DSIP – Lecturer 03

Recruiters In this Field In India

- Sarnoff Corporation
- Kritikal Solutions
- National Instruments
- GE Laboratories
- Ittiam, Bangalore
- Interra Systems, Noida
- Yahoo India (Multimedia Searching)
- nVidia Graphics, Pune (have high requirements)
- Microsoft research
- DRDO labs
- ISRO labs
- …

Book List :

Gonzalez, R. C. and Woods, R. E., "Digital Image Processing", Prentice Hall, 3rd Ed.
Jain, A. K., "Fundamentals of Digital Image Processing", PHI Learning, 1st Ed.
Bernd, J., "Digital Image Processing", Springer, 6th Ed.
Burger, W. and Burge, M. J., "Principles of Digital Image Processing", Springer
Scherzer, O., " Handbook of Mathematical Methods in Imaging", Springer

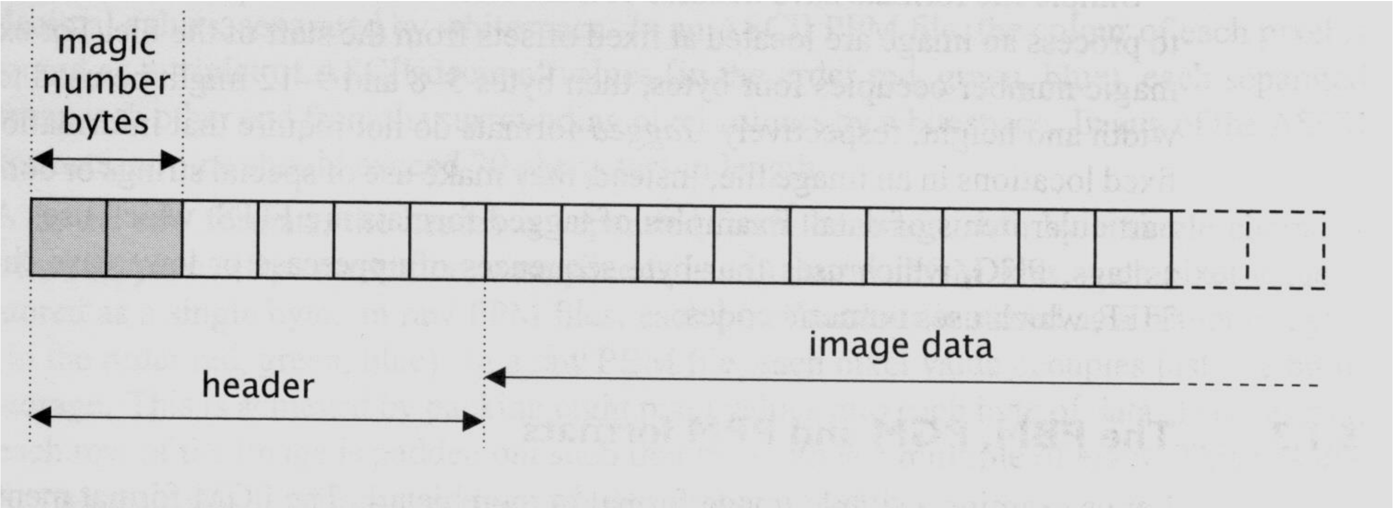
Review

- What is a digital image?
- Image file Formats
- What is digital image processing?
- steps in digital image processing

Image file formats

- Many image formats adhere to the simple model shown below (line by line, no breaks between lines).
- The header contains at least the width and height of the image.
- Most headers begin with a **Signature**

  (i.e., a short sequence of bytes for identifying the file format)



Common image file formats

- GIF (Graphic Interchange Format) -
- PNG (Portable Network Graphics)
- JPEG (Joint Photographic Experts Group)
- TIFF (Tagged Image File Format)
- PGM (Portable Gray Map)
- FITS (Flexible Image Transport System)

PBM/PGM/PPM format

- A popular format for grayscale images (8 bits/pixel)
- Closely-related formats are:
  - PBM (Portable Bitmap), for binary images (1 bit/pixel)
  - PPM (Portable Pixelmap), for color images (24 bits/pixel)

ASCI

```
P2
# a simple PGM image
7 7 255
  120 120 120 120 120 120 120
  120 120 120  33 120 120 120
  120 120 120  33 120 120 120
  120  33  33  33  33  33 120
  120 120 120  33 120 120 120
  120 120 120  33 120 120 120
  120 120 120 120 120 120 120
```

