CHAPTER 3

IMAGES AND GRAPHICS

3.1. Basic Image Concept: Representation and Format

Introduction to Images:

Image is the spatial representation of an object. It may be 2D or 3D scene or another image. Images may be real or virtual. It can be abstractly thought of as continuous function defining usually a rectangular region of plane. **Example**:

- **Recorded image-** photographic, analog video signal or in digital format
- **Computer vision-** video image, digital image or picture
- **Computer graphics-** digital image
- **Multimedia-** deals about all above formats

3.1. Basic Image Concept: Representation and Format

Image:

An image may be defined as two dimensional function f(x, y) where, x y are the spatial co-ordinate and the amplitude of 'f' at any pair of co-ordinates x, y is called the intensity or gray level of image at that point x, y and amplitude values of f are all finite, discrete quantities we all the image is digital image.

3.1. Basic Image Concept: Representation and Format

Digital Image Representation:

A digital image is represented by a matrix of numeric values each representing a quantized intensity value. When *I* is a two-dimensional matrix, then *I(r,c)* is the intensity value at the position corresponding to row *r* and column *c* of the matrix.

Or

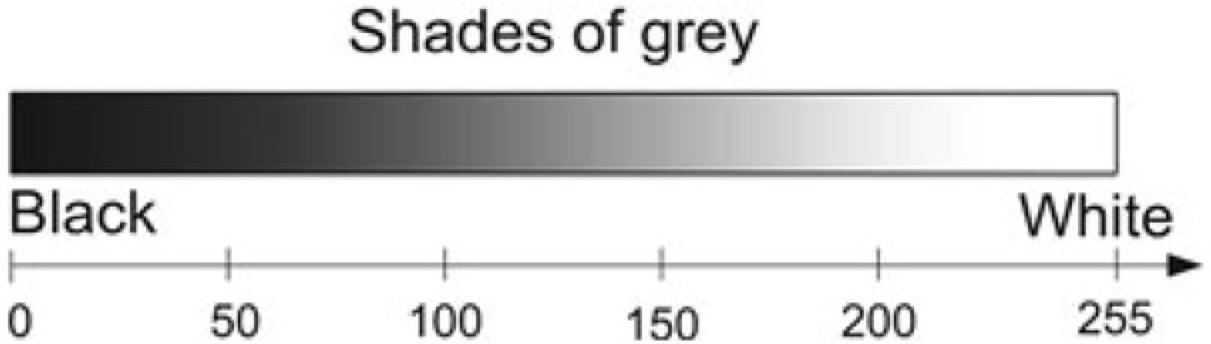
Digital image is represented by two dimensional matrix e.g. **I[x] [y]** .When I is the two dimensional matrix then, **I[x][y]** is the intensity value at the position corresponding to the row x and column y of the matrix.

3.1. Basic Image Concept: Representation and Format

Digital Image Representation:

The points at which an image is sampled are known as picture elements, or pixels.

The pixel values of intensity images are called gray scale levels. If there are just two intensity values (e.g., black and white), they are represented by the numbers 0 and 1. Such images are called binary-valued images. When 8-bit integers are used to store the intensity values, the gray levels range from 0 to 255.



3.1. Basic Image Concept: Representation and Format

Digital Image Representation:

Digital images are often very large, because a number of bits (e.g., 8 bits for 256 discrete gray levels) are required for each pixel, and a large number of pixels (e.g., 640 X 480) are required for representing the images.

a) Binary Image b) Gray-Scale Image c) Color Image


Bitmap/1-bit
Grayscale 8-bit
RGB 8-bit
CMYK 8-bit
RGB 16-bit
RGB 32-bit

3.1. Basic Image Concept: Representation and Format

Intensity

If n bit integers are used to store each pixel‟s intensity value, 2^n different intensities (colors) are possible numbered from 0 to $2^n - 1$.

Intensity is used to describe the brightness and purity of a **color**. When a hue is strong and bright, it is said to be high in **intensity**. When a **color** is faint, dull and gray, it is said to be low in **intensity**. When describing a hue, value refers to its lightness or darkness.

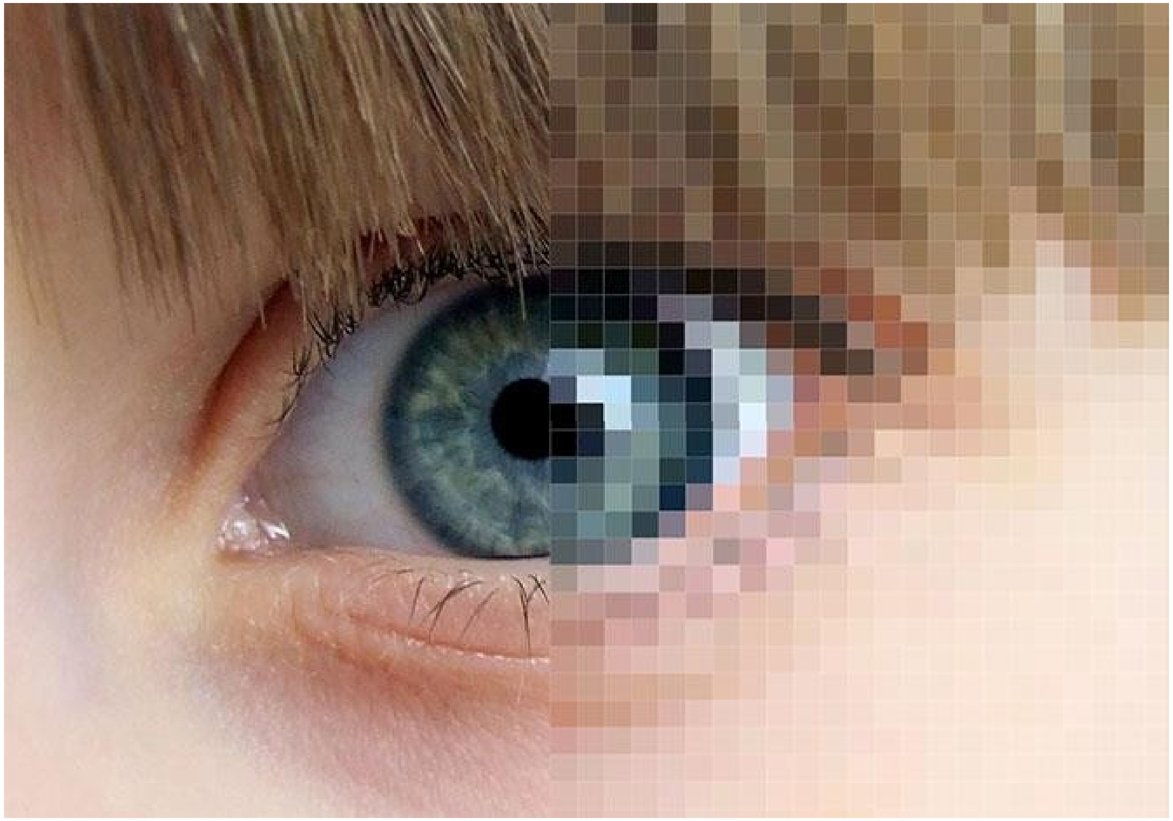
3.1. Basic Image Concept: Representation and Format

Intensity

3.1. Basic Image Concept: Representation and Format

Image resolution

It depends on the distance between pixel grids and imaging system also (persistence and spot profile).



3.1. Basic Image Concept: Representation and Format

Image file-size

It depends on total number of pixels and no. of bits per pixel (quantization).

Image file size = W*L*n bits

Where,

W = width (pixels)

L = length or height (pixels)

n = number of bits per pixel

Numerical

Q.N : Consider three different raster system with resolution 640 by 400, 1280 by 1024 and 2560 by 2048. what size frame buffer (in byte) is needed for each of the system to store 12 bits per pixel ? How much storage is required for each system if 24 bit per pixel are to be stored.

Ans :

1) for 12 bit per pixel system

the frame buffer(in byte) size needed

a. for 640 by 400 resolution $= \frac{(640 \times 400 \times 12)}{8}$

=384000 byte

b. for 1280 by 1024 resolution $= \frac{(1280 \times 1024 \times 12)}{8}$

=1966080 byte

c. for 2560 by 2048 resolution $= \frac{(2560 \times 2048 \times 12)}{8}$

=7864320 byte

Cont…..

