بسم الله الرحمن الرحيم

Computer Vision and Image Processing (CSEL-393)

Lecture 3

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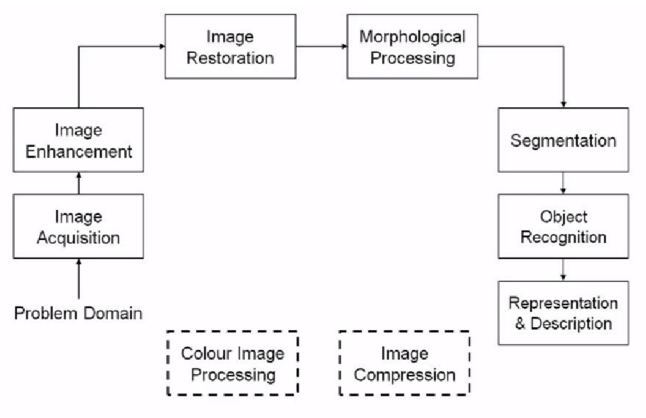
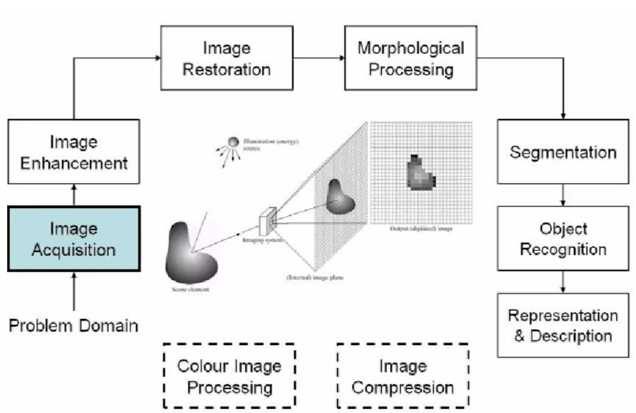
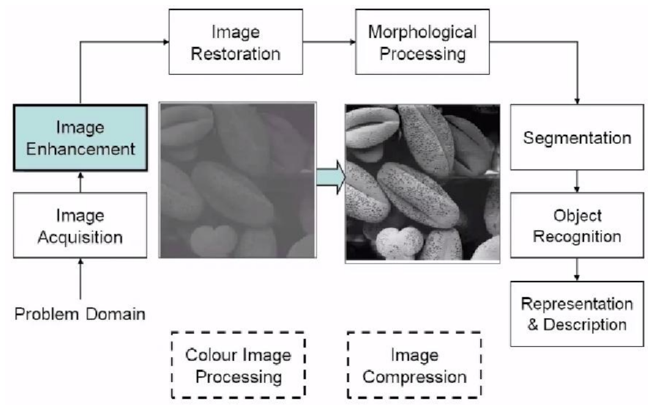
Stages of Image Processing



