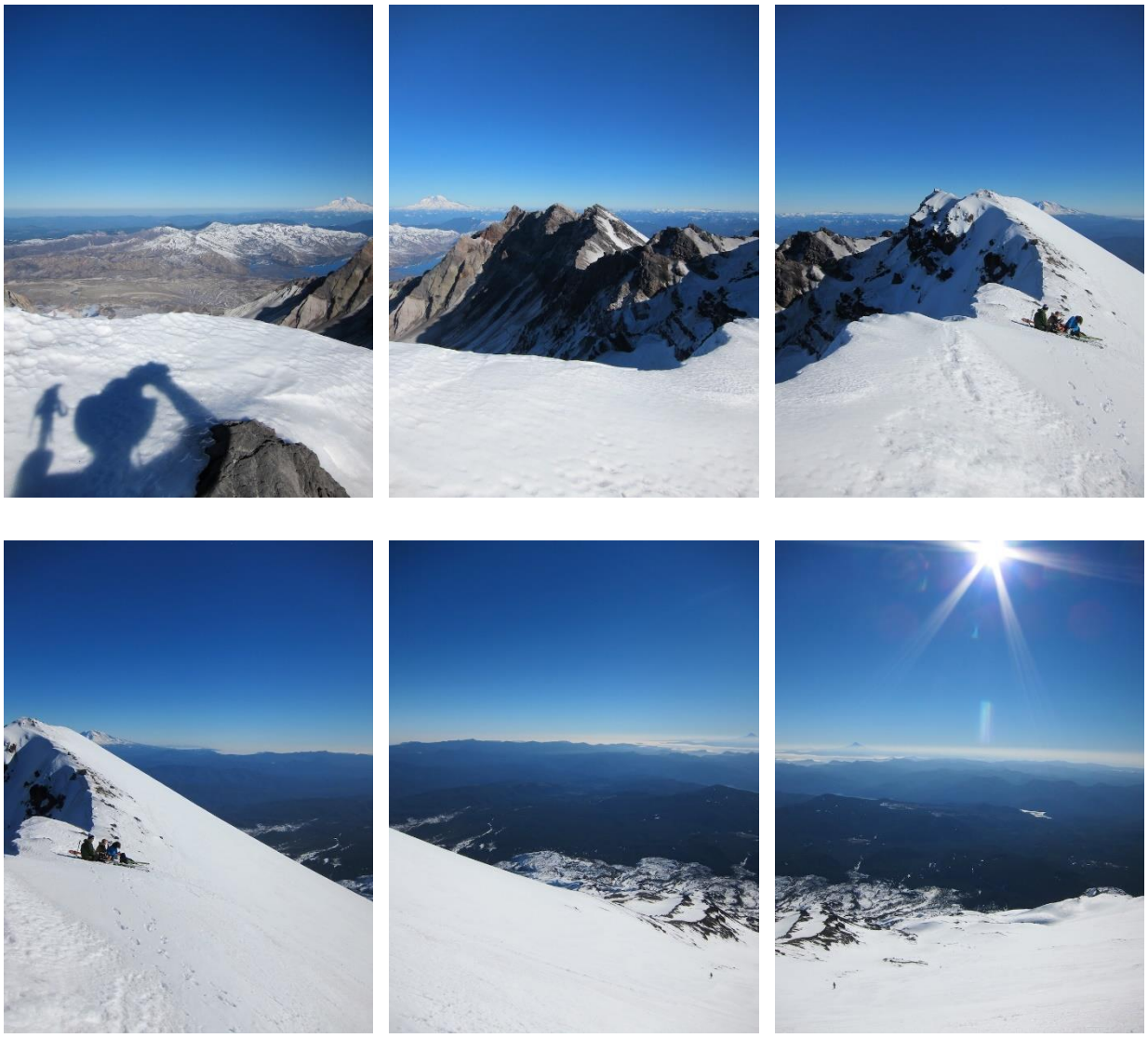
Computer Vision (COL 780)
Assignment-2: Creating Panaromas from Image Stitching

Pulkit Singal (2023AIB2064)

Task-1: Panaroma Creation from Images (Mountain):

Original Images:



1. **Conversion of each image from colored (RGB) to grayscale using cv2.cvtColor():** Each image in the input directory is converted to grayscale for further processing.

2. **Implementation of SIFT Algorithm for finding keypoints:** SIFT Algorithm is implemented for finding the keypoints (x, y) locations and their corresponding descriptors (128 sized feature vectors). The steps involved are:

   1. **Detection of scale-space Extrema:**
      - Scaling of the grayscale image values between 0 and 1.
      - Upsampling of the original image to double the size of the original image. This is done to create more sample points than were present in the original image, to make full use of the input.
      - Creation of 5 octaves, each consisting of s = 3 scales (hence s+3 = 6 images). The images in each octave are Gaussian blurred at different scales. The base value of standard deviation used is 1.6, which is successively incremented with increasing values in the form of k^n * sigma, where $k = 2^{-s}$.

        $$L(x,y,sigma) = G(x,y,sigma) * I(x,y)$$

      - Creation of Difference of Gaussians (DoGs) by subtracting the adjacent Gaussian blurred images in each octave. These are 4 in number.

        $$D(x,y,sigma) = L(x,y,k*sigma) – L(x,y,sigma)$$

      - All the pixels that are local extrema (maxima or minima) in a 3 X 3 neighborhood are selected as potential keypoints.

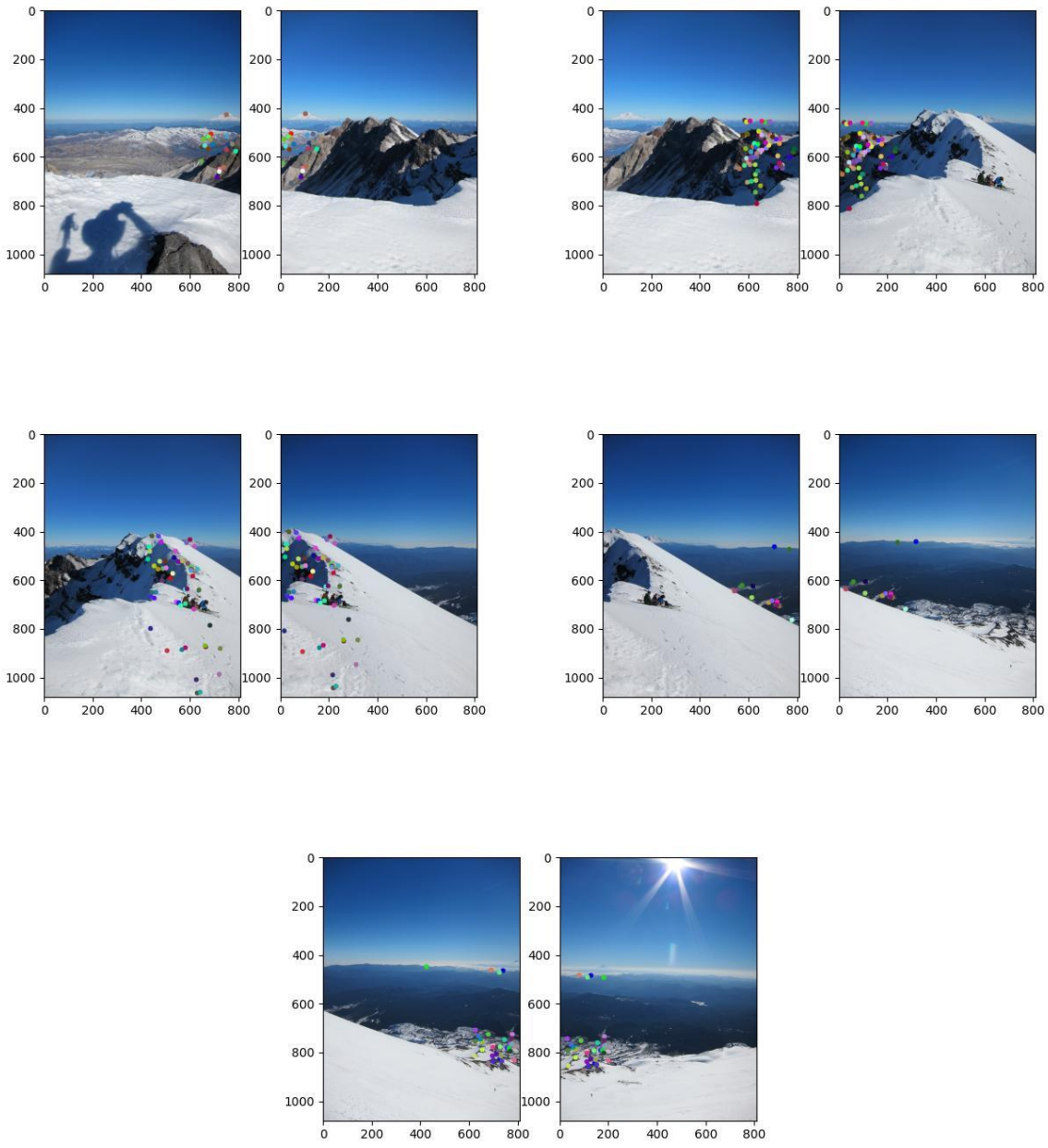
   2. **Eliminating low contrast and poorly edge localized keypoints:**
      - All local extrema with a DoG value less than 0.0025 (these are unstable extrema with low contrast) are discarded.
      - The keypoints along edges are removed by finding the principal curvatures from the Hessian matrix H, and putting a threshold such that:
        $Tr(H)^2 / Det(H) < (r+1)^2 / r$ for r = 10

   3. **Orientation Assignment:**
      - An orientation histogram is formed from the gradient orientations of sample points within a region around the keypoint. The orientation histogram has 36 bins covering the 360-degree range of orientations.
      - Each sample added to the histogram is weighed by its gradient magnitude and by a Gaussian-weighted circular window with a sigma that is 1.5 times that of the scale of the keypoint.
      - The highest peak in the histogram is detected, and then any other local peak that is within 80% of the highest peak is used to also create a keypoint with that orientation.
      - Finally, a parabola is fit to the 3 histogram values closest to each peak to interpolate the peak position for better accuracy.

   4. **The Local Image Descriptor:**
      - The image gradient magnitudes and orientations are sampled around the keypoint location, using the scale of the keypoint to select the level of Gaussian blur for the image.

