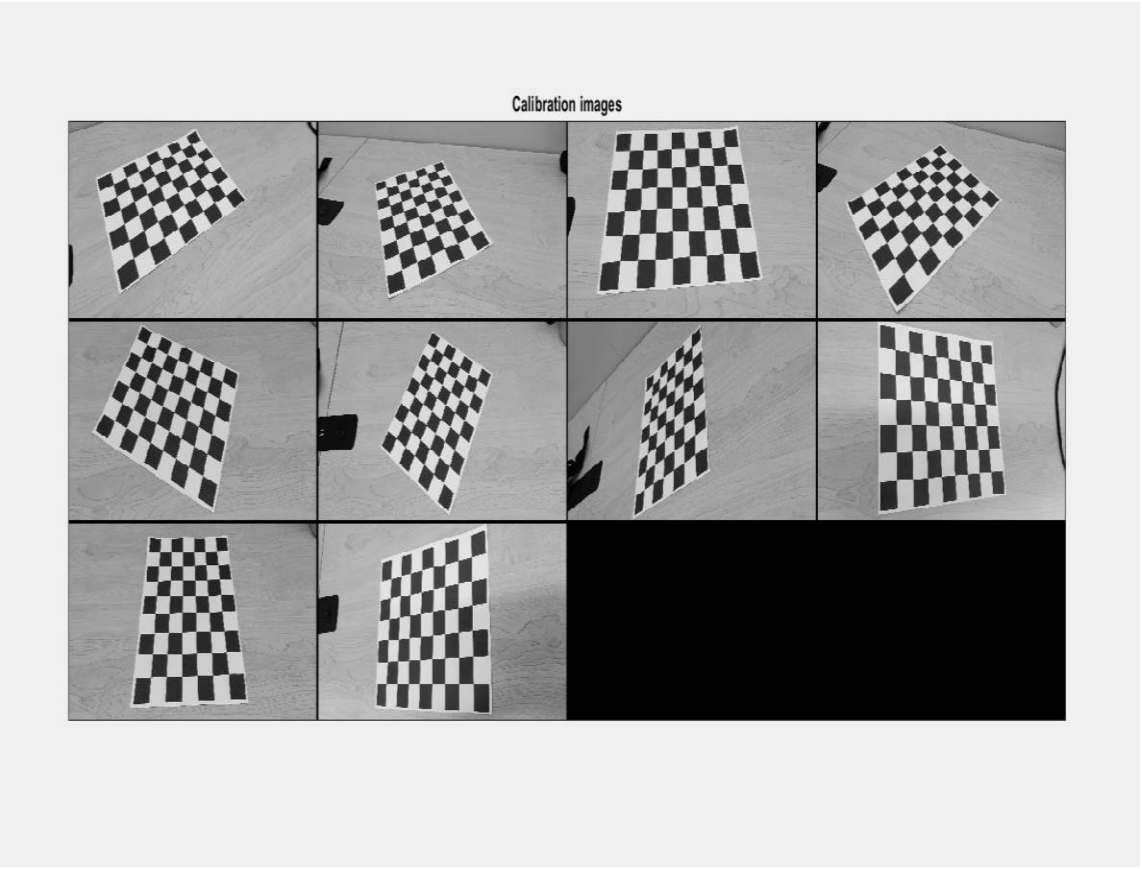
EECE 5554 Robotics Sensing and Navigation

LAB 5 - Camera Mosaic

1. Camera Calibration:

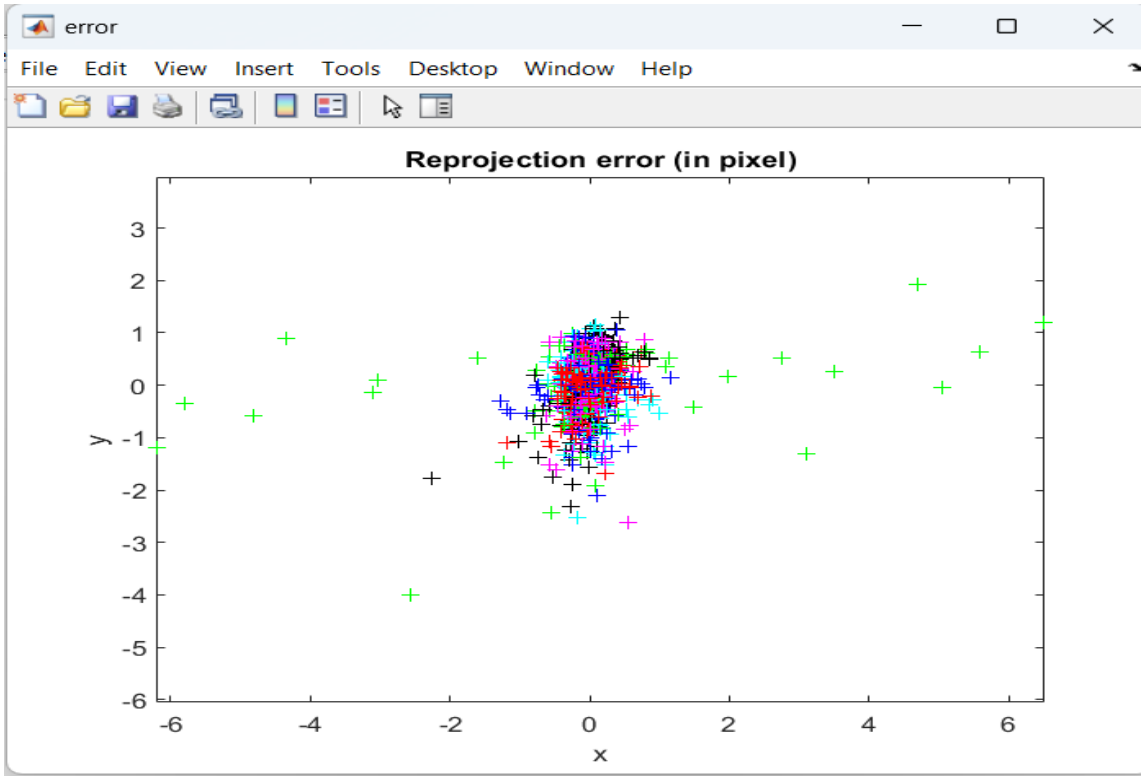
Camera images used for calibration:

Below is the set of images used for calibration.



Reprojection pixel error in report:

Below is the reprojection pixel error.



