In [1]:

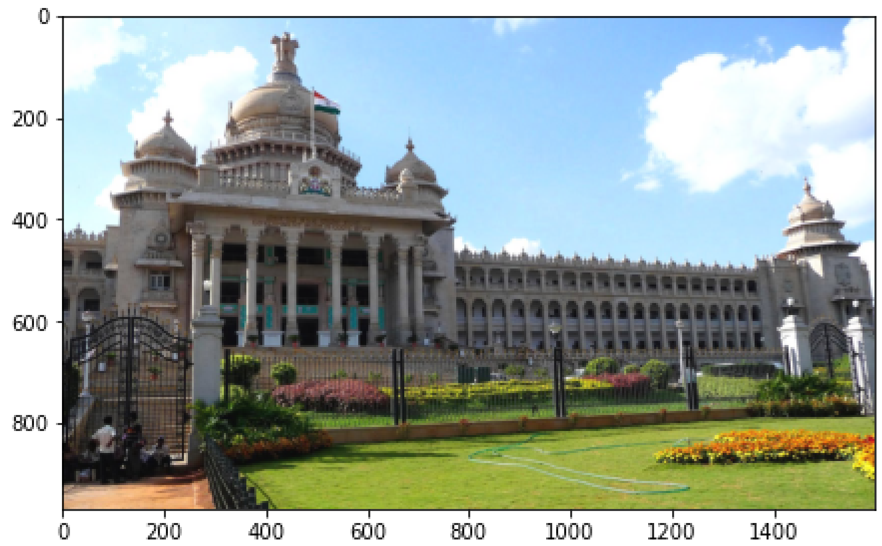
```
import cv2
import numpy as np
import matplotlib.pyplot as plt
import imageio
import imutils
cv2.ocl.setUseOpenCL(False)
```

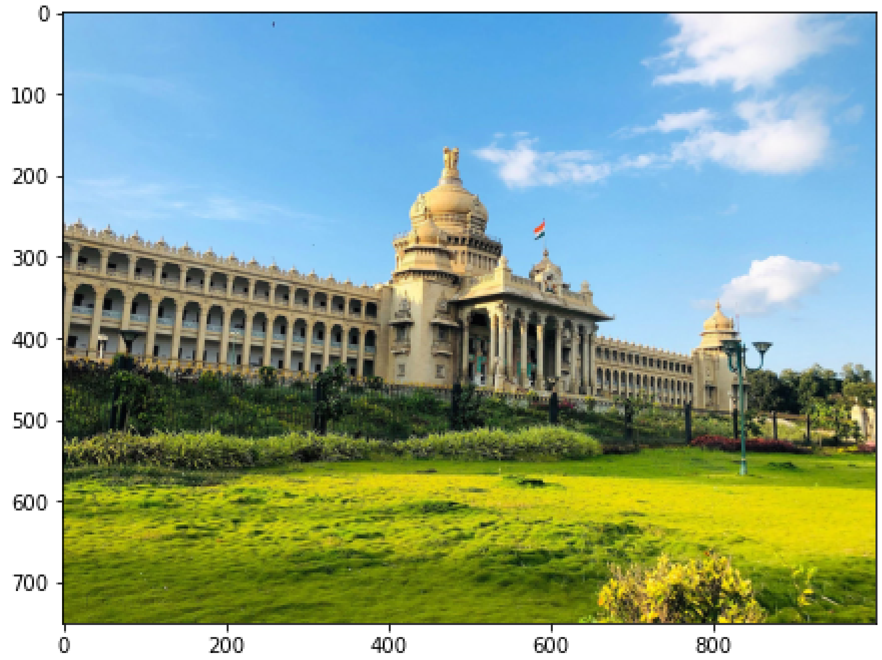
In [2]:

```
feature_extractor = 'orb' # one of 'sift', 'surf', 'brisk', 'orb'
feature_matching = 'bf'
```

In [3]:

```
# read images and transform them to grayscale
trainImg = imageio.imread('h1.jpg')
trainImg_gray = cv2.cvtColor(trainImg, cv2.COLOR_RGB2GRAY)

queryImg = imageio.imread('h.jpg')
# Opencv defines the color channel in the order BGR.
# Transform it to RGB to be compatible to matplotlib
queryImg_gray = cv2.cvtColor(queryImg, cv2.COLOR_RGB2GRAY)

fig, (ax1, ax2) = plt.subplots(nrows=1, ncols=2, constrained_layout=False, figsize=(16,9))
ax1.imshow(queryImg, cmap="gray")
ax1.set_xlabel("Query image", fontsize=14)

ax2.imshow(trainImg, cmap="gray")
ax2.set_xlabel("Train image (Image to be transformed)", fontsize=14)

plt.show()
```


Query image


Train image (Image to be transformed)

In [4]:

```
def detectAndDescribe(image, method=None):
    """
    Compute key points and feature descriptors using an specific method
    """



    # detect and extract features from the image
    if method == 'sift':
        descriptor = cv2.xfeatures2d.SIFT_create()
    elif method == 'surf':
        descriptor = cv2.xfeatures2d.SURF_create()
    elif method == 'brisk':
        descriptor = cv2.BRISK_create()
    elif method == 'orb':
        descriptor = cv2.ORB_create()

    # get keypoints and descriptors
    (kps, features) = descriptor.detectAndCompute(image, None)
```

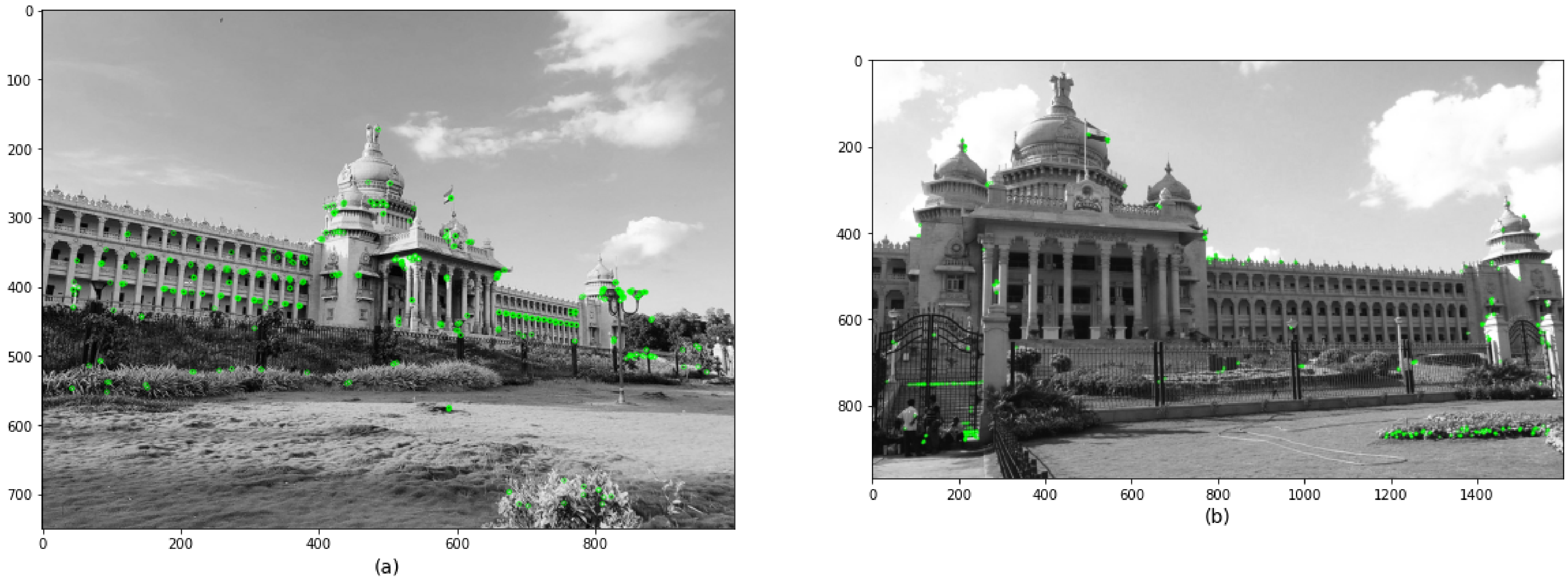
```
    return (kps, features)
```

In [5]:

```
kpsA, featuresA = detectAndDescribe(trainImg_gray, method=feature_extractor)
kpsB, featuresB = detectAndDescribe(queryImg_gray, method=feature_extractor)
```

In [6]:

```
# display the keypoints and features detected on both images
fig, (ax1,ax2) = plt.subplots(nrows=1, ncols=2, figsize=(20,8), constrained_layout=False)
ax1.imshow(cv2.drawKeypoints(trainImg_gray,kpsA,None,color=(0,255,0)))
ax1.set_xlabel("(a)", fontsize=14)
ax2.imshow(cv2.drawKeypoints(queryImg_gray,kpsB,None,color=(0,255,0)))
ax2.set_xlabel("(b)", fontsize=14)

plt.show()
```



In [7]:

```
def createMatcher(method,crossCheck):
    "Create and return a Matcher Object"
```

```python
    if method == 'sift' or method == 'surf':
        bf = cv2.BFMatcher(cv2.NORM_L2, crossCheck=crossCheck)
    elif method == 'orb' or method == 'brisk':
        bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck=crossCheck)
    return bf
```

In [8]:

```python
def matchKeyPointsBF(featuresA, featuresB, method):
    bf = createMatcher(method, crossCheck=True)

    # Match descriptors.
    best_matches = bf.match(featuresA,featuresB)

    # Sort the features in order of distance.
    # The points with small distance (more similarity) are ordered first in the vector
    rawMatches = sorted(best_matches, key = lambda x:x.distance)
    print("Raw matches (Brute force):", len(rawMatches))
    return rawMatches
```

In [9]:

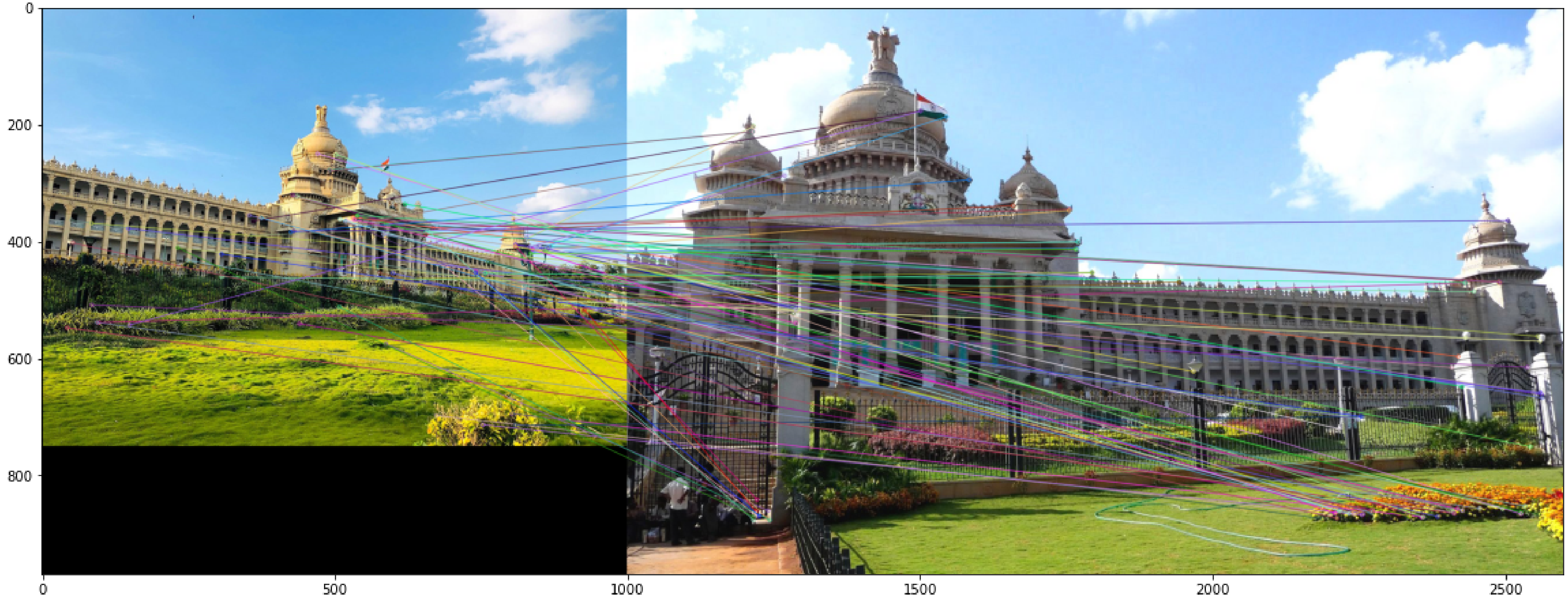
```python
def matchKeyPointsKNN(featuresA, featuresB, ratio, method):
    bf = createMatcher(method, crossCheck=False)
    # compute the raw matches and initialize the list of actual matches
    rawMatches = bf.knnMatch(featuresA, featuresB, 2)
    print("Raw matches (knn):", len(rawMatches))
    matches = []

    # loop over the raw matches
    for m,n in rawMatches:
        if m.distance < n.distance * ratio:
            matches.append(m)
    return matches
```