- To achieve orientation invariance, the gradient orientations are rotated relative to the keypoint orientation.
- A Gaussian weighting function with sigma equal to one-half the width of the descriptor window is used to assign a weight to the magnitude of each sample point.
- Orientation histograms are created over 4x4 sample regions with 8 orientation bins in each.
- The descriptor is formed from a vector containing the values of all the orientation histogram entries, leading to a 4x4x8 = 128 element feature vector for each keypoint.

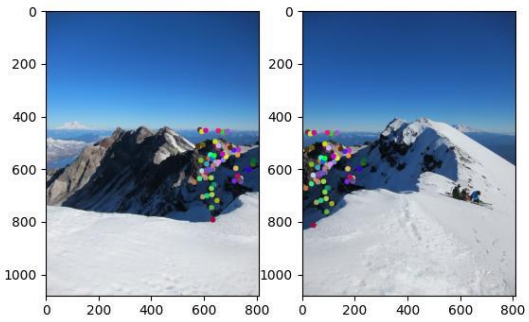
3. **Finding matching keypoints between adjacent images to be stitched**:
    - The Euclidean distance between any two pairs of SIFT keypoints, which are in the right half of the left image and in the left half of the right image, are compared.
    - The matching keypoints are those that satisfy the condition: Nearest_neighbour_distance < 0.6*Second_nearest_neighbour_distance

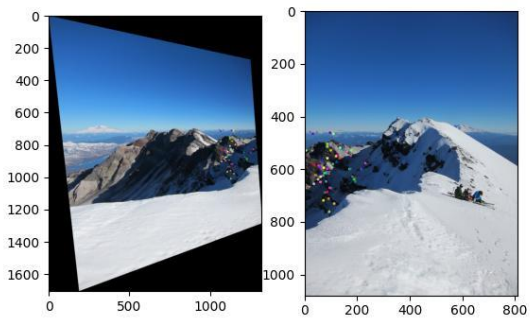


4. **Image Registration and Stitching:** This is implemented in 3 steps, Left Stitch, Right Stitch and Final Stitch.

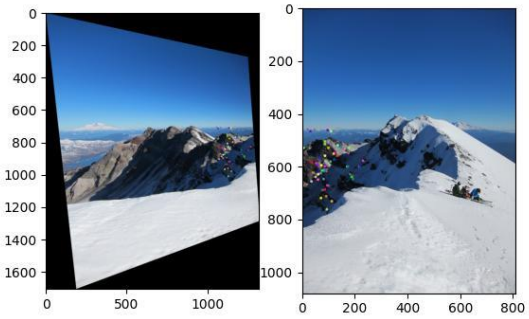
Left Stitch: The stitching is done for the left half set of images from the extreme left end. For a set of two adjacent images:

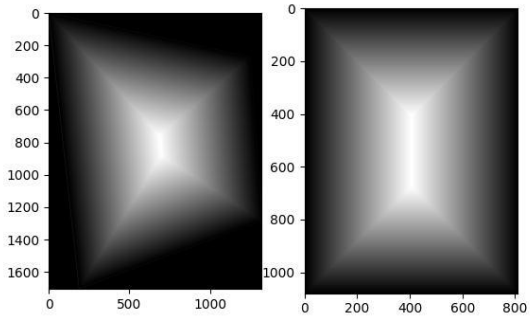
- The Homography matrix of the left image with respect to the coordinate system of the right image is found using the RANSAC algorithm.
- The left image is back-warped to the coordinate system of the right image.



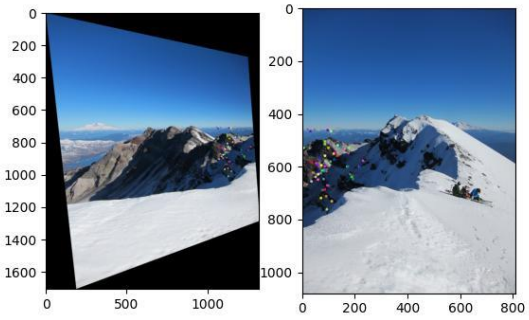


- The two images are then aligned and feathering (weighted average of intensities weighed by the distance of pixel from the image border) approach is used to remove the seam between the two images.



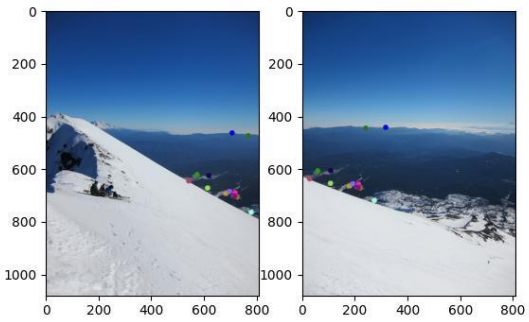


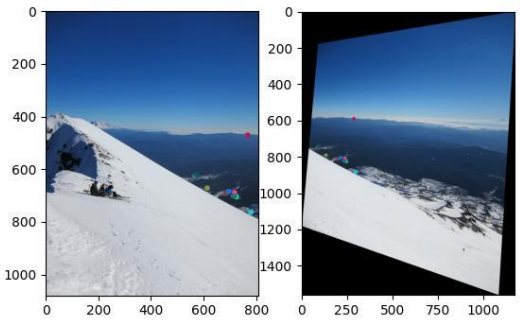
- Now the stitched image is used as the new left image for stitching it with the corresponding right image. The process is repeated till all the left-half images are stitched together.



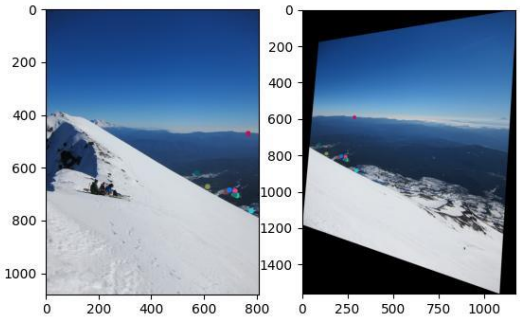
Right Stitch: The stitching is done for the right half set of images from the extreme right end. For a set of two adjacent images:

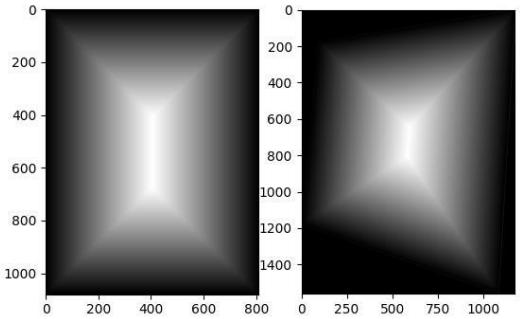
- The Homography matrix of the right image with respect to the coordinate system of the right image is found using the RANSAC algorithm.
- The right image is back-warped to the coordinate system of the left image.



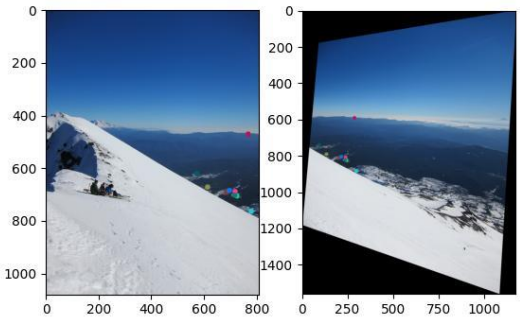


- The two images are then aligned and feathering approach is used to remove the seam between the two images.

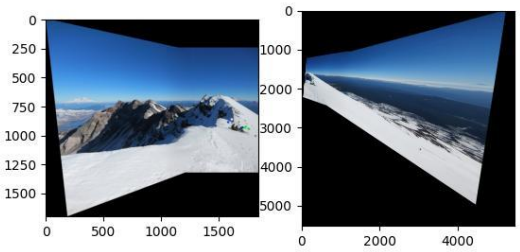


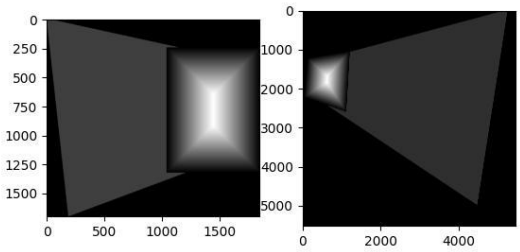


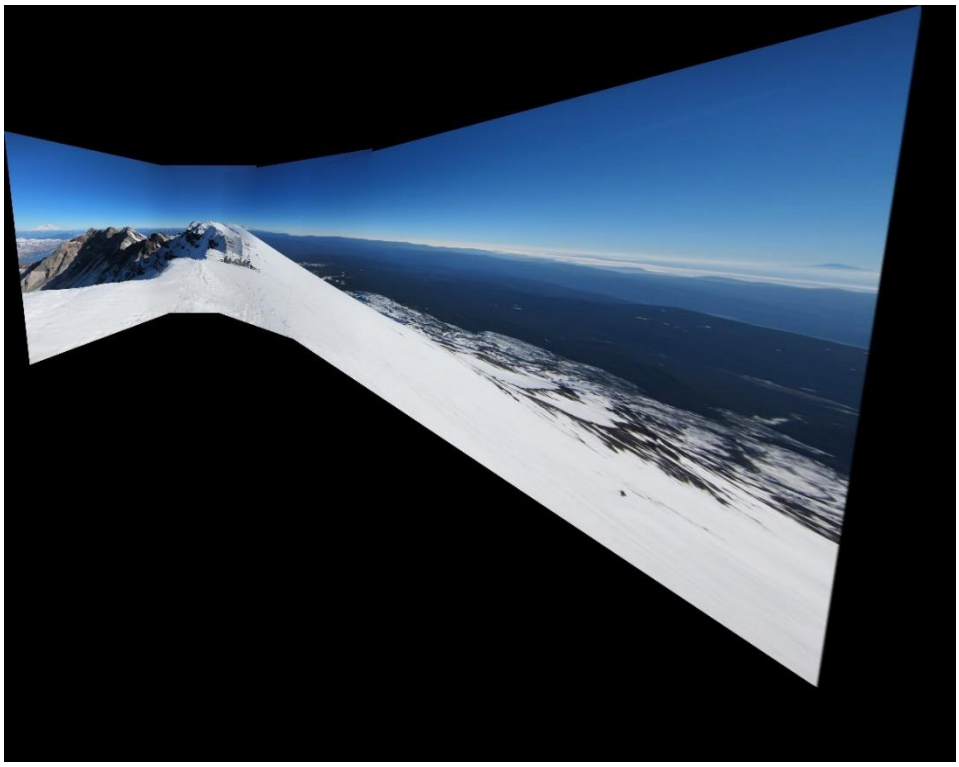
- Now the stitched image is used as the new right image for stitching it with the corresponding left image. The process is repeated till all the right-half images are stitched together.