Calibration parameters in report:

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Initialization of the intrinsic parameters - Number of images: 20


Calibration parameters after initialization:

Focal Length:          fc = [ 1125.95276   1125.95276 ]
Principal point:       cc = [ 799.50000   359.50000 ]
Skew:             alpha_c = [ 0.00000 ]   => angle of pixel = 90.00000 degrees
Distortion:            kc = [ 0.00000   0.00000   0.00000   0.00000   0.00000 ]

Main calibration optimization procedure - Number of images: 20
Gradient descent iterations: 1...2...3...4...5...6...7...8...9...10...11...12...13...14...15...16...17...18...19...20...21...22...23...24...done
Estimation of uncertainties...done


Calibration results after optimization (with uncertainties):

Focal Length:          fc = [ 1237.06103   1231.66237 ] +/- [ 25.65773   23.37211 ]
Principal point:       cc = [ 774.98408   308.99459 ] +/- [ 28.61631   30.17421 ]
Skew:             alpha_c = [ 0.00000 ] +/- [ 0.00000  ]   => angle of pixel axes = 90.00000 +/- 0.00000 degrees
Distortion:            kc = [ 0.07459   -0.55596   0.00219   -0.00706  0.00000 ] +/- [ 0.08559   0.59884   0.00688   0.00854  0.00000 ]
Pixel error:          err = [ 1.71591   1.46760 ]

Note: The numerical errors are approximately three times the standard deviations (for reference).
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The pixel error in the above results is [1.71591 1.46760] is higher for 4k resolution pictures. In some images the corner of the image is not detected properly hence after initial calibration since the observed reprojection error seems to be high, using “Recomp” the image corners are recomputed on all images automatically. Once that is done recalibrating it has resulted in a reduced reprojection error, and the results have been presented below.

calibration results after optimization:

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Calibration results after optimization (with uncertainties):

Focal Length:          fc = [ 1199.76261   1204.73893 ] +/- [ 10.38614   9.42573 ]
Principal point:       cc = [ 778.15093   359.34226 ] +/- [ 10.51773   11.79082 ]
Skew:             alpha_c = [ 0.00000 ] +/- [ 0.00000  ]   => angle of pixel axes = 90.00000 +/- 0.00000 degrees
Distortion:            kc = [ 0.09441   -0.47648   -0.00021   -0.00338  0.00000 ] +/- [ 0.02969   0.20061   0.00262   0.00356  0.00000 ]
Pixel error:          err = [ 0.63555   0.56493 ]

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

After re-extraction of the grid corners on the image the pixel error drops down to [0.63555 0.56493].

An image before and after calibration is in report:

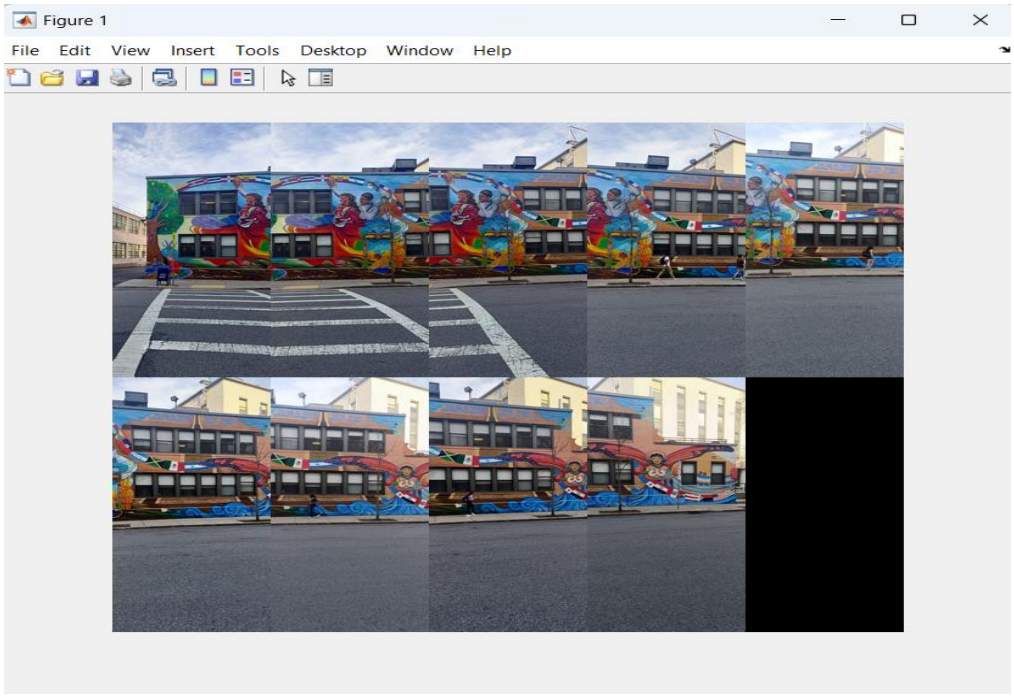
The original image without distortion is below.

The Original image with distortion is below.

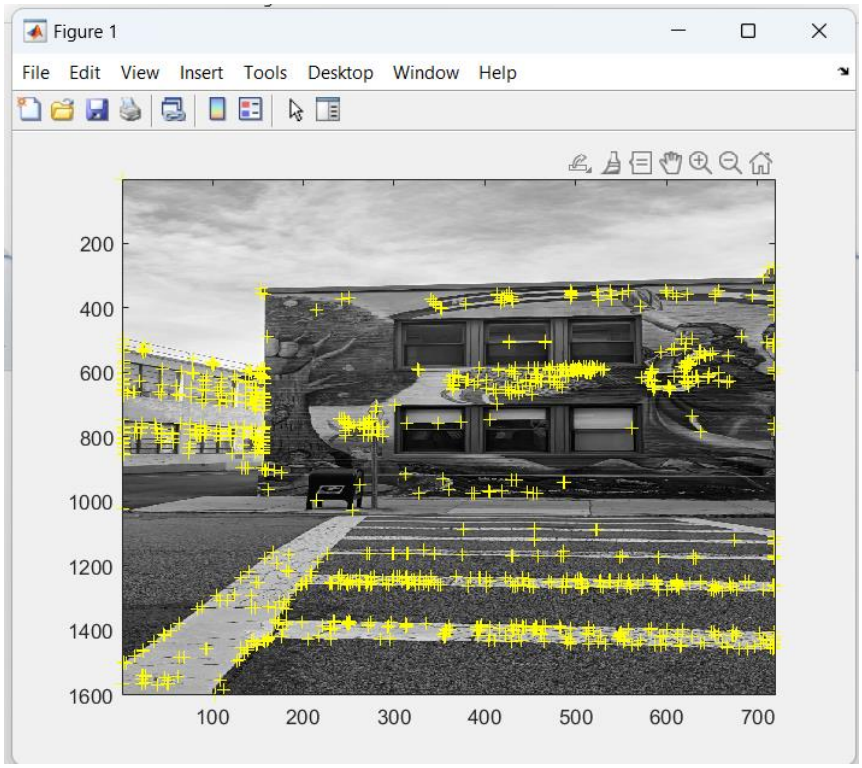
As I am getting a lot of distortion between the original image and the distortion image, I am considering the original image without distortion for LSC Mosaic.

