

Chapter 3

Images and Graphics

3.1 Basic Images Concept

An image is a spatial representation of an object, a two dimensional or three dimensional scenes or another image.

Abstractly, an image is a continuous function defining a rectangular region of a plane.

Intensity image: proportional to radiant energy received by a sensor/detector.

Range image: line of sight distance from sensor position.

An image can be thought of as a function with resulting values of the light intensity at each point over a planar region.

Digital Image Representation

For computer representation, function (e.g. intensity) must be sampled at discrete intervals.

Sampling quantizes the intensity values into discrete intervals.

Point at which an image is sampled are called picture elements or pixels.

Resolution specifies the distance between points accuracy.

A *digital image* is represented by a matrix of numeric values each representing a quantized intensity value.

A digital image is a numeric representation (normal binary) of two dimensional images.

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.

Intensity value can be represented by bits for black and white images (binary valued images), 8 bits for monochrome imagery to encode color or grayscale levels, 24 bit (RGB).

Image Formats

There are different kinds of image formats in the literature. We shall consider the image format that comes out of an image frame grabber, i.e., the captured image format, and the format when images are stored, i.e., the stored image format.

- (i) *Captured Image Format*
- (ii) *Stored Image Format*

Captured Image Format: -

The image format is specified by two main parameters: spatial resolution, which is specified as pixels x pixels (e.g. 640x480) and color encoding, which is specified by bits per pixel. Both parameter values depend on hardware and software for input/output of images.

Stored Image Format: -

When we store an image, we are storing 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.

A *bitmap* is a simple information matrix describing the individual dots that are the smallest elements of resolution on a computer screen or other display or printing device.

Image file format include:

- GIF (Graphic Interchange Format)
- X11 bitmap
- Postscript
- JPEG (Joint Picture Expert Group)
- TIFF (Tagged Image File Format) etc.

There are many file formats used to store bitmaps and vectored drawing. Following is a list of few image file formats.

Format	Extension
Microsoft Windows DIB	.bmp .dib .rle
Microsoft Palette	.pal
Autocad format 2D	.dxf
JPEG	.jpg
Windows Meta file	.wmf
Portable network graphic	.png
Compuserve gif	.gif
Apple Macintosh	.pict .pic .pct

Graphics Format

Graphic image formats are specified through graphics primitives and their attributes.

Graphic primitive – line, rectangle, circle, ellipses, specification 2D and 3D objects.

Graphic attribute – line style, line width, color.

Graphics formats represent a higher level of image representation, i.e., they are not represented by a pixel matrix initially.

PHIGS (Programmer's Hierarchical Interactive Graphics)

GKS (Graphical Kernel System)

3.2 Computer Image Processing

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image.

Image processing usually refers to digital image processing, but optional and analog image processing also are possible.

Computer graphics concern the pictorial synthesis of real or imaginary objects from their computer-based models.

The related field of image processing treats the converse process: the analysis of scenes, or the reconstruction of model from pictures of 2D or 3D objects.

Image Synthesis

Image synthesis is an integral part of all computer user interfaces is indispensable for visualizing 2D, 3D and higher dimensional objects. Areas as diverse as education, science, engineering, medicine, advertising and entertainment all rely on graphics.

Dynamic in Graphics

Graphics are not confined to static pictures. Picture can be dynamically varied; for example, a user can control animation by adjusting the speed, portion of the total scene in view, amount of detail shown, etc.

Motion Dynamic:

With motion dynamic, objects can be moved and enabled with respect to a stationary observer.

Update Dynamic:

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

The Framework of Interactive Graphics System

Image can be generated by video digitizer cards that capture NTSC (PAL) analog signals and create a digital image.

Graphical images are generated using interactive graphics systems.

The high-level conceptual framework of almost any interactive graphics system consists of three software components: *an application model, an application program and a graphics system*, and a hardware component: graphics hardware.

Application Model:

The application model represents the data or objects to be picture on the screen; it is stored in an application database. The model is an application-specific and is created independency of any particular display system.

