CSE 573: Introduction to Computer Vision and Image Processing

Project 2: Image Stitching

Pratibhaa Reddy (UB ID: 50299669)

Lakshmi Chaitanya (UB ID: 50290974)

Goal: The goal of this project is to implement image stitching by using at most 3 images. Here, we stitch all the images to create a panoramic image without using in built stitching libraries.

Introduction:

Image stitching or photo stitching is the process of combining multiple photographic images with overlapping fields of view to produce a segmented panorama or high-resolution image.

Any two given images with overlapping fields of view can be combined by calculating the homography matrix and then warping one image to the another by doing a perspective transform of one image to another using the calculated homography matrix. Using RANSAC (Random Sample Consensus) algorithm, we can determine the homography matrix.

Here, the challenge to find the homography matrix is to order the image. To find the order of given images, we use SIFT features.

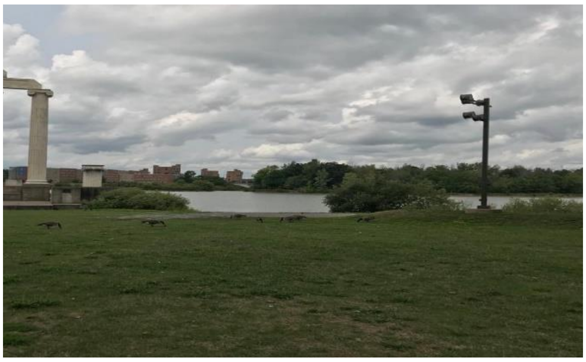
Below are the steps to create a panorama:

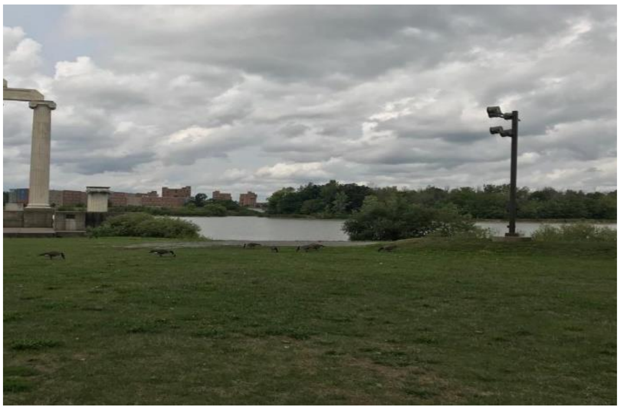
1. Feature Extraction.
2. Matching correspondence between 2 images.
3. Determine Homography.
4. Finding the best homography using Ransac.
5. Warping and stitching the images.

Setting up the environment:

System should setup with the version above python 2.7 and OpenCV 3.0 version. Make sure that the given input images are in left to right order of orientation.

Below are the input images that taken from left to right direction.





Step 1 - Feature Extraction using SIFT:

Here, we use opencv_contrib's SIFT descriptor. Scale-invariant feature transform (SIFT) is a feature detection algorithm to detect and describe local features in images.

We cannot apply matching for an entire image. Hence to make it easier, we first find the key points or features of an image and then try to match the descriptors of images.

Below are the images that show features:

Fig1: Image1

Fig2: Image2

Fig3: Image3

Step 2 - Matching Correspondence between 2 images:

After finding the key points of an image, we will find the correspondence between them. This is because, to join any two images into a panoramic image, overlapping points are needed. These overlapping points will give us an idea of the orientation of the second image w.r.t to the first image. (Based on these common points, we get an idea whether the second image has just slid the bigger image, or it has been rotated and then overlapped, or may be scaled up or down and then fitted.

Here, we find the matches using kNN matcher. Since an image consists of bag of features and we need to find the matching features present in both the images. This can be done by considering the top k points in the feature space from image 1' to every point in the image 1 and if it satisfies the ratio test, that closest point is considered as a match.

Step 3 - Calculate Homography:

After finding the matches between the images, the next step is to calculate the homography matrix.

