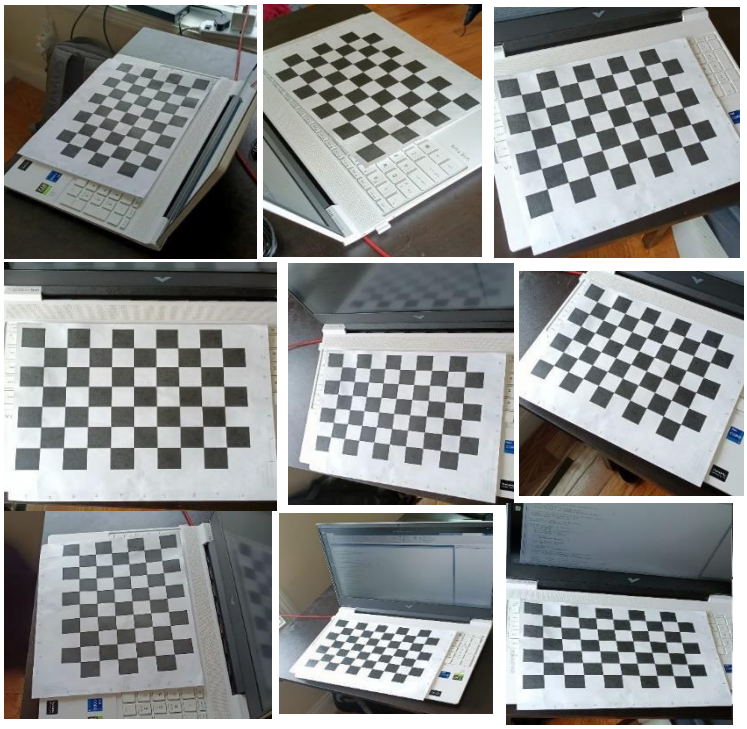
# EECE-5554

# LAB-5

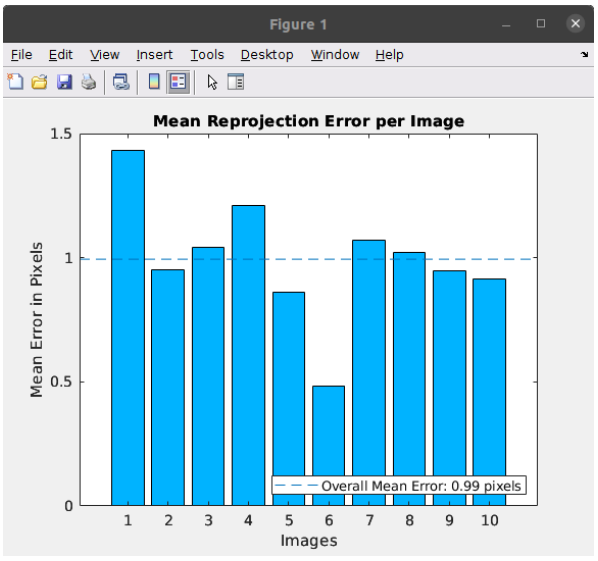
# ROBOT SENSING AND NAVIGATION

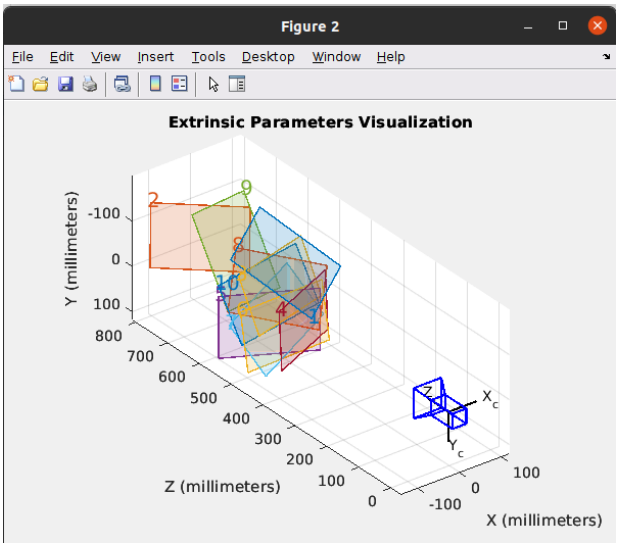
**Camera calibration:**

1. **Camera images used for calibration:**



2. **Reprojection pixel error: 0.99 pixels**



## 3. Calibration parameters:

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                    Standard Errors of Estimated Camera Parameters
                    ----------------------------------------------

Intrinsics
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Focal length (pixels):   [ 1495.5046 +/- 10.9295    1500.8893 +/- 9.9799  ]
Principal point (pixels):[  455.0615 +/- 2.3622     1030.7494 +/- 6.2105  ]
Radial distortion:       [    0.2762 +/- 0.0242       -1.3031 +/- 0.2235  ]

Extrinsics
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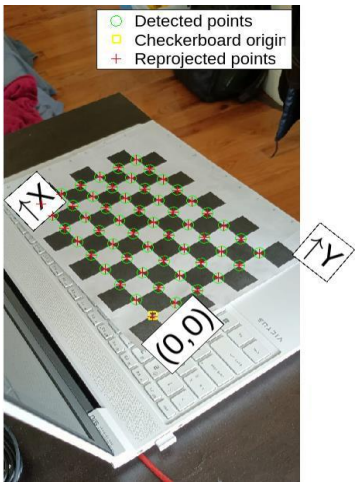
