[1]
```
# import the necessary packages
import numpy as np
import imutils
import cv2
import argparse

# stuff just for IPython
from IPython.display import display
from IPython.display import Image
from matplotlib import pyplot as plt
```

[2]
```
class Stitcher:
    def __init__(self):
        # determine if we are using OpenCV v3.X
        self.isv3 = imutils.is_cv3()

    def stitch(self, images, ratio=0.75, reprojThresh=4.0,
        showMatches=False):
        # unpack the images, then detect keypoints and extract
        # local invariant descriptors from them
        (imageB, imageA) = images
        (kpsA, featuresA) = self.detectAndDescribe(imageA)
        (kpsB, featuresB) = self.detectAndDescribe(imageB)

        # match features between the two images
        M = self.matchKeypoints(kpsA, kpsB,
            featuresA, featuresB, ratio, reprojThresh)

        # if the match is None, then there aren't enough matched
        # keypoints to create a panorama
        if M is None:
            return None

        # otherwise, apply a perspective warp to stitch the images
        # together
        (matches, H, status) = M
        result = cv2.warpPerspective(imageA, H,
            (imageA.shape[1] + imageB.shape[1], imageA.shape[0]))
        result[0:imageB.shape[0], 0:imageB.shape[1]] = imageB

        # check to see if the keypoint matches should be visualized
        if showMatches:
            vis = self.drawMatches(imageA, imageB, kpsA, kpsB, matches,
                status)

            # return a tuple of the stitched image and the
            # visualization
            return (result, vis)
```

```
        # return the stitched image
        return result

    def detectAndDescribe(self, image):
        # convert the image to grayscale
        gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

        # check to see if we are using OpenCV 3.X
        if self.isv3:
            # detect and extract features from the image
            descriptor = cv2.xfeatures2d.SIFT_create()
            (kps, features) = descriptor.detectAndCompute(image, None)

        # otherwise, we are using OpenCV 2.4.X
        else:
            # detect keypoints in the image
            detector = cv2.FeatureDetector_create("SIFT")
            kps = detector.detect(gray)

            # extract features from the image
            extractor = cv2.DescriptorExtractor_create("SIFT")
            (kps, features) = extractor.compute(gray, kps)

        # convert the keypoints from KeyPoint objects to NumPy
        # arrays
        kps = np.float32([kp.pt for kp in kps])

        # return a tuple of keypoints and features
        return (kps, features)

    def matchKeypoints(self, kpsA, kpsB, featuresA, featuresB,
        ratio, reprojThresh):
        # compute the raw matches and initialize the list of actual
        # matches
        matcher = cv2.DescriptorMatcher_create("BruteForce")
        rawMatches = matcher.knnMatch(featuresA, featuresB, 2)
        matches = []

        # loop over the raw matches
        for m in rawMatches:
            # ensure the distance is within a certain ratio of each
            # other (i.e. Lowe's ratio test)
            if len(m) == 2 and m[0].distance < m[1].distance * ratio:
                matches.append((m[0].trainIdx, m[0].queryIdx))

        # computing a homography requires at least 4 matches
        if len(matches) > 4:
            # construct the two sets of points
            ptsA = np.float32([kpsA[i] for (_, i) in matches])
            ptsB = np.float32([kpsB[i] for (i, _) in matches])
```

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

                # return the matches along with the homograpy matrix
                # and status of each matched point
                return (matches, H, status)

            # otherwise, no homograpy could be computed
            return None

        def drawMatches(self, imageA, imageB, kpsA, kpsB, matches, status):
            # initialize the output visualization image
            (hA, wA) = imageA.shape[:2]
            (hB, wB) = imageB.shape[:2]
            vis = np.zeros((max(hA, hB), wA + wB, 3), dtype="uint8")
            vis[0:hA, 0:wA] = imageA
            vis[0:hB, wA:] = imageB

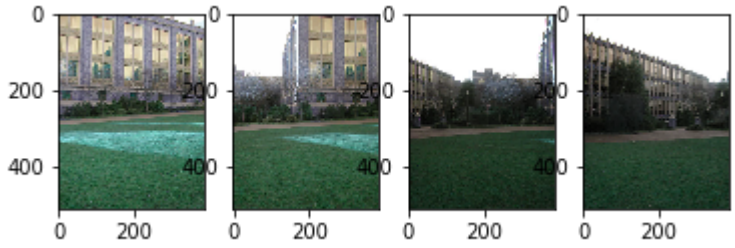
            # loop over the matches
            for ((trainIdx, queryIdx), s) in zip(matches, status):
                # only process the match if the keypoint was successfully
                # matched
                if s == 1:
                    # draw the match
                    ptA = (int(kpsA[queryIdx][0]), int(kpsA[queryIdx][1]))
                    ptB = (int(kpsB[trainIdx][0]) + wA, int(kpsB[trainIdx][1]
                    cv2.line(vis, ptA, ptB, (0, 255, 0), 1)

