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Mosaic Report

Introduction

Feature detection and matching is critical in creating a panorama photograph. The panorama filter on most phones allows people to simply stand in a space and rotate or move their phone in a direction to collect the full structure of the image. We are conducting a similar panorama by creating a photomosaic of calibrated photos from the camera.

Methods

To create the photomosaic, an iPhone 11 Pro camera was calibrated using pictures taken of a checkerboard pattern and the Camera Calibration Toolbox from Caltech. The checkerboard pattern was taped to a folder to take the pictures at various angles. Then pictures were taken of 2 different murals, one with 50% overlap and one with about 15% overlap. Another set of pictures were taken of a cinderblock wall. These images were stitched together to create the photomosaic.

Analysis

The calibration was conducted using the 7 photos shown below in figure 1. The inner set of grid corners were extracted in the calibration toolbox to determine pixel error. After calibration, pixel error was 1.04682 in x and 1.02612 in y. Pixel error magnitude was about 1.46 pixels.

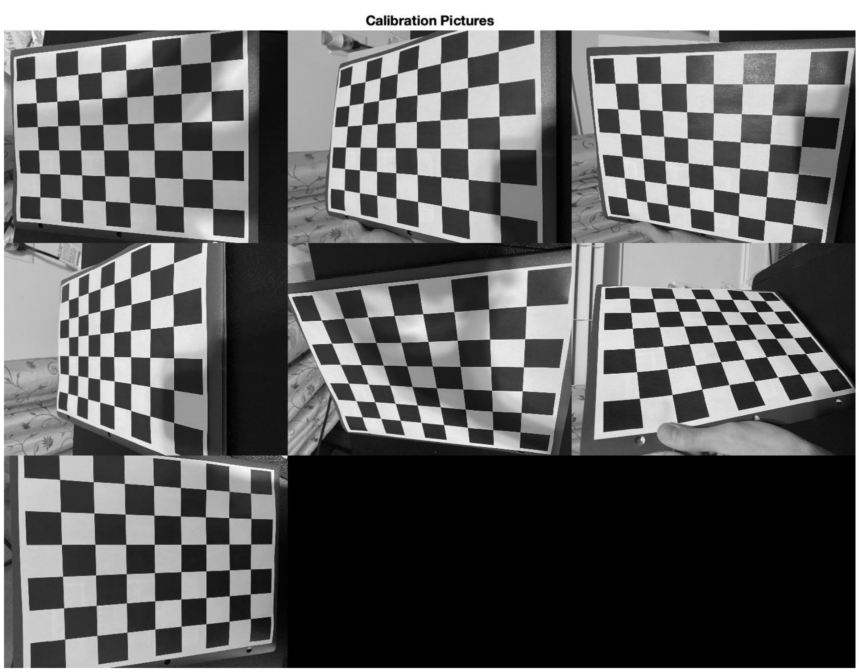


Figure 1: Pictures of the checkerboard used for calibration

The resultant reprojection pixel error is shown in figure 2. Further calibration parameters showed focal length was 763.89659 +/- 7.95738 in x and 761.93185 +/- 7.62933 in y, principal point was 515.54866 +/- 8.93749 in x and 369.59275 +/- 6.65725 in y, skew coefficient was 0, indicating the angle between x and y pixel axes was 90 degrees, and distortion was kc = [0.00680 -0.04253 -0.00094 0.00400 0.00000] +/- [0.03656 0.10155 0.00330 0.00410 0.00000].

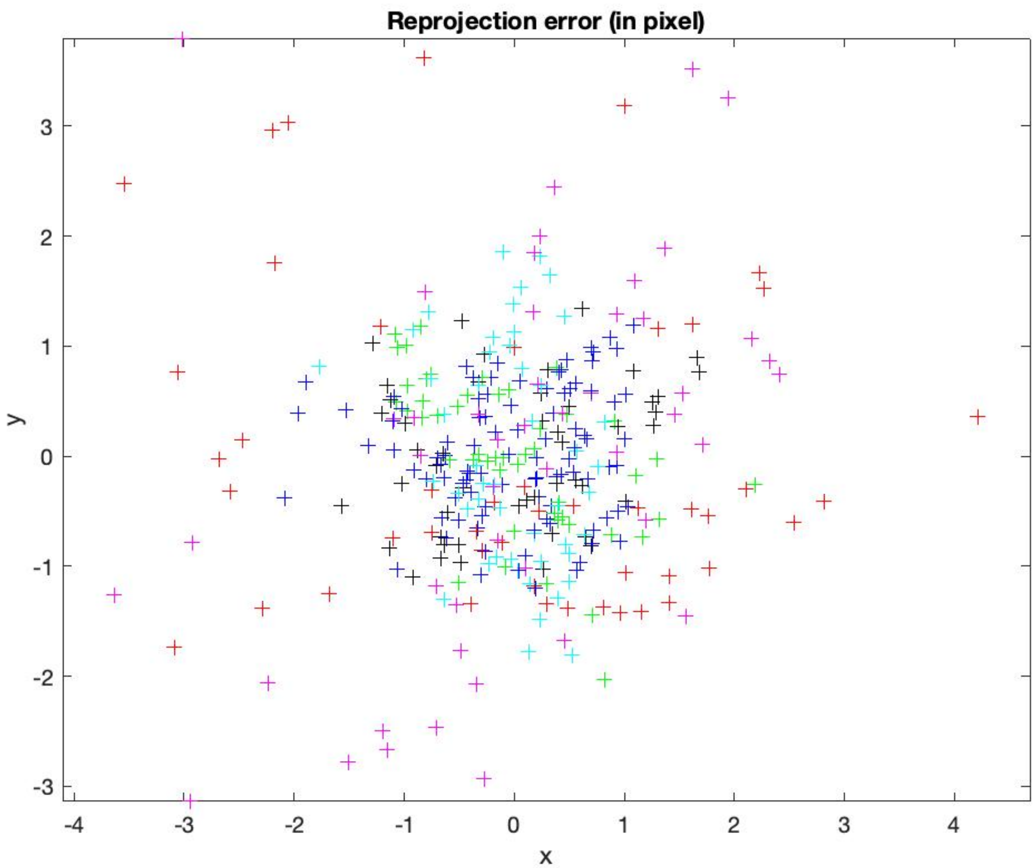
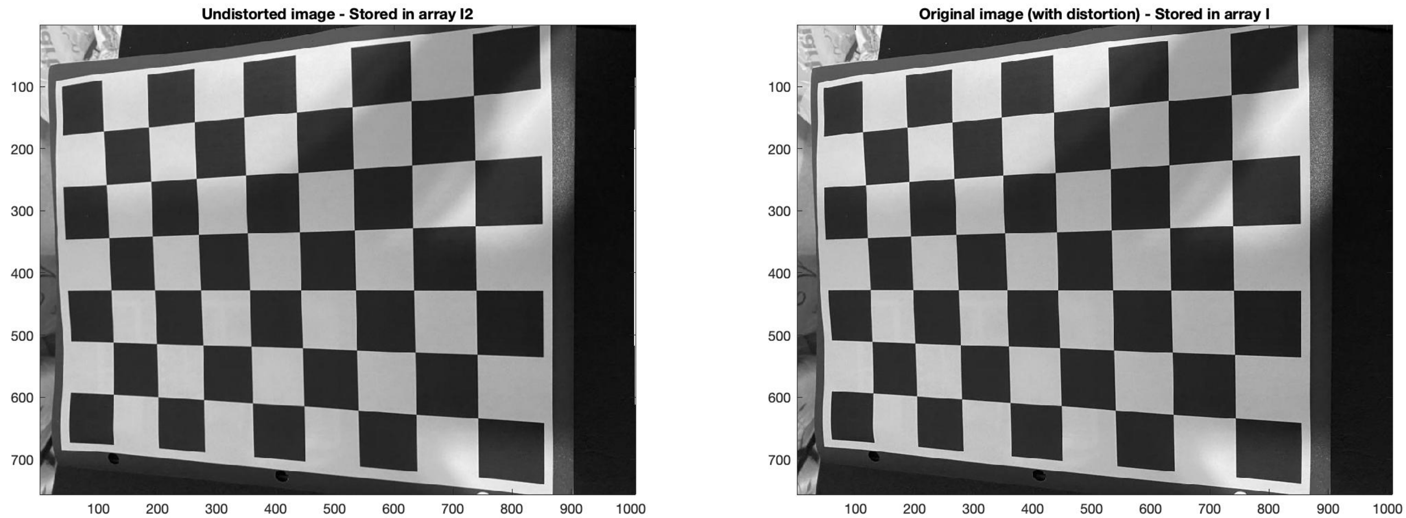


Figure 2: Reprojection Error from Calibration

Although pixel error was small, as in there was lower distortion, it seemed as if there was overcorrection due to the camera being already calibrated. This can be seen in figure 3 where figure 3a, the picture using calibrated parameters shows very little difference between the uncalibrated image. However, there appears to be some warping in the undistorted image, which leads to usage of the images straight from the camera for the panoramas.



(a) (b)

Figure 3: Undistorted vs distorted image

Figure 4 demonstrates a montage of the original images taken from one mural. These photos have at least 50% of overlap amongst one image and its subsequent image.

Figure 5: Montage of original images

To create a panorama of the images, the images were loaded into Matlab and registered successive image pairs by detecting match features using a Harris corner detector to find 2000 points of interest, estimating the affine transformation, and finding the transformation between each image and its previous image. As shown in figure 6, the Harris detector would find corners of interest keeping these as points of interest to match to the other images. The output limits were then computed for each transform and the x limits were averaged to find the center image. Then the center image's inverse was applied to all the other images. Then, a panorama was initialized and the images were mapped into the panorama and overlaid together.

Figure 6: Points of interest determined by Harris detector

As can be seen in figure 7, the panorama fits fairly well together with a few lines not matching up. As can be seen the line below the beard is disconnected and a few of the other lines on the left side of the panorama are disconnected. What could also be noticed is a color difference amongst the pictures. The 2nd image has a darker shade of color compared to the 3rd image. This could be attributed to a change of angles of the picture taken and the change in lighting, adjusting the colors of the pictures and changing how the photos would connect. It seems as if similar color scheme translates to better matched features and connection amongst the pictures as demonstrated on the right side of the of the panorama, where each line is well-connected.

Figure 7: Panorama of the mural with 50% overlap

The same photomosaic algorithm was tested on a brick wall with about 50% overlap. Since the cinderblock wall would have many similarities amongst each image, it would be difficult to tell how the wall should be pieced together since any one of the lines can be connected together.

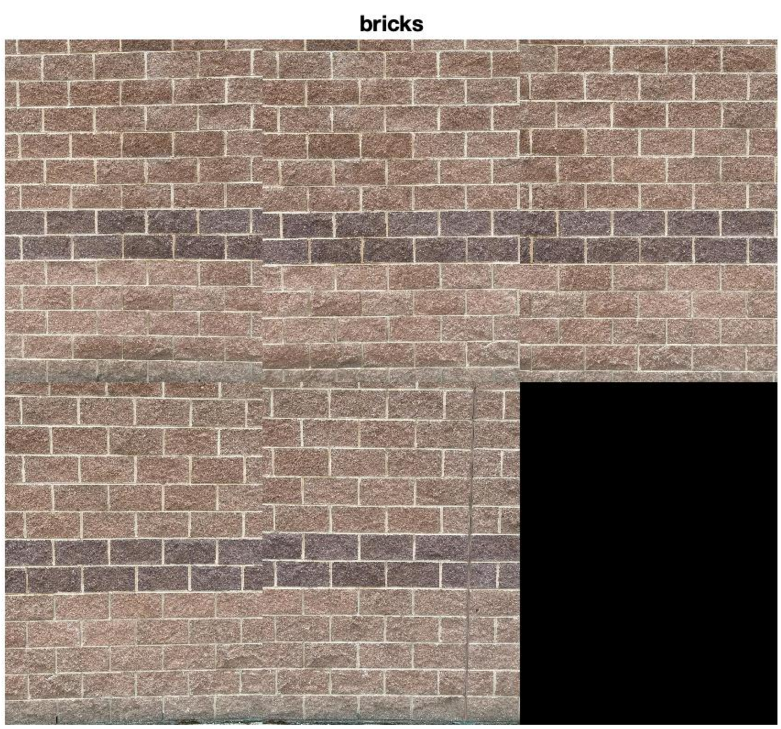


Figure 8: Images of cinderblock wall

However, as seen in figure 9, there was some success in constructing the panorama of the cinderblock wall. The reason is due to the dark 2 layers of cinderblock at towards the bottom of the wall. This area creates a targeted landmark where the points of interest can easily match together to create the panorama. In figure 10, the Harris detector concentrate a very large portion of the points on this darker lined area. Therefore, these features can be matched and stitched, giving a pretty successful panorama. Had this feature not existed, stitching the panorama might have been more difficult and less successful since all the features would have looked the same. This can be seen toward the bottom as there is some disconnect among the cinderblocks, showing difficult in stitching these repeated sequence of cinderblocks together.

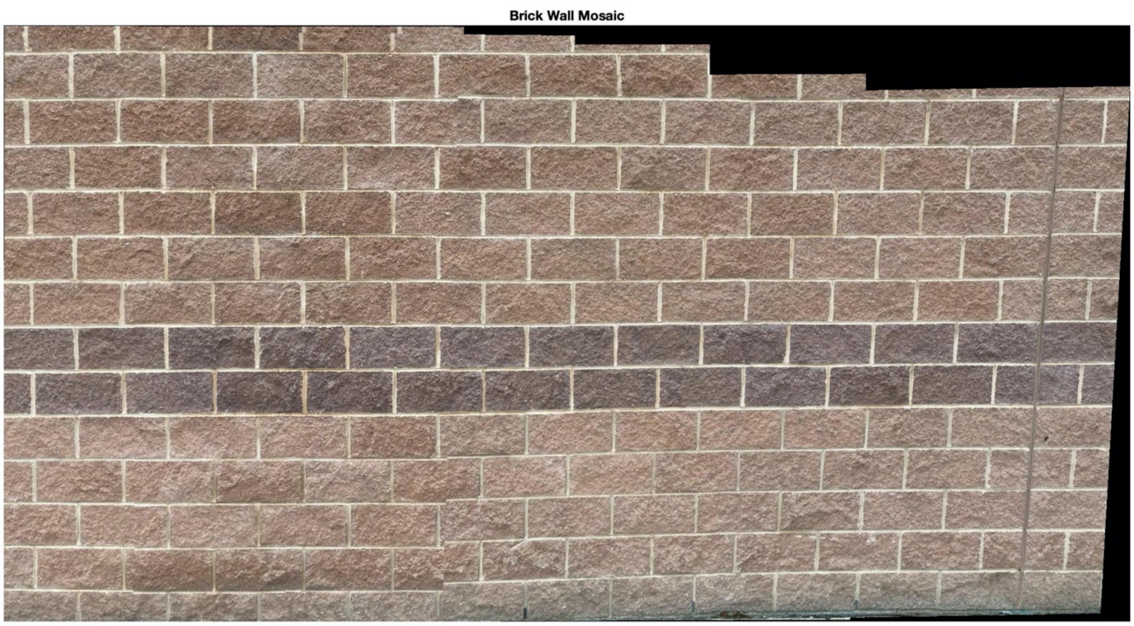


Figure 9: Panorama of cinderblock wall

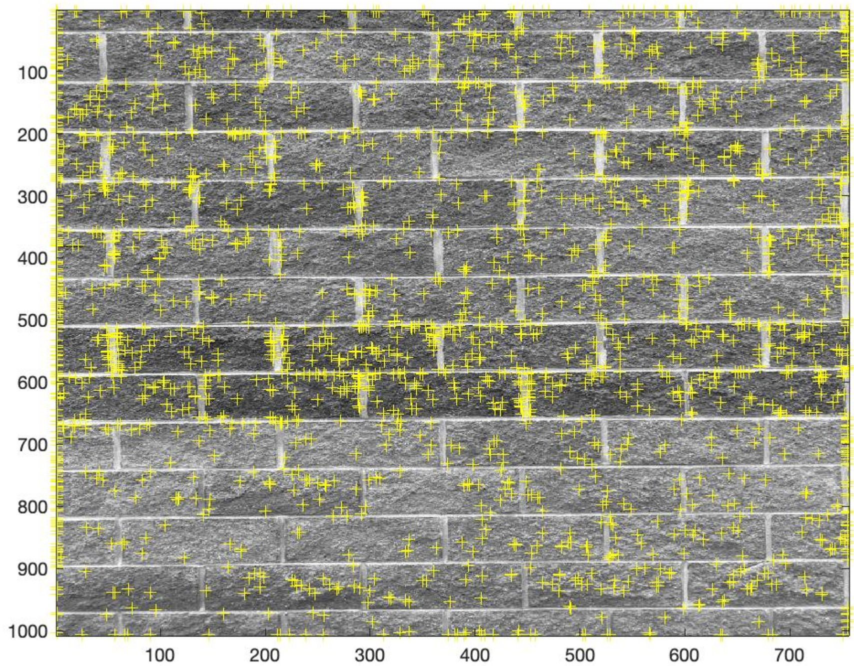


Figure 10: Brick wall intermediate photo

Furthermore, the algorithm was tested on a set of images of a mural with about 15% of overlap as shown in figure 11.

Figure 11: Montage of mural images with 15% overlap

Although, there is much less overlap amongst the images in figure 11 as compared to the images in figure 5, there are still a great portion of shared corners detected by the Harris corner detector as seen in figure 12. Especially, seen in the end of the lacrosse stick and the eye of the skull, there are plenty of features to match between the 2 images.

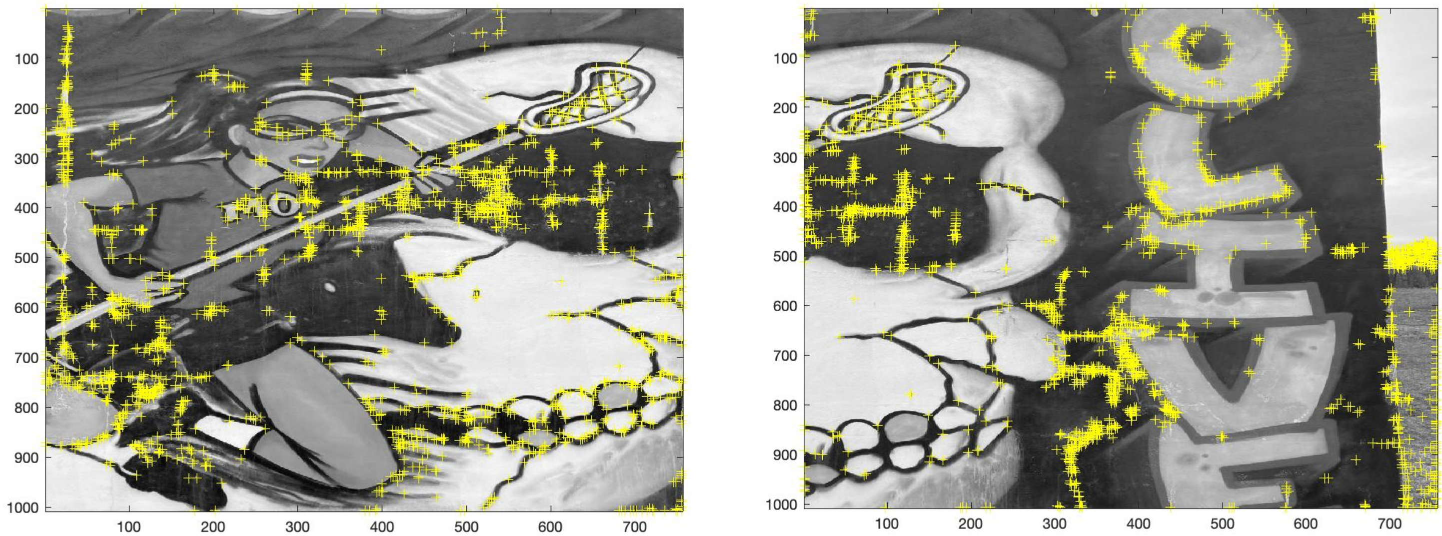


Figure 12: Intermediate images of Harris detector for 15% overlap image

Therefore, the resultant panorama would appear as figure 13 and look successful in the stitching. As compared to the panorama created with 50% overlap, figure 13 looks arguably more successful. This can also be discussed looking at the color scheme again. The colors across the images are consistent and there is not much variation among them. Therefore, it seems easier to match this set of images than the images of figure 5.

Figure 13: Mosaic of images with 15% overlap