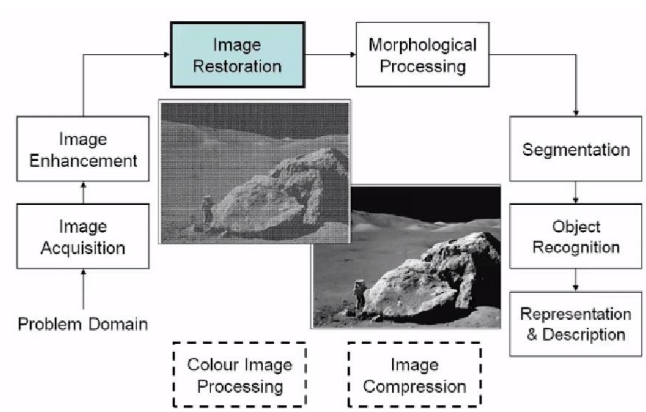
Stages of Image Processing



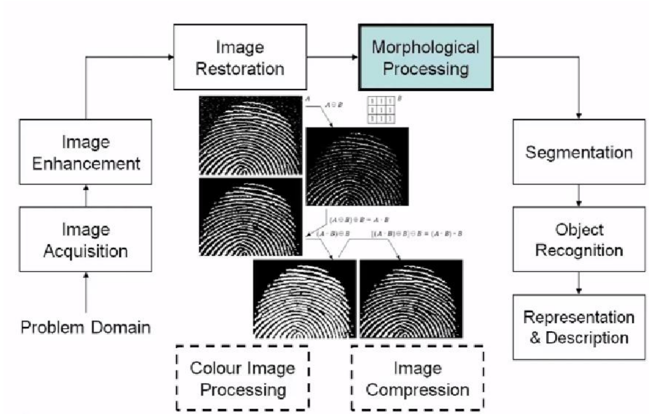
Stages of Image Processing



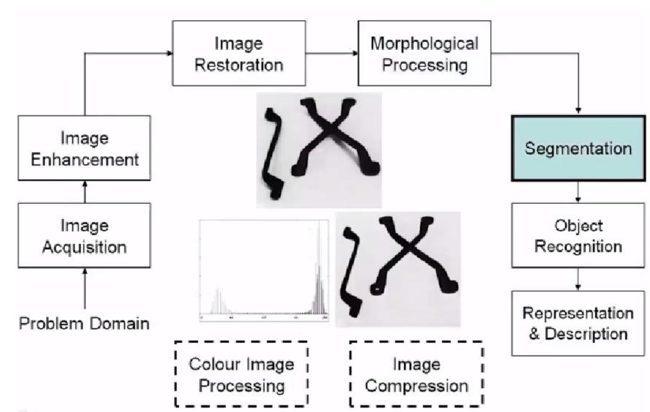
Stages of Image Processing



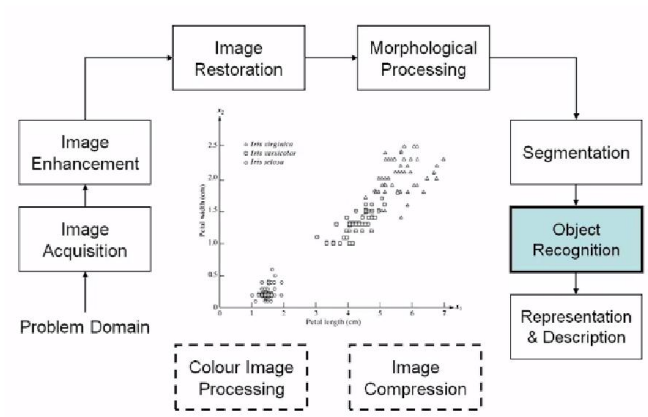
Stages of Image Processing



Stages of Image Processing



Stages of Image Processing



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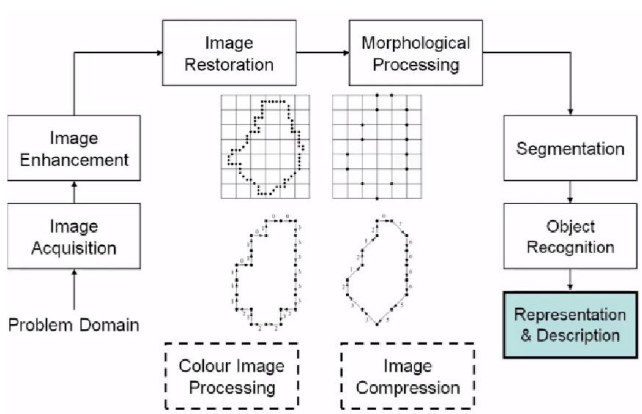
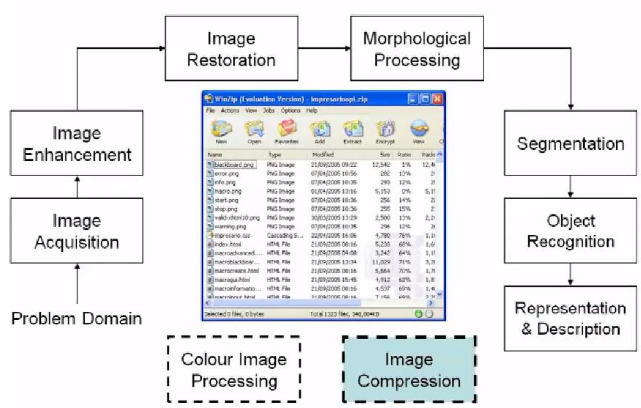


