Handout 02 Digital Image Fundamentals

1. Basic Concepts

(1) Three membranes enclose the eye: the cornea and sclera, choroid, and retina.
(2) Iris is actually a part of choroid and it can contract or expand to control the amount of light that enters the eye.
(3) Images are formed on retina, which contains two kinds of light receptors, cones and rods.
(4) Cones are primarily located in the central portion of the retina, called fovea and are sensitive to color; cone vision is called bright-light vision. Rods are distributed over the retinal surface; they are not involved in color vision and are sensitive to low levels of illumination; rod vision is called dim-light vision. There is a blind spot on the retina.
(5) Perceived brightness is not a simple function of intensity. Consider the “Mach bands” and the “Simultaneous contrast” phenomenon.
(6) The colors that we perceive are determined by the nature of the light reflected from an object.
(7) There are mainly three types of imaging sensors, including single imaging sensor, line sensor, and array sensor.
(8) Pinhole model is widely used to model the imaging process.
(9) A lens focuses light onto the film; rays passing through the center are not deviated; all parallel rays converge to one point on a plane located at the focal length.
(10) A smaller aperture increases the range in which the object is approximately in focus; but small aperture reduces amount of light.
(11) Size of the field of view (FOV) is determined by the size of the retina and the focal length, 
\[ \phi = \arctan \left( \frac{d}{2f} \right), \] where \( d \) is the diameter of the retina and \( f \) represents the focal length.
(12) CCD and CMOS are two imaging sensing technologies.

2. Exercises

(1) Compared with a commercial digital camera, then lens of the human eye can be considered as____, the iris can be considered as____, and the retina can be considered as____.
(2) Are there any defects of the human eye?
(3) Cones are sensitive to____; rods do not respond to____ and is sensitive to______.
(4) When you enter a dark theater on a bright day, it takes an appreciable interval of time before you can see well enough to find an empty seat. Which of the visual process mentioned in our lecture is at play in this situation?
(5) For our humans, perceived brightness is not a simple function of the intensity. Can you give some examples?
(6) We see the grass is green, that is because grass____green light.
(7) There are two images \( A \) and \( B \), whose sizes are 1024*1024 and 256*256, respectively. Is it correct to say that the resolution of \( A \) is greater than \( B \)?
We have a raw image with 320 rows and 480 cols, having 16 different gray levels. How many bytes are needed to store this image?

3. Matlab Programming

Load, save, and display an image  imread, imwrite, imshw, imfinfo, figure
Conversion of images  rgb2gray, im2bw, im2uint8, im2uint16, mat2gray
Algebraic operations of images  imadd, imsubstract, immultiply, imdivide, imabsdiff, imlincomb
Spatial operations of an image  imresize, imrotate, imcrop
Matrix and vector operations  size, rot90, flipud, fliplr, round, floor, ceil
Matrix construction  zeros, ones, true, false, magic, rand, randn

(1) Test the functions of the routine imresize, imcrop, and mat2gray.
(2) Given a gray-scale image with 256 intensity levels. Convert it to images with 128 levels, 64 levels, 16 levels, and 2 levels, respectively and display them.
(3) Load a colorful image, flip it (up-down, or left-right), and display the results.