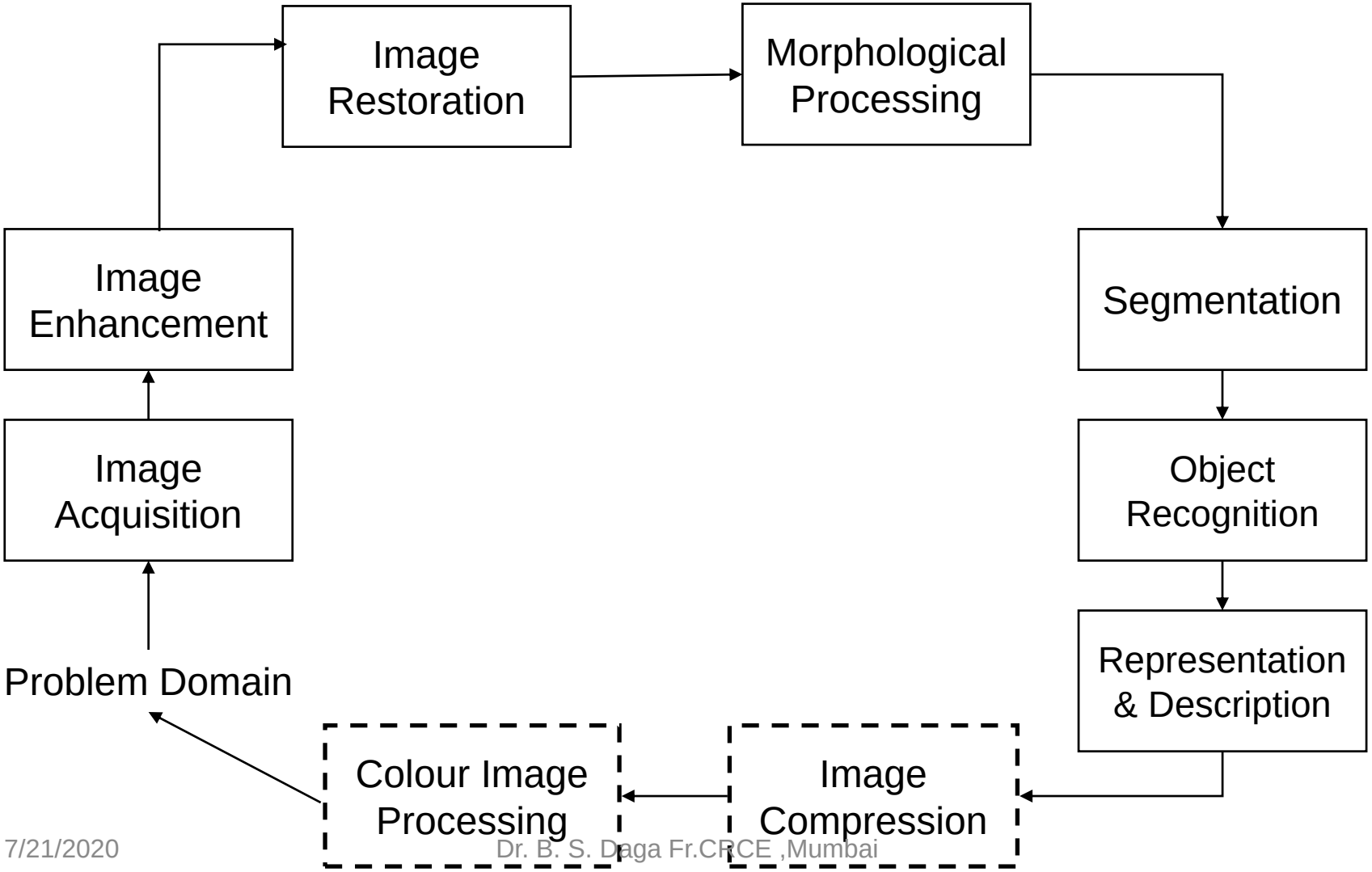
DSIP – Lecturer 02

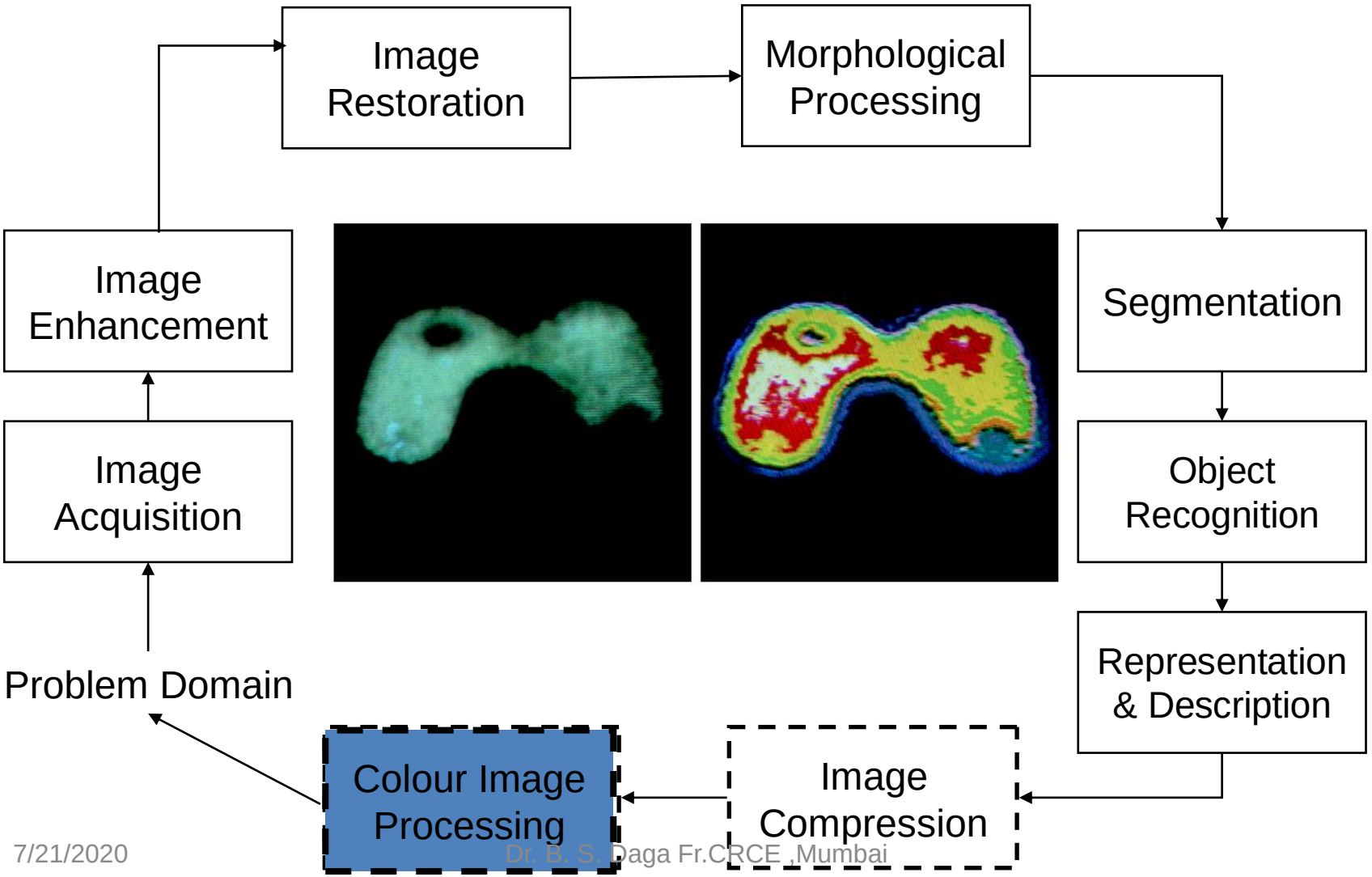
Contents

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

Steps in Digital Image Processing

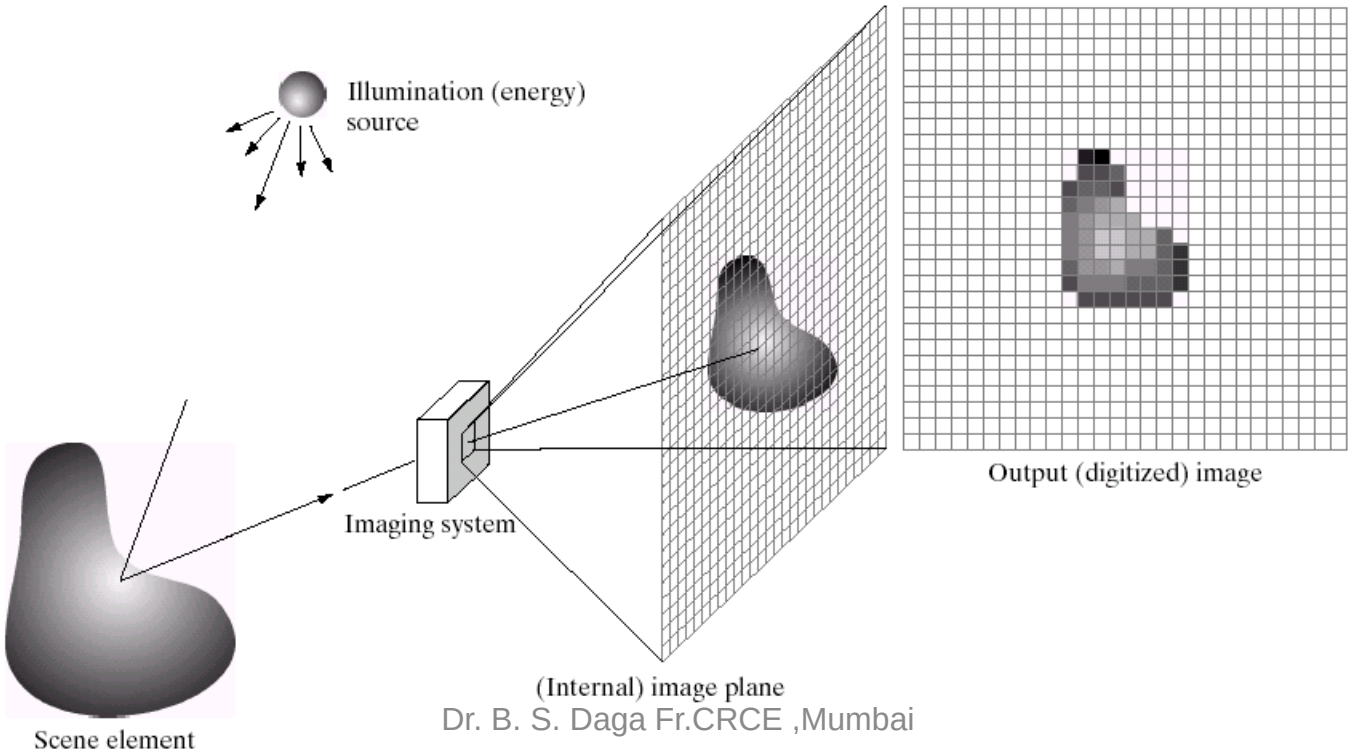


Colour Image Processing



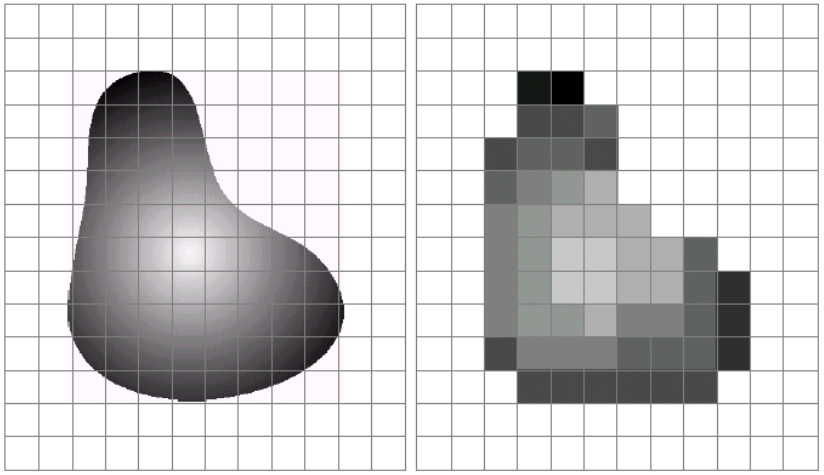
What is a Digital Image?

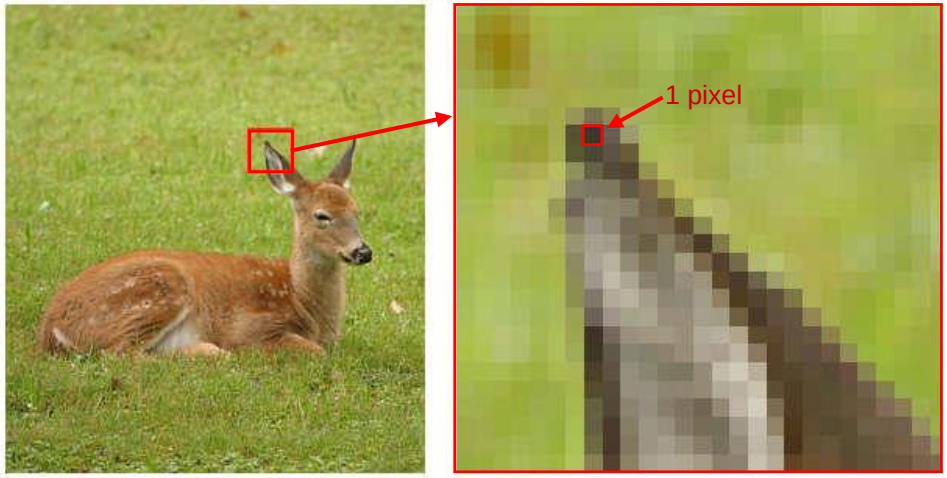
- A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels



What is a Digital Image? (cont…)

- Pixel values typically represent gray levels, colors, heights, opacities etc
- **Remember** *digitization* implies that a digital image is an *approximation* of a real scene





What is a Digital Image? (cont…)

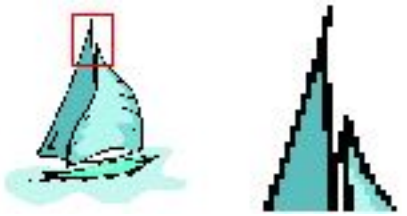
- Common image formats include:
  - 1 sample per point (B&W or Grayscale)
  - 3 samples per point (Red, Green, and Blue)
  - 4 samples per point (Red, Green, Blue, and “Alpha”, a.k.a. Opacity)

- Fo se we will focus on grey

Image Files Formats

Vector vs. Raster Images

- Vector images
  - Preserving sharpness after rescaling
  - Not good for natural scenes
  - Hard to construct
- Raster images
  - Contrastively

