing is the technique where the target word is passed as the next input to the decoder.
- The final step is to calculate the gradients and apply it to the optimizer and backpropagate.

[0]:
```
train_loss_plot = []
valid_loss_plot = []
```

[0]:
```
# @tf.function
def train_step(img_tensor, target, encoder=None, decoder=None):
    loss = 0

    # initializing the hidden state for each batch
    # because the captions are not related from image to image
    hidden = decoder.reset_state(batch_size=target.shape[0])

    dec_input = tf.expand_dims([tokenizer.word_index['<start>']] * target.
 ↪shape[0], 1)

    with tf.GradientTape() as tape:
        features = encoder(img_tensor)
```

```
        for i in range(1, target.shape[1]):
            predictions, hidden, _ = decoder(dec_input, features, hidden,␣
↪"lstm")
            loss += loss_function(target[:, i], predictions)
            dec_input = tf.expand_dims(target[:, i], 1)

    total_loss = (loss / int(target.shape[1]))
    trainable_variables = encoder.trainable_variables + decoder.
↪trainable_variables
    gradients = tape.gradient(loss, trainable_variables)
    optimizer.apply_gradients(zip(gradients, trainable_variables))
    return loss, total_loss


# @tf.function
def valid_step(img_tensor, target, encoder=None, decoder=None):
    loss = 0
    hidden = decoder.reset_state(batch_size=target.shape[0])
    dec_input = tf.expand_dims([tokenizer.word_index['<start>']] * target.
↪shape[0], 1)

    features = encoder(img_tensor)
    for i in range(1, target.shape[1]):
        predictions, hidden, _ = decoder(dec_input, features, hidden, "lstm")
        loss += loss_function(target[:, i], predictions)
        dec_input = tf.expand_dims(target[:, i], 1)

    total_loss = (loss / int(target.shape[1]))

    return loss, total_loss
```

[0]:
```
def startTraining(start_epoch, EPOCHS, training_data=None,␣
↪validation_data=None, encoder=None, decoder=None):
    for epoch in range(start_epoch, EPOCHS):
        start = time.time()
        train_total_loss = 0
        valid_total_loss = 0

        train_num_steps = 0
        valid_num_steps = 0


        for (batch, (img_tensor, target)) in enumerate(training_data):
            batch_loss, t_loss = train_step(img_tensor, target, encoder,␣
↪decoder)
            train_total_loss += t_loss
            train_num_steps += 1
```

```
            if batch % 100 == 0:
                print (f'Epoch {epoch + 1} Batch {batch} Loss {batch_loss.
↪numpy()/int(target.shape[1]):.4f}')


        for (b, (tensor, tar)) in enumerate(validation_data):
            # print(tensor, tar)
            _, t_loss = valid_step(tensor, tar, encoder, decoder)
            valid_total_loss += t_loss
            valid_num_steps += 1


        train_loss_steps = train_total_loss / train_num_steps
        valid_loss_steps = valid_total_loss / valid_num_steps

        train_loss_plot.append(train_loss_steps)
        valid_loss_plot.append(valid_loss_steps)


        # if epoch % 3 == 0:
        #     ckpt_manager.save()

        print (f'Epoch: {epoch + 1}; Train Loss: {train_loss_steps:.6f};␣
↪Validation loss: {valid_loss_steps:.6f}')
        print (f'Time taken for {epoch + 1}; Epoch {time.time() - start} sec\n')

        wandb.log({"train_loss": train_loss_steps, "valid_loss":␣
↪valid_loss_steps, "epoch": epoch + 1})

        if input("Save weights: ") == "y":
            save()
            print("Weights Saved")

        if input("Terminate: ") == "y":
            print("finished Training")
            return None
```

[0]:
```
encoder = CNN_Encoder(embedding_dim)
attention = SoftAttention(units)
decoder = RNN_Decoder(attention, embedding_dim, units, vocab_size)
```

[61]:
```
startTraining(start_epoch, EPOCHS, training_data=train_dataset,␣
↪validation_data=valid_dataset, encoder=encoder, decoder=decoder)
```

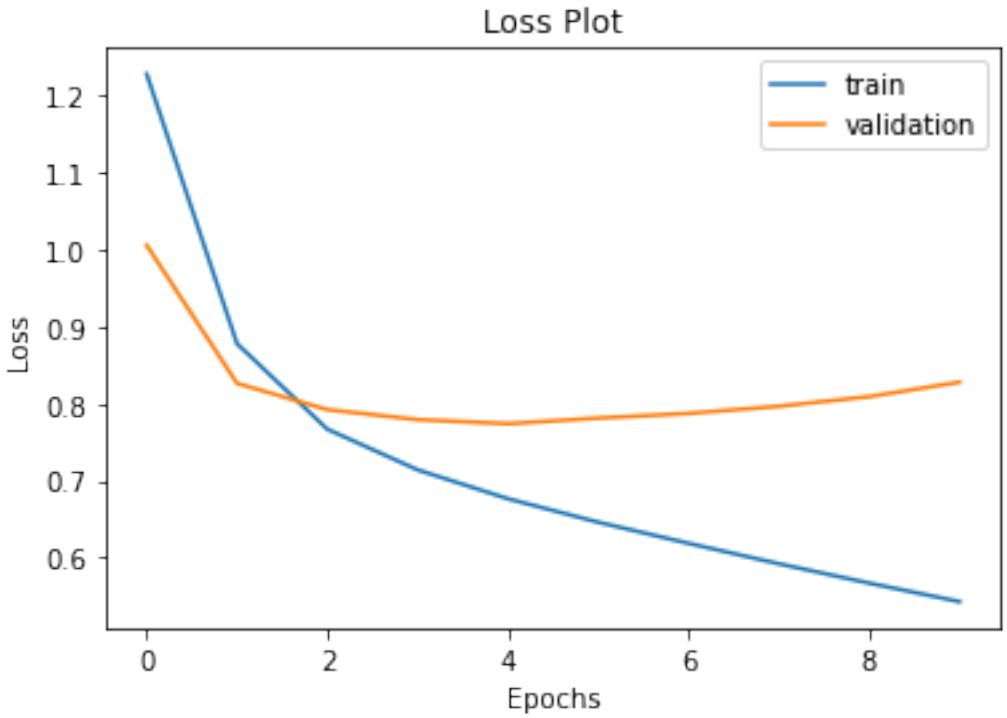
```
Epoch 1 Batch 0 Loss 2.1394
Epoch 1 Batch 100 Loss 1.3223
Epoch 1 Batch 200 Loss 1.2835
```

```
Epoch 1 Batch 300 Loss 1.2329
Epoch 1 Batch 400 Loss 1.1657
Epoch 1 Batch 500 Loss 1.0535
Epoch: 1; Train Loss: 1.228358; Validation loss: 1.005958
Time taken for 1; Epoch 850.2502801418304 sec

Save weights: y
Weights Saved
Terminate: n
Epoch 2 Batch 0 Loss 0.9921
Epoch 2 Batch 100 Loss 0.9718
Epoch 2 Batch 200 Loss 0.9550
Epoch 2 Batch 300 Loss 0.9418
Epoch 2 Batch 400 Loss 0.8109
Epoch 2 Batch 500 Loss 0.8075
Epoch: 2; Train Loss: 0.878002; Validation loss: 0.826471
Time taken for 2; Epoch 864.7819554805756 sec

Save weights: y
Weights Saved
Terminate: n
Epoch 3 Batch 0 Loss 0.7966
Epoch 3 Batch 100 Loss 0.8063
Epoch 3 Batch 200 Loss 0.8142
Epoch 3 Batch 300 Loss 0.7205
Epoch 3 Batch 400 Loss 0.6949
Epoch 3 Batch 500 Loss 0.7867
Epoch: 3; Train Loss: 0.766892; Validation loss: 0.792328
Time taken for 3; Epoch 866.5353519916534 sec

Save weights: y
Weights Saved
Terminate: n
Epoch 4 Batch 0 Loss 0.7862
Epoch 4 Batch 100 Loss 0.6735
Epoch 4 Batch 200 Loss 0.7137
Epoch 4 Batch 300 Loss 0.7040
Epoch 4 Batch 400 Loss 0.6861
Epoch 4 Batch 500 Loss 0.7380
Epoch: 4; Train Loss: 0.714045; Validation loss: 0.779327
Time taken for 4; Epoch 873.8853802680969 sec

Save weights: y
Weights Saved
Terminate: n
Epoch 5 Batch 0 Loss 0.7145
Epoch 5 Batch 100 Loss 0.6868
Epoch 5 Batch 200 Loss 0.7124
```

```
Epoch 5 Batch 300 Loss 0.6534
Epoch 5 Batch 400 Loss 0.6597
Epoch 5 Batch 500 Loss 0.6590
Epoch: 5; Train Loss: 0.676530; Validation loss: 0.774025
Time taken for 5; Epoch 872.0828177928925 sec

Save weights: y
Weights Saved
Terminate: n
Epoch 6 Batch 0 Loss 0.7419
Epoch 6 Batch 100 Loss 0.6085
Epoch 6 Batch 200 Loss 0.6504
Epoch 6 Batch 300 Loss 0.6121
Epoch 6 Batch 400 Loss 0.6141
Epoch 6 Batch 500 Loss 0.7018
Epoch: 6; Train Loss: 0.646019; Validation loss: 0.781322
Time taken for 6; Epoch 877.4589960575104 sec

Save weights: n
Terminate: n
Epoch 7 Batch 0 Loss 0.6581
Epoch 7 Batch 100 Loss 0.6662
Epoch 7 Batch 200 Loss 0.6422
Epoch 7 Batch 300 Loss 0.6173
Epoch 7 Batch 400 Loss 0.5924
Epoch 7 Batch 500 Loss 0.5870
Epoch: 7; Train Loss: 0.618556; Validation loss: 0.787416
Time taken for 7; Epoch 872.9390561580658 sec

Save weights: n
Terminate: n
Epoch 8 Batch 0 Loss 0.6305
Epoch 8 Batch 100 Loss 0.5757
Epoch 8 Batch 200 Loss 0.5977
Epoch 8 Batch 300 Loss 0.6197
Epoch 8 Batch 400 Loss 0.5765
Epoch 8 Batch 500 Loss 0.5455
Epoch: 8; Train Loss: 0.592001; Validation loss: 0.796695
Time taken for 8; Epoch 865.4335935115814 sec

Save weights: n
Terminate: n
Epoch 9 Batch 0 Loss 0.6293
Epoch 9 Batch 100 Loss 0.6162
Epoch 9 Batch 200 Loss 0.5778
Epoch 9 Batch 300 Loss 0.5799
Epoch 9 Batch 400 Loss 0.5657
Epoch 9 Batch 500 Loss 0.5653
```

```
Epoch: 9; Train Loss: 0.566862; Validation loss: 0.809250
Time taken for 9; Epoch 853.5799715518951 sec

Save weights: n
Terminate: n
Epoch 10 Batch 0 Loss 0.5499
Epoch 10 Batch 100 Loss 0.5461
Epoch 10 Batch 200 Loss 0.5043
Epoch 10 Batch 300 Loss 0.5540
Epoch 10 Batch 400 Loss 0.5671
Epoch 10 Batch 500 Loss 0.5759
Epoch: 10; Train Loss: 0.542814; Validation loss: 0.828003
Time taken for 10; Epoch 862.9952504634857 sec

Save weights: n
Terminate: y
finished Training
```