2. LSC Mosaic:

LSC image set



Distribution of Harris corners across LSU image set



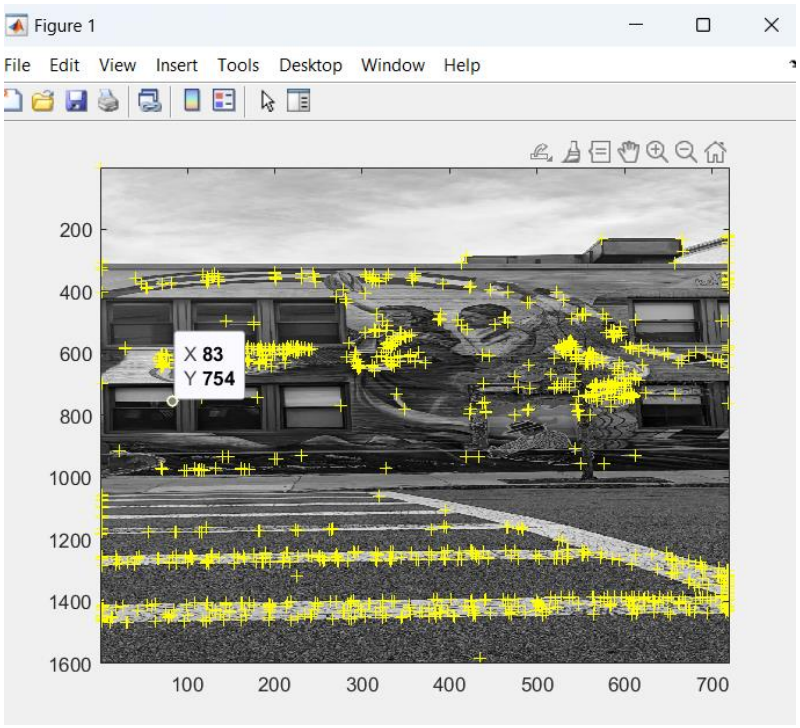


Figure 1
File Edit View Insert Tools Desktop Window Help
X 83
Y 754
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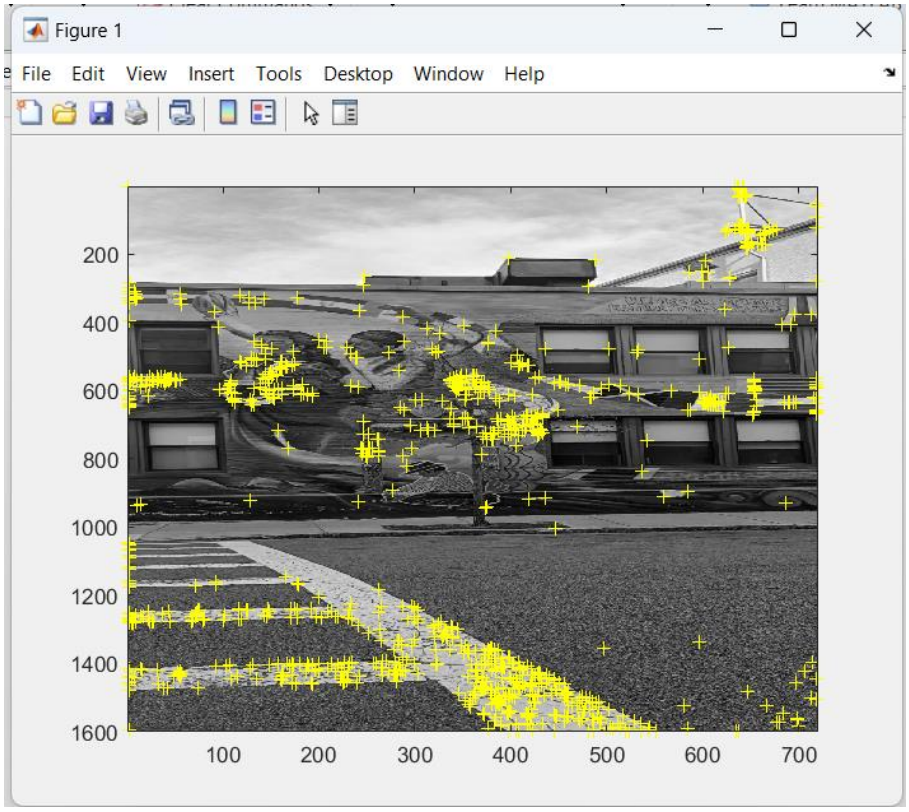
Figure 1
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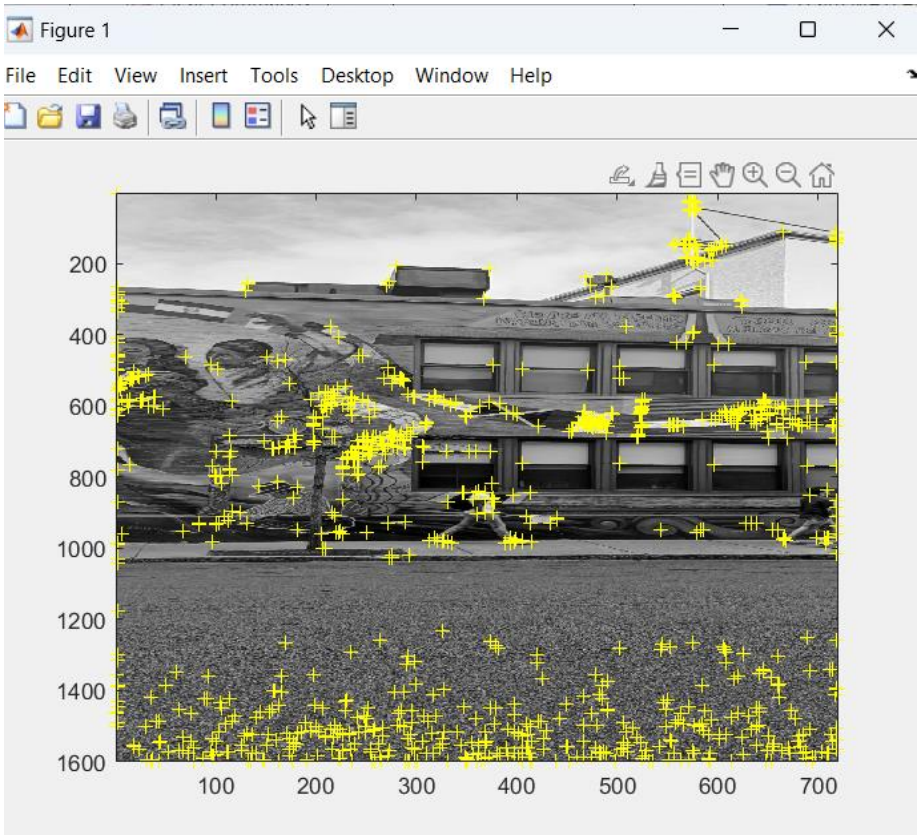
Figure 1
File Edit View Insert Tools Desktop Window Help
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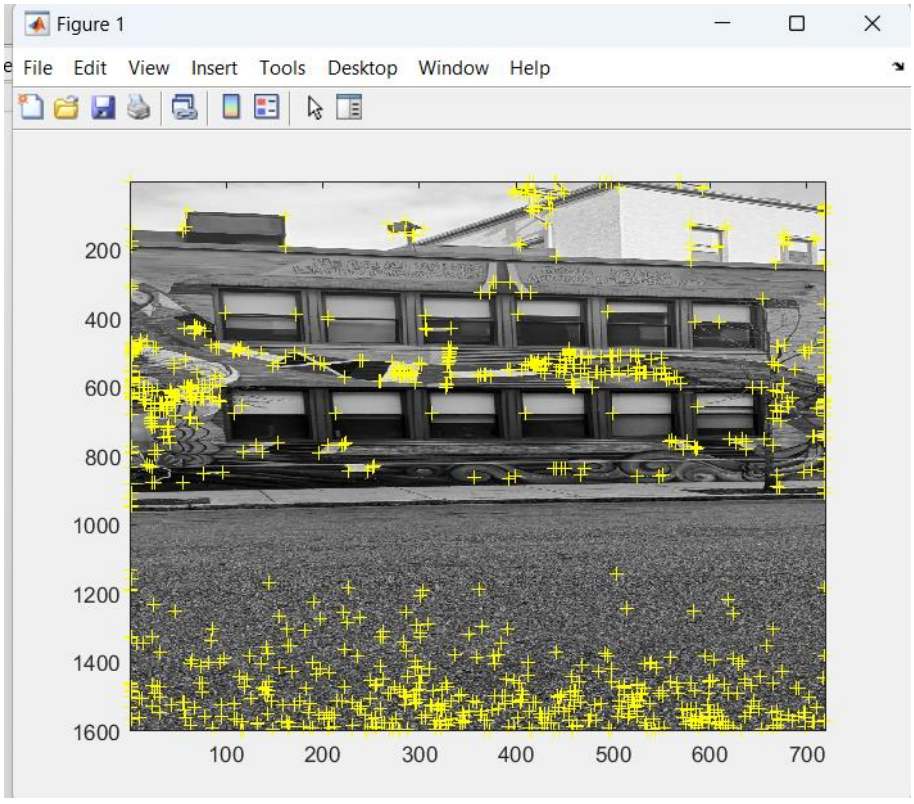