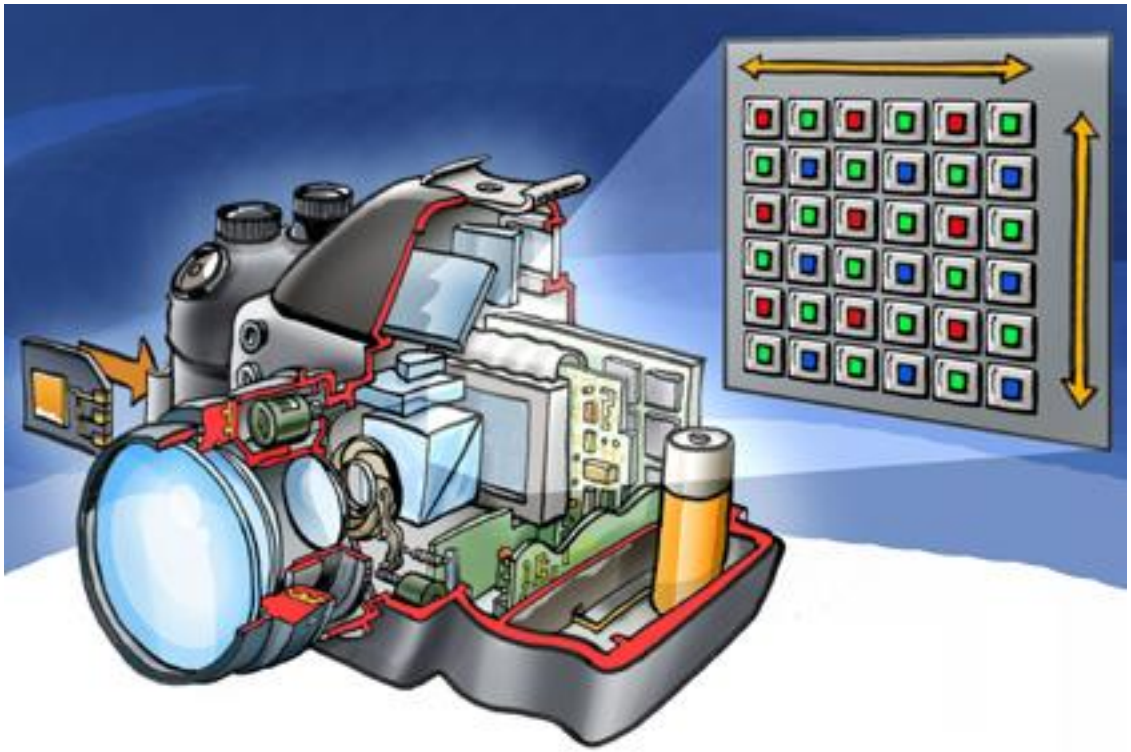


Vector Images

- Vector images are far more flexible. They are constructed using proportional formulas rather than pixels.
- **EPS**, **AI** and **PDF** are perfect for creating graphics that require frequent resizing.
- The logo and brand graphics are been created as a vector, and always have a master file.

Raster Image

- Formed by a digital camera



Pixel Resolution

- N pixels high by M pixels wide → M×N

Color Depth

- Number of bits for a single pixel
  - 1-bit color: black and white
  - 8-bit color: gray-scale
  - 24-bit color: true color

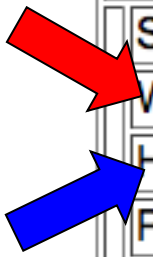
File Format

- Header: characteristics of the image
  - Size, color map, compression method, ……
- Data value:
  - Pixel values, index values
- Common formats
  - BMP, GIF, PNG, JPEG, TIFF ……

BMP Format

- BMP header format

Name	Size	Description
Header	14 bytes	Windows Structure: BITMAPFILEHEADER
Signature	2 bytes	'BM'
FileSize	4 bytes	File size in bytes
reserved	4 bytes	unused (=0)
DataOffset	4 bytes	File offset to Raster Data



InfoHeader	40 bytes	Windows Structure: BITMAPINFOHEADER
Size	4 bytes	Size of InfoHeader =40
Width	4 bytes	Bitmap Width
Height	4 bytes	Bitmap Height
Planes	2 bytes	Number of Planes (=1)
BitCount	2 bytes	Bits per Pixel 1 = monochrome palette. NumColors = 1 4 = 4bit palletized. NumColors = 16 8 = 8bit palletized. NumColors = 256 16 = 16bit RGB. NumColors = 65536 (?) 24 = 24bit RGB. NumColors = 16M
Compression	4 bytes	Type of Compression 0 = BI_RGB no compression 1 = BI_RLE8 8bit RLE encoding 2 = BI_RLE4 4bit RLE encoding
ImageSize	4 bytes	(compressed) Size of Image It is valid to set this =0 if Compression = 0
XpixelsPerM	4 bytes	horizontal resolution: Pixels/meter
YpixelsPerM	4 bytes	vertical resolution: Pixels/meter
ColorsUsed	4 bytes	Number of actually used colors
ColorsImportant	4 bytes	Number of important colors 0 = all

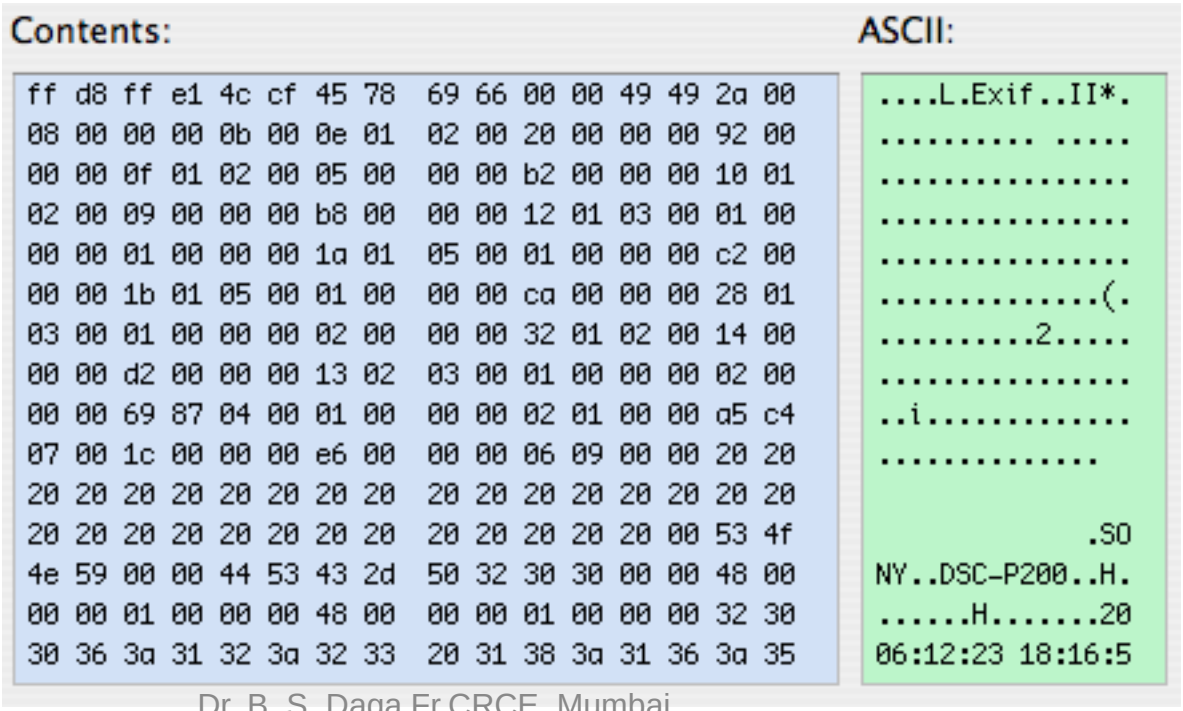
ColorTable		4 * NumColors bytes	present only if Info.BitsPerPixel <= 8 colors should be ordered by importance
	Red	1 byte	Red intensity
	Green	1 byte	Green intensity
	Blue	1 byte	Blue intensity
	reserved	1 byte	unused (=0)
repeated NumColors times			

