All lab assignments must be done individually. You should submit your codes to SUCourse during the lab hours (In-Lab Code Submission) and you should submit your lab-reports within one week after the lab (Post-Lab Report).
Grading : In-lab Codes has a weight of 20% and Post-lab Reports has a weight of 80%. Your programs should be modular, bug-free, commented in MATLAB, self- explanatory. Also, your report should include necessary comments and discussions. Please note that if you miss the lab, you will get automatically zero (even if you submit post-lab report)

In this lab, you will detect corners using Tomasi Kanade cornerness measure and detect lines and circles by using MATLAB's built-in Hough transform functions.

Important Note: You should complete the lab until the end of the lab hours and submit all your codes to SUCourse as a single zip file. Deadline for submission to SUCourse is **until the end of the lab,which is 18:30**.

Things to do:

Write one program to detect corners using Tomasi Kanade cornerness measure, and two programs ("lab4houghlines.m" and "lab4houghcircles.m") to detect lines and circles by using MATLAB's **built-in functions for Hough transform with different parameters**. Use "tic-toc" commands to evaluate the execution time performances for each of Hough transform method..

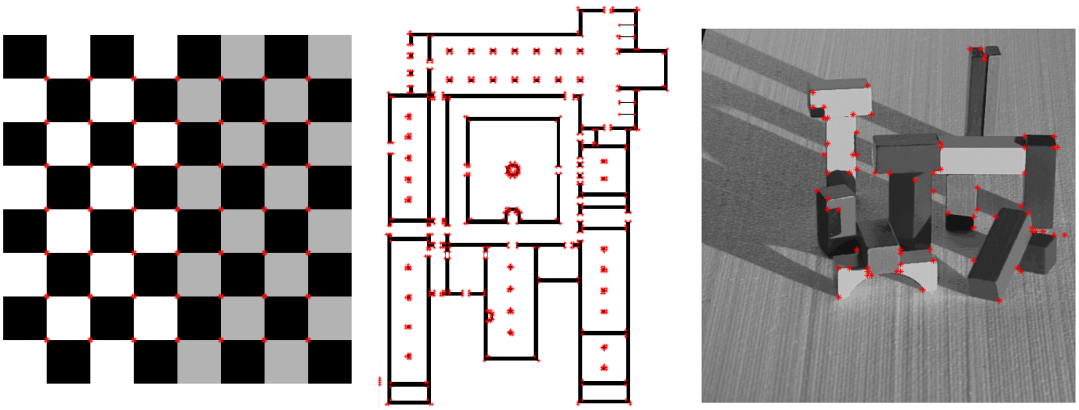
- **Corner Detection:** In order to detect the corners in a grayscale image by employing Kanade-Tomasi algorithm, you can apply the following steps:
  - Create a checkerboard image by calling the built-in command `checkboard` in MATLAB
  - Compute the gradients G_x and G_y of the image (Hint: You can use `[Gx,Gy] = imgradientxy(I);`)
  - Create H matrix of each pixel in a window as follows

$$H = \begin{bmatrix} \sum I_x^2 & \sum I_x I_y \\ \sum I_x I_y & \sum I_y^2 \end{bmatrix} \tag{1}$$

    where I_x and I_y are the image gradients of a window along x and y directions, respectively.
  - Compute the eigenvalues λ_1 and λ_2 of H.(Hint: You can use `eig command in MATLAB`)
  - If $\min(\lambda_1, \lambda_2)$ >Threshold, add the pixel coordinates to corner list.

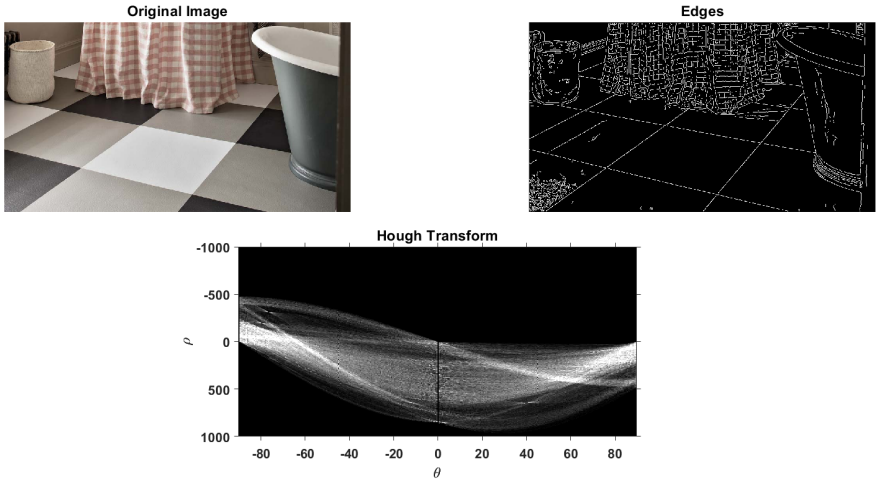
Now write a function which takes an image and a threshold as inputs and utilize "**Kanade-Tomasi Corner Detection Algorithm**" to return the detected corner points. Your function name should be "lab4ktcorners.m".

Detect the corners in other two images provided and your results should look as :

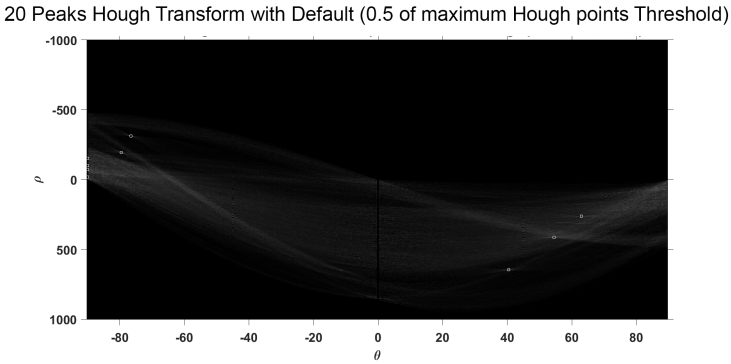


Line Detection

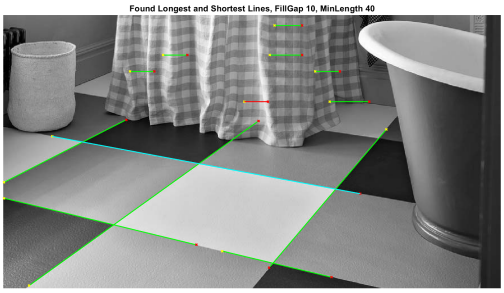
- Read an image named `checker.jpg` and convert it to a black-white edge image with your edge detector choice.
- Obtain the Hough transform of the black-white image and display it along ρ vs θ axes. *Hint*: use `'hough'` function



- Select the peak Hough points with an appropriate threshold (e.g., half of the maximum Hough points). *Hint*: use `'houghpeaks'` function



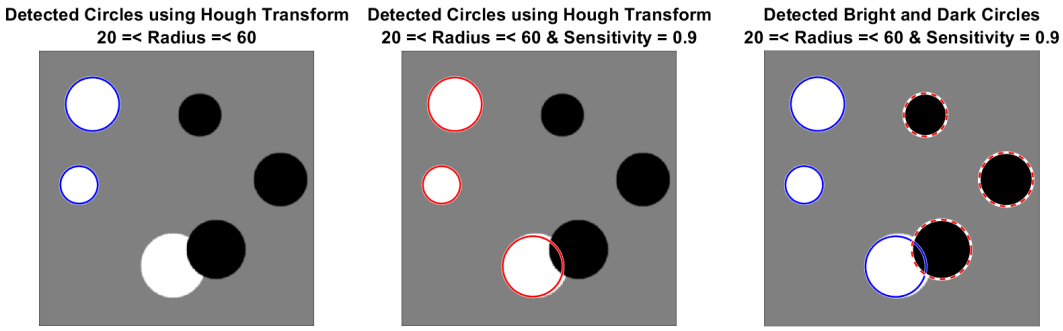
- Find the lines in the image by using these peak points *Hint*: use `'houghlines'` function
- Plot all the lines that you detected with green color and highlight the longest and shortest detected lines with cyan and red color, respectively. What are the maximum and minimum lengths of the detected lines?



Circle Detection

- Load a demo image of MATLAB named `'circlesBrightDark.png'` , which contains several circles with different sizes.
- Convert it to a black-white image.
- Detect all the circles with radius r such that $20 \leq r \leq 60$ pixels by using Hough transform. *Hint*: use `'imfindcircles'` function
- Change `'Sensitivity'` factor and test the performance of circle detection
- Change `'ObjectPolarity'` parameter to detect `'bright'` and `'dark'` circles separately

  You can call the function as `imfindcircles(I,[Rmin, Rmax],'Parameter',value)` where parameter can be `'Sensitivity'` and value is a number between 0 and 1, or `'ObjectPolarity'` and value is either `'bright'` or `'dark'`.



Post Lab

Post lab reports must include brief explanations of each method that you used in this lab. Provide resulting images by utilizing all these methods and discuss your results.Discuss the performance of Kanade-Tomasi corner detector on different images. Discuss also how the change in the parameters such as threshold or sensitivity factor affect the accuracy of the line and circle detection.

Deadline for post lab report submission to SUCourse+: **04 December 2020, 23:55**.