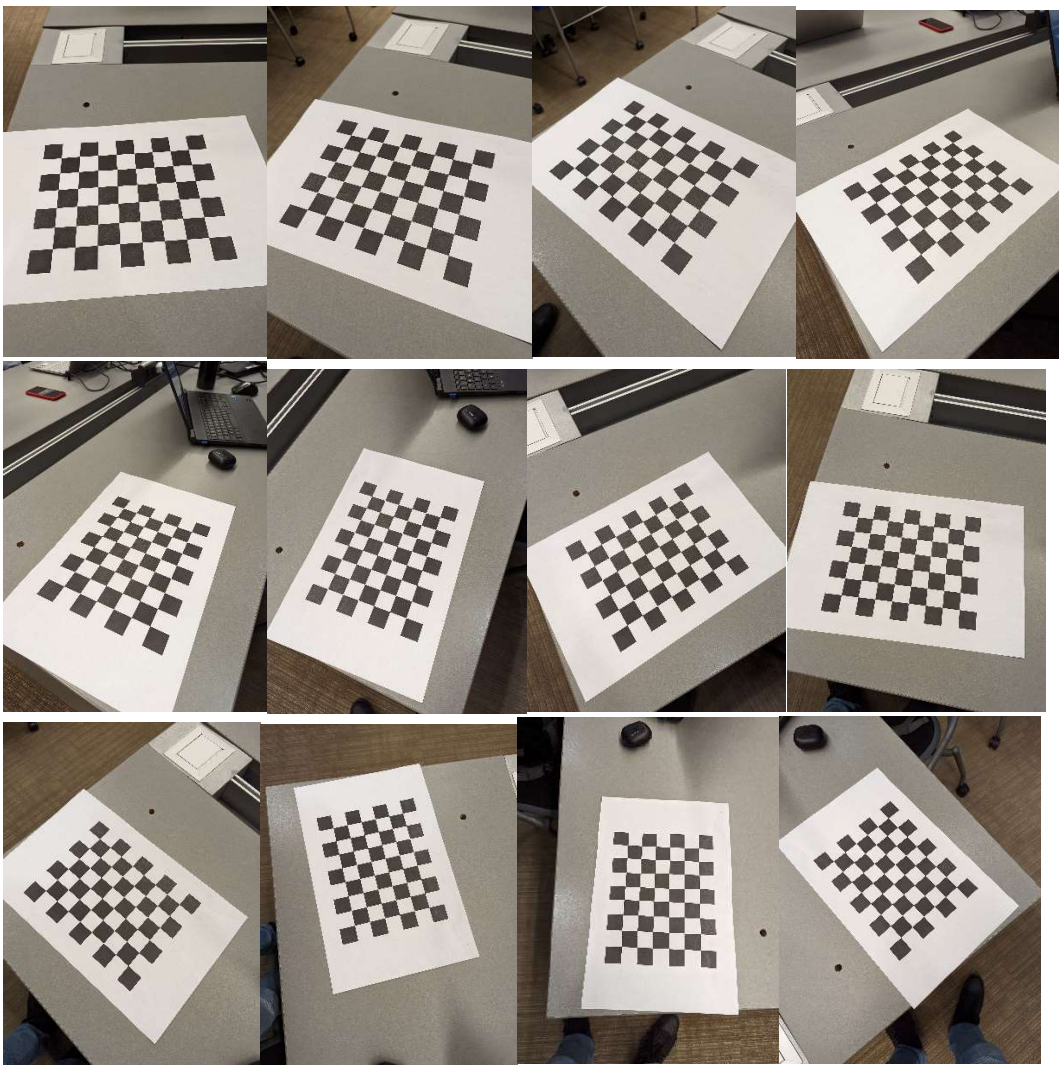
LAB 5

The aim of this lab is to create photo mosaics using sets of images. The lab is divided into 2 sections –

i. Phone camera error estimation using Caltech Camera calibrator.
ii. Photo Mosaic creation using different sets of images.