Binary

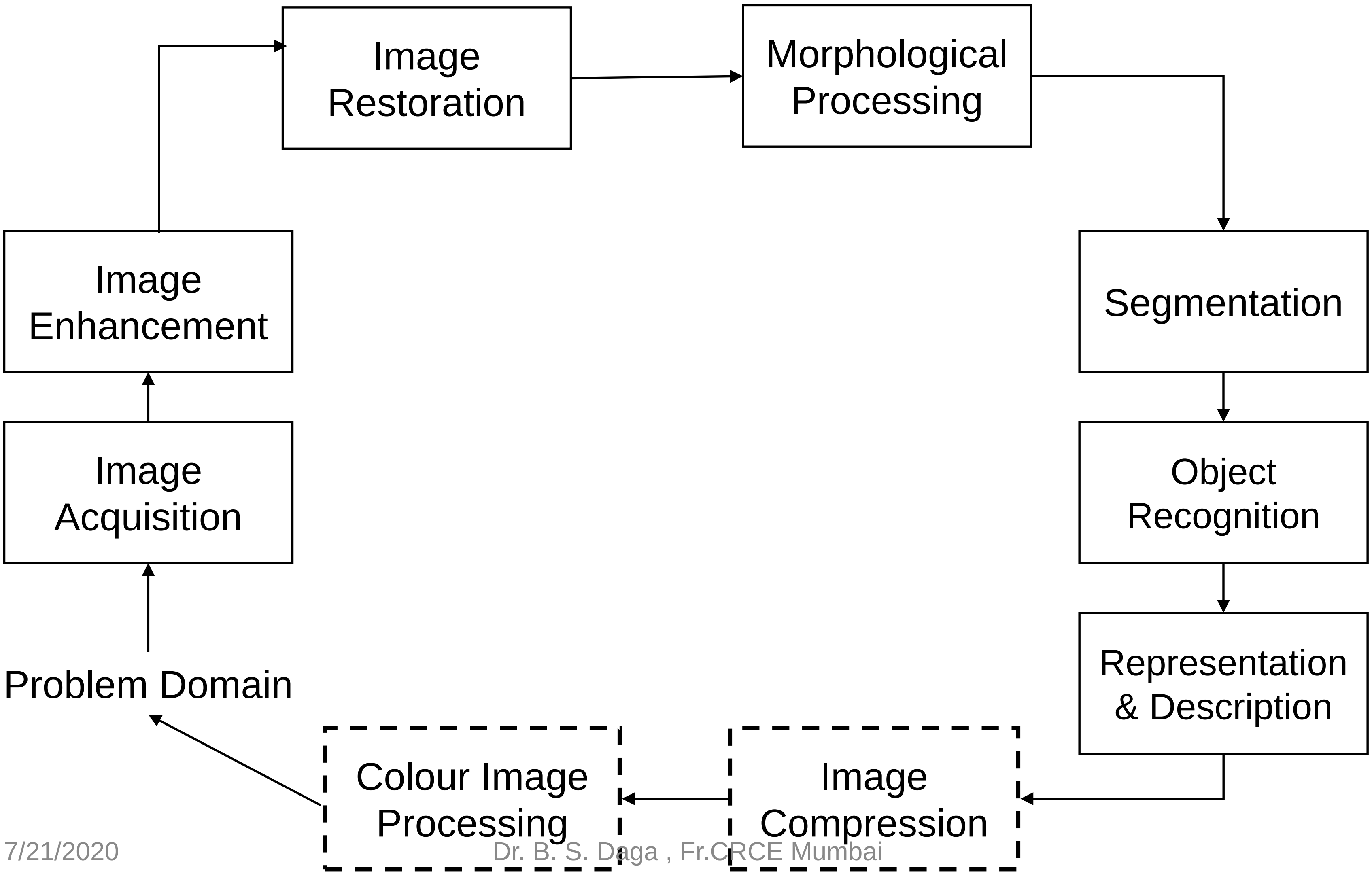
```
P5
# a simple PGM image
7 7 255
xxxxxxxxxx!xxxxxx!xxxx!!!!!xxxx!xxxxxx!xxxxxxxxxx
```

ASCII or binary (raw) storage

Signatures of the various PBM, PGM and PPM image formats.

Signature	Image type	Storage type
P1	binary	ASCII
P2	greyscale	ASCII
P3	RGB	ASCII
P4	binary	raw bytes
P5	greyscale	raw bytes
P6	RGB	raw bytes

Steps in Digital Image Processing



Contents

- Image Formation Model
- Image Planes Geometry
- Different image acquiring Systems
- Image Sampling and Quantization

A Simple model of image formation

- The scene is illuminated by a single source.
- The scene reflects radiation towards the camera.
- The camera senses it via solid state cells (CCD cameras)

