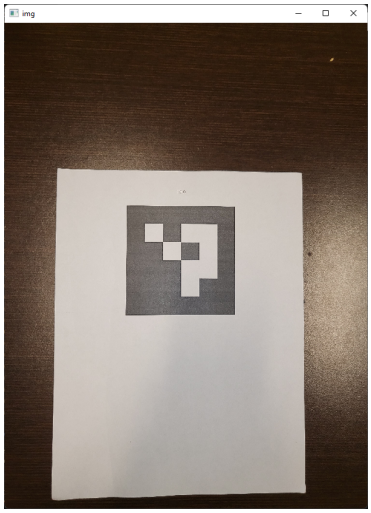
Due to the high degree of variation within my dataset, my preprocessing pipeline is the result of many different attempts and strategies to eliminate environmental conditions and normalize the resulting image.

I also attempted to use CLAHE for value normalization to overcome shadows, but it ended up just increasing the noise level and making edge separation more difficult. I think this is because the contrast from shadow to light was not significantly different from the dark and light tiles on the markers.

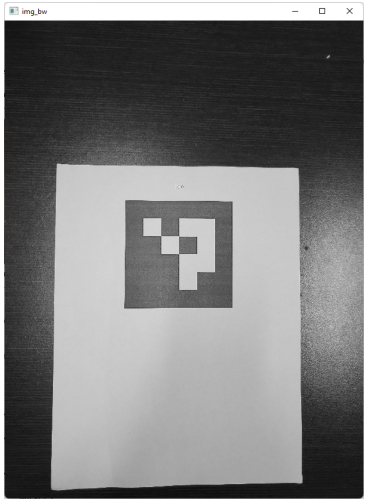
(Sorry for the long page count, I couldn't get the images to stack horizontally).

Here is an outline of the current pipeline:

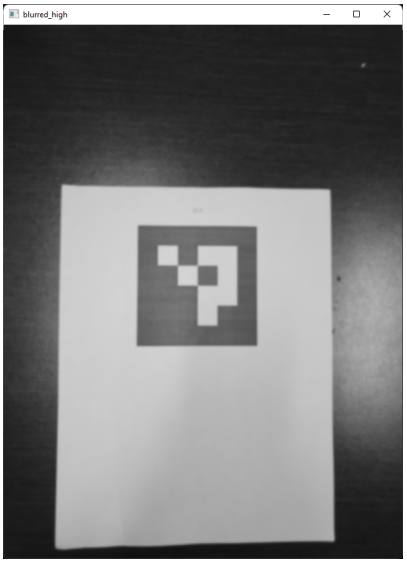
1. Original image read in from dataset



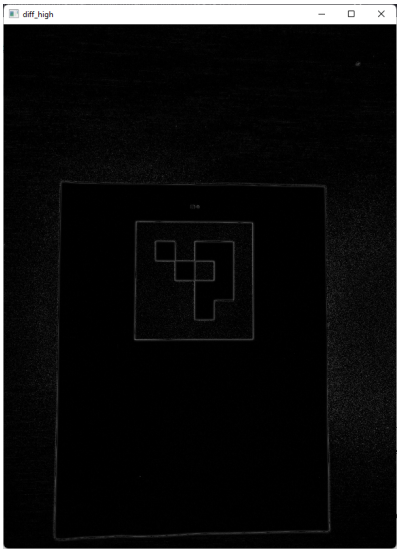
2. Convert to grayscale



3. “High pass” edge detection
    a. Gaussian blur with a large kernel applied to image

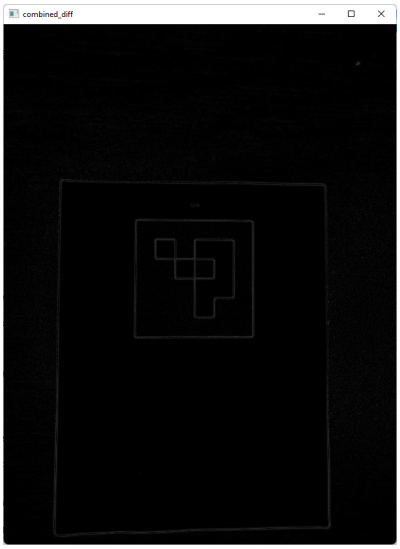


    b. This blur is subtracted from the original image

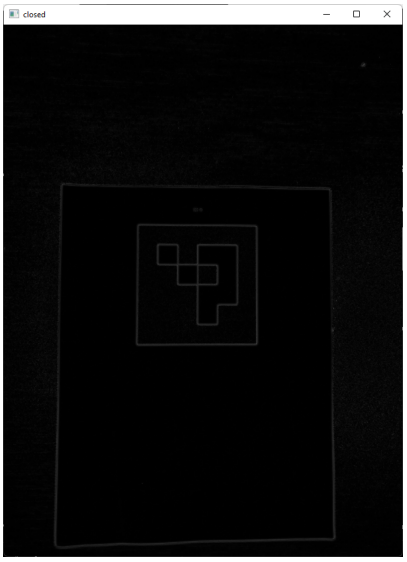


4. “Low pass” edge detection
    a. Gaussian blur with a small kernel applied to image
    b. This blur is subtracted from the original image
5. Combined edge detection
    a. High and low pass results are subtracted resulting in an image depicting the edges of the source image

