Computer Vision and Imaging [06-30213]
Assignment 1

9am, Monday, 8 March 2021

Submission deadline:	**9am (GMT), Monday, 15 March 2021**
Instructor:	Dr. Hyung Jin Chang
	Dr. Yixing Gao
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Total marks:	100
Contribution to overall module mark:	25%
Submission Method:	This assignment must be submitted through Canvas.

Important note on plagiarism

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Instructions

This assessment is summative and contains three parts. In Part 1, you will answer theoretical questions. In Part 2, you will perform local image feature detection and extraction, add and remove image noise to images using MATLAB. In Part 3, you will work on image segmentation.

Your answer must be submitted to Canvas before the deadline in the form of a single zip archive file containing:

1. Your answers to the questions in prose and diagrams. This should take the form of a single PDF document with the answers for each question using the provided LaTeX template.

2. Your code and any accompanying files necessary to execute the code for any programming questions as specified in the LaTeX template.

and a separate PDF document with the answers for Turnitin checking (two files in total). Some or all of the text of each question is emphasised using *italics*. This emphasis indicates a question that must be explicitly answered or a task that must be completed.

Part 1

Question 1.1 **[6 marks]** *Consider the following image matrix and kernel (Figure 1). Produce the resulting convolved image matrix for the central dashed region. What affect does this kernel have? (Consider both this image and larger example images)*

Kernel

-1	-1	-1
-1	8	-1
-1	-1	-1

*

Image

8	6	17	118	172
4	8	11	112	178
11	9	13	131	164
8	9	18	141	168
5	7	15	128	170

Figure 1: An example Image and Kernel

Question 1.2 **[7 marks]** *Another pair of filter kernels are shown in Figure 2. What are their responses to uniform brightness? Are the filters isotropic or anisotropic and explain the terms. Which filter would you use for finding edges? What kind of edges would you use it to find?*

A

0	-1	-1	-1	-1	0
-1	-2	-3	-3	-2	-1
-1	-3	12	12	-3	-1
-1	-3	12	12	-3	-1
-1	-2	-3	-3	-2	-1
0	-1	-1	-1	-1	0

B

1	1	1	1	1	1
-1	-2	-3	-3	-2	-1
-1	-3	-4	-4	-3	-1
1	3	4	4	3	1
1	2	3	3	2	1
-1	-1	-1	-1	-1	-1

Figure 2: A pair of filter kernels

Question 1.3 **[7 marks]** *Is it possible to use the intrinsic and extrinsic camera properties to transform from a point in the camera 2D pixel coordinate system to a point in the world 3D coordinate system, and why?*

Part 2

Local image feature extraction and matching

Question 2.1.1 **[10 marks]** *Add gaussian (mean = 0.3, variance = 0.5), salt & pepper (noise density = 0.75) and speckle image noise to dom.jpg using the* ***imnoise*** *function. Show the images using subplot and add title to each image separately (See example in Figure 3.). Discuss your observations.*