PART I

Camera is calibrated using a planar checker box with individual square dimensions as 30mm x 30 mm. We take images of this checker box from different angles to analyze the effects of distortion on the image. The images used for calibration are attached below -



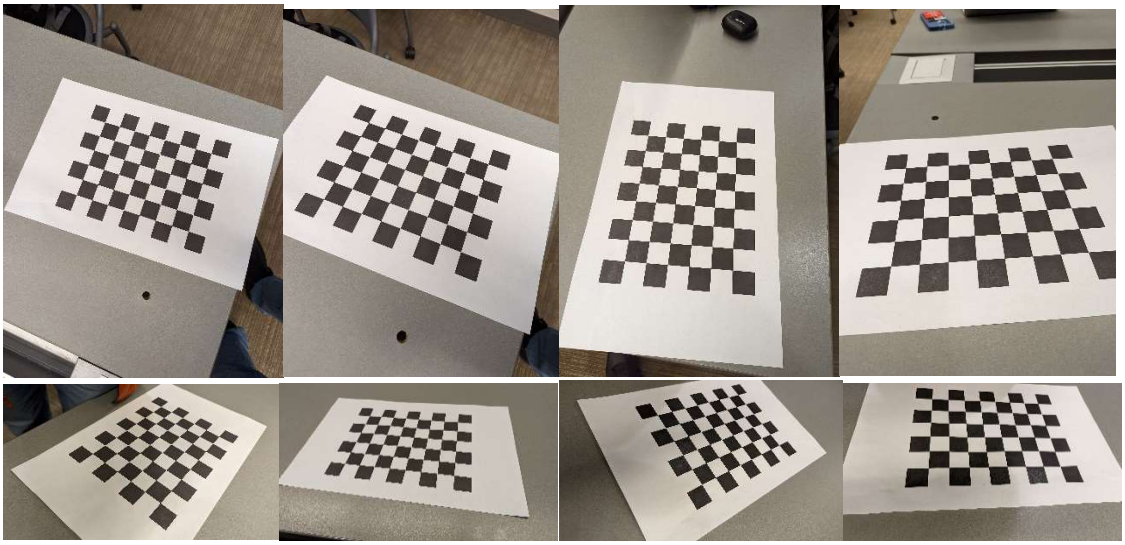


Fig 1. – Images used for calibration, with all variations in angles.

The images are taken with different focal lengths and angles to ensure it captures variation in dataset

After selecting the corners for autodetection of squares, we perform calibration to understand the camera calibration parameters and reprojection error. These are as follows –

```
Calibration results after optimization (with uncertainties):

Focal Length:          fc = [ 2884.73918   2882.87381 ] +/- [ 33.06262   27.81732 ]
Principal point:       cc = [ 1566.25537   2063.81827 ] +/- [ 11.40829   30.93055 ]
Skew:             alpha_c = [ 0.00000 ] +/- [ 0.00000  ]   => angle of pixel axes = 90.00000 +/- 0.00000 degrees
Distortion:            kc = [ 0.15629   -0.60647   0.00110   0.00502  0.00000 ] +/- [ 0.01485   0.08063   0.00162   0.00159  0.00000 ]
Pixel error:          err = [ 0.76215   0.99399 ]

Note: The numerical errors are approximately three times the standard deviations (for reference).
```

Fig 2. – Calibration results

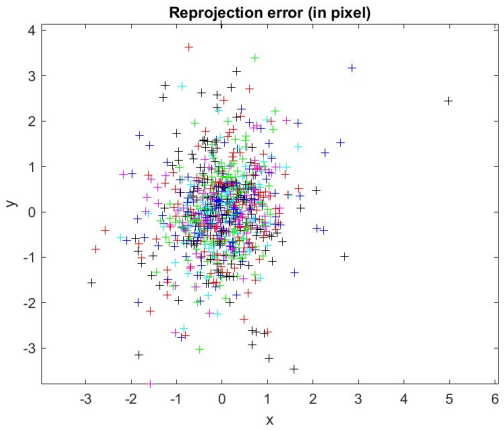


Fig 3. – Reprojection error

We can see the reprojection error in pixels is [0.76215 0.99399]. The reprojection for first 4 images can be seen below as to how it looks –

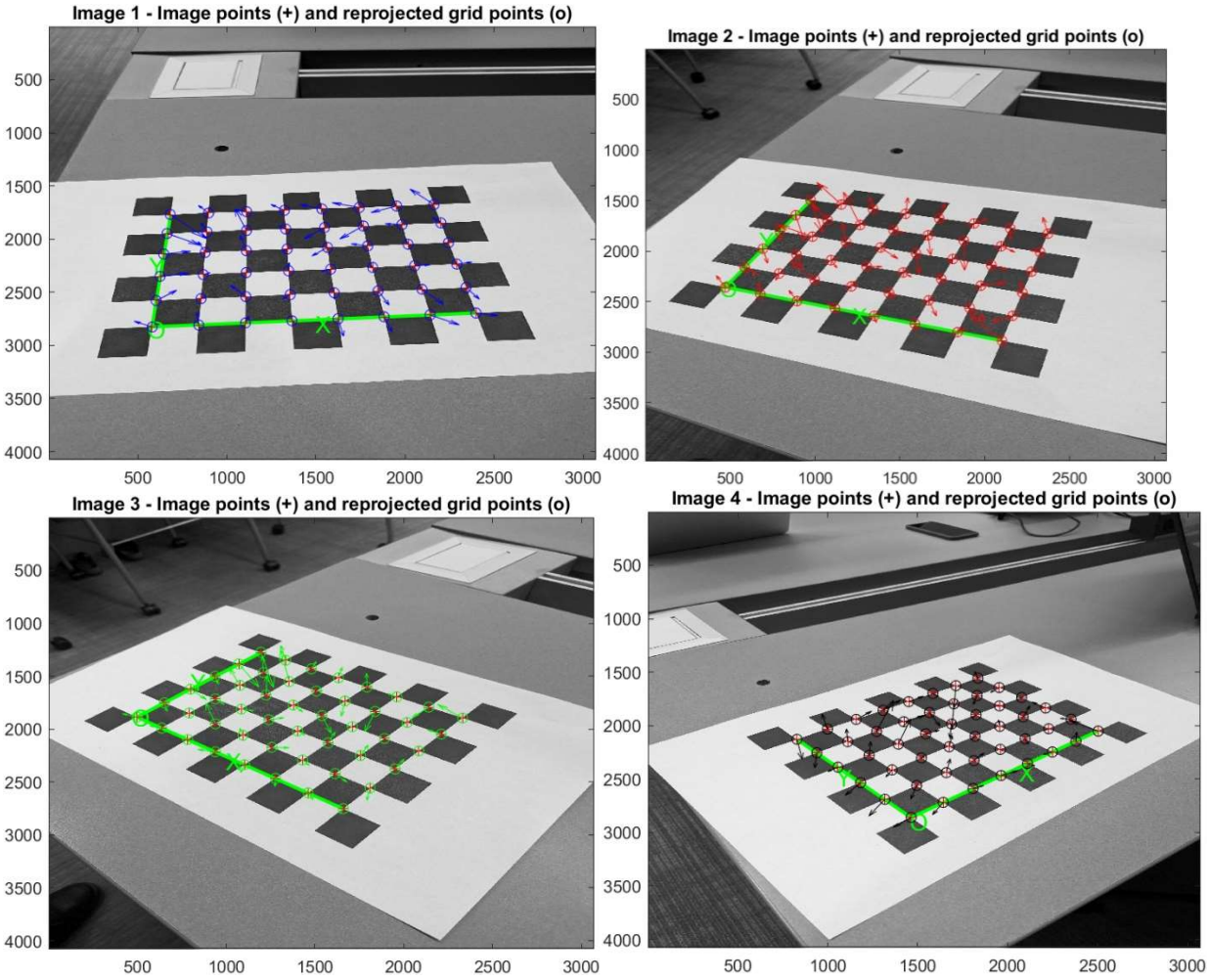


Fig 4. – Visualization of reprojection for the first 4 images.

We use these parameters for undistorting any image. 1st image is shown below, before and after distortion. A random image is also shown for undistorting example –