[62]:
```
plt.plot(train_loss_plot, label="train")
plt.plot(valid_loss_plot, label="validation")
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.title('Loss Plot')
plt.legend()
plt.show()
```



[0]:
```
# wandb.save('./checkpoints/train/*ckpt*')
```

10 Loading weights back

[0]:
```
!unzip -qq all.zip
!unzip -qq Attention.zip
!unzip -qq Encoder.zip
!unzip -qq Decoder.zip

!rm -rf Attention.zip Encoder.zip Decoder.zip
```

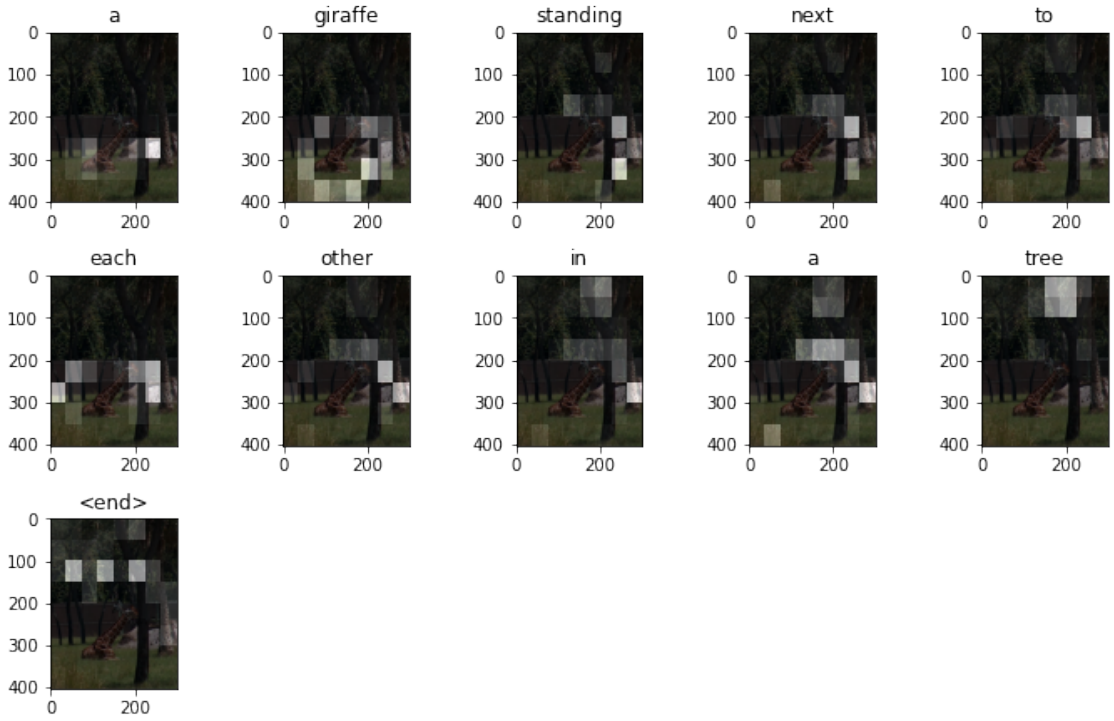
[65]:
```
encoder2 = CNN_Encoder(embedding_dim)
encoder2.load_weights("./Encoder/encoder_weights")

attention2 = SoftAttention(units)
attention2.load_weights("./Attention/attention_weights")

decoder2 = RNN_Decoder(attention, embedding_dim, units, vocab_size)
decoder2.load_weights("./Decoder/decoder_weights")
```

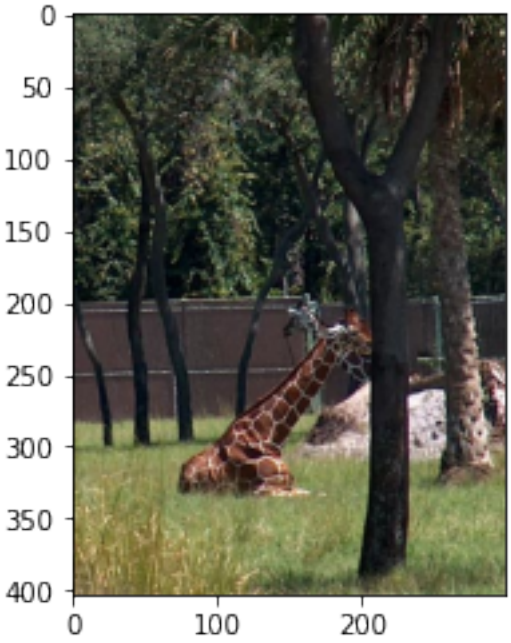
[65]:
```
<tensorflow.python.training.tracking.util.CheckpointLoadStatus at
0x7f8cf7e25ba8>
```

