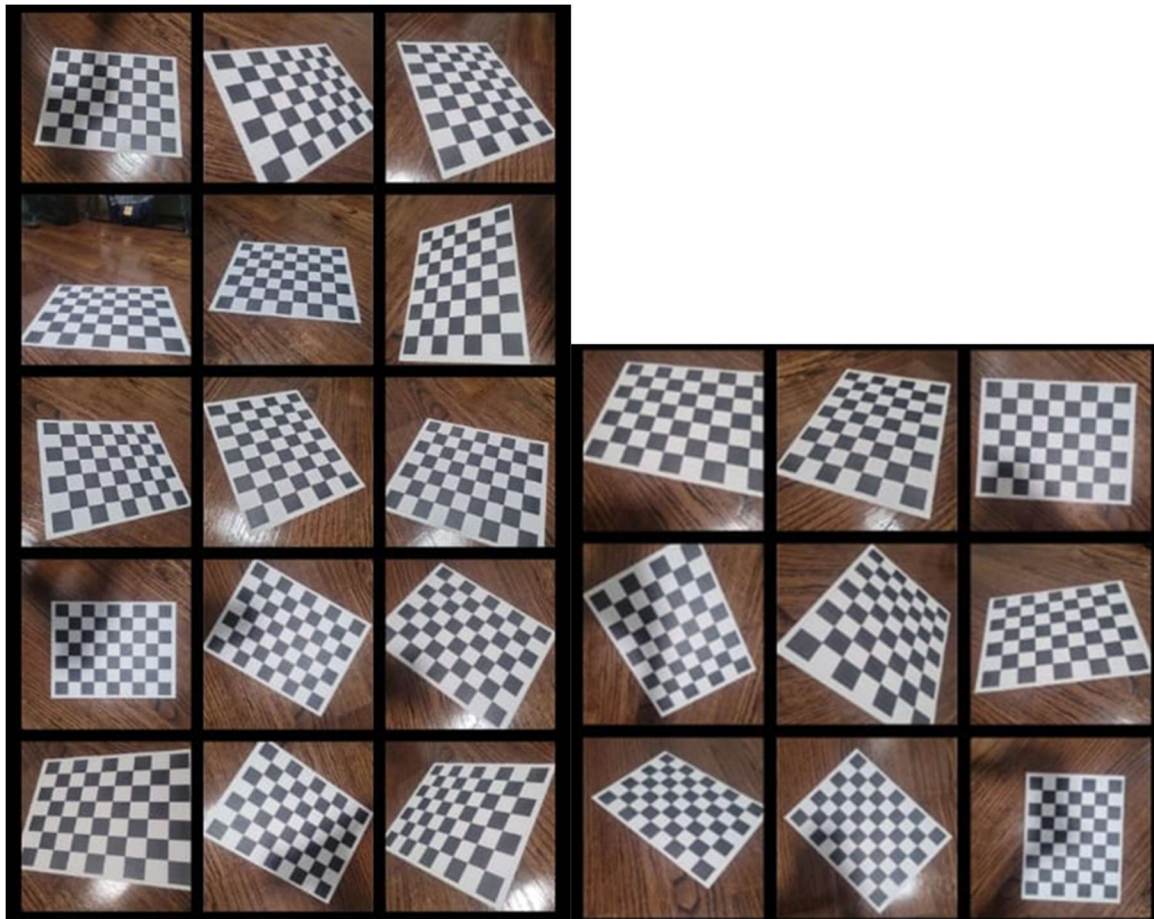


Saad Ahmed Mohammed
Robot Sensing and navigation
LAB 5 Report

Camera Calibration:

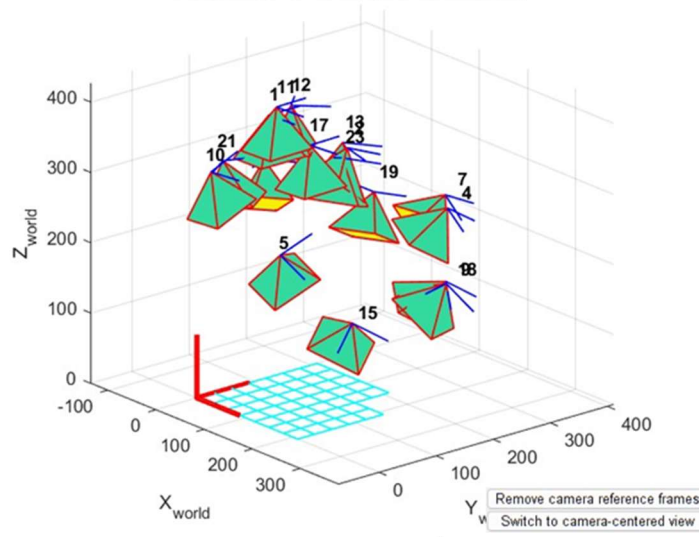
The checkerboard pattern of 8x6 with 30x30mm dimension boxes was used to calibrate the camera using a Samsung S20 FE phone.



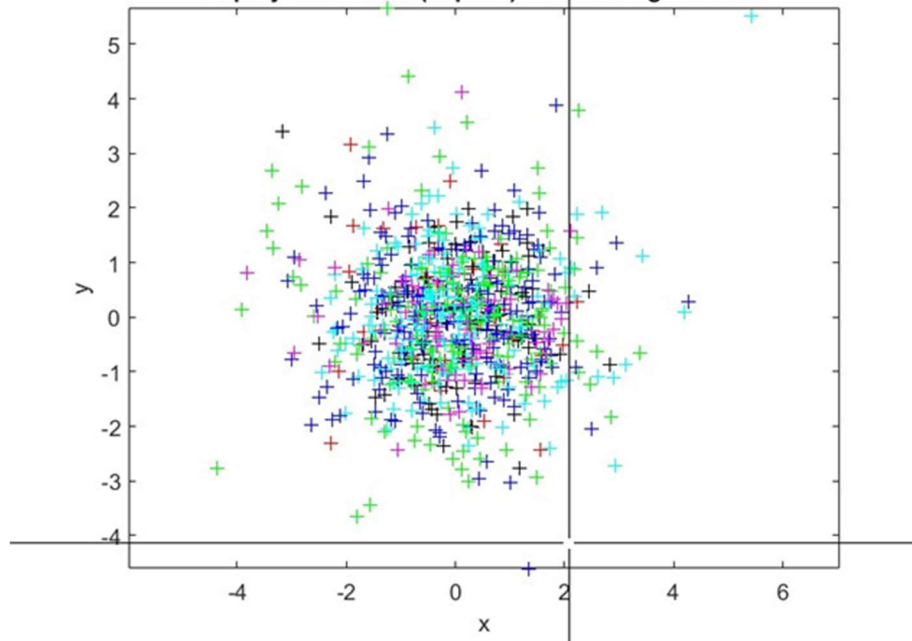
The Caltech Calibration Toolbox was utilized to calibrate the camera on a mobile phone. The calculated reprojection errors were determined to be quite low, which may be attributed to pre-processing of the camera images by the phone manufacturer. The camera images used to calculate the calibration parameters and reprojection error are shown in Figure 1.

Calibration results after optimization (with uncertainties):

Extrinsic parameters (world-centered)



Reprojection error (in pixel) - To exit: right button



Focal Length: $fc = [3131.57487 \ 3132.87910] \pm [9.31353 \ 9.05278]$

Principal point: $cc = [2016.70738 \ 1470.94013] \pm [11.04895 \ 11.14055]$

Skew: $\alpha_c = [0.00000] \pm [0.00000] \Rightarrow \text{angle of pixel axes} = 90.00000 \pm 0.00000$ degrees