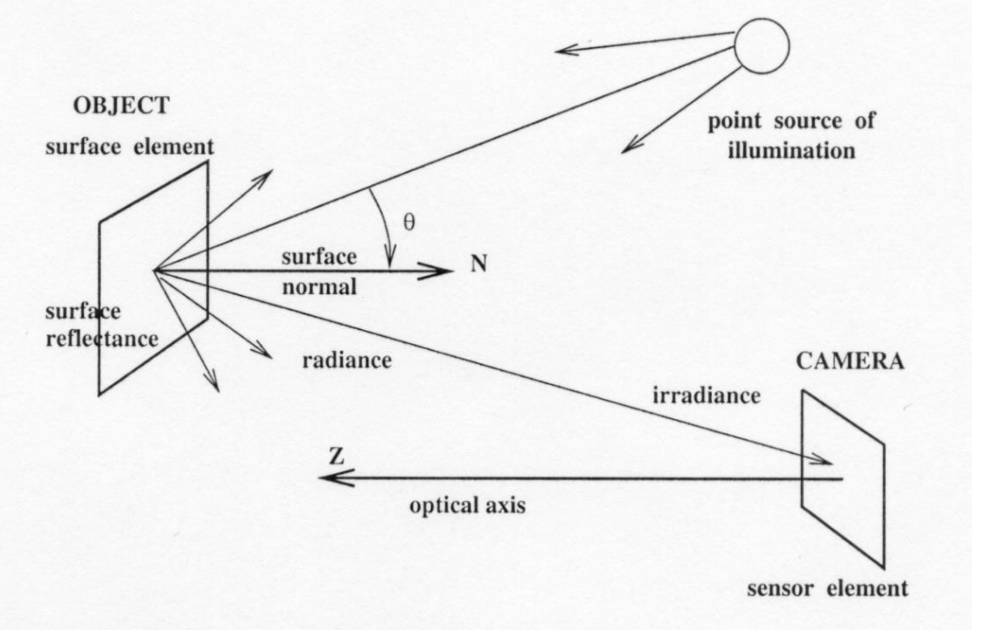


Image formation (cont'd)

- There are two parts to the image formation process:

(1) The **geometry**, which determines where in the image plane the projection of a point in the scene will be located.

Simple model: $\mathbf{f(x,y) = i(x,y)\ r(x,y)}$

(2) The **physics of light**, which determines the brightness of a point in the image plane.

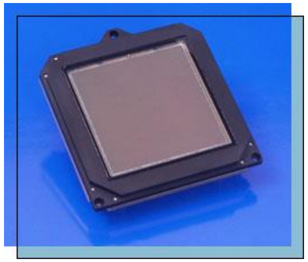
Tessilations

The **geometry** in which image plane can be divided

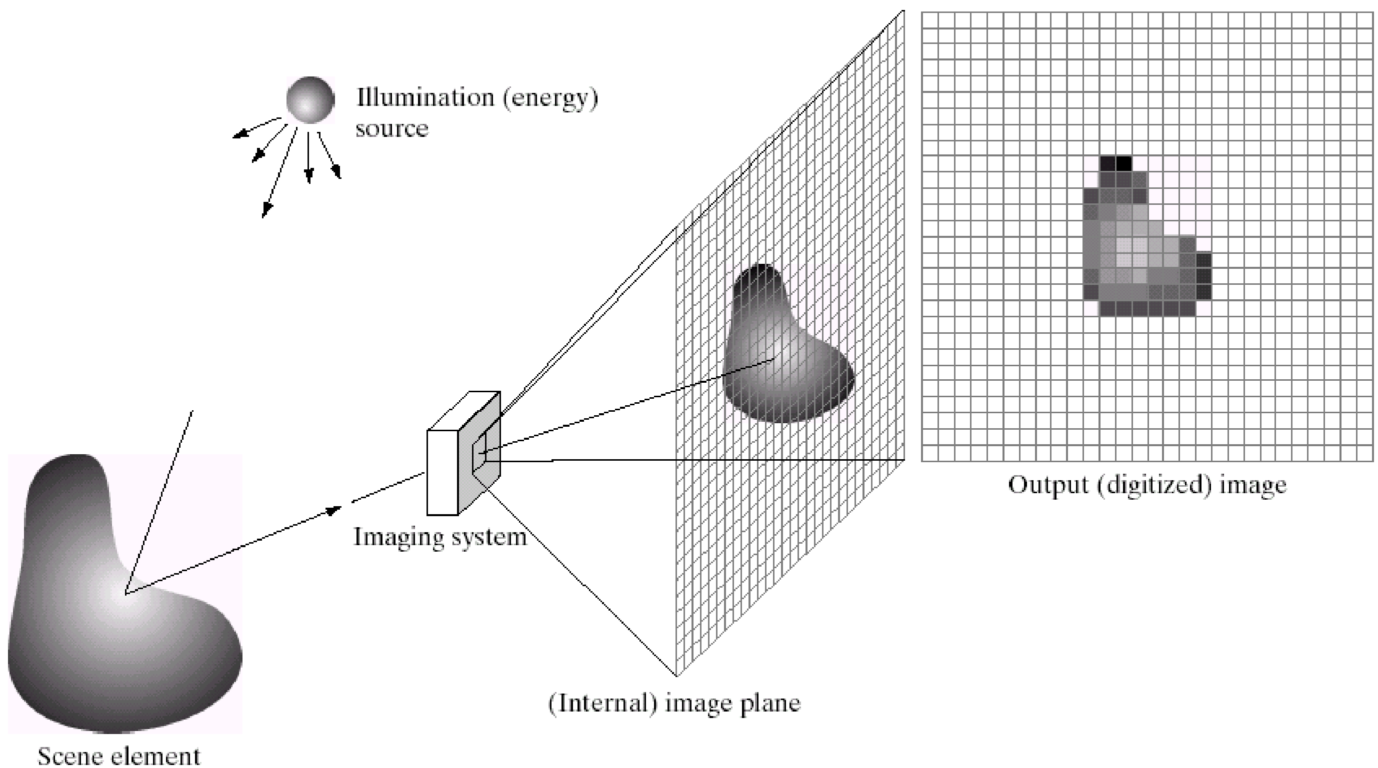
- Square Grid
- Hexagonal Grid
- Triangular Grid