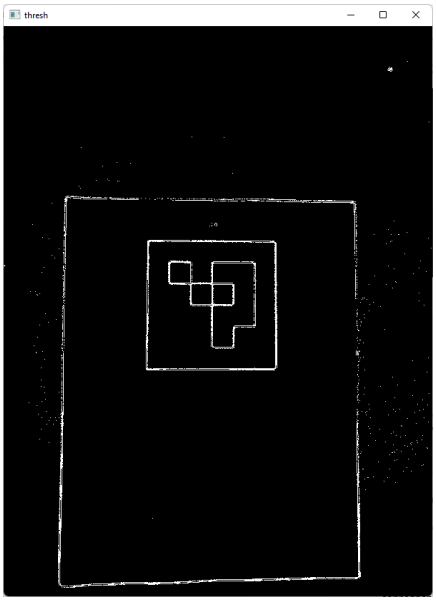
b. Combining the high and low passes removes more softer edges from lighting or shadows and noise



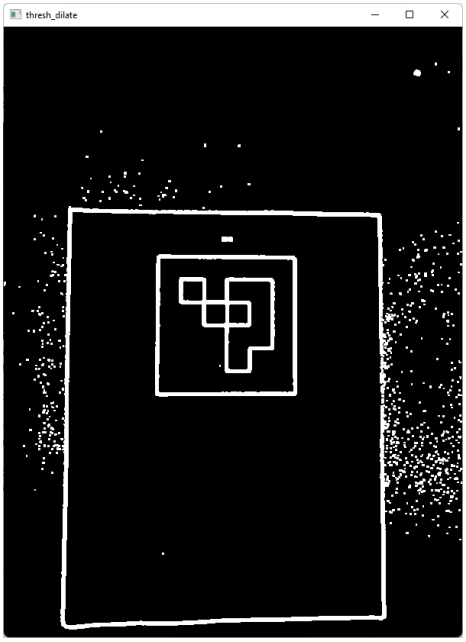
6. Morphological operations
    a. Closure to fill gap between inner and outer border of the edges



7. Thresholding
    a. Simple binary threshold applied to remove as much noise and well defined edges as possible

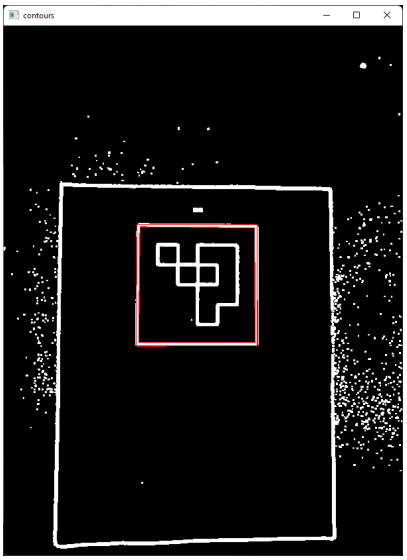


8. Morphological operations
    a. Closure applied again to connect less well defined edges of the markers
    b. Dilation applied to increase the width of edges for easier contour detection

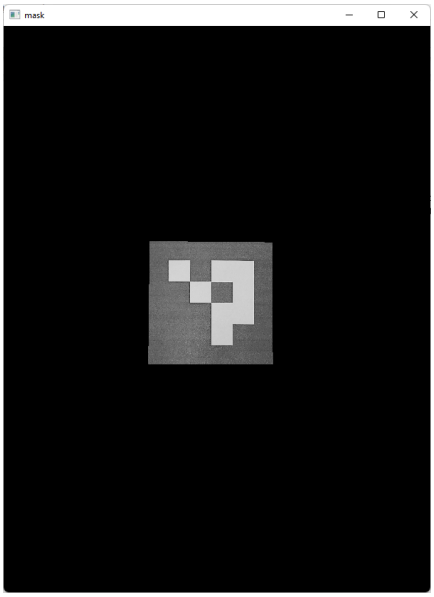


9. Contour detection and processing
    a. Contours with an area above a threshold are considered as potential markers

b. Polygon approximation is then run to select four sided polygons corresponding to square markers
c. Overly long / rectangular polygons are filtered out by a ratio from the mean side length



10. Subject masking
    a. At this point, the contour of potential matches is converted to a mask to isolate the area of the original image
11. Histogram filtering
    a. Each masked section has its value histogram calculated to look for the presence of two distinct peaks, indicating a two tone pattern corresponding to the markers black and white tiles
    b. Potential markers without two distinct colors are eliminate
    c. Value peaks are computed into weighted averages to determine the high and low value of tiles for later analysis



Examples of valid detection regardless of obscuring shadows and perspective