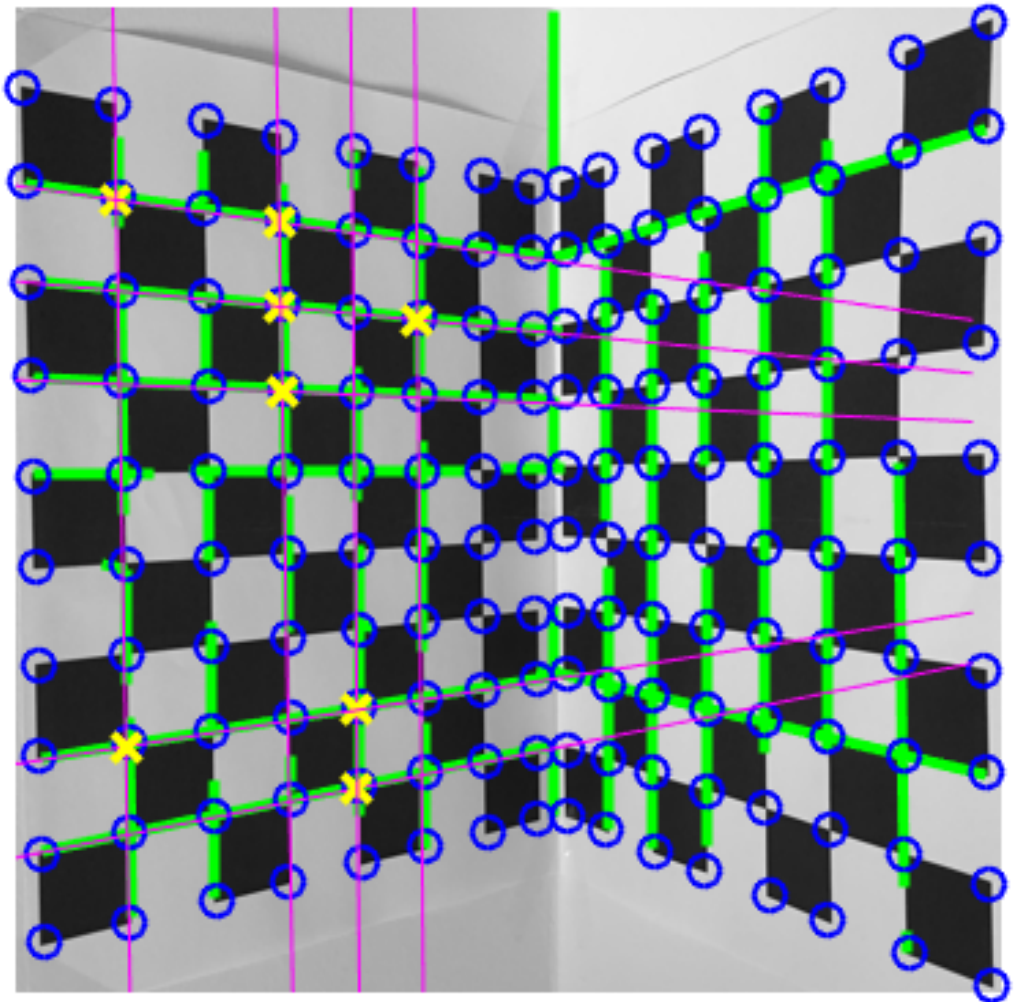
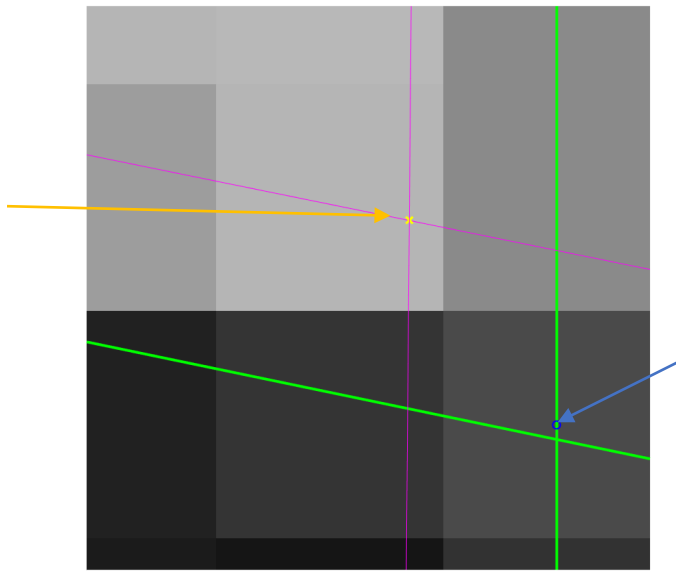
Aynur Süne - 21041

