ENGN4528/6528 Computer Vision 2019
Computer-Lab-1 (CLab-1)

Objectives:

This is CLab-1 for ENGN4528/6528. The objective of this lab is to help you familiar with basic image I/O functions in Matlab or Python. Note, however, in all the lab task descriptions given below, we by default use Matlab as the preferred language. You are however free to choose Python if you are more comfortable with Python. If you have not used Matlab or Python before, this lab is an opportunity to get you to quickly familiar with basic language usages of Matlab/Python for image processing and computer vision.

Special Notes:

1. Each computer lab has three weeks: session-A and session-B. Tutors/Lab instructor will provide basic supervision to both sessions.
2. Your Lab will be marked based on the overall quality of your Lab Report. The report is to be uploaded to Wattle site before the due time, which is usually on the Friday evening of Week-3 session of your lab.
3. It is normal if you cannot finish all the tasks within the two 2-hour sessions — these tasks are designed so that you will have to spend about 9 hours to finish all the tasks including finishing your Lab report. This suggests that, before attending the third lab session (in Week-2 of each CLab), you must make sure that you have almost complete 80%.

Academic Integrity

You are expected to comply with the University Policy on Academic Integrity and Plagiarism. You are allowed to talk with / work with other students on lab and project assignments. You can share ideas but not code, you should submit your own work. Your course instructors reserve the right to determine an appropriate penalty based on the violation of academic dishonesty that occurs. Violations of the university policy can result in severe penalties.

CLab-1 Tasks

1 Matlab Warm-up. (2 marks, 0.2 per each)

Describe (in words where appropriate) the result/function of each of the following Matlab commands in your report. Use the Matlab *help* command if necessary, but try to generate the output without entering these commands into Matlab. DO NOT submit a screenshot of the result of using Matlab.

(1) a = [1 : 2 : 5 0; 51 :2: 100] ;

(2) b = a(2,:);

(3) f = randn(500, 1);

(4) g = f(find(f > 0)) ;

(5) x = zeros (1,100) + 0.25 ;

(6) y = 0.5 .* ones(1,length(x));

(7) z = x + y;

(8) a = [1: 300];

(9) b = a([end: -1:1]);

(10) b(b≤50)=0;

2 Basic Coding Practice (1 marks, 0.2 per each)

Write functions to process an input grayscale image with following requirements, where you need to write a script to load an image, apply each transformation to the input, and display the results in a figure using the Matlab *subplot()* function. Label each subplot with an appropriate title.

(1) Load a grayscale image, and map the image to its negative image, in which the lightest values appear dark and vice versa. Display it side by side with its original version.

(2) Map the image to its ”mirror image”, i.e., flipping it left to right.

(3) Swap the red and green colour channels of the input.

(4) Average the input image with its mirror image (use typecasting).

(5) Add or subtract a random value between [0,255] to every pixel in the grayscale image, then clip the new image to have a minimum value of 0 and a maximum value of 255.

Hint: Do the necessary typecasting (uint8 and double) when processing and displaying the images. Some useful Matlab functions are: *title()*, *subplot()*, *imread()*, *imshow()*, *mean()*.

3 Basic Image I/O (2 marks)

In this task, you are asked to:

1. Take three frontal face photos of yourself, under different lighting conditions, against a white wall. The image should be in landscape shape (e.e. the longer side is in the horizontal direction).

   Hint: Make sure the three photos are under different, yet normal, lighting conditions. Try to avoid ”extreme” lighting condition (e.g., pure dark, or pure white or saturated), otherwise you will add some unnecessary difficulties to your own ”face recognition” task in the subsequent CLab.

   Note: Your photos will be used for this class only, and for the C-Labs component of the course during this semester. All photo files uploaded to Wattle will be deleted at the end of this semester. By submitting your photos to Wattle, you agree you understand this. You are allowed to post any face photos to the public domain.

2. Re-scale the images to a size of 1024 columns × 720 rows, and save them to JPG image files named ’face_01_UId.jpg’, ’face_02_UId.jpg’ and ’face_03_UId.jpg’ (replace UId with your uniID, the resized images need to be included in your submitted file).

