Robotics Sensing and Navigation

Lab 4 Report

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1. Camera Calibration.
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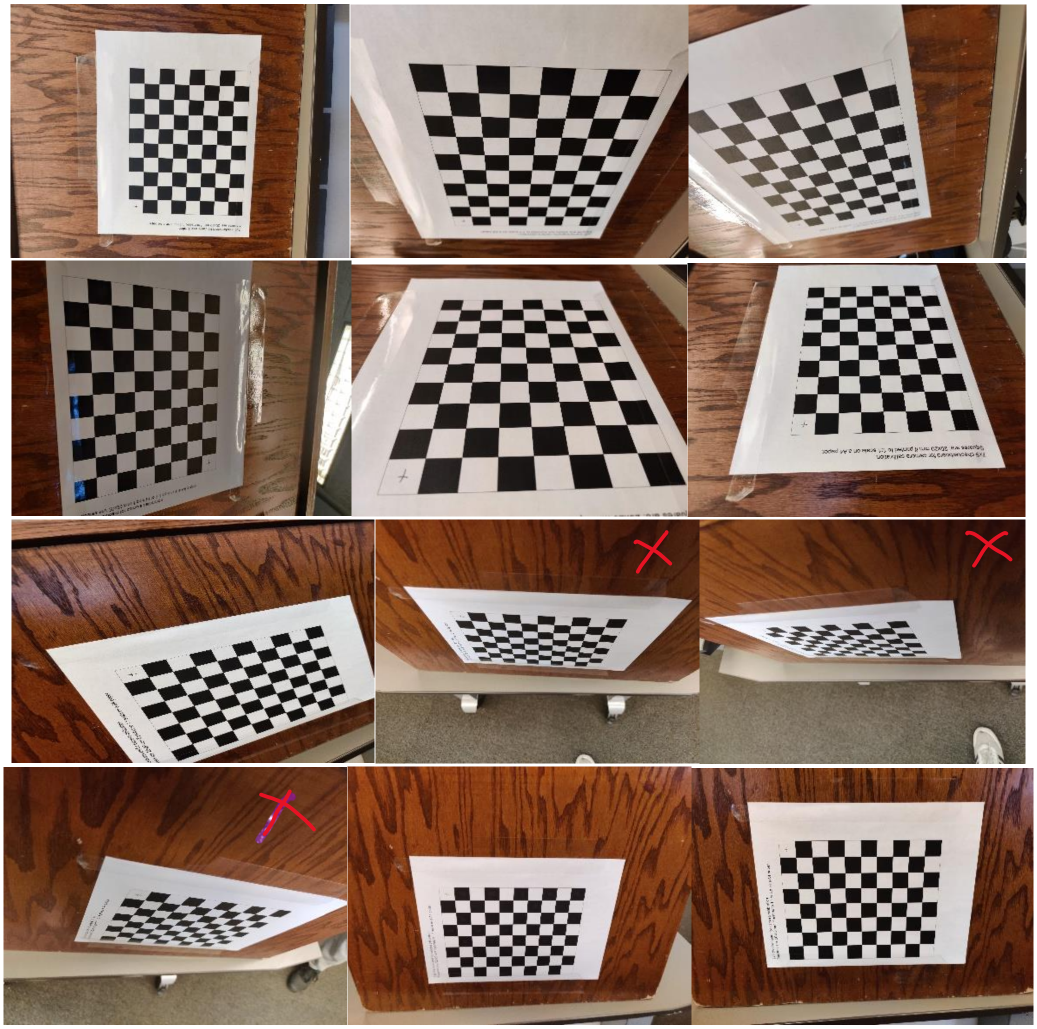
Calibration:



Originally, I took 12 images of the checkerboard for the calibration purpose. Later during the calibration procedure, it was taken to notice that 3 images had very high distortion outliers since those images had content other than checkerboard involved in them. Hence, the images marked with red (X) in the above figure were manually removed while calculating the camera calibration.

The mean reprojection error was found to be 1.69 pixels. Reprojection error estimation for each individual checkerboard image can be seen in the below graph.

Upon removing image 4, the calibration error reduces to 1.54 pixels.

