IMAGE WARPING and MOSAICING

Part A: Image Warping and Mosaicing

Part A.1: Shoot the Pictures

Description: Take two or more pictures with a projective transformation (perspective transformation) between them. The most common approach is to fix the center of projection (COP) and rotate the camera to take the photos.

My approach: I took multiple photos of the same scene, keeping the camera position roughly fixed and only changing the shooting angle to obtain image pairs with projective transformation relationships. This ensures that there is the required perspective transformation relationship between the images.

Results: The following shows examples of the images I captured.

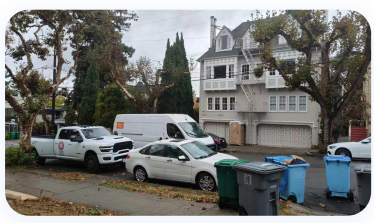


Image 1

Image 2

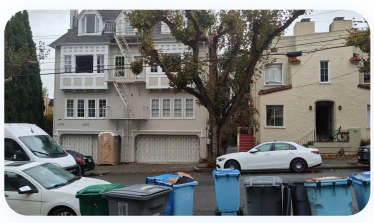


Image 3

Image 1

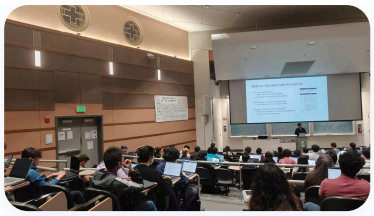


Image 2

Image 3

Part A.2: Recover Homographies

Description: Before aligning images, you need to recover the transformation parameters between each pair of images. In our case, the transformation is a homography: p'=Hp, where H is a 3x3 matrix with 8 degrees of freedom (the lower right corner is a scaling factor that can be set to 1).

My approach: Implemented the computeH function to calculate the homography matrix H through n corresponding point pairs. Using linear system solving method, the problem is transformed into the form Ah=b, where h is a vector of 8 unknown entries of H. When n>4, the system is overdetermined, and the least squares method is used to solve it.

Main code:

▶ Show Code

Results: Example of homography matrix obtained by this function: [[1.05280819e+00 8.95665586e-02 -2.70773387e+01] [-8.27119946e-02 1.05850720e+00 -2.57703311e+01] [-7.77872637e-05 3.13425327e-04 1.00000000e+00]]

Part A.3: Warp the Images

Description: Knowing the parameters of the homography transformation, you can use this homography matrix to transform each image toward the reference image. Two interpolation methods were implemented: nearest neighbor interpolation and bilinear interpolation.

My approach: Implemented the warpImage function, supporting two interpolation methods. Using inverse transformation (to avoid holes in the

output image), calculating the bounding box of the output image, and then performing inverse transformation for each pixel to find the corresponding position in the source image.

Main code:

▶ Show Code

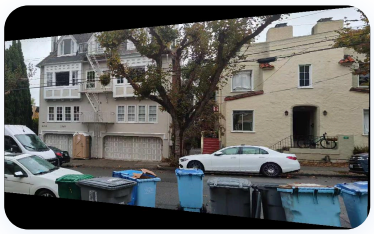
Results: The following shows the results of image transformation using two interpolation methods.

Nearest Neighbor Interpolation

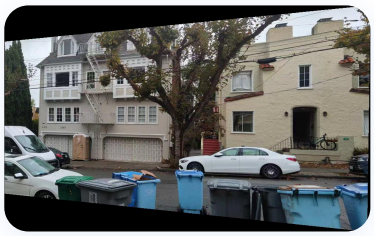
Bilinear Interpolation

Nearest Neighbor Interpolation

Bilinear Interpolation



Nearest Neighbor Interpolation



Bilinear Interpolation

Part A.4: Blend Images into a Mosaic

Description: Fuse the transformed images to create an image mosaic. Alpha blending is used to achieve seamless stitching.

My approach: Implemented the create_mosaic function, which transforms and aligns multiple images according to the calculated homography matrices, and then uses alpha blending technique to fuse them into a seamless panoramic image. The alpha value is calculated based on the distance from the center of the image to achieve smooth transition.

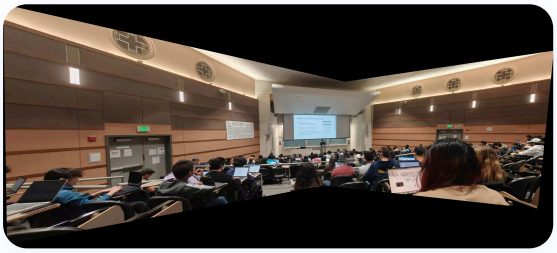
Main code:

▶ Show Code

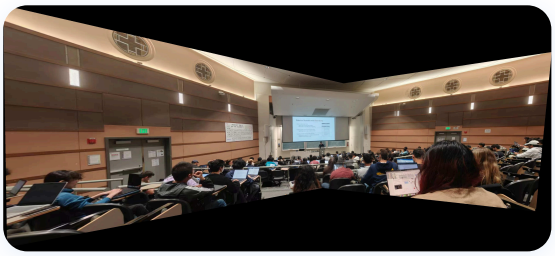
Results: The following shows the image mosaic results generated using two interpolation methods.