11 Step 7: Prediction

[0]:
```
# testing on validation set
```

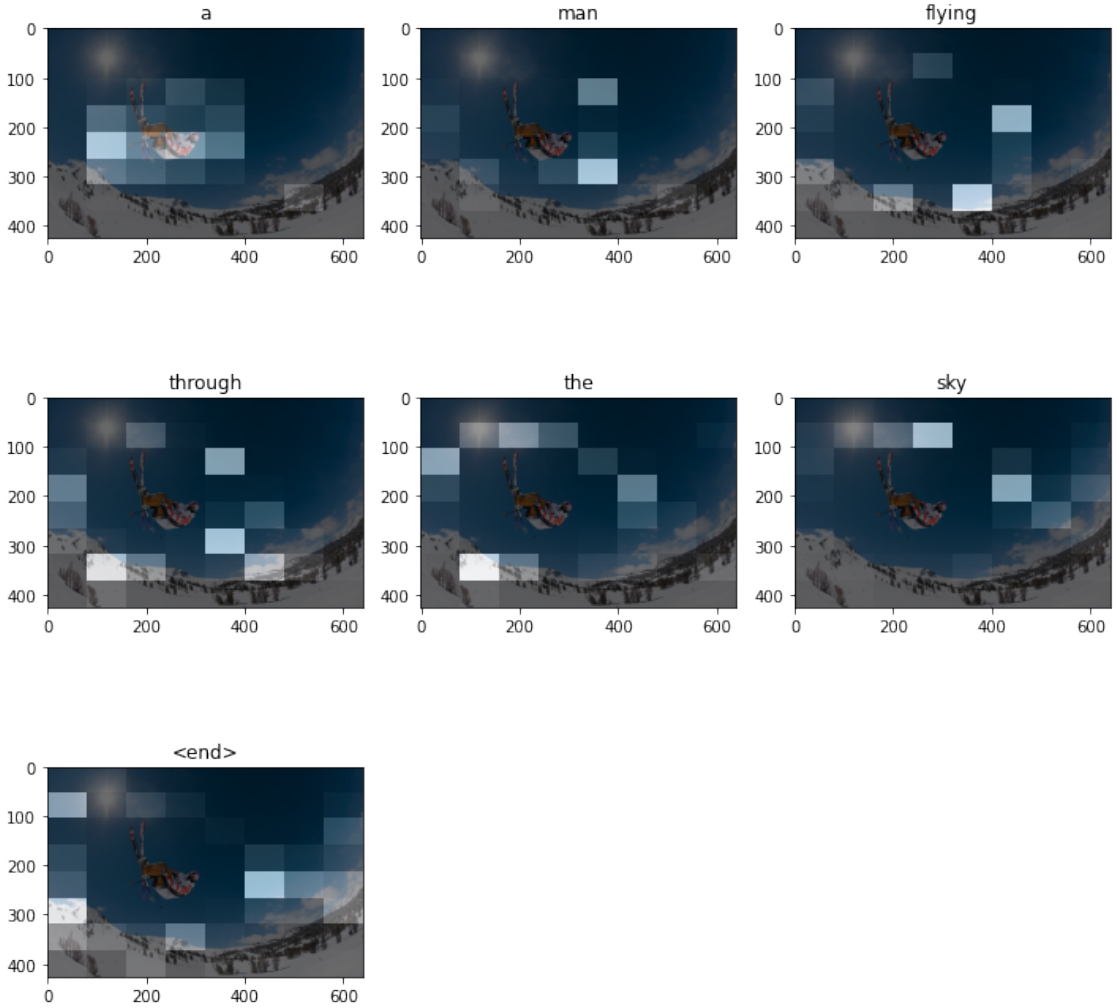
```
WARNING:tensorflow:10 out of the last 10 calls to <function load_image at
0x7fe7a0ebb840> triggered tf.function retracing. Tracing is expensive and the
excessive number of tracings is likely due to passing python objects instead of
tensors. Also, tf.function has experimental_relax_shapes=True option that
relaxes argument shapes that can avoid unnecessary retracing. Please refer to ht
tps://www.tensorflow.org/tutorials/customization/performance#python_or_tensor_ar
gs and https://www.tensorflow.org/api_docs/python/tf/function for more details.
Real Caption: <start> a giraffe laying on lush green grass next to trees <end>
Prediction Caption: a giraffe standing next to each other in a tree <end>
2963 /content/train2014/COCO_train2014_000000424978.jpg
```





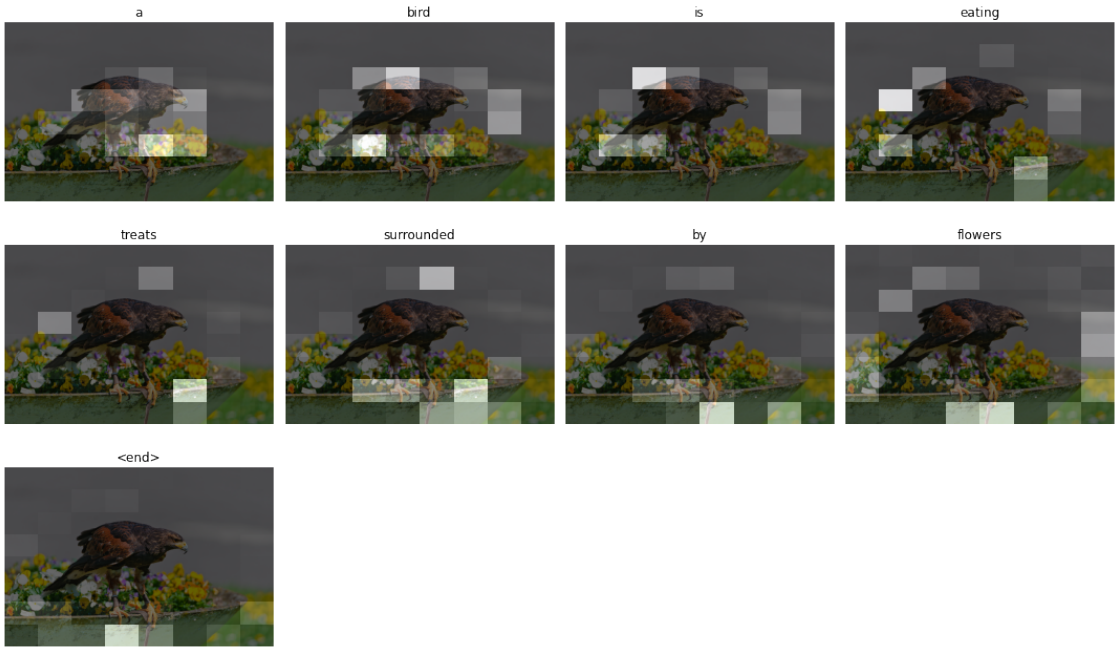
[0]:
```
predict()
```

```
WARNING:tensorflow:11 out of the last 11 calls to <function load_image at
0x7fe7a0ebb840> triggered tf.function retracing. Tracing is expensive and the
excessive number of tracings is likely due to passing python objects instead of
tensors. Also, tf.function has experimental_relax_shapes=True option that
relaxes argument shapes that can avoid unnecessary retracing. Please refer to ht
tps://www.tensorflow.org/tutorials/customization/performance#python_or_tensor_ar
gs and https://www.tensorflow.org/api_docs/python/tf/function for more details.
Real Caption: <start> a man on snow skis who is performing a jump <end>
Prediction Caption: a man flying through the sky <end>
8032 /content/train2014/COCO_train2014_000000247906.jpg
```



