



University of Kurdistan

Digital Image Processing (DIP)

Lecture 2: Digital Image Fundamentals

Instructor:

Kaveh Mollazade, Ph.D.

Department of Biosystems Engineering, Faculty of Agriculture, University of Kurdistan,
Sanandaj, IRAN.

Contents

This lecture will cover:

- The human visual system
- Light and the electromagnetic spectrum
- Image representation
- Image sensing and acquisition
- Sampling, quantization, and resolution



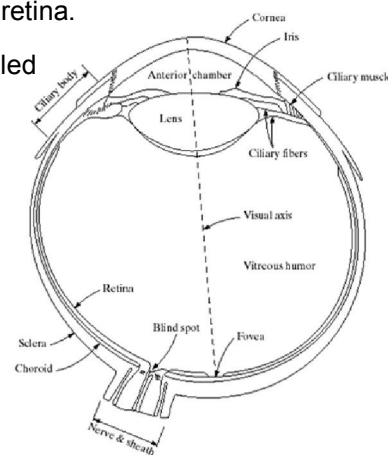
Human visual system

- The best vision model we have!
- Knowledge of how images form in the eye can help us with processing digital images.
- We will take just a whirlwind tour of the human visual system.

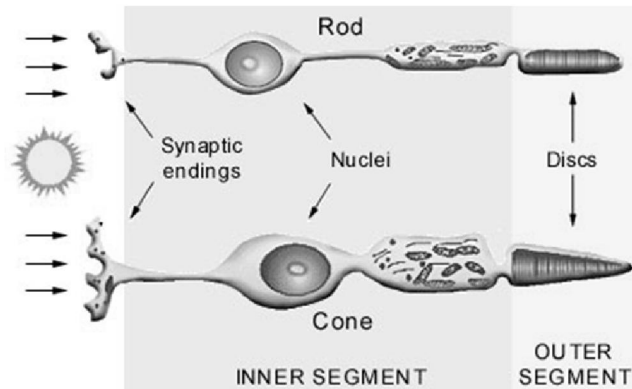


Structure of the human eye

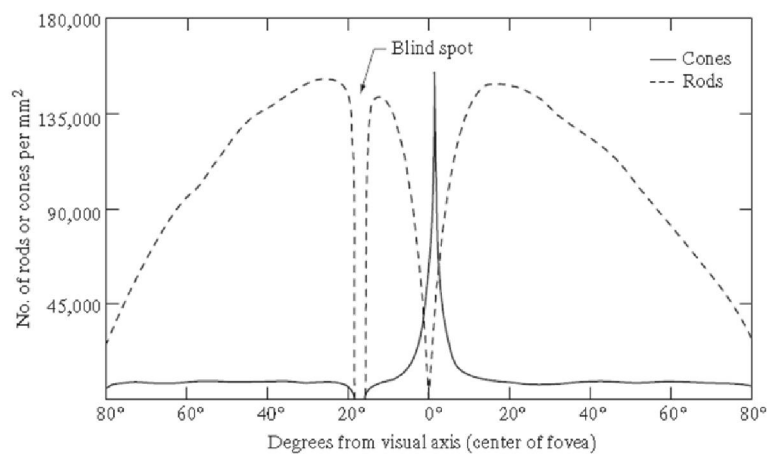
- The lens focuses light from objects onto the retina.
- The retina is covered with light receptors called *cones* (6-7 million) and *rods* (75-150 million).
- Cones are concentrated around the fovea and are very sensitive to colour.
- Rods are more spread out and are sensitive to low levels of illumination.



Structure of the human eye (cont ...)



Structure of the human eye (cont ...)



Cones and rods distribution



Structure of the human eye (cont ...)



Blind-spot experiment

Draw an image similar to that below on a piece of paper (the dot and cross are about 6 inches apart).