Application Program:

The application program handles user input. It produces views by sending to the third component, the graphics system, a series of graphics output commands that contain both a detailed geometric description of what is to be viewed and the attributes describing how the objects should appear.

Graphics System:

The graphics system is responsible for actually producing the picture from the detailed descriptions and for passing the user's input to the application program for processing.

The graphics system is an intermediary component between the application program and the display hardware.

Graphics Hardware:

At the hardware level, a computer receives input from interaction devices and output images to display devices.

Input:

Current input technology provide us with the ubiquitous mouse, the data tablet and transparent, touch sensitive panel mounted on the screen.

The other graphics input are track-balls, space-balls or the data glove. Track-ball can be made to sense rotation about the vertical axis in addition to the about two horizontal axes.

A space-ball is a rigid sphere containing strain gauges. The user pushes or pulls the sphere in any direction, providing 3D translation and orientation.

The data glove records hand position and orientation as well as finger movements. It is a glove covered with small, lightweight sensors.

Output: Raster Display

Most common type of graphic monitors using raster scan display type
CRT Point plotting device

Based on TV technology

Electron beam is swept across the screen, one row at a time from top to bottom, starting at the upper left corner of the display

Process is repeated until the entire screen is covered, and the beam is then returned to the upper left corner to start a new scan

Beam intensity is turned *on* and *off* to create a pattern of illuminated spots

Pictures are dynamically stored in a piece of memory known as *frame buffer* or *refresh buffer*

This buffer holds the set of intensity values all the screen points (pixels)
Requirement to control the intensity of the screen positions:

Simple black and white system:

- 1 bit per pixel
(bitmap) Color system:
- 24 bits/pixel (maximum no. of color representation, pixmap)

Frame buffer or refresh buffer (storage) requirements:

Large storage

e.g. 24 bits/pel, screen resolution of
1024x1024 requires 3mb of RAM

Refresh rate: 60 to 80 frames per second

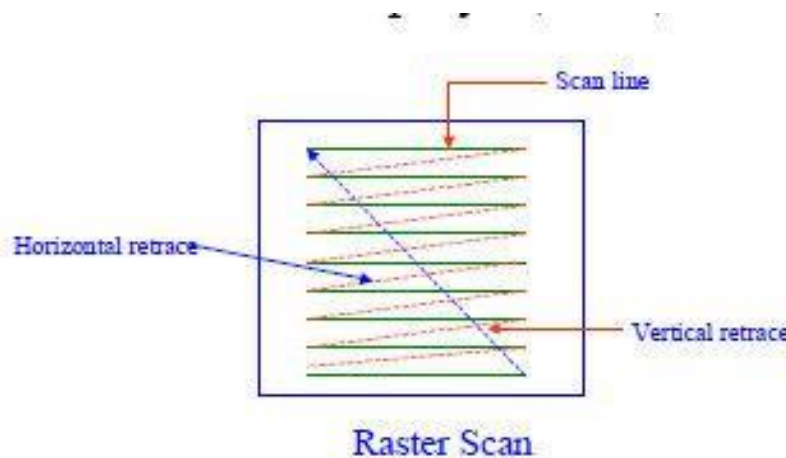


Figure 3.1 Raster Scan

Advantages of Raster Scan Display:

- Capable of presenting bright pictures
- Unaffected by picture complexity
- Suitable for showing dynamic motion
- Lower cost
- Ability to display areas filled with solid colors or patterns

Disadvantages of Raster Scan Display:

- Requires large amount of memory (RAM)
- Produced “stair stepped” appearance of diagonal lines on the image (known as **aliasing** effect)
- True line cannot be represented exactly due to the discretization of the display surface (discrete nature of pixel representation)

Image Analysis

Image analysis is concerned with techniques for extracting descriptions from images that are necessary for high-level scene analysis methods.

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 processing includes image enhancement, pattern detection and recognition and scene analysis and computer vision.

Image enhancement deals with improving image quality by eliminating noise or by enhancing contrast.

Pattern detection and recognition deal with detecting and clarifying standard patterns and finding distortions from these patterns.

Scene analysis and computer vision deal with recognizing and reconstructing 3D models of a scene from several 2D images.

Image Recognition Steps

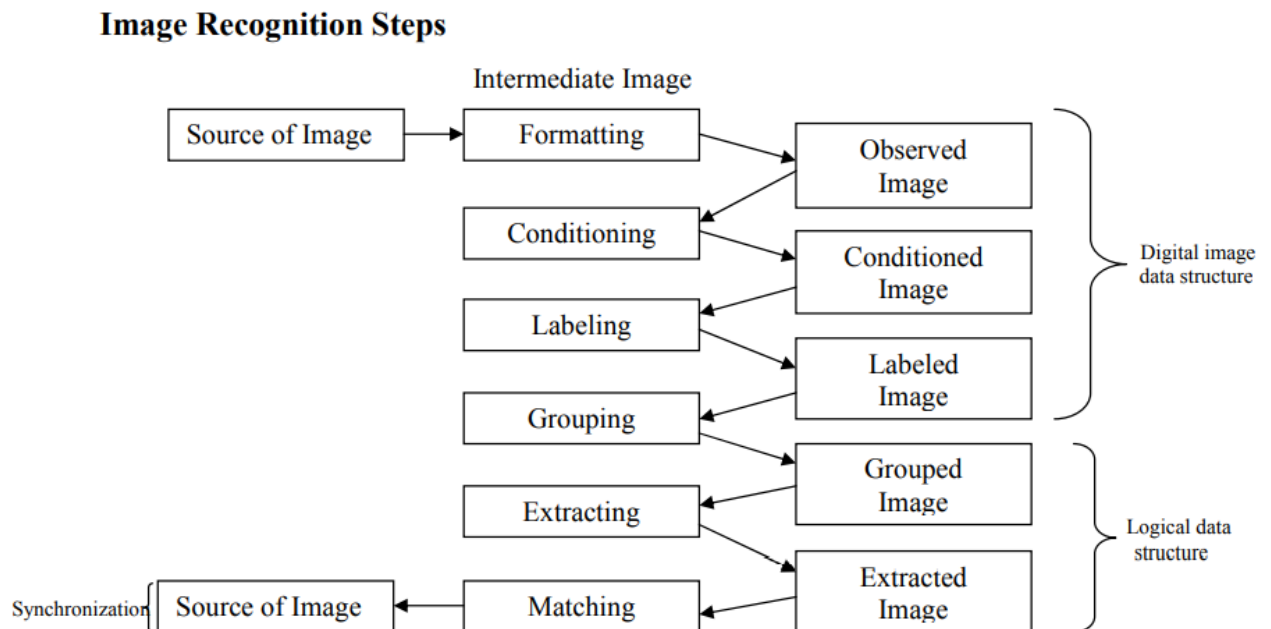


Figure 3.2 Image Recognition Steps

Formatting

Capturing an image from a camera and bringing it into a digital form. It means that we will have a digital representation of an image in the form of pixels.

Conditioning

In image, there is usually uninteresting object introduced during digitize as noise. In conditioning, interesting objects are highlighted by suppressing or analyzing uninteresting in systematic or patterned variations. Conditioning is typically applied uniformly and is context-independent.

Labeling

The informative pattern has structure as a spatial arrangement of events, each spatial event being a set of connected pixels. Labeling determines in what kinds of spatial events each pixel participates.

E.g. edge detection technique

Edge detection technique determines continuous adjacent pairs which differ in intensity or color. Another labeling operation must occur after edge detection, namely thresholding.

Thresholding specifies which edges should be accepted and which should not; the thresholding operation filters only the significant edges from the image and labels them.

Grouping

It can turn edges into line by determining edges belongs to same spatial event. A grouping operation, where edges are grouped into lines, is called line filtering. The grouping operation involves a change of logical data structure.

Extracting

Generating list of properties from set of pixel in spatial event. Extraction can also measure topological or spatial relationship between two or more grouping.

Matching

After the completion of the extracting operation, the events occurring on the image have been identified and measured but the events in and of themselves have no meaning.

It is the matching operation that determines the interpretation of some related set of image events, associating these events with some given three dimensional object or two-dimensional shape.

The classic example is template matching, which compares the examined pattern with stored models (templates) of known patterns and chooses the best match.

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 data transport because image transmission is bursty (The burst is caused by the large size of the image).

Image transmission requires reliable transport.

Time-dependence is not a dominant characteristic of the image in contrast to audio/video transmission.

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

Raw Image Data Transmission

The image is generated through a video digitizer and transmitted in its digital format.

$$\text{Size} = \text{Spatial_resolution} \times \text{Pixel_quantization}$$

For example, the transmission of an image with a resolution of 640 x 480 pixels and pixel quantization of 8 bit per pixel requires transmission of 307,200 bytes through the network.

Compressed Image Data Transmission

The image is generated through a video digitizer and compressed before transmission.

The reduction of image size depends on the compression method and compression rate.

JPEG (Joint Picture Expert Group) & MPEG (Motion Picture Expert Group)

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.

3.3 Image Enhancement

Enhancement is the process an image so that the result is more suitable than the original image for a specific application.

Enhancement approaches:

Spatial domain:

Spatial domain techniques are techniques that operate directly on pixels.

Frequency domain:

Frequency domain techniques are based on modifying the Fourier transform of an image.

$$g(x,y)=T[f(x,y)]$$

$f(x,y)$: input image, $g(x,y)$: processed image

T : an operator

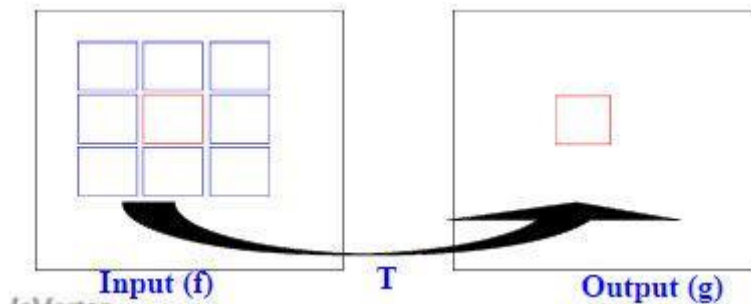


Figure 3.3: Background of Spatial Domain

Spatial Domain: Point Processing

$$s=T(r)$$

r : gray-level at (x,y) in original image $f(x,y)$

s : gray-level at (x,y) in processed image $g(x,y)$ T

is called gray-level transformation or mapping

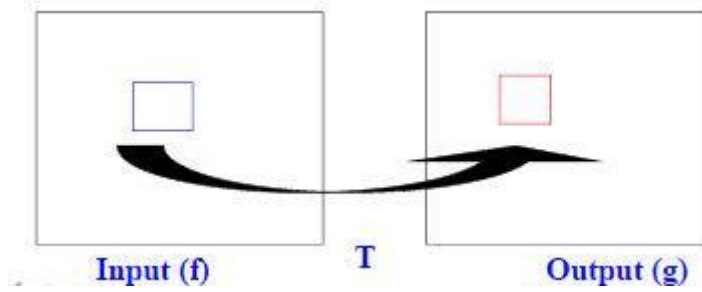
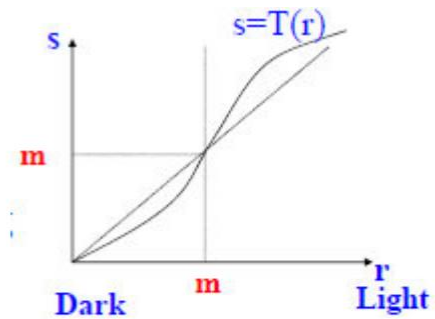


Figure 3.4: Spatial Domain: Point Processing

Contrast Stretching: to get an image with higher contrast than the original image. The gray levels below m are darkened and the levels above m are brightened.



Contrast Stretching



Original



Enhanced

Figure 3.5: Contrast Stretching