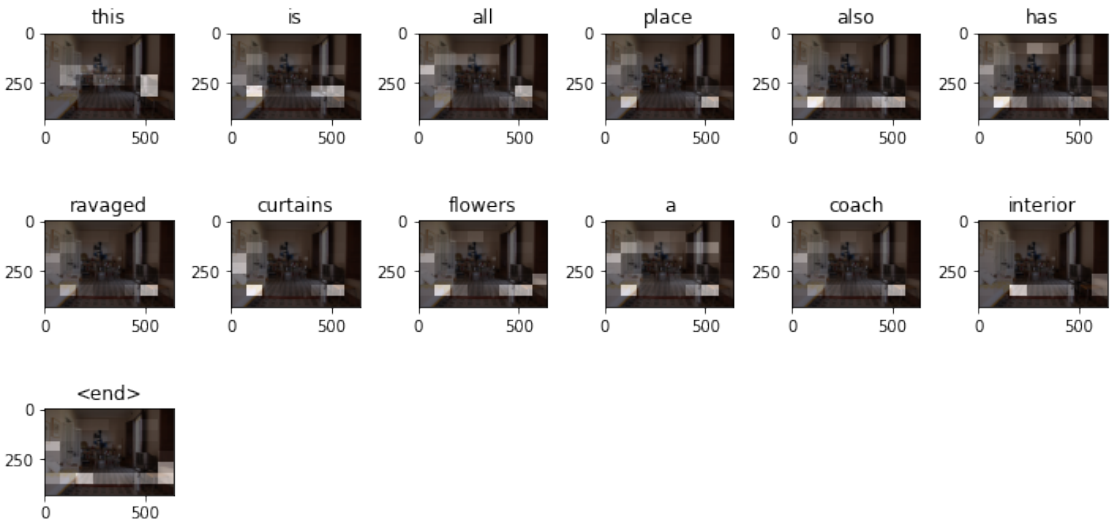
[71]:
```
predict(2936, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> bird on edge of sill looking to the left <end>
Prediction Caption: a bird is eating treats surrounded by flowers <end>
2936 /content/train2014/COCO_train2014_000000164997.jpg
```



[0]:
```
predict()
```

```
WARNING:tensorflow:11 out of the last 11 calls to <function load_image at
0x7fe7a0ebb840> triggered tf.function retracing. Tracing is expensive and the
excessive number of tracings is likely due to passing python objects instead of
tensors. Also, tf.function has experimental_relax_shapes=True option that
relaxes argument shapes that can avoid unnecessary retracing. Please refer to ht
tps://www.tensorflow.org/tutorials/customization/performance#python_or_tensor_ar
gs and https://www.tensorflow.org/api_docs/python/tf/function for more details.
Real Caption: <start> a empty kitchen that has table with two chairs <end>
Prediction Caption: this is all place also has ravaged curtains flowers a coach
interior <end>
6286 /content/train2014/COCO_train2014_000000365003.jpg
```



[76]:
```
predict(encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a baby is lying next to a large teddy bear <end>
Prediction Caption: a teddy bear is decorated with two teddy bear <end>
5402 /content/train2014/COCO_train2014_000000080016.jpg
```


a
teddy
bear
is
decorated
with
two
teddy
bear
<end>

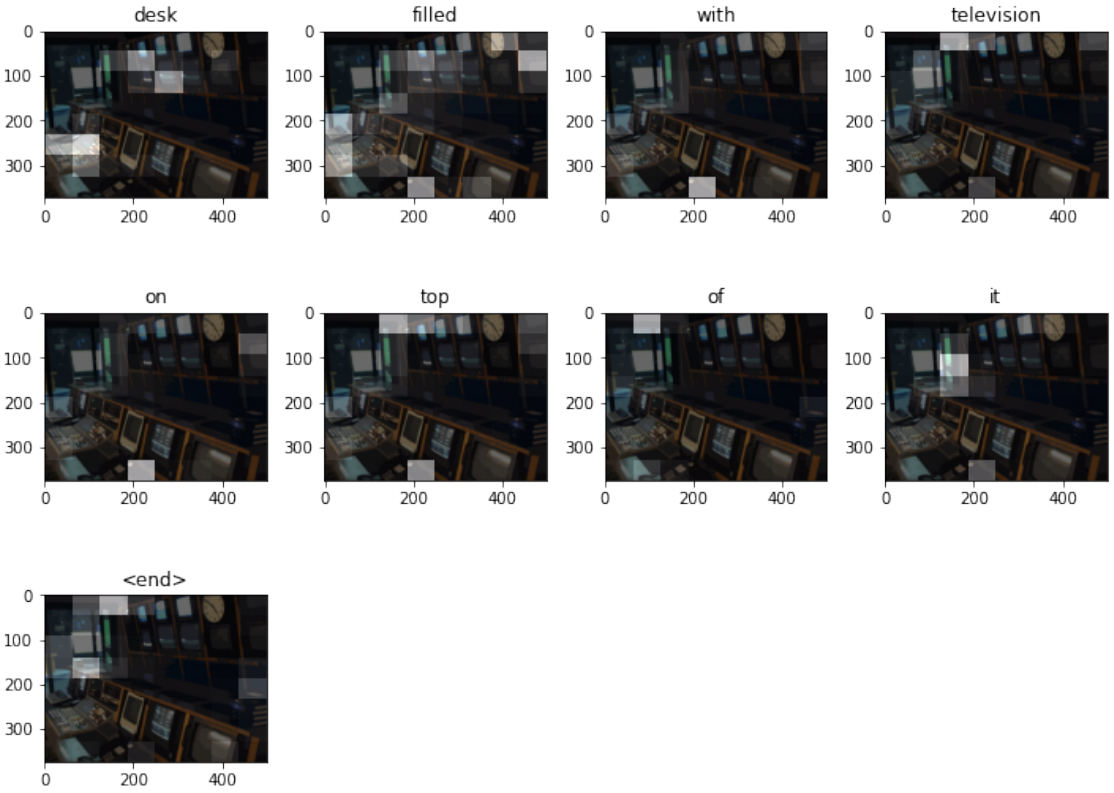
[78]:
```
predict(id=4046, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a couple of elephants that are by the pond <end>
```

```
Prediction Caption: a group of elephants relax along water in a body of water
<end>
4046 /content/train2014/COCO_train2014_000000080105.jpg
```

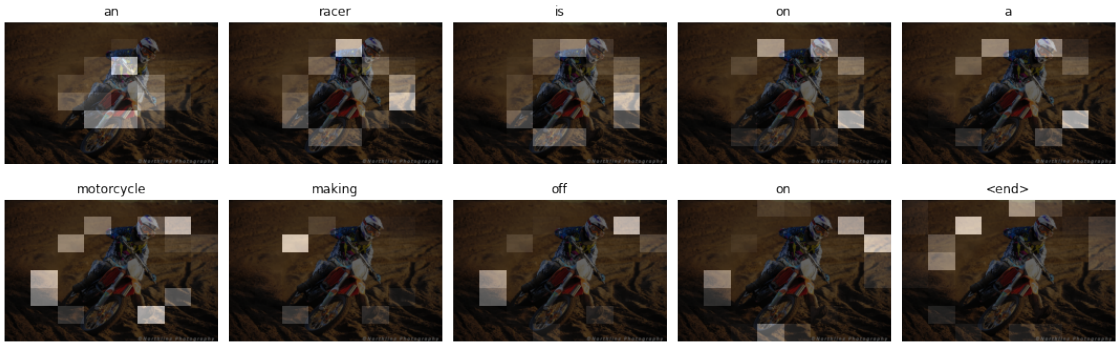
[0]:
```
predict(id=2187, encoder=encoder2, decoder=decoder2)
```

```
WARNING:tensorflow:11 out of the last 11 calls to <function load_image at
0x7fe7a0ebb840> triggered tf.function retracing. Tracing is expensive and the
excessive number of tracings is likely due to passing python objects instead of
tensors. Also, tf.function has experimental_relax_shapes=True option that
relaxes argument shapes that can avoid unnecessary retracing. Please refer to ht
tps://www.tensorflow.org/tutorials/customization/performance#python_or_tensor_ar
gs and https://www.tensorflow.org/api_docs/python/tf/function for more details.
Real Caption: <start> a room with rows of televisions and a vhs tapes <end>
Prediction Caption: desk filled with television on top of it <end>
2187 /content/train2014/COCO_train2014_000000442774.jpg
```