Digital cameras

- A digital camera replaces film with a sensor array.
  - Each cell in the array is light-sensitive diode that converts photons to electrons
  - Two common types
    - Charge Coupled Device (CCD)
    - Complementary metal oxide semiconductor (CMOS)

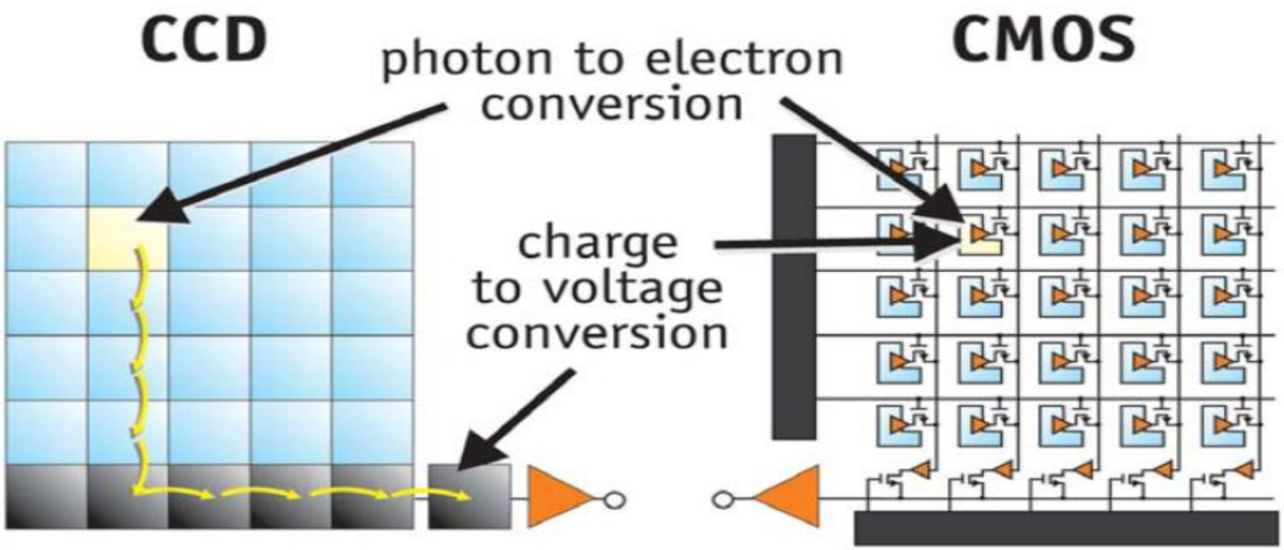


Digital cameras (cont'd)



CCD Cameras

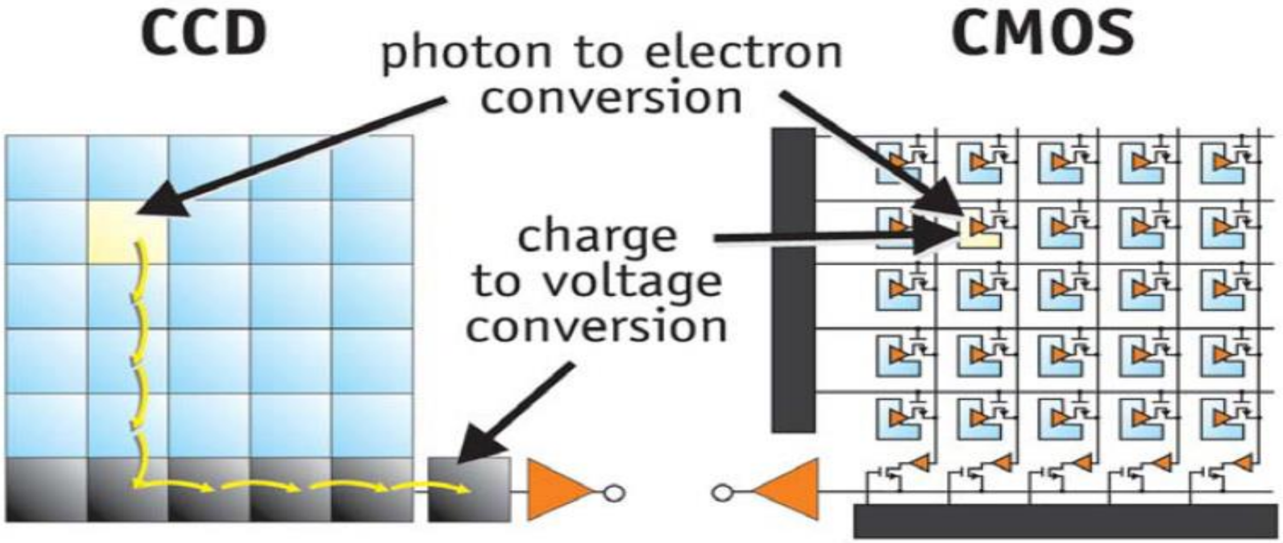
- CCDs move photogenerated charge from pixel to pixel and convert it to voltage at an output node.
- An **analog-to-digital converter (ADC)** then turns each pixel's value into a digital value.



