In [2]:

```
from absl import logging

import matplotlib.pyplot as plt
import numpy as np
from PIL import Image, ImageOps
from scipy.spatial import cKDTree
from skimage.feature import plot_matches
from skimage.measure import ransac
from skimage.transform import AffineTransform
from six import BytesIO

import tensorflow as tf

import tensorflow_hub as hub
from six.moves.urllib.request import urlopen
```

In [5]:

```
images = "Bridge of Sighs"
if images == "Bridge of Sighs":
  # from: https://commons.wikimedia.org/wiki/File:Bridge_of_Sighs,_Oxford.jpg
  # by: N.H. Fischer
  IMAGE_1_URL = 'https://upload.wikimedia.org/wikipedia/commons/2/28/Bridge_of_Sighs%2C_Oxford.jpg'
  # from https://commons.wikimedia.org/wiki/File:The_Bridge_of_Sighs_and_Sheldonian_Theatre,_Oxford.jpg
  # by: Matthew Hoser
  IMAGE_2_URL = 'https://upload.wikimedia.org/wikipedia/commons/c/c3/The_Bridge_of_Sighs_and_Sheldonian_Theatre%2C_O
elif images == "Golden Gate":
  IMAGE_1_URL = 'https://upload.wikimedia.org/wikipedia/commons/1/1e/Golden_gate2.jpg'
  IMAGE_2_URL = 'https://upload.wikimedia.org/wikipedia/commons/3/3e/GoldenGateBridge.jpg'
elif images == "Acropolis":
  IMAGE_1_URL = 'https://upload.wikimedia.org/wikipedia/commons/c/ce/2006_01_21_Ath%C3%A8nes_Parth%C3%A9non.JPG'
  IMAGE_2_URL = 'https://upload.wikimedia.org/wikipedia/commons/5/5c/ACROPOLIS_1969_-_panoramio_-_jean_melis.jpg'
else:
  IMAGE_1_URL = 'https://upload.wikimedia.org/wikipedia/commons/d/d8/Eiffel_Tower%2C_November_15%2C_2011.jpg'
  IMAGE_2_URL = 'https://upload.wikimedia.org/wikipedia/commons/a/a8/Eiffel_Tower_from_immediately_beside_it%2C_Pari
```

In [6]:

```
def download_and_resize(name, url, new_width=256, new_height=256):
  path = tf.keras.utils.get_file(url.split('/')[-1], url)
  image = Image.open(path)
  image = ImageOps.fit(image, (new_width, new_height), Image.ANTIALIAS)
  return image
```

In [7]:

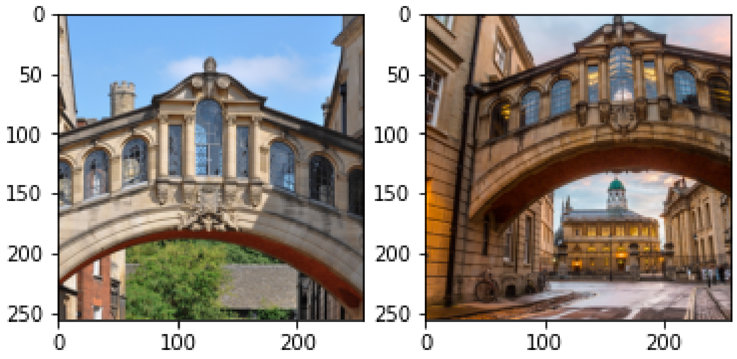
```
image1 = download_and_resize('image_1.jpg', IMAGE_1_URL)
image2 = download_and_resize('image_2.jpg', IMAGE_2_URL)

plt.subplot(1,2,1)
plt.imshow(image1)
plt.subplot(1,2,2)
plt.imshow(image2)
```

```
Downloading data from https://upload.wikimedia.org/wikipedia/commons/2/28/Bridge_of_Sighs%2C_Oxford.jpg
7020544/7013850 [==============================] - 0s 0us/step
Downloading data from https://upload.wikimedia.org/wikipedia/commons/c/c3/The_Bridge_of_Sighs_and_Sheldonian_Theatre%
2C_Oxford.jpg
14172160/14164194 [==============================] - 0s 0us/step
```