3. Choose one face image, for example, face_01, and then program a short computer code that does the following tasks:

   (a) Read this face image from its JPG file, and resize the image to 768 × 512 in columns × rows ($0.2'$).

   (b) Convert the colour image into three grayscale channels, i.e., R,G,B images, and display each of the three channel grayscale images separately ($0.2'$ for each channel, $0.6'$ in total).

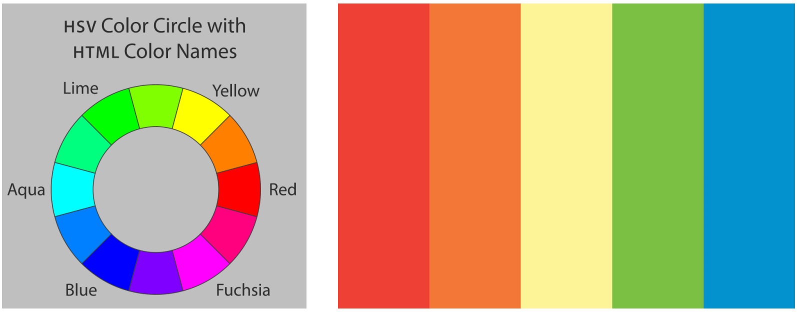
   (c) Compute the 3 histograms for each of the grayscale images, and display the 3 histograms ($0.2'$ for each histogram, $0.6'$ in total).

   (d) Apply histogram equalisation to the resized image and its three grayscale channels, and then display the 4 histograms ($0.15'$ for each histogram, $0.6'$ in total). (**Hint:** you can use Matlab’s inbuilt *histeq()* function).

4 Color Space Conversion (5 marks)

Use the two images in Fig.1 to study color space conversion from RGB to HSV (you can download them from the Wattle site):

1. Based on the formulation of RGB-to-HSV conversion, write your own function *cvRGB2HSV()* that converts the RGB image to HSV color space ($1.4'$). Read in Fig.1(a) and convert it with your function, and then display the H, S, V channels in your report ($0.2'$ for each channel, $0.6'$ in total).



(a) Colour wheel

(b) Palettes

Figure 1: Color images for color space conversion

2. Compute the average H values of five color regions in Fig.1(b) with your function and the Matlab's inbuilt function *rgb2hsv()*. Print both of them under the corresponding regions (0.2′ for each value, 1′ in total). You also need to explain how to distinguish and divide the five regions, and how to calculate the average Hue value (2′, higher marks only for the smarter solution).

5 Image Denoising via Gaussian Filter (4 marks)

1. Read in one of your colour face images. Crop a square image region corresponding to the central facial part of the image, resize it to 512×512, and save this square region to a new grayscale image. Please display the two images. Make sure the pixel value range of this new image is within [0, 255] (0.5′).

2. Add Gaussian noise to this new 512×512 image (if you are using Matlab, you can use function *imnoise()*). Use the following Gaussian noise with zero mean, and standard deviation of 30 (0.5′).

   Hint: Make sure your input image range is within [0, 255]. Kindly, note that Matlab function imnoise() normalizes the input in the range [0,1] by default. So, normalize your variance accordingly like variance = (standard deviation^2)/(255^2) if you are using *imnoise()* in default setting.

3. Display the two histograms side by side, one before adding the noise and one after adding the noise (0.25′ for each histogram, 0.5′ in total).

4. Implement your own Matlab function that performs a 9×9 Gaussian filtering (1′). Your function interface is:

   my_Gauss_filter (noisy_image, my_9×9_gausskernel, output_image)

   Apply your Gaussian filter to the above two noisy images, and display the smoothed images and visually check their noise-removal effects (0.25′ for each image, 0.5′ in total).

One of the key parameters to choose for the task of image filtering is the standard deviation of your Gaussian filter. You may need to test and compare different Gaussian kernels with different standard deviations ($0.5'$).

Note: In doing this task you MUST NOT use any Matlab's inbuilt image filtering functions (e.g. *imfilter()*, *filter2()*, *conv2()*, or *filter()*, *conv()*). In other words, you are required to code your own 2D filtering matlab code, based on the original mathematical definition for 2D convolution. However, you are allowed to use Matlab's function *fspecial()* to generate a 9×9 sized Gaussian kernel.

