University of California, Santa Cruz

ECE 237 - Image Processing and Reconstruction

Spring 2021 Mini-Exam (10% of grade)

This exam tests introductory material on image processing and reconstruction for 2D images in grayscale and color. Skills on finding, exploring and selecting a proper method for contrast adjustment, denoising, object recognition, identifying and tracking objects, real space filtering using convolution and Fourier (spatial frequency) space filtering are tested. This is an open book exam and there plenty of time for you to finish it (no time pressure). Please let Sara know if you need extra time to finish the exam due to any special circumstances.

Recommended References to help you with the exam

- Digital Image Processing using MATLAB, Gonzales and Woods, any edition
- ImageJ user manual (freely available as PDF to download)
- Course Lecture Slides (available on canvas)

How to present your answers

For full credit, you need to provide solutions that are clear, neat and organized and use excellent college level English to motivate your solutions and answers. For more information on grading see the Syllabus on canvas.

1. Open the images C1 (photograph of photographer Homai Vyarawalla) and C2, which is a blood sample microscope image. The many red disks are red blood cells. The purple cell in the center is a white blood cell. Source: https://uwosh.edu/medicaltechnology/students/elementary-hematology/. Do this in both ImageJ and MATLAB.

a. Display the images in a nice way by adjusting the contrast and ensuring the scaling is proper. Display the grayscale image in grayscale and with a false lookup table of your choice. Display the color image both in grayscale and in color. Show and briefly discuss your results. What method did you use to display/convert the image to grayscale? (1p)

b. Apply a blur filter of your choice to one of the image C1 using both ImageJ and MATLAB. Describe what methods you used (same or different?) and how the method(s) works. Display the result. (1p)

2. Find and count the red blood cells in image C2 using an automated or semi-automated method for object recognition either in MATLAB or in FIJI. (This can be any method you like, if you cannot think of any method, you can for example use TrackMate).

a. Describe what method you used and how it works. (1p)

b. Compare the automated / semi-automated result you got to the result you get when you count the particles using computer-assisted manual annotation with the ImageJ Cell Counter. Display your result windows showing both your annotation and the automated result. How accurate is your method? (1p)

3. An operation in mathematical morphology is an “opening”, which is erosion followed by dilation. Describe what this does to an image. Binarize the example image “rice” that we used in class and perform an opening. What happens if you set the size of the structuring element to a relatively large value? (2p)

4. Transform the RGB image C2 to an HSV (Hue, Saturation, Value) image and find all the purple pixels in the image. Explain how you can use this method as a help to find the white blood cells in the sample. Note: you will need to define a cutoff value for how purple and perhaps also how saturated and how bright (value) pixels you want to find. Do a visual inspection of the result to set these cutoffs to get a reasonable result. If you need help and inspiration on this, see help file LabHelpColorSegmentationWBC.m under LabHelp files on canvas (2p)

5. Describe the difference between an “ideal” (binary mask) filter and a non-ideal filter (such as a Butterworth) when implementing *e.g.* a low-pass filter in Fourier space. Which filter would be more likely to cause ringing artifacts? (1p)

6. What is the Nyquist sampling criterion and what may happen if you don't fulfill it? If you are imaging with 500 nm resolution at 10x magnification, how big can the pixels of your camera be for you to be sampling at Nyquist? (1p)