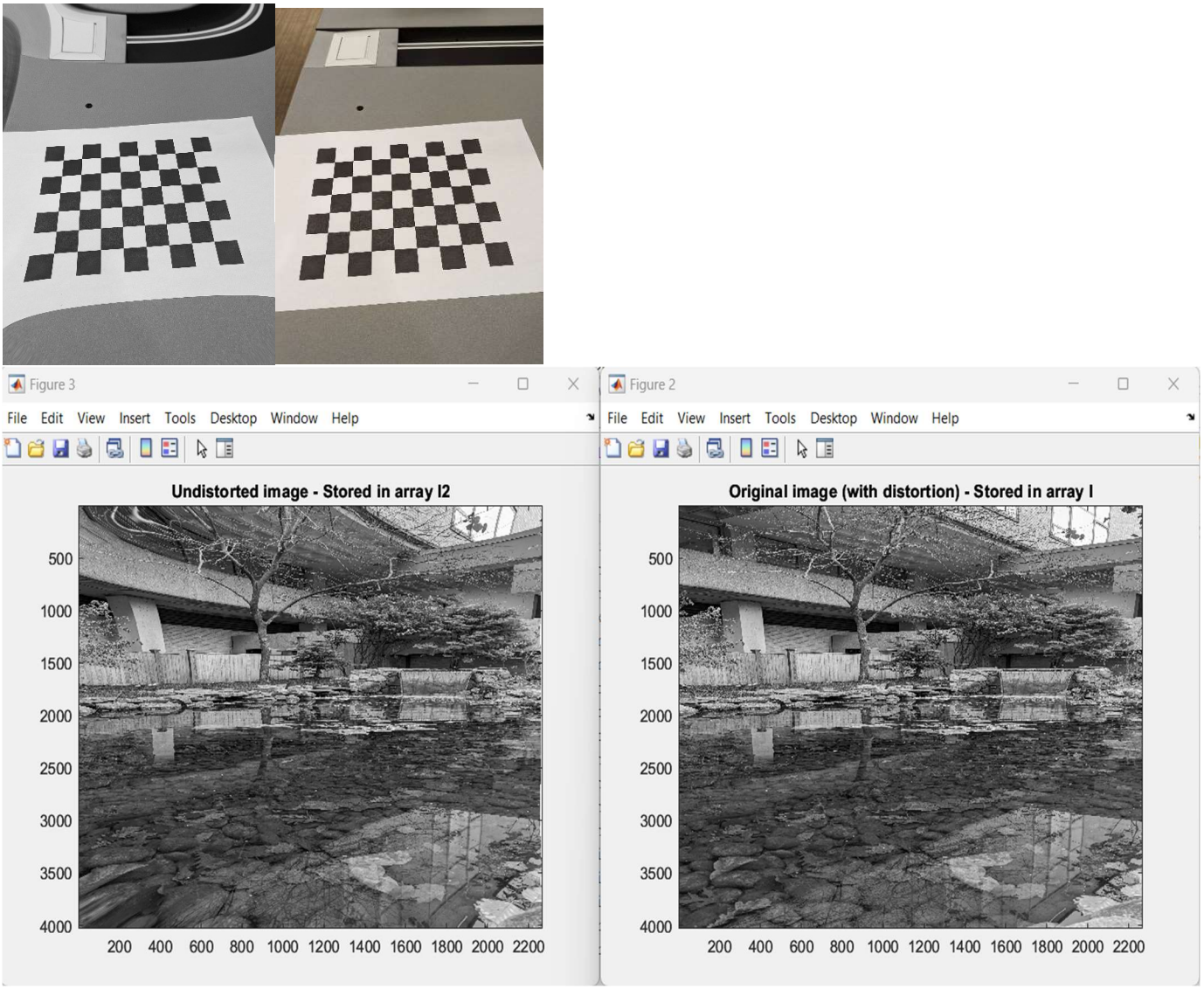


Fig 5. Comparison between distorted and undistorted images'

As we can see from fig.5 the undistortion works very well in the center, but the image gets messed up along the borders. This may be because the distortion parameters estimated are not precise because we are only using 20 images for estimating these values or the intrinsic errors fluctuate a lot when camera parameters are changed (focal length, resolution, aperture, etc.), hence the net reprojection error will not undistort all the images equally, and in fact by undistorting the images with wrong parameters we are introducing new distortions. But, since the distortion error estimated is < 1, we won't be using calibrated images for stitching.

PART II

A. Latino Student Center –

8 images were taken with approximately 50% overlap between the consecutive images. These are –

