Computer Science - The City College of New York
CSC 471 - Fall 2017 3D **Computer Vision**

Assignment 1 (Deadline: Sept 15 before midnight)
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Note: All the writings of your assignment must be in "soft" copies (in a single PDF file) by sending to Prof. Zhu <cv.zhu.ccny@gmail.com> via an email attachment. You are responsible for the lose of your submissions if you don't include **"CSc 471 Computer Vision Assignment 1** " (exactly) in the **subject** of your email. For your programming part, in addition to the writing report, please also send your source code - in their original formats; please don't format them into PDF or Word formats. Please don't send in your images and executable. You may want to include images as they show results of your work. Do write your names and IDs (last four digits) in both files for your report and the code.

1. Writing Assignments (10x4 = 40 points)

(1). How does an image change (e.g., objects' sizes in the image, field of view, etc.) if the focal length of a pinhole camera is varied?

(2). Give an intuitive explanation of the reason why a pinhole camera has an infinite depth of field.

(3). In the thin lens model, $1/o + 1/i = 1/f$, there are three variables, the focal length f, the object distance o and the image distance i (please refer to Slide # 19 of the Image Formation lecture). If we define $Z = o-f$, and $z = i-f$, please write two a few words to describe the physical meanings of Z and z, and then prove that $Z*z = f*f$ given $1/o + 1/i = 1/f$.

(4). Prove that, in the pinhole camera model, three collinear points (i.e., they lie on a line) in 3D space are imaged into three collinear points on the image plane. You may either use geometric reasoning (with line drawings) or algebra deduction (using equations).

2. Programming Assignments (Matlab preferred - here is a quick matlab tutorial. You may use C++ or Java if you like, but you may need to bring your own machine to me in my office hours to run your programs when I ask you. If you don't have a Matlab license, CUNY has recently made several software available for use (including MathWorks MatLab), through the CUNY Virtual Desktop.) (15x4 = 60 points)

Image formation. In this small project, you are going to use Matlab to read, manipulate and write image data. The purpose of the project is to make you familiar with the basic digital image formations. Your program should do the following things:

1. Read in a color image C1(x,y) = (R(x,y), G(x,y), B(x,y)) in Windows BMP format, and display it.

2. Display the images of the three color components, R(x,y), G(x,y) and B(x,y), separately. You should display three black-white-like images.
3. Generate an intensity image I(x,y) and display it. You should use the equation I = 0.299R + 0.587G + 0.114B (the NTSC standard for luminance) and tell us what are the differences of the intensity image thus generated from the one using a simple average of the R, G and B components.
4. The original intensity image should have 256 gray levels. Please uniformly quantize this image into K levels (with K=4, 16, 32, 64). As an example, when K=2, pixels whose values are below 128 are turned to 0, otherwise to 255. Display the four quantized images with four different K levels and tell us how the images still look like the original ones.
5.
6. Quantize the original three-band color image C1(x,y) into K level color images CK(x,y)= (R'(x,y), G'(x,y), B'(x,y)) (with uniform intervals) , and display them. You may choose K=2 and 4 (for each band). Do they have any advantages in viewing and/or in computer processing (e.g. segmentation)?
7. Quantize the original three-band color image C1(x,y) into a color image CL(x,y)= (R'(x,y), G'(x,y), B'(x,y)) (with a logarithmic function) , and display it. You may choose a function I' =C ln (I+1) (for each band), where I is the original value (0~255) , I' is the quantized value, and C is a constant to scale I' into (0~255), and ln is the natural logarithm. Please find the best C value so for an input in the range of 0-255, the output range is still 0 - 255. Note that when I = 0, I' = 0 too.

Please for each of the above, provide your analysis / observations / conclusions, rather than just show the experimental results in images and/or charts.

I have provided a piece of starting code for you to use. Questions a and b have been done. You only need to work on c to f (15x4 = 60 points). You may use Prof. Zhu's old ID picture for testing your algorithm.