Distortion: $kc = [0.00984 \ 0.03199 \ -0.00160 \ -0.00220 \ 0.00000] \pm [0.01007 \ 0.03696 \ 0.00134 \ 0.00133 \ 0.00000]$

Pixel error: **err = [1.22291 1.18047]**

before the error was coming more than 2 then I reduced to 1.2

LSC mosaic:

The Figure below shows the original dataset of images used for image stitching. The Harris Corner Detector Algorithm is being utilized in a lab segment to estimate points of interest, specifically corners, in each image. These corners are used to locate and estimate transformations of features around them in two images. The Maximum points and Window size input arguments of the Harris Detector are adjusted to ensure that points of interest are evenly distributed throughout the image. This tuning results in improved performance in generating panoramas, as demonstrated in the accompanying picture. Additionally, the detected points of interest in the images are shown in the figure.

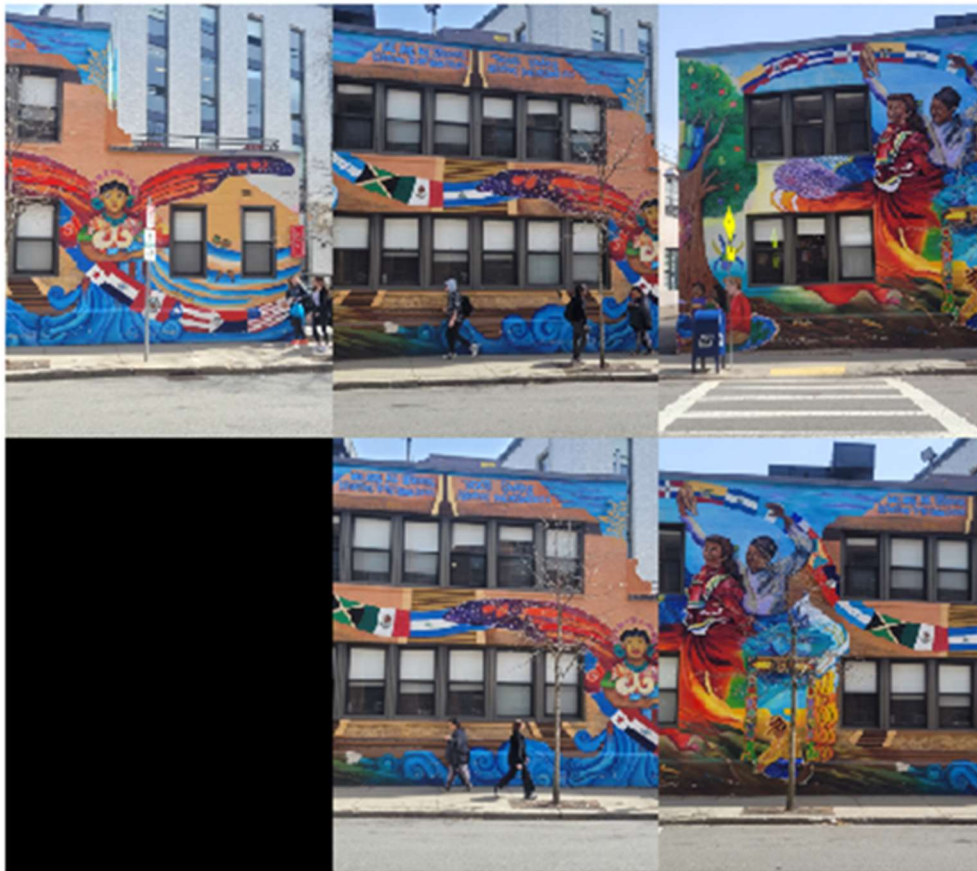


Figure 1 montage of latino center

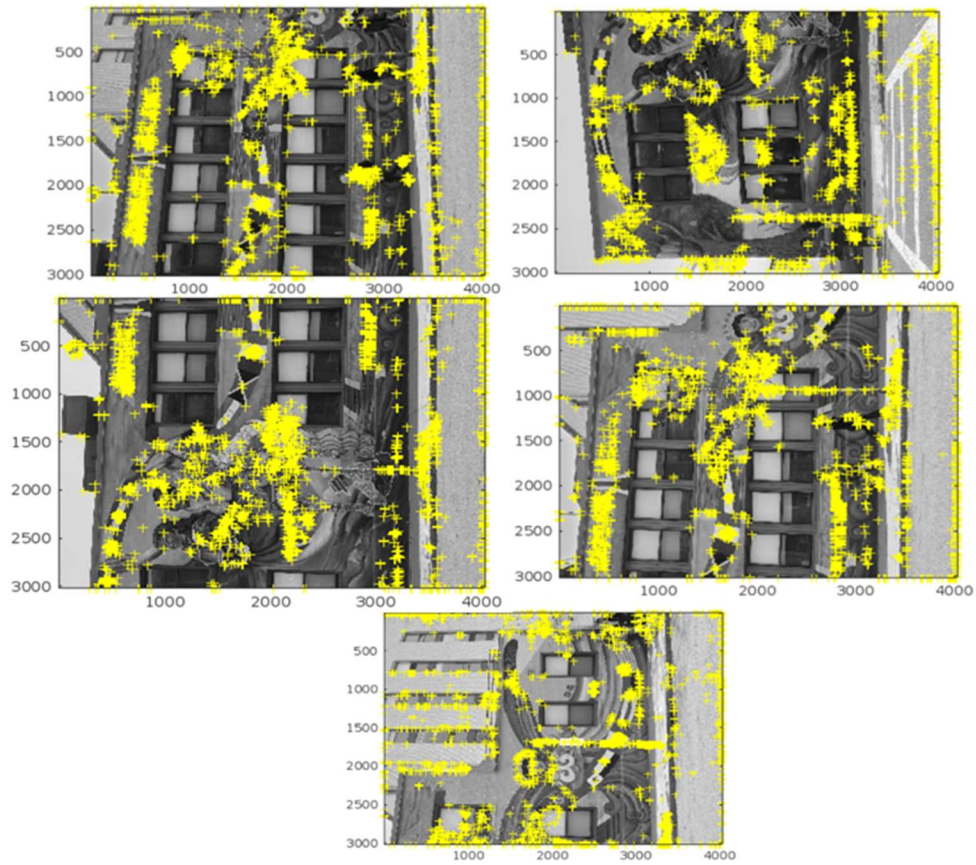


Figure 2 Harris corner detection

