Homework 1

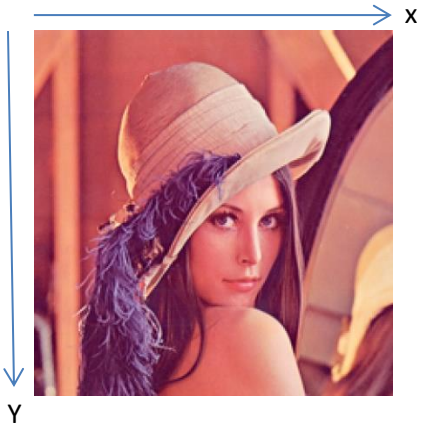
1. **An image can be thought of as: (Circle all correct answers)**
   - A 2-dimensional array of numbers ranging from some minimum to some maximum
   - A function f of x and y: f(x,y)
   - Something generated by a camera

2. **Define an image as a function**:

Think of an image as a collection of intensities at different locations along x and y, where x∈R and y∈R. Suppose x is 0->127, y is 0->127, and the intensity range is 0->255, fill up the blanks of the following equation:

I = f(x,y) *where* f:[2 , 3] *[5 , 6] -> [0 , 34]

3. **Define a color image as a function:**



Which equations are correct? (Circle all correct answers)

- f: R×R->R^3
- b) f: R×R×R->R×R

f: R×R->R×R×R

d) f: R×R×R->R

4. **Quantize an image:**

Here is a patch of a digital image,

1.1	2.3	5
3.2	4.9	7.6
-1.2	5.1	2.7

If we only have a small set of integers to represent the values of the pixels, say {0,1,2,3,4,5}, try to quantize the image following rules:

1) Round down: 1.6->1

2) Limits: anything<0 - >0; anything>5 -> 5

Quantized values of image are given in table below

1	2	5
3	5	7
-2	5	3

5. **List at least 5 applications of computer vision**.

The various applications of computer vision are

Remote Sensing: Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation.

Image Search: You want to build an image search engine where a user uploads a picture and relevant images are returned.

Motion Capture: Used for scanning the various movements of objects

Automotive: Used in automotive industry for the development of self-driving cars Ex: Tesla

Healthcare: Helping healthcare professionals accurately classify conditions and illnesses by reducing and eliminating inaccurate diagnoses

6. **Why is computer vision difficult?**

When us humans view an image, we perceive objects, people or a landscape. When machines view images, all they see are numbers that represent individual pixels. The various reasons which make computer vision difficult are

1) Swathes of data

2)Inherent loss of information

3)Dealing with noise

4)Requirements for interpretation

To derive effective solutions, we should apply the probabilistic models and algorithms. These algorithms need to be trained effectively to obtain the optimal solution and still it cannot be trusted completely which is termed as Inverse problem.

7. **What is the difference among computer vision, computer graphics and image processing?**
   a) Image Processing: Conversion of image to its digital form and perform the various operations to manipulate the image and extract the information
      Eg: Smoothing, stretching, contrasting
   b) Computer Vision: Computer vision is an interdisciplinary scientific field that deals with how computers can be made to gain high-level understanding from digital images or video
      Eg: Facial Recognition,3D Modelling
   c) Computer Graphics: Process of creating pictures and videos using the computers for better understanding
      Eg: UI Design, Vector graphics

8. **What are the two major parameters of a camera which control the exposure of images? If an image was over-exposed, how can we adjust the camera?**
   The two major parameters are:
   a) Shutter speed: The amount of time that the shutter is open is called the shutter speed. It can control the amount of light reaching the sensor.
   b) Aperture: It is the size of the hole in the camera lens through which the light passes to get to the sensor.
      If the image is overexposed, it can be controlled by decreasing the illumination or by increasing the shutter speed.

9. **How to convert analog image to digital image? How to choose sampling rate to avoid aliasing?**
   Analog image can be converted to digital image by following steps:

Sampling: Sampling is a process used in statistical analysis in which a predetermined number of observations are taken from a larger population. It is of types such as up sampling and down sampling. Sampling is done on X variable

Quantization: It is the process of mapping an input from a continuous or otherwise large set of values to a discrete set. It is done on Y variable

The Nyquist sampling rate is the lowest sampling rate that can be used to avoid the aliasing

10. **What is the advantage of CIE XYZ color coordinates compared with CIE RGB? What is the benefit of L*a*b* color space? Today's cameras use a color filter array (CFA) to capture colors. According to Bayer pattern, half sensors are green filters. Why?**
    A large negative amount of red light must be added to get a color match in CIE RGB. Therefore, new color space CIE XYZ was developed which contained all spectral colors with positive octant.

    The output generated by human visual system is roughly logarithmic, therefore L*a*b was developed. This clearly stated the differences in luminance which were relatively uniform. Half sensors are green filters because luminance signal is mostly determined by green values and the visual system is much more sensitive to high frequency detail in luminance than in chrominance.