Georgia Institute of Technology
George W. Woodruff School of Mechanical Engineering
ME6406 Machine Vision (Fall 2018)
Assignment #1: Due **Thursday September 6, 2018 (23:59pm)**

All programs should be written using MATLAB. To save the image from the ME6406 website page, point the mouse cursor on the image and click on the mouse's right button. Choose <Save image as>. Solutions must include m-files, results, and an explanation of your results in a document. All m-files must be submitted electronically in a zipped file **through T-square**. A confirmation email will be sent on receipt of submission. Late solutions will be penalized at 10% deduction from the homework score, and will NOT be accepted one day after due date.

1. Pin-hole optics

Consider a pinhole projection area of diameter D_1 that scans across a bright circular landmark with diameter D_2. As shown in Figure 1, the distance s of the pinhole center is measured from the line joining the two intersecting points, where δA denotes the area of the overlap region.

a) **Derive** an expression for $\boldsymbol{\delta A / \delta O}$ in terms of $S=(s/D_1)$ and $\lambda=(D_2/D_1)$, where δO is the area of the pin-hole projection.

b) **Plot** $\delta A/\delta O$ as a function of S, where $-0.5\le S\le 0.5$ and $\lambda=4$.

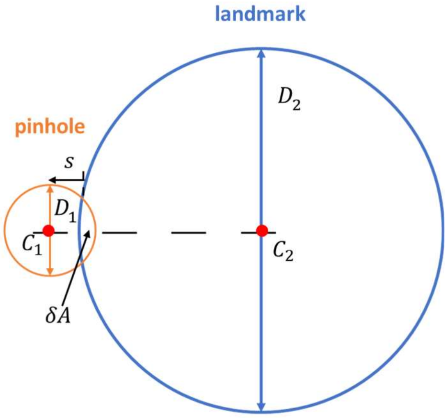


Figure 1. Pin-hole

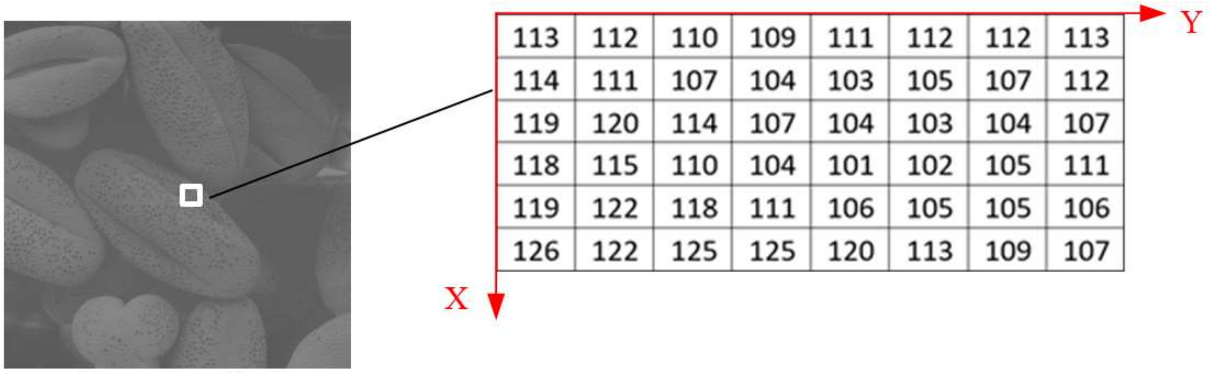
2. Histogram equalization

a) The sub-region of the pollen image shown in Fig. 2 is an 8-bit gray scale image matrix. Carry out histogram equalization by completing Table 1. Show the sub-region matrix after histogram equalization.

Table 1

Gray level	# of pixels	cdf	q_k	round(q_k)
101	1	1	5.313	5
⋮	⋮	⋮	⋮	⋮
126	1	48	255	255

b) Perform histogram equalization on an image by writing a Matlab script for the following:
I. Read in and display the 'pollen.bmp'.
II. Compare by displaying the original and processed images and their histograms.
Suggested Matlab functions: imshow, imhist or hist, histeq



113	112	110	109	111	112	112	113
114	111	107	104	103	105	107	112
119	120	114	107	104	103	104	107
118	115	110	104	101	102	105	111
119	122	118	111	106	105	105	106
126	122	125	125	120	113	109	107

Figure 2. pollen.bmp

3. Filtering masks

Sobel operator

a) Use a 3x3 Sobel operator to calculate the *magnitude* and *direction* of the gradient at pixel (5, 2) 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.)

b) Write a Matlab script to compute the gradient of an image. For illustration, use the Sobel operator on the image “checker.png” shown in Fig. 3(a). Display the gradient images (G_x, G_y, G). Suggested Matlab functions: edge.m

Gaussian operator

c) Plot the Gaussian function in the range $(-5 \le x \le 5,\ -5 \le y \le 5)$ with: $\sigma = 1,\ 2,\ 5$:

$$G(x,y)=\frac{1}{\sqrt{2\pi}\sigma}\exp\left(\frac{-(x^2+y^2)}{2\sigma^2}\right)$$

Suggested Matlab functions: meshgrid.m, surf.m

d) Use a Gaussian filter mask with different $\sigma\,(=1,\ 2,\ 5)$ to smooth the image ‘salt_and_pepper_noise.png (Fig. 3b). Use the proper mask size and compare the effect of σ on the smoothed image.

Suggested Matlab functions: imfilter.m

e) DoG is the difference between two Gaussians. Perform edge detections with DoG function on the image “checker.png”. (use $\sigma = 1$ and $\sigma = 5$)

4. Low-level information processing

This problem shows the process of obtaining some low-level information from an image (Fig. 4).

a) Read in and convert the image ‘nut_and_shell.png’ into a gray-scale image. Binarize the image using 3 different thresholds. Preferably one over-estimate, one under-estimate, one in between. (hint: look at histogram to get an idea of what thresholds to pick).

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

c) Find the outer boundaries of the nut and shell.

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

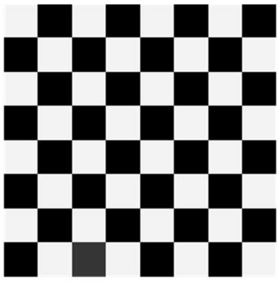


Figure 3(a).
checker .png

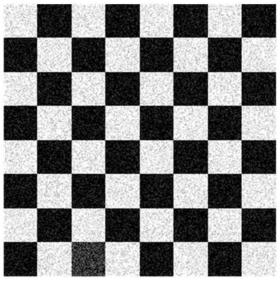


Figure 3(b).
salt_and_pepper_checker .png

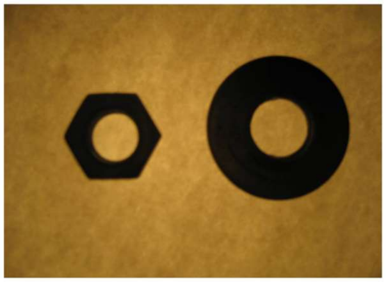


Figure 4. nut_and_shell.bmp