Final Stitch: Now both the Left Stitch and Right Stitch halves are stitched together to create a Panaroma.







Panaroma with seam removal

Panaroma without seam removal

Task-2: Panaroma Creation from Videos (vid2.mp4)

1. **Equi-spaced frames are extracted from the given video file, and the images are written to a folder.**





2. **All the other steps remain the same as that in Task-1.**

Office

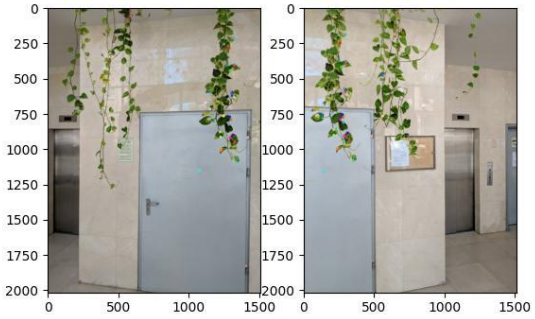
Step 1:

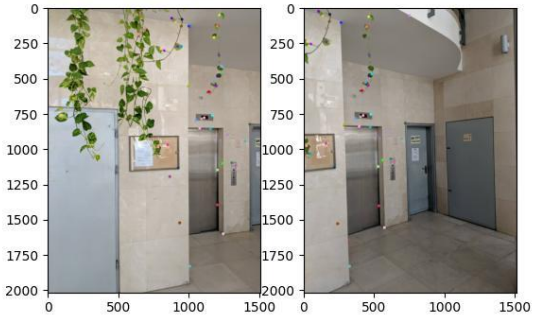


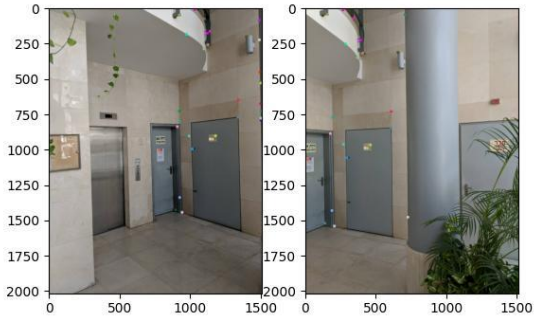



Step 2:

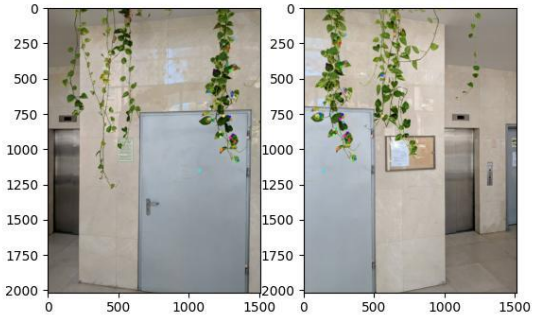
Step 3:

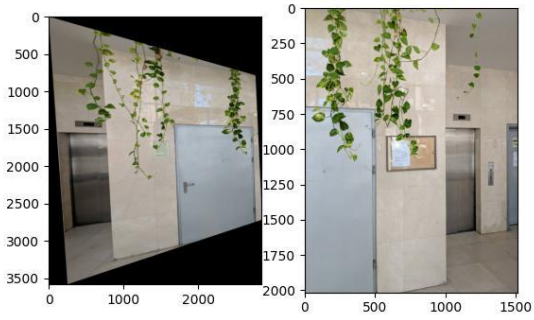


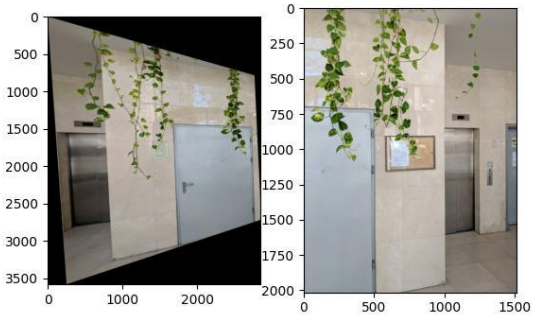


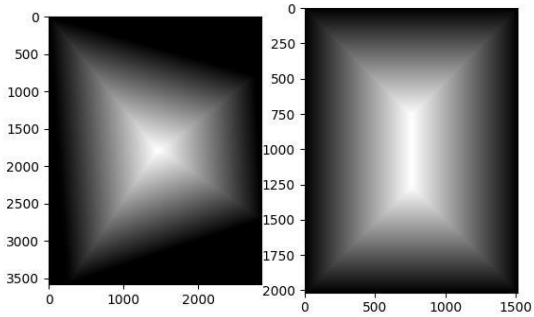


Step 4:
Left Stitch:

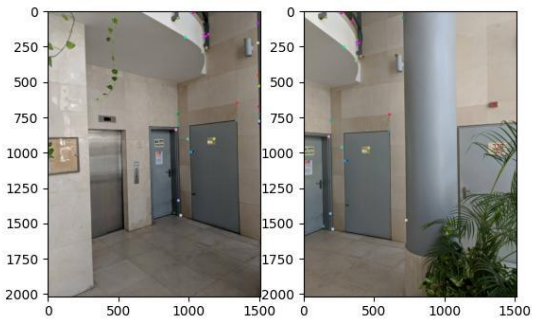


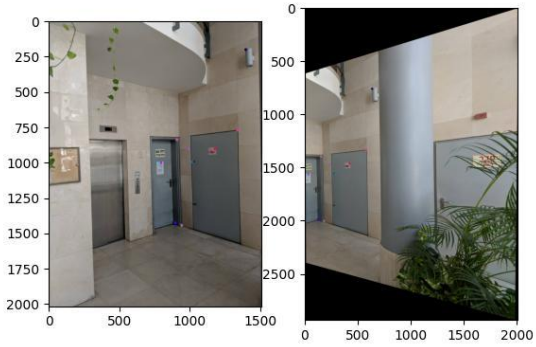


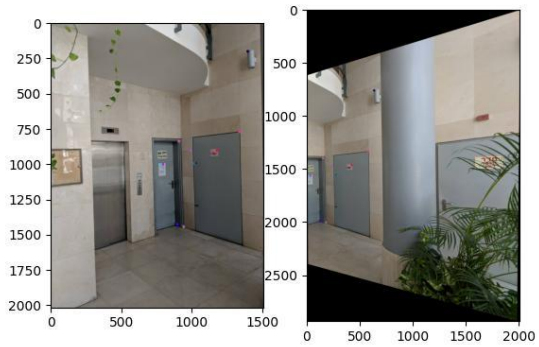


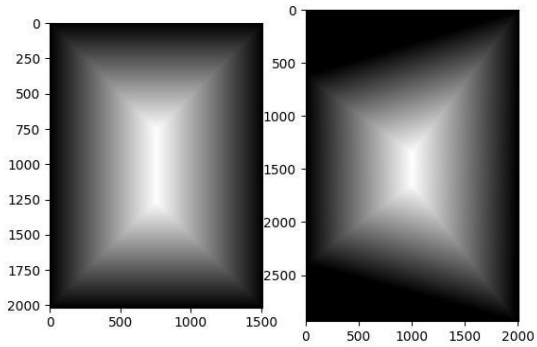


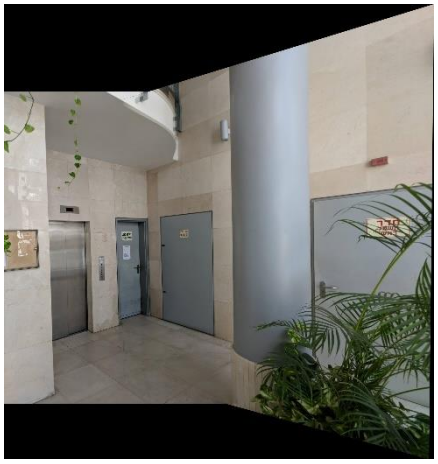
Right Stitch:



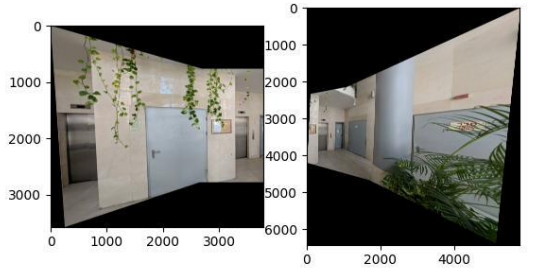


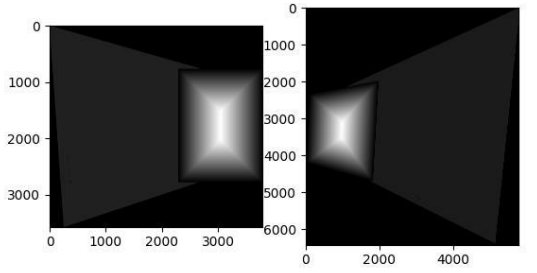




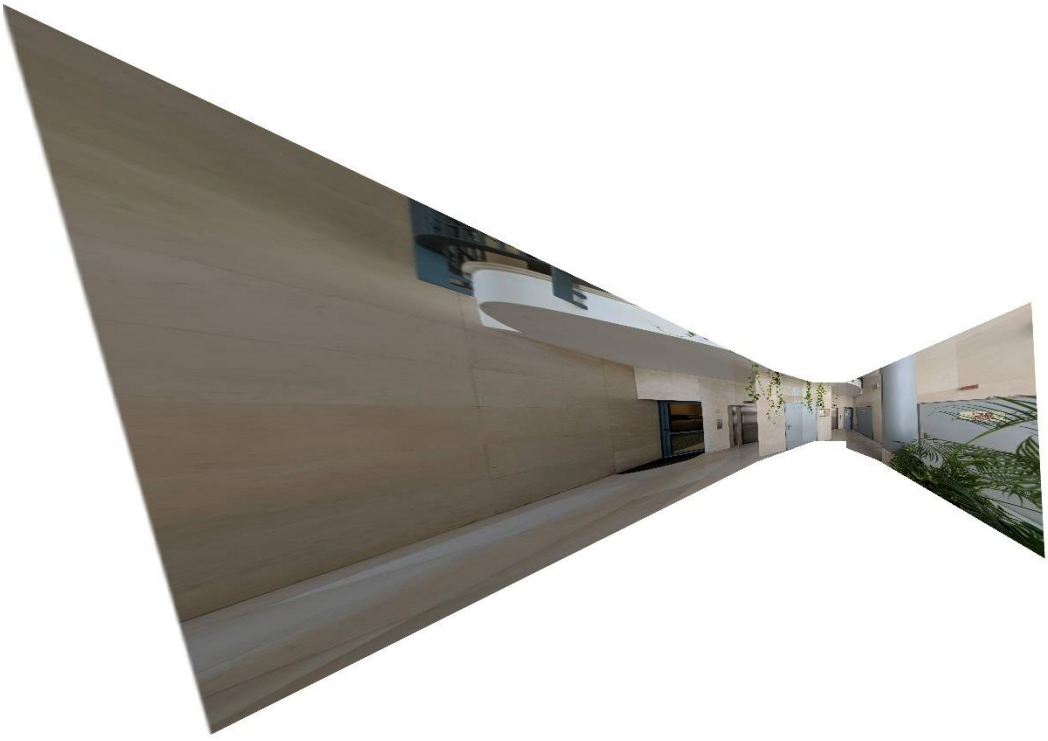


Final Stitch:





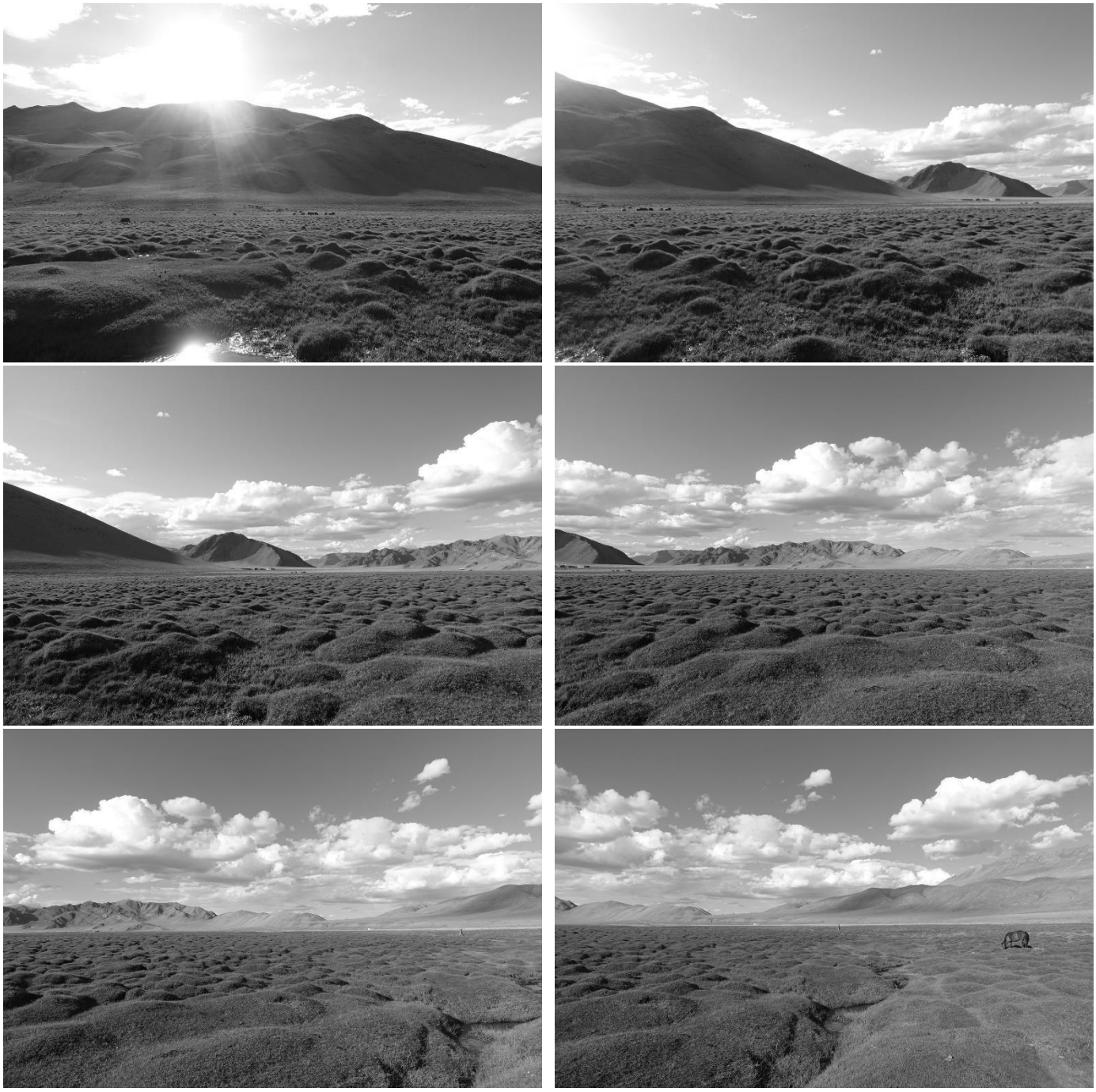
Panaroma with seam removal



Panaroma without seam removal

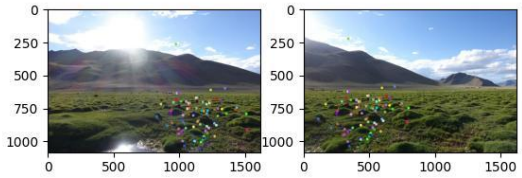
Field

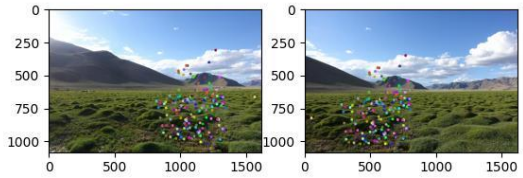
Step 1:

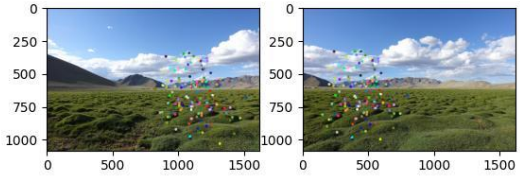


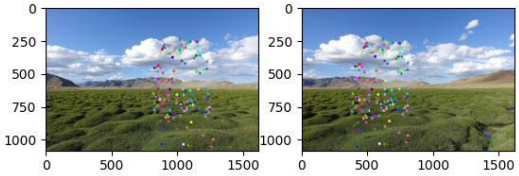
Step 2:

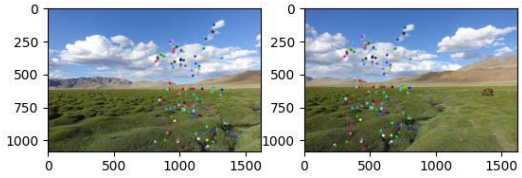
Step 3:


0
250
500
750
1000
0
500
1000
1500

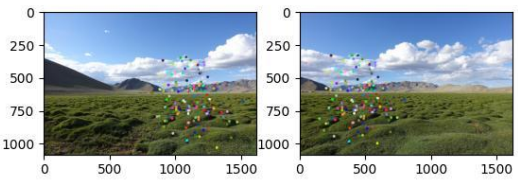

0
250
500
750
1000
0
500
1000
1500

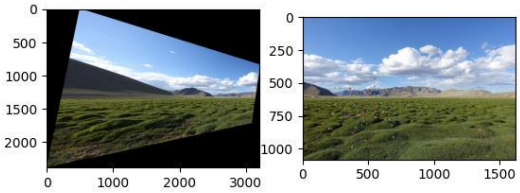

0
250
500
750
1000
0
500
1000
1500

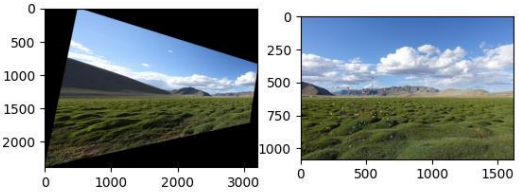

0
250
500
750
1000
0
500
1000
1500

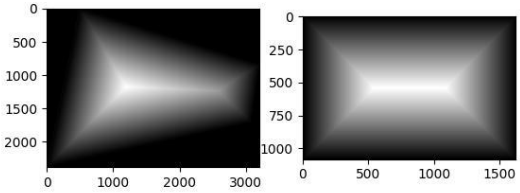

0
250
500
750
1000
0
500
1000
1500

Step 4:
Left Stitch:

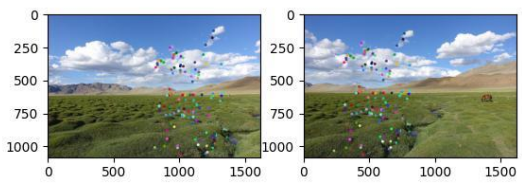
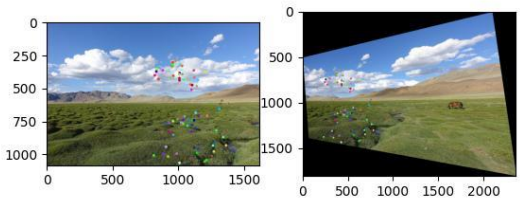
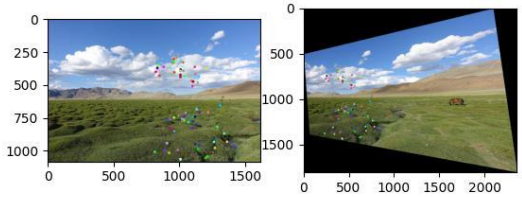
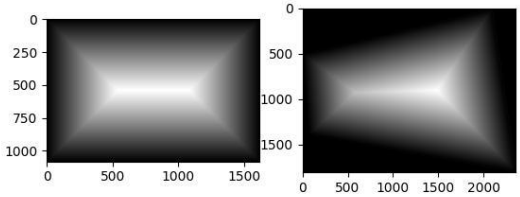