2) for 24 bit per pixel system

the frame buffer(in byte) size needed

a. for 640 by 400 resolution $= \frac{(640 \times 400 \times 24)}{8}$

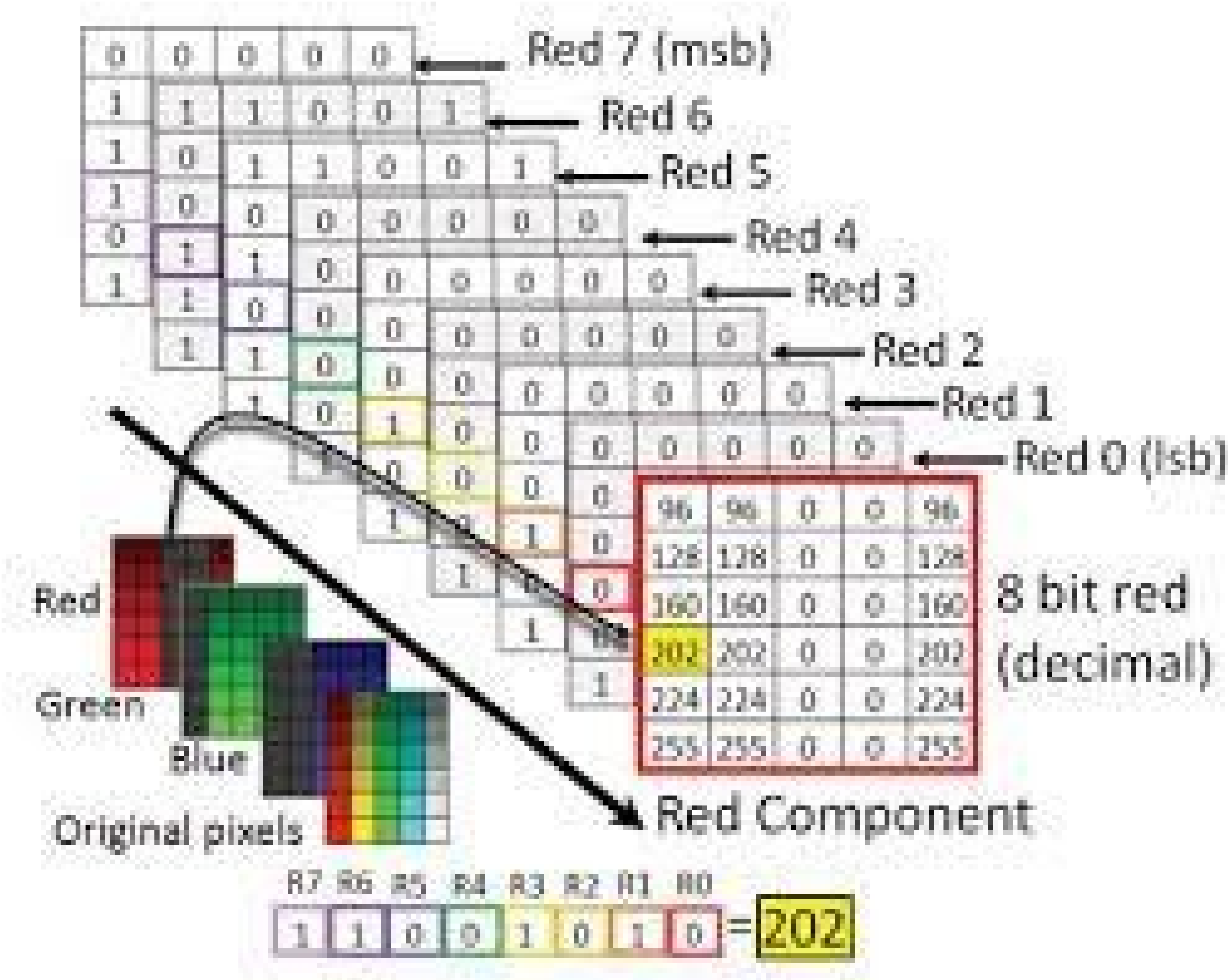
$=768000$ byte

b. for 1280 by 1024 resolution $= \frac{(1280 \times 1024 \times 24)}{8}$

$=3932160$ byte

c. for 2560 by 2048 resolution $= \frac{(2560 \times 2048 \times 24)}{8}$

$=15728600$byte


Red 7 (msb)
Red 6
Red 5
Red 4
Red 3
Red 2
Red 1
Red 0 (lsb)
8 bit red
(decimal)
Red
Green
Blue
Original pixels
Red Component
R7 R6 R5 R4 R3 R2 R1 R0
1 1 0 0 1 0 1 0 = 202

3.1. Basic Image Concept: Representation and Format

Image Formats

Image formats are basically of two kinds:

(1) **Captured Image Format**

(2) **Stored Image Format**

3.1. Basic Image Concept: Representation and Format

Image Format

1) **Capture Image format**

This is the format that comes out from an image frame grabber, such as VideoPix card, Parallax XVideo, etc. It is specified by mainly two parameters:

- Spatial Resolution (specified by pixel × pixel)
- Color encoding (specified by bits per pixel)

Both these parameter values depend on hardware and software for the input/output of images.

For example, for image capturing on a SPARCstation, the VideoPix card and its software are used. The spatial resolution is 320x240 pixels and the color can be encoded with 1-bit (a binary image format), 8-bit (color or grayscale) or 24-bit (color-RGB).

3.1. Basic Image Concept: Representation and Format

Image Format

1) Capture Image format

Captured Image Format is specified by:

spatial resolution (pixels x pixels) and *color encoding* (bits per pixel)

Examples:

VideoPix™ / SunVideo™ card:

spatial resolution:	320 x 240 pixels
color encoding:	1-bit (binary image), 8-bit (color or greyscale)
	24-bit (color-RGB)

SunVideo™ card (capture and compression card with 30* fps (frames per second)):

CellB	30 fps	MPEG1 IP frames	17 fps
JPEG	30 fps	Capture YUV	30 fps
MPEG1 I frames	30 fps	Capture RGB-8/24	30 / 12 fps

* At least 25 frames per second are necessary if continuous motion is to be presented. However, it is possible to "cheat" a little and to work with smaller frame rates.

3.1. Basic Image Concept: Representation and Format

Image Format

2) Stored Image Format

While storing an image, we store a two-dimensional array of values, in which each value represents the data associated with a pixel in the image. For a bitmap, this value is a binary digit.

For a color image (pixmap), the value may be a collection of:

- Three numbers representing the intensities of the red, green and blue components of the color at that pixel.
- Three numbers that are indices to tables of the red, green and blue intensities.
- A single number that is an index to a table of color triples.
- An index to any number of other data structures that can represent a color.
- Four or five spectral samples for each other.

3.1. Basic Image Concept: Representation and Format

Image Format

2) Stored Image Format…

In addition, each pixel may have other information associated with it; e.g., three numbers indicating the normal to the surface drawn at that pixel.

Information associated with the image as a whole, e.g., width, height, depth, name of the creator, etc. may also have to be stored.

The image may be compressed before storage for saving storage space.

Some current image file formats for storing images include GIF, X11 Bitmap, Sun Rasterfile, PostScript, IRIS, JPEG, TIFF, etc.

3.1. Basic Image Concept: Representation and Format

Graphics Format

Graphics image formats are specified through graphics primitives and their attributes. Graphics primitives include lines, rectangles, etc. specifying 2D objects or polyhedron, etc. specifying 3D objects. A graphics package determines which primitives are supported. Attributes of the graphics primitives include line style, line width, color effect, etc., that affect the outcome of the graphical image.

3.1. Basic Image Concept: Representation and Format

Graphics Format

Graphics primitives and their attributes represent a higher level of an image representation where the graphical images are not represented by a pixel matrix. As an advantage, data to be stored per graphical image is reduced, and manipulation of the graphical image becomes easier. However, this higher level of representation needs to be converted at some point of the image processing into the lower level of the image representation, e.g., when the image is to be displayed. Graphics packages such as SRGP can be used for this conversion (from graphics primitives to bitmap or pixmap). A bitmap is an array of pixel values with one bit for each pixel. A pixmap is an array of pixel values with multiple bits (e.g., 8 bits for 256 colors) for each pixel.

3.1. Basic Image Concept: Representation and Format

Graphics image formats **are specified through:**

- *graphics primitives*: lines, rectangles, circles, ellipses, text strings (2D), polyhedron (3D)
- *attributes*: line style, line width, color affect.

Graphics primitives and their attributes represent a higher level of an image representation. The graphics package determines which primitives are supported.

Advantages:

+ Reduction of the graphical image data
+ Easier manipulation of graphical images.

Disadvantage:

- Additional conversion step from graphical primitives and attributes to its pixel representation

Formats:

- SRGP (Simple Raster Graphics Package), one way conversion to bit-/pixmap
- PHICS (Programmer's Hierarchical Interactive Graphics Systems) and
- GKS (Graphical Kernel System) only image representation is in pixmap

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Computer Image Processing

Computer graphics concern the pictorial synthesis of real or imaginary objects from their computer-based models. But Image Processing treats in converse process i.e. analysis of scenes or reconstruction of models from pictures of 2D and 3D objects. Computer image processing comprises of image synthesis (generation) and image analysis (recognition).

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image Synthesis

Image synthesis deals with the generation of images of real or imaginary objects. It is an integral part of all computer user interfaces and is essential for visualizing 2D, 3D and higher dimensional objects. Some of the applications of image synthesis (areas which use image synthesis) are:

(1) *User Interface*

(2) *Office automation and electronic publishing*

(3) *Simulation and Animation for Scientific Visualization and Entertainment*

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

(1) User Interface

- Point-and-click facility
- Menu-driven

(2) Office automation and electronic publishing

- Desktop publishing
- Electronic publishing
- Hypermedia Systems

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

(3) Simulation and Animation for Scientific Visualization and Entertainment

- Simulation of real time systems
- Visualization of time-varying behavior of systems
- Abstract representation of complex mathematical expressions
- Models for fluid flow, chemical reaction etc.
- Cartoons
- Flying logos and more exciting visual for movies

Image Synthesis can be dynamic. Similarly, interactive graphics systems are used for image synthesis.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image synthesis **(generation) is an integral part of all computer graphical user interfaces and indispensable for visualising 2D, 3D and higher dimensional objects. E.g.:**

Graphical User Interface (GUI): **desktop windows system with icons and menu items**

- Office Automation and Electronic Publishing: desktop publishing, Hypermedia systems
- Simulation and Animation for Scientific Visualisation and Entertainment

Pictures can be dynamically varied by adjusting the animation speed, portion of the total scene in view, the amount of details shown etc.

- *Motion Dynamics:* Objects are moved and enabled with respect to a stationary or also dynamic observer, e.g. flight simulator.
- *Update Dynamics:* Objects being viewed are changed in shape, color, or other properties, e.g. deformation of an in-flight aeroplane structure.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Dynamics in Graphics

Graphics are not confined to static pictures. Pictures can be dynamically varied, e.g., the portion of the total scene in view, amount of detail shown, etc. of an animation can be controlled by the user. Dynamics can be of two kinds:

Motion Dynamics:

With motion dynamics

- Objects can be moved and enabled with respect to a stationary observer.
- The object can remain stationary and the view around it can move.
- Both the objects and the camera can move.

Update Dynamics:

Update Dynamics is the actual change of the shape, color, or other properties of the objects being viewed.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image Analysis

Image analysis is concerned with techniques for extracting descriptions of objects from images. Image analysis techniques include computation of perceived brightness and color, partial or complete recovery of three-dimensional data in the scene, location of discontinuities corresponding to objects in the scene and characterization of the properties of uniform regions in the image.

Image analysis involves activities where the different properties of the image, its orientation and other data related to it is extracted, evaluated, compared in order to get some result. It may deal with calculating the intensity, hue, saturation of the image, the centroid, and identification of noise, detection of patterns or recognition of the image itself. It might result in a complete recovery of 3D data in the scene.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image analysis has profuse importance in several areas and they are

- Criminology
- Biometrics
- Analysis of aerial surveillance photographs
- Medicine
- Analysis of slow scan television images of the moon or of plates gathered from space probes
- Machine vision

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image analysis is used in areas such as

- Aerial surveillance photographs
- Slow scan images of the moon or of planets gathered from space probes
- Television images taken from an industrial robot‟s visual sensor
- X-ray images and computerized axial tomography (CAT) scans, etc.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Sub-areas of image analysis includes

- Image Enhancement

  It deals with improving image quality by eliminating noise (extraneous or missing pixels) or by enhancing contrast.