Figure 1
File Edit View Insert Tools Desktop Window Help
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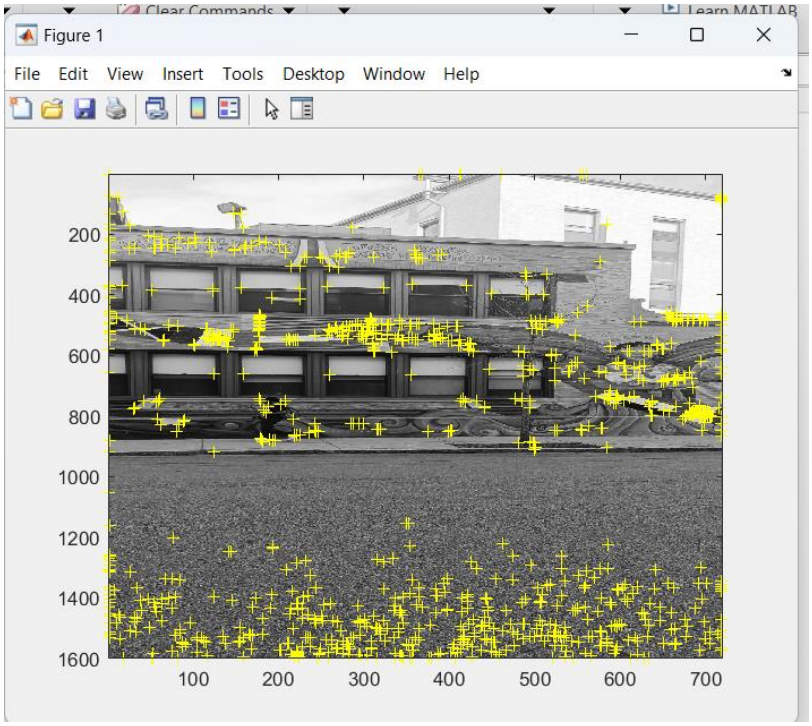
Figure 1
File Edit View Insert Tools Desktop Window Help
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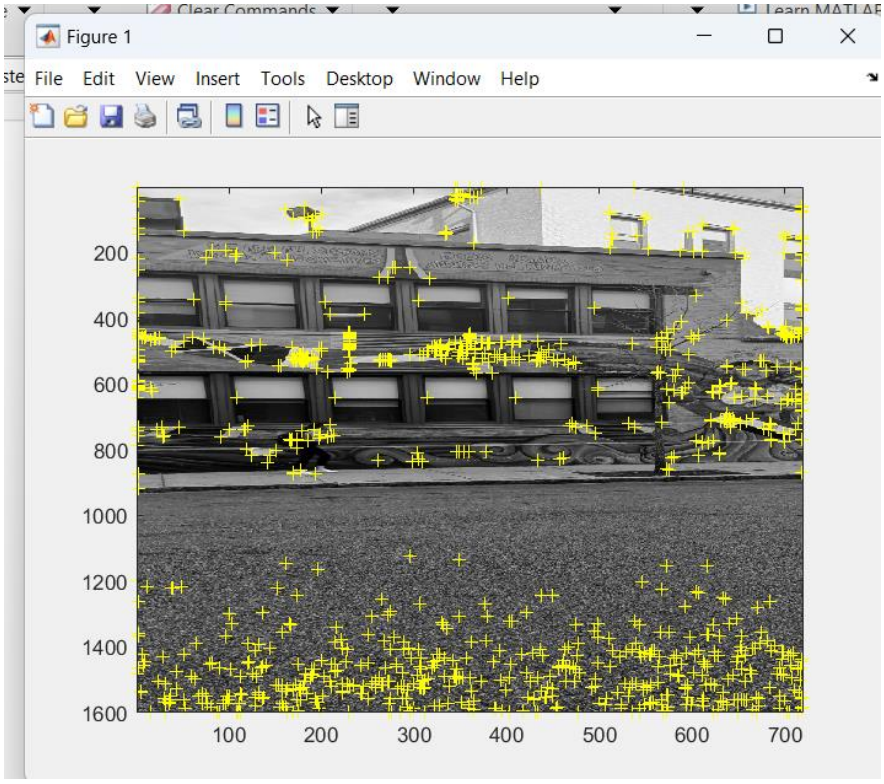
Figure 1
File Edit View Insert Tools Desktop Window Help
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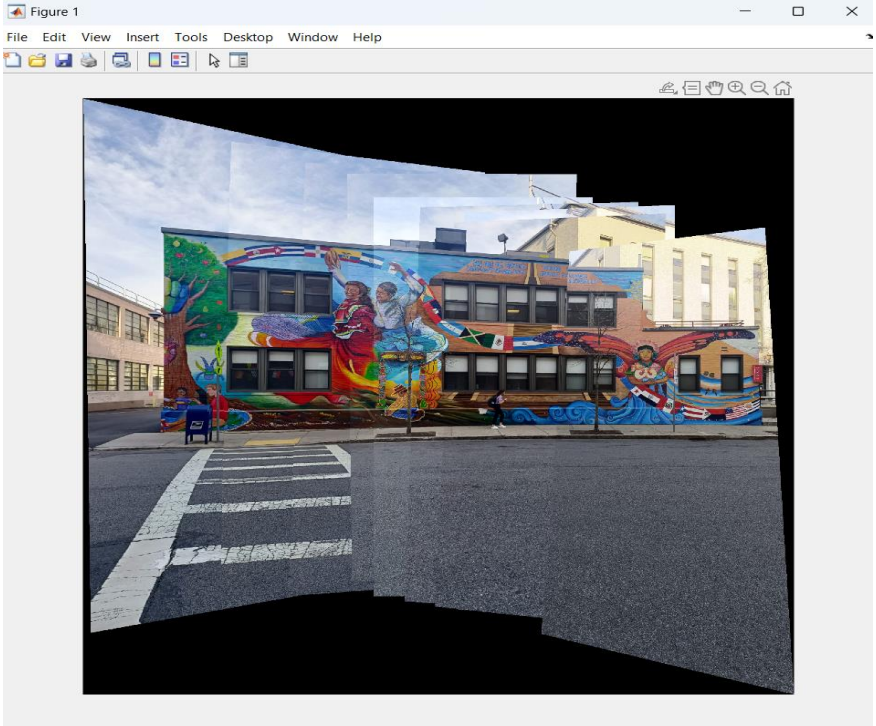
Final LSC mosaic