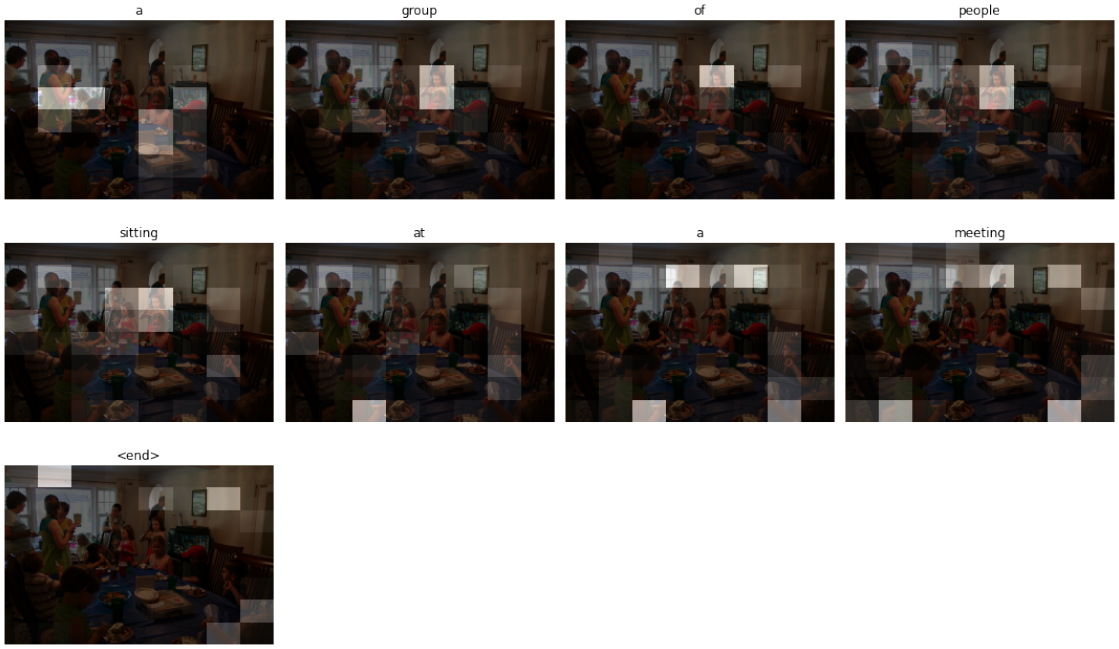
[82]:
```
predict(id=10, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a man riding a dirt bike on top of a dirt road <end>
Prediction Caption: an racer is on a motorcycle making off on <end>
10 /content/train2014/COCO_train2014_000000439268.jpg
```



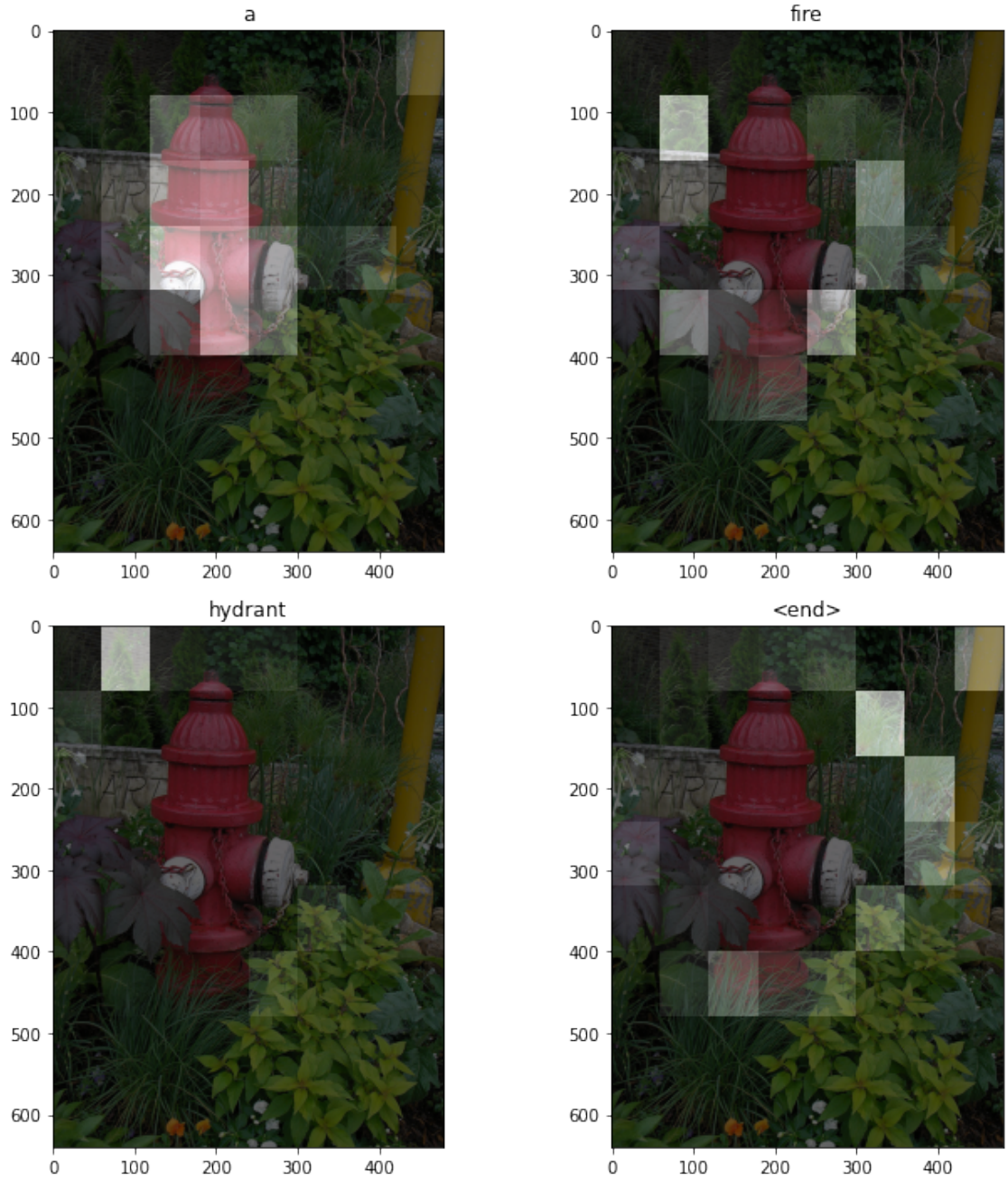
[83]:
```
predict(882, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a group of people sitting and standing around a table
<end>
Prediction Caption: a group of people sitting at a meeting <end>
882 /content/train2014/COCO_train2014_000000468125.jpg
```



[0]:
```
predict(341, encoder=encoder2, decoder=decoder2)
```

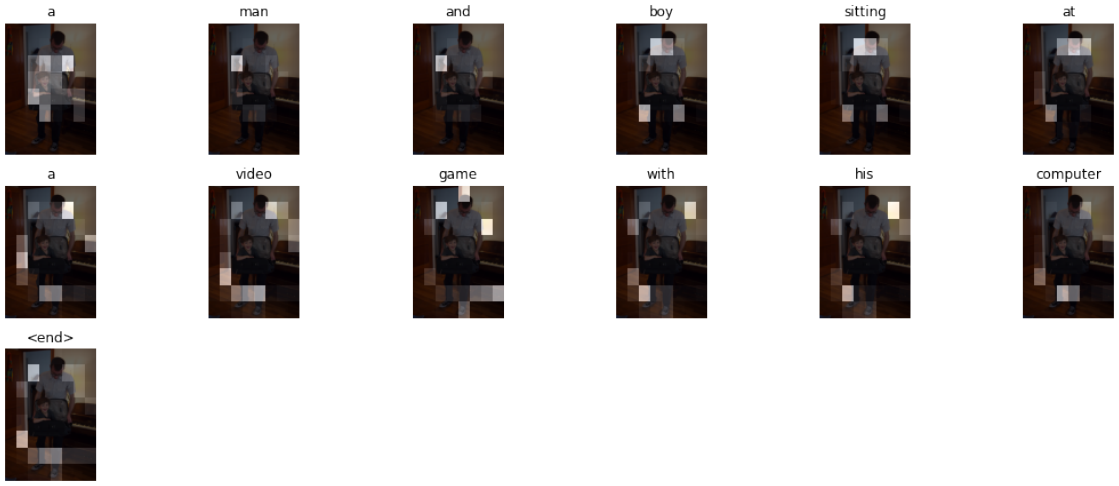
```
Real Caption: <start> a red fire hydrant surrounded by a lush garden <end>
Prediction Caption: a fire hydrant <end>
341 /content/train2014/COCO_train2014_000000143339.jpg
```



