Image Acquisition

Image Sensing and Acquisition

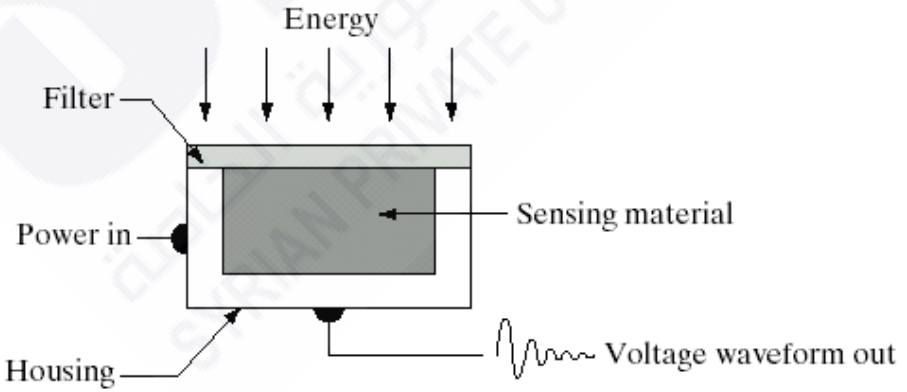
Image acquisition using a single sensor:

A **sensor** is a device used to transform illumination energy into electrical signal

Imaging Sensor: **incoming energy is transformed into a voltage.**

PHOTODIODE IS AN EXAMPLE WHERE THE OUTPUT VOLTAGE IS PROPORTIONAL TO LIGHT.

The filter improves selectivity of light in a band of certain color.



How to generate an image using single sensor?

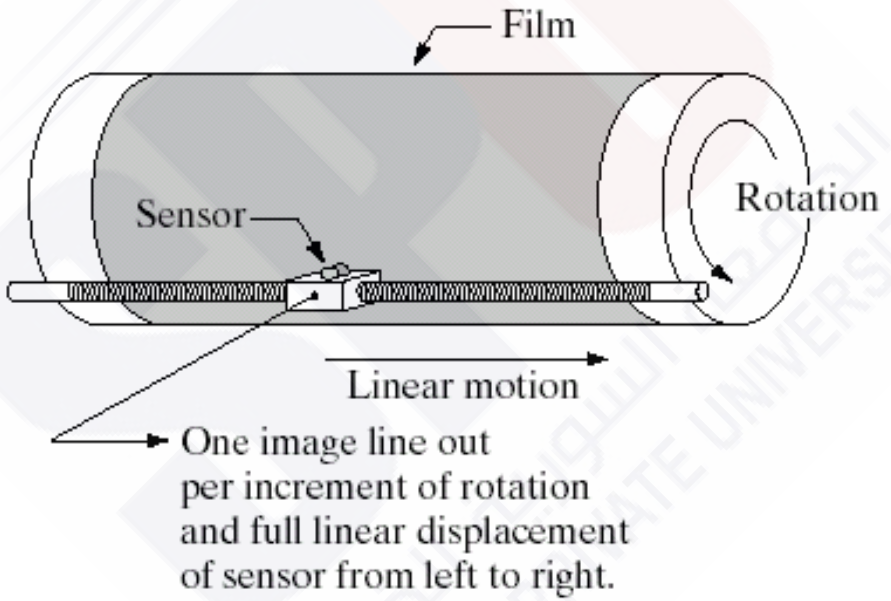


FIGURE 2.13 Combining a single sensor with motion to generate a 2-D image.

Image acquisition using Sensor strips:

Used in imaging systems mounted on an aircraft flying in an constant altitude and speed or office document scanners.