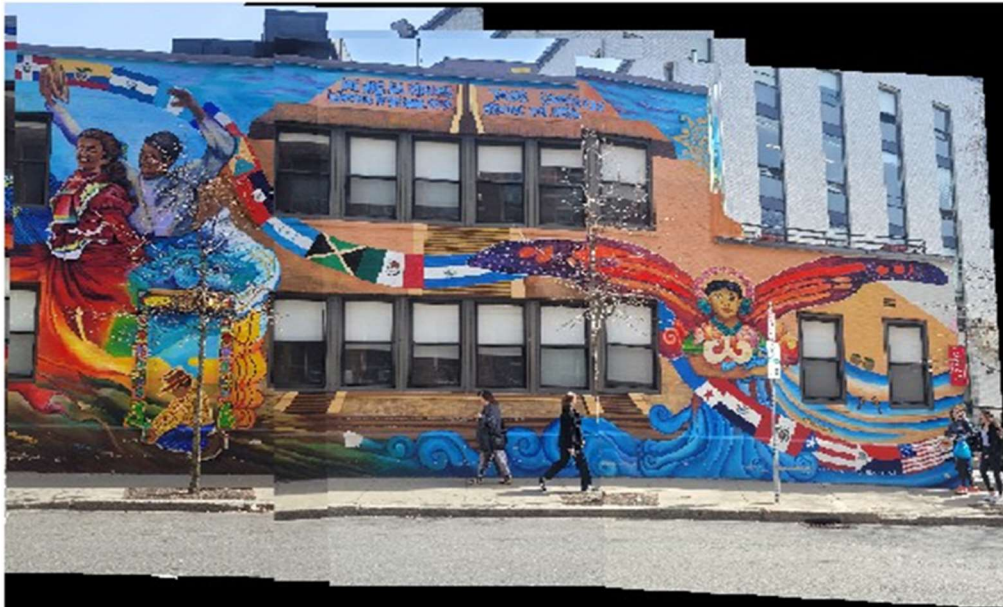


Figure 3 Harris corner detection

harris points: 1500

window size : 4x4

The image shown above was created by using 1500 feature points detected using the Harris corner detection algorithm. The resulting mosaic closely resembles the original scene. Although there is some offset on the terrace.

Mosaic block/brick wall :



Figure 4 brick wall input images

When dealing with a dataset of brick wall, it was observed that a significant number of iterations were necessary to create a panorama. The corners detected by the Harris detector are displayed in Figure. In comparison to the LSC mural dataset, a higher number of Harris corners were needed to estimate the transformation matrices for the brick or Cinder wall dataset. Furthermore, the confidence level for estimating the transformation was considerably lower of around 14% than lsc data set. This difference can be attributed to the presence of repetitive features throughout the image or the lack of distinct features in the brick or Cinder wall dataset.