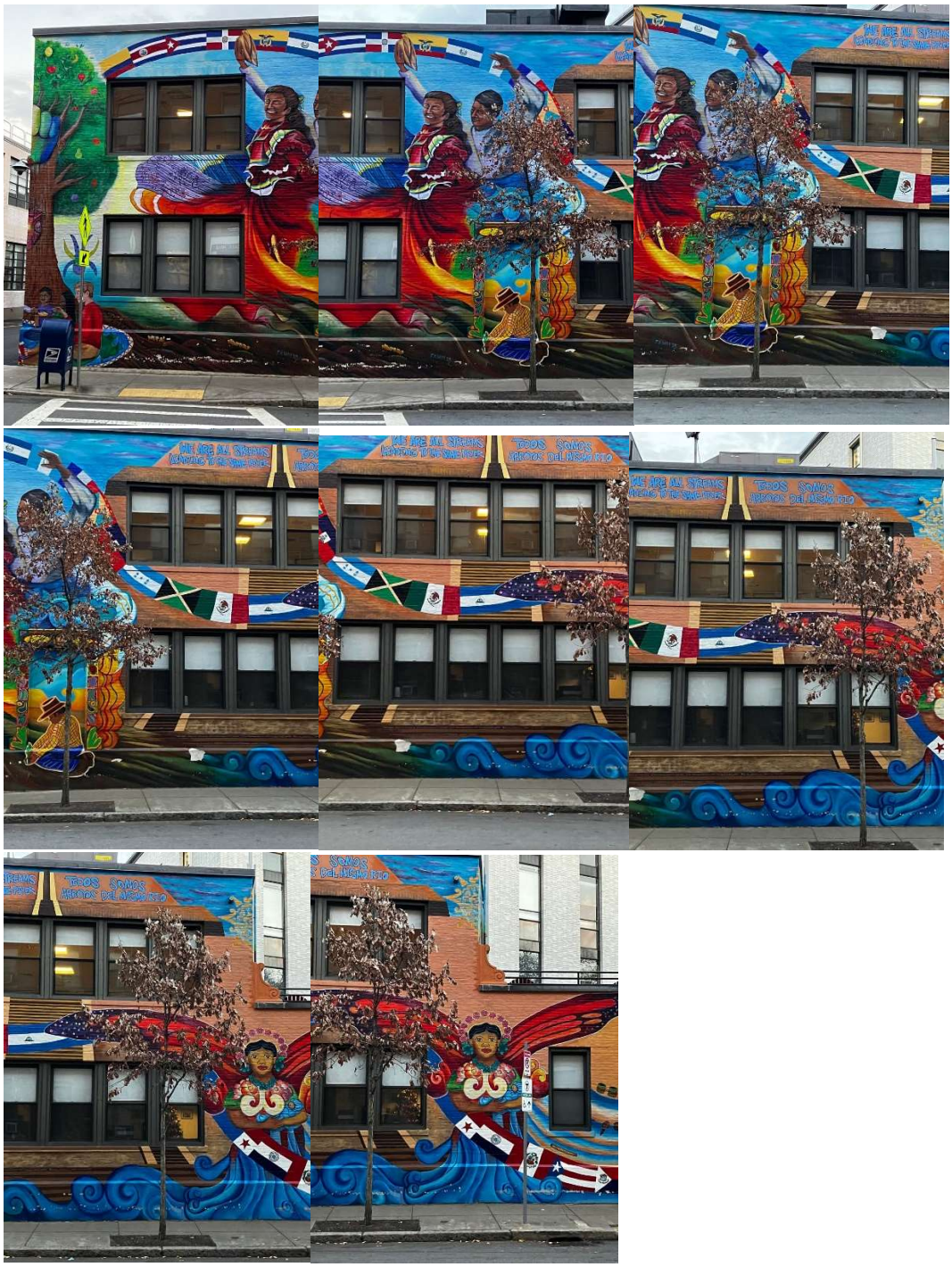


Fig. 8. – Latino building Center images (50% overlap)

Harris corner detection is applied to all the images to detect the important features –