Homography matrix will use these matching points, to estimate a relative orientation transform within the two images. H is used to convert one to another by using the below equation where P1 = (x,y) & P2 = (x',y')

H * P1 = P2

The homography matrix is estimated by using Direct linear transformation. Each point can be presented in the form of a matrix B of R(2x9) and H can be flattened and represented in the form of a vector h as below:

$$B = \begin{bmatrix} x_i & y_i & 1 & 0 & 0 & 0 & -x'_i x_i & -x'_i y_i & -x'_i \\ 0 & 0 & 0 & x_i & y_i & 1 & -y'_i x_i & -y'_i y_i & -y'_i \end{bmatrix}$$

$$h = \begin{bmatrix} h_{00} \\ h_{01} \\ h_{02} \\ h_{10} \\ h_{11} \\ h_{12} \\ h_{20} \\ h_{20} \\ h_{21} \\ h_{22} \end{bmatrix}$$

Matrix A with R(2x9) will be 'n' matrices stacked vertically. Below is the Matrix A:

$$A = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & -x'_1 x_1 & -x'_1 y_1 & -x'_1 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -y'_1 x_1 & -y'_1 y_1 & -y'_1 \\ & & & & & \dots & & & \\ x_n & y_n & 1 & 0 & 0 & 0 & -x'_n x_n & -x'_n y_n & -x'_n \\ 0 & 0 & 0 & x_n & y_n & 1 & -y'_n x_n & -y'_n y_n & -y'_n \end{bmatrix}$$

We need to solve for h such that Ah=0 or minimize ||Ah-0||2. Hence, h will be the eigen vector corresponding to the smallest eigen value of the matrix A * Transpose of A.

Now, the homography matrix H is the vector h which is converted to a unit vector and reshaped to R(3x3).

Step 4 - Finding the best homography using RANSAC

Random sample consensus (RANSAC) is an iterative method to estimate parameters of a mathematical model from a set of observed data that contains outliers, when outliers are to be accorded no influence on the values of the estimates.

Algorithm for RANSAC:

1. Select randomly the minimum number of points required to determine the model parameter.
2. Solve the parameters of the model
3. Determine how many points from the set of all points fit with a predefined tolerance.
4. If the fraction of the number of inliers over the total number of points in the set exceeds a predefined threshold, re-estimate the model parameters using all the identified inliers and terminate.
5. Otherwise, Repeat Step 1 to 4.

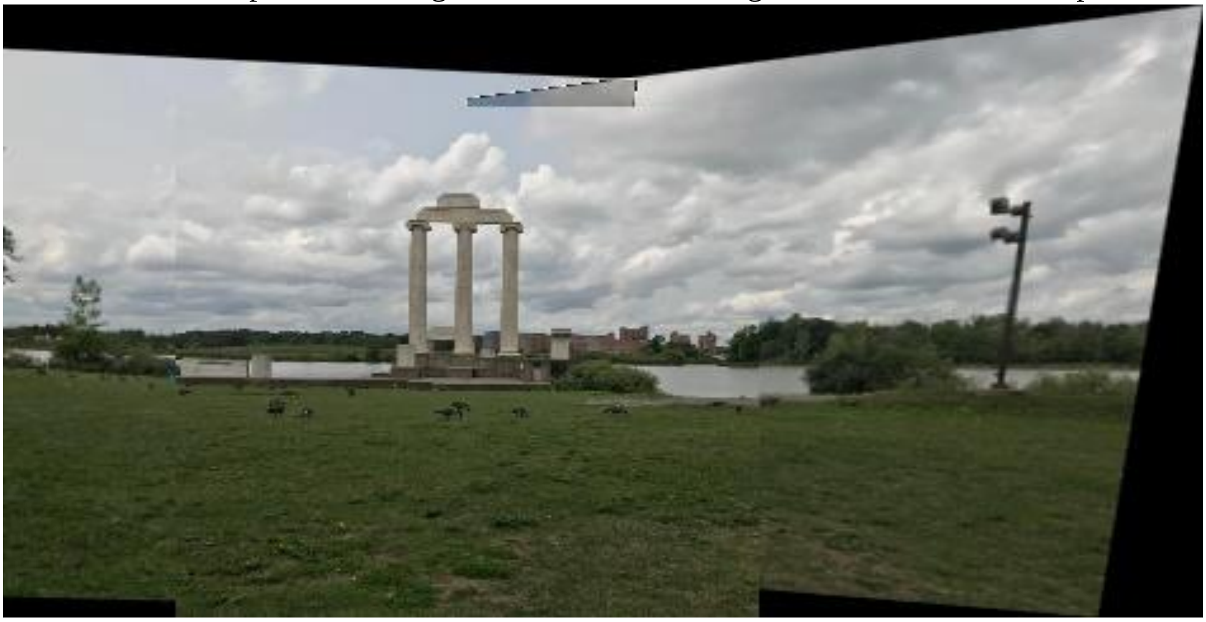
Step 5 - Warping and Stitching

After determining the best homography using Ransac, we know how the second image will look from the current image's perspective, we need to transform it into a new space. This transformation mimics the phenomenon that we undergo, i.e., the slightly distorted, and altered image that we see from our periphery. This process is known as wrapping. We are converting an image based on a new transformation.