Cinder block/brick wall “mosaic”:

Initial images with Harris corners:

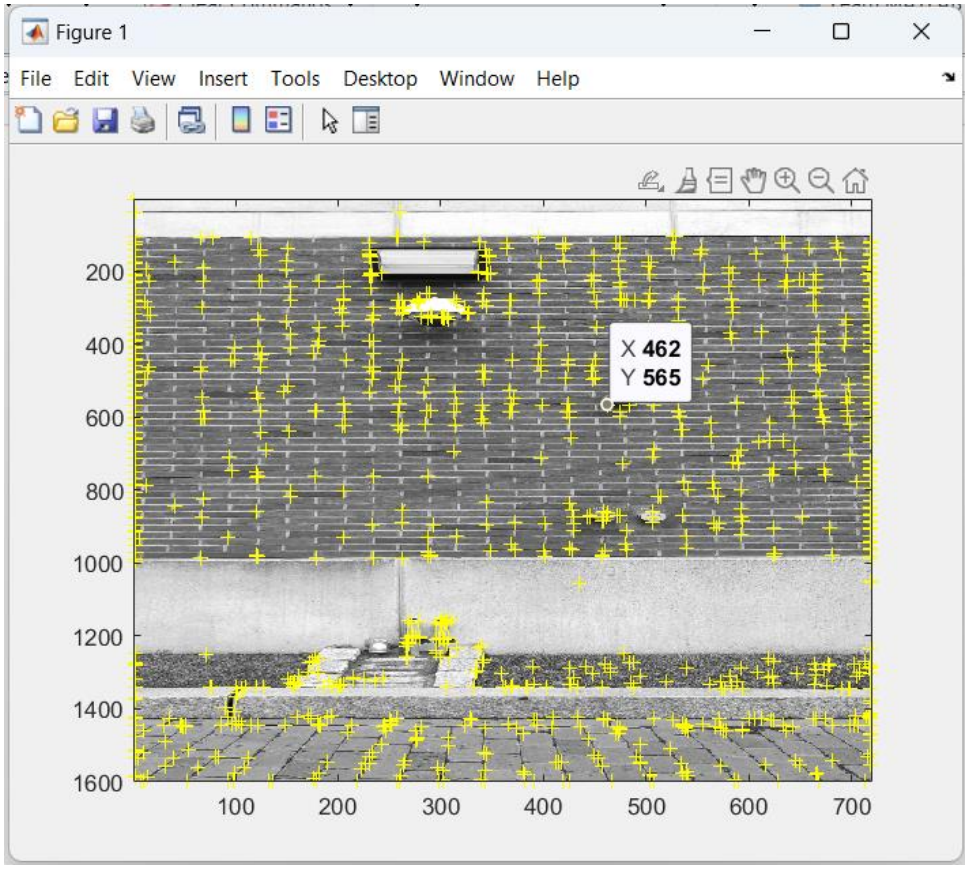


Figure 1
File Edit View Insert Tools Desktop Window Help
X 462
Y 565
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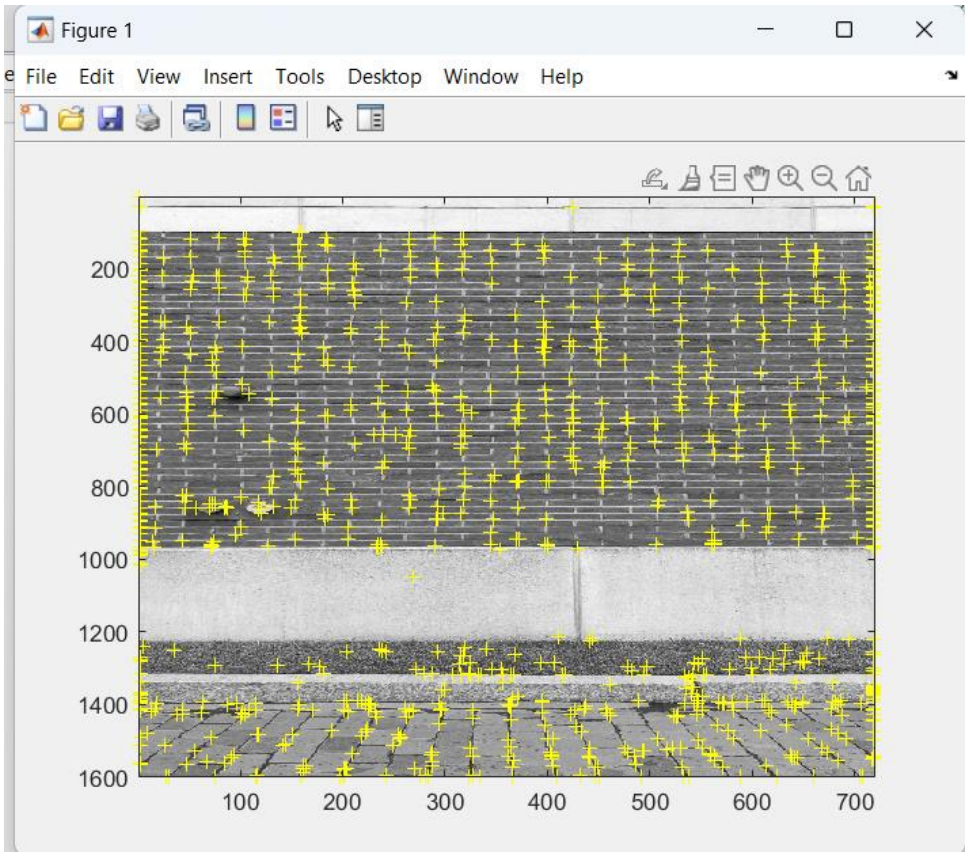
Figure 1
