In [54]:
```
import zipfile

# Specify the paths to the zip files
flickr8k_dataset_zip = 'Flickr8k_Dataset.zip'
flickr8k_text_zip = 'Flickr8k_text.zip'

# Specify the directories where you want to extract the files
dataset_extract_dir = 'zipfileCNN+NLPt'
text_extract_dir = 'zipfileCNN+NLP'

# Unzip the Flickr8k_Dataset.zip file
with zipfile.ZipFile(flickr8k_dataset_zip, 'r') as zip_ref:
    zip_ref.extractall(dataset_extract_dir)

# Unzip the Flickr8k_text.zip file
with zipfile.ZipFile(flickr8k_text_zip, 'r') as zip_ref:
    zip_ref.extractall(text_extract_dir)

print("Files extracted successfully!")
```
```
Files extracted successfully!
```

In [ ]:
```
pip install --upgrade tensorflow
```

In [2]:
```
import numpy as np
from numpy import array
import matplotlib.pyplot as plt
%matplotlib inline

import string
import os
import glob
from PIL import Image
from time import time

from keras import Input, layers
from keras import optimizers
from keras.optimizers import Adam
from keras.preprocessing import sequence
from keras.preprocessing import image

from keras.preprocessing.sequence import pad_sequences
from keras.layers import LSTM, Embedding, Dense, Activation, Flatten, Reshape, Dropout


from keras.applications.inception_v3 import InceptionV3
from keras.applications.inception_v3 import preprocess_input
from keras.models import Model
from tensorflow.keras.utils import to_categorical
import pickle
```

In [3]:
```
import tensorflow as tf
from tensorflow.keras.preprocessing import sequence
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.layers import LSTM, Embedding, Dense, Activation, Flatten, Reshape, Dropout
import tensorflow as tf
from tensorflow.keras.preprocessing import sequence
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.layers import LSTM, Embedding, Dense, Activation, Flatten, Reshape, Dropout, Bidirectional
from tensorflow.keras.layers import Add
from tensorflow.keras.applications import InceptionV3

import tensorflow as tf
from tensorflow.keras.preprocessing import sequence
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.layers import LSTM, Embedding, Dense, Activation, Flatten, Reshape, Dropout, Bidirectional
from tensorflow.keras.layers import Add
from tensorflow.keras.applications import InceptionV3
```

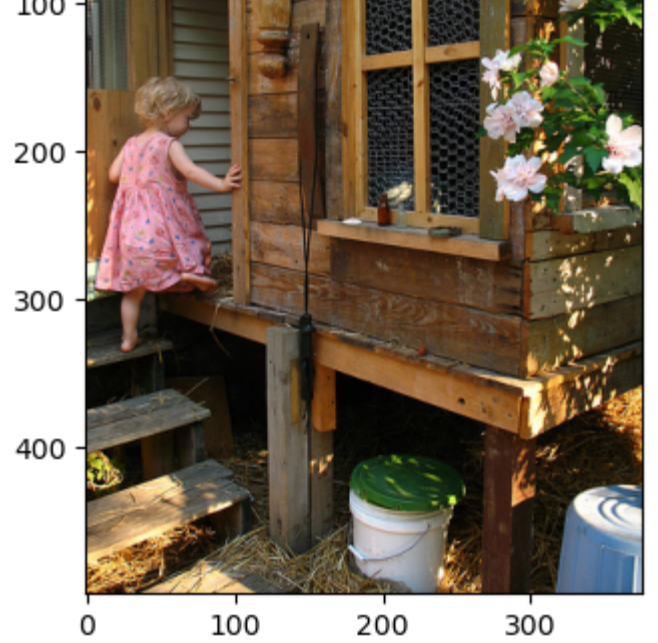
In [4]:
```
token_path = "zipfileCNN+NLP/Flickr8k.token.txt"
train_images_path = 'zipfileCNN+NLP/Flickr_8k.trainImages.txt'
test_images_path = 'zipfileCNN+NLP/Flickr_8k.testImages.txt'
images_path = 'zipfileCNN+NLPt/Flicker8k_Dataset'

doc = open(token_path,'r').read()
print(doc[:410])
```
```
1000268201_693b08cb0e.jpg#0     A child in a pink dress is climbing up a set of stairs in an entry way .
1000268201_693b08cb0e.jpg#1     A girl going into a wooden building .
1000268201_693b08cb0e.jpg#2     A little girl climbing into a wooden playhouse .
1000268201_693b08cb0e.jpg#3     A little girl climbing the stairs to her playhouse .
1000268201_693b08cb0e.jpg#4     A little girl in a pink dress going into a wooden cabin .
```