[91]:
```
predict(8800, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a man holding a piece of luggage with a kid inside of it
```

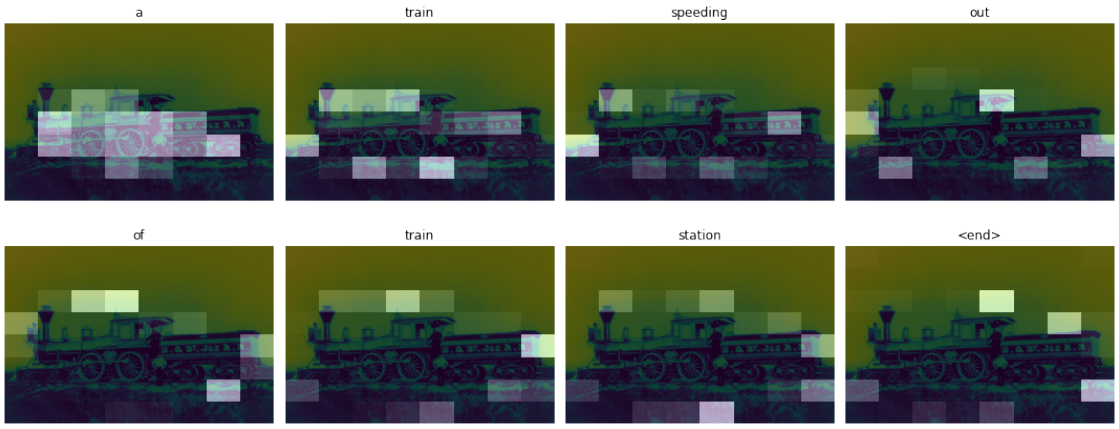
```
<end>
Prediction Caption: a man and boy sitting at a video game with his computer
<end>
8800 /content/train2014/COCO_train2014_000000283548.jpg
```



[92]:
```
predict(6607, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a train with two people in front of it during a sunny day
```

<end>
Prediction Caption: a train speeding out of train station <end>
6607 /content/train2014/COCO_train2014_000000480482.jpg



[93]:
```
predict(326, encoder=encoder2, decoder=decoder2)
```

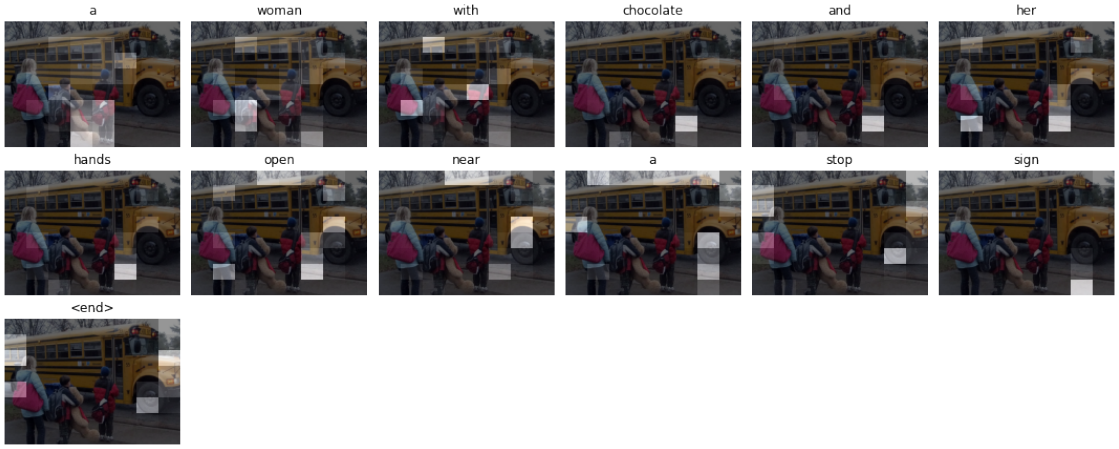
Real Caption: <start> several dishes of various types of fruits vegetables <unk> and soup <end>
Prediction Caption: a restaurant table topped with plates are layed along by a

```
table near plastic bottles <end>
326 /content/train2014/COCO_train2014_000000419666.jpg
```

[98]:
```
predict(8834, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> there are children that are boarding the school bus <end>
```

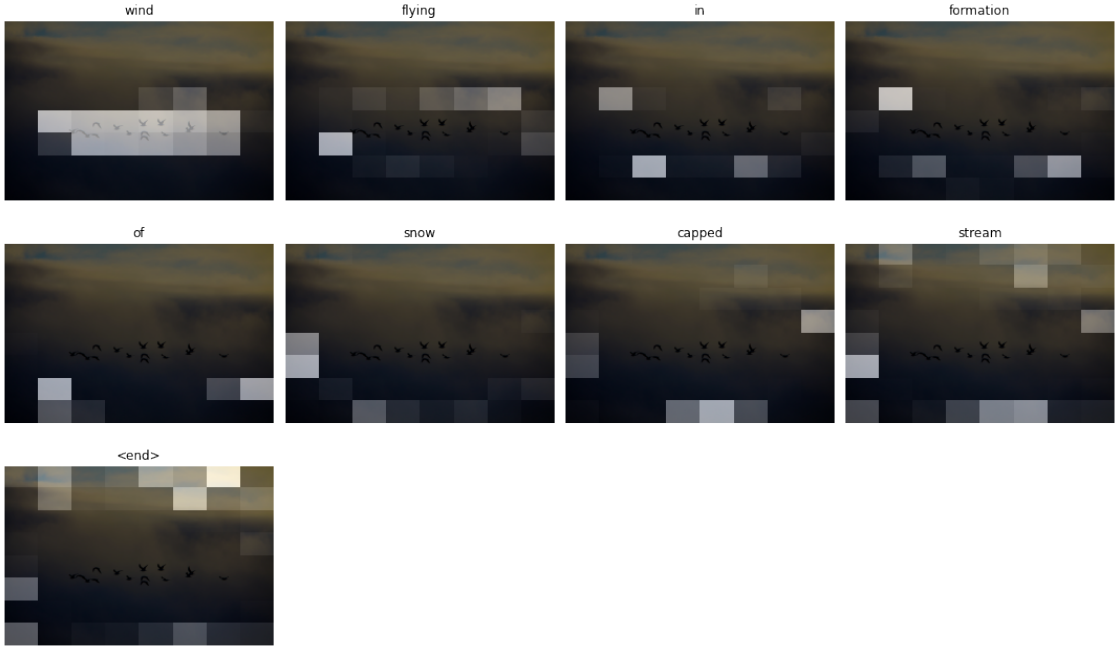
```
Prediction Caption: a woman with chocolate and her hands open near a stop sign
<end>
8834 /content/train2014/COCO_train2014_000000205283.jpg
```