Out[7]:

```
<matplotlib.image.AxesImage at 0x7fe042d88a90>
```



In [8]:

```
def download_and_resize(name, url, new_width=256, new_height=256):
  path = tf.keras.utils.get_file(url.split('/')[-1], url)
  image = Image.open(path)
  image = ImageOps.fit(image, (new_width, new_height), Image.ANTIALIAS)
  return image
```

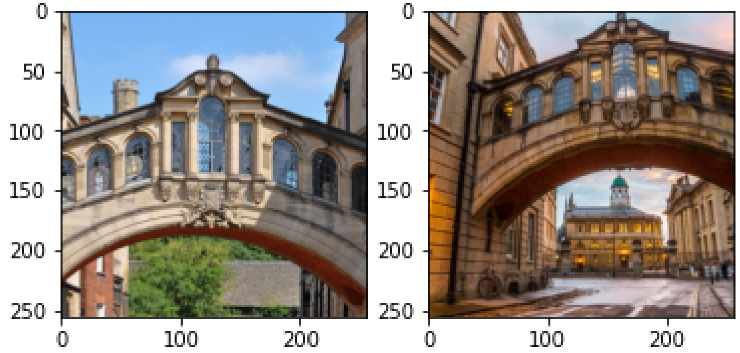
In [9]:

```
image1 = download_and_resize('image_1.jpg', IMAGE_1_URL)
image2 = download_and_resize('image_2.jpg', IMAGE_2_URL)

plt.subplot(1,2,1)
plt.imshow(image1)
plt.subplot(1,2,2)
plt.imshow(image2)
```

Out[9]:

```
<matplotlib.image.AxesImage at 0x7fe042c2ff10>
```



In [10]:

```python
delf = hub.load('https://tfhub.dev/google/delf/1').signatures['default']
```

In [11]:

```python
def run_delf(image):
  np_image = np.array(image)
  float_image = tf.image.convert_image_dtype(np_image, tf.float32)

  return delf(
      image=float_image,
      score_threshold=tf.constant(100.0),
      image_scales=tf.constant([0.25, 0.3536, 0.5, 0.7071, 1.0, 1.4142, 2.0]),
      max_feature_num=tf.constant(1000))
```

In [13]:

```python
result1 = run_delf(image1)
result2 = run_delf(image2)
```

In [14]:

```python
def match_images(image1, image2, result1, result2):
  distance_threshold = 0.8

  # Read features.
  num_features_1 = result1['locations'].shape[0]
  print("Loaded image 1's %d features" % num_features_1)

  num_features_2 = result2['locations'].shape[0]
  print("Loaded image 2's %d features" % num_features_2)

  # Find nearest-neighbor matches using a KD tree.
  d1_tree = cKDTree(result1['descriptors'])
  _, indices = d1_tree.query(
      result2['descriptors'],
      distance_upper_bound=distance_threshold)

  # Select feature locations for putative matches.
  locations_2_to_use = np.array([
      result2['locations'][i,]
      for i in range(num_features_2)
      if indices[i] != num_features_1
  ])
  locations_1_to_use = np.array([
      result1['locations'][indices[i],]
      for i in range(num_features_2)
      if indices[i] != num_features_1
  ])

  # Perform geometric verification using RANSAC.
  _, inliers = ransac(
      (locations_1_to_use, locations_2_to_use),
      AffineTransform,
      min_samples=3,
      residual_threshold=20,
      max_trials=1000)

  print('Found %d inliers' % sum(inliers))

  # Visualize correspondences.
  _, ax = plt.subplots()
  inlier_idxs = np.nonzero(inliers)[0]
  plot_matches(
      ax,
      image1,
      image2,
      locations_1_to_use,
      locations_2_to_use,
      np.column_stack((inlier_idxs, inlier_idxs)),
      matches_color='b')
  ax.axis('off')
  ax.set_title('DELF correspondences')

match_images(image1, image2, result1, result2)
```

```
Loaded image 1's 233 features
Loaded image 2's 262 features
Found 51 inliers
```

DELF correspondences