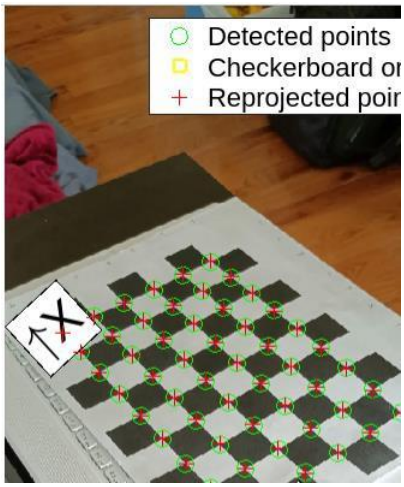
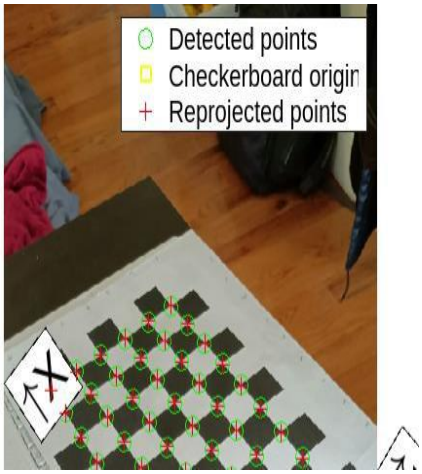
Rotation vectors:
                         [   -0.4014 +/- 0.0026       -0.6651 +/- 0.0035       -2.1354 +/- 0.0012  ]
                         [   -0.5525 +/- 0.0034        0.3319 +/- 0.0028        0.3043 +/- 0.0012  ]
                         [   -0.4154 +/- 0.0031       -0.2795 +/- 0.0028       -0.0406 +/- 0.0009  ]
                         [   -0.0853 +/- 0.0038       -0.4602 +/- 0.0031        0.0368 +/- 0.0011  ]
                         [   -0.1763 +/- 0.0040        0.4096 +/- 0.0036        0.0810 +/- 0.0011  ]
                         [   -0.1837 +/- 0.0062       -0.0257 +/- 0.0041       -0.0013 +/- 0.0005  ]
                         [   -0.5418 +/- 0.0037       -0.2374 +/- 0.0028       -0.3095 +/- 0.0008  ]