BMP Example

Address:	Contents:		ASCII:
00000000	42 4d 36 12 00 00 00 00	00 00 36 04 00 00 28 00	BM6.....6...(.
00000010	00 00 3d 00 00 00 38 00	00 00 01 00 08 00 00 00	..=...8.....
00000020	00 00 00 00 00 00 13 0b	00 00 13 0b 00 00 00 00	.....
00000030	00 00 00 00 00 00 ff ff	ff 00 cc ff ff 00 99 ff	.....
00000040	ff 00 66 ff ff 00 33 ff	ff 00 00 ff ff 00 ff cc	..f...3.....
00000050	ff 00 cc cc ff 00 99 cc	ff 00 66 cc ff 00 33 cc	.....f...3.
00000060	ff 00 00 cc ff 00 ff 99	ff 00 cc 99 ff 00 99 99	.....
00000070	ff 00 66 99 ff 00 33 99	ff 00 00 99 ff 00 ff 66	..f...3.....f
00000080	ff 00 cc 66 ff 00 99 66	ff 00 66 66 ff 00 33 66	...f...f..ff..3f
00000090	ff 00 00 66 ff 00 ff 33	ff 00 cc 33 ff 00 99 33	...f...3...3...3
000000a0	ff 00 66 33 ff 00 33 33	ff 00 00 33 ff 00 ff 00	..f3..33...3....
000000b0	ff 00 cc 00 ff 00 99 00	ff 00 66 00 ff 00 33 00	.....f...3.
000000c0	ff 00 00 00 ff 00 ff ff	cc 00 cc ff cc 00 99 ff	.....
000000d0	cc 00 66 ff cc 00 33 ff	cc 00 00 ff cc 00 ff cc	..f...3.....
000000e0	cc 00 cc cc cc 00 99 cc	cc 00 66 cc cc 00 33 cc	.....f...3.

Hexadecimal Dumps

- Image file is often saved as a binary file.
- Binary file can be shown in hexadecimal dump.



Contents:

```
ff d8 ff e1 4c cf 45 78  69 66 00 00 49 49 2a 00
08 00 00 00 0b 00 0e 01  02 00 20 00 00 00 92 00
00 00 0f 01 02 00 05 00  00 00 b2 00 00 00 10 01
02 00 09 00 00 00 b8 00  00 00 12 01 03 00 01 00
00 00 01 00 00 00 1a 01  05 00 01 00 00 00 c2 00
00 00 1b 01 05 00 01 00  00 00 ca 00 00 00 28 01
03 00 01 00 00 00 02 00  00 00 32 01 02 00 14 00
00 00 d2 00 00 00 13 02  03 00 01 00 00 00 02 00
00 00 69 87 04 00 01 00  00 00 02 01 00 00 a5 c4
07 00 1c 00 00 00 e6 00  00 00 06 09 00 00 20 20
20 20 20 20 20 20 20 20  20 20 20 20 20 20 20 20
20 20 20 20 20 20 20 20  20 20 20 20 20 00 53 4f
4e 59 00 00 44 53 43 2d  50 32 30 30 00 00 48 00
00 00 01 00 00 00 48 00  00 00 01 00 00 00 32 30
30 36 3a 31 32 3a 32 33  20 31 38 3a 31 36 3a 35
```

ASCII:

```
....L.Exif..II*.
.......... .....
................
................
................
.............(.
.........2.....
................
..i.............
.............
                .SO
NY..DSC-P200..H.
......H.......20
06:12:23 18:16:5
```

GIF Format

Name	Size	Description
Signature	6 bytes	'GIF87a' or 'GIF89a'
GlobalDescriptor	7 bytes	global descriptor, always present
Width	2 bytes	width in pixels
Height	2 bytes	height in pixels
Flags	1 byte	global descriptor flags
GlobalColorMap	bit 7	=1 if GlobalColorMap exists (should be true in almost all cases) =0 if default map is used, or if every image has a LocalColorMap
ColorResolutionBits	bits 6-4	+1 = significant bits per color in GlobalColorMap
reserved	bit 3	=0
PixelBits	bits 2-0	+1 = ColorDepth, NumberOfGlobalColors := $2^{ColorDepth}$
BackgroundColor	1 byte	background color number (from GlobalColorMap or default map)
AspectRatio	1 byte	usually =0
GlobalColorMap	NumberOfGlobalColors * 3	global color table, present only when GlobalDescriptor.Flags.GlobalColorMap = 1
Red	1 byte	red intensity of color (not necessarily 8 significant bits)
Green	1 byte	green intensity of color (not necessarily 8 significant bits)
Blue	1 byte	blue intensity of color (not necessarily 8 significant bits)
repeated NumberOfGlobalColors times		