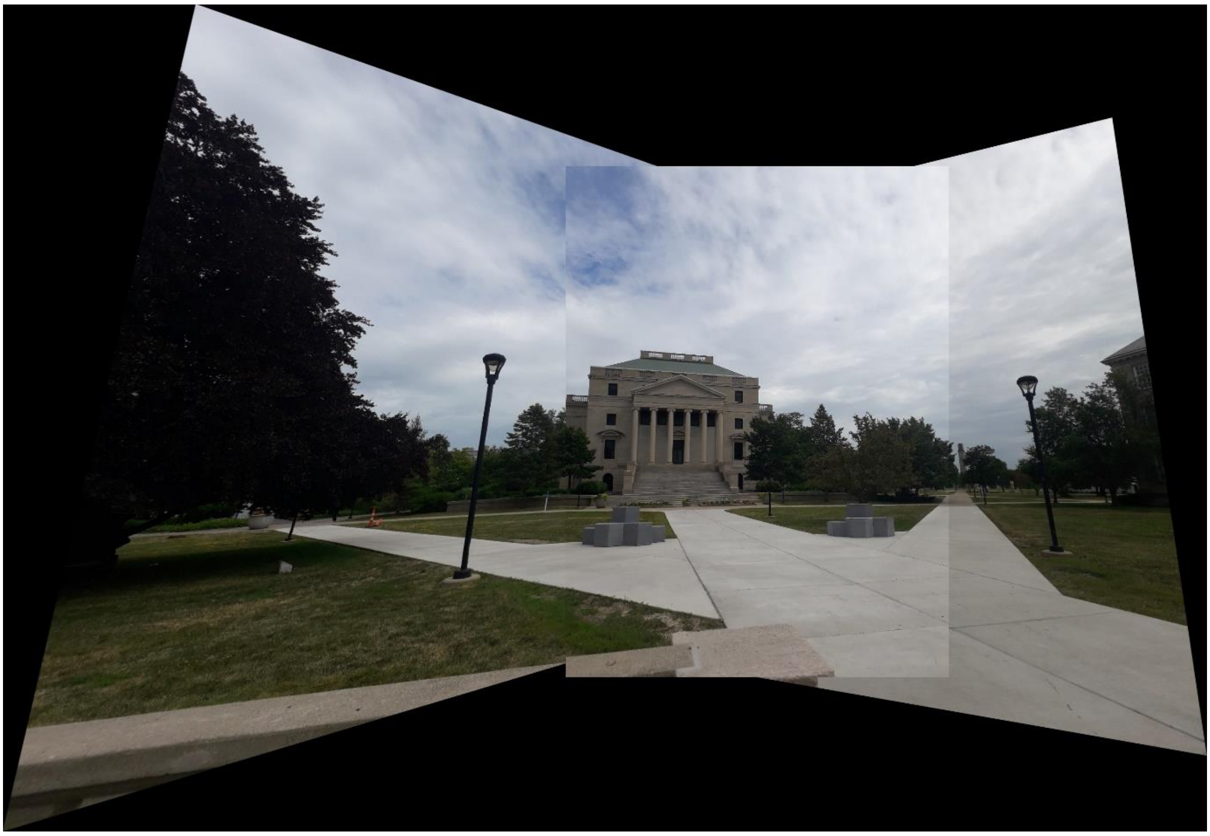
Here, panorama size changes with homography matrix. Hence, we can obtain the new dimensions by multiplying the corners of the image to be warped with the homography matrix H. The new coordinates are then used to form a translation matrix H' that shifts the image to be warped I such that the information will not be lost. Hence, the image I is warped using the dot product of H and H'.

After warping the images, we can perform stitching which can be done by computing H using RANSAC followed by warping one image over the another. The image resulting from warping can be reused for stitching with the last image which results a panorama image.

Below is the panorama image for the first set of images that are taken as an input.



Below image is the panoramic image for another set of images



Below is the image of Panorama when a different algorithm is used:

Below is the image of panorama after applying in built FlannBasedMatcher and findhomography functions:

References

1. http://6.869.csail.mit.edu/fa12/lectures/lecture13ransac/lecture13ransac.pdf
2. http://www.cse.yorku.ca/~kosta/CompVis_Notes/ransac.pdf