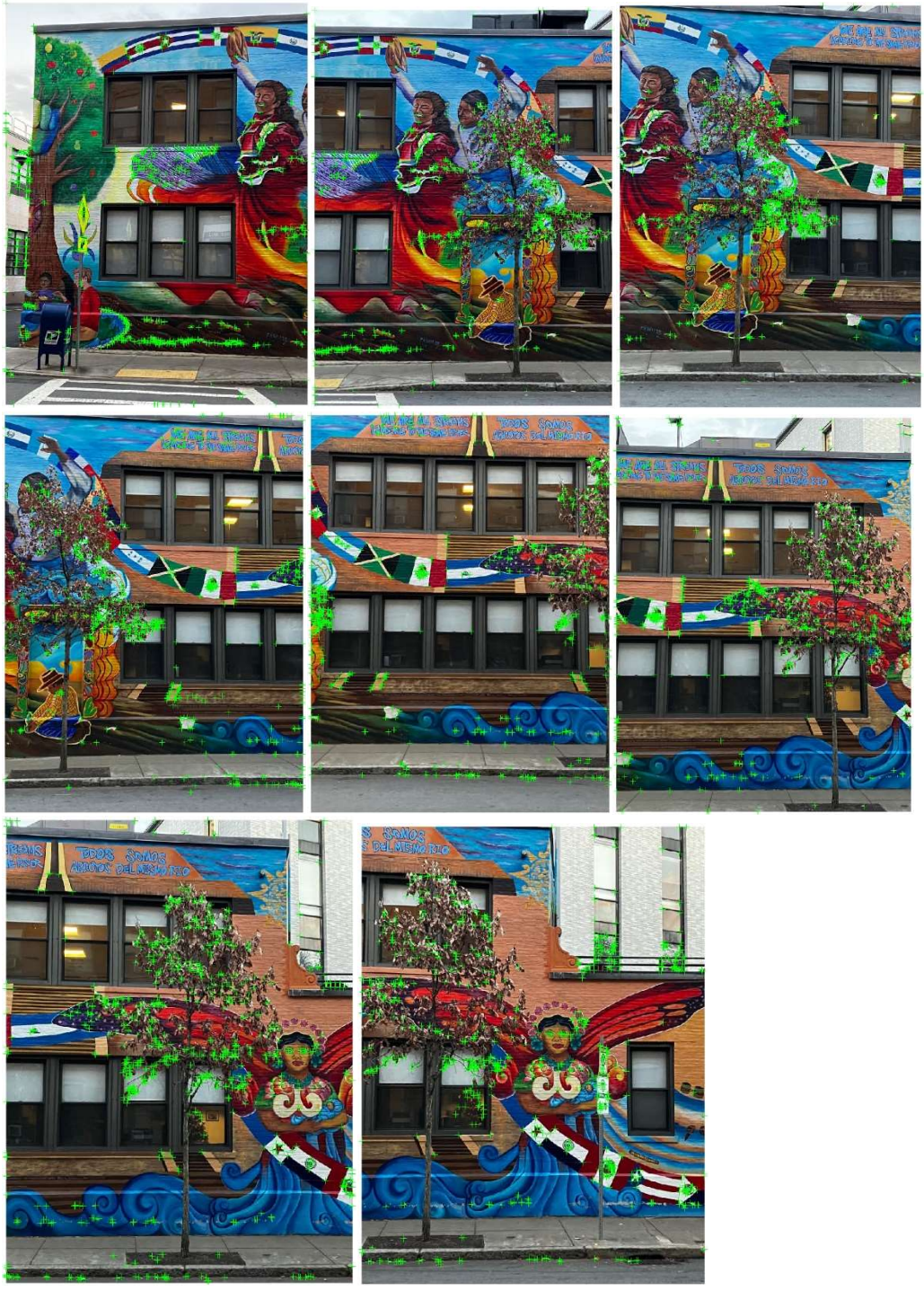


Fig 9. – Harris feature detection for individual images.