In [10]:

```python
print("Using: {} feature matcher".format(feature_matching))

fig = plt.figure(figsize=(20,8))

if feature_matching == 'bf':
    matches = matchKeyPointsBF(featuresA, featuresB, method=feature_extractor)
    img3 = cv2.drawMatches(trainImg,kpsA,queryImg,kpsB,matches[:100],
                           None,flags=cv2.DrawMatchesFlags_NOT_DRAW_SINGLE_POINTS)
```

```
elif feature_matching == 'knn':
    matches = matchKeyPointsKNN(featuresA, featuresB, ratio=0.75, method=feature_extractor)
    img3 = cv2.drawMatches(trainImg,kpsA,queryImg,kpsB,np.random.choice(matches,100),
                           None,flags=cv2.DrawMatchesFlags_NOT_DRAW_SINGLE_POINTS)


plt.imshow(img3)
plt.show()
```

```
Using: bf feature matcher
Raw matches (Brute force): 138
```



In [11]:

```
def getHomography(kpsA, kpsB, featuresA, featuresB, matches, reprojThresh):
    # convert the keypoints to numpy arrays
    kpsA = np.float32([kp.pt for kp in kpsA])
    kpsB = np.float32([kp.pt for kp in kpsB])

    if len(matches) > 4:

        # construct the two sets of points
```

```
        ptsA = np.float32([kpsA[m.queryIdx] for m in matches])
        ptsB = np.float32([kpsB[m.trainIdx] for m in matches])

        # estimate the homography between the sets of points
        (H, status) = cv2.findHomography(ptsA, ptsB, cv2.RANSAC,
            reprojThresh)

        return (matches, H, status)
    else:
        return None
```

In [12]:

```
M = getHomography(kpsA, kpsB, featuresA, featuresB, matches, reprojThresh=4)
if M is None:
    print("Error!")
(matches, H, status) = M
print(H)
```

```
[[-1.99843063e+00 -2.01088236e+00  1.48880176e+03]
 [-6.20286426e-01 -6.20104986e-01  4.59138102e+02]
 [-1.33856583e-03 -1.35526690e-03  1.00000000e+00]]
```

In [13]:

```
# Apply panorama correction
width = trainImg.shape[1] + queryImg.shape[1]
height = trainImg.shape[0] + queryImg.shape[0]

result = cv2.warpPerspective(trainImg, H, (width, height))
result[0:queryImg.shape[0], 0:queryImg.shape[1]] = queryImg

plt.figure(figsize=(20,10))
plt.imshow(result)

plt.axis('off')
plt.show()
```

In [17]:

```
# transform the panorama image to grayscale and threshold it
gray = cv2.cvtColor(result, cv2.COLOR_BGR2GRAY)
thresh = cv2.threshold(gray, 0, 255, cv2.THRESH_BINARY)[1]

# Finds contours from the binary image
cnts = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
cnts = imutils.grab_contours(cnts)
```

```python
# get the maximum contour area
c = max(cnts, key=cv2.contourArea)

# get a bbox from the contour area
(x, y, w, h) = cv2.boundingRect(c)

# crop the image to the bbox coordinates
result = result[y:y + h, x:x + w]

# show the cropped image
plt.figure(figsize=(20,10))
plt.imshow(result)
```

Out[17]:

```
<matplotlib.image.AxesImage at 0x21138b5e280>
```

In [ ]:

In [ ]: