Georgia Institute of Technology
George W. Woodruff School of Mechanical Engineering
ME6406 Machine Vision (Fall 2021)
Assignment #1: (ME6406A Due **Wednesday September 15th 2021, 23:59pm EDT**)

All programs should be written using MATLAB. Solutions must be consolidated into a **single pdf file** (including all results and an explanation of results) and a **zip file** (including all m-files used for the results). Solutions must be submitted electronically through **Canvas**. Late solutions will be penalized at 10% deduction from the homework score, and will NOT be accepted 24 hours after due date.

1. Pin-hole optics

Consider a dark edge projected through a pinhole. Show that

$$\rho = \frac{\delta A}{\delta O} = \frac{1}{\pi}\left[\cos^{-1}\frac{s}{R} - \frac{s}{R}\sqrt{1-\left(\frac{s}{R}\right)^2}\right]$$

where $-R \le s \le R$; s is the displacement of the pinhole center from the edge; δO is the pin hole projection area; and δA is portion of δO in the dark area. Plot ρ as a function of s/R.

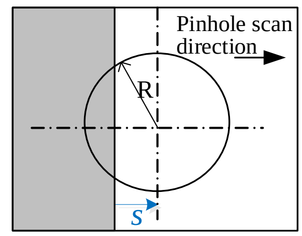
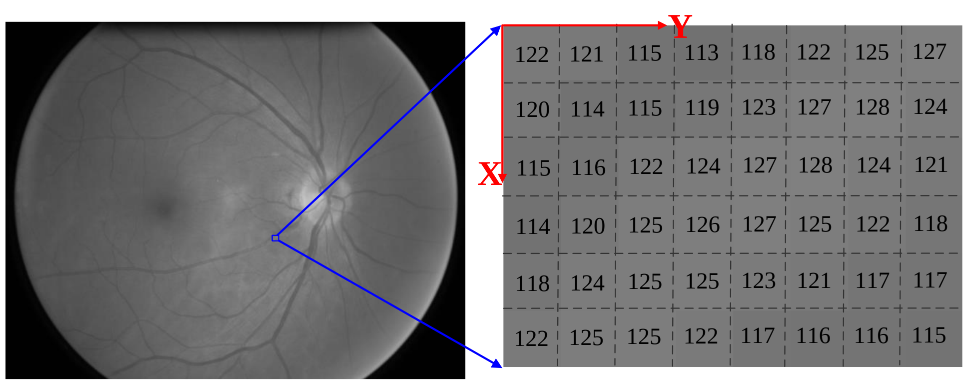


Fig. 1

2. Histogram equalization

Figure 2 shows an 8-bit gray-scale image of an eye-retina.



122	121	115	113	118	122	125	127
120	114	115	119	123	127	128	124
115	116	122	124	127	128	124	121
114	120	125	126	127	125	122	118
118	124	125	125	123	121	117	117
122	125	125	122	117	116	116	115

Fig. 2 eyeball.png

(a) Perform a histogram equalization of the sub-region shown in image matrix; give your results by completing Table 1. Show the histogram equalized results of sub-region matrix.

Table 1

Gray level	**# of pixels**	**cdf**	q_k	**round(q_k)**
113	1	1	5.31	5
: :	: :	: :	: :	: :
128	2	48	255	255

(b) Perform histogram equalization on an image by writing a Matlab script for the following:

I. Read in and display the image ‘eyeball.png’.

II. Compare by displaying the original and processed images and their histograms.

Suggested Matlab functions: imshow, imhist or hist, histeq

3. Filtering masks

   (a) Show the value of a 5x5 Gaussian filter with σ equal to 2 pixels.

   Sobel operator

   (b) Use a 3x3 Sobel operator to calculate the *magnitude* and *direction* of the gradient at pixel (X, Y)=(4, 5) in Fig. 2. Indicate the direction of the gradient on the pixel. (Note: Sobel operator is coordinate dependent. Be sure to use consistent coordinate systems on the sub-regions.)

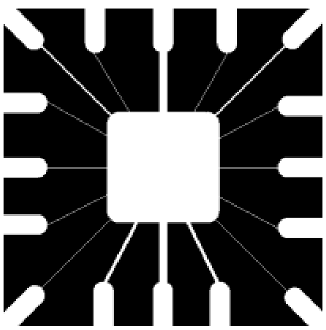
   (c) Write a Matlab script to compute the gradient of an image. For illustration, use the Sobel operator on the image "IC_pin.png" shown Fig. 3(a). Display the gradient images (G_x, G_y, G). *Suggested Matlab functions: edge.m*

   Gaussian operator and Difference of Gaussian (DOG):

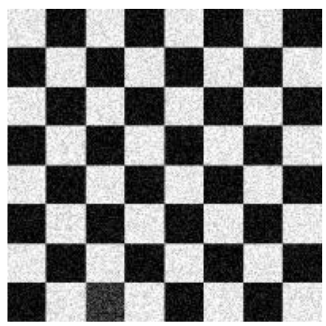
   (d) Use an $m\times m$ Gaussian filter mask with different $\sigma\left(=1,\ 2 \text{ and } 5\right)$ to smooth the noisy image shown in Fig. 3(b). Compare the effect of σ on the smoothed image. *Suggested Matlab functions: imfilter.m.*

   Notes: 'Smoothing effects are more prominent as sigma increases. Mask size increases as sigma increases.

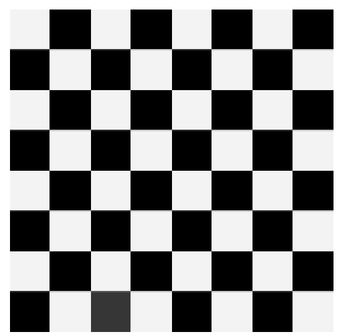
   (e) Perform DoG operation (with $\sigma=1$ and $\sigma=2$) on Fig. 3(c) and show the processed image.



(a) 'IC_pin.png'



(b) 'salt_and_pepper_checker.png'



(c) 'checker.png'

Fig. 3

4. Low-level information processing

   (a) Read in and convert the image (Fig. 4) into a gray-scale image. Binarize the image using three different thresholds; the "best or preferred" value, and an over-estimate and under-estimate values. (Use image histogram to help pick the threshold values).

   (b) Obtain the area and centroid of the two objects (nut and shelf) in the image with an appropriate threshold.

Suggested Matlab functions: rgb2gray.m, im2bw.m, bwlabel.m, regionprops.m

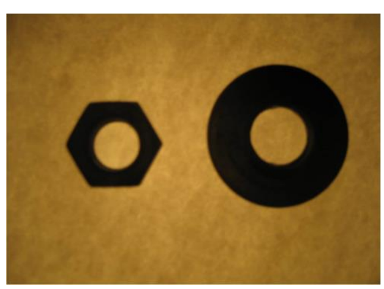


Figure 4 'nut_and_shell.png'