- Pattern Detection and Recognition

  It deals with detecting and clarifying standard patterns and finding distortions from these patterns.

- Scene Analysis and Computer Vision

  It deals with recognizing and reconstructing 3D models of a scene from several 2D images. An example is an industrial root sensing the relative sizes, shapes, positions and colors of objects.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image Recognition

To fully recognize an object in an image means knowing that there is an agreement between the sensory projections and the observed image. How the object appears in the image is specified by the spatial configuration of the pixel values. Thus, agreement between the observed spatial configuration and the expected sensory projections is required.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

This, in turn, requires the following capabilities.

- Infer explicitly or implicitly an object‟s position and orientation from the spatial configuration. This requires the capability to infer which pixels are parts of the object. Also, object features such as special markings, curves, lines, etc. have to be distinguished.

- Confirm that the inference is correct. This depends on matching the distinguishing image features with corresponding object features.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image recognition steps

Image recognition involves the following six steps:

1. Image formatting
2. Conditioning
3. Labeling
4. Grouping
5. Extracting
6. Matching

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

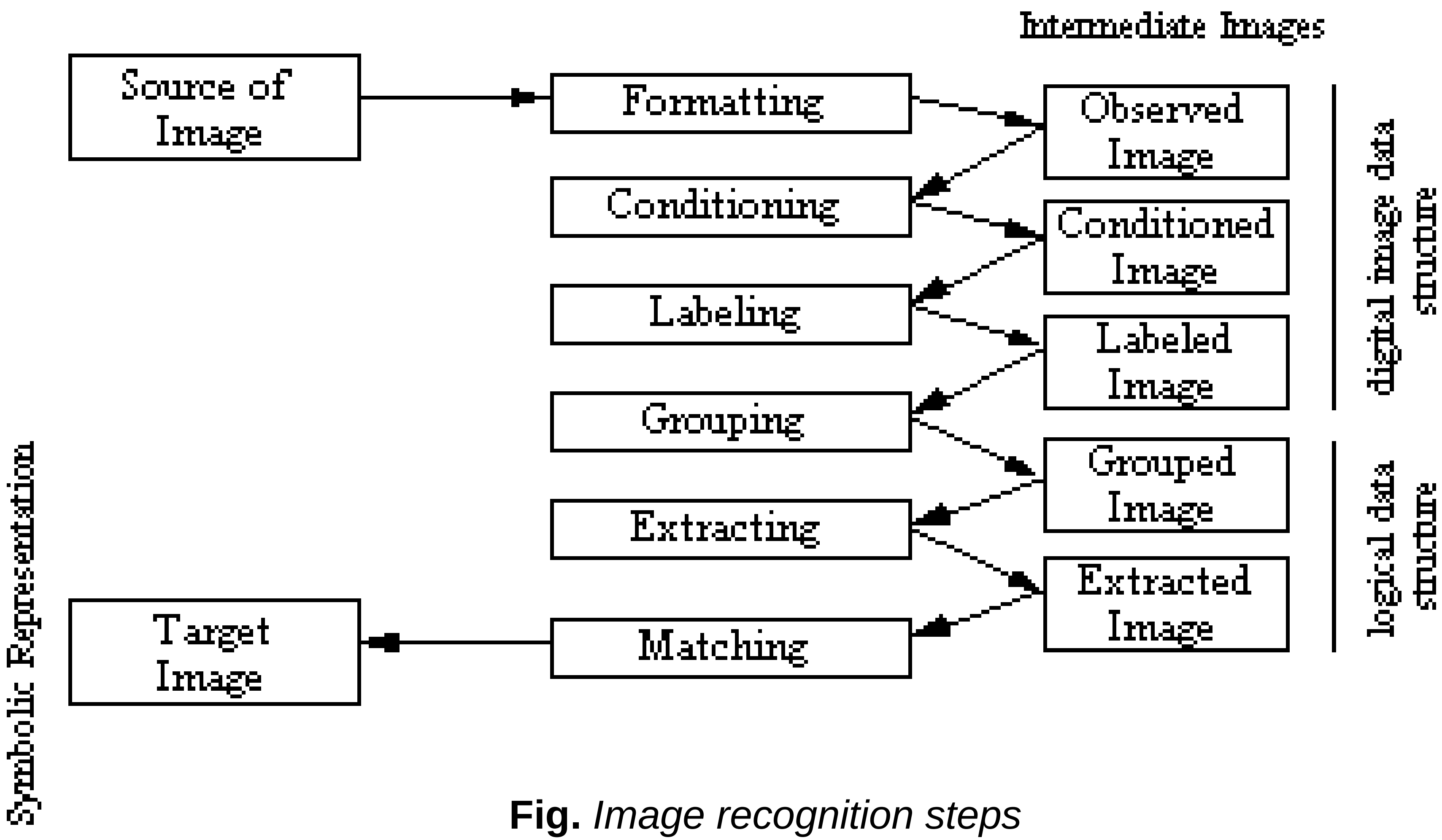


Fig. *Image recognition steps*

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

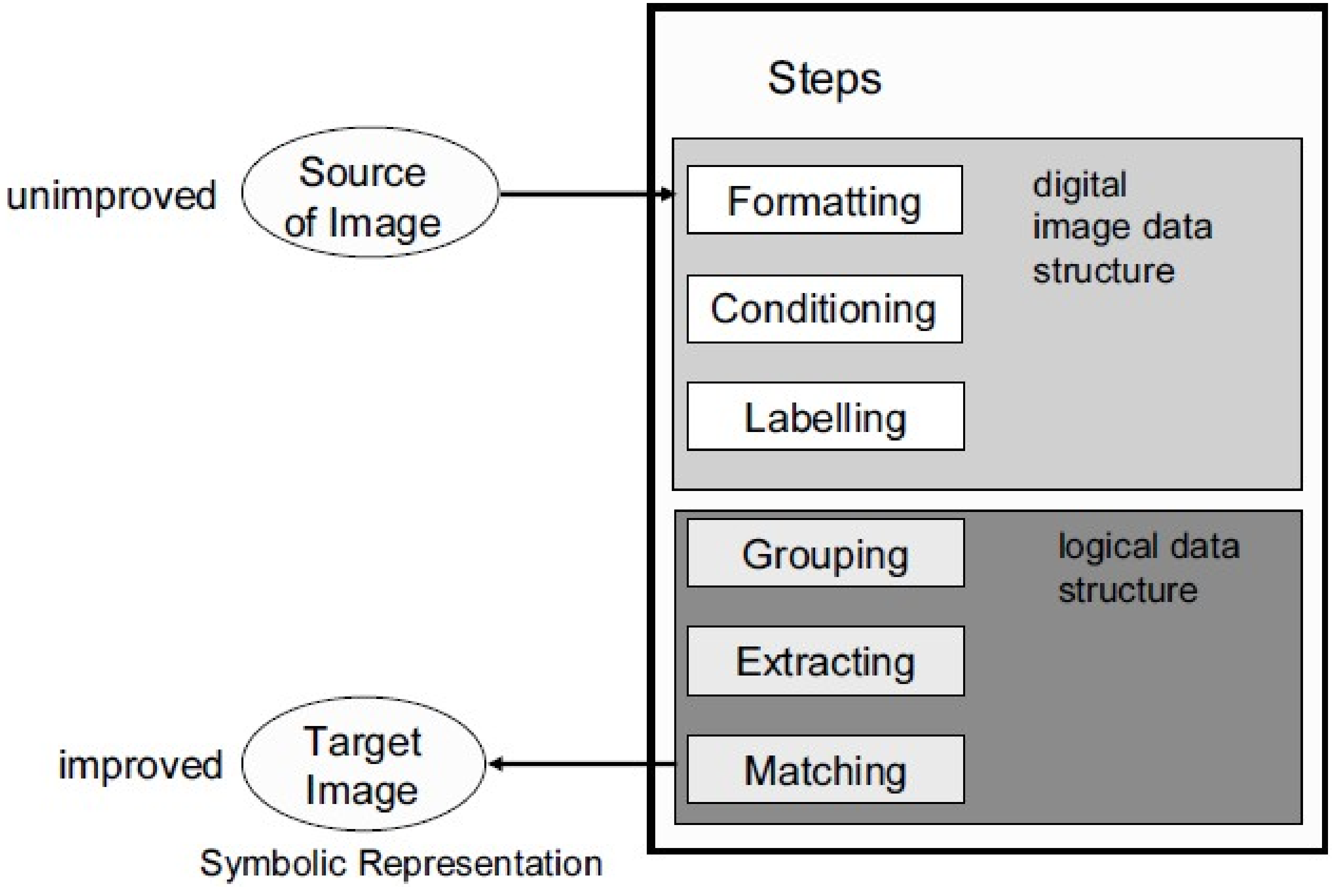


Fig. *Image recognition steps*

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

(1) Image Formatting

It refers to **capturing an image** from a camera and **bringing it into a digital form**, i.e., generating a digital representation of an image in the form of pixels.

(2) Conditioning

The image usually contains some **unwanted variations** or **noise** that makes the recognition process difficult and complex. Conditioning is a process in which the image are **eliminated** or suppressed so that they do not have influence over the recognition process.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

(3) Labeling

The object of interest usually exhibit some pattern or structure dependent on the spatial position and the connectivity of the individual pixels. **Edge Detection** is an example of labeling in which the boundary of the object of interest is determined. An edge is said to occur at a point in the image if some image attribute changes in value discontinuously at that point. It may result in locating many edges of which some may not be the part of object of interest so they need to be filtered or ignored.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

(4) Grouping

Grouping involves arranging the pixels or the events (e.g. edge) so that they **produce some meaningful shape and structure**. The grouping operation may involve calculation of neighborhood, connectivity and adjacency of the pixels. The edges may be grouped into lines (line fitting operation), curves may be grouped to form circle or any other structure. It may result in identifying the pixels of interest or creation of data structures of spatial event.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

(5) Extracting

Extraction is a process in which the data and attributes related to **the images are computed or calculated**. It ends up **creating a list of pixel properties** like centroid, angular orientation, intensity, spatial position etc. The groups are evaluated for regions. For e.g. if the group is an arc, average curvature is a candidate property.