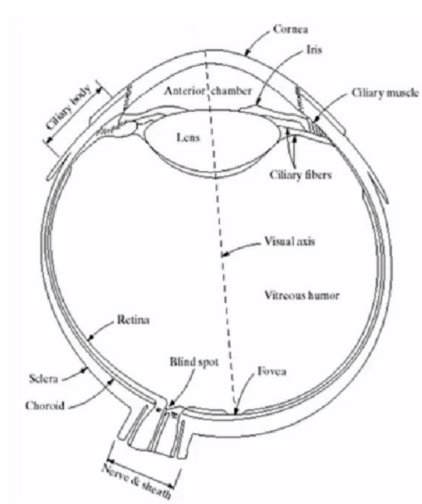
Stages of Image Processing



Human Visual System

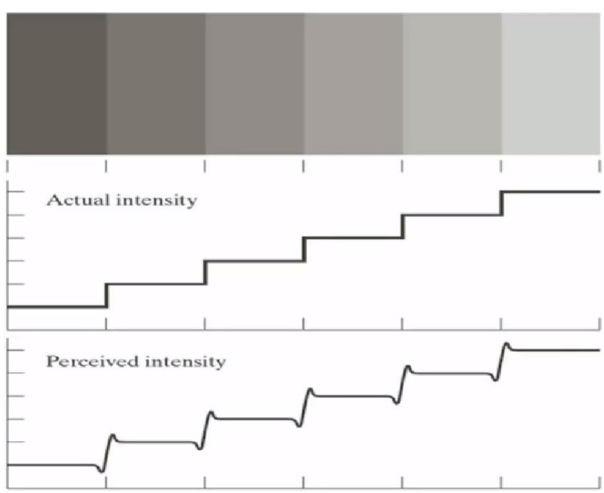
- The human eye is a slightly asymmetrical sphere with an average diameter of the length of 20mm to 25mm.
- The external object is seen as the camera take the picture of any object.
- Light enters the eye through a small hole called the **pupil**, a black looking aperture having the quality of contraction of eye when exposed to bright light and is focused on the retina which is like a camera film.
- **Lens**: focuses light from object onto the retina
- **Retina:** is covered with light receptors called **cones** (6 to 7 million which are highly sensitive to colors) and rods (75 to 150 million which are sensitive to low levels of illumination(means color is darker, which color is brighter). Human visualizes the colored image in daylight due to these cones. The cone vision is also called as photopic or bright-light vision.
- **Image formation in Eye**

1. Lens of the eye focus an image of the outside world
2. Image of formed onto a light-sensitive membrane in the back of the eye, called retina
3. The lens of the eye focuses light on the photoreceptive cells of the retina which detects the photons of light and responds by producing neural impulses.



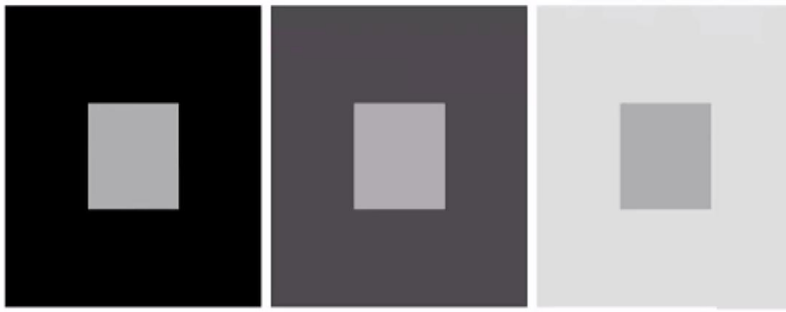
Human Visual System

- The human visual system can perceive approximately 10^10 different light intensity levels (which involves identification of number of colors and marking boundary of colors in a perceived visual scene)