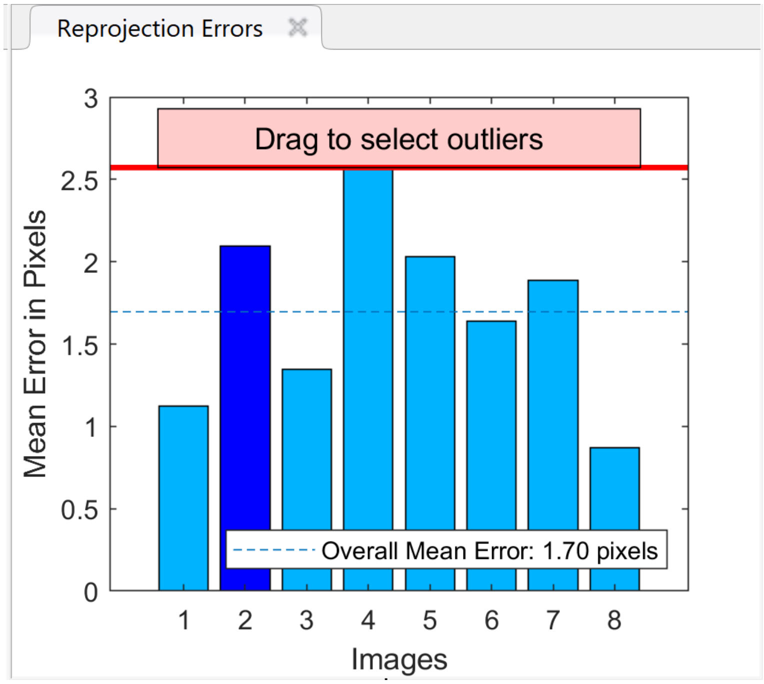


Fig 2: Reprojection errors for each checkerboard image.

The below figure represents the checkerboard centric camera angles from which the photos were taken to calibrate the error in the camera used.

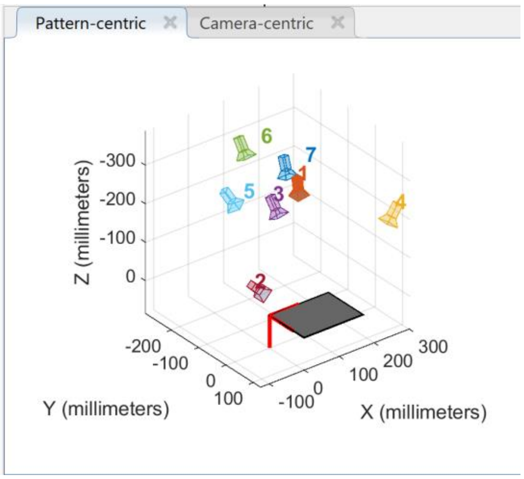


Fig 3: Pattern-Centric Representation of camera angles.

The below figure represents the camera centric representation of the photos taken from different checkerboard images assuming camera is fixed.

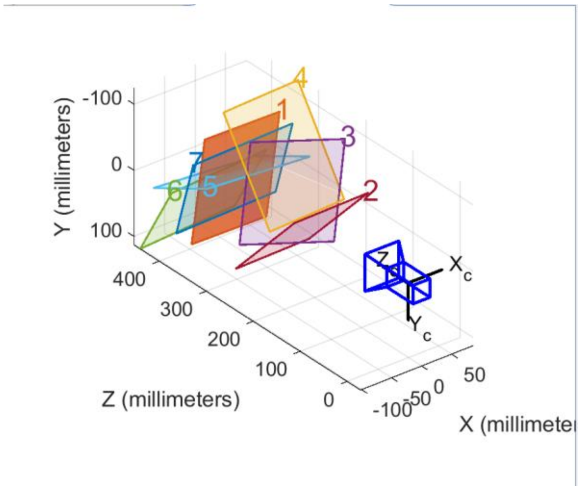
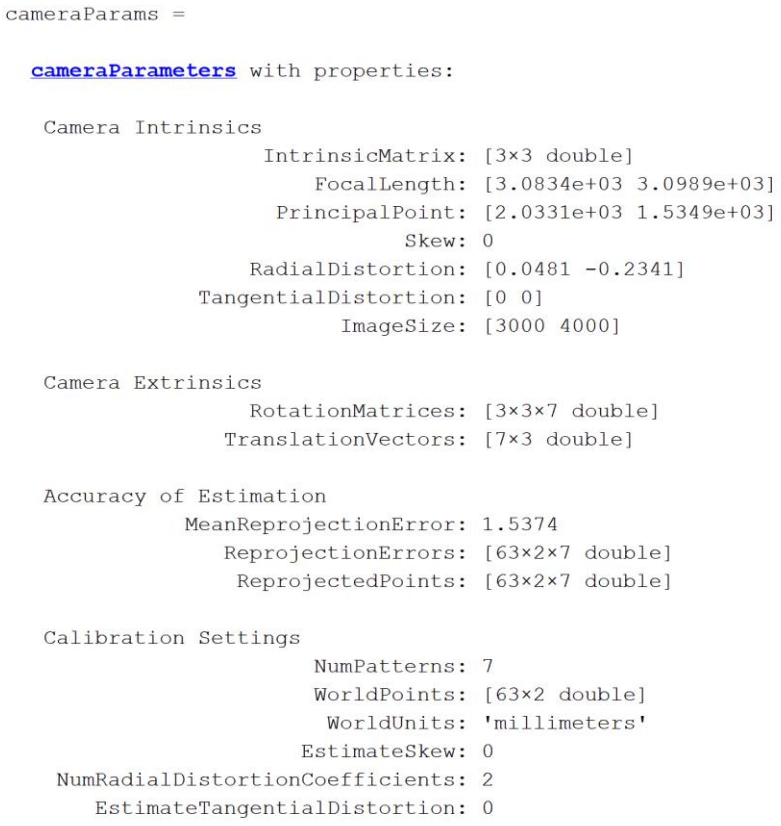


