# Computer Vision
# HW3 Report

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## Introduction:

In this assignment, we used Scale-invariant feature transform(SIFT) to detect keypoints and features of two images. Matching these features of two images and draw a matched line. Used these keypoints to find a homography H, and stitch two images together.

## Implementation procedure:

1) Use the SIFT algorithm to detect key points and features of the image, directly using the OpenCV library in this step.Good key points will be unique when doing image comparison, and not be easily confused with other key points.The Corner is the one of the part that's easily to be the key points.There are many algorithms to detect key points,such as Hessian affine region detector、MSER、SIFT、SURF, and we used SIFT.

2) Matching feature of two images by key points,and calculate the local invariant descriptors near the region of keypoint. After finding key points of image, we used the SIFT algorithm to calculate the local invariant descriptors. We choose 16x16 windows nearby a keypoint, dividing the window into 4x4 regions. To calculate the orientation histogram of each region, then we can get a 128 dimension descriptor. There are many algorithms to calculate the local invariant descriptors, such as MSER、SIFT and SURF, and we used SIFT.

3) Homography matrix estimation using RANSAC, homography matrix is also called transform matrix that will stitch the 2 images together based on their matching points. We just need four key points to calculate the homography matrix in our model. So, if we have more than four key points, we can calculate many homography matrices. We can use the RANSAC (Random sample Consensus) algorithm to find the best one.

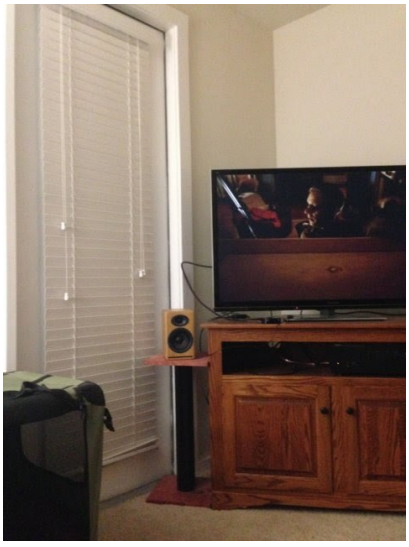
   Steps of RANSAC:
   1. Random select some key points to calculate the homography matrix
   2. Calculate the homography matrix
   3. Takes all Good matching feature to calculate $P = HP'$ 、$P$ is the matching feature,and $P'$is the estimate feature, and find which feature is closer than deviation, and add it up. It's called Inliers.

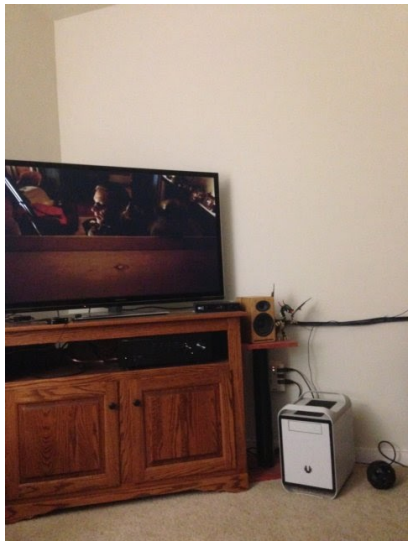
4. Then, use homography matrix H to calculate $||P' - P||$ ,if it is closer than deviation, we call this homography matrix H is "reliable". Inliers is the number of features which is closer than deviation. The more Inliers are, the more better H is.

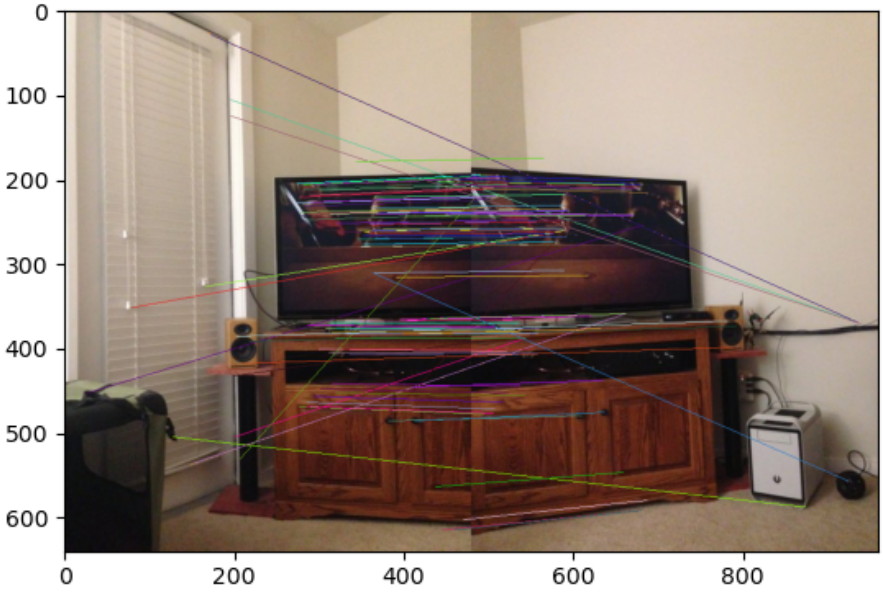
5. Repeat step 1 to step 4, then find the best homography matrix H.