[103]:
```
predict(5863, encoder=encoder2, decoder=decoder2)
```

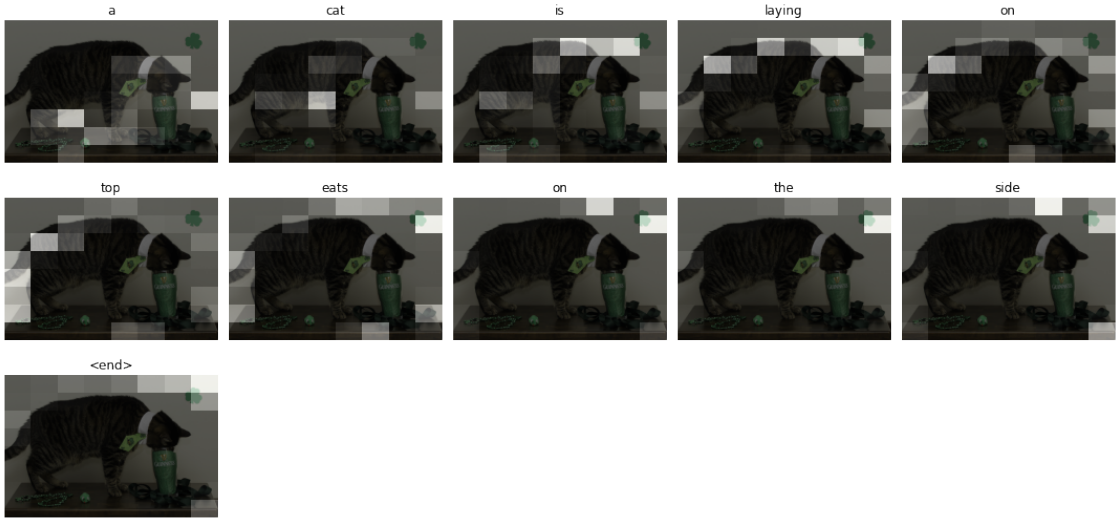
```
Real Caption: <start> black birds are flying against a cloudy sky <end>
```

Prediction Caption: wind flying in formation of snow capped stream <end>
5863 /content/train2014/COCO_train2014_000000514356.jpg



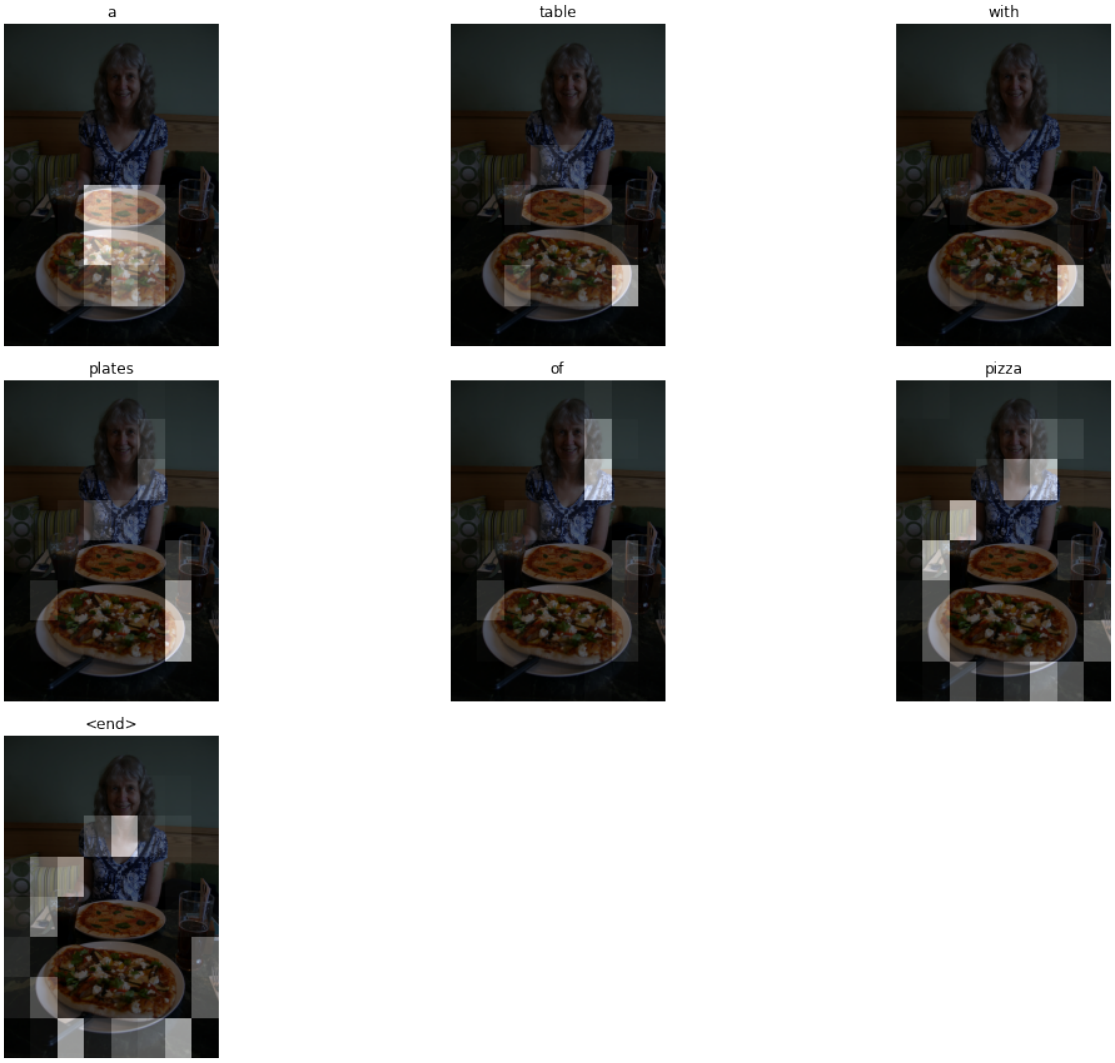
[109]:
```
predict(2722, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a brown and black cat puts his face in a cup <end>
Prediction Caption: a cat is laying on top eats on the side <end>
2722 /content/train2014/COCO_train2014_000000276514.jpg
```



[114]:
```
predict(6739, encoder=encoder2, decoder=decoder2)
```

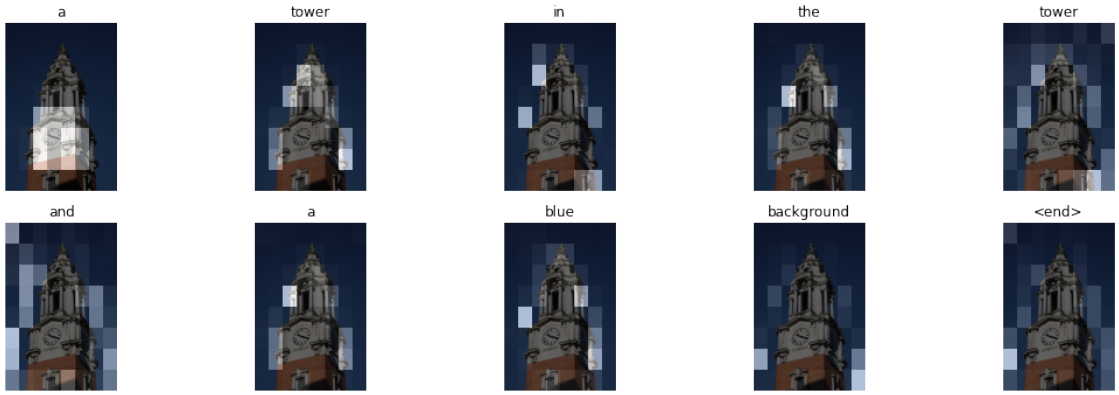
```
Real Caption: <start> a woman sits at a table with pizza and drinks <end>
Prediction Caption: a table with plates of pizza <end>
6739 /content/train2014/COCO_train2014_000000081201.jpg
```



[0]:
```
predict(id=884, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a large tower has a clock towards the top <end>
```