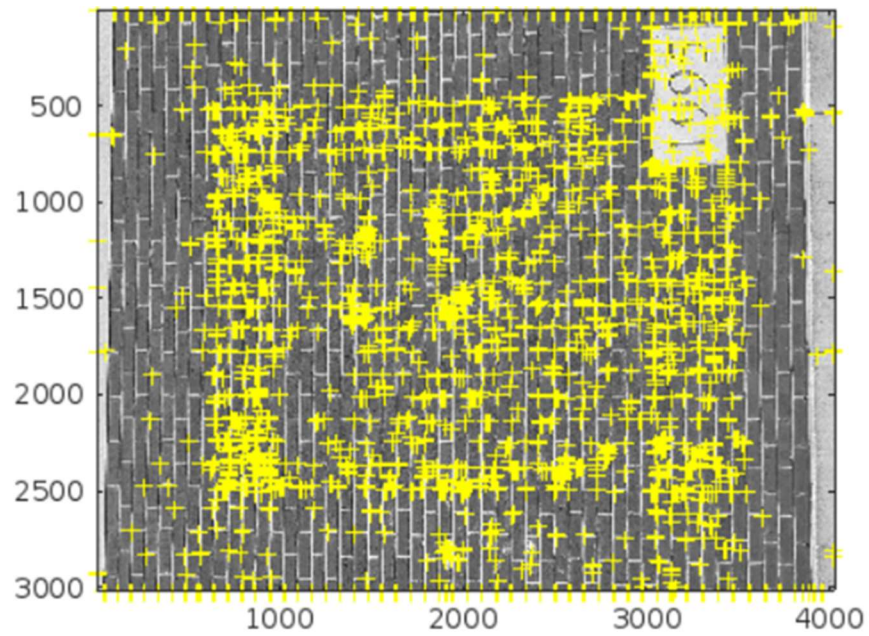
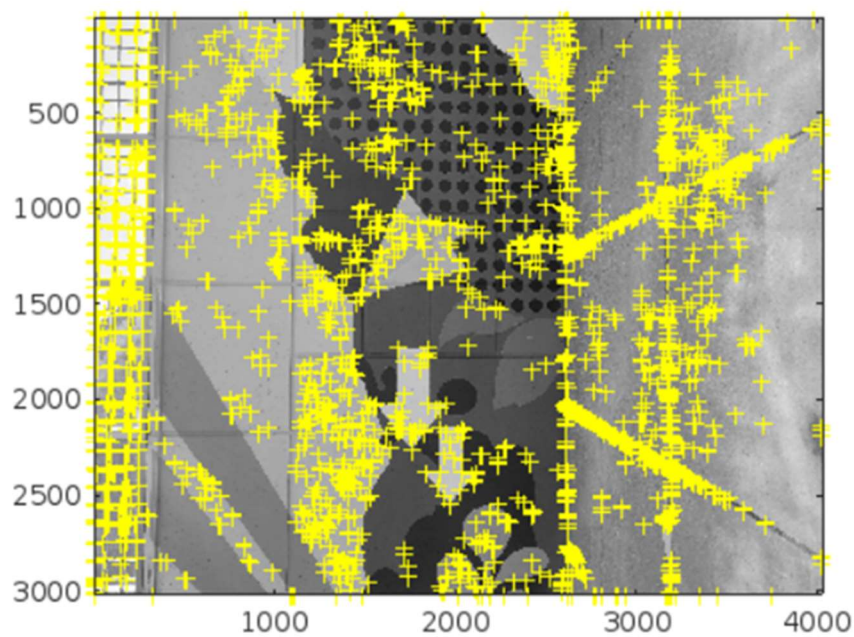
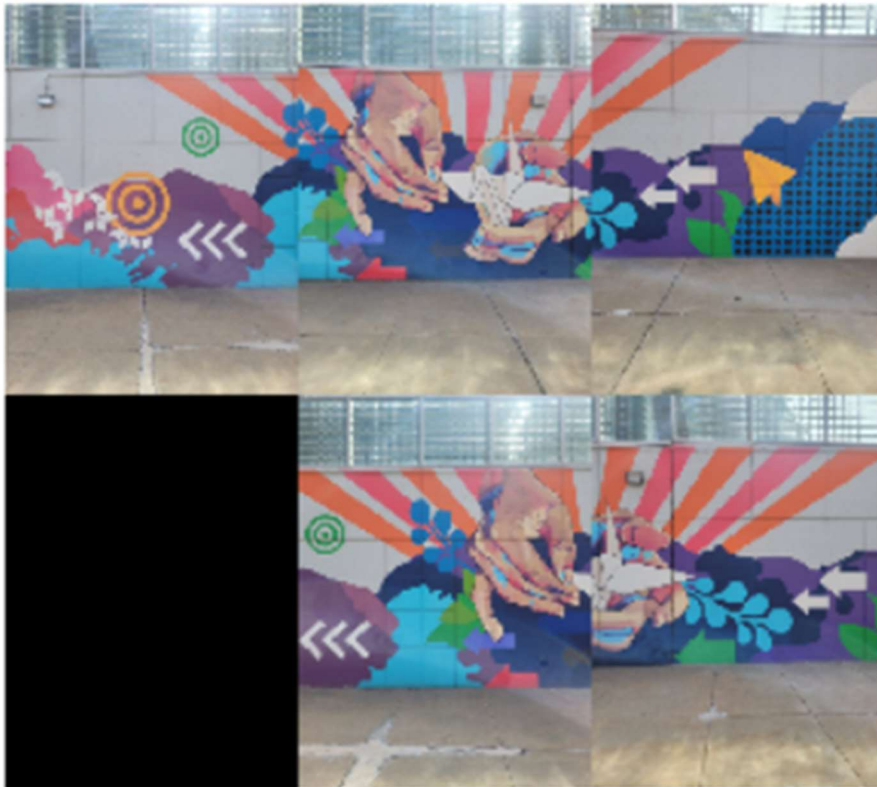


Figure 5 Final output brick wall

The Harris corner detection algorithm was employed with the following parameters: Max Points = 4000, indicating that a maximum of 4000 corners were detected in the images. Grid Divisions = [4 2], indicating that the image was divided into an 4x2 grid for corner detection, resulting in a total of 8 grid cells. The estimated geometric transformation used was an affine transformation with a confidence level of 80%.