GIF Example

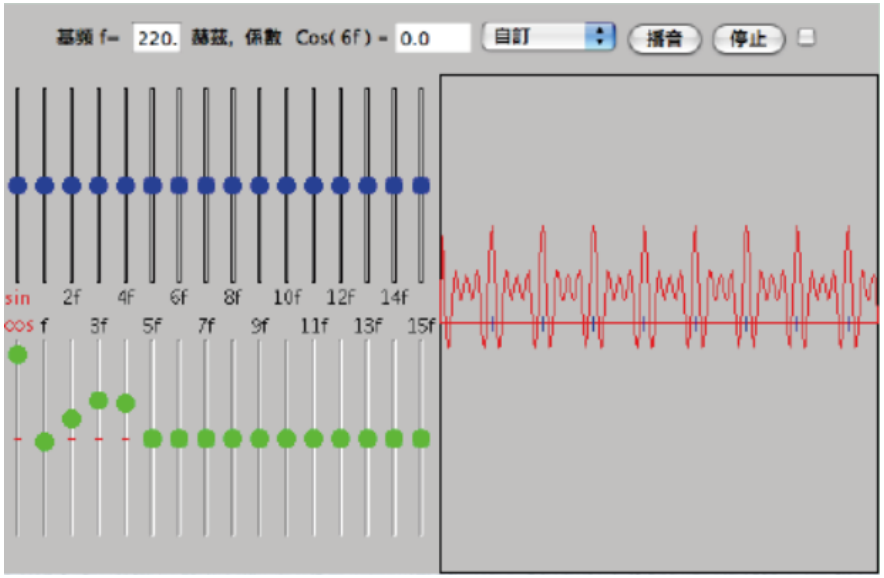
Address:	Contents:																ASCII:
00000000	47	49	46	38	39	61	3d	00	38	00	77	00	31	21	ff	0b	GIF89a=.8.w.1!..
00000010	4d	53	4f	46	46	49	43	45	39	2e	30	0d	00	00	00	01	MSOFFICE9.0.....
00000020	73	52	47	42	00	ae	ce	1c	e9	00	21	ff	0b	4d	53	4f	sRGB......!..MSO
00000030	46	46	49	43	45	39	2e	30	17	00	00	00	0b	6d	73	4f	FFICE9.0.....msO
00000040	50	4d	53	4f	46	46	49	43	45	39	2e	30	42	3c	a4	f5	PMSOFFICE9.0B<..
00000050	00	21	ff	0b	4d	53	4f	46	46	49	43	45	39	2e	30	15	.!..MSOFFICE9.0.
00000060	00	00	00	09	70	48	59	73	00	00	0e	68	00	00	0e	69	....pHYs...h...i
00000070	01	e0	5c	1d	2a	00	2c	00	00	00	00	3d	00	38	00	87	..\.*.,....=.8..
00000080	ff	d4	26	ff	e3	71	fd	b1	48	ff	de	59	ec	54	34	59	..&..q..H..Y.T4Y
00000090	85	32	a8	8b	07	ff	f4	c7	70	8c	31	2a	2a	2a	ff	d2	.2......p.1***..
000000a0	1b	ff	e9	92	ff	23	1f	9d	7b	0b	4c	7b	31	ff	f1	bb	.....#..{.L{1...
000000b0	d8	d2	58	fd	cb	39	ff	d4	2f	f0	29	20	ff	e7	85	be	..X..9../.) ....
000000c0	c4	60	ff	fb	e6	69	92	47	ff	f8	d8	fe	da	43	fd	ca	.`...i.G.....C..
000000d0	00	38	70	2e	ab	b0	54	4d	8a	3f	f8	87	4a	aa	aa	aa	.8p...TM.?..J...
000000e0	fe	d9	3d	95	a6	50	ff	ec	a1	e9	bd	32	e0	25	14	ff	..=..P.....2.%..

PNG Format

- LZW (Lempel-Ziv-Welch) algorithm (1978)
- Patents of Sperry, Unisys, and IBM (1983)
- LZW published by Welch (1984)
- GIF announced by CompuServe (1987 & 1989)
- Unisys' patent enforcement (1994)
- "Burn All GIFs" campaign (1999)
- Patents expired (2003-2006)