            # return the visualization
            return vis
```

[3]

```
# test sequence 1: load images #
imageA = cv2.imread('pano1_0008.jpg')
imageB = cv2.imread('pano1_0009.jpg')
imageC = cv2.imread('pano1_0010.jpg')
imageD = cv2.imread('pano1_0011.jpg')

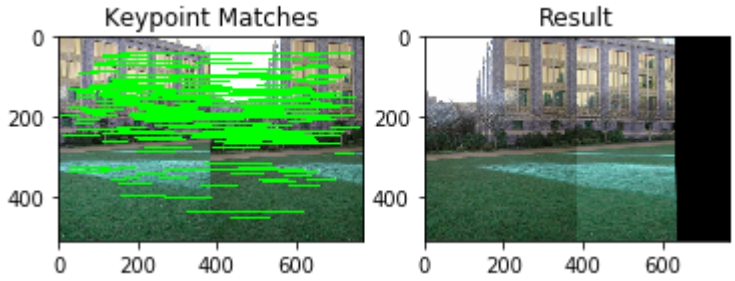
plt.subplot(1,4,1)
plt.imshow(imageA)
plt.subplot(1,4,2)
plt.imshow(imageB)
plt.subplot(1,4,3)
plt.imshow(imageC)
plt.subplot(1,4,4)
plt.imshow(imageD)
plt.show()
```



[4]
```
# test sequence 2: run stitcher on two images #

stitcher = Stitcher()
(result,vis) = stitcher.stitch([imageB,imageA],showMatches = True)

plt.subplot(1,2,1)
plt.imshow(vis)
plt.title("Keypoint Matches")
plt.subplot(1,2,2)
plt.imshow(result)
plt.title("Result")
plt.show()
```

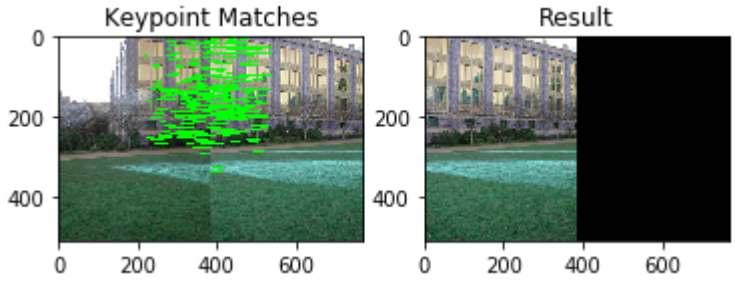


[5]
```
# note that the order does appear to matter.
# trying to reverse the order of the inputs into the stitcher
# gets you something like this

(result,vis) = stitcher.stitch([imageA,imageB],showMatches = True)

plt.subplot(1,2,1)
plt.imshow(vis)
plt.title("Keypoint Matches")
plt.subplot(1,2,2)
plt.imshow(result)
plt.title("Result")
plt.show()
# Note that the result obtained is not a stitched image.

# this is just to put things back as they were after the demonstration
(result,vis) = stitcher.stitch([imageB,imageA],showMatches = True)
```

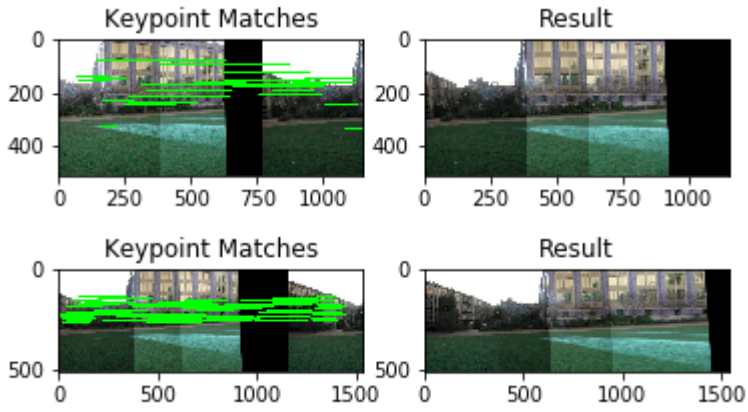


[6]
```
# now we need to start stitching multiple images together
current_pano = result
(result,vis) = stitcher.stitch([imageC,current_pano],showMatches = True)

plt.subplot(1,2,1)
plt.imshow(vis)
plt.title("Keypoint Matches")
plt.subplot(1,2,2)
plt.imshow(result)
plt.title("Result")
plt.show()

current_pano = result
(result,vis) = stitcher.stitch([imageD,current_pano],showMatches = True)

plt.subplot(1,2,1)
plt.imshow(vis)
plt.title("Keypoint Matches")
plt.subplot(1,2,2)
plt.imshow(result)
plt.title("Result")
plt.show()
```



[7]