Digital Image Processing

Introduction

Uses of image processing

- Computer vision as preprocessing step
- Images compression
- Has many active research areas
- As computer vision gets more important, so does image processing

Image

- Abstract or realistic representation of a scene
- It could be a picture or a digital image
- There are two types of digital images
  - Continuous / parametric: called a vector image
  - Discreet Images: Fixed sized and represented as matrices, we will only work on discreet digital images

Discreet images

- Entire image is stored as a matrix
- Matrix cells can contain a single value or a group of values for multiple color channels
- Generated (CGI, computer generated image)
  - Rasterized from vector images
  - Generated from fractals or other mathematical formulas
  - A rendered 3D scene
  - Common properties include sharp edges and flat colors
  - Too clean
- Acquired images
  - Using a camera or a scanner
  - Has softer features
  - Contains naturally occurring noise as well as noise caused by acquisition process
  - Acquisition process reduces the amount of details in the real scene
  - Fully capturing a real 1 m^2 scene would need 10^{71} pixels
  - Thus the amount of details would be lowered and this process is called sampling
  - Restricting the acquired brightness level to a finite range is called quantization

Sampling

- Each sample is represented as a pixel
- In acquisition devices, the image sensors contain separate elements for each pixel
- During sampling, each element will record the amount of photons hitting the area
- During sampling, each element will take photons from multiple objects, if they are close to each other. This is the reason why acquired images do not have extremely sharp edges
- Changing the sampling rate of the image is called resampling
- Up sampling (zooming) can be used to increase the size of the image, however, this will not increase the amount of information contained within the image
- Down sampling (shrinking) can be used to decrease the size of the image, and generally will result in the loss of information
- Sampling can cause strange spatial effects like aliasing and moire effect

Quantization

- The operation of converting number of photons hitting a sensor element to a number
- Generally, images are saved as 8-bit RGB (red, green, blue) format which requires 3 bytes per sample
- Each different color value stored per pixel is called a channel
- Average, minimum and maximum intensity should be considered while performing quantization
- In an 8-bit image, maximum number that a pixel can get is 255. This represent the maximum intensity
- In a black and white image, maximum intensity signifies white color, whereas 0 represents black
- Quantization can cause over and under exposed images as well as inaccuracies under low light conditions

Requantization

- Changing bits/channel or channels of a digital image
- The transformation can be performed to change color image to grayscale or vice versa
- Different color representations can be converted to each other
- Converting a color or grayscale image to a mono-chrome (black and white image) is also a requantization operation