5. Compare your result with that by Matlab's inbuilt 9×9 Gaussian filter, e.g. *filter2()*, or *imfilter()*. Please show that the two results are nearly identical ($0.5'$).

   Further reading material: `http://setosa.io/ev/image-kernels/`

6 Implement Your 3×3 Median and Sobel Filter (4 marks)

1. **Median filter**. Add 10% salt and pepper noise to your original colour face image, e.g., to randomly pick 10% of the image pixels, and change their values to either pure white or pure black at 50-50 chance. Implement your own 3×3 Median Filter, and use it to denoise your noisy face image. Display the results ($1'$), and then compare your result with Matlab's inbuilt 3×3 median filter ($0.5'$). Which filter (Gaussian or Median) is more suitable for removing salt-and-pepper noise ($0.2'$)? Why ($0.8'$)?

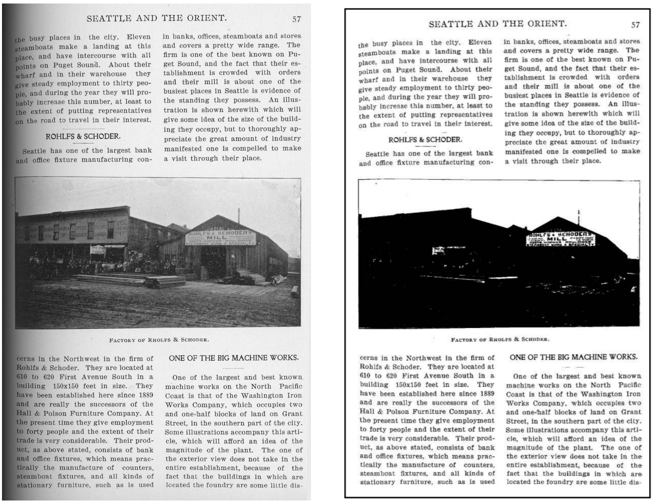
2. **Sobel edge detector**. You need to implement your own 3×3 Sobel filter. Again, you must not use Matlab's inbuilt edge detection filter. Test it on your face images ($1'$), and compare your result with Matlab's inbuilt Sobel edge detection function ($0.5'$).

7 Image Morphology (4 marks)

The digital library contains large collections of digitized books. Some book pages need to be scanned. However, due to the curvature of the pages, there always exist uneven illumination in the scanned images, especially near the spine (seeing Fig.2(a)). For optical character recognition (OCR), the scanned images are first binarized and then further processed by the OCR engine. This question aims to study how to eliminate the effect of uneven illumination in binary images.

1. Read in the image file ”book_page.jpg” and convert it to the grayscale image (the image is from the Stanford University).

2. Generate a binary image by performing global thresholding. You can use the Matlab's inbuilt function *graythresh()* to automatically choose the threshold. Display the binary image ($0.5'$), and show the histogram of the original image's gray values and mark the threshold of the chosen threshold on the histogram ($0.5'$).



SEATTLE AND THE ORIENT. 57

the busy places in the city. Eleven steamboats make a landing at this place, and have intercourse with all points on Puget Sound. About their wharf and in their warehouse they give steady employment to thirty people, and during the year they will probably increase this number, at least to the extent of putting representatives on the road to travel in their interest.

ROHLFS & SCHODER.

Seattle has one of the largest bank and office fixture manufacturing concerns in the Northwest in the firm of Rohlfs & Schoder. They are located at 610 to 620 First Avenue South in a building 150x150 feet in size. They have been established here since 1889 and are really the successors of the Hall & Polson Furniture Company. At the present time they give employment to forty people and the extent of their trade is very considerable. Their product, as above stated, consists of bank and office fixtures, which means practically the manufacture of counters, steamboat fixtures, and all kinds of stationary furniture, such as is used in banks, offices, steamboats and stores and covers a pretty wide range. The firm is one of the best known on Puget Sound, and the fact that their establishment is crowded with orders and their mill is about one of the busiest places in Seattle is evidence of the standing they possess. An illustration is shown herewith which will give some idea of the size of the building they occupy, but to thoroughly appreciate the great amount of industry manifested one is compelled to make a visit through their place.

