

## Corner Detection - Solution

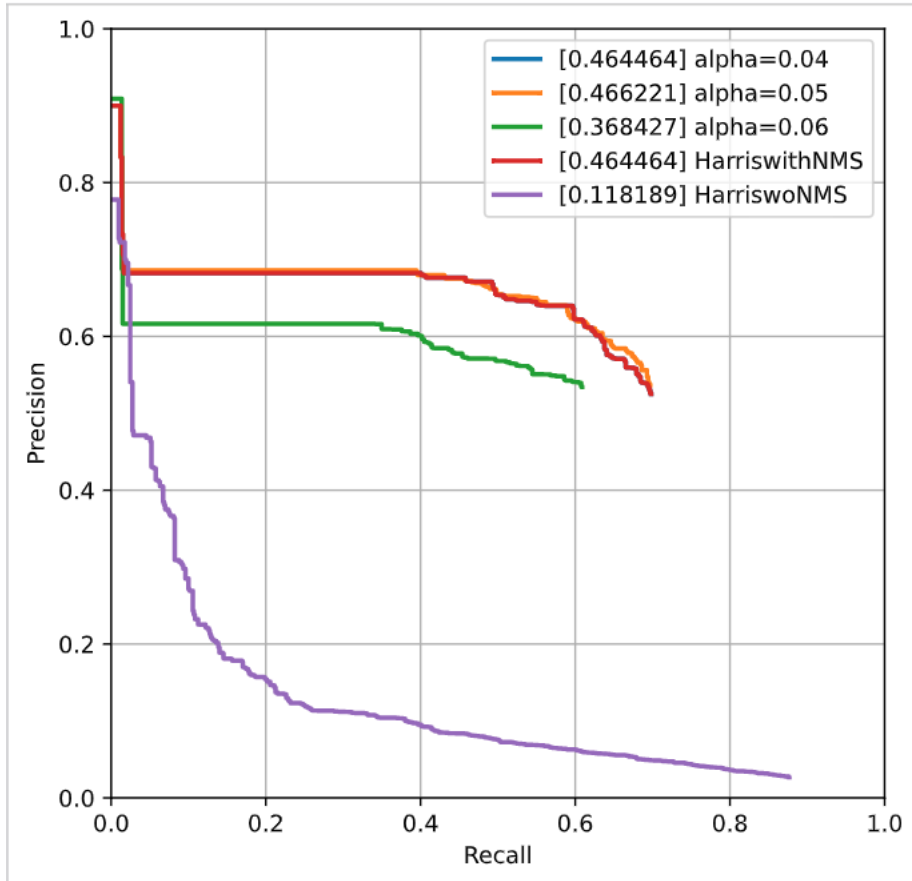
### Method Description:

In my implementation of the Harris Corner Detection, I first calculated the image gradients (or partial gradients of each pixel) with the first-order derivative filters. Then I calculated the moment matrix (or structural tensor) with the calculated image gradients.

$$M = \begin{bmatrix} \sum_{x,y} w(x,y) I_x^2 & \sum_{x,y} w(x,y) I_x I_y \\ \sum_{x,y} w(x,y) I_x I_y & \sum_{x,y} w(x,y) I_y^2 \end{bmatrix}$$

Based on the moment matrix, I was able to calculate the response with  $\det(M) - k * (\text{trace}(M))^2$ . For each pixel are thresholded to find the locations of potential corners. However, this can lead to multiple detections of the same corner due to noise or overlapping regions. So I applied a NMS to the response to sidestep that problem. To reach the maximum performance, I adjusted parameter multiple times, I tried window size from 3-6, and alpha from 0.04-0.06, eventually found that when  $\alpha = 0.05$ , window size =  $3*3$ . The AP reaches the highest.

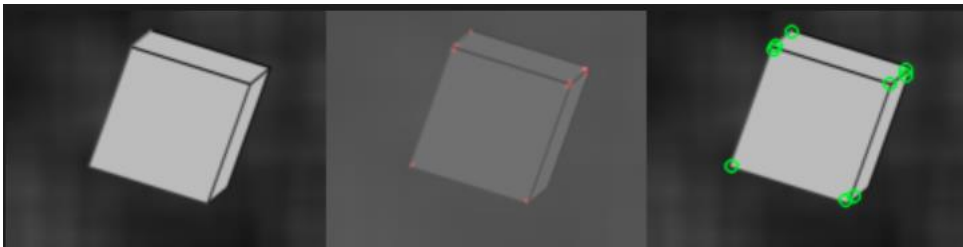
### Precision Recall Plot:



**Results Table:**

Method	Average Precision	Runtime
Random	0.002	0.001
Harris w/o NMS	<b>0.118</b>	<b>0.001</b>
Harris w/ NMS	<b>0.466</b>	<b>0.07</b>
Alpha=0.04	<b>0.457</b>	<b>0.06</b>
Alpha=0.05	<b>0.467</b>	<b>0.06</b>
Val set of numbers of the bestmodel(From Gradescope)	<b>0.466</b>	<b>0.06</b>

**Visualizations:**





The implementation of the corner detection reached in general satisfying results. In relatively simple images, it is able to detect all of the corners. However, in complex scenes, my algorithm mis-labeled some of the corners. For example, as we can see in the front of the ECE Building, my implementation mislabeled the cross of the sidebar of the windows as corner, which is understandable. There indeed exists rapid intensity change at those points. I also missed some of the corners, for example, the top of the Beck man institute was mislabeled. The eventual results lies between 0.464 to 0.467. Also, even though I applied NMS, in the first image we can still notice multiple corners were marked at the corners of the cube.