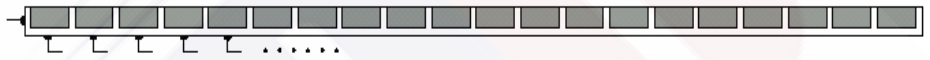
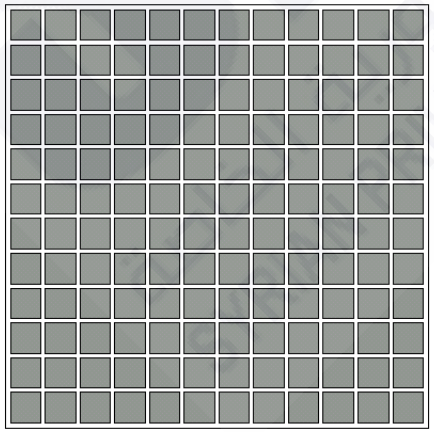


Image acquisition using sensor arrays:

CCD arrays in digital cameras4000×4000)elements or more.



A Simple Image Formation Model

An **Image** is a two dimensional function of the form: $f(x,y)$
The value of f at coordinates (x,y) is a positive scalar whose physical meaning is determined by the nature of the image.

$$0 < f(x,y) < \infty$$

$$f(x, y) = i(x, y)\, r(x,y)$$

Where : $0 < i(x, y) < \infty$ *and* $0 < r(x, y) < 1$

i(x,y): **illumination** and r(x,y): **reflectance** or absorption of energy by the object in the scene if image is formed form transmission of illumination through a medium $r(x,y)$ is transmissivity (X-ray images)

Representing Digital Images

Sampling and quantization of a continuous image *f(x,y)* will transform it into digital image . it can be represented by an array of N×M Dimension. where N is the number of samples in *y* direction, M is the number of samples in *x* direction.

y = 0,1,2,3,…..N-1 N number of colons

x =0,1,2,3,……M-1 M number of rows

x,*y* are called spatial coordinates

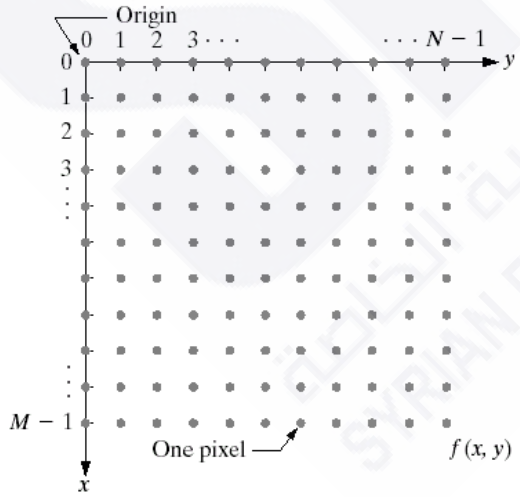


FIGURE 2.18 Coordinate convention used in this book to represent digital images.

Numerical array representation of an M*N elements (pixel) image

$$f(x, y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0, N-1) \\ f(1,0) & f(1,1) & \cdots & f(1, N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1, N-1) \end{bmatrix}$$

Matrix representation:

$$\mathbf{A} = \begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,N-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,N-1} \\ \vdots & \vdots & & \vdots \\ a_{M-1,0} & a_{M-1,1} & \cdots & a_{M-1,N-1} \end{bmatrix}$$

Number of bits to store an image ?

Digitization needs to chose number of intensity levels L which should be positive integer. Due to storage and quantization hardware

$$L = 2^k$$

[0,L-1] is the dynamic range of an image.

Image contrast: the difference between the highest and the lowest intensity levels in an image.