mosaic with different overlap:

15% overlap:



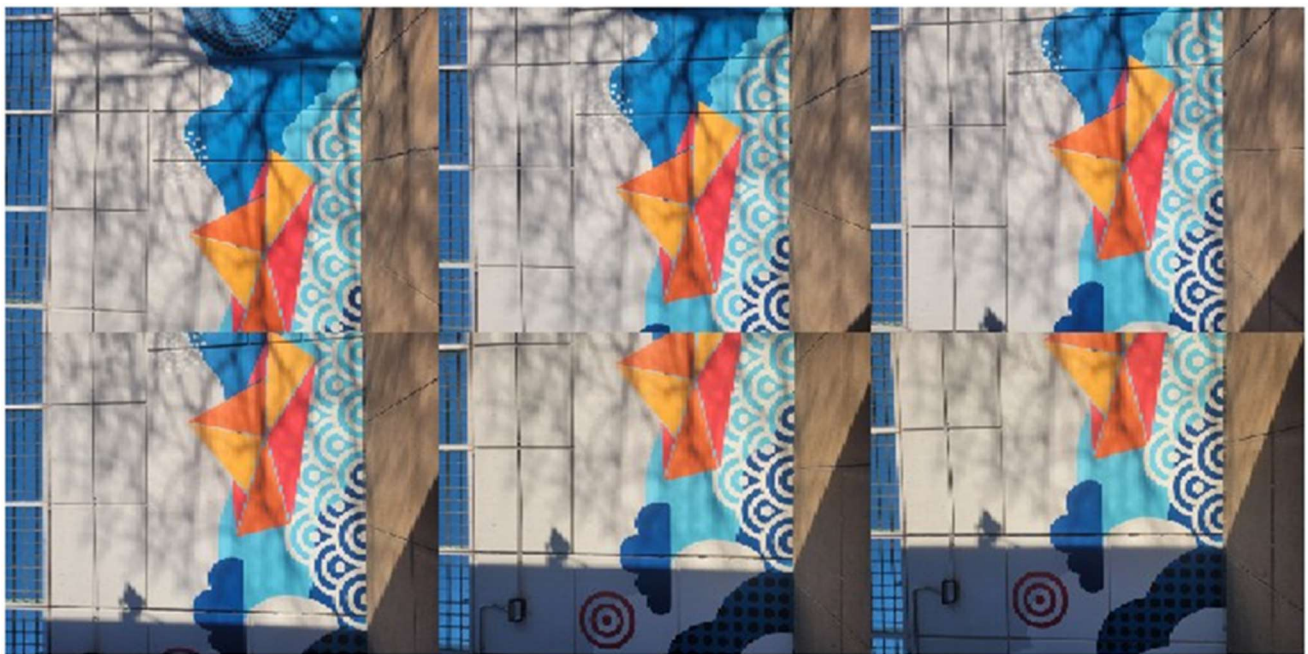
To stitch together the mural images, a dataset with 15% overlapping was utilized. Harris corner

detection was applied with a higher threshold of 3000 corners detected for a window size of [4 4]. This was done to ensure a sufficient number of corners were detected in the left and rightmost regions of the image where overlapping between consecutive images was limited.