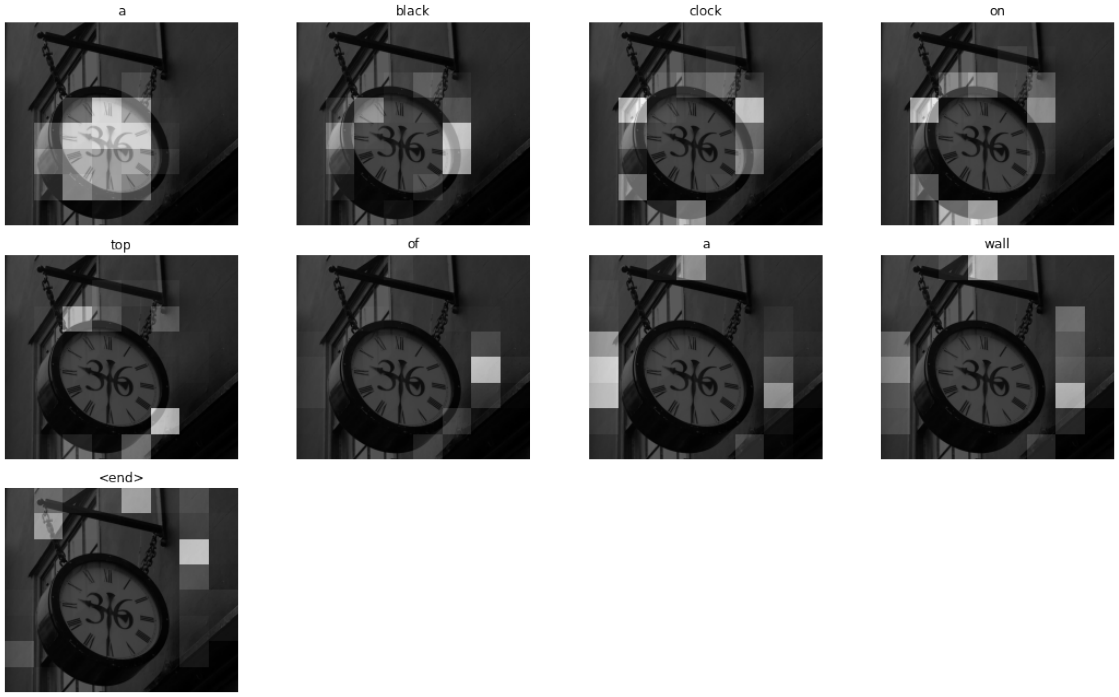
```
Prediction Caption: a tower in the tower and a blue background <end>
884 /content/train2014/COCO_train2014_000000576608.jpg
```



[147]:
```
predict(id=5555, encoder=encoder2, decoder=decoder2)
```

```
Real Caption: <start> a round clock with the numbers 3 and 6 in the center is
```

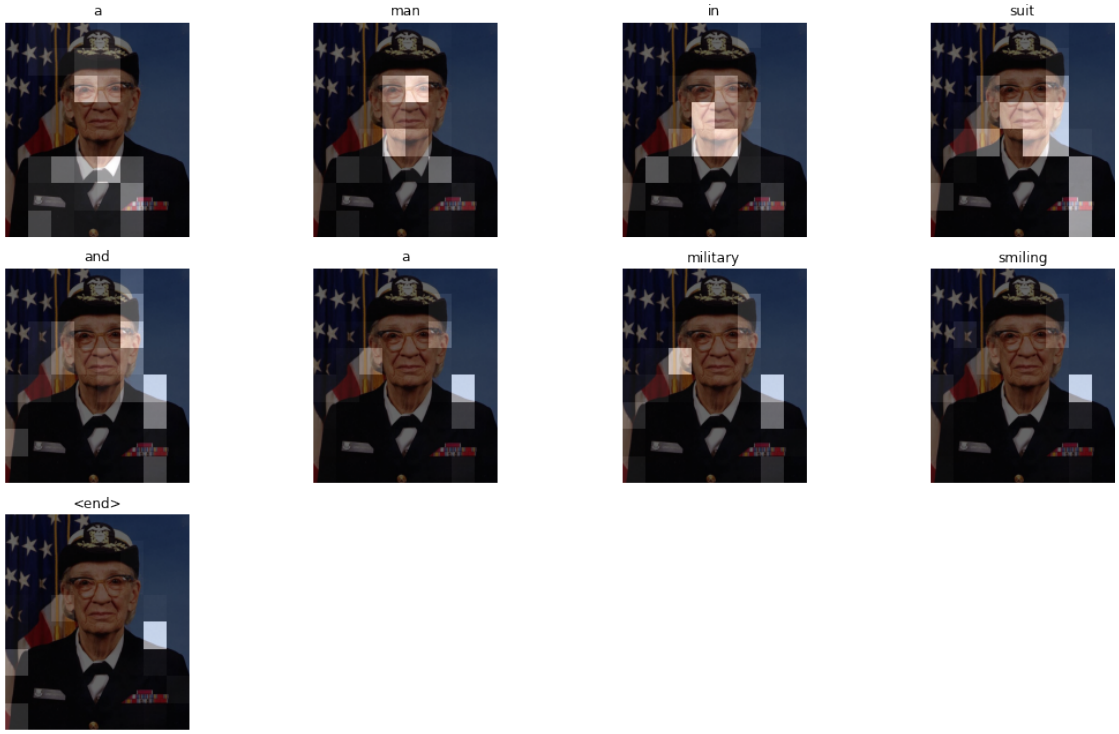
hanging from two black metal chains with a time of 9 31 <end>
Prediction Caption: a black clock on top of a wall <end>
5555 /content/train2014/COCO_train2014_000000160589.jpg



12 Testing on other images

[163]:
```
image_url = "https://www.tensorflow.org/tutorials/text/image_captioning_files/
 ↪output_9Psd1quzaAWg_2.png" #@param {type:"string"}
image_extension = image_url[-4:]
image_path = tf.keras.utils.get_file('image'+image_extension,
                                     cache_subdir="/content/",
                                     origin=image_url)
predict(name=image_path, encoder=encoder2, decoder=decoder2)
os.remove(image_path)
```

```
Downloading data from https://www.tensorflow.org/tutorials/text/image_captioning
_files/output_9Psd1quzaAWg_2.png
458752/458338 [==============================] - 0s 0us/step
Prediction Caption: a man in suit and a military smiling <end>
None /content/image.png
```


a
man
in
suit
and
a
military
smiling
<end>

[167]:
```
image_url = "https://raw.githubusercontent.com/veb-101/Image-Captioning/master/
 ↪test_images/laptop_working.jpg" #@param {type:"string"}
image_extension = image_url[-4:]
image_path = tf.keras.utils.get_file('image'+image_extension,
                                     cache_subdir="/content/",
                                     origin=image_url)
predict(name=image_path, encoder=encoder2, decoder=decoder2)
```

```
os.remove(image_path)
```

```
Downloading data from https://raw.githubusercontent.com/veb-101/Image-
Captioning/master/test_images/laptop_working.jpg
8192/7003 [==================================] - 0s 0us/step
Prediction Caption: a man is sitting in an apartment complex with long table
with a cell phone phones <end>
None /content/image.jpg
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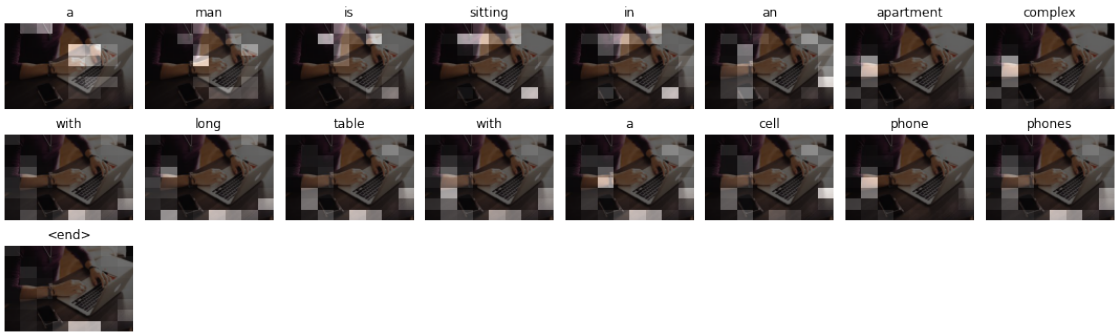

[0]:

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Prediction Caption: various vehicles on both sides <end>
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↪#@param {type:"string"}
image_extension = image_url[-4:]
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predict(name=image_path, encoder=encoder2, decoder=decoder2)
os.remove(image_path)
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Downloading data from https://images.unsplash.com/photo-1565560665589-37da0a3899
49?ixlib=rb-1.2.1&ixid=eyJhcHBfaWQiOjEyMDd9&auto=format&fit=crop&w=500&q=60
98304/95861 [==============================] - 0s 0us/step
Prediction Caption: men with bags on street <end>
None /content/imageq=60
```


men
with
bags
on
street
<end>


TAURANT
NARGILE