Multimedia Information Retrieval and Technology

Lecture14 Image Data Representations

•By : Laura Liu

•Room: EE314

•Tel. no. 7756

Xi'an Jiaotong-Liverpool University

西交利物浦大学

Graphics and Image Data Representations

- Image Data Types
  - 1-bit Images (binary image)
  - 8-bit Gray-level Images
- 24-bit Color Images and Color Histogram
- 8-bit Color Images and Color Look-up Tables (LUTs)

Graphics/Image Data Types

- The number of file formats used in multimedia continues to proliferate.

- Table 3.1 shows a list of some file formats.

File Import				File Export	
Image	Sound	Video	Anim.	Image	Video
.BMP, .DIB, .GIF, .JPG, .PICT, .PNG, .PNT, .PSD, .TGA, .TIFF, .WMF	.AIFF .AU .MP3 .WAV	.AVI .MOV	.DIR .FLA .FLC .FLI .GIF .PPT	.BMP	.AVI .MOV

- Image Data Types
  - 1-bit Images (binary image)
  - 8-bit Gray-level Images
- 24-bit Color Images and Color Histogram
- 8-bit Color Images and Color Look-up Tables (LUTs)

1-bit Images

- Image consist of **pixels**, picture elements in digital images.
- Each pixel is stored as a single bit (0 or 1), so also referred to as **binary image**.
- 1-bit **monochrome** image since it contains no color.
- Fig. 3.1 shows a 1-bit image (called "Lena" by multimedia scientists - this is a standard image used to illustrate many algorithms).

Fig. 3.1: Monochrome 1-bit Lena image.

8-bit Gray-level Images

Each pixel has a gray-value between 0 and 255.

Each pixel is represented by a single byte; e.g., a dark pixel might have a value of 10, and a bright one might be 230.

- **Bitmap**: The two-dimensional array of pixel values that represents the graphics/image data.

8-bit Gray-level Images

•**Image resolution** refers to the number of pixels in a digital image (higher resolution always yields better quality).

- Fairly high resolution might be $1{,}600 \times 1{,}200$,
- Whereas lower resolution might be 640×480.

Aspect ratio 4:3. We don’t have to adopt this ratio, but it has been found to look natural.

8-bit Gray-level Images

8-bit image can be thought of as a set of 1-bit bit-planes, where each plane consists of a 1-bit representation of the image at higher and higher levels of "elevation":

- a bit is turned on if the image pixel has a nonzero value that is at or above that bit level.
- 8 bit-planes make up a single byte that stores values between 0 and 255.

8-bit Gray-level Images

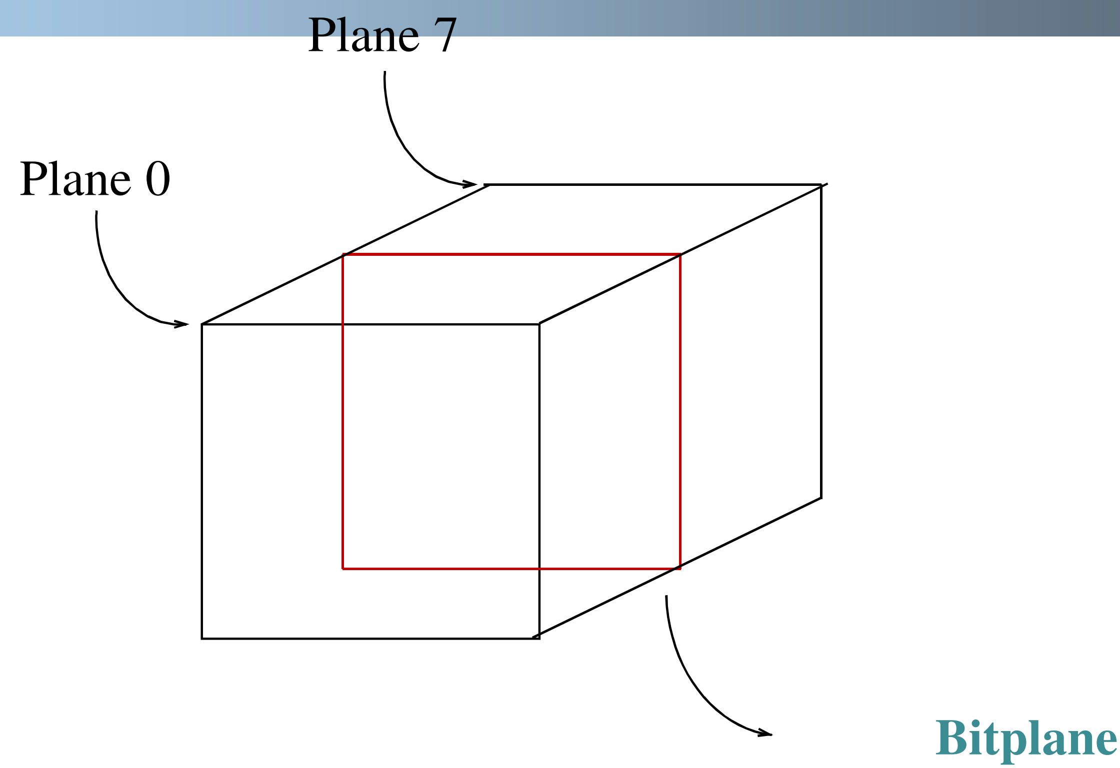

Fig. 3.2:Bit-planes for 8-bit grayscale image.