In [8]:
```
descriptions = dict()
for line in doc.split('\n'):
        tokens = line.split()
        if len(line) > 2:
          image_id = tokens[0].split('.')[0]
          image_desc = ' '.join(tokens[1:])
          if image_id not in descriptions:
              descriptions[image_id] = list()
          descriptions[image_id].append(image_desc)
descriptions['1000268201_693b08cb0e']
```

Out[8]:
```
['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 .']
```

In [10]:
```
table = str.maketrans('', '', string.punctuation)
for key, desc_list in descriptions.items():
    for i in range(len(desc_list)):
        desc = desc_list[i]
        desc = desc.split()
        desc = [word.lower() for word in desc]
        desc = [w.translate(table) for w in desc]
        desc_list[i] =  ' '.join(desc)
```

In [12]:
```
images_path = 'zipfileCNN+NLPt/Flicker8k_Dataset/'
pic = '1000268201_693b08cb0e.jpg'
x=plt.imread(images_path+pic)
plt.imshow(x)
plt.show()
descriptions['1000268201_693b08cb0e']
```



Out[12]:
```
['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 ']
```

In [14]:
```
vocabulary = set()
for key in descriptions.keys():
        [vocabulary.update(d.split()) for d in descriptions[key]]
print('Original Vocabulary Size: %d' % len(vocabulary))
```
```
Original Vocabulary Size: 8828
```

In [18]:
```
lines = list()
for key, desc_list in descriptions.items():
    for desc in desc_list:
        lines.append(key + ' ' + desc)
new_descriptions = '\n'.join(lines)
```

In [20]:
```
doc = open(train_images_path,'r').read()
dataset = list()
for line in doc.split('\n'):
    if len(line) > 1:
      identifier = line.split('.')[0]
      dataset.append(identifier)

train = set(dataset)
```

In [98]:
```
!wget http://nlp.stanford.edu/data/glove.6B.zip
!unzip glove.6B.zip
```
```
--2025-02-06 16:50:19--  http://nlp.stanford.edu/data/glove.6B.zip
Resolving nlp.stanford.edu (nlp.stanford.edu)... 171.64.67.140
Connecting to nlp.stanford.edu (nlp.stanford.edu)|171.64.67.140|:80... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://nlp.stanford.edu/data/glove.6B.zip [following]
--2025-02-06 16:50:20--  https://nlp.stanford.edu/data/glove.6B.zip
Connecting to nlp.stanford.edu (nlp.stanford.edu)|171.64.67.140|:443... connected.
Unable to establish SSL connection.
'unzip' is not recognized as an internal or external command,
operable program or batch file.
```

In [ ]:
```
img = glob.glob(images_path + '*.jpg')
train_images = set(open(train_images_path, 'r').read().strip().split('\n'))
train_img = []
for i in img:
    if i[len(images_path):] in train_images:
        train_img.append(i)

test_images = set(open(test_images_path, 'r').read().strip().split('\n'))
test_img = []
for i in img:
    if i[len(images_path):] in test_images:
        test_img.append(i)
```

In [ ]:
```
train_descriptions = dict()
for line in new_descriptions.split('\n'):
    tokens = line.split()
    image_id, image_desc = tokens[0], tokens[1:]
    if image_id in train:
        if image_id not in train_descriptions:
            train_descriptions[image_id] = list()
        desc = 'startseq ' + ' '.join(image_desc) + ' endseq'
        train_descriptions[image_id].append(desc)
```

In [ ]:
```
all_train_captions = []
for key, val in train_descriptions.items():
    for cap in val:
        all_train_captions.append(cap)
```