FACTORY OF RHOLFS & SCHODER.

ONE OF THE BIG MACHINE WORKS.

One of the largest and best known machine works on the North Pacific Coast is that of the Washington Iron Works Company, which occupies two and one-half blocks of land on Grant Street, in the southern part of the city. Some illustrations accompany this article, which will afford an idea of the magnitude of the plant. The one of the exterior view does not take in the entire establishment, because of the fact that the buildings in which are located the foundry are some little dis-

SEATTLE AND THE ORIENT. 57

the busy places in the city. Eleven steamboats make a landing at this place, and have intercourse with all points on Puget Sound. About their wharf and in their warehouse they give steady employment to thirty people, and during the year they will probably increase this number, at least to the extent of putting representatives on the road to travel in their interest.

ROHLFS & SCHODER.

Seattle has one of the largest bank and office fixture manufacturing concerns in the Northwest in the firm of Rohlfs & Schoder. They are located at 610 to 620 First Avenue South in a building 150x150 feet in size. They have been established here since 1889 and are really the successors of the Hall & Polson Furniture Company. At the present time they give employment to forty people and the extent of their trade is very considerable. Their product, as above stated, consists of bank and office fixtures, which means practically the manufacture of counters, steamboat fixtures, and all kinds of stationary furniture, such as is used in banks, offices, steamboats and stores and covers a pretty wide range. The firm is one of the best known on Puget Sound, and the fact that their establishment is crowded with orders and their mill is about one of the busiest places in Seattle is evidence of the standing they possess. An illustration is shown herewith which will give some idea of the size of the building they occupy, but to thoroughly appreciate the great amount of industry manifested one is compelled to make a visit through their place.

FACTORY OF RHOLFS & SCHODER.

ONE OF THE BIG MACHINE WORKS.

One of the largest and best known machine works on the North Pacific Coast is that of the Washington Iron Works Company, which occupies two and one-half blocks of land on Grant Street, in the southern part of the city. Some illustrations accompany this article, which will afford an idea of the magnitude of the plant. The one of the exterior view does not take in the entire establishment, because of the fact that the buildings in which are located the foundry are some little dis-

(a) Scanned book page

(b) Desired binary image

Figure 2: Images for image morphology

(**Hint:** you may find some parts of the text near the spine are no longer visible after binarization)

3. Design and implement your own algorithm that can eliminate the invisible text region effect caused by global thresholding (2′, the final mark is mainly dependent on the quality of the binary image. One desired output is shown in Fig.2(b) for reference only.)

   Hint: One possible solution is to perform local thresholding. More specifically, (1) use a horizontally sliding window; (2) within each window, compute the local variance of grayscale values; (3) manually set a threshold T_v; (4) if the local variance exceeds T_v, binarize the local region with *graythresh()*. Feel free to design your own algorithm; if so, please specify the main steps.

4. Test the effects of applying Matlab's inbuilt morphological operators of 'erosion', 'dilation', 'opening', and 'closing' to the binary image, and visually compare them in your report (0.25′ for each image, 1′ in total).

8 Image Rotation (3 marks)

Choose one of your favorite images (such as Fig. 3) and resize it to 512×512,

1. Implement your own function *my_rotation()* for image rotation by any given angle between $[-90°, 90°]$. Display images rotated by $-90°$, $-60°$, $-30°$, $30°$, and $60°$ (0.2′ for each image, 1′ in total).

2. Compare forward and backward mapping, and analyze their difference (1′).

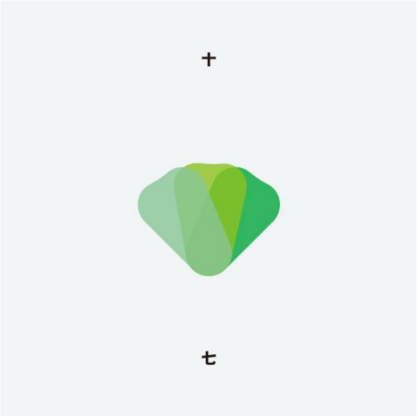


Figure 3: Sample image for rotation

3. Compare different interpolation methods, and analyze their difference ($1'$).

   Hint: When analyzing the difference, you can focus on: (1) visual results; (2) the principles in terms of formulation or others relevant; (3) advantages and drawbacks; (4) the computational complexity. You can also think about it from other aspects.