The final stiched image can be seen below –

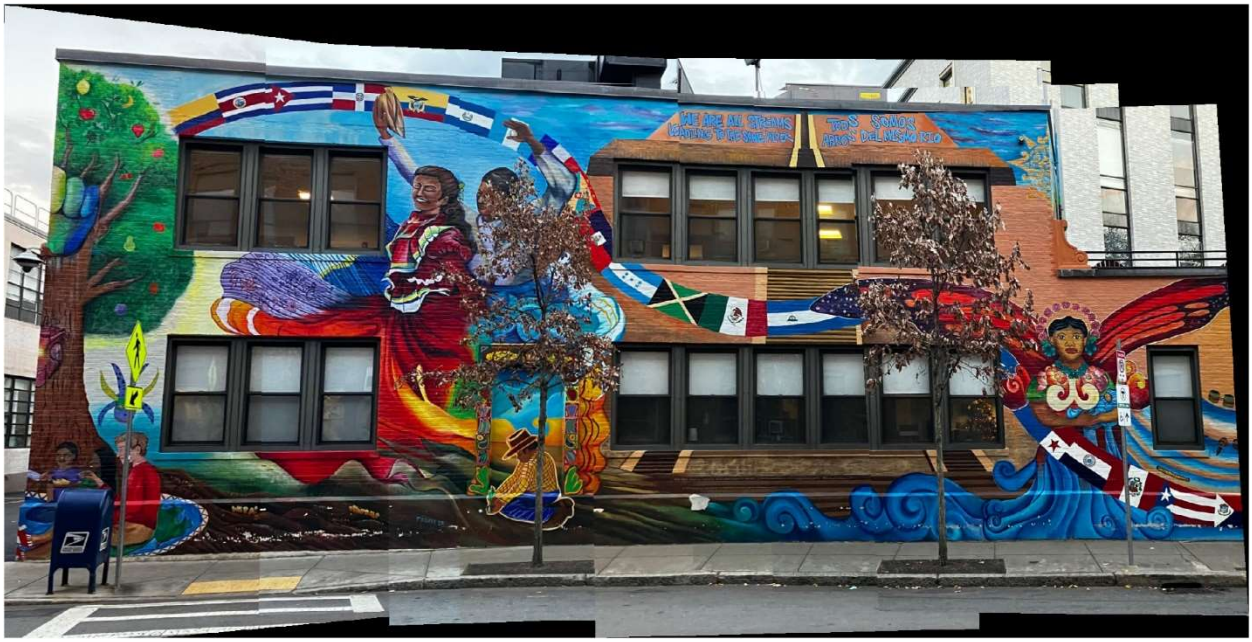


Fig. 10 – Final stitched image of LSC building.

The stitching did not give a lot of errors as there were lots of common features in between the images as seen from fig 9. The images were taken to ensure that at least there is 50% overlap between consecutive images, hence the feature overlap was also efficient. Following are the parameters (Maximum number of interest points – kept it to maximum, Tile – Which divides the images into the specified sections and then search for features)

```
[y, x, m] = harris(grayImage, 800, 'tile', [2 2]);
```

B. Cinder Block wall –

Following are the 8 images for the cinder block wall in Jamaica Plains near Stony Brooks with Harris corners –

Fig 11. – Cinder block wall along with the Harris corners.

Fig 12. – Stitched cinder block image.

For Cinder block wall, as the corners detected in the image are equally spaced it will be more difficult for the feature matching between consecutive images which was not the case for LSC building. Hence, when first the stitching was performed, we were getting error of singular matrix (a non-invertible matrix) when feature mapping between consecutive images. To overcome this, we resize the image for original quality (resolution) to 30-50% quality, this decreases the image noise (thus helps in discarding less significant corners) and helps identifying the dominant corners hence efficient feature mapping between the consecutive images. The rest of the features – max number of features, tile size, confidence interval, etc. is same as for LSC. The subjective performance is also inferior to LSC mosaic because of the reasons above.

C. Comparison between 50% and 15% overlap –

Following are the initial images for at least 50% (8 images) and 15% (5 images) overlap of a graffiti near Ryder Hall in Northeastern University.