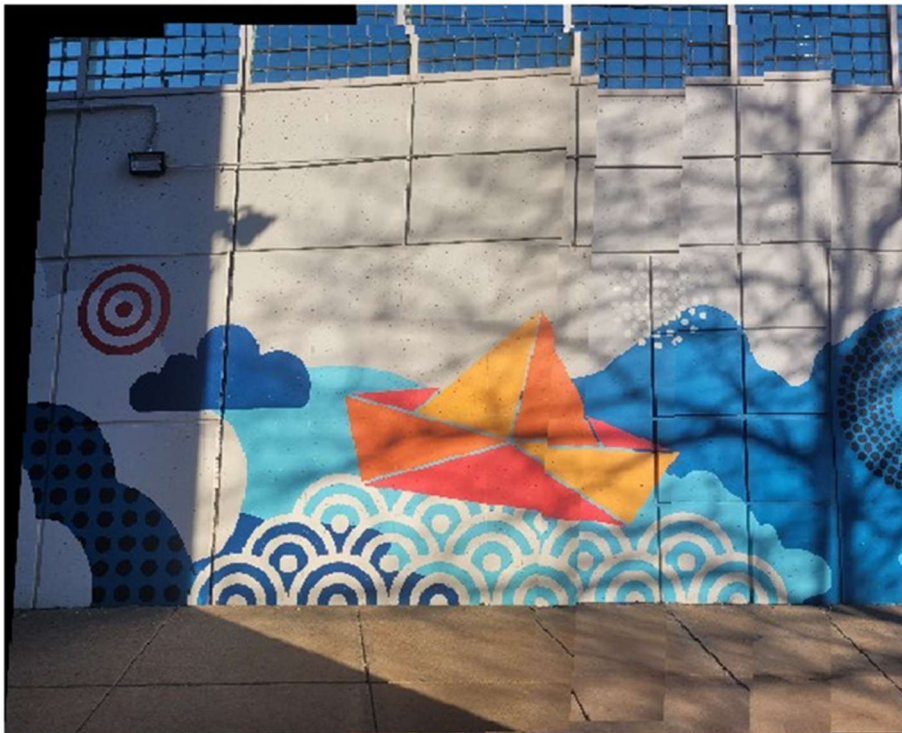
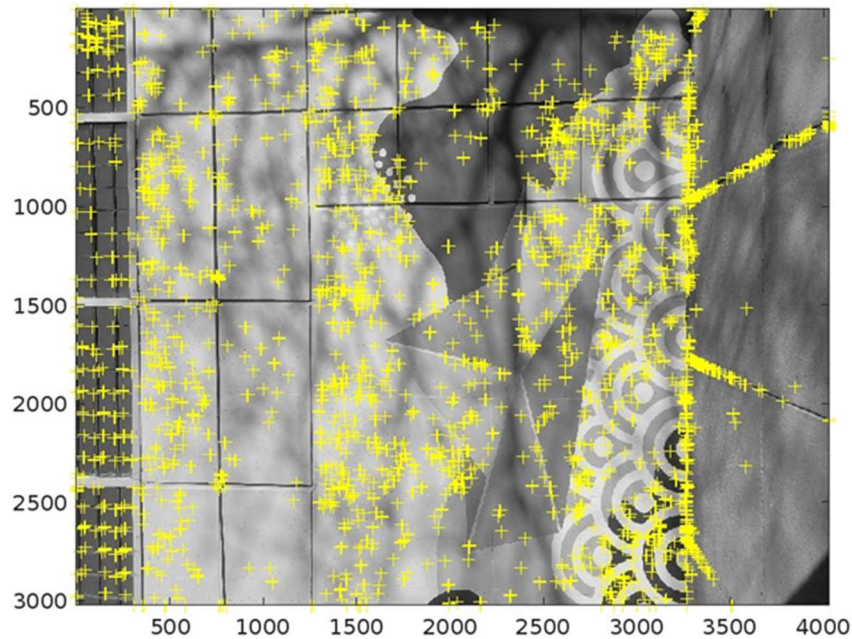


After conducting several experiments with different parameters, the optimal outcomes were achieved using the following configurations: Harris Corner Detection: Max Points = 3000, Grid Divisions = [4 4] Geometric Transformation: Affine transformation, Confidence level = 90.

50% overlap



The Ruggles wall mural depicting a boat was employed as the source images for the stitching process. The images used in this process are illustrated below, along with the corners detected by the Harris Detector. To guarantee evenly distributed corners, the Harris Detector was set to detect a maximum of 1500 points with a window size of [4 4].



The above figure shows optimal results with good corner detection and stitching of images that are around 50% similar.

