



Chapter-3

Multimedia System (Pokhara University)



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Chapter 3 - Image and Graphics

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

Digital Image Representation

An image can be abstractly thought of as a continuous function with resulting values of the light intensity at each point over a planar region. For digital computer operations, this function needs to be sampled at discrete intervals. The sampling quantizes the intensity values into discrete levels.

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.

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.

The accuracy with which the original image is represented is affected by resolution. 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.

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 $2^n - 1$.

Image resolution

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

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

Image Formats

Image formats are basically of two kinds:

(1) Captured 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 320 X 240 pixels and the color can be encoded with 1-bit (a binary image format), 8-bit (color or grayscale) or 24-bit (color-RGB).

(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.

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.

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.

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.

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).

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 indispensable for visualizing 2D, 3D and higher dimensional objects. Some of the applications of image synthesis (areas which use image synthesis) are:

(1) User Interface

- ✓ Point-and-click facility
- ✓ Menu-driven

(2) Office automation and electronic publishing

- ✓ Desktop publishing
- ✓ Electronic publishing
- ✓ Hypermedia Systems

(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.

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.

The Framework of Interactive Graphics

Graphical images are generated using interactive graphics systems (e.g., SRGP). The high level conceptual framework of almost any interactive graphics system consists of three software components:

An application model

It represents the data or objects to be pictured on the screen. It typically stores descriptions of primitives that define the shape of components of the object, object attributes and connectivity relationships that describe how the components fit together. It is stored in an application database. The model is application-specific, and is created independently of any display system.

An application program

It converts the description of the primitives from the application model into the procedure calls or commands the graphics system uses to create an image. This conversion involves two steps:

- ✓ Extraction of the portions to be viewed (from the application database) using some selection or query system
- ✓ Conversion of the extracted geometry into proper format

Hence, the application program produces views by sending to the graphics system, a series of graphics output commands.

A graphics system

The graphics system is an intermediary between the application program and the display hardware. It is responsible for actually producing the picture. It performs two kinds of transformations:

- ✓ Output transformations (from objects in the application model to a view of the model)
- ✓ Input transformations (from user actions to application program inputs that cause the application to make changes in the model and/or picture)

The application program consists of a graphics subroutine library or package, which includes output subroutines corresponding to various primitives, attributes and other elements.

Graphics Hardware

This is the hardware that receives input from interaction devices and outputs images to display devices. Below are given the input and output to the graphics hardware.

Graphics Hardware - Input

Input to the graphics hardware is provided through the input devices such as the mouse, the data tablet, the touch panel, etc. Other devices include track-balls, space-balls and the data glove. Even audio communication is used for providing input to graphics hardware.

Graphics Hardware - Output

Output from the graphics hardware is displayed through the output devices such as raster displays. Raster displays have a display controller, which can be a hardware component that receives and interprets sequences of output commands or a software component of the graphics library package.

Raster displays store display primitives in a refresh buffer in terms of their component pixels. The complete image on a raster display is formed from the raster, which is a set of horizontal raster lines (rows of pixels). The raster is thus stored as a matrix of pixels representing the entire screen area. The entire image is scanned out sequentially by the image display subsystem, called the video controller. An important property of raster displays is the refresh rate, which is 60 Hz or higher.

Raster displays can be used for areas filled with solid colors or patterns. Also, the refresh process is independent of the image complexity.

Dithering

Dithering is a process used in output devices (monitor screens and some printers) to produce shades of gray or tints of colors. The idea is to visually produce an effect on the image that is as close to the original image as possible but using less color.

It is a process used to expand the range of available intensity. Dithering uses the eye's capability for spatial integration, which means that if we view a very small area from a sufficiently large viewing distance, our eyes average fine detail within the small area and record only the overall intensity of the area. Dithering uses two techniques:

Clustered-dot ordered dithering (halftoning)

Four adjacent pixels are used for presenting the desired intensity of a single color. By illuminating none, any one, two, three or all four of the adjacent pixels, different intensities of the color are displayed. The dither matrix can be used to represent the patterns used. This technique is used in devices that are not able to display individual dots (e.g., laser printers).

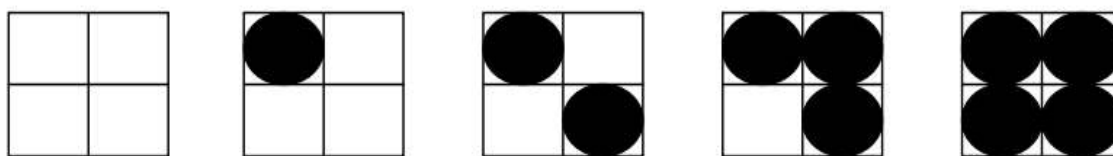


Fig.: Five intensity levels approximated with four 2 X 2 dither patterns.

Dispersed-dot ordered dithering

This technique is used for devices such as CRT displays that can display individual dots. Using the 2 X 2 dither pattern, a color CRT display can present 125 colors as follows:

Each pattern can display five intensities for each color (Red, Green or Blue), by using the halftone patterns as in clustered-dot ordered dithering. Hence total number of resultant intensities = $5 \times 5 \times 5 = 125$ color combinations.

Dithering is the process of juxtaposing pixels of two colors to create the illusion that a third color is present. A simple example is an image with only black and white pixels palette. By combining black and white pixels in complex patterns a graphic system/ program like adobe Photoshop can create the illusion of gray values.

Most images are dithered in diffusion or randomized pattern to diminish the harsh transition from one color to another. But dithering also reduces the overall sharpness of an image and it often introduces a grainy pattern in the image.

Thus dithering is a process of creating the illusion of new colors and shades by varying the pattern of dots. Dithering is usually called halftoning, and shades of gray are called halftones.

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.

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

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.

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 robot sensing the relative sizes, shapes, positions and colors of objects.

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.

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.

The kind of object, background, imaging sensor and viewpoint of the sensor all determine whether the recognition problem is easy or difficult.

Image recognition is usually performed on digital images that are represented by a pixel matrix. The only information available to an image recognition system is the light intensities of each pixel and the location of a pixel in relation to its neighbors. From this information, image recognition systems must recover information that enables objects to be located and recognized, and, in the case of stereoscopic images, depth information that informs us of the spatial relationship between objects in a scene.

Image recognition involves the following six steps:

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

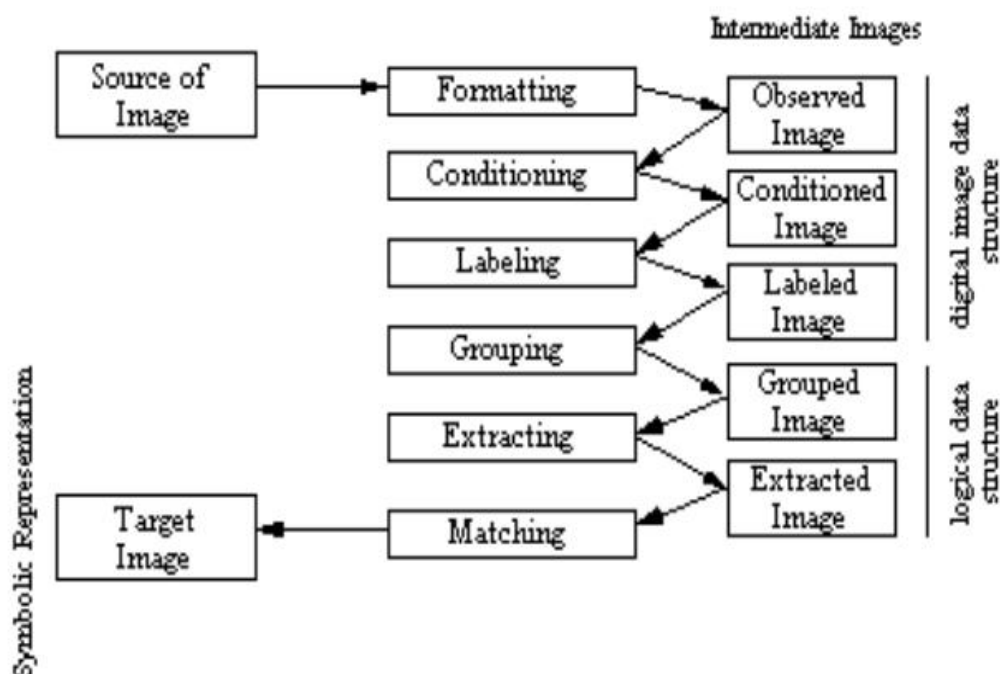


Figure: Image recognition steps

(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) 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.

(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.

(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.

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:

Raw image data transmission

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

$$\text{Size} = \text{Spatial_Resolution} \times \text{Pixel_Quantization}$$

For example, the transmission of an image with a resolution of 640 X 480 pixels and pixel quantization of 8 bits per pixel requires $640 \times 480 \times 8 = 2457600$ bits (=307,200 bytes).

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.

References:

- ✓ "Multimedia: Computing, Communications and Applications", Ralf Steinmetz and Klara Nahrstedt, Pearson Education Asia
- ✓ "Multimedia Communications, Applications, Networks, protocols and Standards", Fred Halsall, Pearson Education Asia
- ✓ "Multimedia Systems", John F. Koegel Buford, Pearson Education Asia

Assignments:

- (1) Explain and discuss the steps involved in image analysis.
- (2) Explain the image synthesis. What are the image recognition steps? Explain with the help of block diagram.
- (3) What are the basic parameters that are to be looked into while representing image in a computer? Explain.
- (4) What are the image recognition steps? Explain briefly.

A Gentle Advice:

Please go through your text books and reference books for detail study!!! Thank you all.