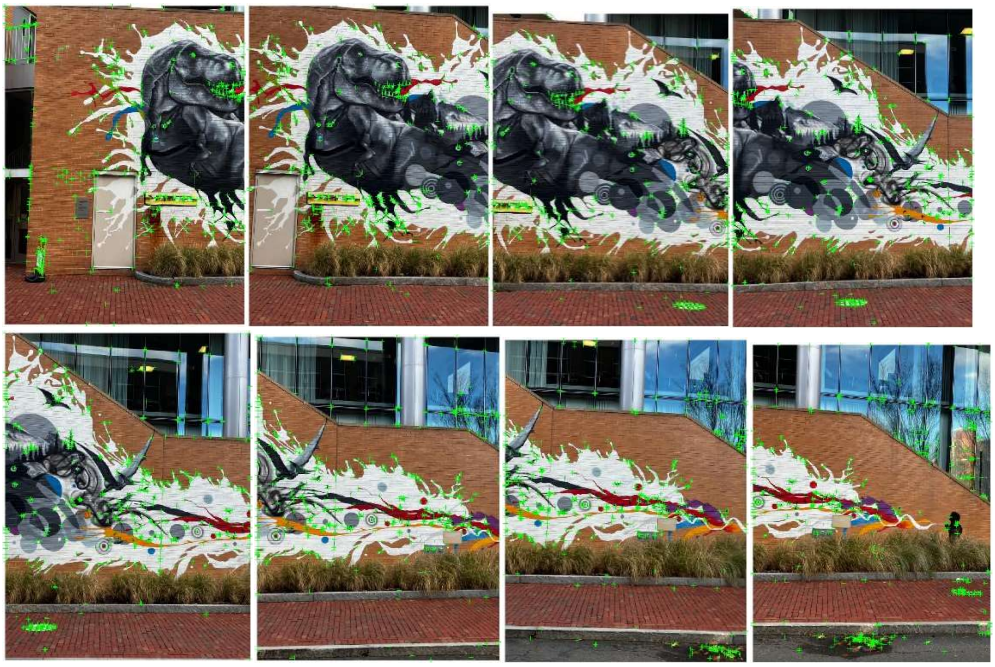


Fig 13. - At least 50% overlap graffiti images with Harris corners.

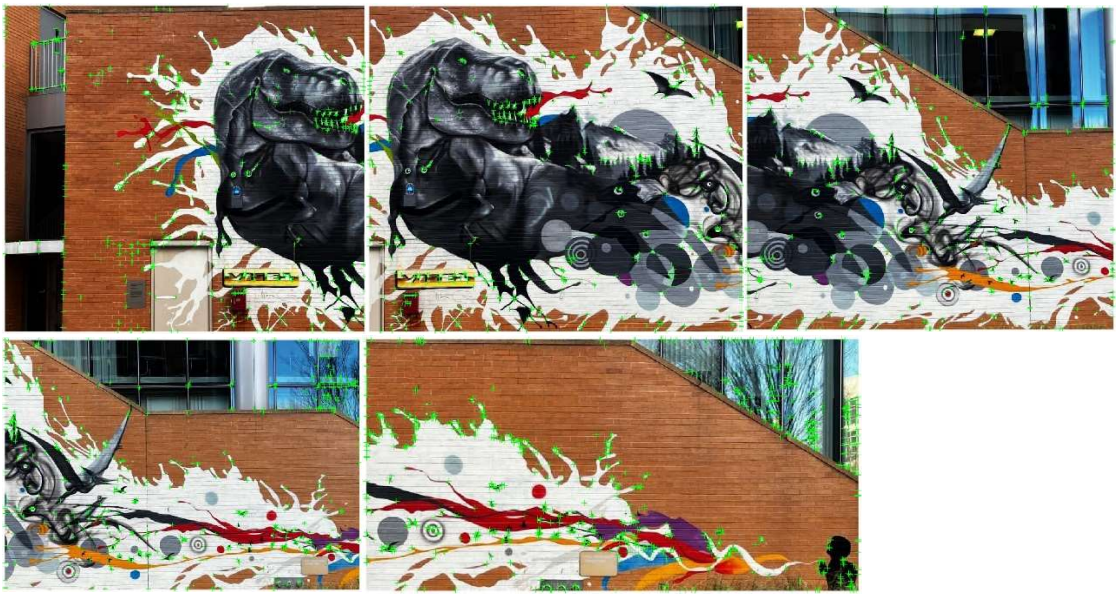


Fig 14. – Approximate 15% overlap graffiti images with Harris corners.

Fig. 15 – Mosaic of 50% overlap graffiti images.

Fig. 16 – Mosaic of 15% overlap images.

Visually itself we can figure out that a lot of changes were made in the 15% overlap mosaic to converge to the results shown above. The performance is satisfactory in both the images, but the 15% overlap image has loss of information because of all the adjustments made for feature mapping between consecutive images. The main issue was finding the matching features in just 15% of the common area. The following adjustments were made for the convergence seen in Fig. 16 –

A. Resizing – Decreasing image resolution for decreasing image noise, the same reason as mentioned in B.
B. Cropping – The image was cropped to remove similar confusing features, for example the glass above was removed, the bricks below were removed, only informative sections were kept for efficient mapping.
C. Contrast – The contrast was increased for the image, as when it gets converted to greyscale the dominant corners are easily detected because of sharp change in intensity.

D. Highlights – The highlights for the image, working similarly to contrast, was increased.

While performing these changes, an iterative approach was adapted to ensure we are not over modifying the image, as it signifies loss of information or modification in information. The initial approach was playing with the Harris parameters, but when these parameters also did not help us in converging to the results, I performed these photo modifications. Same can be done using convolution with different filters but with the scope of this assignment and time availability this approach was adopted.

Same MATLAB code is used for stitching all images, with same parameters as mentioned above the code name is image_stitching.m and is attached in analysis folder.