In [ ]:
```
word_count_threshold = 10
word_counts = {}
nsents = 0
for sent in all_train_captions:
    nsents += 1
    for w in sent.split(' '):
        word_counts[w] = word_counts.get(w, 0) + 1
vocab = [w for w in word_counts if word_counts[w] >= word_count_threshold]

print('Vocabulary = %d' % (len(vocab)))
```
```
Vocabulary = 1659
```

In [ ]:
```
ixtoword = {}
wordtoix = {}
ix = 1
for w in vocab:
    wordtoix[w] = ix
    ixtoword[ix] = w
    ix += 1

vocab_size = len(ixtoword) + 1
```

In [ ]:
```
all_desc = list()
for key in train_descriptions.keys():
    [all_desc.append(d) for d in train_descriptions[key]]
lines = all_desc
max_length = max(len(d.split()) for d in lines)

print('Description Length: %d' % max_length)
```
```
Description Length: 38
```

In [ ]:
```
embeddings_index = {}
f = open(os.path.join('glove.6B.200d.txt'), encoding="utf-8")
for line in f:
    values = line.split()
    word = values[0]
    coefs = np.asarray(values[1:], dtype='float32')
    embeddings_index[word] = coefs
```

In [ ]:
```
embedding_dim = 200
embedding_matrix = np.zeros((vocab_size, embedding_dim))
for word, i in wordtoix.items():
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None:
        embedding_matrix[i] = embedding_vector
```

In [ ]:
```
model = InceptionV3(weights='imagenet')
```

In [ ]:
```
model_new = Model(model.input, model.layers[-2].output)
```

In [ ]:
```
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
```

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

encoding_train = {}
for img in train_img:
    encoding_train[img[len(images_path):]] = encode(img)
train_features = encoding_train

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

In [ ]:
```
inputs1 = Input(shape=(2048,))
fe1 = Dropout(0.5)(inputs1)
fe2 = Dense(256, activation='relu')(fe1)

inputs2 = Input(shape=(max_length,))
se1 = Embedding(vocab_size, embedding_dim, mask_zero=True)(inputs2)
se2 = Dropout(0.5)(se1)
se3 = LSTM(256)(se2)

decoder1 = add([fe2, se3])
decoder2 = Dense(256, activation='relu')(decoder1)
outputs = Dense(vocab_size, activation='softmax')(decoder2)

model = Model(inputs=[inputs1, inputs2], outputs=outputs)
model.summary()
```
```
Model: "model_1"
__________________________________________________________________________________________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================================
input_3 (InputLayer)            [(None, 38)]         0
__________________________________________________________________________________________________
input_2 (InputLayer)            [(None, 2048)]       0
__________________________________________________________________________________________________
embedding (Embedding)           (None, 38, 200)      332000      input_3[0][0]
__________________________________________________________________________________________________
dropout (Dropout)               (None, 2048)         0           input_2[0][0]
__________________________________________________________________________________________________
dropout_1 (Dropout)             (None, 38, 200)      0           embedding[0][0]
__________________________________________________________________________________________________
dense (Dense)                   (None, 256)          524544      dropout[0][0]
__________________________________________________________________________________________________
lstm (LSTM)                     (None, 256)          467968      dropout_1[0][0]
__________________________________________________________________________________________________
add (Add)                       (None, 256)          0           dense[0][0]
                                                                 lstm[0][0]
__________________________________________________________________________________________________
dense_1 (Dense)                 (None, 256)          65792       add[0][0]
__________________________________________________________________________________________________
dense_2 (Dense)                 (None, 1660)         426620      dense_1[0][0]
==================================================================================================
Total params: 1,816,924
Trainable params: 1,816,924
Non-trainable params: 0
__________________________________________________________________________________________________
```

In [ ]:
```
with open("/content/drive/MyDrive/encoded_train_images.pkl", "wb") as encoded_pickle:
    pickle.dump(encoding_train, encoded_pickle)
```

In [ ]:
```
# Save the bottleneck test features to disk
with open("/content/drive/MyDrive/encoded_test_images.pkl", "wb") as encoded_pickle:
    pickle.dump(encoding_test, encoded_pickle)
```