Clab-* Report

ENGN4528/6528

name
UID
Master/Bachelor

dd/mm/yyyy

Lab Report Requirement

1 Files

Upload a single ZIP file by the due date. You must use the following file name: CLab-1/2/3-Report-Uxxxxxx.zip, replacing Uxxxxx with your uni-ID.

Your ZIP file must contain the following contents:

(a) Three JPG photos of yourself (Only for CLab 1, requirements are in CLab1 Task 3).

(b) A PDF of your Lab Report. The report generally contains sample results from all the Lab Tasks, along with necessary comments and descriptions, questions and answers. For more detail. Please refer to the following Template and General Instructions for Lab Report on the next page.

(c) A file named “code” to include all your *.m files.

2 Lab Report

Kindly document different question under respective headings provided with the assignment. For example:

Task-1: Basic Image I/O

1. Your first question under this theme

Documentation, observations, results, analysis etc.

2. Your second question under this theme

Documentation, observations, results, analysis etc.

3. Your third question under this theme

Documentation, observations, results, analysis etc.

2.1 General Formatting Instruction

- Kindly use the same font single-spaced type for the entire document as much as possible, you may use the bold and italic version of the same font to highlight the important points. Few recommended fonts are Times New Roman, Times, which are quite widely used font to document projects and research papers. Too big or too small font sizes are not encouraged.

- Kindly, use appropriate font size for sections heading and its contents accordingly. For example, 14-15 point Times, boldface type for heading and 11-12 point single-spaced type for the content is one of the widely used font sizes for documenting research papers.

- Please number all your sections and subsections of the tasks as provided in the assignment.

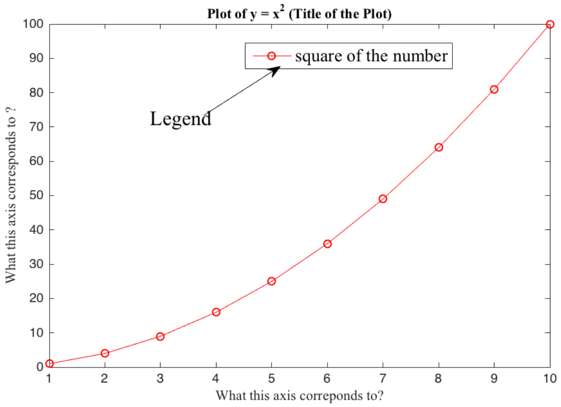
- Please show the images mentioned in each task to make your answer more clear. **Brief explanations on how you solve the problem are expected**.

- Please give your own answer following the question guidelines.

- Handwriting draft is not permitted.

2.2 Table, Figures and Plots

This is one of the important aspects of evaluating your report. The figures and the caption of the tables must be appropriately addressed. The figure should have an appropriate title if required. All the legends in the figure should be properly highlighted. The caption of the figure should explain your observation and understanding which may comprise of quantitative or qualitative evaluation to endorse your observation. Some of the widely used font to caption your figure, table and callouts are 10-11 point Roman type, 10-11 point Helvetica non-boldface type. Kindly, adjust the size of the figure in the document appropriately such that its clearly visible and perfectly eligible to illustrate your observation. We encourage you to look into the below example for reference. Note: You cannot insist we can zoom in or out to see tiny details on the graphs, plots, photographs, illustration, etc. Also, make sure the figures you include in your document is not a copyright image.



Caption: Variation in the y-axis corresponding to the values in the x-axis and What does this mean, your observations?

For the tables, graphs and others as well, kindly document the purpose of the statistical illustration which should include titles and proper labelling of the data and statistics.

Please follow the requirements to write your own Lab report.

=========== END of C-Lab-1 =========