Human creates overlap of the colors boundaries

Simultaneous Contrast



An example of Mach bands

Light-Electromagnetic Spectrum

- Reading assignment
- Text book: Section 1.3

Image Representation

- A digital Image is composed of a finite number of elements each of which has a particular location and value
- These elements are referred to as **Picture Elements**, **Image Elements**, or **Pixels**
- Intensity Values
  - Black and White
  - Gray Scale
  - Color

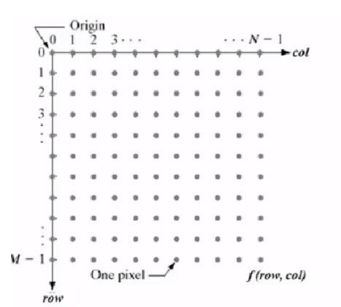


Image Acquisition

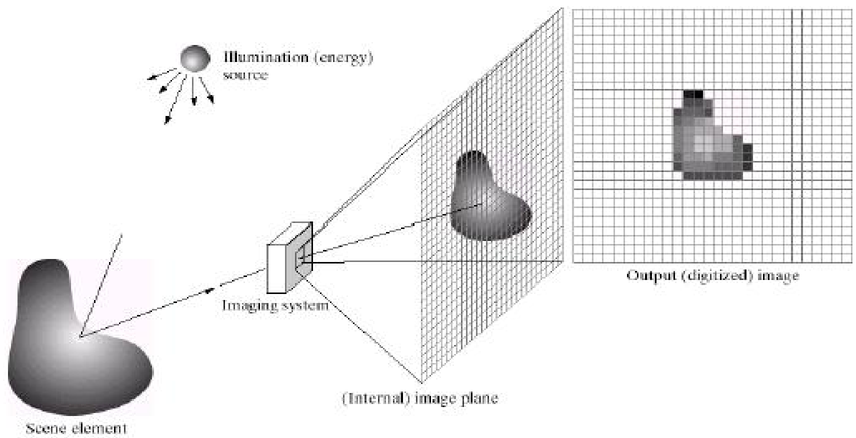


Image sampling and Quantization

- Human eye see objects in terms of **analog signal**
- Computer saves or represent the image in the form of **digital signal**
- In analog domain, an image is defined as two dimensional
  1. **Spatial Location**
  2. **Color intensity**
- **Sampling: Digitization of coordinates values is called sampling**
- **Quantization: Digitization of amplitude values is called Quantization**

Image sampling and Quantization

- Human eye see objects in terms of **analog signal**
- Computer saves or represent the image in the form of **digital signal**
- In analog domain, an image is defined as two dimensional
  1. **Spatial Location (coordinate values)**
  2. **Color intensity (amplitude)**

Image sampling and Quantization

- **Sampling:** Digitization of coordinates values is called sampling
- **Quantization:** Digitization of ampli values is called Quantization