Nearest Neighbor Interpolation Mosaic

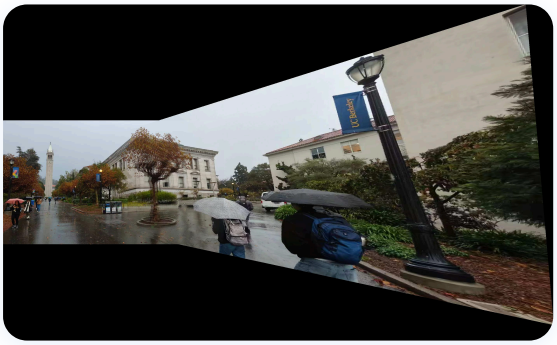
Bilinear Interpolation Mosaic



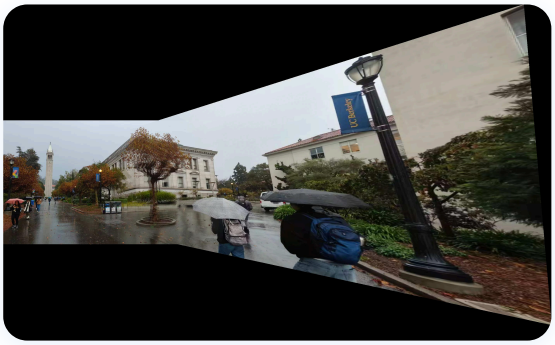
Nearest Neighbor Interpolation Mosaic



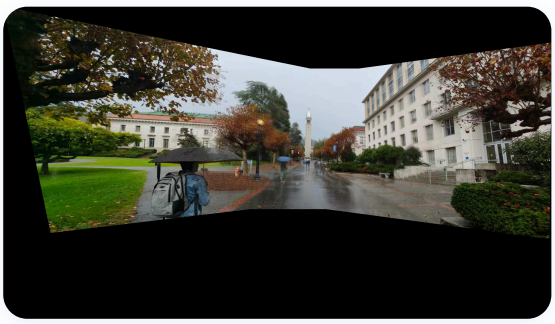
Bilinear Interpolation Mosaic



Nearest Neighbor Interpolation Mosaic

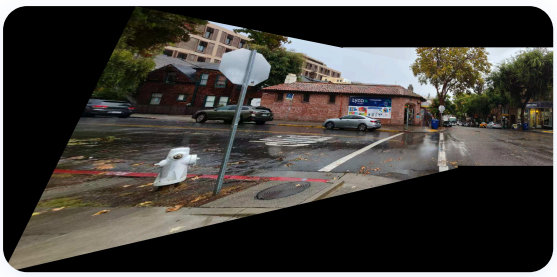


Bilinear Interpolation Mosaic

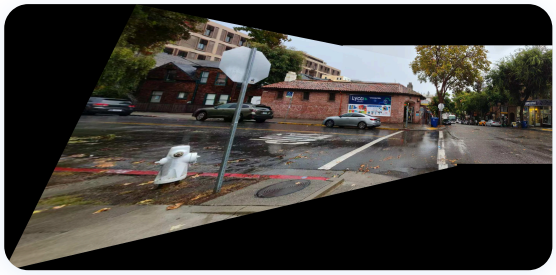


Bilinear Interpolation Mosaic

Nearest Neighbor Interpolation Mosaic



Nearest Neighbor Interpolation Mosaic



Bilinear Interpolation Mosaic

Part A.5: Summary

Project completion status:

1. Implemented the homography matrix calculation function computeH
2. Implemented two interpolation methods: nearest neighbor interpolation and bilinear interpolation
3. Completed the image rectification function
4. Completed the image stitching function
5. Used Alpha blending technology to achieve seamless stitching

Problems encountered and solutions:

1. During image transformation, boundary processing is a key issue. By calculating the bounding box of the transformed image, all content is ensured to be included.
2. When stitching images, direct stitching produces obvious seams. By using Alpha blending technology, the mixing weight is determined according to the pixel distance from the center of the image, achieving smooth transition.
3. Coordinate system conversion needs to be handled correctly during inverse transformation to ensure accurate pixel position mapping.

Comparison of two interpolation methods:

The nearest neighbor interpolation method is simple and fast, but produces jagged edges and lower image quality.

The bilinear interpolation method has slightly higher computational complexity, but can produce smoother image effects and higher quality.

In practical applications, bilinear interpolation is a better choice.