                         [   -0.4723 +/- 0.0033        0.1884 +/- 0.0025        0.4569 +/- 0.0008  ]
                         [   -0.3643 +/- 0.0032        0.4010 +/- 0.0031        1.4580 +/- 0.0010  ]
                         [   -0.4589 +/- 0.0033       -0.0651 +/- 0.0025       -0.0994 +/- 0.0007  ]

Translation vectors (millimeters):
                         [   -0.5246 +/- 0.6795       -8.7082 +/- 1.7607      429.8943 +/- 3.2973  ]
                         [  -95.7063 +/- 1.2629     -124.2017 +/- 3.2128      810.9150 +/- 5.4783  ]
                         [ -106.8228 +/- 0.8230      -99.0442 +/- 2.0507      520.7905 +/- 3.6250  ]
                         [  -73.1130 +/- 0.7188      -46.1620 +/- 1.7944      437.6800 +/- 3.2195  ]
                         [  -94.2302 +/- 0.9263      -12.5337 +/- 2.4682      600.6773 +/- 4.0179  ]
                         [ -108.6164 +/- 0.7942      -23.4399 +/- 2.0970      512.4333 +/- 3.6746  ]
                         [ -123.7432 +/- 0.8188        7.0230 +/- 2.1862      528.1667 +/- 3.8438  ]
                         [  -55.3074 +/- 0.9136     -109.2739 +/- 2.3244      595.3007 +/- 4.0669  ]
                         [   33.0027 +/- 1.0754     -162.7170 +/- 2.6280      686.5695 +/- 4.7615  ]
                         [ -127.6614 +/- 0.8621      -68.6670 +/- 2.2025      556.4716 +/- 3.9353  ]
>>
```

## 4. An image before and after calibration:

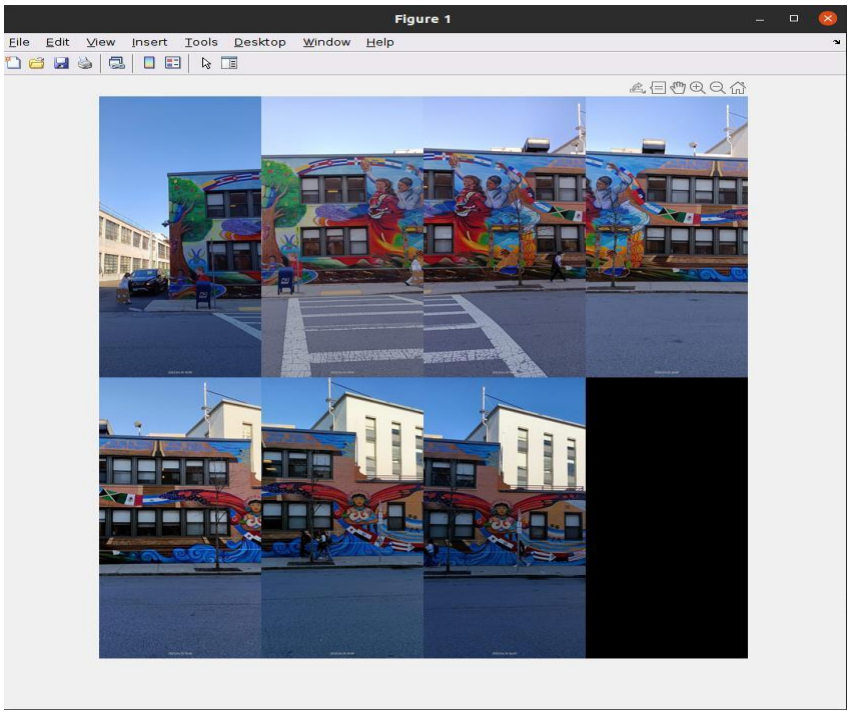


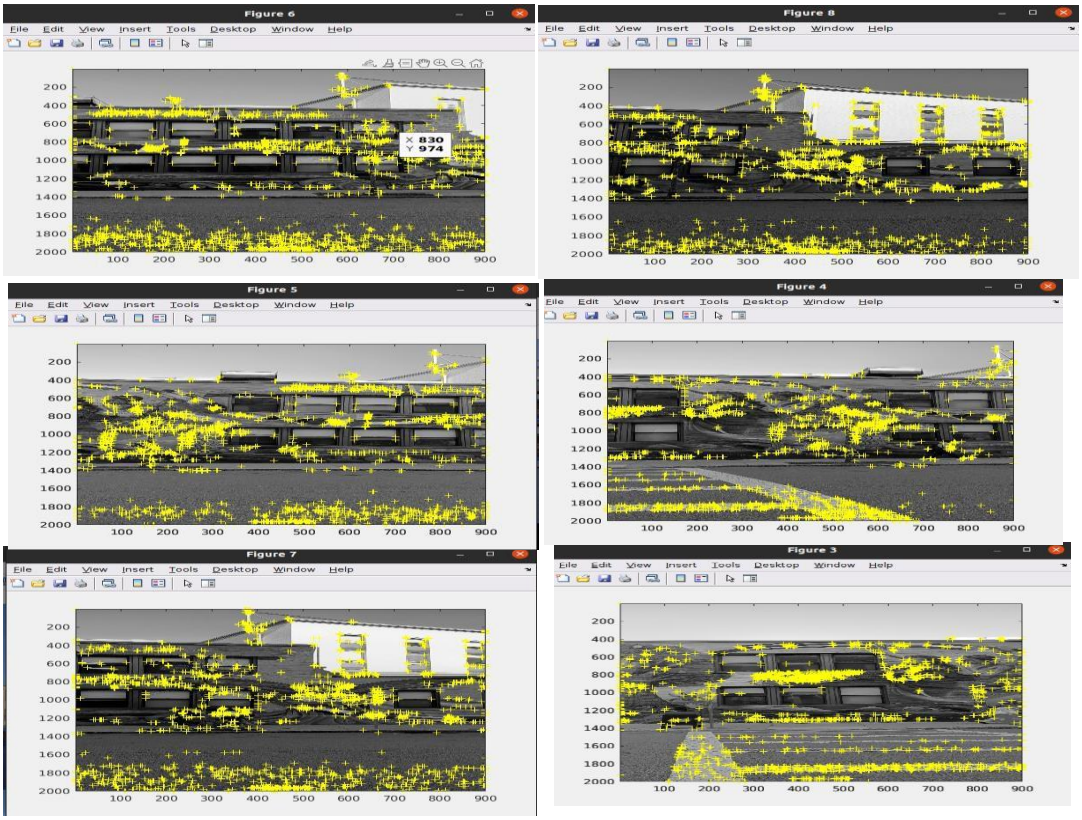



**LSC mosaic:**

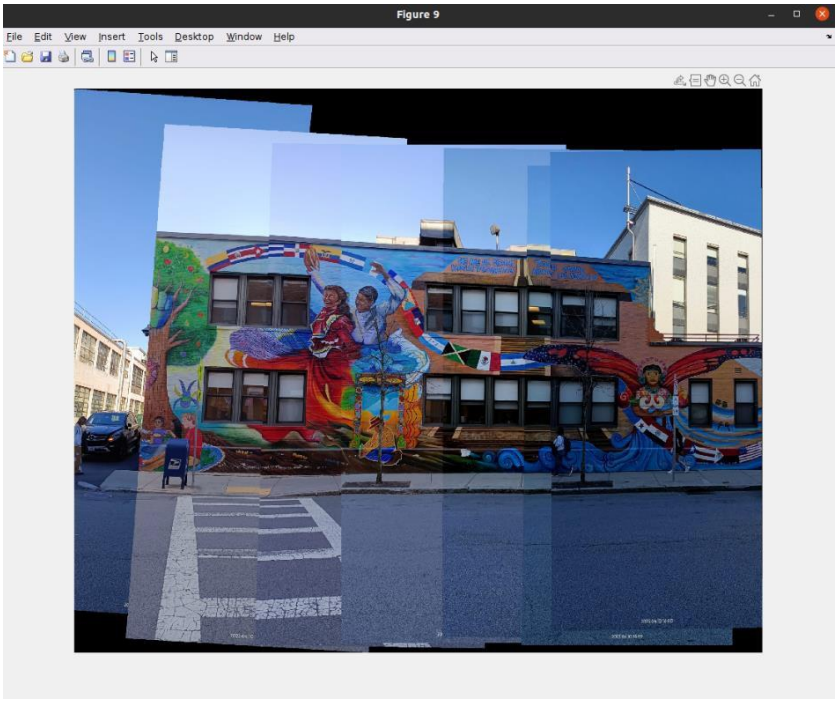
1. **LSC image set:**




2. **Distribution of Harris corners across LSU image set:**



## 3. Final LSC mosaic:

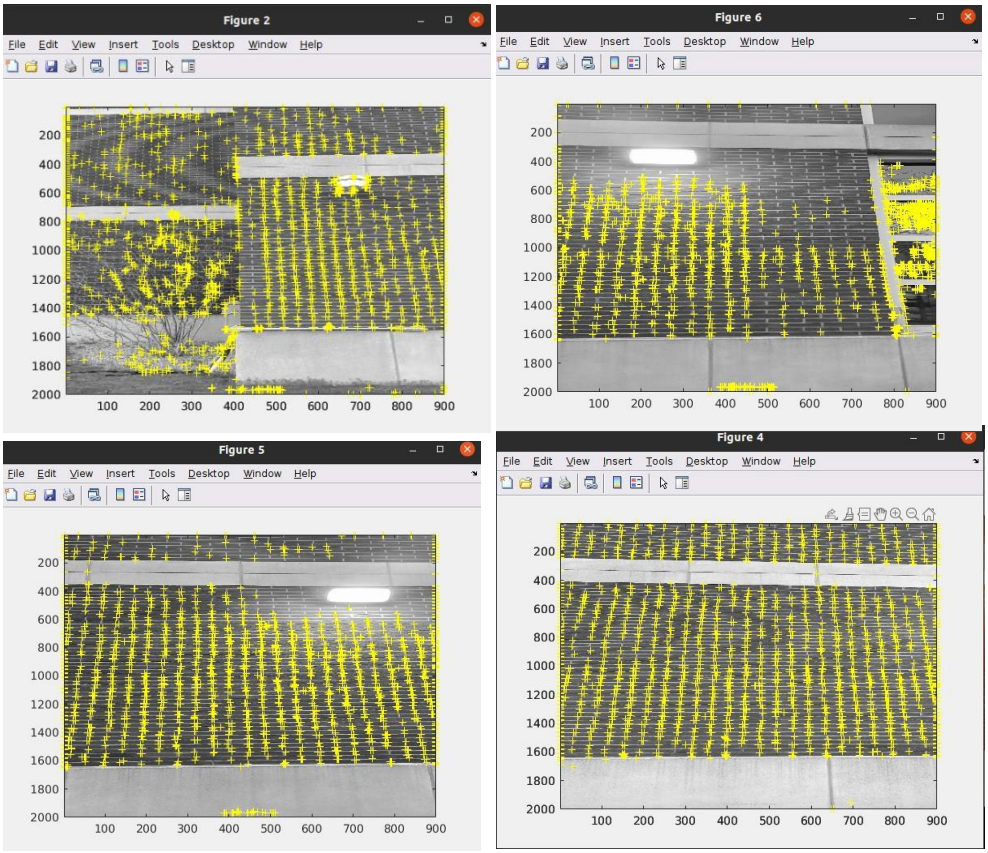



## 4. Discussion of adjustment/intermediate image steps:

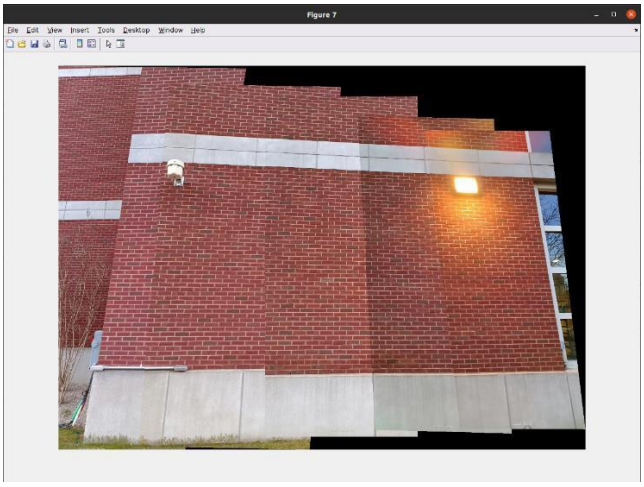
Since the images were already calibrated by the mobile's camera and since further calibration of the image is causing errors for stitching the images we have directly used the camera images. For the image mosaic using the harris features detector after reading the images, harris features were detected utilizing the harris.m file which was called in pano.m file and once the features were detected and plotted, using tforms(n)=estgeotform2d(matchedPoints,matchedPointsPrev,"affine"/"Projective","Confidence",99,'Max NumTrials', 2000); where the confidence remained unchanged while using both the transformations. So, except obtaining the Harris corners and storing those corner points in points which were later used to compare matched points and the previous points in transformations to obtain the image mosaic no other changes were made to the parameters.