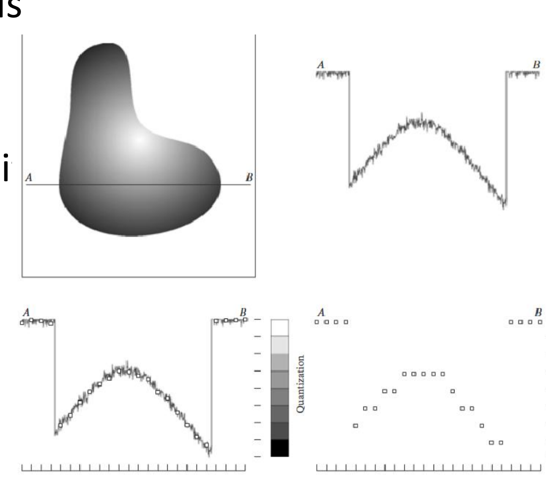


Image sampling and Quantization

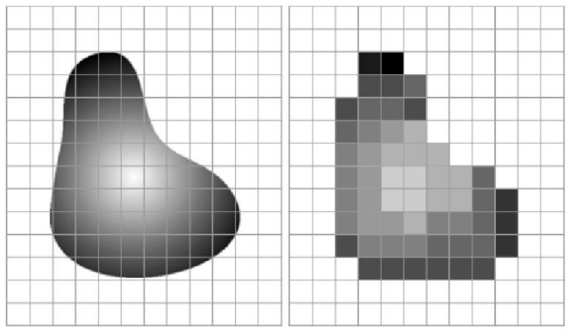


Image Enhancement in Spatial Domain

- Image Enhancement is to improve the quality of a given image

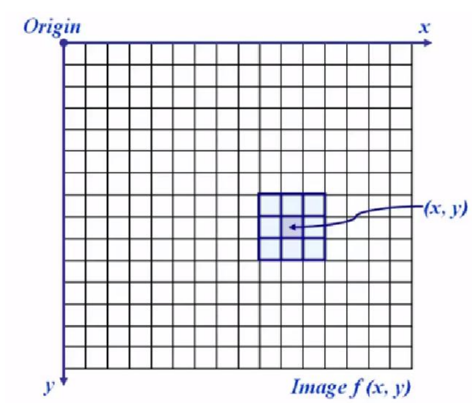
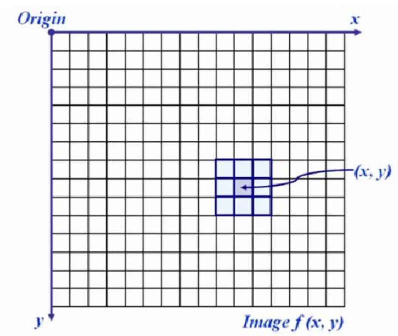


Image Enhancement in Spatial Domain

- In spatial domain an operation (linear or non-linear) is performed on the pixels in the neighborhood of coordinate (x,y) in the input image F(x,y), giving enhanced image F' (x,y)
- Filtering
- Neighborhood can be any shape but generally it is rectangular (3x3, 5x5, 9x9 etc)

$$g(x,y) = T[f(x,y)]$$



Grey Scale Manipulation

- Simplest form of window (1x1)
- Assume input gray scale values (r) are in range [0, L-1] (in 8 bit images L = 256)
- N^{th} root Transformation

$$s = c\,(r)^n$$

Grey Scale Manipulation

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Grey Scale Manipulation

FIGURE 3.3 Some basic gray-level transformation functions used for image enhancement.

- Linear: Negative, Identity
- Logarithmic: Log, Inverse Log
- Power-Law: *n*th power, *n*th root

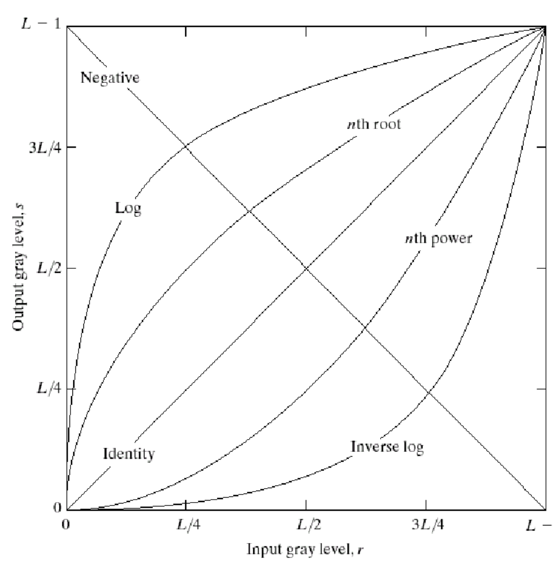
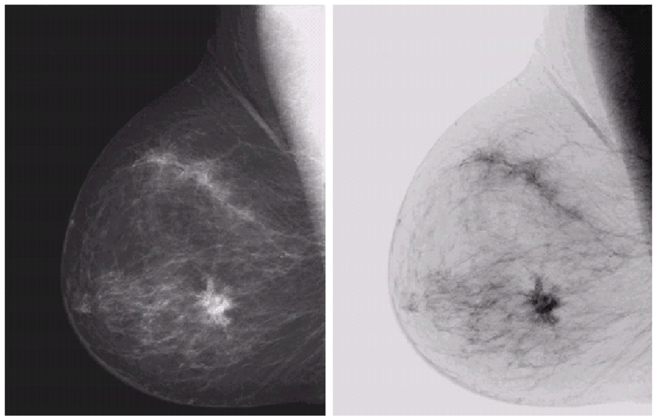


Image Negative



a b

FIGURE 3.4
(a) Original digital mammogram.
(b) Negative image obtained using the negative transformation in Eq. (3.2-1).
(Courtesy of G.E. Medical Systems.)