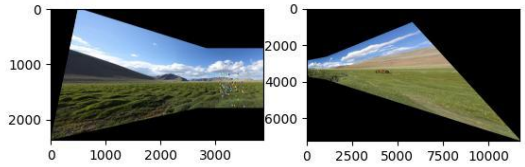


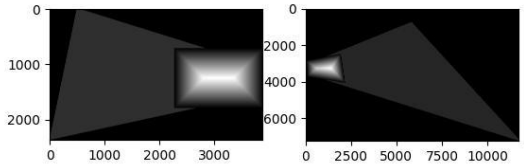


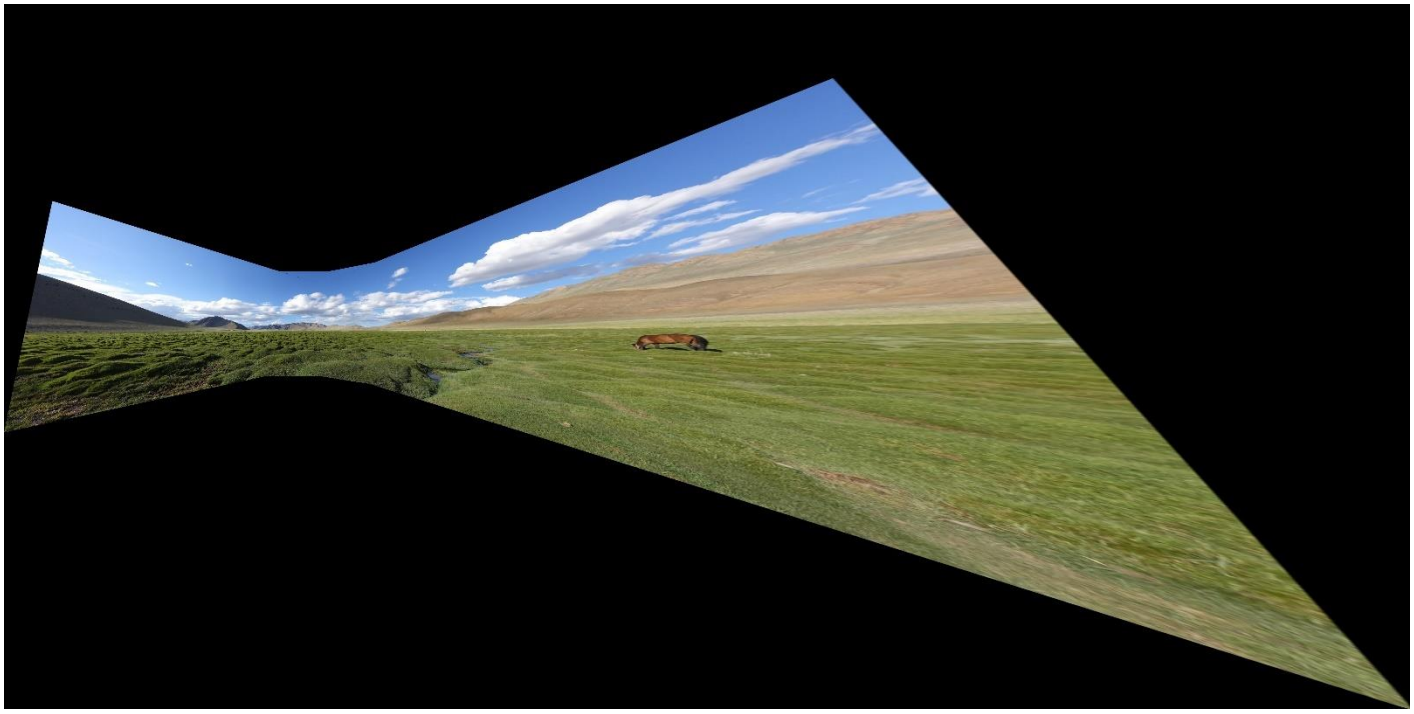
Right Stitch:


Final Stitch:







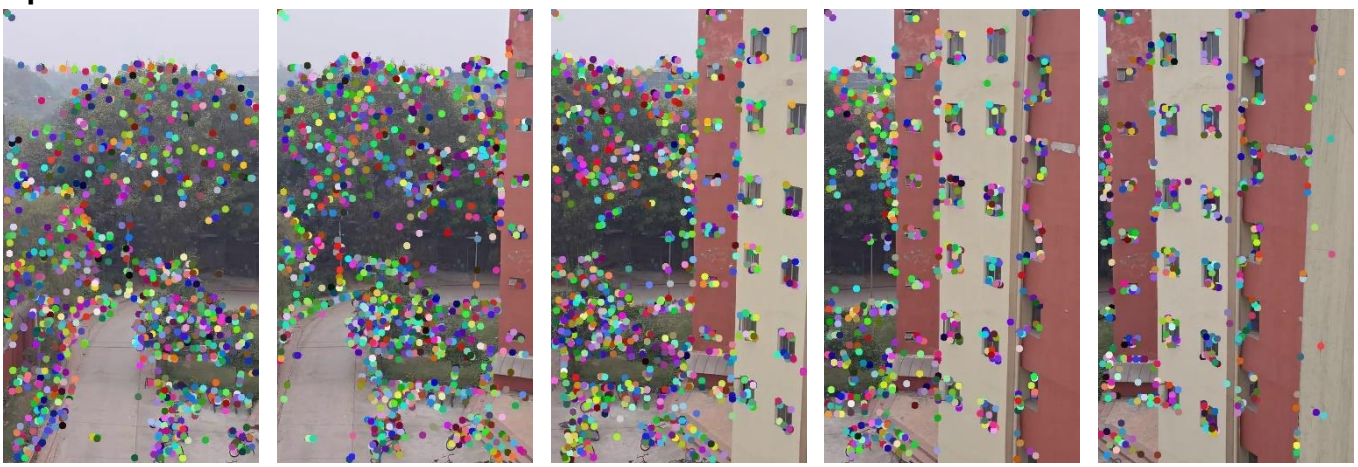
Panaroma with seam removal

vid1.mp4

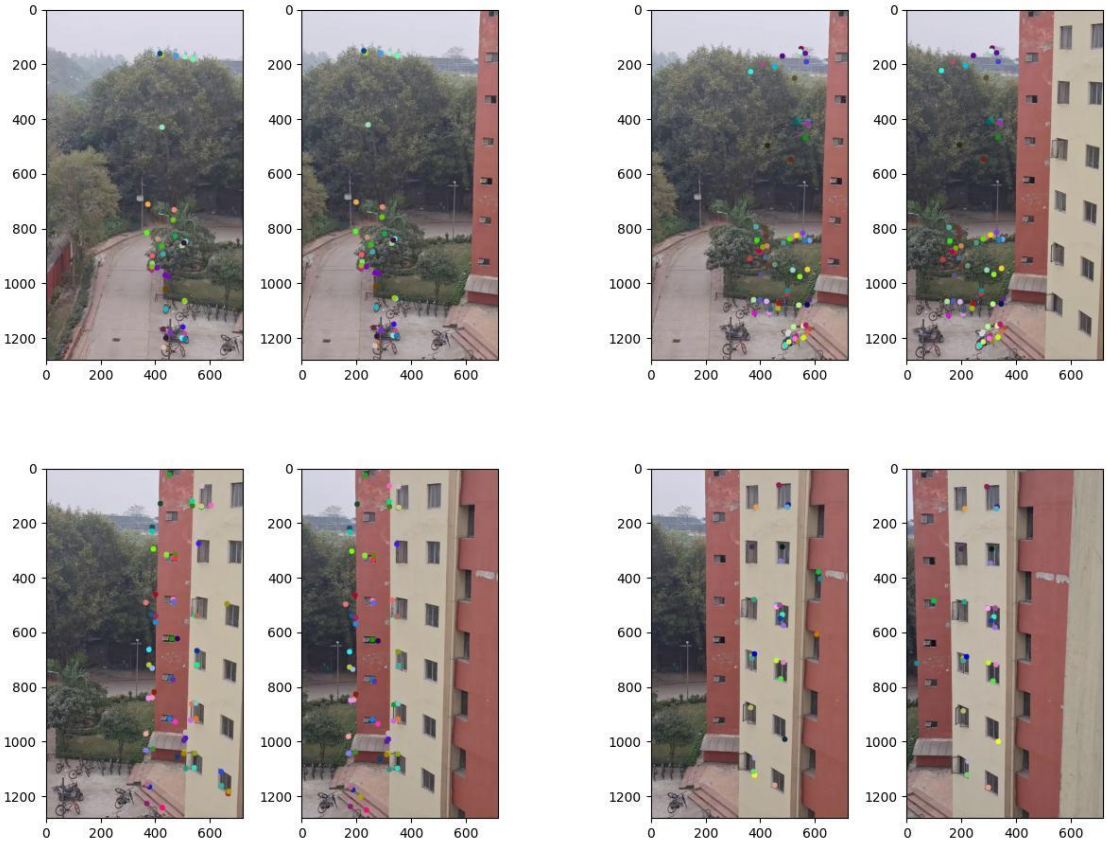
Images Extracted:

Step 1:

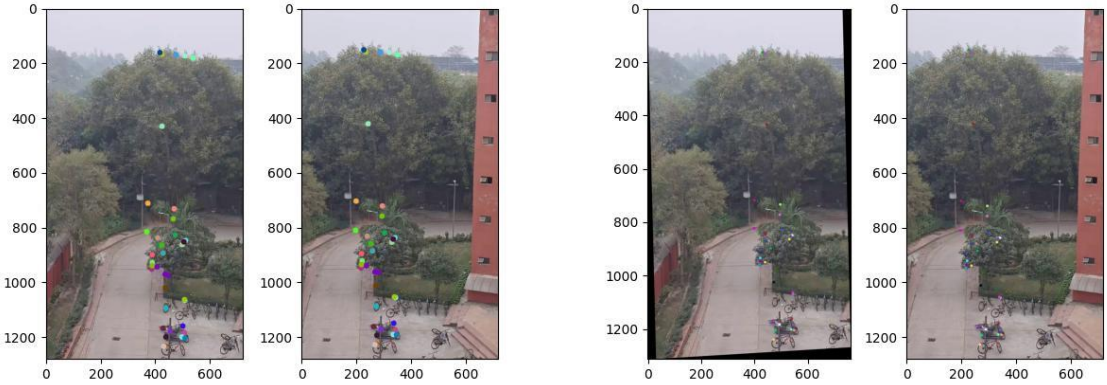
Step 2:

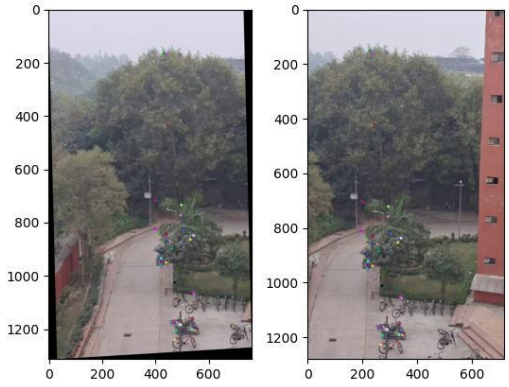
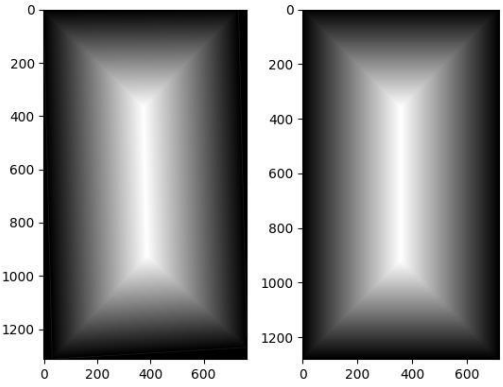
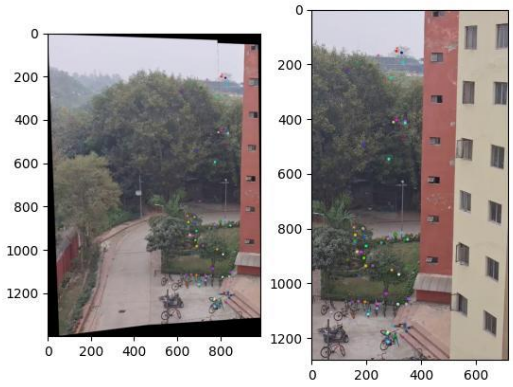
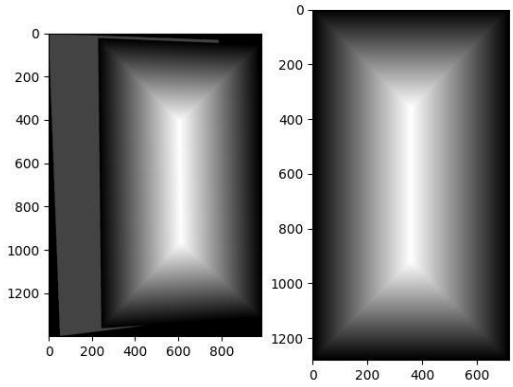


Step 3:

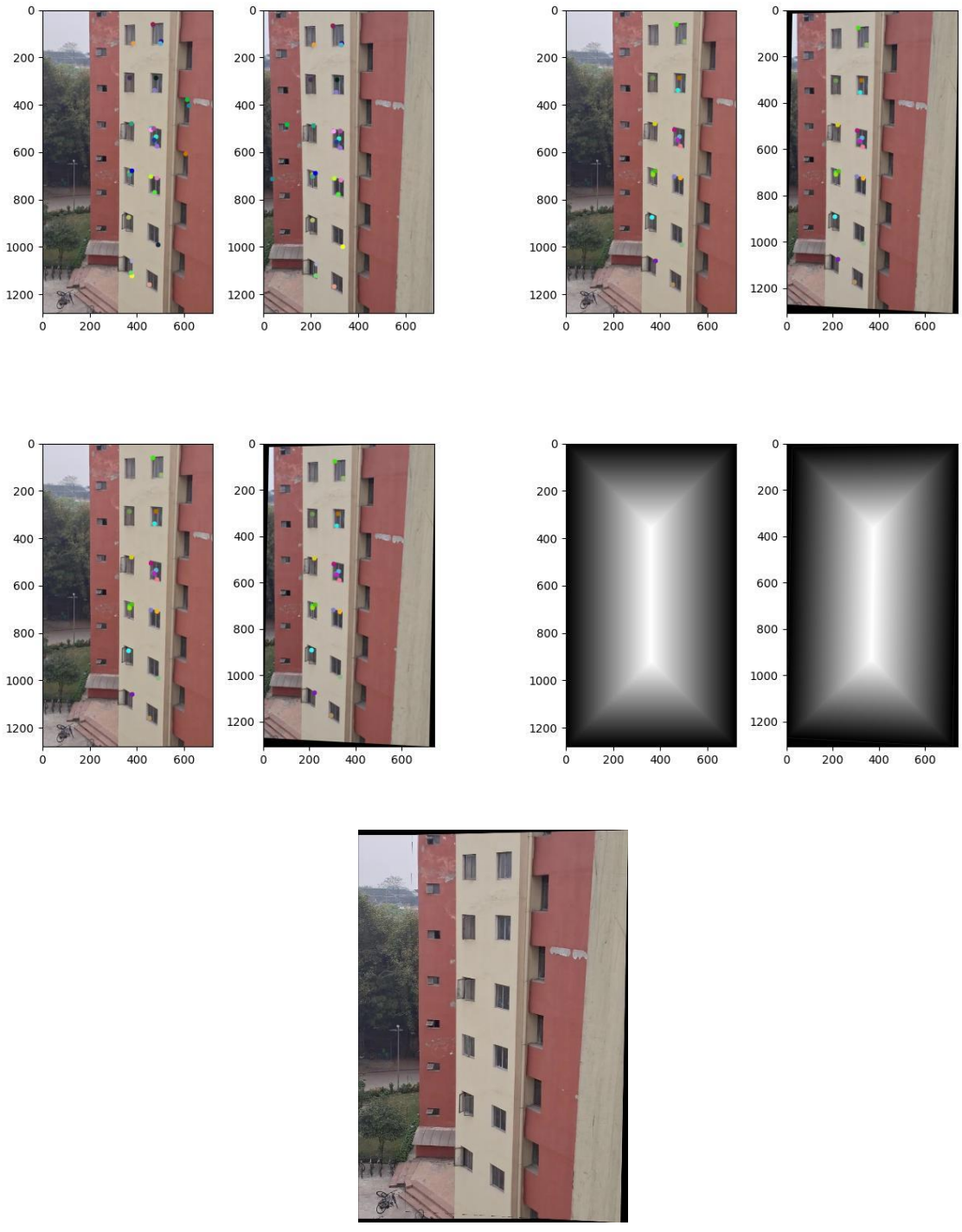


Step 4:
Left Stitch:

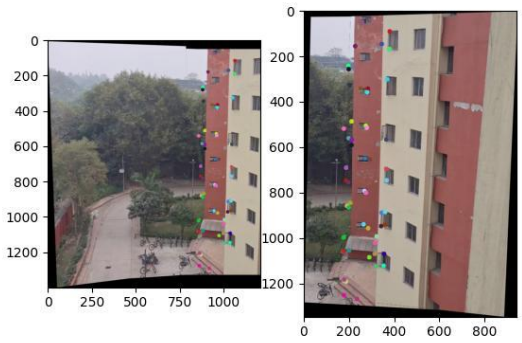


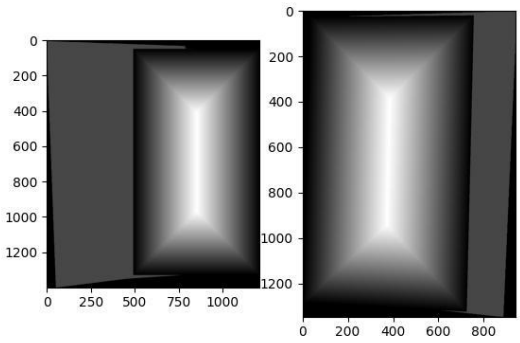






Right Stitch:



Final Stitch:





Panaroma with seam removal

Panaroma without seam removal

vid2.mp4

Images Extracted:



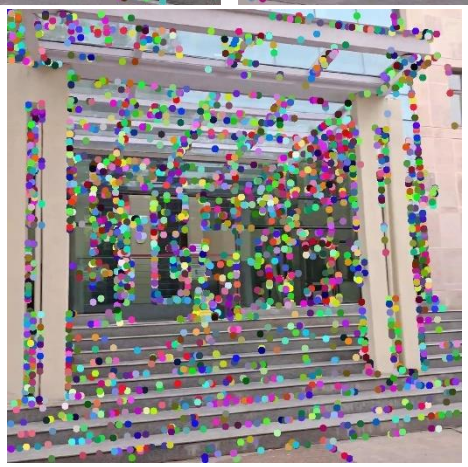


Step 1:

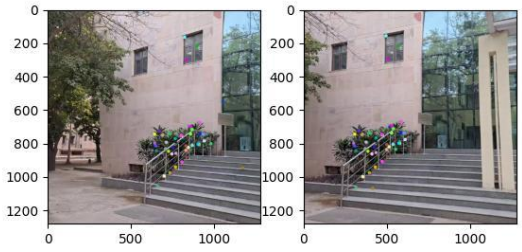


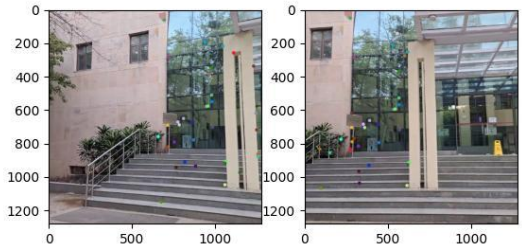

Step 2:

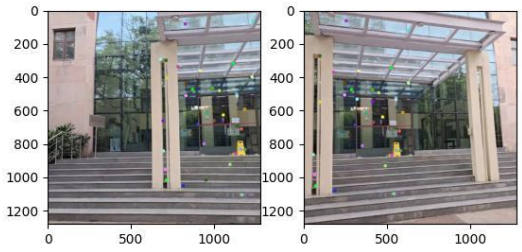


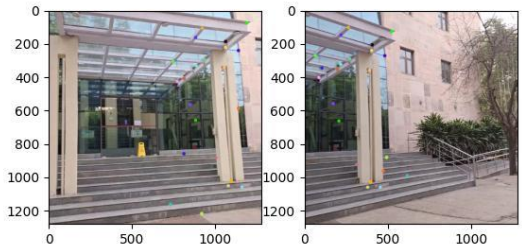




Step 3:

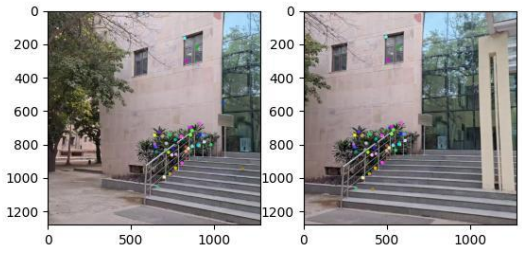


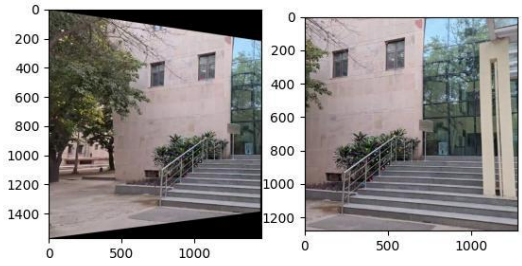


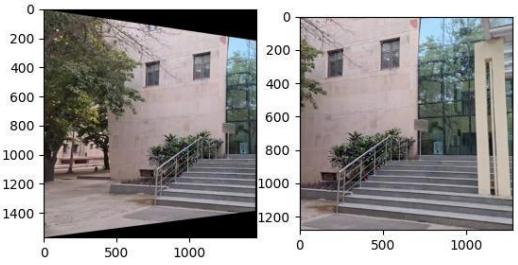


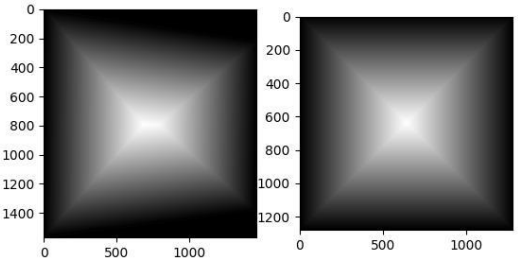


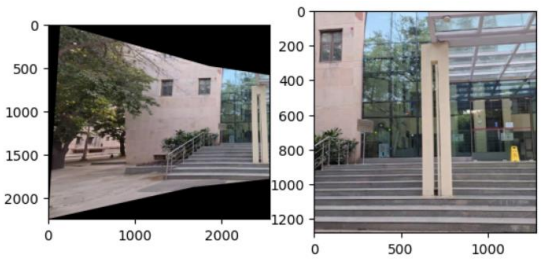
Step 4:
Left Stitch:

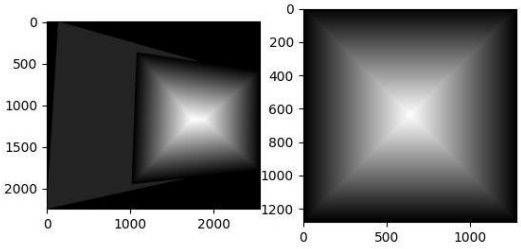


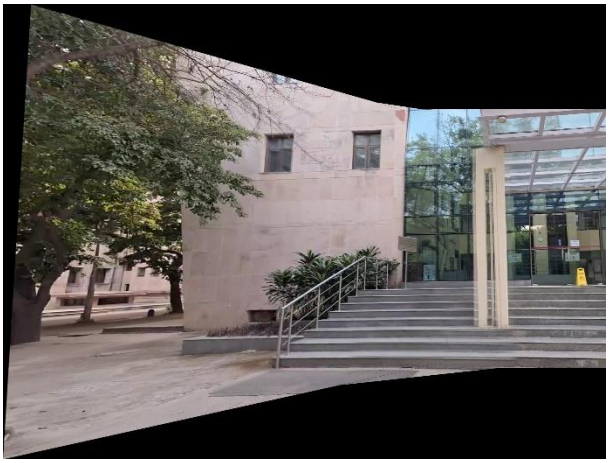




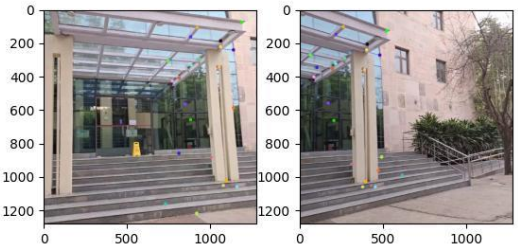


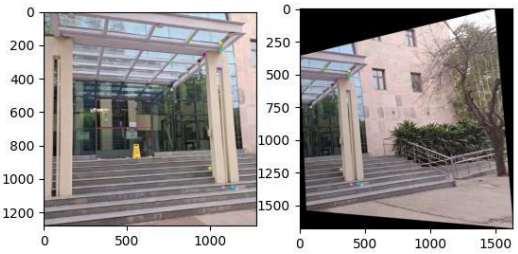


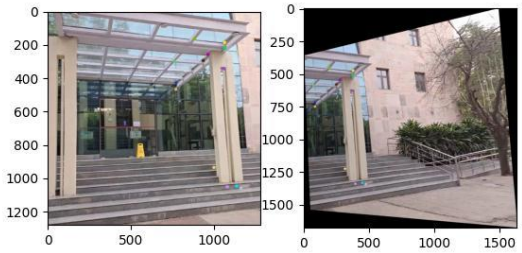


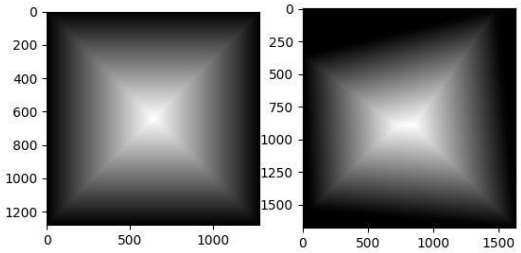


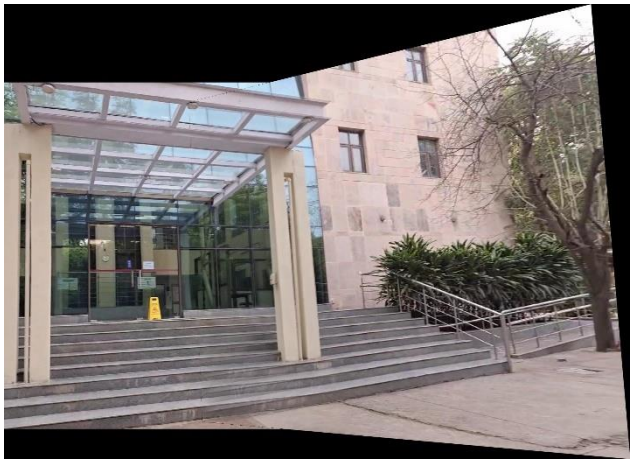
Right Stitch:



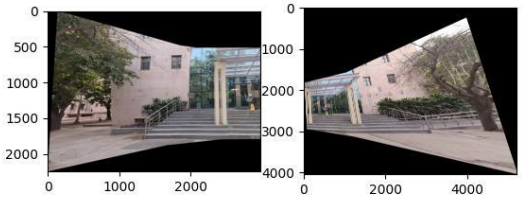


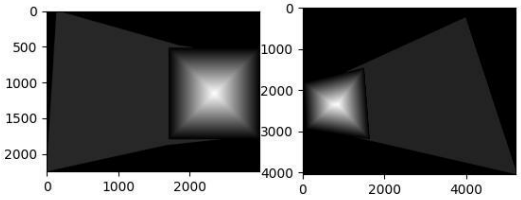


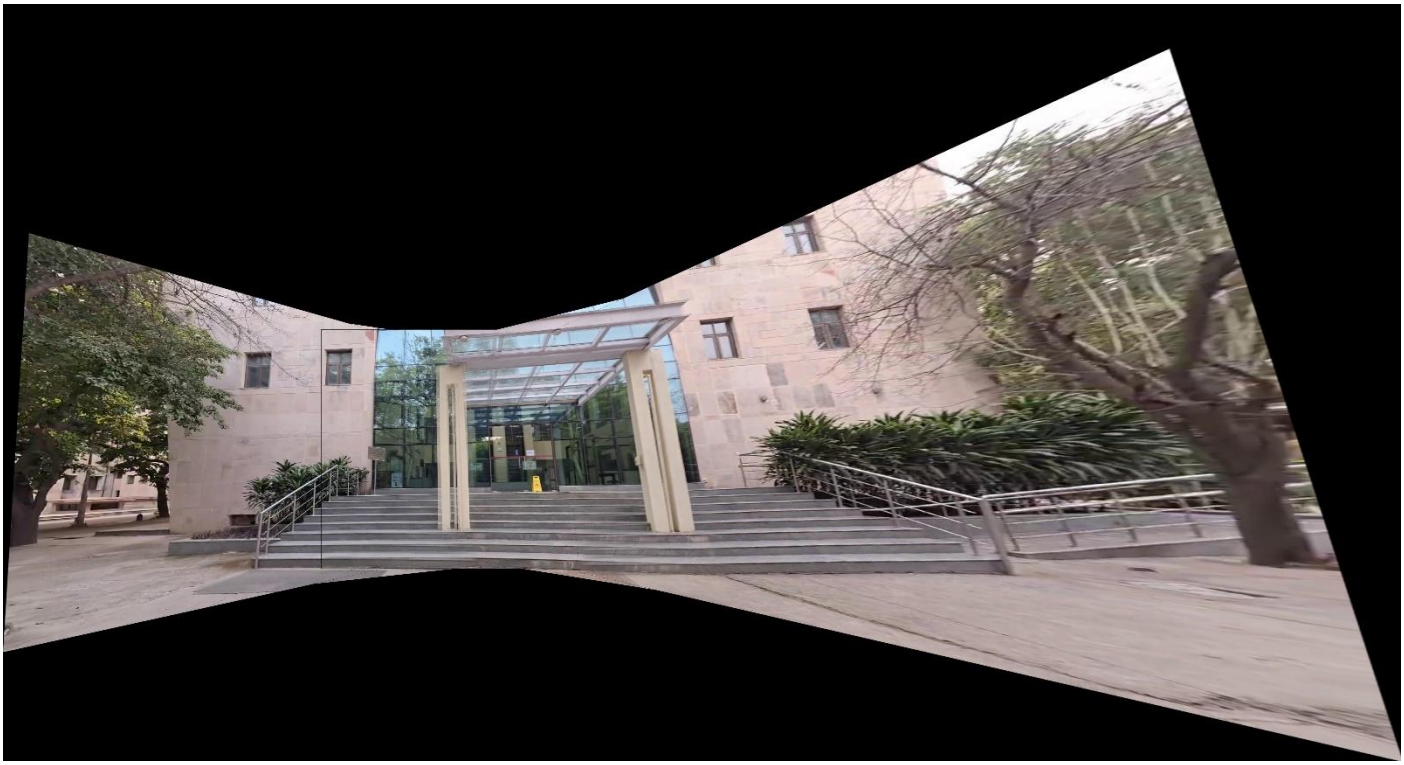




Final Stitch:







Panaroma with seam removal

Panaroma without seam removal

vid3.mp4

Images Extracted:

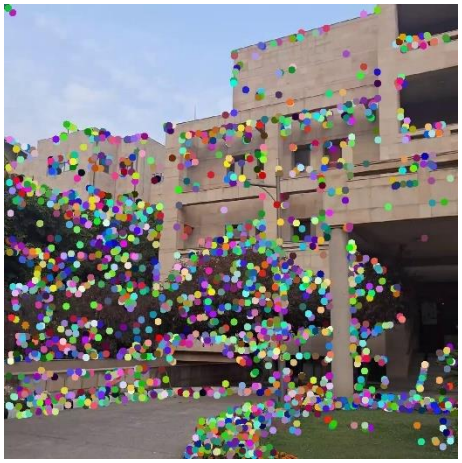
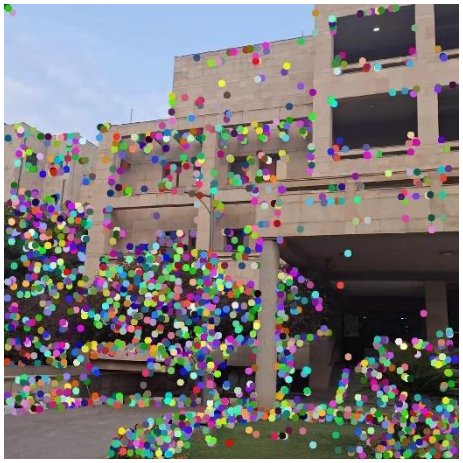


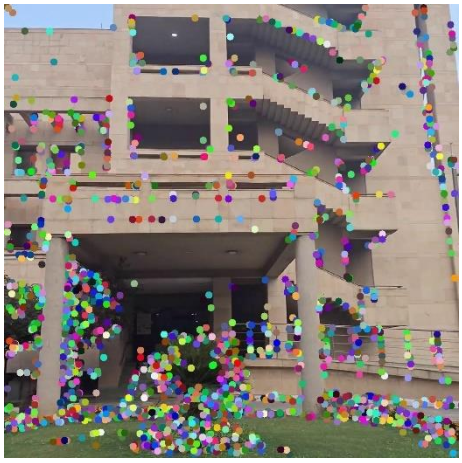
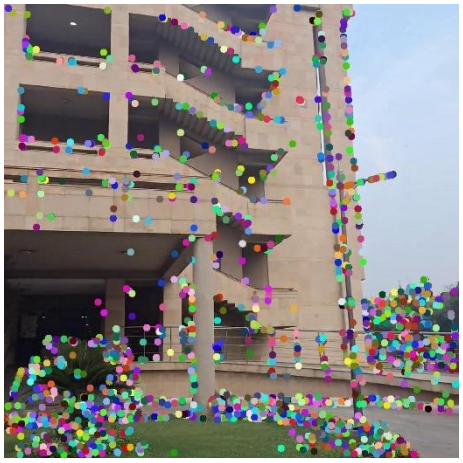


Step 1:

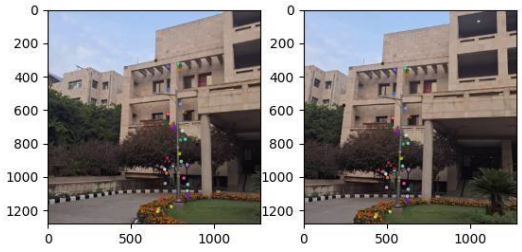


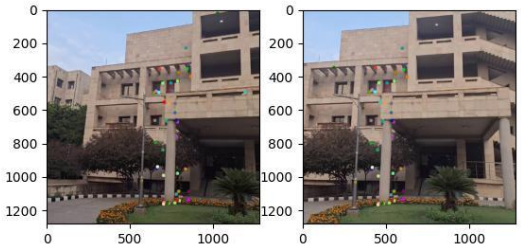

Step 2:

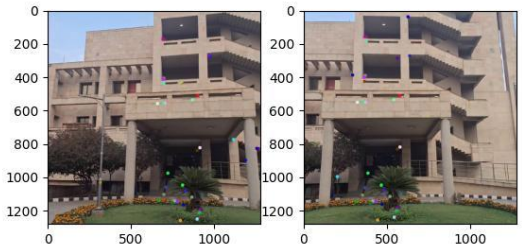



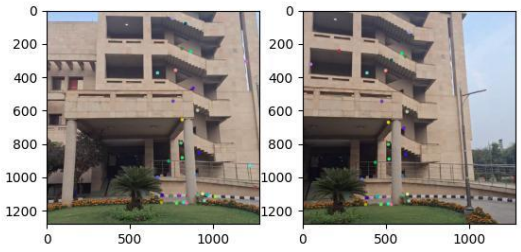



Step 3:

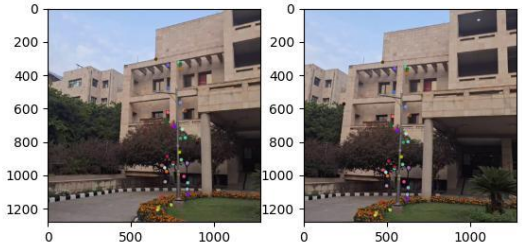


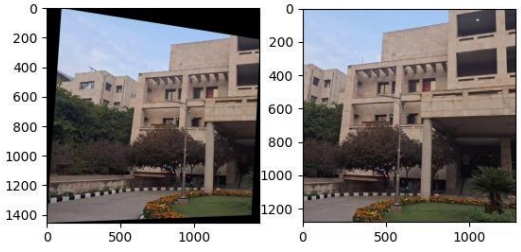


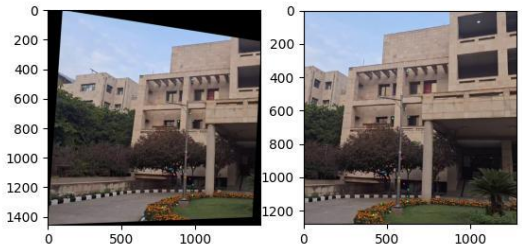


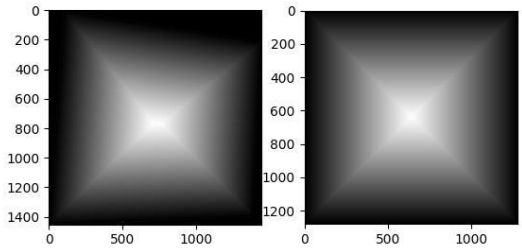


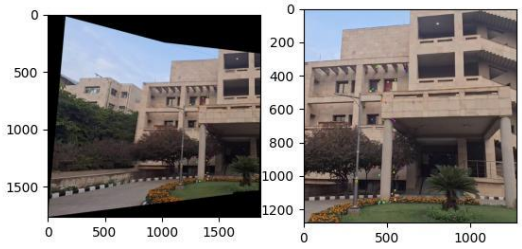
Step 4:

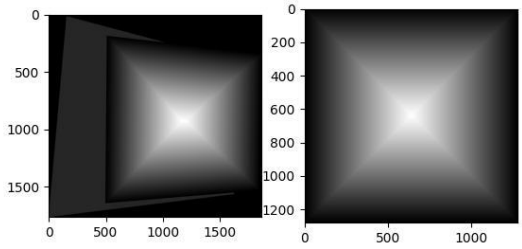




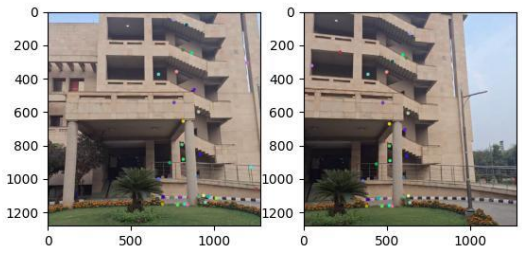
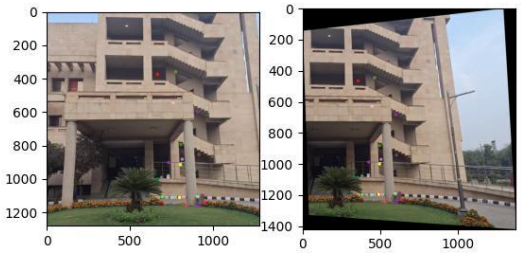
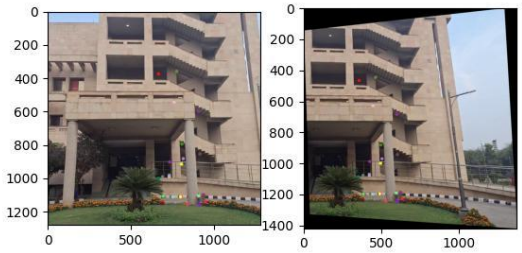
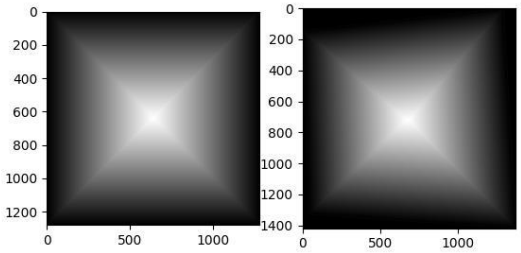




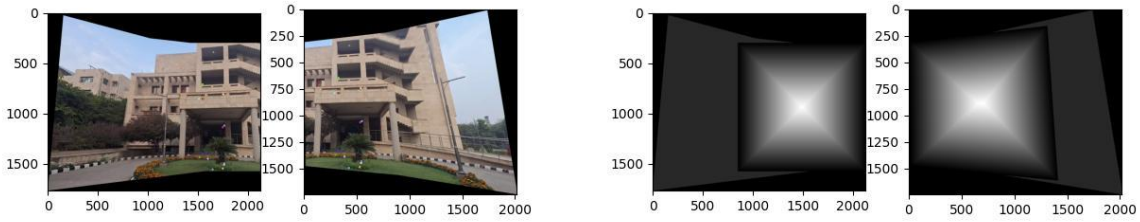




Right Stitch:


Final Stitch:



Panaroma with seam removal

Paranoma without seam removal

Library functions used:

1. NumPy: For Matrix Algebra
2. OpenCV: For reading and writing images
3. os: For reading files from folders
4. sys: For taking arguments as input
5. math: For mathematics operations like square root, ceil, floor, etc.
6. random: For generating random numbers