## Cinder block/brick wall “mosaic”:

1. **Initial images with Harris corners:**




## 2.Final cinder block image:

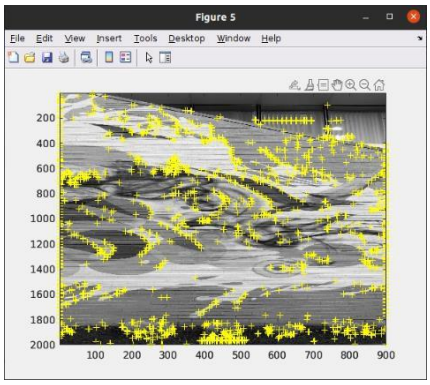


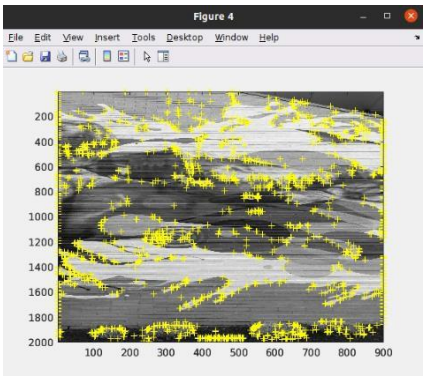
### 3.Explanation of cinder block/brick wall performance compared to the LSC mural:

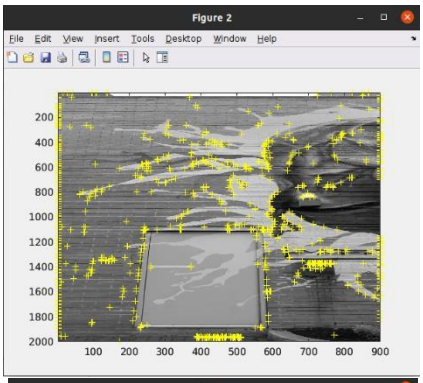
While making the mosaic of the Cinder blocks errors related to “morzcat” and “imwarp” and also a singularity error so the numbe of images was reduced to 5 and since the images were taken not from the cinder blocks as