EE417 Post-Lab #5



In the resulting image shown above, blue circles are corners detected using Harris Corner Operation and green lines are detected lines using Hough Lines. For the sake of simplicity, edges and corners found are plotted on the same output image. Several edges are found manually as in the lab and plotted as magenta lines, later on crossing points are calculated and plotted as yellow *x.* Blue Harris corners and yellow crossing points seem to overlap but when zooming in, it can be observed that they are detected on different coordinates. Distance between Harris corner and crossing points are also calculated.

First, image is converted to gray-scale and resized because true resolution of the image was too big for MATLAB to work properly. Later on, Hough Lines algorithm is applied to draw green lines in the image above, by first extracting edges with Canny and finding Hough Peaks from the matrix created from *hough* function. Hough lines are found and put in a struct called *lines* in the same way as the previous lab. Edges we would like to find the crossing point are selected manually from this struct that contains starting and ending points, rho and theta values of the lines. Later, Harris Corner is applied. Then, 8 crossing points and lines of these crossing points are plotted using sinusoid equation that will be discussed below.



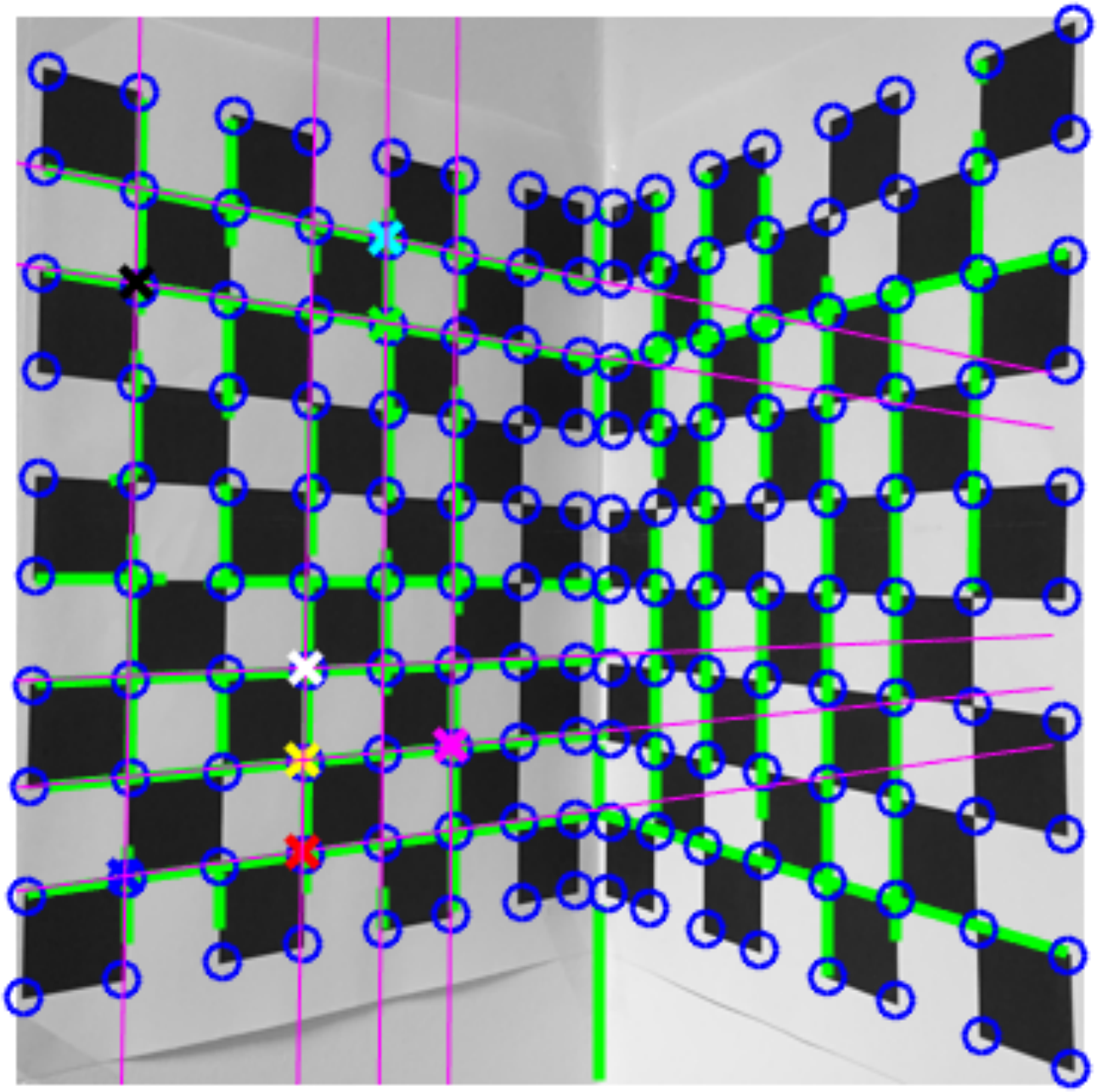
To be able to detect every kind of line, sinusoid equation is used for detecting green lines. Formula is as follows:

$$x\ cos(\theta) + y\ sin(\theta) = \rho$$

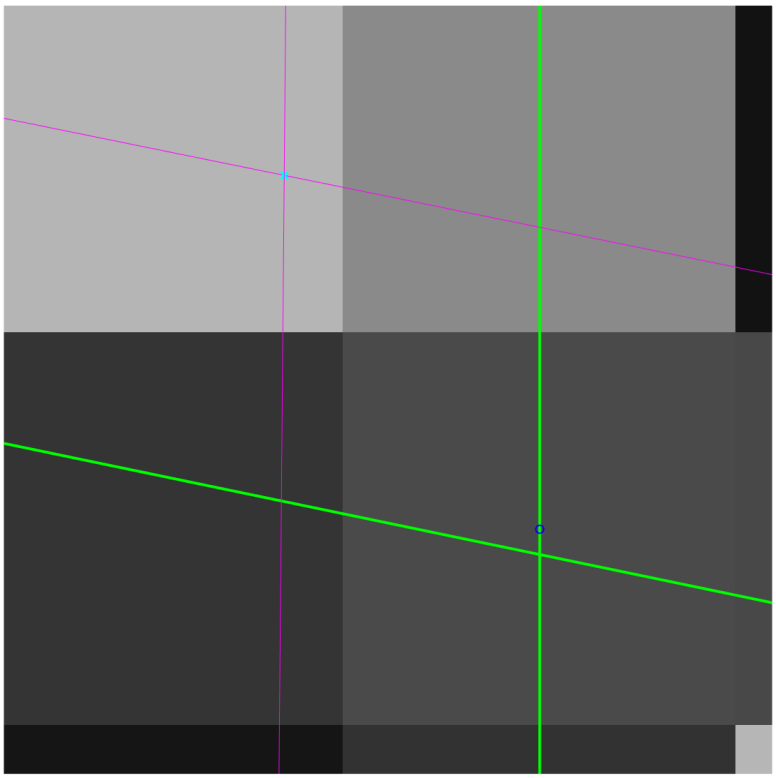
First, two green line which have an intersecting point with each other are chosen manually from output image. Rho and Theta values of these lines are already known from Hough line detection part. First, we redraw the lines we choose among green ones in magenta color but this time using the equation above. Rho and Theta values cause small deviations from actual green line as can be observed from above image. We can find x and y coordinates of the crossing point by solving this equation for both magenta lines' rho and theta values to get unique x and y values that provides both equations. We can write these equations in matrix form as below:

$$\begin{bmatrix}\rho 1\\ \rho 2\end{bmatrix} = \begin{bmatrix}cos\theta 1 & sin\theta 1\\ cos\theta 2 & sin\theta 2\end{bmatrix}\begin{bmatrix}x\\ y\end{bmatrix}$$

where $\rho 1$ and $\theta 1$ are rho and theta parameters of first magenta line, and $\rho 2$ and $\theta 2$ are rho and theta parameters of the second magenta line that we would like to find the intersecting point (x,y). We can leave $\begin{bmatrix}x\\ y\end{bmatrix}$ alone by multiplying rho values $\begin{bmatrix}\rho 1\\ \rho 2\end{bmatrix}$ by the inverse of $\begin{bmatrix}cos\theta 1 & sin\theta 1\\ cos\theta 2 & sin\theta 2\end{bmatrix}$. Rho and Theta values that are already known are plugged into the equation matrix and proper x and y coordinates are found that indicates crossing point of two lines we have chosen.



First Point (colour cyan)



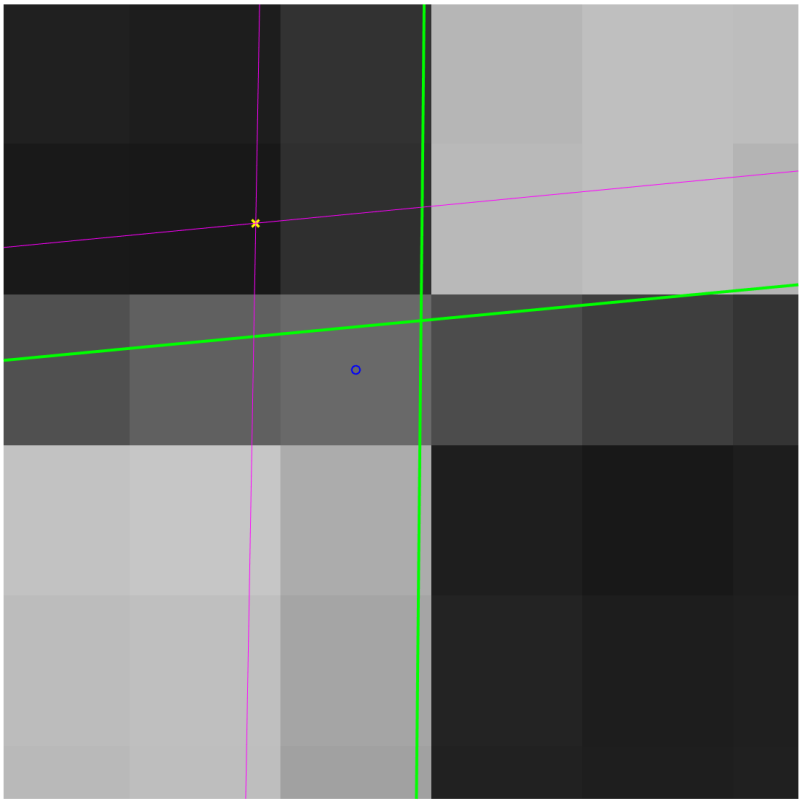
Line 1:
point1: [126 65]
point2: [126 164]
theta: 0.5000
rho: 126

Line 2:
point1: [10 52]
point2: [198 91]
theta: -78.5000
rho: -48.6000

Harris Corner: 126,76

Distance between Harris Corner:
1.1119

Second Point (colour yellow)



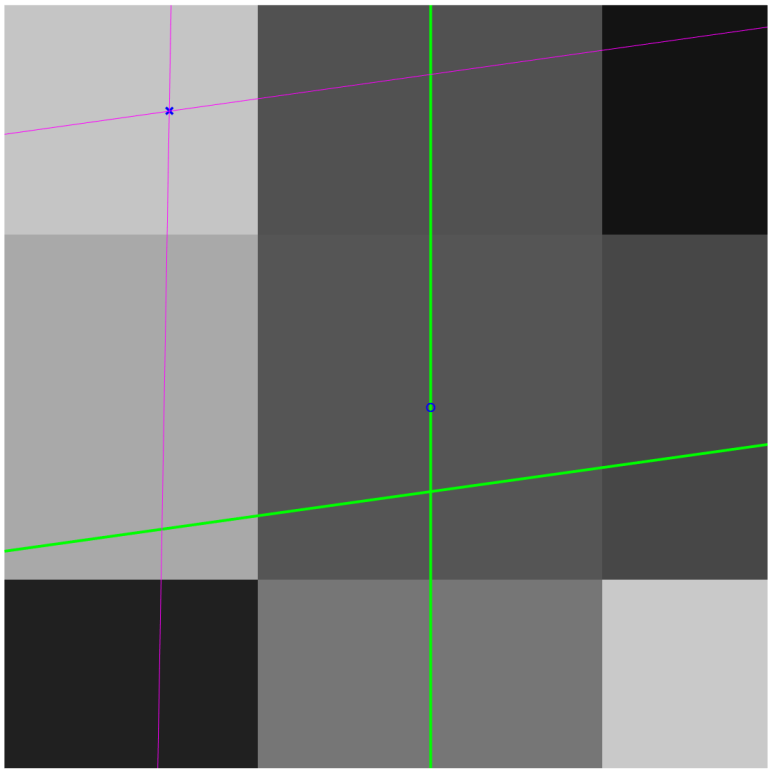
Line 1:
point1: [11 260]
point2: [200 242]
theta: 84.5000
rho: 259.2000

Line 2:
point1: [99 193]
point2: [98 296]
theta: 1
rho: 101.7000

Harris Corner: 98,252

Distance between Harris Corner:
1.1795

Third Point (colour blue)



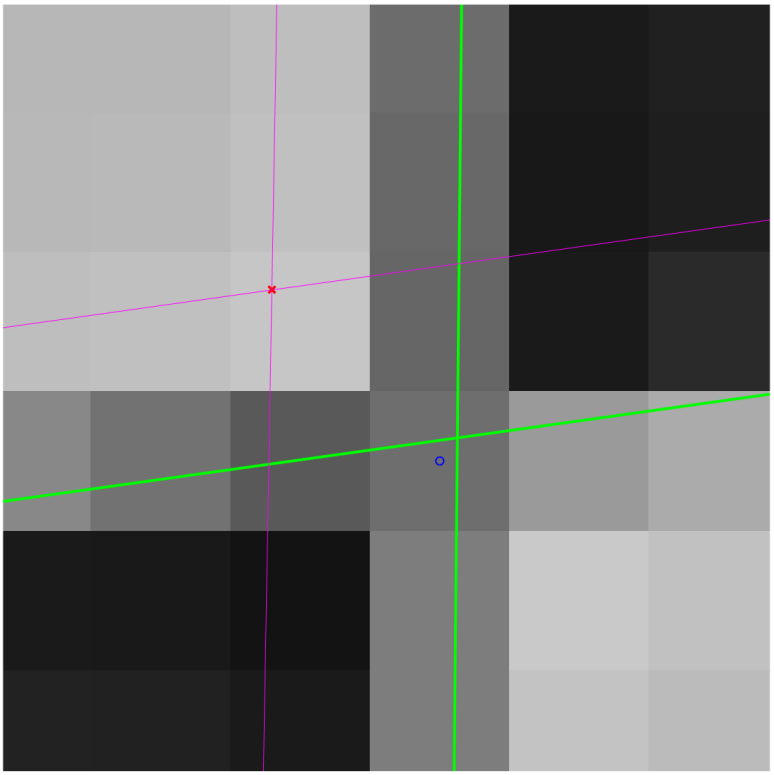
Line 1:
point1: [4 296]
point2: [197 269]
theta: 82
rho: 292.5000

Line 2:
point1: [38 280]
point2: [38 313]
theta: 1
rho: 42.3000

Harris Corner: 38,291

Distance between Harris Corner:
1.1460

Fourth Point (colour red)



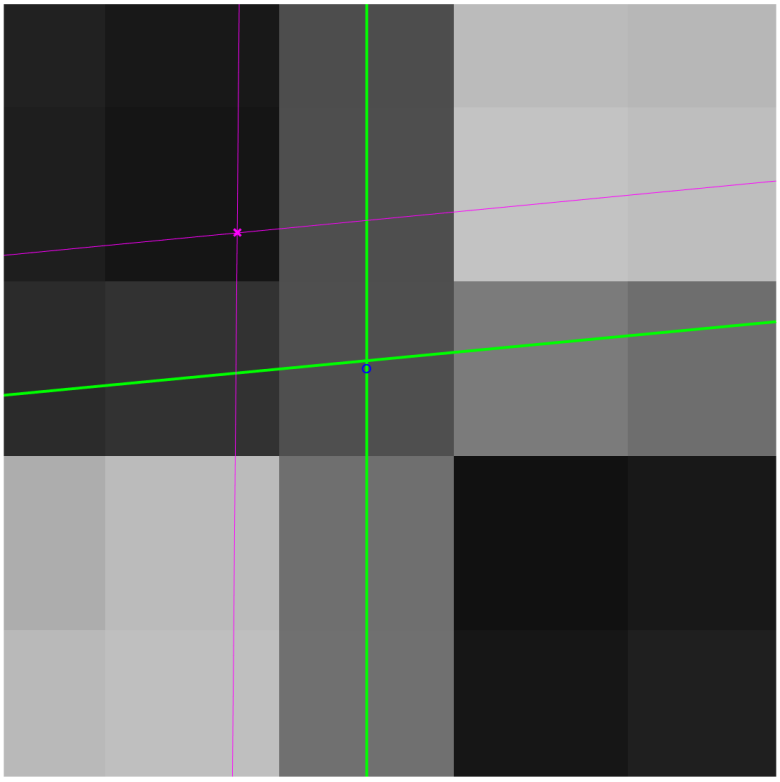
Line 1:
point1: [4 296]
point2: [197 269]
theta: 82
rho: 292.5000

Line 2:
point1: [99 193]
point2: [98 296]
theta: 1
rho: 101.7000

Harris Corner: 98,283

Distance between Harris Corner:
1.7199

Fifth Point (colour magenta)



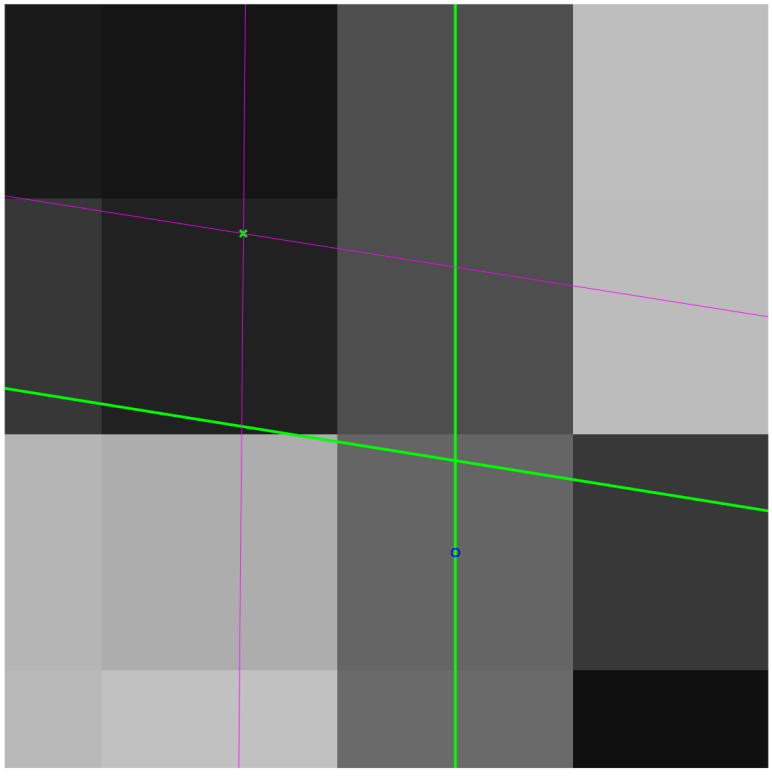
Line 1:
point1: [148 226]
point2: [148 302]
theta: 0.5000
rho: 149.4000

Line 2:
point1: [11 260]
point2: [200 242]
theta: 84.5000
rho: 259.2000

Harris Corner: 148,247

Distance between Harris Corner:
1.0776

Sixth Point (colour green)



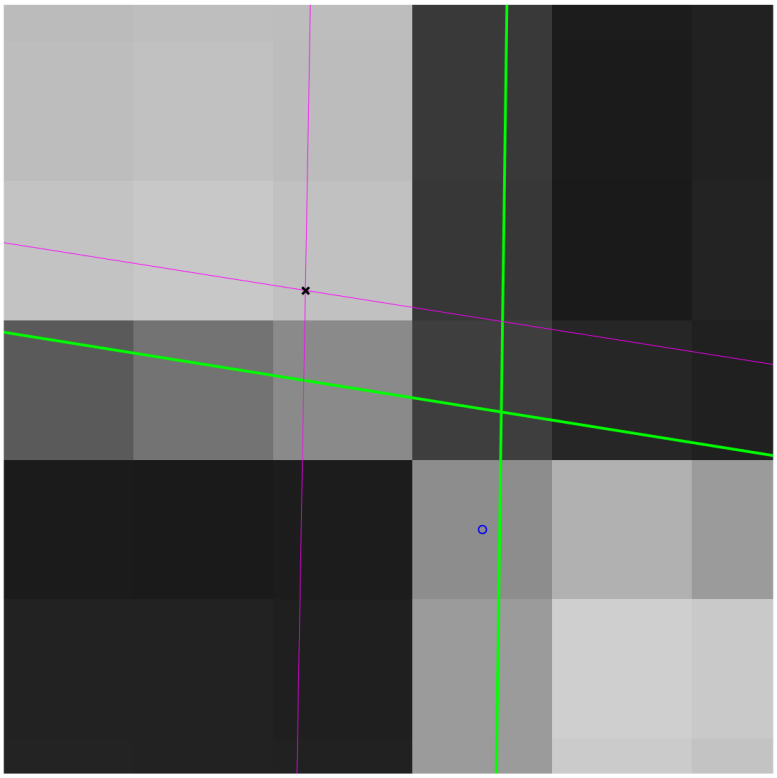
Line 1:
point1: [126 65]
point2: [126 164]
theta: 0.5000
rho: 126

Line 2:
point1: [10 86]
point2: [197 116]
theta: -81
rho: -82.8000

Harris Corner: 126,105

Distance between Harris Corner:
1.6256

Seventh Point (colour black)



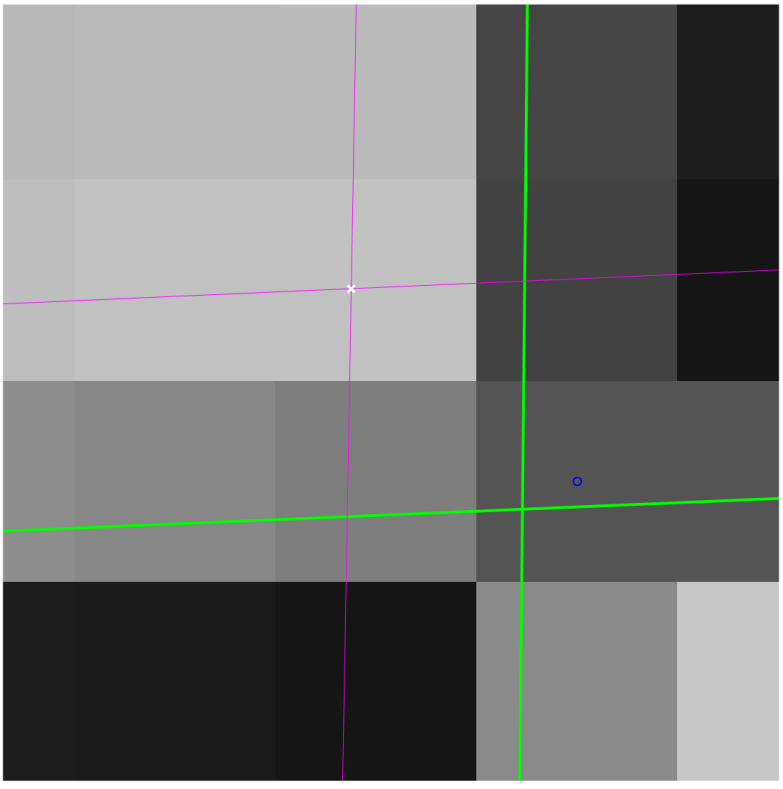
Line1:
point1: [10 86]
point2: [197 116]
theta: -81
rho: -82.8000

Line 2:
point1: [40 175]
point2: [39 259]
theta: 1
rho: 42.3000

Harris Corner: 42,92

Distance between Harris Corner:
2.1352

Eighth Point (colour white)



Line1:
point1: [7 225]
point2: [197 217]
theta: 87.5000
rho: 224.1000

Line2:
point1: [99 193]
point2: [98 296]
theta: 1
rho: 101.7000

Harris Corner: 99,221

Distance between Harris Corner:
1.4790

Harris Corner are at the center of the pixel and Hough lines are more accurate about pixel locations so there is a difference observed between corner locations of the two methods. Also angle of the line affects the line accuracy mentioned earlier, magenta and green lines are not the same even though they meant to be. When line accuracy change, intersection point accuracy also changes in a negative way. The distance between these methods are very small so one is not significantly better than other. But there are different methods we have not mentioned that could be used for camera calibration and gives better results, but these topics are out of scope.