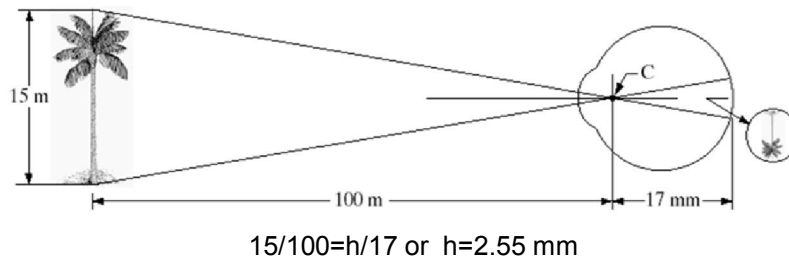
Close your right eye and focus on the cross with your left eye. Hold the image about 20 inches away from your face and move it slowly towards you.

The dot should disappear!



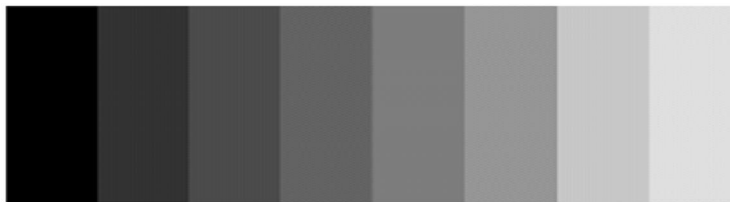
Image formation in the eye

- Muscles within the eye can be used to change the shape of the lens allowing us focus on objects that are near or far away.
- An image is focused onto the retina causing rods and cones to become excited which ultimately send signals to the brain.



Brightness adaptation and discrimination

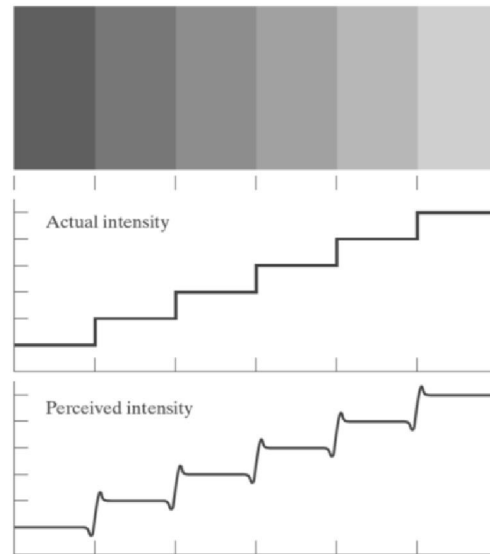
- The human visual system can perceive approximately 10^{10} different light intensity levels.
- However, at any one time we can only discriminate between a much smaller number – *brightness adaptation*
- Similarly, the *perceived intensity* of a region is related to the light intensities of the regions surrounding it.



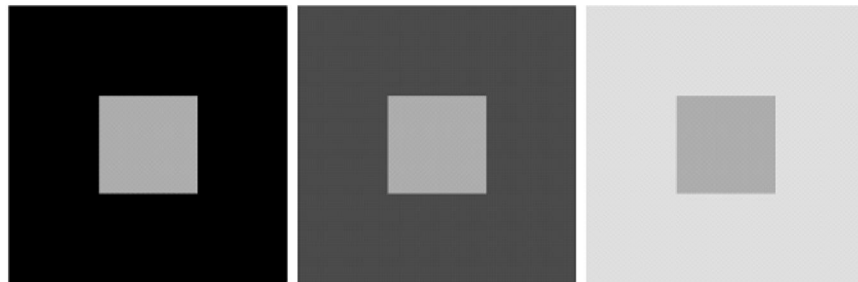
An example of Mach bands



Brightness adaptation and discrimination (cont ...)



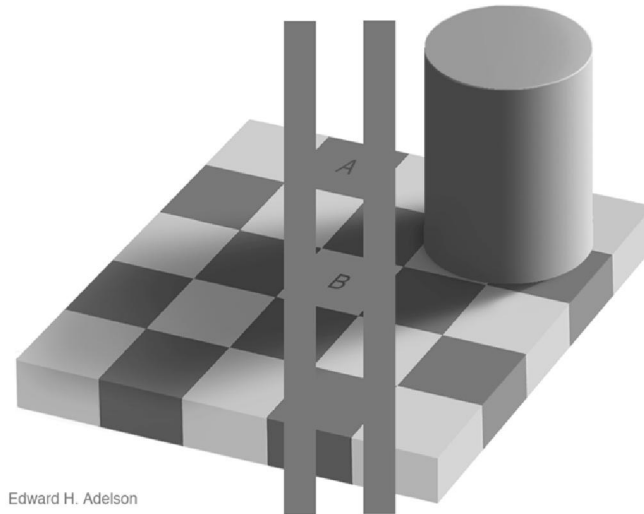
Brightness adaptation and discrimination (cont ...)



An example of *simultaneous contrast*



Brightness adaptation and discrimination (cont ...)

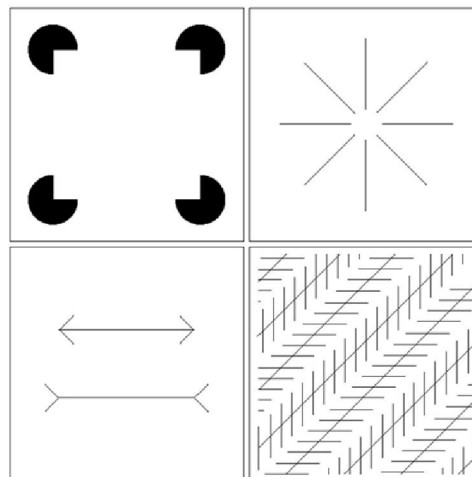


Edward H. Adelson



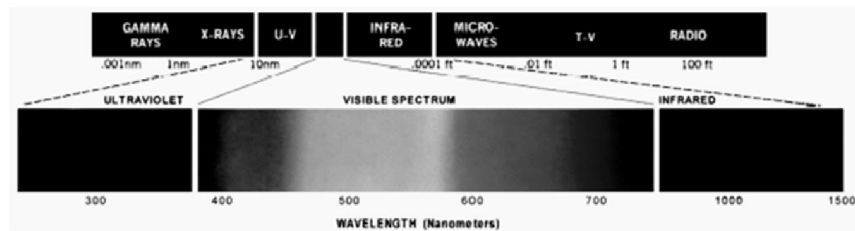
Optical illusions

Our visual systems play lots of interesting tricks on us.



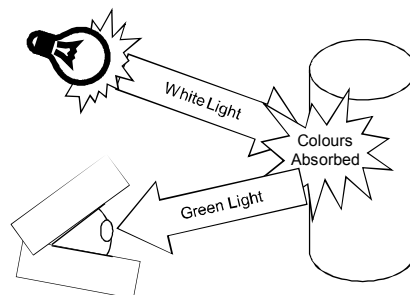
Light and the electromagnetic spectrum

- Light is just a particular part of the electromagnetic spectrum that can be sensed by the human eye.
- The electromagnetic spectrum is split up according to the wavelengths of different forms of energy.



Reflected light

- The colours that we perceive are determined by the nature of the light reflected from an object.
- For example, if white light is shone onto a green object most wavelengths are absorbed, while green light is reflected from the object.



Sampling, quantization, and resolution

In the following slides we will consider what is involved in capturing a digital image of a real-world scene

- Image sensing and representation
- Sampling and quantization
- Resolution



Image representation

- Before we discuss image acquisition recall that a digital image is composed of M rows and N columns of pixels each storing a value.

- Pixel values are most often grey levels in the range 0-255 (black-white).

- We will see later on that images can easily be represented as matrices.

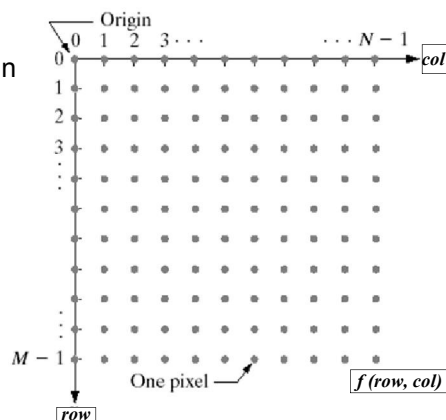


Image acquisition

Images are typically generated by *illuminating a scene* and absorbing the energy reflected by the objects in that scene.

– Typical notions of illumination and scene can be way off:

- X-rays of a skeleton
- Ultrasound of an unborn baby
- Electro-microscopic images of molecules

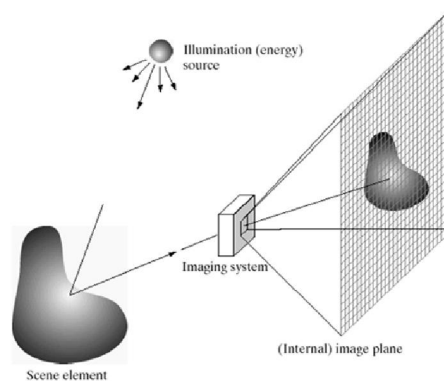


Image sensing

- Incoming energy lands on a sensor material responsive to that type of energy and this generates a voltage.
- Collections of sensors are arranged to capture images.

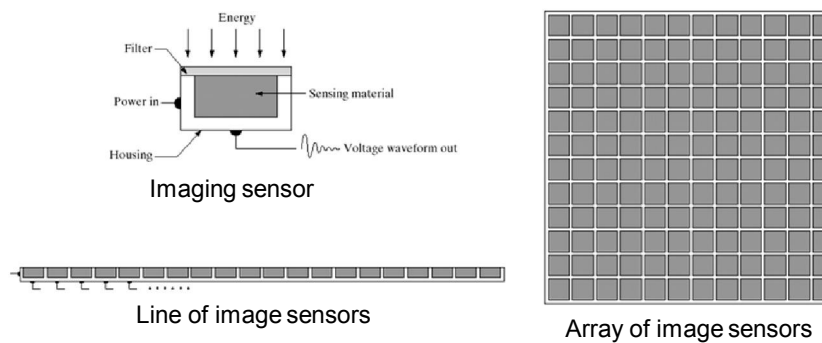


Image sensing (cont ...)

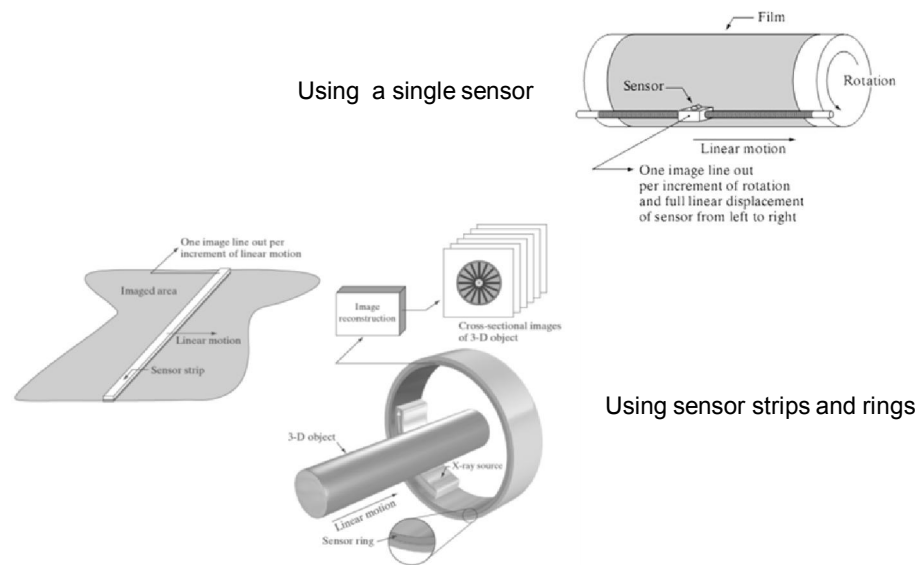


Image sampling and quantization

- A digital sensor can only measure a limited number of **samples** at a **discrete** set of energy levels.
- *Quantisation* is the process of converting a continuous **analogue** signal into a digital representation of this signal.

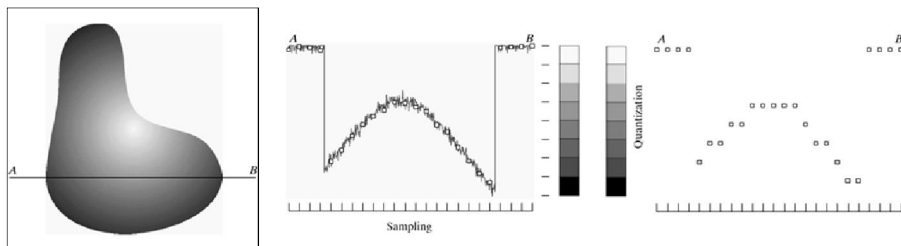
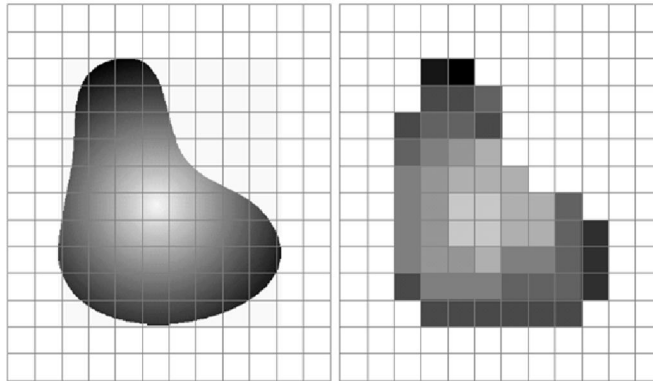
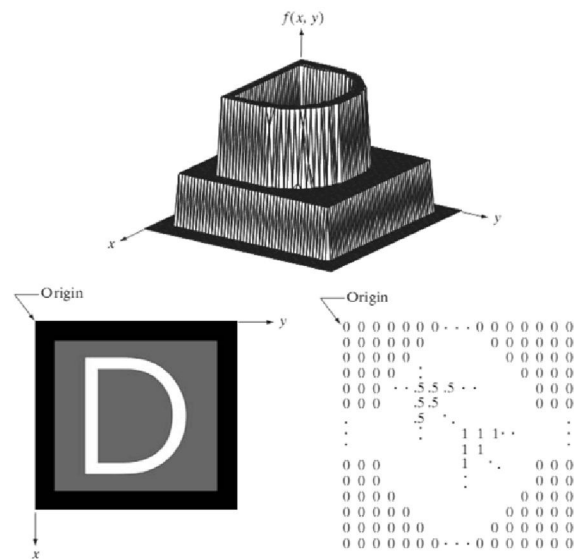


Image sampling and quantization (cont ...)

Remember that a digital image is always only an **approximation** of a real world scene.



Digital image representation



Spatial resolution

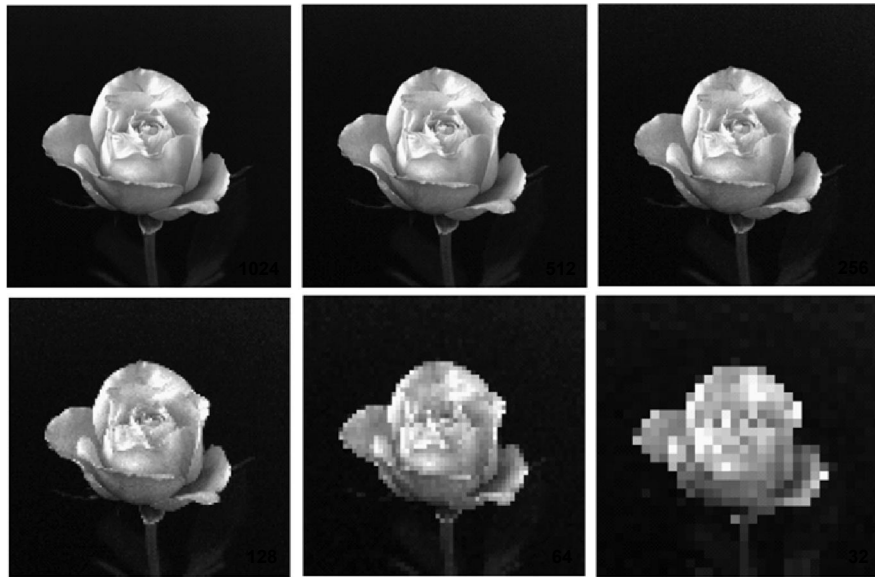
- The *spatial resolution* of an image is determined by how sampling was carried out.
- *Spatial resolution* simply refers to the smallest discernable detail in an image.
- Vision specialists will often talk about pixel size.
- Graphic designers will talk about *dots per inch* (DPI).



Spatial resolution (cont ...)



Spatial resolution (cont ...)



Intensity level resolution

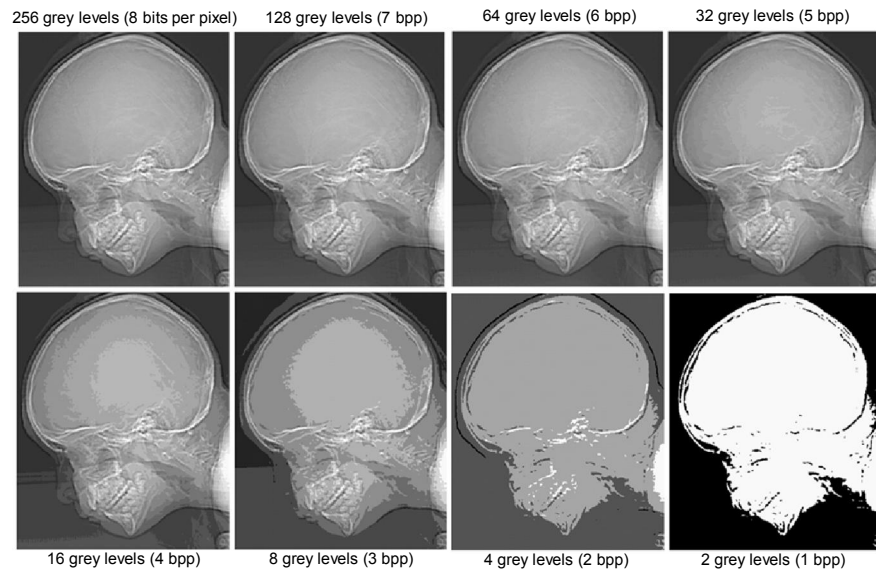
Intensity level resolution refers to the number of intensity levels used to represent the image.

- The more intensity levels used, the finer the level of detail discernable in an image.
- Intensity level resolution is usually given in terms of the number of bits used to store each intensity level.

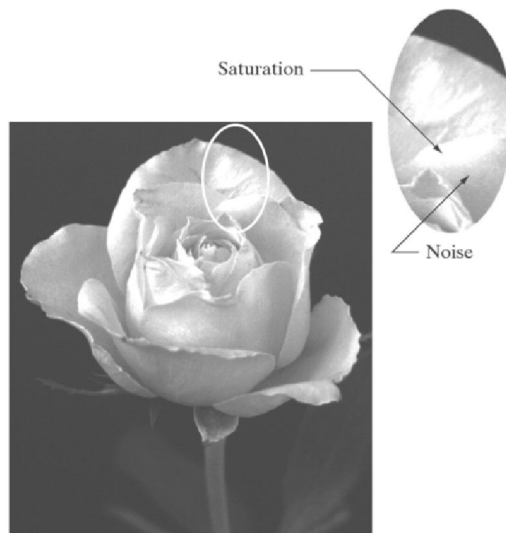
Number of Bits	Number of Intensity Levels	Examples
1	2	0, 1
2	4	00, 01, 10, 11
4	16	0000, 0101, 1111
8	256	00110011, 01010101
16	65,536	10101010101010



Intensity level resolution (cont ...)



Saturation & noise



Resolution: How much is enough?

The big question with resolution is always *how much is enough?*

- This all depends on what is in the image and what you would like to do with it.
- Key questions include:
 - Does the image look aesthetically pleasing?
 - Can you see what you need to see within the image?



Resolution: How much is enough? (cont ...)



The picture on the right is fine for counting the number of cars, but not for reading the plate number.



Summary

We have looked at:

- Human visual system
- Light and the electromagnetic spectrum
- Image representation
- Image sensing and acquisition
- Sampling, quantization, and resolution

Next time we start to look at techniques for image enhancement.