(6) Matching

Matching is the phase in which the image under consideration is related with some pre-defined object, properties, shape or structure. Matching may involve template matching in which the templates are already stored in the database and the image under consideration is compared with it or it may involve complex neural process to identify and classify the image.

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image Transmission

Image transmission takes into account transmission of digital images through computer networks.

There are several requirements on the networks when images are transmitted

- The network must accommodate bursty transport data, because image transmission is bursty (due to large image sizes).
- Transport should be reliable.
- Time-dependence is not dominant as in audio/video transmission.

Image size depends on the image representation format used for transmission. There are several possibilities:

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image Transmission …..

Raw image data transmission

The image is generated through as video digitizer and transmitted in its digital format. The image size is calculated as:

Size = Spatial_Resolution X Pixel_Quantization

For example, the transmission of an image with a resolution of 640 X 480 pixels and pixel quantization of 8 bits per pixel requires

640 X 480 X 8 = 2457600 bits (=307,200 bytes).

3.2. Image Processing Fundamentals: Synthesis, Analysis and Transmission.

Image Transmission …..

Compressed image data transmission

The image is generated through a video digitizer and compressed before transmission. Methods such as JPEG or MPEG are used for compression. The reduction of image size depends on the compression method and compression rate.

Symbolic image data transmission

The image is represented through symbolic data representation as image primitives (e.g., 2D or 3D geometric representation), attributes and other control information. This image representation method is used in computer graphics. Image size is equal to the structure size, which carries the transmitted symbolic information of the image.

3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Image enhancement :

The process of improving the quality of a digitally stored image by manipulating the image with software.

It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. Advanced image enhancement software also supports many filters for altering images in various ways.

Programs specialized for image enhancement are sometimes called *image editors*.

3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

What Is Image Enhancement?

Image enhancement is the process of making images more useful

<u>The reasons for doing this include</u>

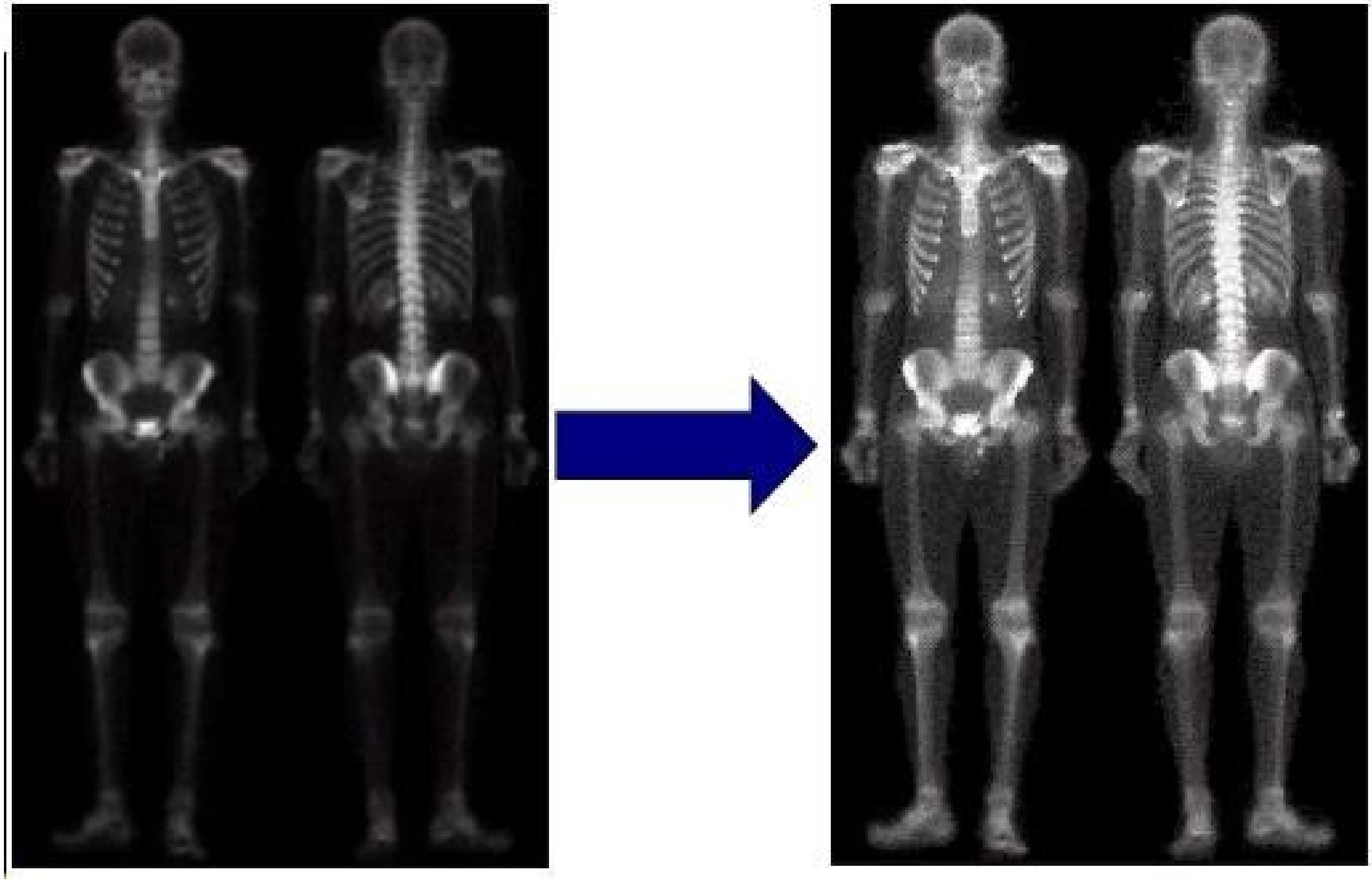
- – Highlighting interesting detail in images
- – Removing noise from images
- – Making images more visually appealing

3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Image Enhancement Examples

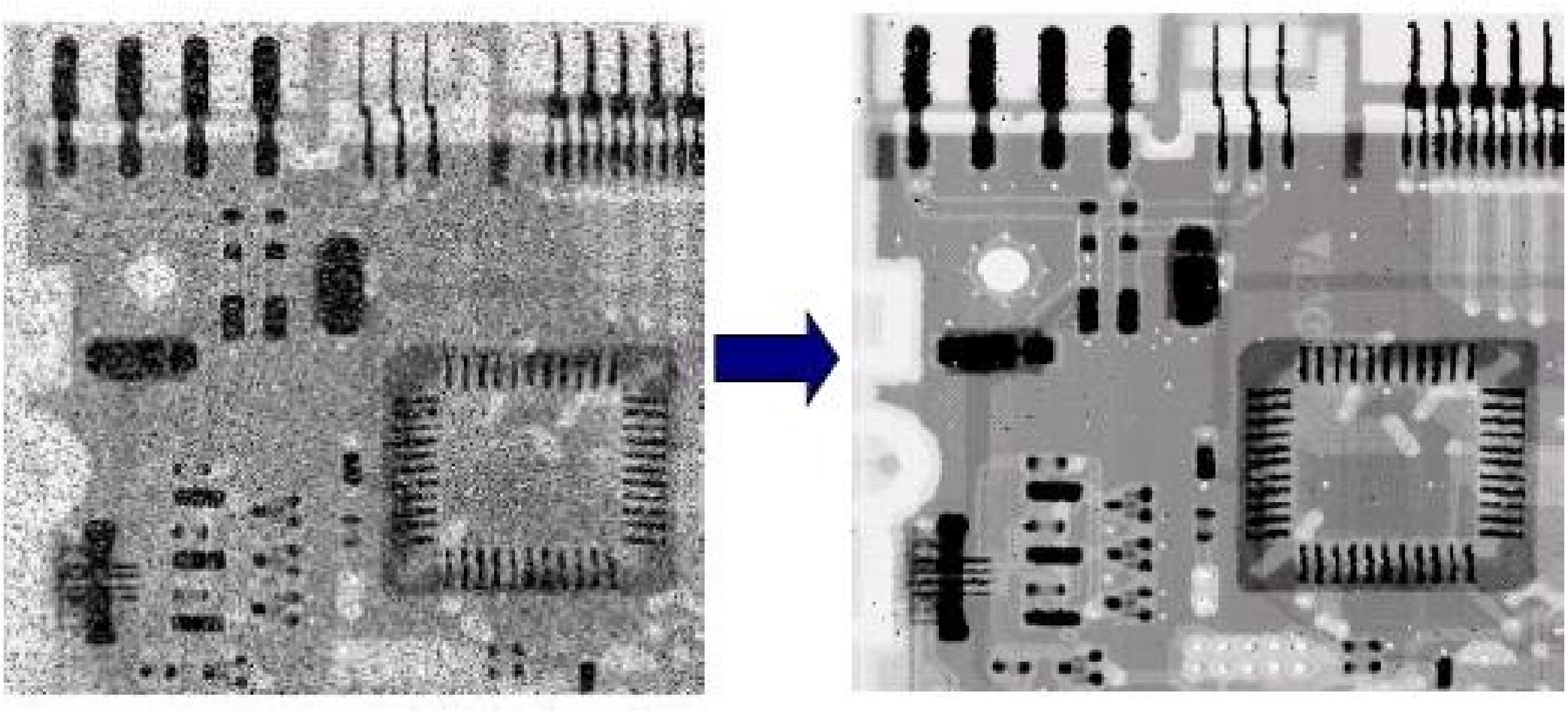
3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Image Enhancement Examples (cont…)



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Image Enhancement Examples (cont…)



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Enhancement by point processing

The simplest spatial domain operations occur when the neighborhood is simply the pixel itself

In this case *T* is referred to as a *grey level transformation function* or a *point processing operation*

Point processing operations take the form

$$s = T(r)$$

where *s* refers to the processed image pixel value and *r* refers to the original image pixel value

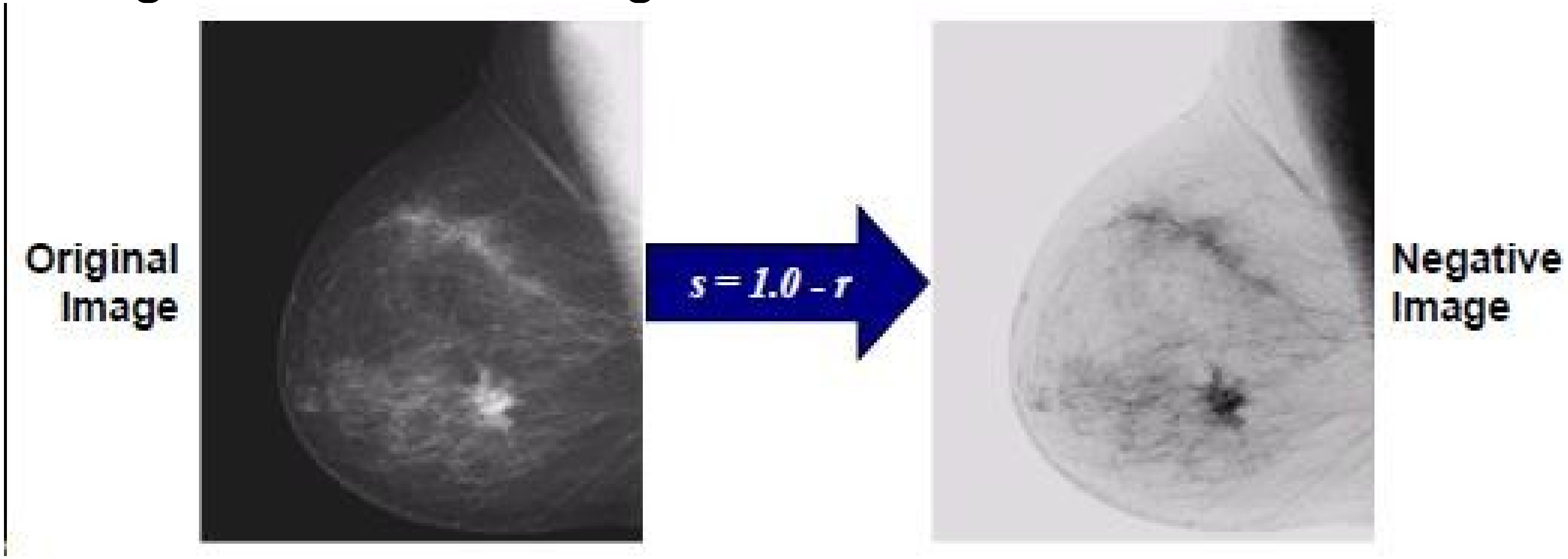
3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Point Processing Example:

Negative Images

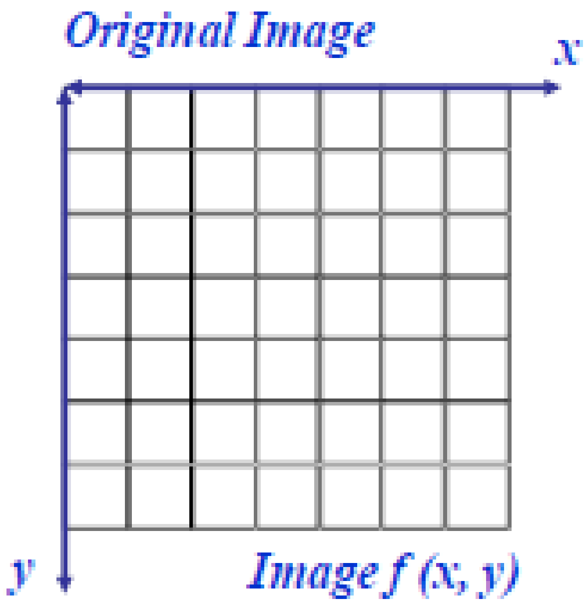
Negative images are useful for enhancing white or grey detail embedded in dark regions of an image

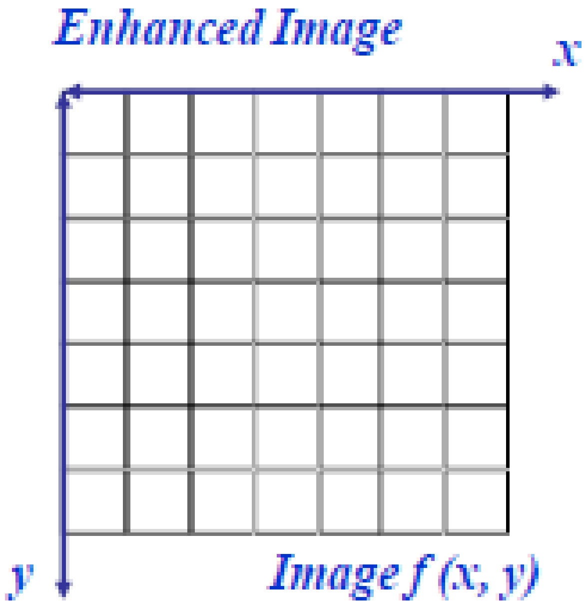
- Note how much clearer the tissue is in the negative image of the mammogram below



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Enhancement by point processing



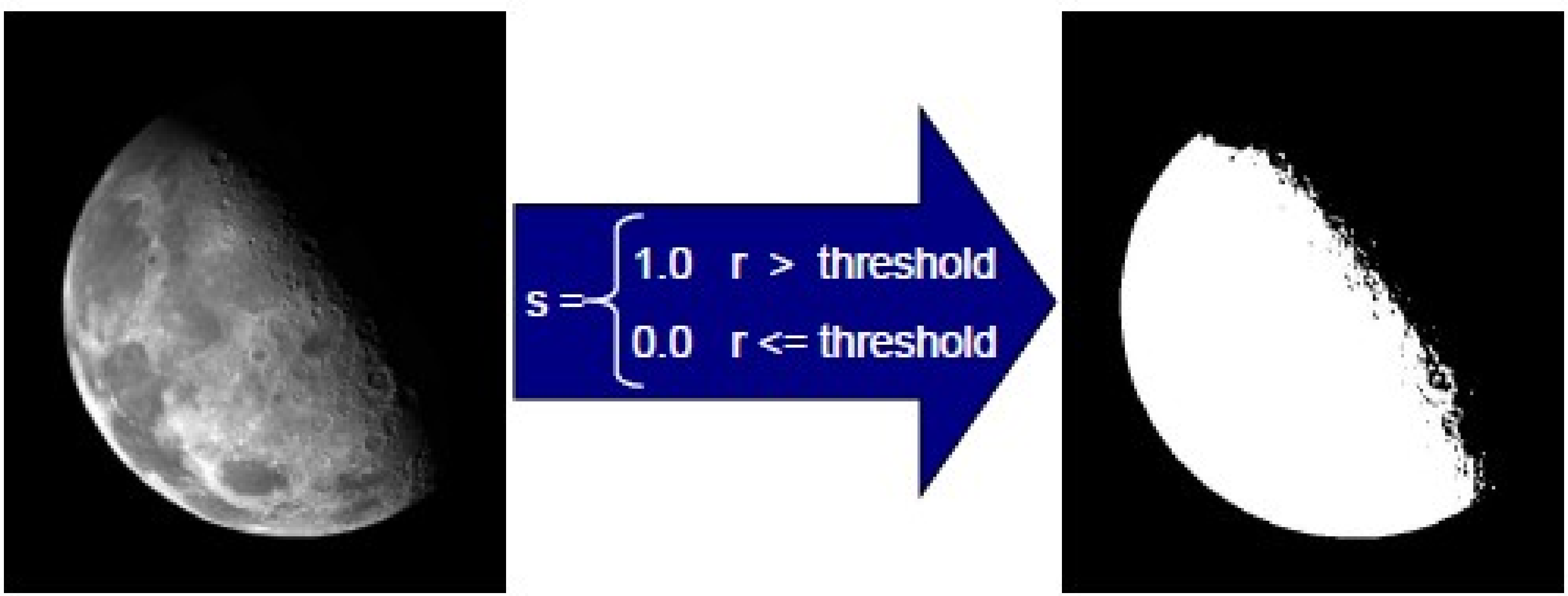


$$s = intensity_{max} - r$$

3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

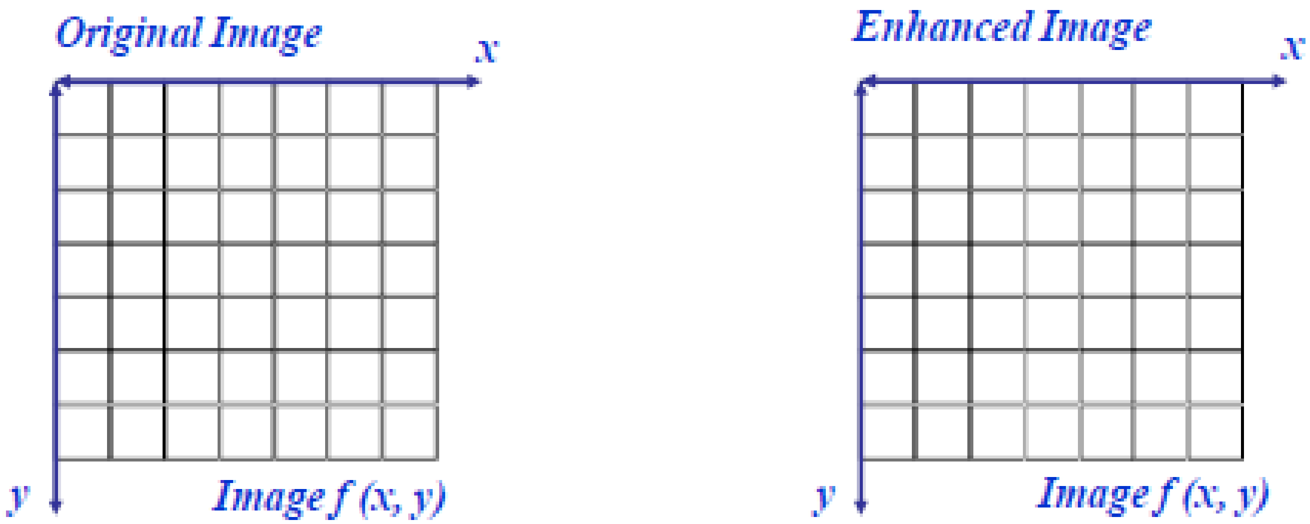
Enhancement by point processing

Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Enhancement by point processing



$$s = \begin{cases} 1.0 & r > threshold \\ 0.0 & r <= threshold \end{cases}$$

3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Spatial Filtering

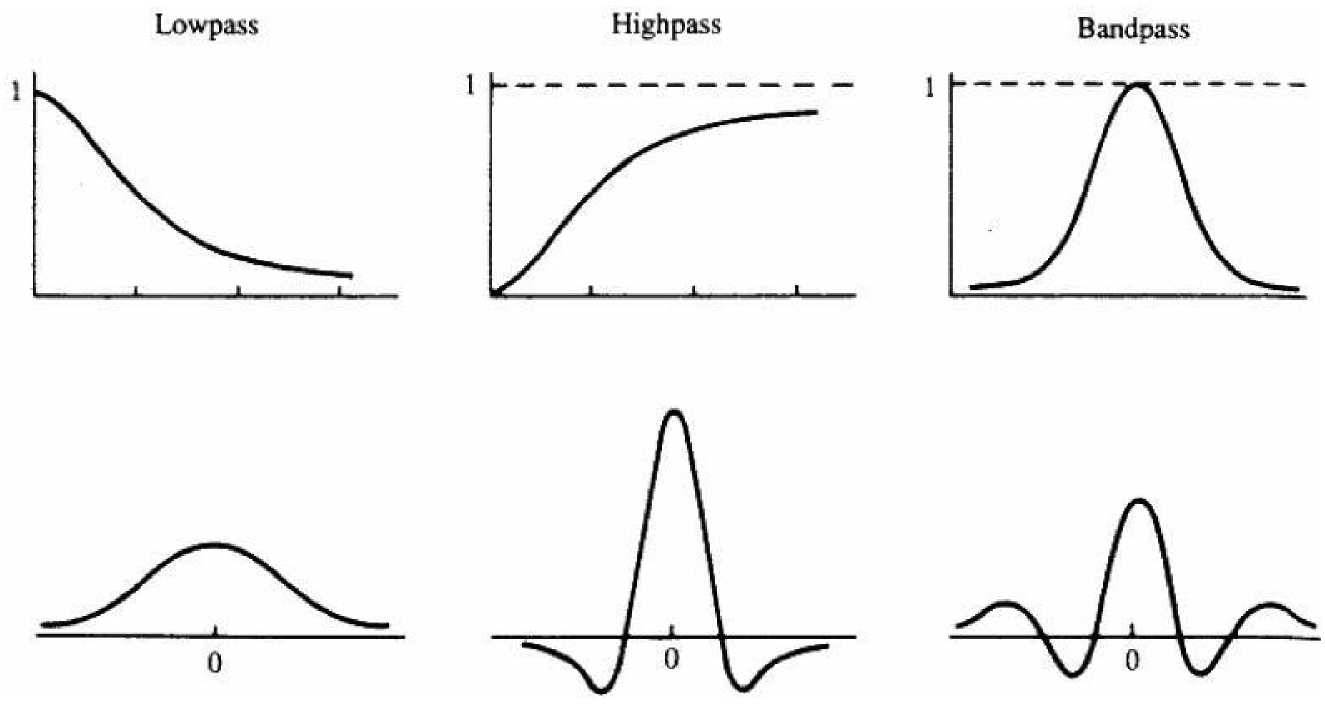
Use of spatial masks for filtering is called spatial filtering

May be linear or nonlinear

- Linear filters
  - Lowpass: attenuate (or eliminate) high frequency components such as characterized by edges and sharp details in an image
- Net effect is image blurring
  - Highpass: attenuate (or eliminate) low frequency components such as slowly varying characteristics
- Net effect is a sharpening of edges and other details
  - Bandpass: attenuate (or eliminate) a given frequency range
- Used primarily for image restoration(are of little interest for image enhancement)

3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

- Filters in the frequency domain and corresponding spatial filters
- Basic approach is to sum products between mask coefficients and pixel values



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

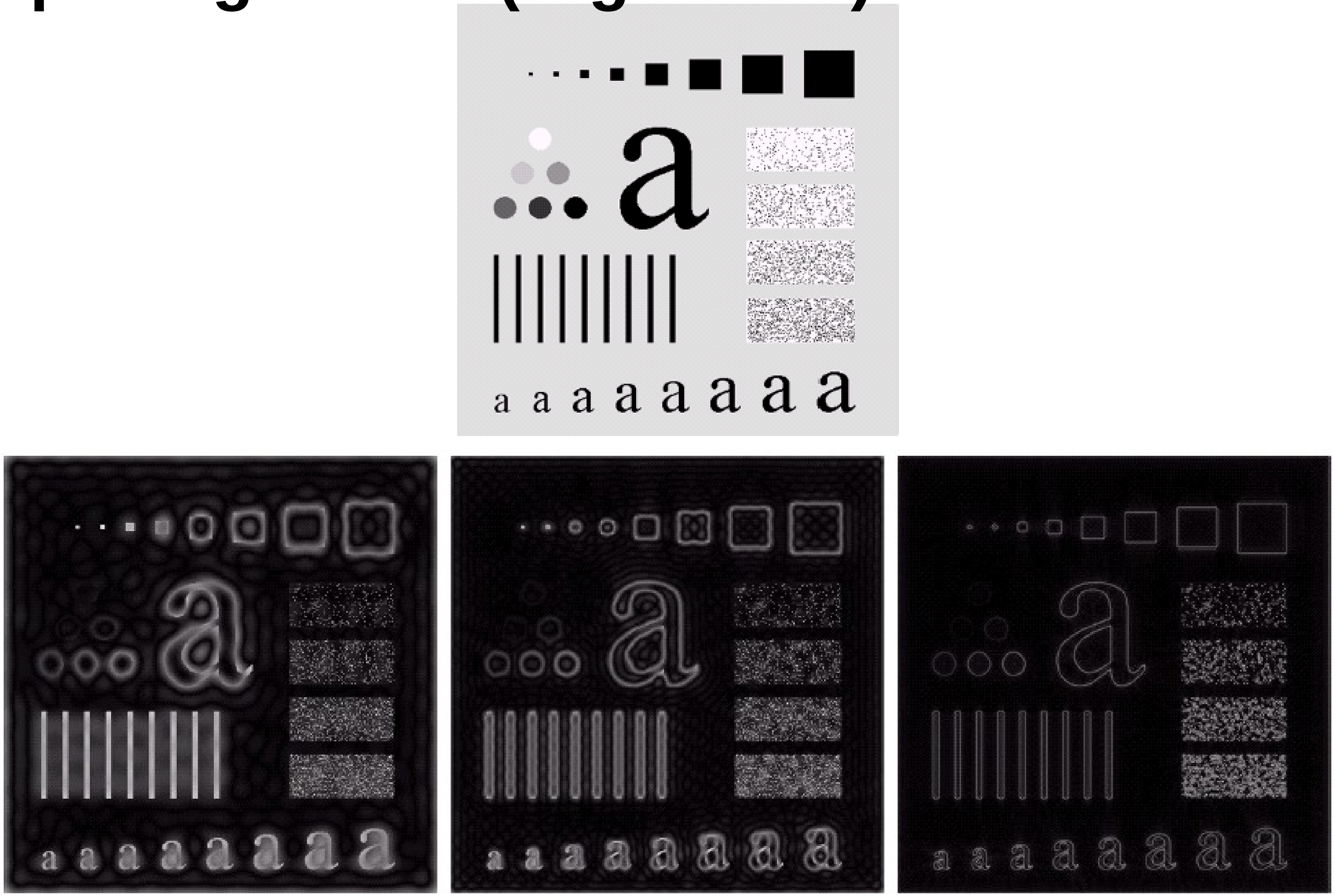
Sharpening Filters (High Pass)

Original

Filtered using ideal HPF

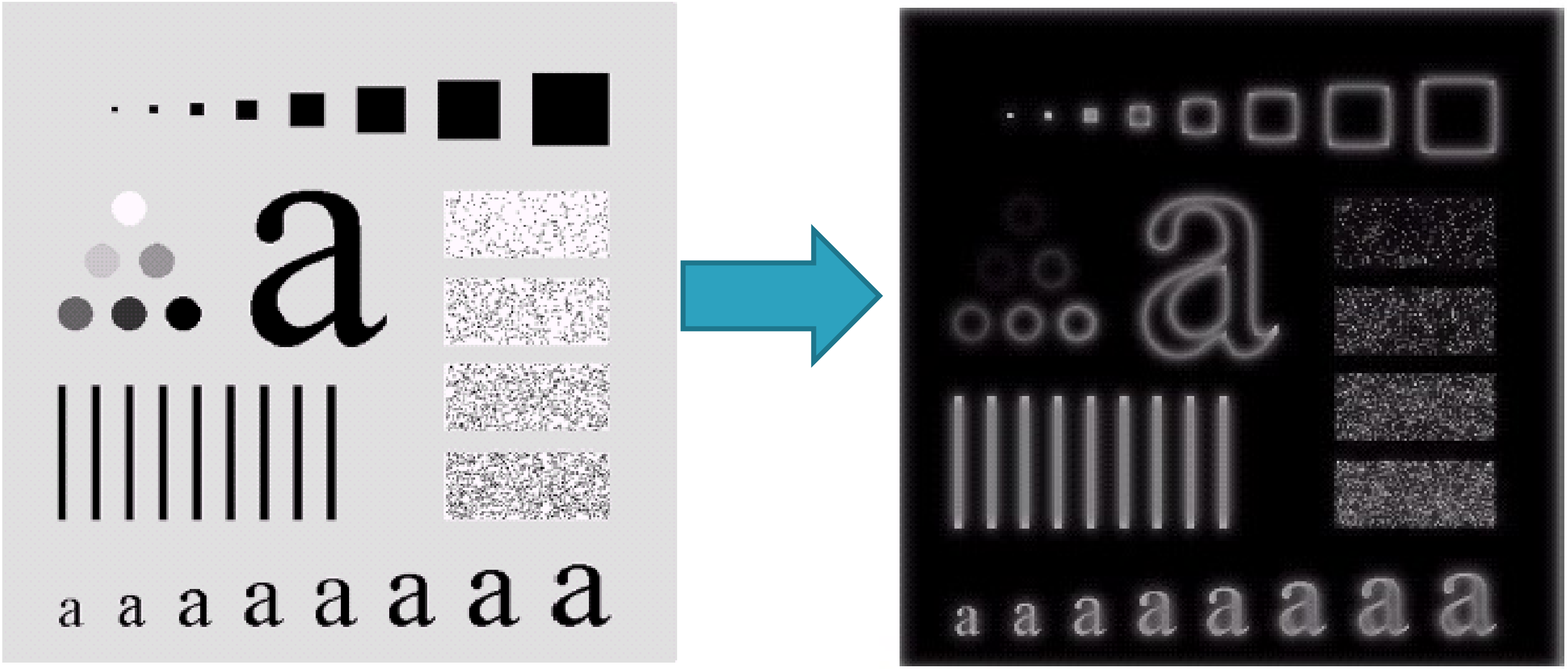
3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Sharpening Filters (High Pass)



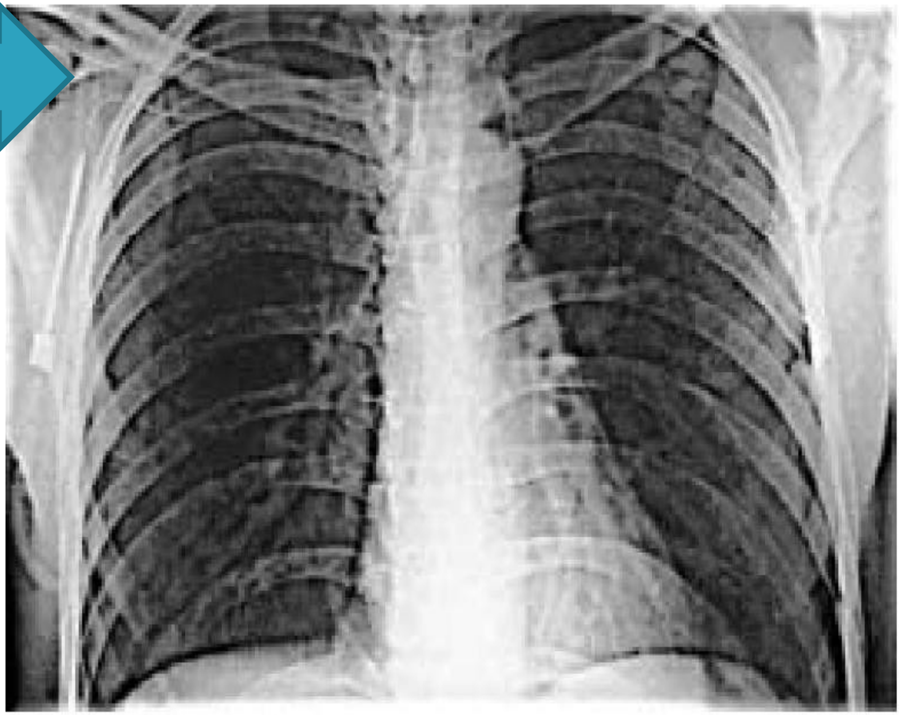
3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Sharpening Filters (High Pass)



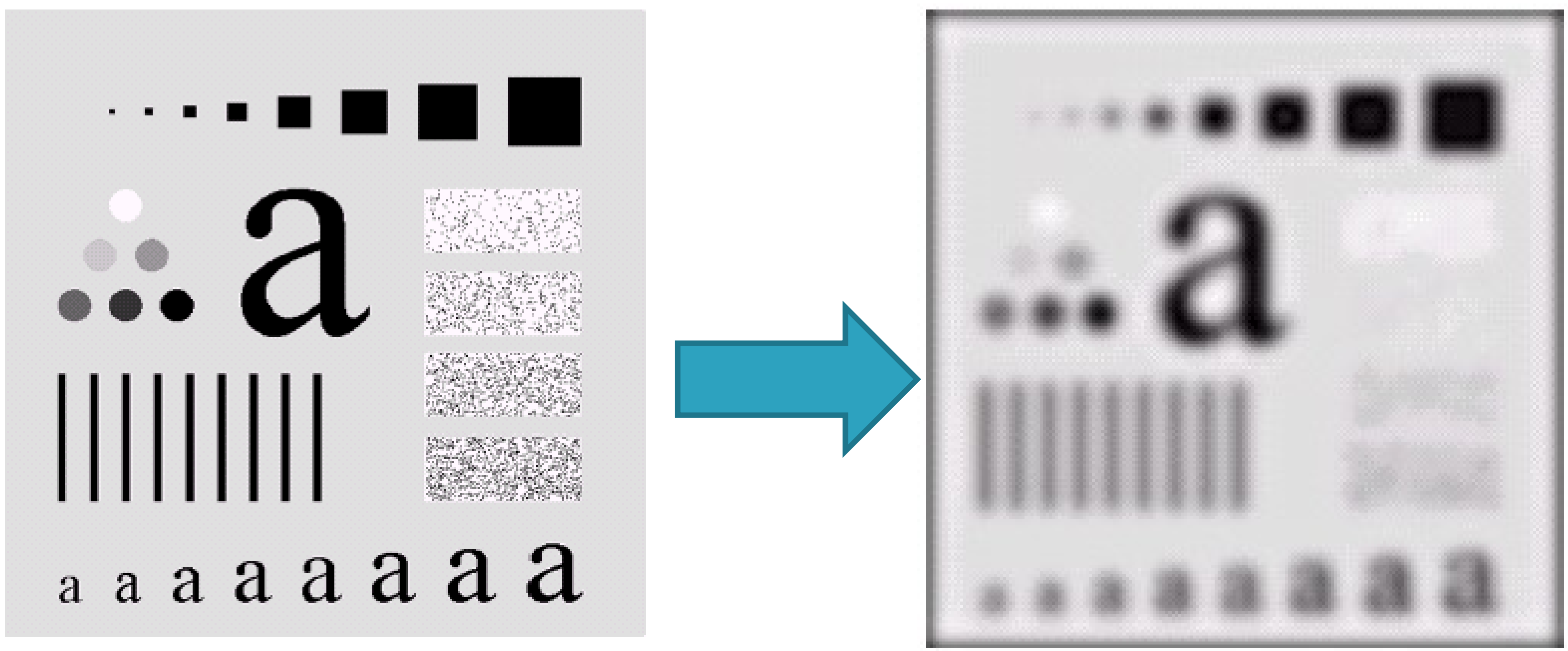
3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Sharpening Filters (High Pass)



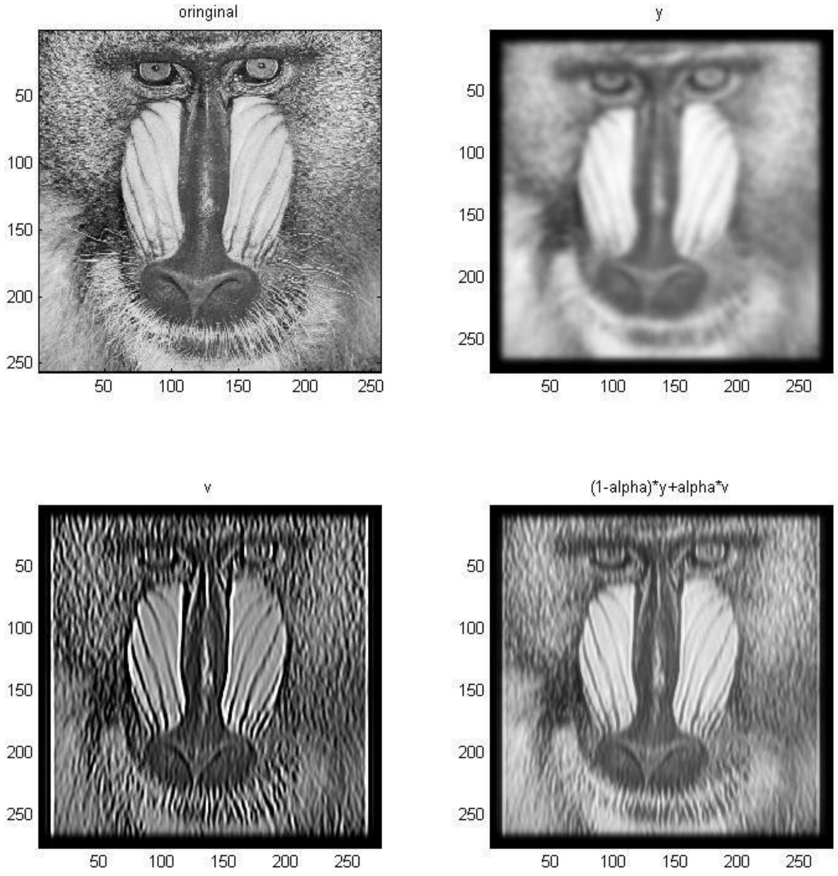
3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Ideal Low pass Filter



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Band pass Filter



3.3. Image Enhancement : Enhancement by point processing, spatial filtering, Color image processing

Color image processing

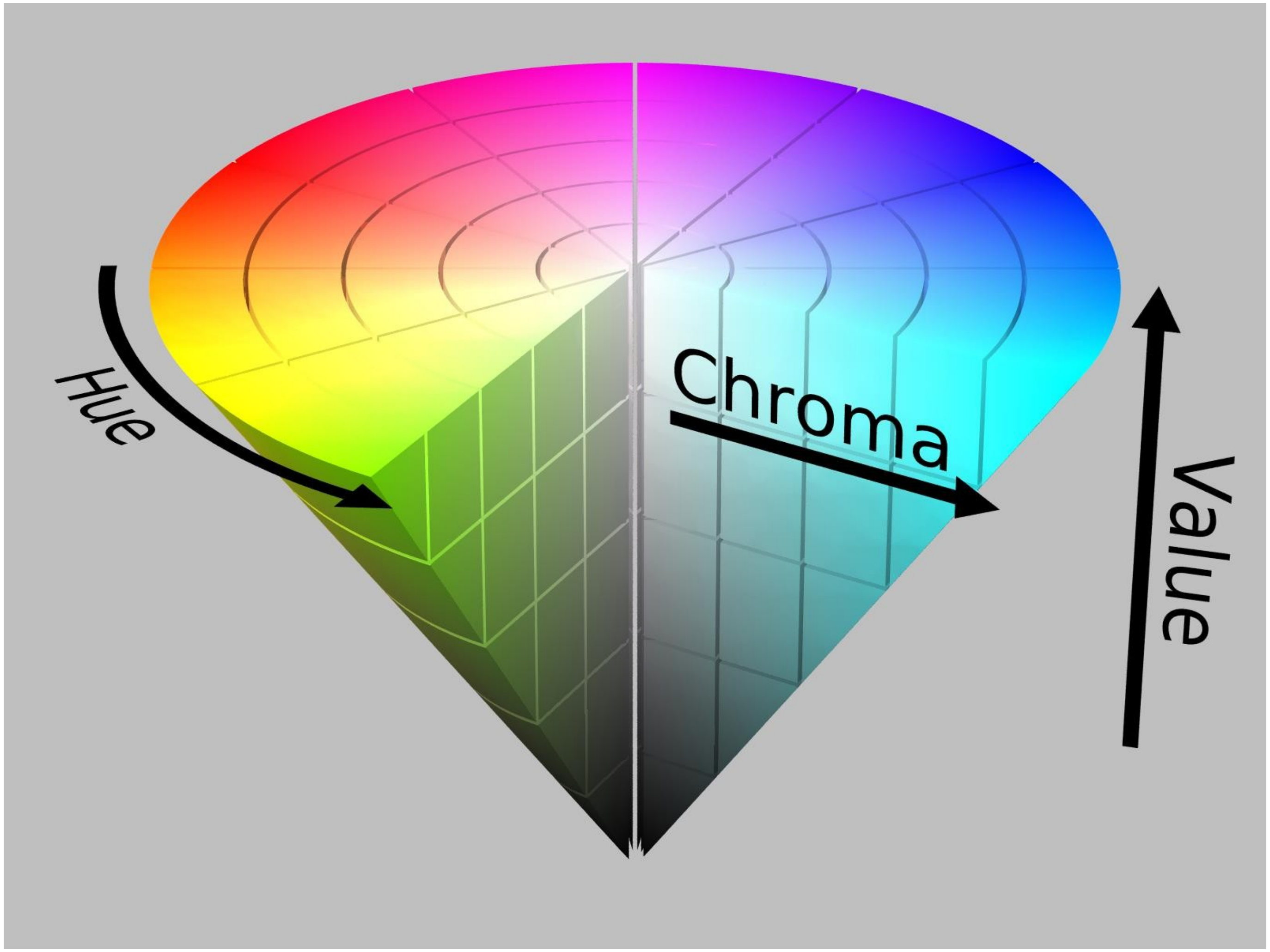
A **(digital) color image** is a digital image that includes color information for each pixel.

The RGB color space is commonly used in computer displays, but other spaces such as HSV, and are often used in other contexts.

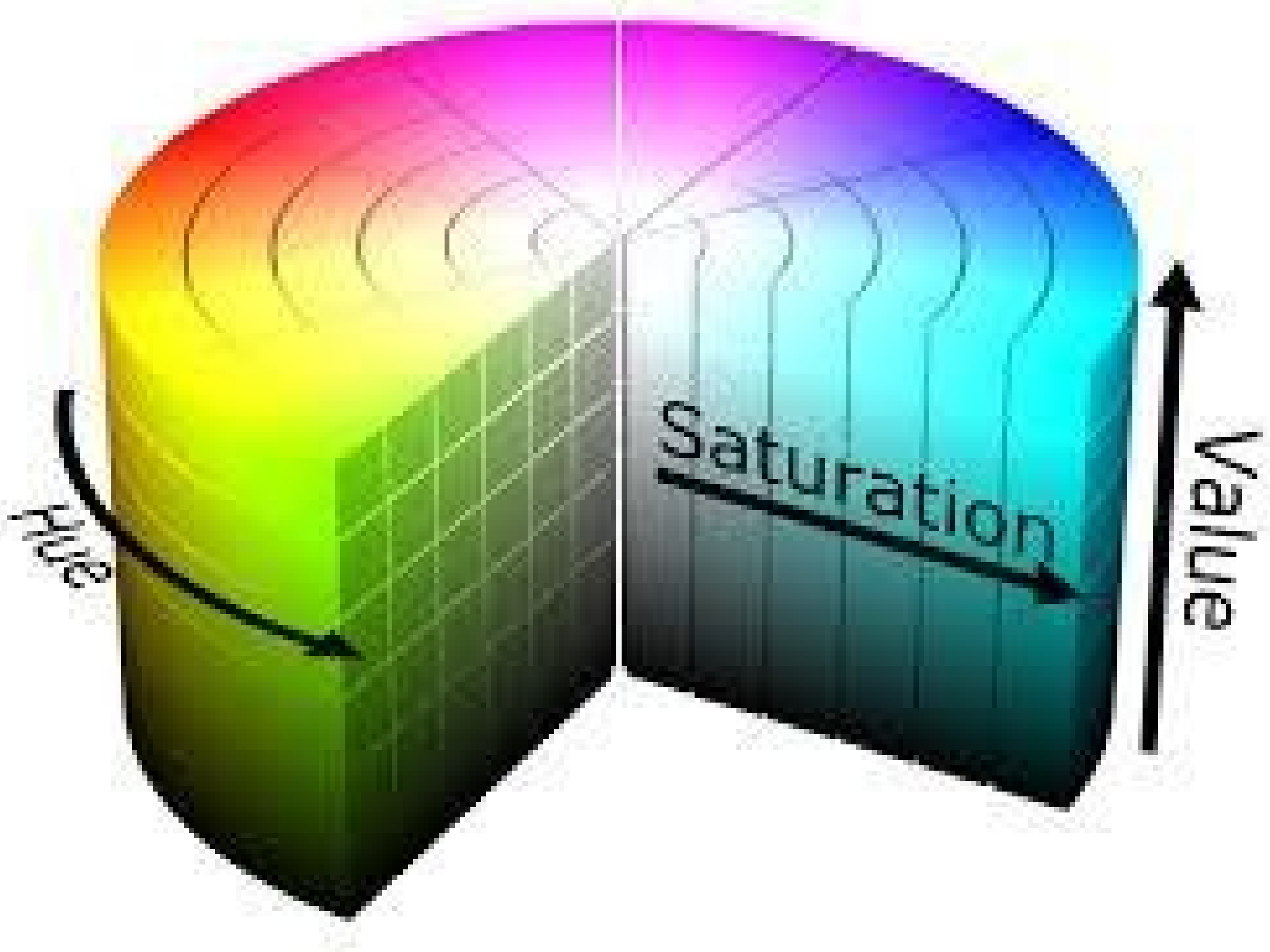
A color image has three values (or channels) per pixel and they measure the intensity and chrominance of light.

The actual information stored in the digital image data is the brightness information in each spectral band.

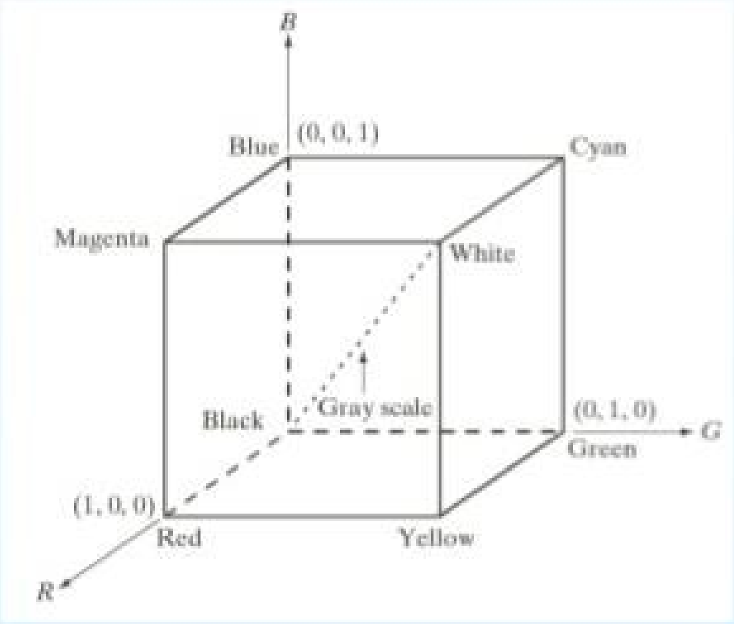
Color image processing (HSV)

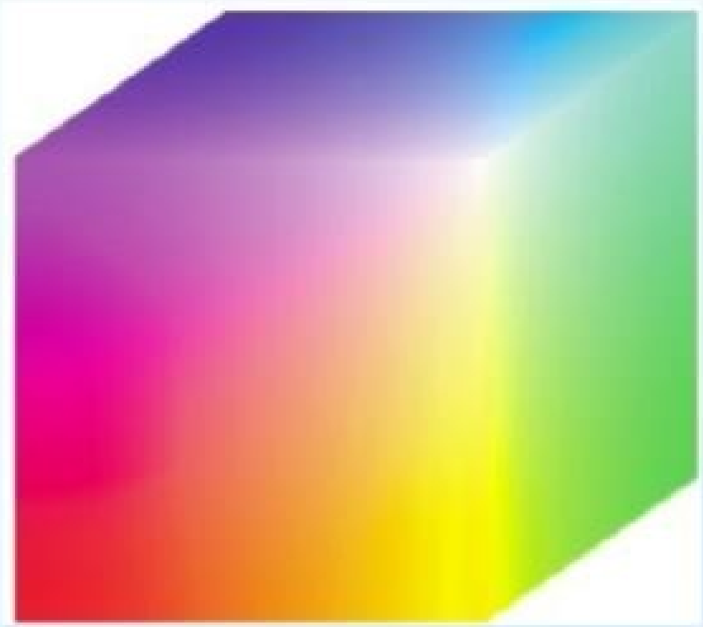


Color image processing (HSV)



Color image processing (RGB)





Color image processing (RGB / CMYK)