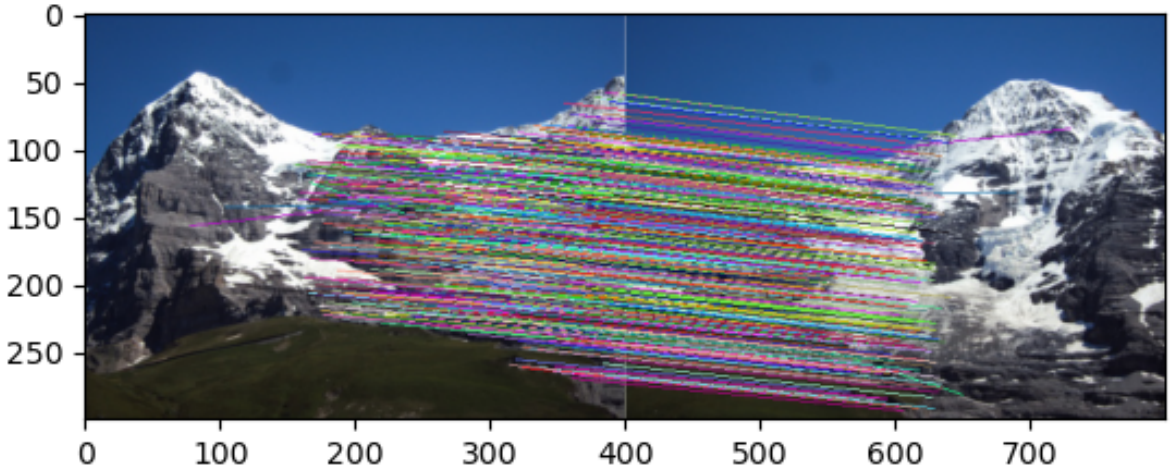
4) Perspective warping, we are going to stitch two images together. A perspective transform may combine one or more operations like rotation, scale, translation, or shear. The means to transform one of the images so that both images merge as one. Our method is to use a homography matrix to transform the right image, then store it on a blank region. Finally, add the left image on it, we can get a stitched image.

**Experimental result :**





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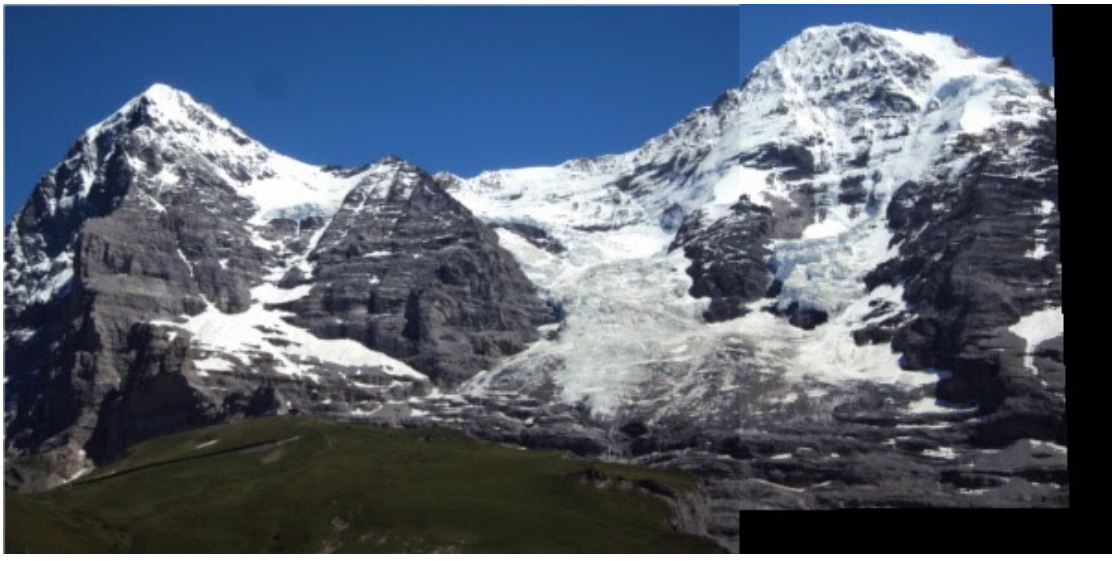

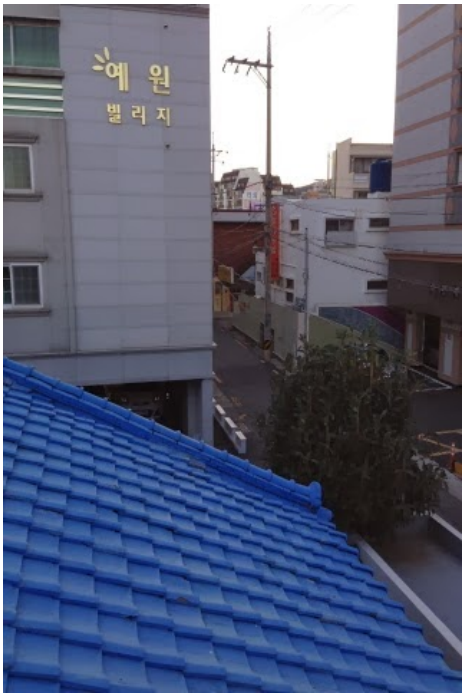
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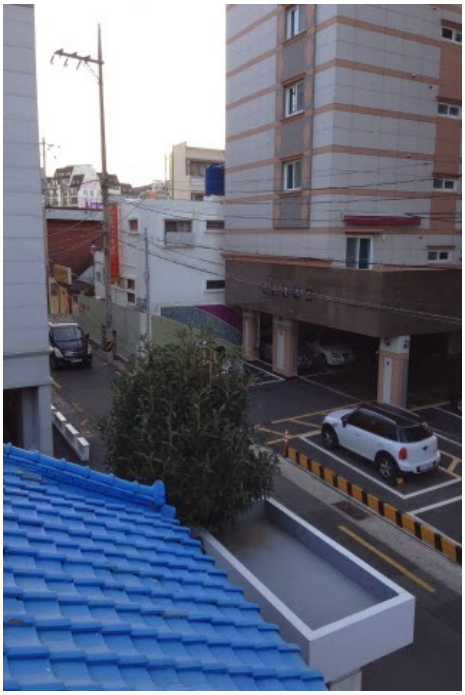