JPEG Format

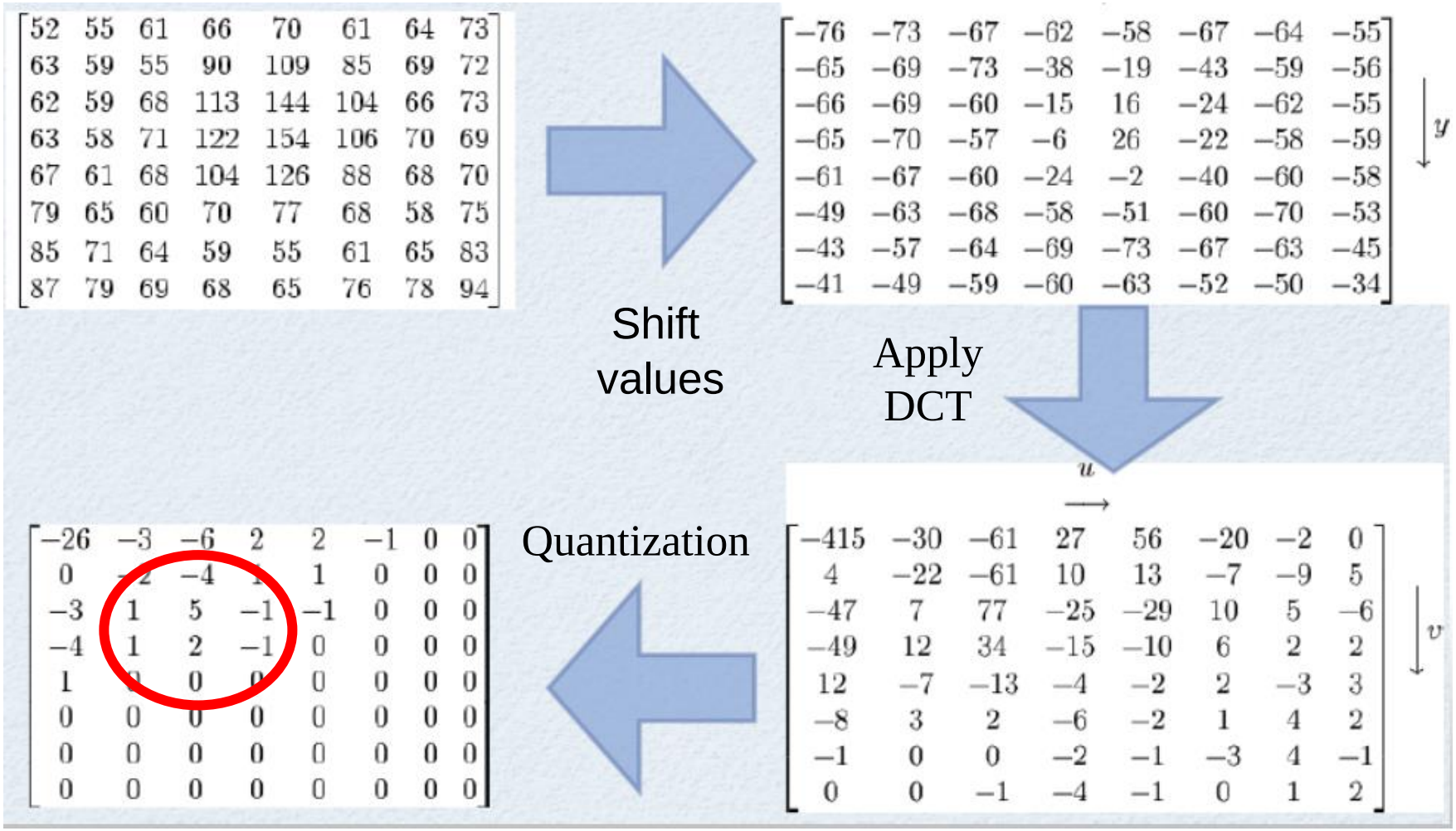
- Encoding using DCT (Discrete Cosine Transform)
- A Fourier-related transform
- Fourier transform simulator



Steps of JPEG Compression

- Splitting the image into blocks of 8×8 pixels
- Applying DCT to each block
- Storing the magnitudes of the low-frequency components

- Example: http://en.wikipedia.org/wiki/JPEG



TIFF Format

- A flexible, adaptable file format for handling images within a single file
- Color space: grayscale, RGB, YCbCr, CMYK, ……
- Compression: raw data, LZW, JPEG, …..
- Copyright holder: Aldus → Adobe

- TIFF header

Bytes 0-1: The byte order used within the file. Legal values are:

"II" (4949.H)

"MM" (4D4D.H)

In the "II" format, byte order is always from the least significant byte to the most significant byte, for both 16-bit and 32-bit integers This is called *little-endian* byte order. In the "MM" format, byte order is always from most significant to least significant, for both 16-bit and 32-bit integers. This is called *big-endian* byte order.

Bytes 2-3 An arbitrary but carefully chosen number (42) that further identifies the file as a TIFF file.

The byte order depends on the value of Bytes 0-1.

Bytes 4-7 The offset (in bytes) of the first IFD. The directory may be at any location in the file after the header but *must begin on a word boundary*. In particular, an Image File Directory may follow the image data it describes. Readers must follow the pointers wherever they may lead.

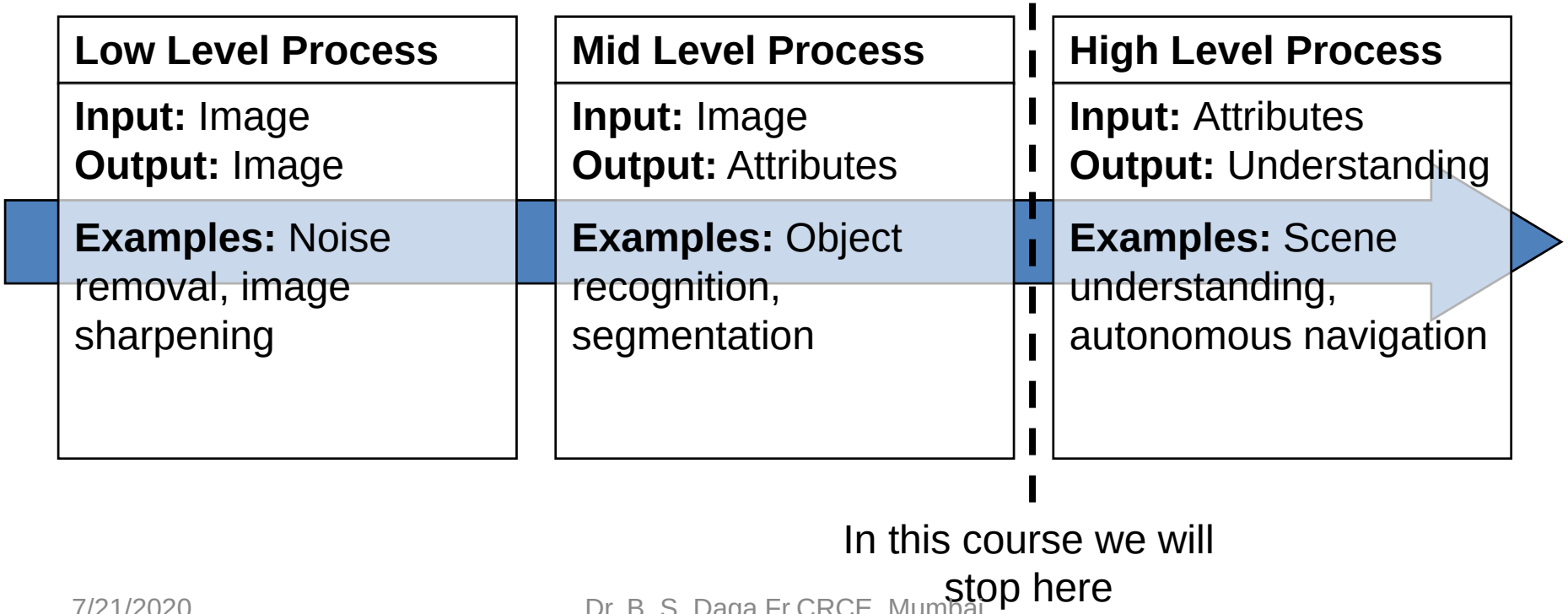
The term *byte offset* is always used in this document to refer to a location with respect to the beginning of the TIFF file. The first byte of the file has an offset of 0

What is Digital Image Processing?

- Digital image processing focuses on two major tasks
  - Improvement of pictorial information for human interpretation
  - Processing of image data for storage, transmission and representation for autonomous machine perception
- Some argument about where image processing ends and fields such as image analysis and computer vision start

Image processing Levels

- The continuum from image processing to computer vision can be broken up into low-, mid- and high-level processes



Summary

- We have looked at:
  - What is a digital image from multiple interpretations?
  - Key stages in digital image processing
  - What is digital image processing?
  - Areas of digital image processing

Image Formation and Representation

CS485/685 Computer Vision

Dr. George Bebis

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)

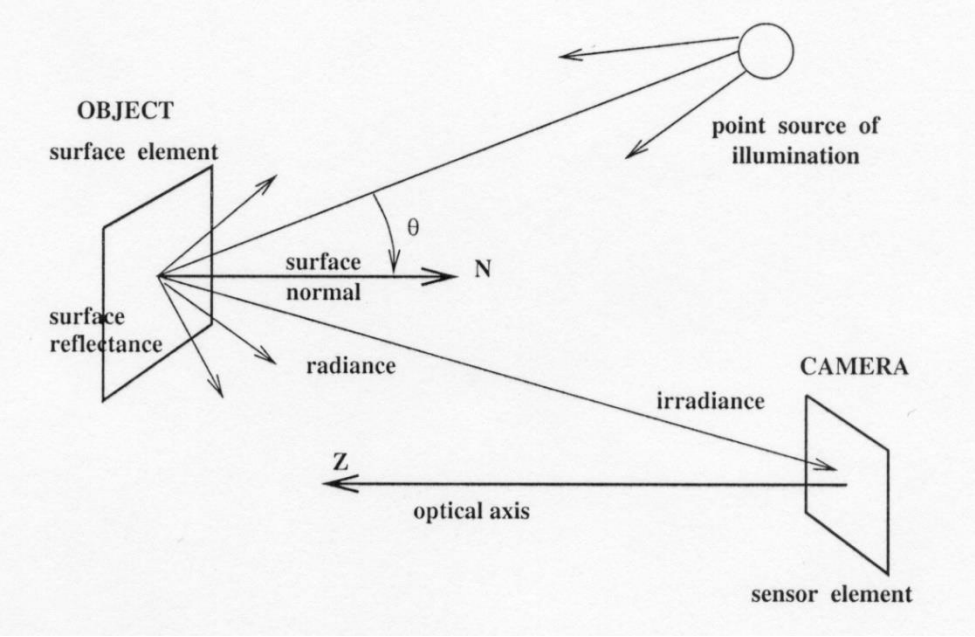


Image formation (cont'd)

- There are two parts to the image formation process:

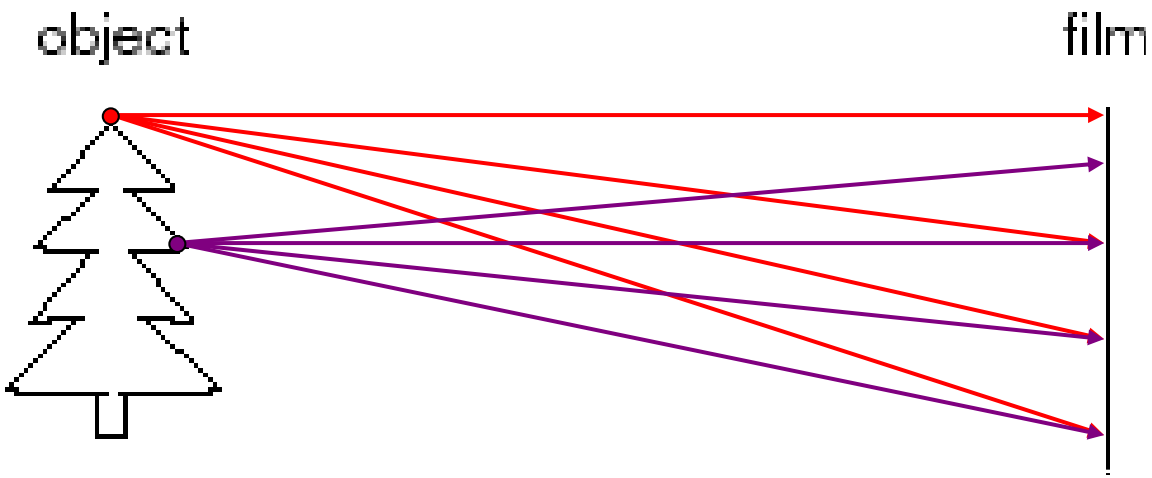
(1) The **geometry**, which determines where in the image plane the projection of a point in the scene will be located.

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

i: illumination, r: reflectance

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

Let's design a camera



- Put a piece of film in front of an object - do we get a reasonable image?
  - Blurring - need to be more selective!