Number of bits to store an image $b = M \times N \times k$

N/k	1 ($L = 2$)	2 ($L = 4$)	3 ($L = 8$)	4 ($L = 16$)	5 ($L = 32$)	6 ($L = 64$)	7 ($L = 128$)	8 ($L = 256$)
32	1,024	2,048	3,072	4,096	5,120	6,144	7,168	8,192
64	4,096	8,192	12,288	16,384	20,480	24,576	28,672	32,768
128	16,384	32,768	49,152	65,536	81,920	98,304	114,688	131,072
256	65,536	131,072	196,608	262,144	327,680	393,216	458,752	524,288
512	262,144	524,288	786,432	1,048,576	1,310,720	1,572,864	1,835,008	2,097,152
1024	1,048,576	2,097,152	3,145,728	4,194,304	5,242,880	6,291,456	7,340,032	8,388,608
2048	4,194,304	8,388,608	12,582,912	16,777,216	20,971,520	25,165,824	29,369,128	33,554,432
4096	16,777,216	33,554,432	50,331,648	67,108,864	83,886,080	100,663,296	117,440,512	134,217,728
8192	67,108,864	134,217,728	201,326,592	268,435,456	335,544,320	402,653,184	469,762,048	536,870,912

SPATIAL and INTENSITY Resolution

SPATIAL RESOLUTION : is a measure of smallest discernable details in an image. We use black and white chart of lines of different width to test the resolution of a system. It is related to imaging system ,size of CCD, the area to be imaged.

INTENSITY RESOLUTION:

Number of bits used to quantize intensity.

Usually 8 bits are used.

What are the effects of lower number of bits ?

Zooming and Shrinking

This topic is related to image sampling and quantization because zooming may be viewed as oversampling, while shrinking may be viewed as under sampling. The key difference between these two operations and sampling and quantizing an original continuous image is that zooming and shrinking are applied to a *digital image*.

Image Interpolation

interpolation is the process of using known data to estimate values at unknown locations,
A basic tool used in zooming, shrinking, rotating and geometric correction. when we need Image resampling?

- **Nearest neighbor interpolation**
  the value assigned to a new pixel is the the value of its nearest neighbor.
- **Bilinear interpolation**

$$v(x, y) = ax + by + cxy + d$$

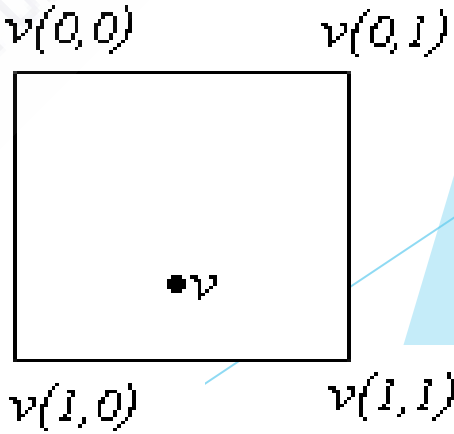
Exercise:

Geometric transformation of an image (ex. rotation or scaling) will involve interpolation techniques to estimate image values in new locations. Find the image value of a point v(0.7,0.4) using:

a. nearest neighbor interpolation
b. bilinear interpolation

v(0,0)=40; v(0,1)= 50; v(1,0)= 35; v(1,1)=100

$$v(x, y) = ax + by + cxy + d$$



Problem

A common measure of transmission for digital data is the *baud rate*, defined as the number of bits transmitted per second. Generally, transmission is accomplished in packets consisting of a start bit, a byte (8 bits) of information, and a stop bit.
Using these facts, answer the following:
(a) How many minutes would it take to transmit a 1024 * 1024 image with 256 Intensity levels using a 56K baud modem?
(b) What would the time be at 3000K baud, a representative medium speed of a phone DSL (Digital Subscriber Line) connection?

Answers (a) 3.12 minutes (b) 3 sec.

Problem

High-definition television (HDTV) generates images with 1080 horizontal TV lines (each frame takes $1/60^{th}$ second in duration). The width-to-height aspect ratio of the images is 16:9. The fact that the number of horizontal lines is fixed determines the vertical resolution of the images. A company has designed an image capture system that generates digital images from HDTV images. The resolution of each TV (horizontal) line in their system is in proportion to vertical resolution, with the proportion being the width-to-height ratio of the images.

Each pixel in the color image has 24 bits of intensity resolution, 8 bits each for a red, a green, and a blue image. These three "primary" images form a color image.

How many mega bytes would it take to store a 1-hour HDTV movie?

END OF PRESENTATION