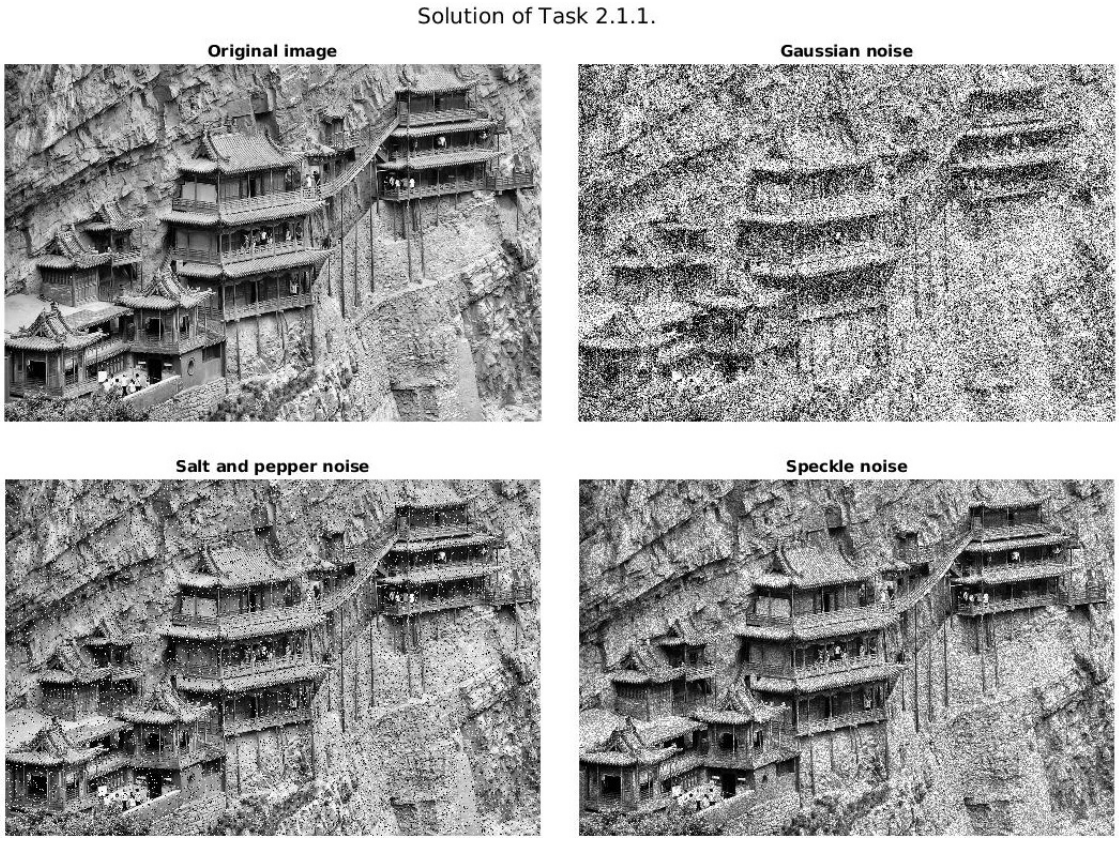

Figure 3: Example result of 2.1.1.

Question 2.1.2 **[10 marks]** *Implement minimum, maximum, median and mean filters for image noise removal. Remove the previously added noises from the images with Gaussian and Salt&Pepper noise using 5x5 structuring element. Show the results using subplot and add title to each image separately (See example in Figure 4.). How well did they work and why? Discuss your observations.*

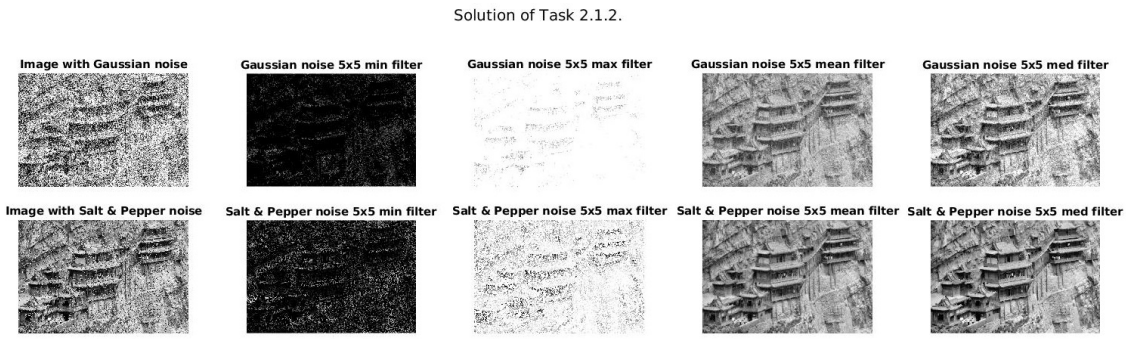

Figure 4: Example result of 2.1.2.

Question 2.2 **[20 marks]** *Extract features from the Salt&Pepper image (from Question 2.1.1) and the denoised images (from Question 2.1.2, note that this is not the original image), compare results and visualize them. In case you could not complete 2.1.2. you can use the original image for this Question, but points will be deducted. Display all of your results similarly to Figure 5., indicate it in the title if you used the original image. Discuss your observations.*

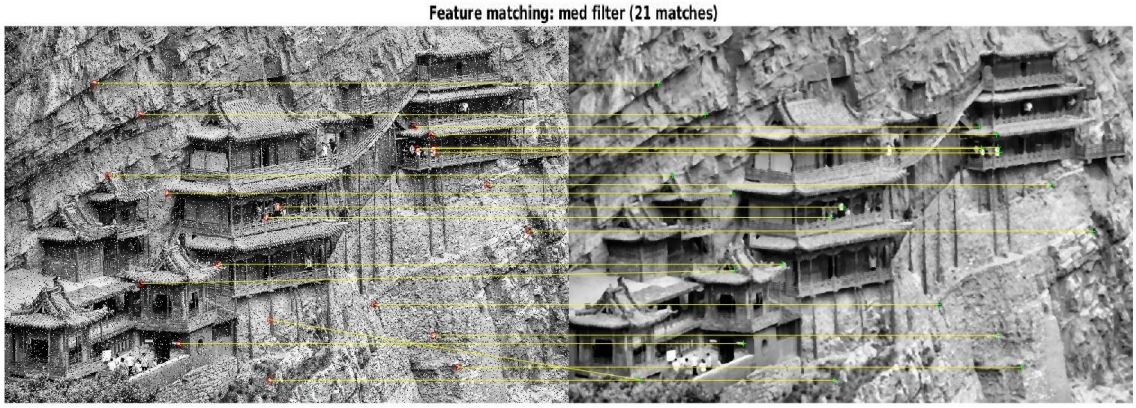

Figure 5: Example result of 2.2.

Part 3

Image segmentation task

> "Image segmentation is a commonly used technique in digital image processing and analysis to partition an image into multiple parts or regions, often based on the characteristics of the pixels in the image. Image segmentation could involve separating foreground from background, or clustering regions of pixels based on similarities in color or shape. For example, a common application of image segmentation in medical imaging is to detect and label pixels in an image or voxels of a 3D volume that represent a tumor in a patients brain or other organs." - Matlab Image Segmentation
>
> OTSU's method (matlab function graythresh) is an example of an Matlab Segmentaion function: "OTSU's method chooses a threshold that minimizes the intraclass variance of the thresholded black and white pixels".

Question 3.1 [14 marks] *Image 'cells.png' is an example of cells tagged with green fluorescent protein (GFP), imaged using a fluorescence microscope. Firstly, use the OTSU's method of segmentation (See Matlab function graythresh) with no pre-processing or filters. Then segment the cells using ANY method/s you consider appropriate, with any pre-processing and/or filters. Justify the choice of your best performing method (or a sequence of methods), list the values of all the parameters used and justify their choices. Compare your results to the results of using the OTSU's method and comment on the reasons for the observed differences in results. If other methods produce worse results than the default OTSU's method, then please explain why you think this is.*

Please note that some groups of cells overlap. Separating them is quite hard so is acceptable to leave the most difficult ones clustered together and count them as one. There will be extra marks for those students who manage to separate all the cells.

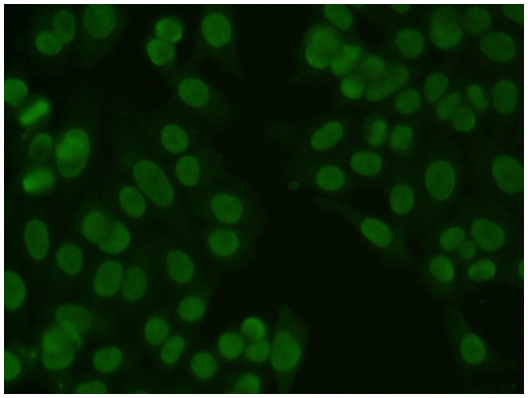

Figure 6: Cells tagged with GFP, imaged using a fluorescence microscope.

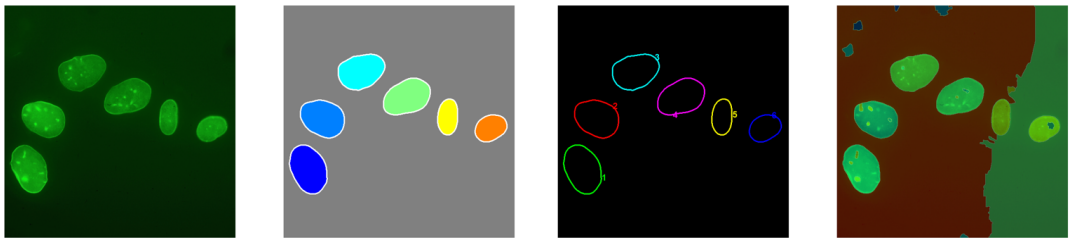

Figure 7: An example of the various ways a cell segmentation could be displayed. This does not necessarily have to be reproduced for this question, but is here as a guide. Note, this image is not the same as the original cells.png.

Question 3.2 [10 marks] *Use either the default OTSU's method, or your best method. For visual verification superimpose the outlines of the cells on the original image. Apply any pre-processing (e.g. smoothing) or post-processing operations (mathematical morphology operations such as erosion, dilation, opening, closing, etc.) to get as smooth as possible - but as accurate as possible - boundaries of the segmented cells. Explain the purpose and the outcome(s) of any operation that you have used.*

Question 3.3 *Compute the cell statistics from the default OTSU method:*

Question 3.3.1 [6 marks] *Area (in pixels) of each cell*

Question 3.3.2 [6 marks] *Mean brightness (in green channel) of each cell*

Question 3.3.3 [4 marks] *Mean and standard deviation for the area and brightness for all the cells in the image*