Fig 4: Camera-Centric Representation.

The camera Params calculated are as follows:



```
cameraParams =

  cameraParameters with properties:

   Camera Intrinsics
                    IntrinsicMatrix: [3×3 double]
                        FocalLength: [3.0834e+03 3.0989e+03]
                     PrincipalPoint: [2.0331e+03 1.5349e+03]
                               Skew: 0
                   RadialDistortion: [0.0481 -0.2341]
               TangentialDistortion: [0 0]
                          ImageSize: [3000 4000]

   Camera Extrinsics
                   RotationMatrices: [3×3×7 double]
                 TranslationVectors: [7×3 double]

   Accuracy of Estimation
              MeanReprojectionError: 1.5374
                 ReprojectionErrors: [63×2×7 double]
                  ReprojectedPoints: [63×2×7 double]

   Calibration Settings
                        NumPatterns: 7
                        WorldPoints: [63×2 double]
                         WorldUnits: 'millimeters'
                       EstimateSkew: 0
    NumRadialDistortionCoefficients: 2
       EstimateTangentialDistortion: 0
```

Part 2: Photo Mosaicing.

The following images were used to create the mosaic:

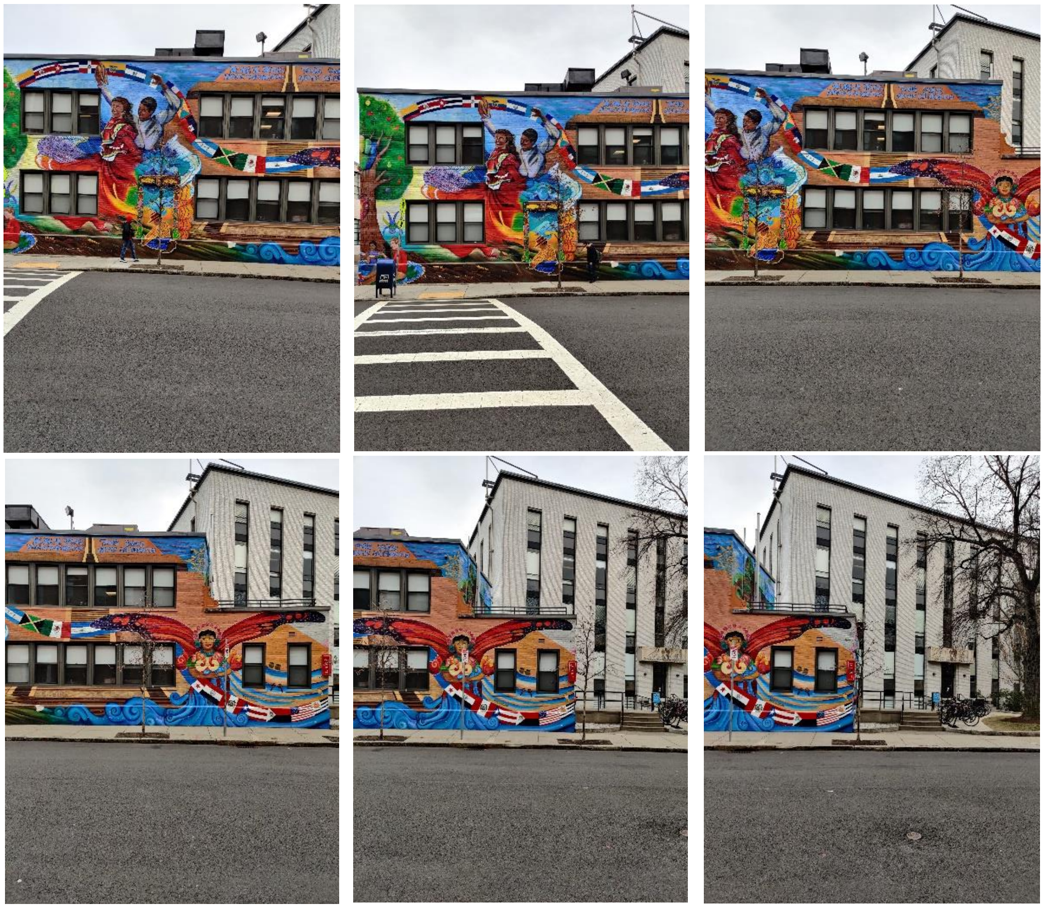


Fig 5: Images used to create the mosaic.

Here all the images were first resized to the size of [1280 960], which is approximately 1 Megapixel.
Then, each of these images were corrected from the distortion errors estimated during camera calibration.

A few examples of the above images before and after distortion are shown below:

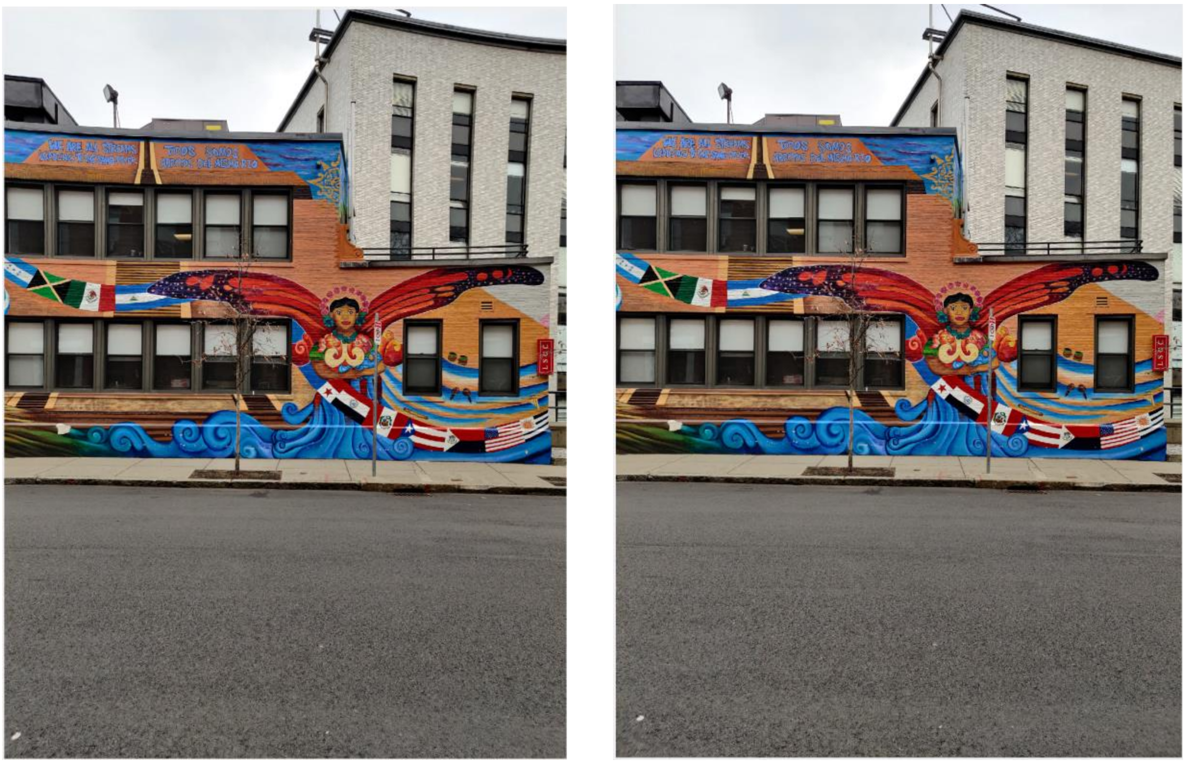


Fig 6: After Distortion Removal Before Removing Distortion

We could observe the clear difference in the above 2 images in the corners of the images.