In [ ]:
```
model.layers[2].set_weights([embedding_matrix])
model.layers[2].trainable = False
```

In [ ]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam')
```

In [ ]:
```
def data_generator(descriptions, photos, wordtoix, max_length, num_photos_per_batch):
    X1, X2, y = list(), list(), list()
    n=0
    # loop for ever over images
    while 1:
        for key, desc_list in descriptions.items():
            n+=1
            # retrieve the photo feature
            photo = photos[key+'.jpg']
            for desc in desc_list:
                # encode the sequence
                seq = [wordtoix[word] for word in desc.split(' ') if word in wordtoix]
                # split one sequence into multiple X, y pairs
                for i in range(1, len(seq)):
                    # split into input and output pair
                    in_seq, out_seq = seq[:i], seq[i]
                    # pad input sequence
                    in_seq = pad_sequences([in_seq], maxlen=max_length)[0]
                    # encode output sequence
                    out_seq = to_categorical([out_seq], num_classes=vocab_size)[0]
                    # store
                    X1.append(photo)
                    X2.append(in_seq)
                    y.append(out_seq)

            if n==num_photos_per_batch:
                yield ([array(X1), array(X2)], array(y))
                X1, X2, y = list(), list(), list()
                n=0
```

In [ ]:
```
epochs = 30
batch_size = 3
steps = len(train_descriptions)//batch_size

generator = data_generator(train_descriptions, train_features, wordtoix, max_length, batch_size)
model.fit(generator, epochs=epochs, steps_per_epoch=steps, verbose=1)
```
```
Epoch 1/30
2000/2000 [==============================] - 308s 146ms/step - loss: 4.1669
Epoch 2/30
2000/2000 [==============================] - 293s 146ms/step - loss: 3.0937
Epoch 3/30
2000/2000 [==============================] - 293s 147ms/step - loss: 2.8661
Epoch 4/30
2000/2000 [==============================] - 292s 146ms/step - loss: 2.7350
Epoch 5/30
2000/2000 [==============================] - 292s 146ms/step - loss: 2.6422
Epoch 6/30
2000/2000 [==============================] - 297s 148ms/step - loss: 2.5727
Epoch 7/30
2000/2000 [==============================] - 292s 146ms/step - loss: 2.5217
Epoch 8/30
2000/2000 [==============================] - 289s 145ms/step - loss: 2.4776
Epoch 9/30
2000/2000 [==============================] - 288s 144ms/step - loss: 2.4403
Epoch 10/30
2000/2000 [==============================] - 288s 144ms/step - loss: 2.4089
Epoch 11/30
2000/2000 [==============================] - 293s 146ms/step - loss: 2.3796
Epoch 12/30
2000/2000 [==============================] - 291s 146ms/step - loss: 2.3555
Epoch 13/30
2000/2000 [==============================] - 290s 145ms/step - loss: 2.3372
Epoch 14/30
2000/2000 [==============================] - 289s 145ms/step - loss: 2.3150
Epoch 15/30
2000/2000 [==============================] - 291s 146ms/step - loss: 2.3000
Epoch 16/30
2000/2000 [==============================] - 293s 147ms/step - loss: 2.2883
Epoch 17/30
2000/2000 [==============================] - 292s 146ms/step - loss: 2.2718
Epoch 18/30
2000/2000 [==============================] - 289s 145ms/step - loss: 2.2588
Epoch 19/30
2000/2000 [==============================] - 283s 142ms/step - loss: 2.2459
Epoch 20/30
2000/2000 [==============================] - 282s 141ms/step - loss: 2.2322
Epoch 21/30
2000/2000 [==============================] - 283s 141ms/step - loss: 2.2257
Epoch 22/30
2000/2000 [==============================] - 281s 140ms/step - loss: 2.2172
Epoch 23/30
2000/2000 [==============================] - 280s 140ms/step - loss: 2.2063
Epoch 24/30
2000/2000 [==============================] - 280s 140ms/step - loss: 2.2000
Epoch 25/30
2000/2000 [==============================] - 279s 139ms/step - loss: 2.1926
Epoch 26/30
2000/2000 [==============================] - 279s 139ms/step - loss: 2.1877
Epoch 27/30
2000/2000 [==============================] - 279s 139ms/step - loss: 2.1794
Epoch 28/30
2000/2000 [==============================] - 278s 139ms/step - loss: 2.1724
Epoch 29/30
2000/2000 [==============================] - 278s 139ms/step - loss: 2.1683
Epoch 30/30
2000/2000 [==============================] - 278s 139ms/step - loss: 2.1636
```

Out[ ]:
```
<keras.callbacks.History at 0x7f36cd62b9d0>
```

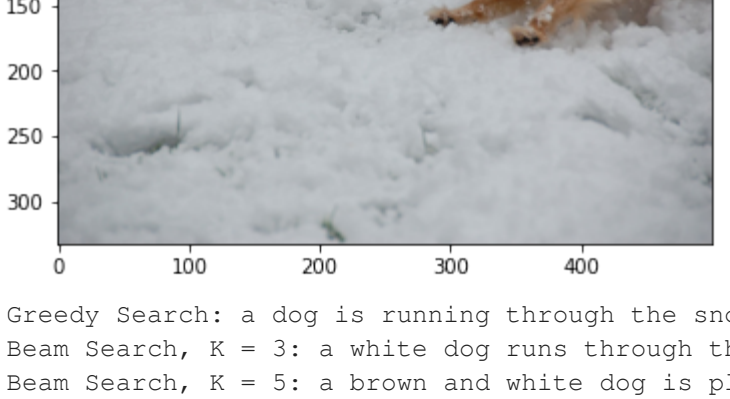
In [ ]:
```
model.save('content/drive/MyDrive/model.h5')
```
```
/usr/local/lib/python3.7/dist-packages/keras/utils/generic_utils.py:497: CustomMaskWarning: Custom mask layers require a config and must override get_config. When loading, the custo
m mask layer must be passed to the custom_objects argument.
  category=CustomMaskWarning)
```

In [ ]:
```
model.save_weights('content/drive/MyDrive/model_30.h5')
```

In [ ]:
```
def greedySearch(photo):
    in_text = 'startseq'
    for i in range(max_length):
        sequence = [wordtoix[w] for w in in_text.split() if w in wordtoix]
        sequence = pad_sequences([sequence], maxlen=max_length)
        yhat = model.predict([photo,sequence], verbose=0)
        yhat = np.argmax(yhat)
        word = ixtoword[yhat]
        in_text += ' ' + word
        if word == 'endseq':
            break