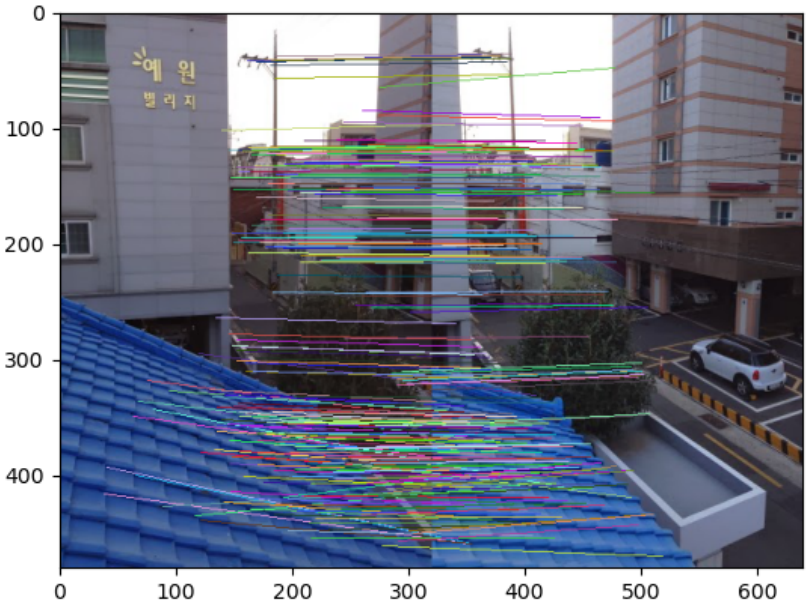
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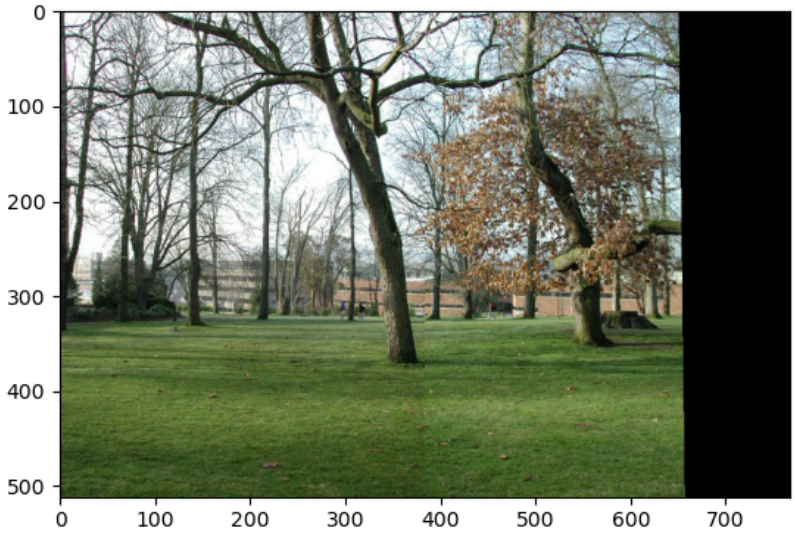
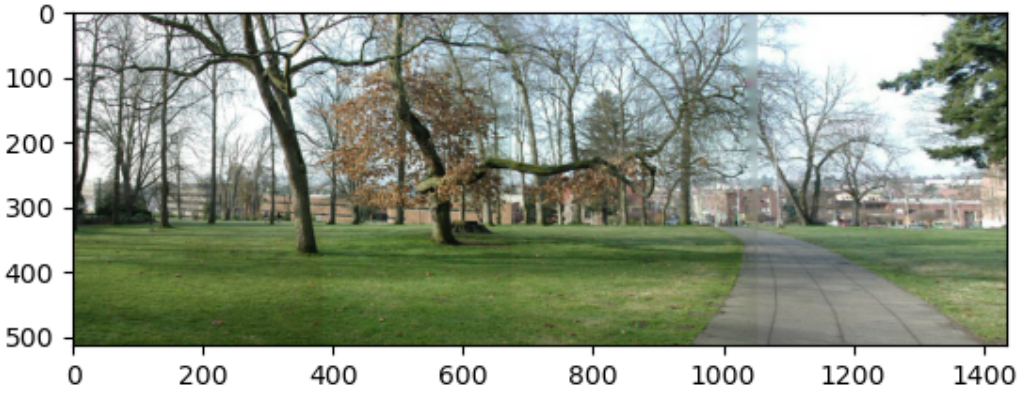
out testing data, stitch 2 images




out testing data, stitch 4 images



**Discussion:**

1. Although the SIFT algorithm can detect features and calculate local invariant descriptors, the weak point of SIFT is it just can be used on grayscale pictures. So, in this assignment, we have to change the colorful image to a grayscale picture.

2. When matching features of two images, we need to calculate the distance between feature points of the left image and some candidate points of right. We set a threshold = 4.0, let $feature\ distance < ratio \times candidate\ distance$ .
   I think ratio is very important in this part. Because if there is no threshold, we will not distinguish many similar-looking points.Then, we can't find good matching feature points.

3. In the last steps, perspective warping part. Our implementation will appear black region on the right side. Compared to opencv, it didn't. If we want to stitch more than two images, we need to crop black region before saving it. So, we modify the code to crop black region, and stitch 4 images.

**Conclusion:**

This assignment is to introduce the principle of photo stitching. First, find the key points for the two photos, and match the key points of the two photos. Then, calculate the Homography of the two photos based on the compared key points, and stitched together.

According to the selection of different algorithms, the key points and descriptors found will be different, and the effectiveness and correctness will also be different. This report used SIFT to implement it, but it does not compare the differences with other algorithms.RANSAC is a method that can find the best Homography, gradually finding the best solution by random sampling.We can stitch two photos into a new photo by using homography. In fact, a homography matrix can only handle projection conversion,so the photo may be distorted. However, this problem is beyond the scope of this assignment.