Below is the figure formed after Mosaicing all the distortion removed and resized inages together using the Harris code provided to us.

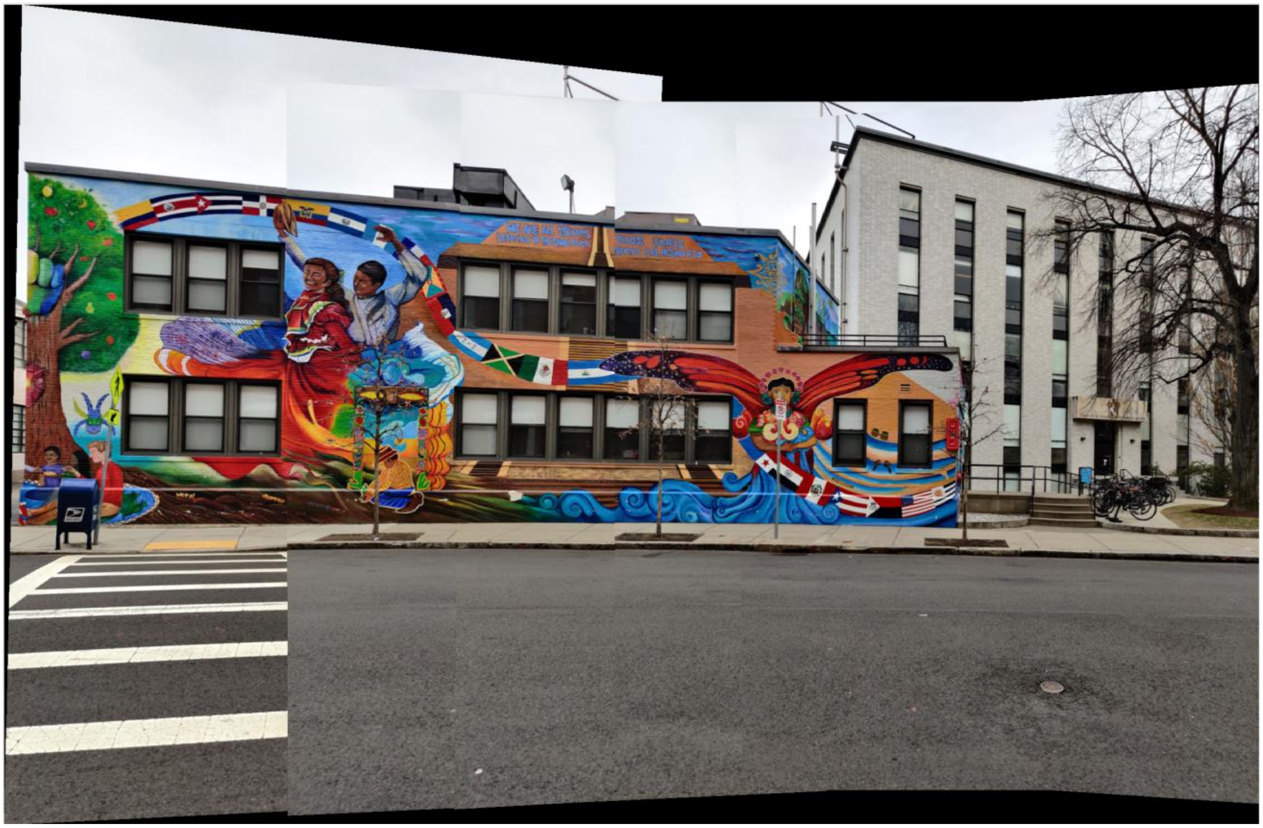


Fig 7: Mosaic Generated

Part -3.1: Mosaic on Cinder Wall Blocks

I used the following images to form the mosaic.

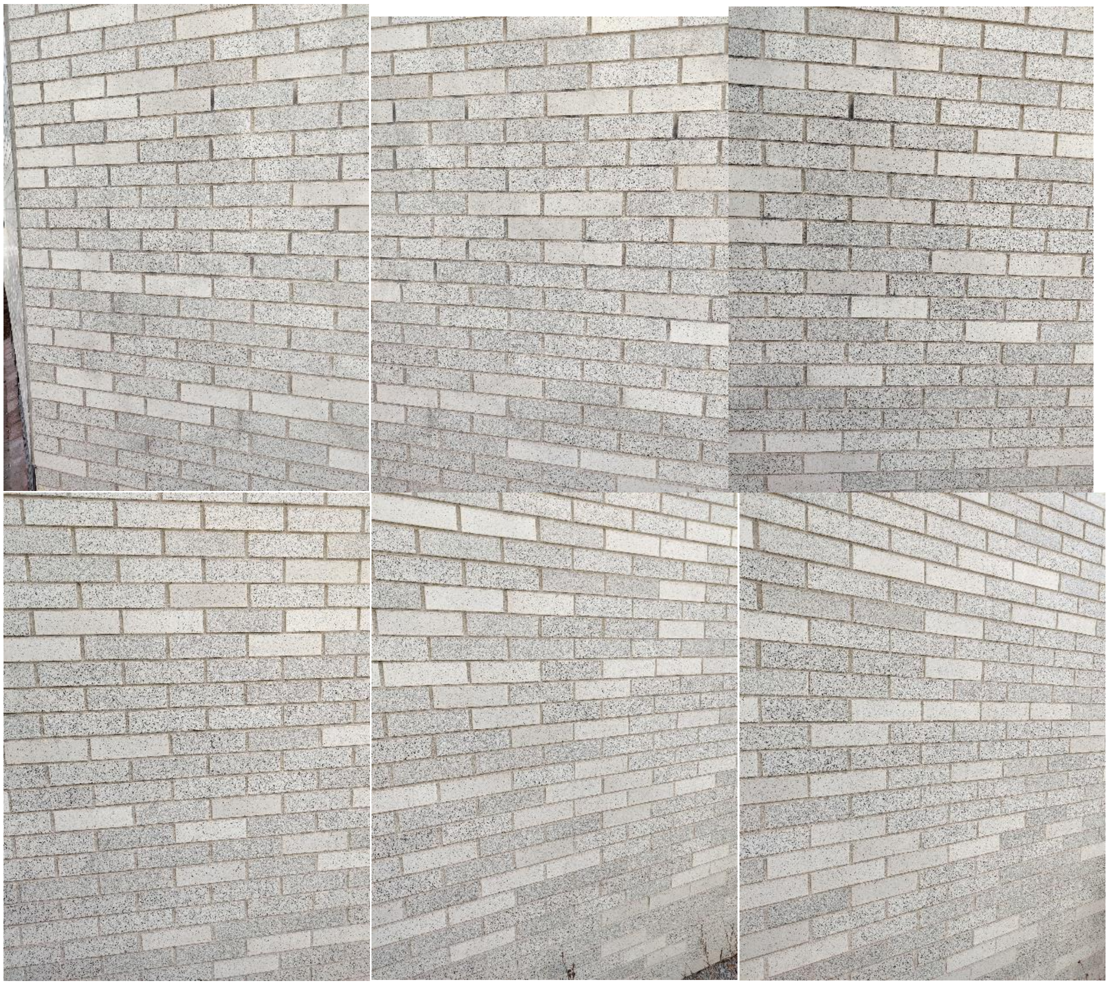


Fig: 8. Raw Images used to do the mosaic

Here, most of the features extracted are very similar to each other since they are of very similar texture throughout the image.

Therefore, the algorithm failed to recognize enough number of unique points to match the features. Hence, I select all features (unique and non-unique) from each image and match it with the corresponding features of the other images. In that way, similar features were mapped with other similar features.

Below is the mosaic of the formed Image:

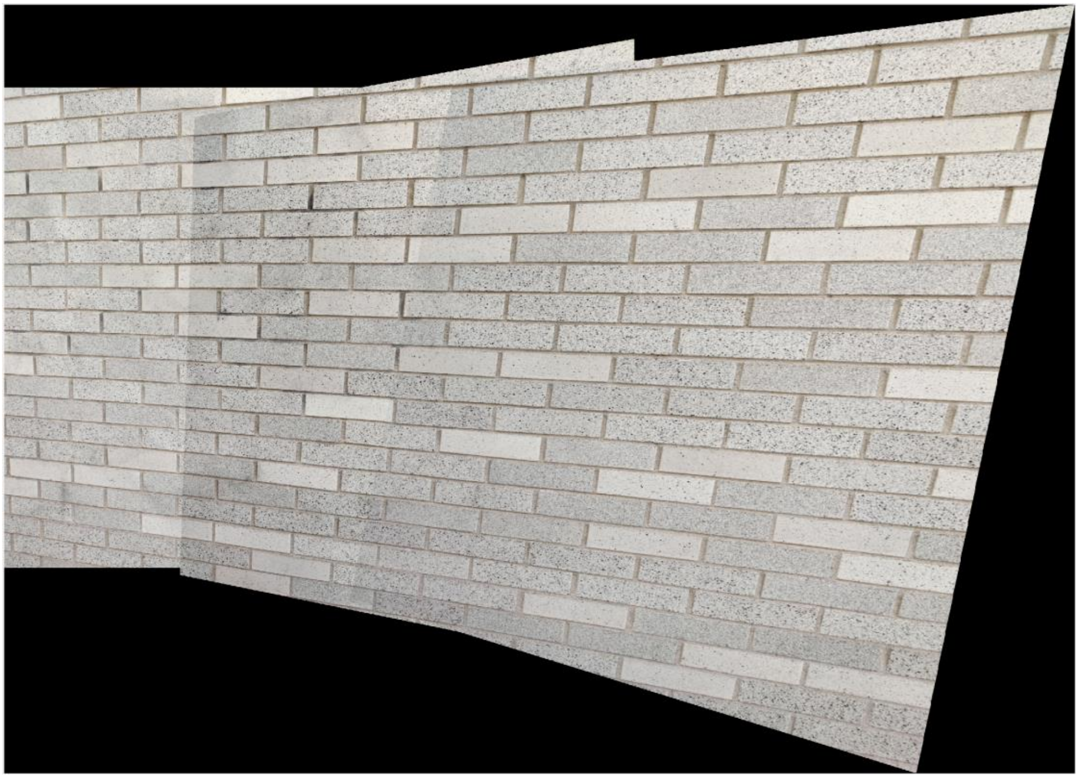
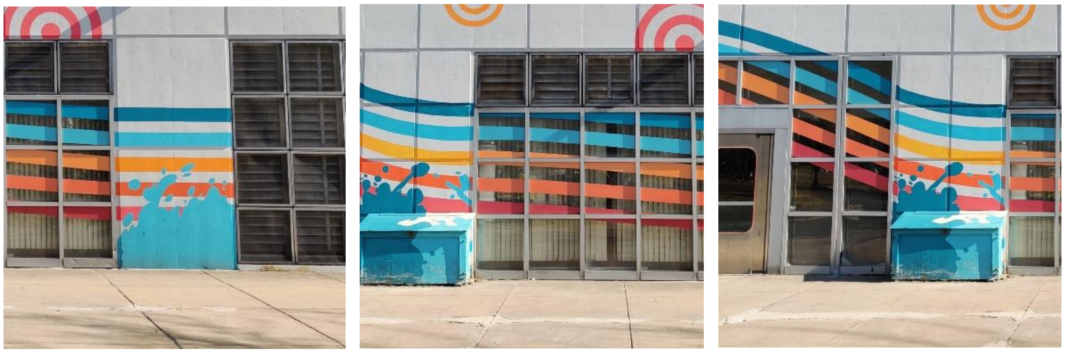


Fig 9: Mosaic of the cider block wall matched using all features extracted.

Part 3.2: Create Mosaic of a graffiti with 15% overlap.

I used the following images for this part.



Here, the number of unique points obtained were a lot since its was an image with lot of texture thus allowing Harris feature detector to detect many unique features. But the number of unique features that matched from one image to another were considerably less which causes the issue since the current algorithm with projective matching requires a minimum of 4 points to be matched with each other. Hence, I changed the algorithm to map using the similarity, by which the images would need only 2 unique point matched to create the mosaic between them.

Below is the mosaic formed from these 3 raw images.