per the matlab’s prescription affine transformation was used. The tile size, confidence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

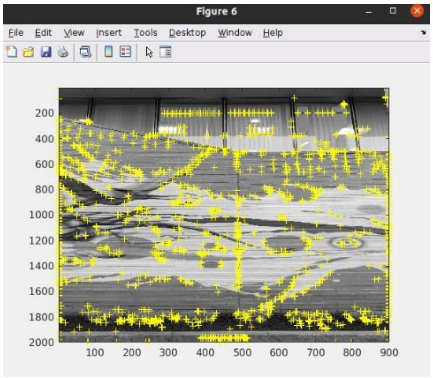
## Third Mosaic:

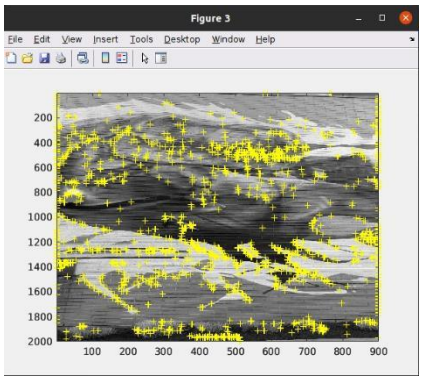
### 1. Initial images with Harris corners with 15% overlap:

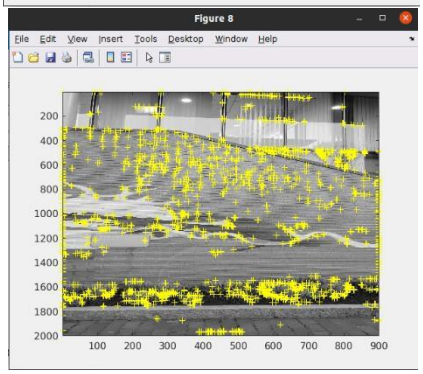


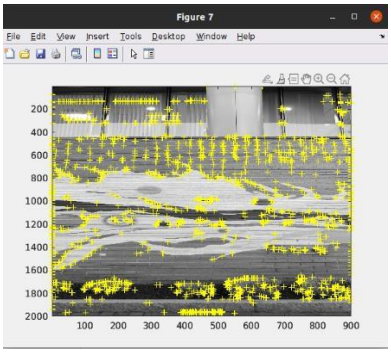



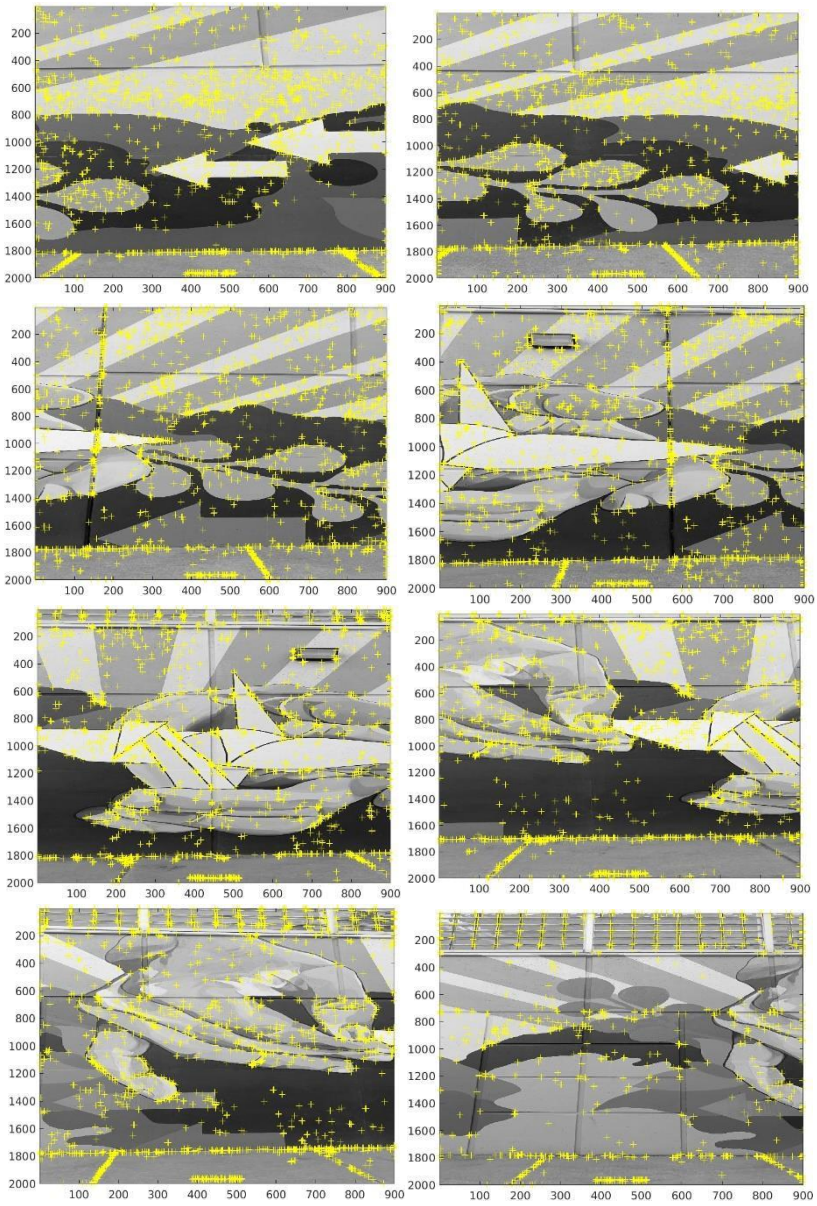



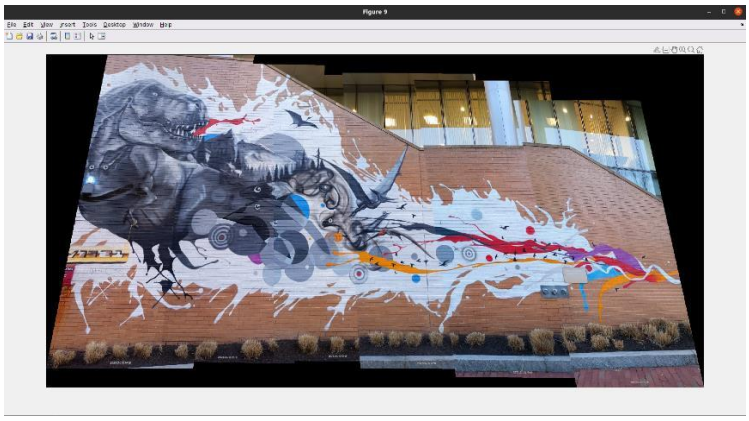



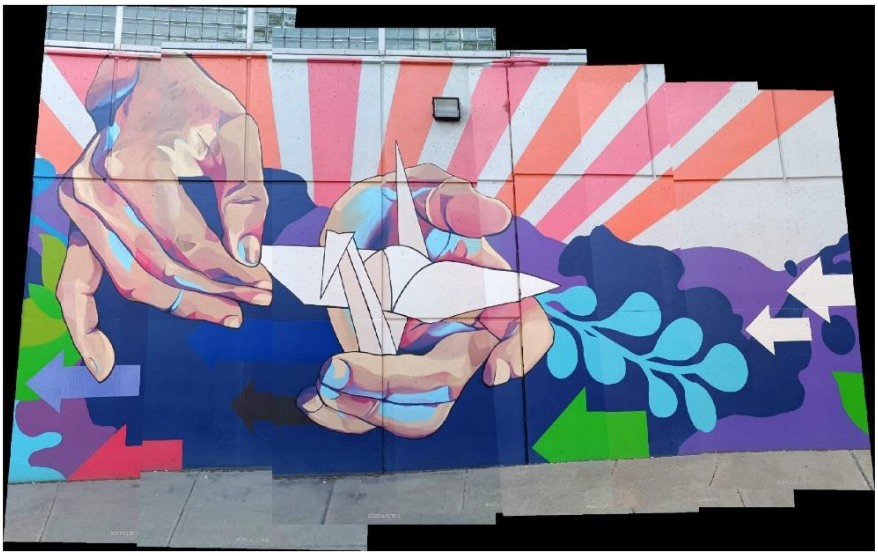
2. **Initial images with Harris corners with 50% overlap:**



3. **Final mosaic with 15% overlap:**



4. **Final mosaic with 50% overlap:**



5. **Discussion of performance with 15% overlap and 50% overlap:**

   For 15% overlapping the overlapping is not that accurate and for 50 percent overlapping the overlapping is accurate , when the confidence level is 99.

6. **Description of any adjustments/modifications we made:**

   Modification is done for the 15% percent overlap file, The confidence level is changed to 50 percent to accurately overlap the images.