Image Negative: $s = L - 1 - r$

Log Transformation

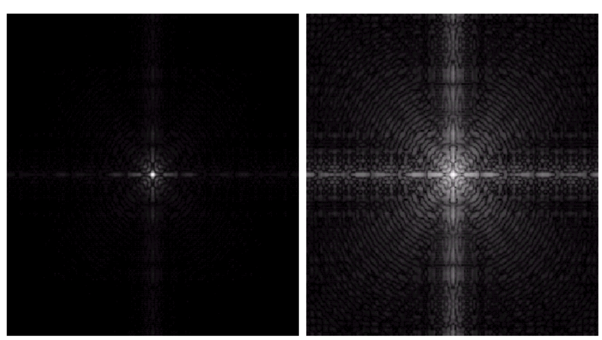
$$s = c \log(1+r)$$

c: constant

- Compresses the dynamic range of images with large variations in pixel values
- Useful when the input graylevel values may have extremely large range of values

a b

FIGURE 3.5
(a) Fourier spectrum.
(b) Result of applying the log transformation given in Eq. (3.2-2) with $c = 1$.



Power Law Transformation

- $s = cr^{\gamma}$
- C, γ : positive constants
- Gamma correction
- Maps a narrow range of dark input values into a wider range of output values or vice versa

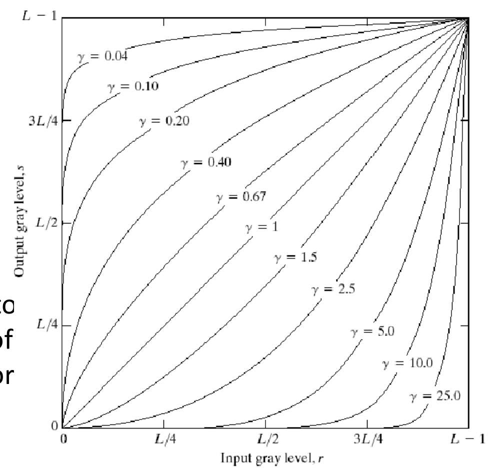


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases).

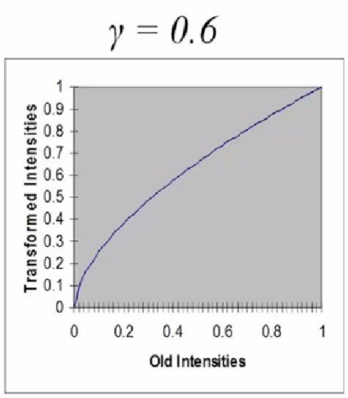
Example of Power Law Transformation

Maps a narrow range of dark input values into a wider range of output values or vice versa

Identification of cavities (holes)

Example of Power Law Transformation

Maps a narrow range of dark input values into a wider range of output values or vice versa



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Example of Power Law Transformation

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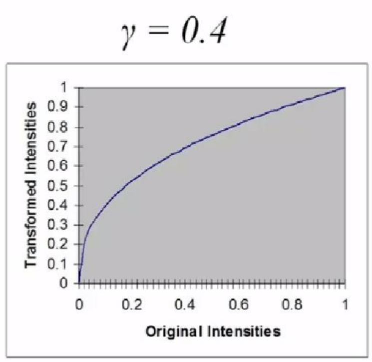
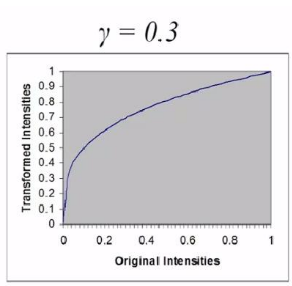


Example of Power Law Transformation

Maps a narrow range of dark input values into a wider range of output values or vice versa



Example of Power Law Transformation

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