    final = in_text.split()
    final = final[1:-1]
    final = ' '.join(final)
    return final
```

In [ ]:
```
def beam_search_predictions(image, beam_index = 3):
    start = [wordtoix["startseq"]]
    start_word = [[start, 0.0]]
    while len(start_word[0][0]) < max_length:
        temp = []
        for s in start_word:
            par_caps = sequence.pad_sequences([s[0]], maxlen=max_length, padding='post')
            preds = model.predict([image,par_caps], verbose=0)
            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 = [ixtoword[i] for i in start_word]
    final_caption = []

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

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

In [ ]:
```
pic = '2398605966_1d0c9e6a20.jpg'
image = encoding_test[pic].reshape((1,2048))
x=plt.imread(images_path+pic)
plt.imshow(x)
plt.show()

print("Greedy Search:",greedySearch(image))
print("Beam Search, K = 3:",beam_search_predictions(image, beam_index = 3))
print("Beam Search, K = 5:",beam_search_predictions(image, beam_index = 5))
print("Beam Search, K = 7:",beam_search_predictions(image, beam_index = 7))
print("Beam Search, K = 10:",beam_search_predictions(image, beam_index = 10))
```



```
Greedy Search: a dog is running through the snow
Beam Search, K = 3: a white dog runs through the snow
Beam Search, K = 5: a brown and white dog is playing in the snow
```

```
Beam Search, K = 7: a brown and white dog is playing in the snow
Beam Search, K = 10: a brown and white dog is playing in the snow
```

In [ ]: