Corner Detection - Solution Template

NOTE: All values and figures in this template are examples that you will need to replace with your own results

1. **Method Description.** : Describe the different methods and their key implementation detials.

   The first step is to Calculating image gradients in x and y direction by the

   ```
   dx = signal.convolve2d(image_gray, np.array([[-1, 0, 1]]),
   mode='same', boundary='symm')
   dy = signal.convolve2d(image_gray, np.array([[-1, 0, 1]]).T,
   mode='same', boundary='symm')
   ```

   Then, we can use the scipy.ndimage.gaussian_filter() function to get the dxx, dxy, dyy. Then, by the math, by can calculate the cornerness score value of each point by

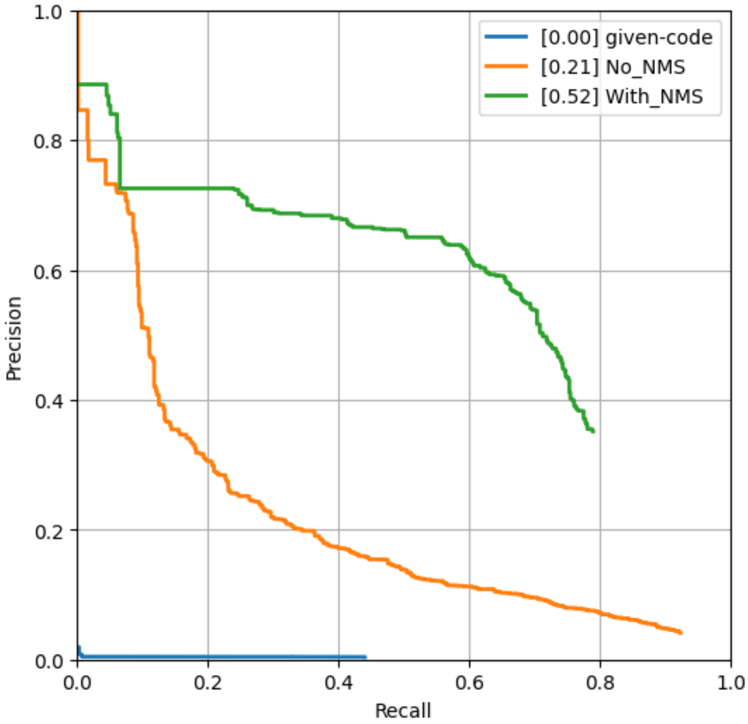
   ```
   detM = dxx * dyy - dxy**2
   traceM = (dxx+dyy)**2
   response = detM - alpha * traceM
   ```

   The alpha is between 0.04 to 0.06.

   For the Non maximum suppression. The method I use is to compare cornerness score value with the cloeset 8 pixels. If its cornerness score value is smaller than the neighbor, it will be reset to 0. Otherwise, we keep it.

   And we always nomalize our results to 0 to 255 at the end.

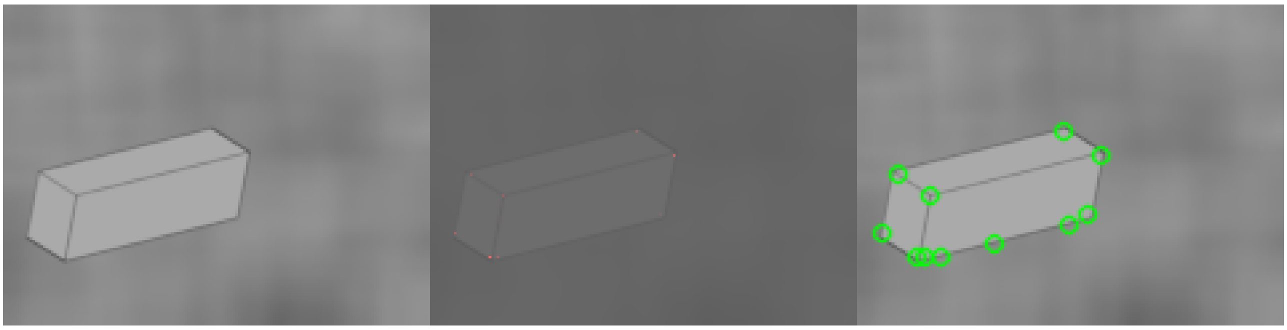
2. **Precision Recall Plot.** : Use corner_plot.py to add curves for the different methods that you implemented into a single plot.

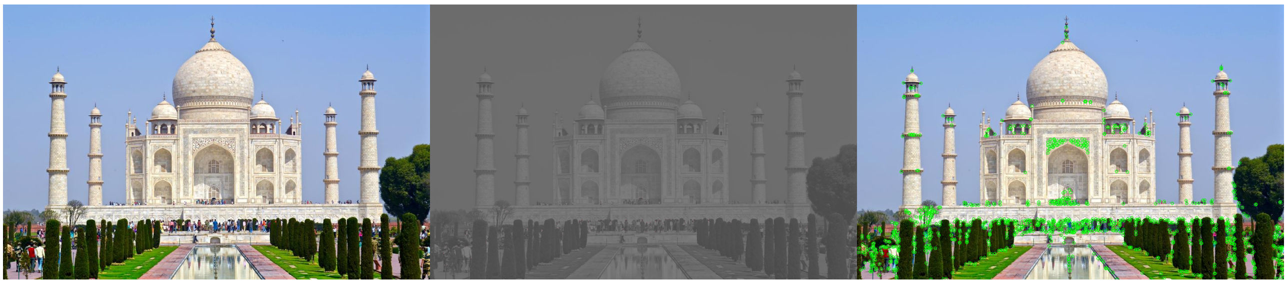


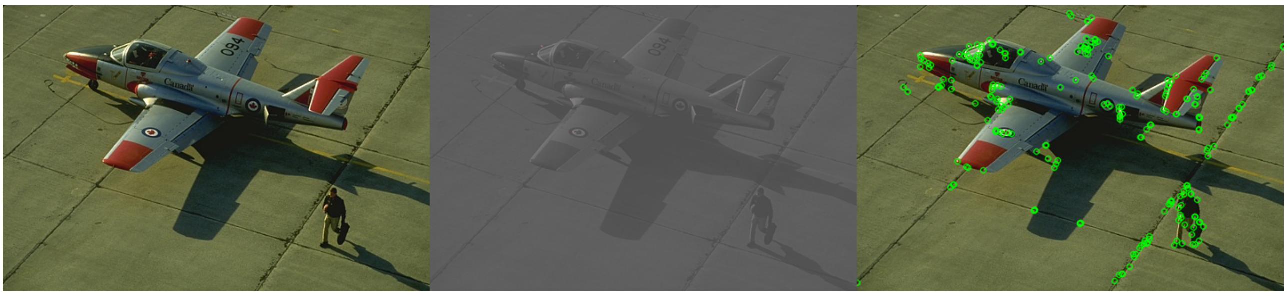
3. **Results Table.** : Present the performance metrics for each implementation part in a table format

Method	Average Precision	Runtime
Random	0.001	0.001
Harris w/o NMS	0.210335	0.003740
Harris w/ NMS	0.522736	0.508317
Hyper-parameters tried (1) [alpha = 0.05;np.array([[-1, 0, 1]];sigma = 0; window = 2]	0.437521	0.185428
Hyper-parameters tried (2) [alpha = 0.05;np.array([[-1, 0, 1]];sigma = 1; window = 1]	0.445783	0.188328
Test set numbers of best model [alpha = 0.05;np.array([[-1, 0, 1]];sigma = 1; window = 2]	0.522736	0.508317

4. **Visualizations.** Include visualization on 3 images. Comment on your observations, where does your corner detector work well, where it doesn't and why? We aslo provided some images in data/vis for testing, but you are free to use your own images as well.







5. **Bells and Whistles.** : Include details of the bells and whistles that you tried here.

   Present the performance metrics for the bells and whistles in a table format

Method	Average Precision	Runtime
Best base Implementation (from above)		
Bells and whistle (1) compare with more than 8 pixels. Instead of finding the eight neibors around the pixel for NMS, we can calculate the pixels within a range and find the pixles within the radius. Although it turns out that the radius of 1 is the best results, which is similar to compare with the 8 closest pixels.	0.522736	0.508317
Bells and whistle (2) We can adjust the window sigma and the filter we use. I tried several versions and find that [alpha = 0.05;np.array([[-1, 0, 1]];sigma = 1; window = 2] can improve the AP score	522736	508317
Bells and whistle (n) [extra credit])		