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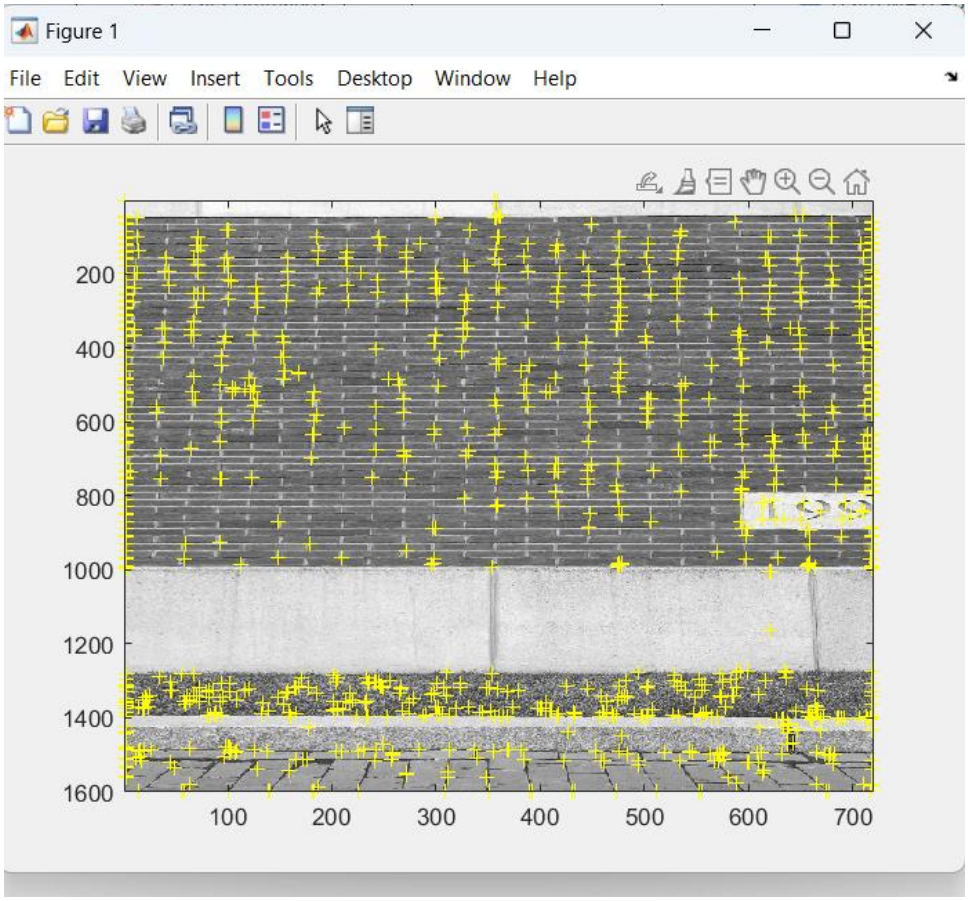
Figure 1
File Edit View Insert Tools Desktop Window Help
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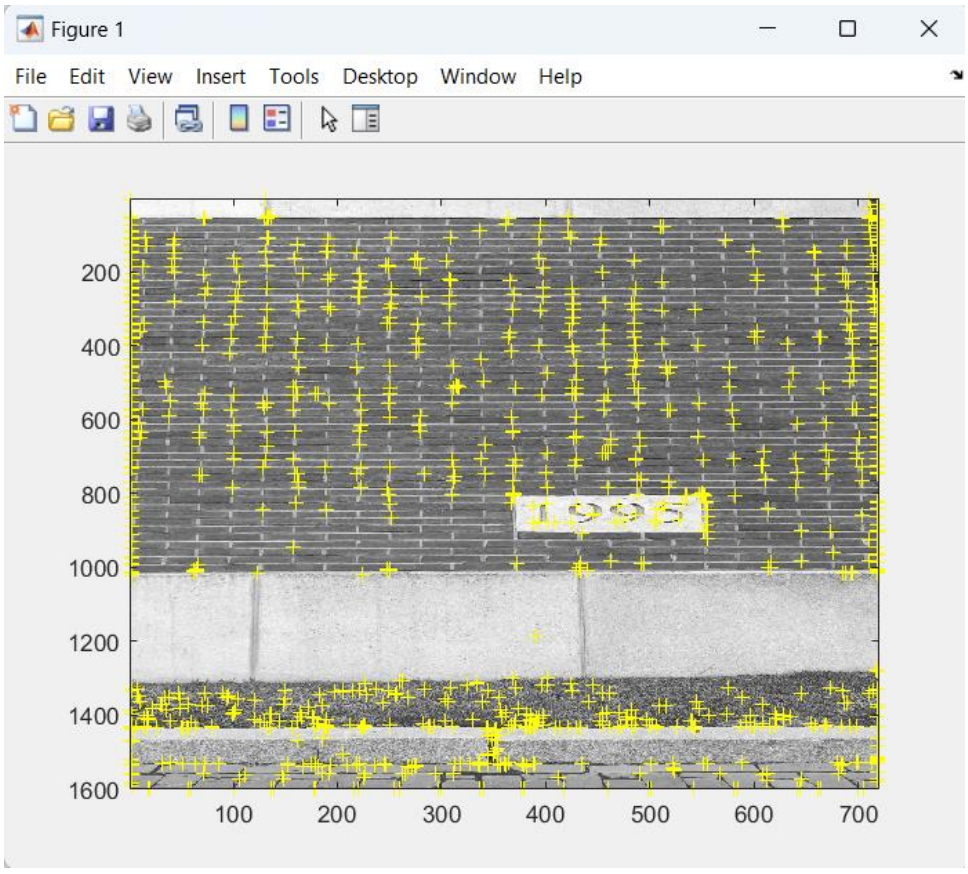
Figure 1
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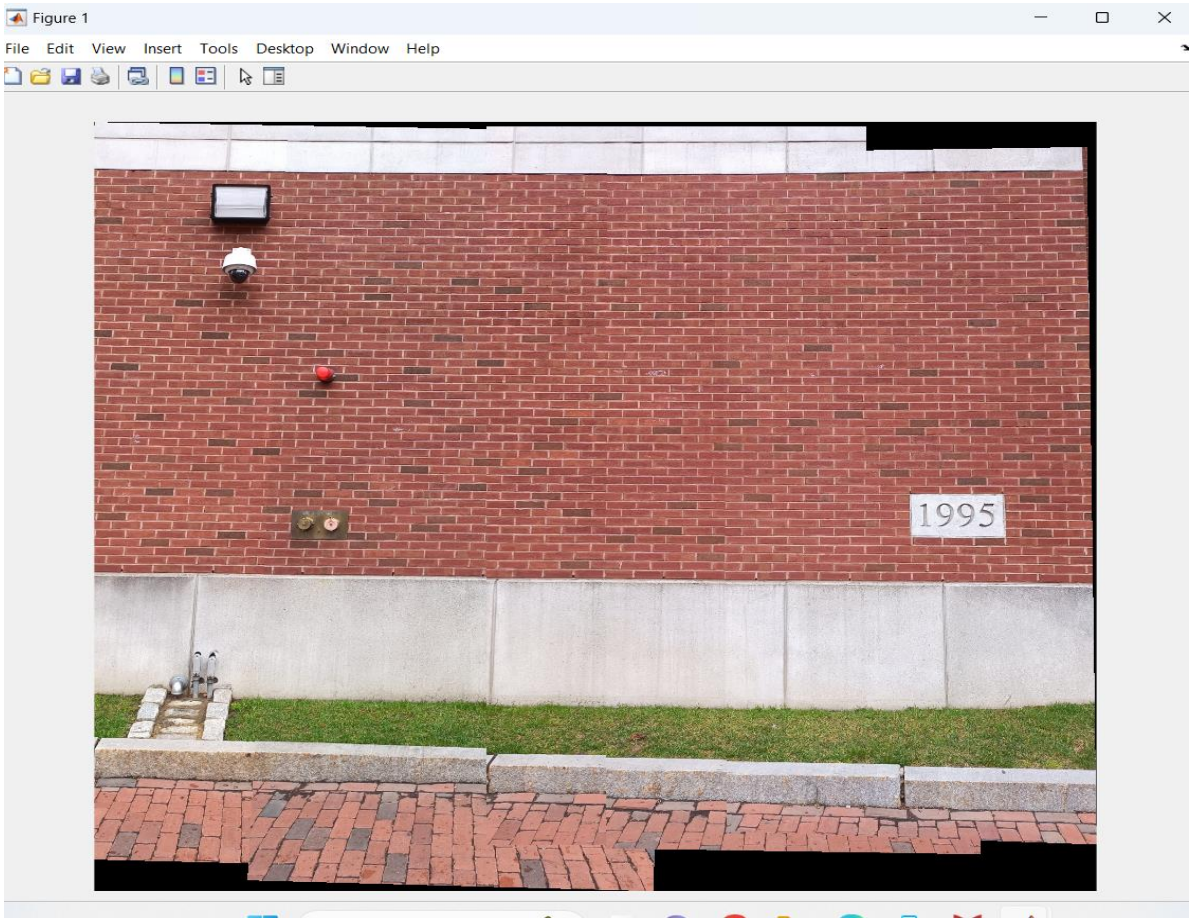
Final cinder block image:

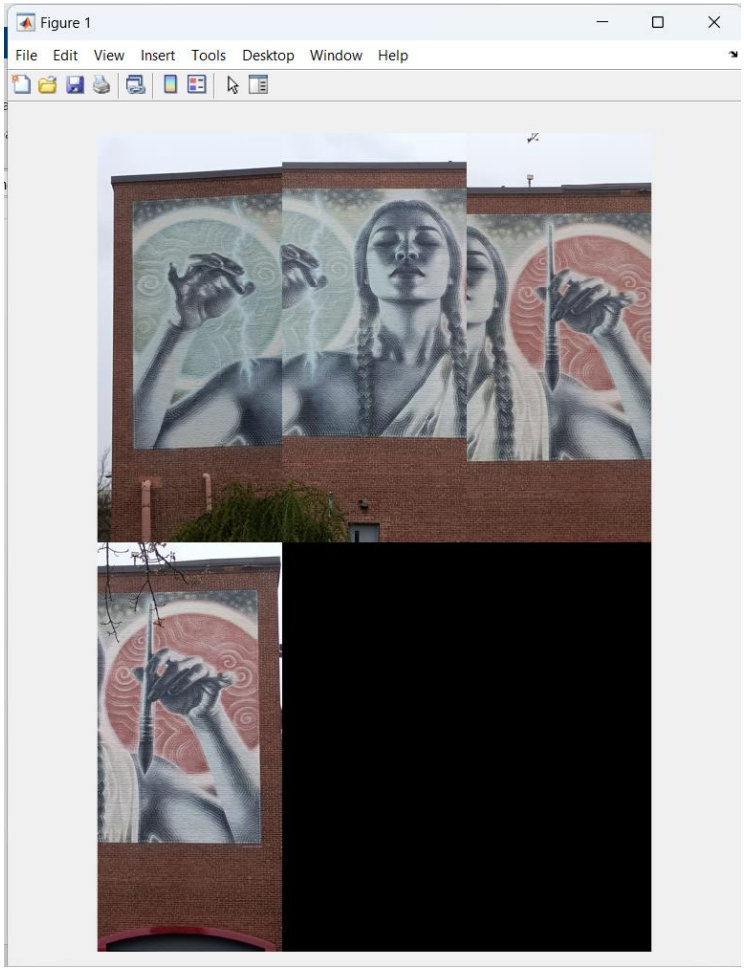


Explanation of cinder block/brick wall performance compared to the LSC mural

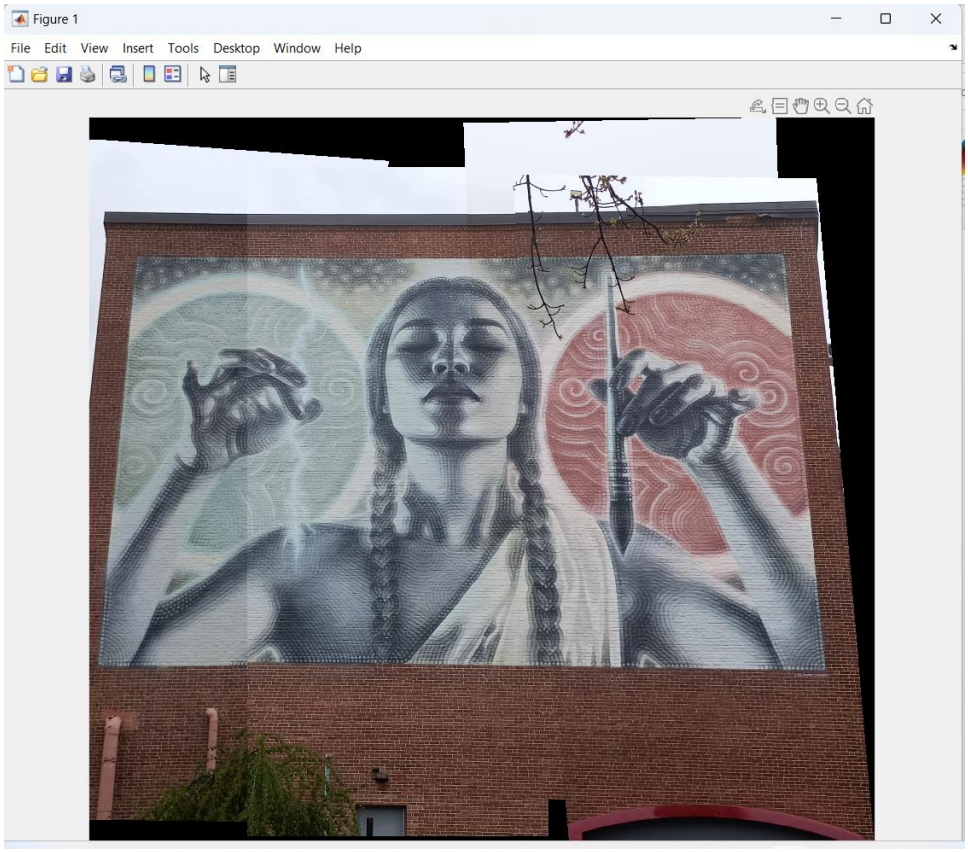
While making the mosaic of the Cinder blocks errors related to “morzcat” and “imwarp” and also a singularity error so the number of images was reduced to 5 and since the images were taken not from the cinder blocks as per the MATLAB's prescription affine transformation was used. The tile size, confidence etc. all were the same.

3.Third “mosaic”

Initial images with Harris corners with 50% overlap

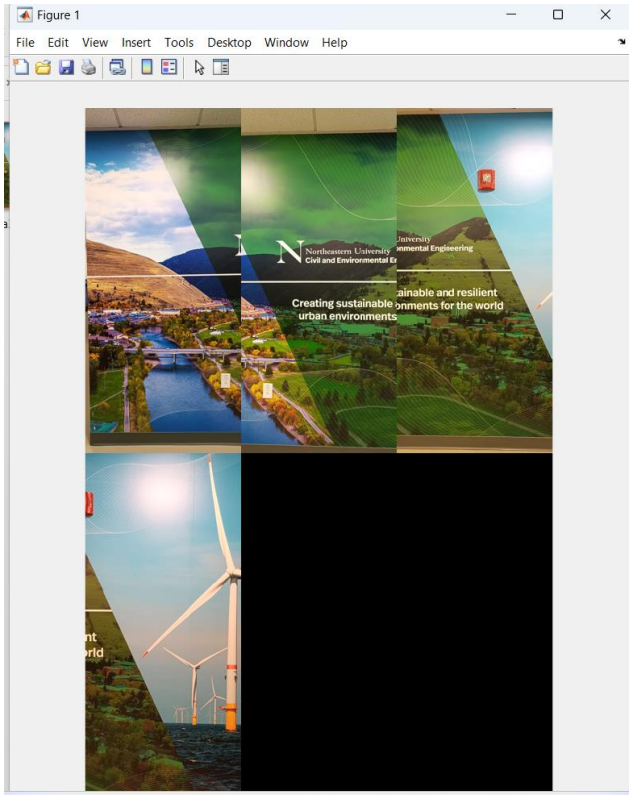


Final mosaic with 50% overlap

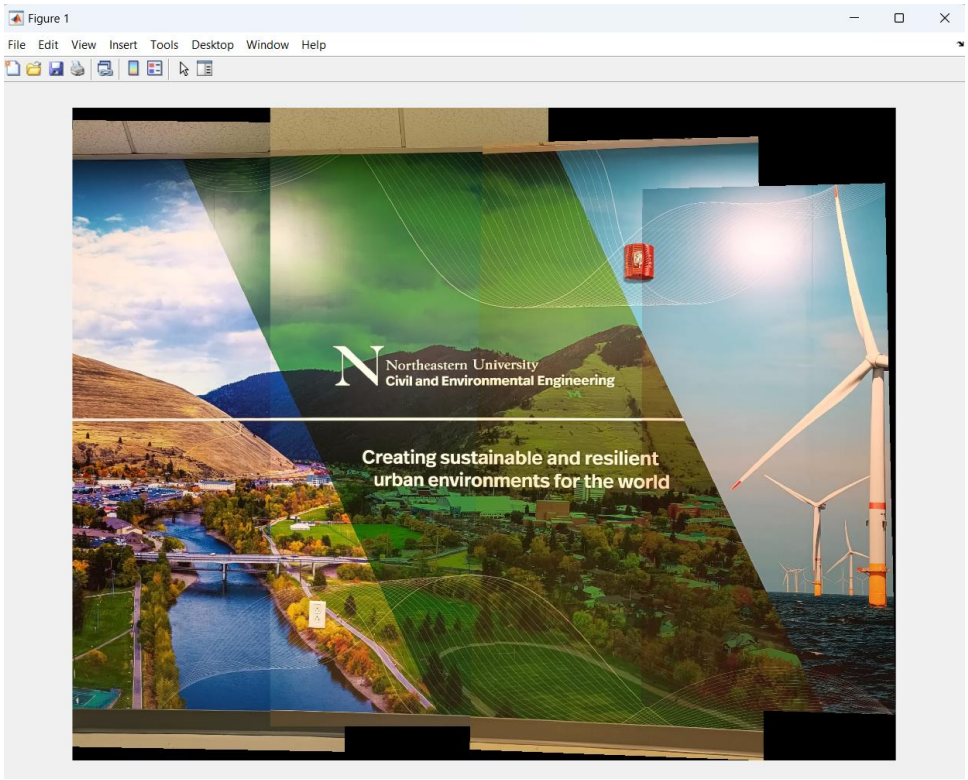


There were no changes made to the 50% overlap images code. The code has run without any errors and the certain dominant features which were highlighted with harris features were considered and compared to later make image stitching but certain features like light poles etc. which weren't seen in the harris features points have occurred in multiple frames with improper outputs

Initial images with Harris corners with 15% overlap



Final mosaic with 15% overlap



For the case of 15% overlap images, the tile size initially was set to [3 3], the maximum numbe of interest points was set to 1000 initially and while going through all the images the tile size and interest points were changed back to the [2 2] and 2000 respectively