http://www.dalsa.com/shared/content/pdfs/CCD_vs_CMOS_Litwiller_2005.pdf

CMOS Cameras

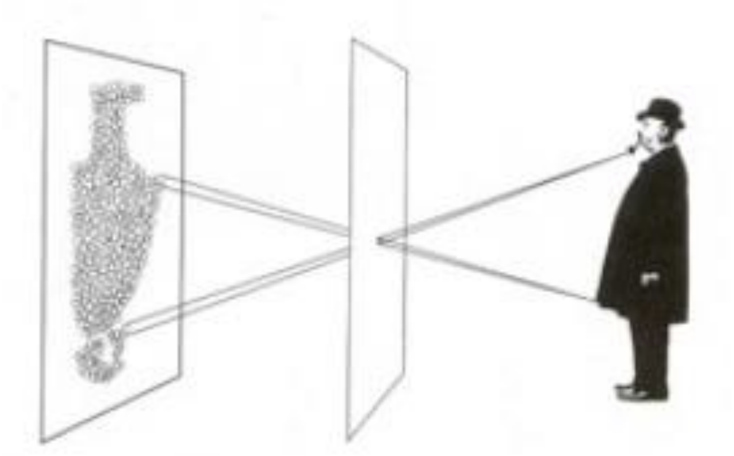
- CMOs convert charge to voltage inside each element.
- Uses several transistors at each pixel to amplify and move the charge using more traditional wires.
- The CMOS signal is digital, so it needs no ADC.



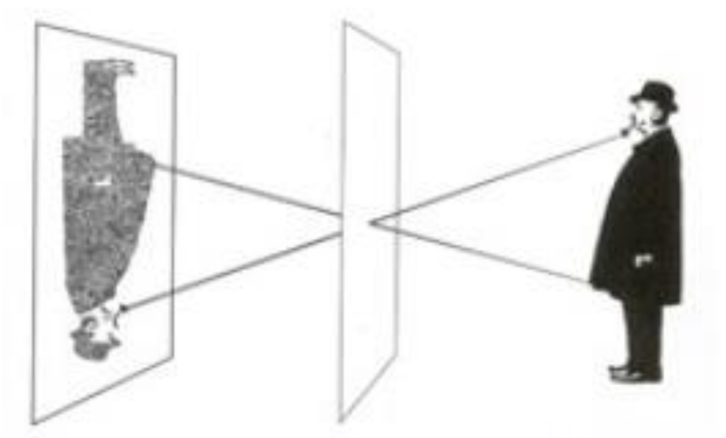
http://www.dalsa.com/shared/content/pdfs/CCD_vs_CMOS_Litwiller_2005.pdf

What is the effect of aperture size?

Large aperture: light from the source spreads across the image (i.e., not properly focused), making it blurry!



Small aperture: reduces blurring but (i) it limits the amount of light entering the camera and (ii) causes light diffraction.



Some Image Acquiring Systems :

- Videocon Tube
- A Line Scan CCD sensor
- Image Orthicon Tube
- Iconoscope Tube
- Image Dissector Tube

Image Sampling and Quantization

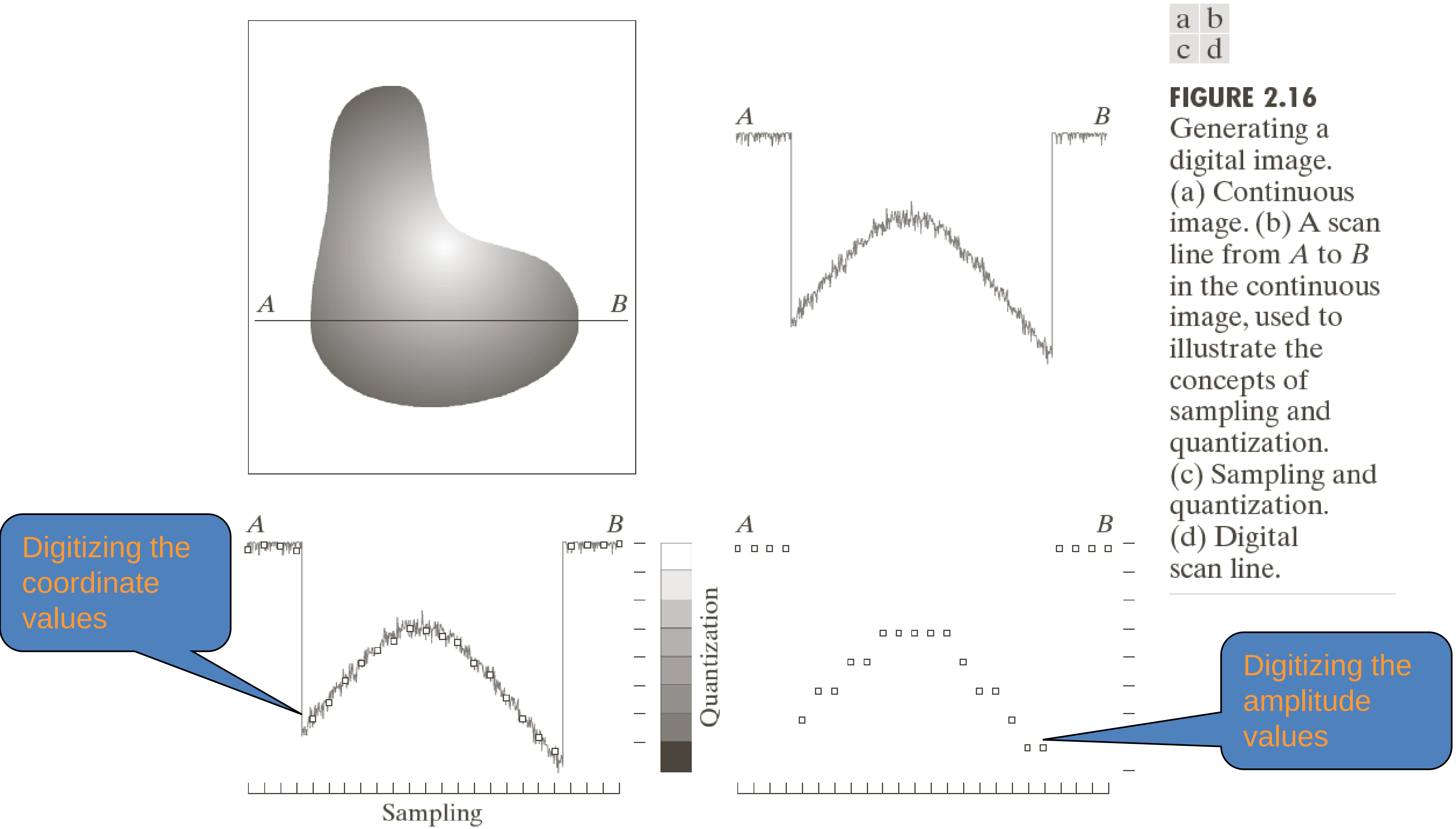


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

Image Sampling and Quantization

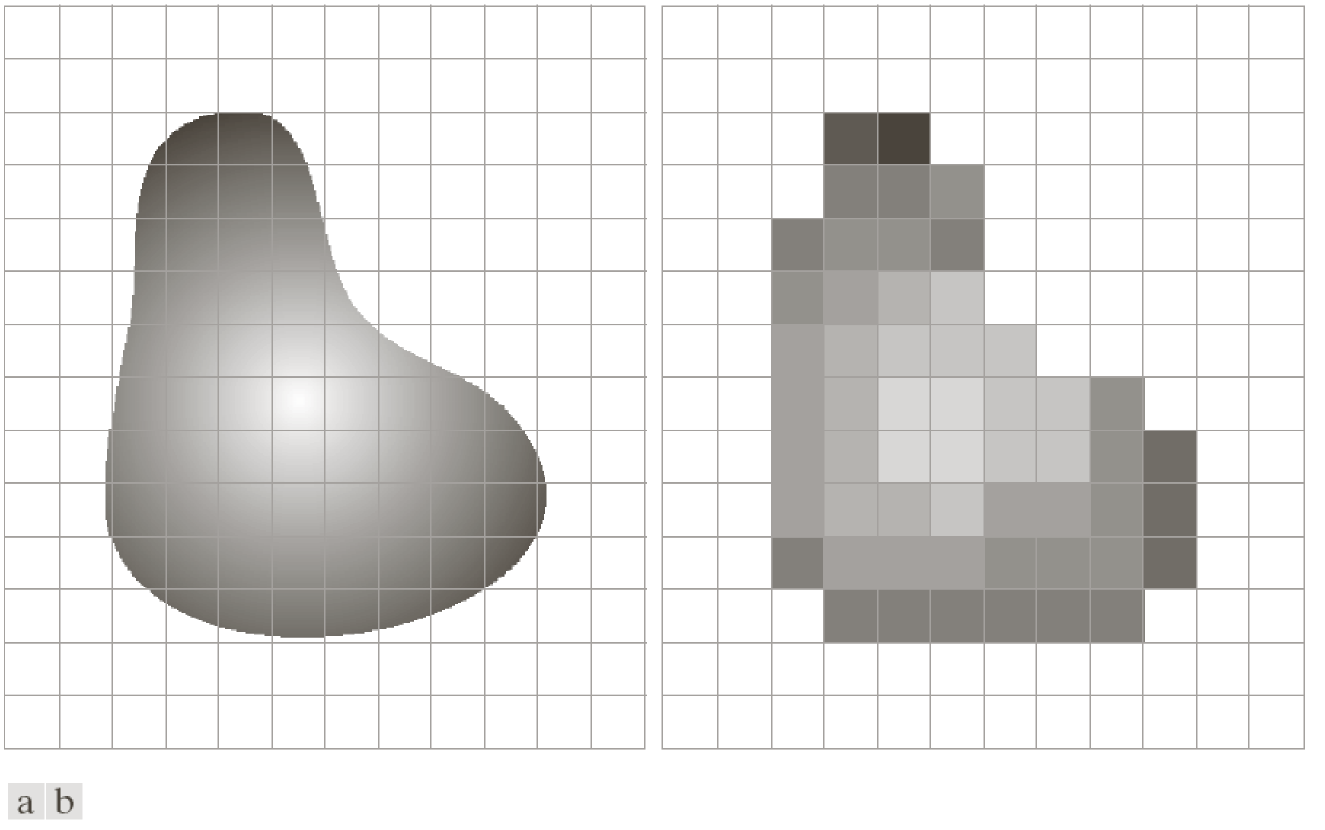
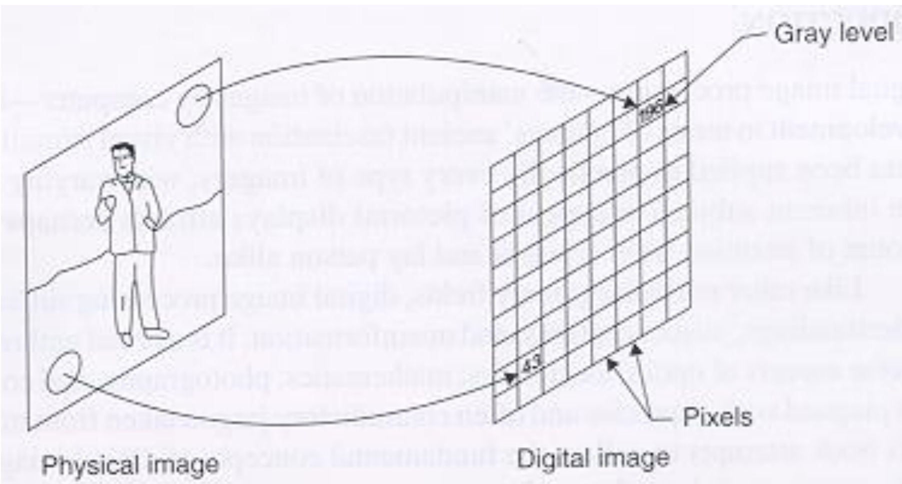
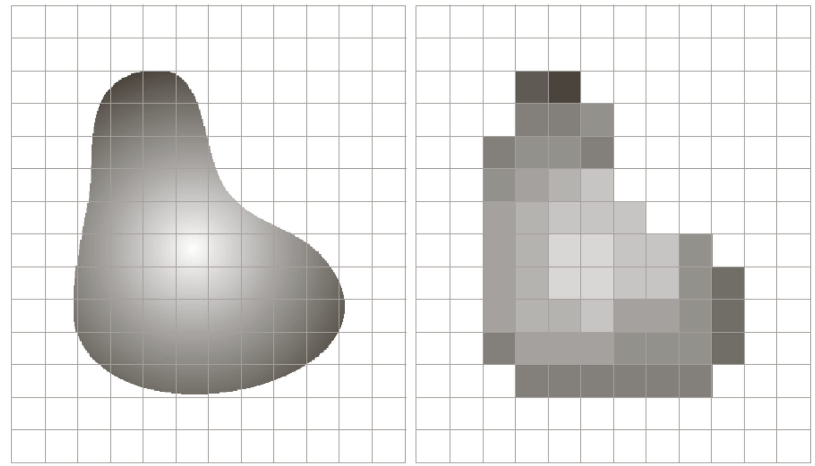


FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

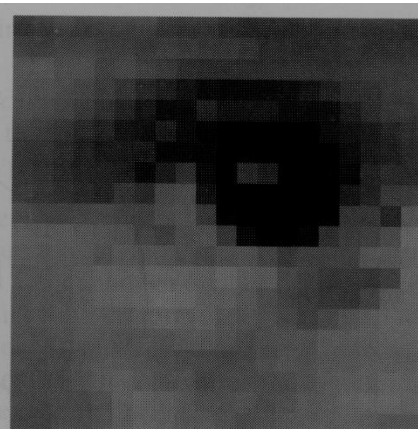
Sampling & Quantizations - Results





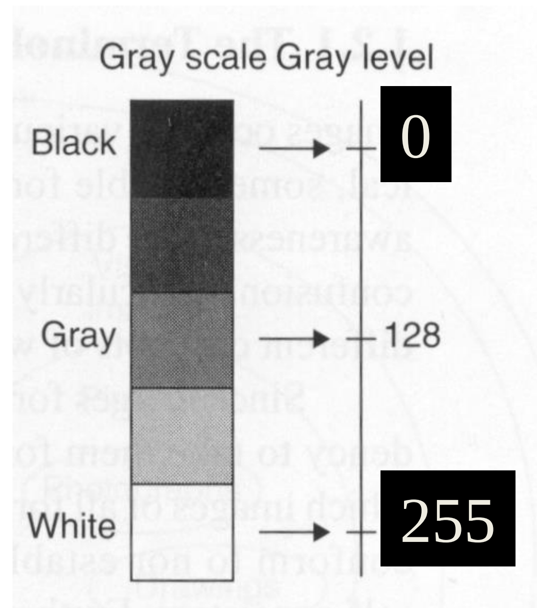
- **Sampling**: measure the value of an image by a finite number of points.
- **Quantization**: represent measured value (i.e., voltage) at the sampled point by an integer.

Digital Image Form



117	125	133	127	130	130	133	121	116	115	100	91	93	94	99	103	112	105	109	106
134	133	138	138	132	134	130	133	128	123	121	113	106	102	99	106	113	109	109	113
146	147	138	140	125	134	124	115	102	96	93	94	99	96	99	100	103	110	109	110
144	141	136	130	120	108	88	74	53	37	31	37	35	39	53	79	93	100	109	116
139	136	129	119	102	85	58	31	41	77	51	53	53	33	37	41	69	94	105	108
132	127	117	102	87	57	49	77	42	28	17	15	13	13	17	41	53	69	88	100
124	120	108	94	72	74	72	31	35	31	15	13	15	11	15	13	46	75	83	96
125	115	102	93	88	82	42	79	113	41	19	100	82	11	11	17	31	91	99	100
124	116	109	99	91	113	99	140	144	57	20	20	15	11	15	17	63	87	119	124
136	133	133	135	138	133	132	144	150	120	24	17	15	15	17	20	115	113	88	150
158	157	157	154	149	145	133	127	146	150	116	35	20	19	28	105	124	128	141	171
155	154	156	155	146	155	154	154	147	139	148	150	138	120	128	129	130	151	156	165
150	151	154	162	166	167	169	174	172	167	177	166	164	140	134	120	121	120	127	172
145	149	151	157	165	169	173	179	176	166	166	157	145	136	129	124	120	136	163	168
144	148	153	160	159	158	165	172	165	169	157	151	149	141	130	140	151	162	169	167
144	141	147	155	154	149	156	151	157	157	151	144	147	147	149	159	158	159	166	165
139	140	140	150	153	151	150	146	140	139	138	140	145	151	149	156	156	162	162	161
136	134	138	146	156	164	153	146	145	136	139	139	140	141	149	157	159	161	169	166
136	133	136	135	144	159	168	159	151	142	141	145	139	146	153	156	164	167	172	168
133	129	140	142	146	159	167	165	154	151	146	141	147	154	156	160	161	157	153	154

8 bits/pixel



Matrix Representation

- The representation of an M×N numerical array as

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

Representing Digital Images

- The representation of an M×N numerical array as

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

Representing Digital Images

- The representation of an M×N numerical array in MATLAB

$$f(x,y)=\begin{bmatrix} f(1,1) & f(1,2) & \dots & f(1,N) \\ f(2,1) & f(2,2) & \dots & f(2,N) \\ \dots & \dots & \dots & \dots \\ f(M,1) & f(M,2) & \dots & f(M,N) \end{bmatrix}$$

Representing Digital Images

- Discrete intensity interval $[0, L-1]$, $L=2^k$
- Total Number of bits b , required to store a $M \times N$ digitized image

$$b = M \times N \times k$$

Number of Storage Bits

TABLE 2.1
Number of storage bits for various values of N and 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

Visual Illustrations of Concepts :

- Digital Image discrete Sampled Version
- Image Sampling – Example
- Image Quantization – Example

A **digital** image is a discrete (**sampled**, **quantized**) version .

- Image as a **function**, *f* (*x,y*) , or a 2D *signal*
  - *It* gives the **intensity** at position (*x,y*)

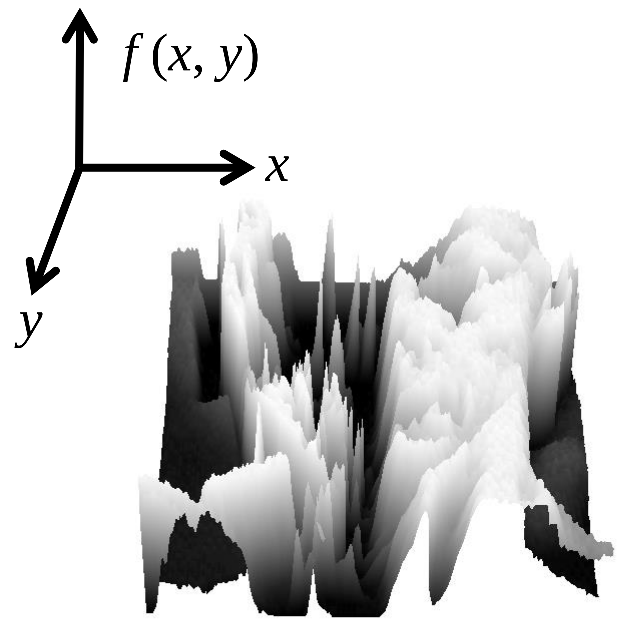


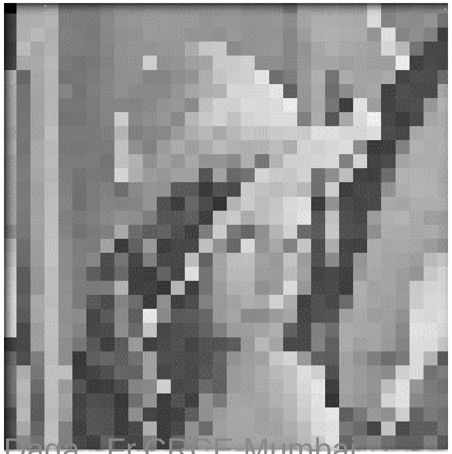
Image Sampling - Example

original image

sampled by a factor of 2

sampled by a factor of 4

sampled by a factor of 8



Images have been resized for easier comparison

Image Quantization - Example

- 256 gray levels (8bits/pixel) 32 gray levels (5 bits/pixel) 16 gray levels (4 bits/pixel)



- 8 gray levels (3 bits/pixel) 4 gray levels (2 bits/pixel) 2 gray levels (1 bit/pixel)