8-bit Gray-level Images

- Each pixel is usually stored as a byte (a value between 0 to 255), so a 640 $\times$ 480 grayscale image requires 300 kB of storage (640 $\times$ 480 = 307, 200).
- Fig. 3.3 shows the Lena image again, but this time in grayscale.

Fig. 3.3: Grayscale image of Lena.

Exercise

- Suppose we decide to quantize an 8-bit grayscale image down to just 2 bits of accuracy. What is the simplest way to do so? What ranges of byte values in the original image are mapped to what quantized values?

Dithering

- When print, things become more complex.
- 600 dots-per-inch (dpi) printer.
  - **DPI** is a measure of spatial printing, in particular the number of individual dots that can be placed in a line within the span of 1 inch (2.54 cm).
- Such a device can usually only print a dot or not print it.

Dithering

- When an image is printed, the basic strategy of dithering is used, which trades intensity resolution for spatial resolution to provide ability to print multi-level images on 2-level (1-bit) printers.

- Dithering is used to calculate patterns of dots such that values from 0 to 255 correspond to patterns that correctly represent darker and brighter pixel values, for printing on a 1-bit printer.

Dithering

- The main strategy is to replace a pixel value by a larger pattern, say 2×2 or 4×4, (replace each pixel by an $n \times n$ matrix of dots) such that the number of printed dots approximates the varying-sized disks of ink used in halftone printing (intensity).

- **Half-tone printing** is an analog process that uses smaller or larger filled circles of black ink to represent shading, for newspaper printing.

- If the intensity is greater than the dither matrix entry then print an **on** dot at that entry location:

Xi'an Jiaotong-Liverpool University
西交利物浦大學

Dithering-Example

- A 2*2 dither matrix:

$$\begin{pmatrix} 0 & 2 \\ 3 & 1 \end{pmatrix}$$

- n*n matrix can represent $n^2 + 1$ levels of intensity resolution.

1. re-map image values in 0..255 into the new range 0..4 (integer).
2. if the pixel value is 0 we print nothing, in a 2×2 area of printer output.
3. But if the pixel value is 4 we print all four dots.

Xi'an Jiaotong-Liverpool University
西交利物浦大學

Exercise

- How many levels of intensity resolution a 3*3 matrix can represent?
- Design a 3*3 dither matrix.

(a) (b) (c)

Fig. 3.4: Dithering of grayscale images.

(a): 8-bit grey image “lena gray.bmp”. (b): Dithered version of the image. (c): Detail of dithered version.

- Image Data Types
  - 1-bit Images (binary image)
  - 8-bit Gray-level Images
- 24-bit Color Images and Color Histogram
- 8-bit Color Images and Color Look-up Tables (LUTs)

Image Data Types

- The most common data types for graphics and image file formats: **24-bit color and 8-bit color**.
- Some formats are restricted to particular hardware or operating system platforms, while others are "cross-platform" formats.
- Even if some formats are not cross-platform, there are conversion applications that will recognize and translate formats from one system to another.

Image Data Types

- Most image formats incorporate some variation of a **compression** technique due to the large storage size of image files.
- Compression techniques can be classified into either **lossless** or **lossy**.

24-bit Color Images

In a color 24-bit image, each pixel is represented by three bytes, usually representing RGB.

This format supports $256 \times 256 \times 256$ possible combined colors, or a total of 16,777,216 possible colors.

However such flexibility does result in a storage penalty: A 640×480 24-bit color image would require 921.6 kB of storage without any compression.

24-bit Color Images

Fig. 3.5 shows the image forestfire.bmp. A 24-bit image in Microsoft Windows BMP format. Also shown are the grayscale images for just the Red, Green, and Blue channels, for this image.

(a)

(b)

(c)

(d)

Fig. 3.5 High-resolution color and separate R, G, B color channel images. (a): Example of 24-bit color image forestfire.bmp” . (b, c, d): R, G, and B color channels for this image

Color Histogram

- Suppose all the colors in a 24-bit image were collected in a 256 x 256 x 256 set of cells.
- **Count how many pixels belong to each of these colors stored in that cell.**
  - E.g., if exactly 23 pixels have RGB values (45, 200, 91) then store the value 23 in a three-dimensional array, at the element indexed by the index values [45, 200, 91].
- This data structure is called a ***color histogram***.

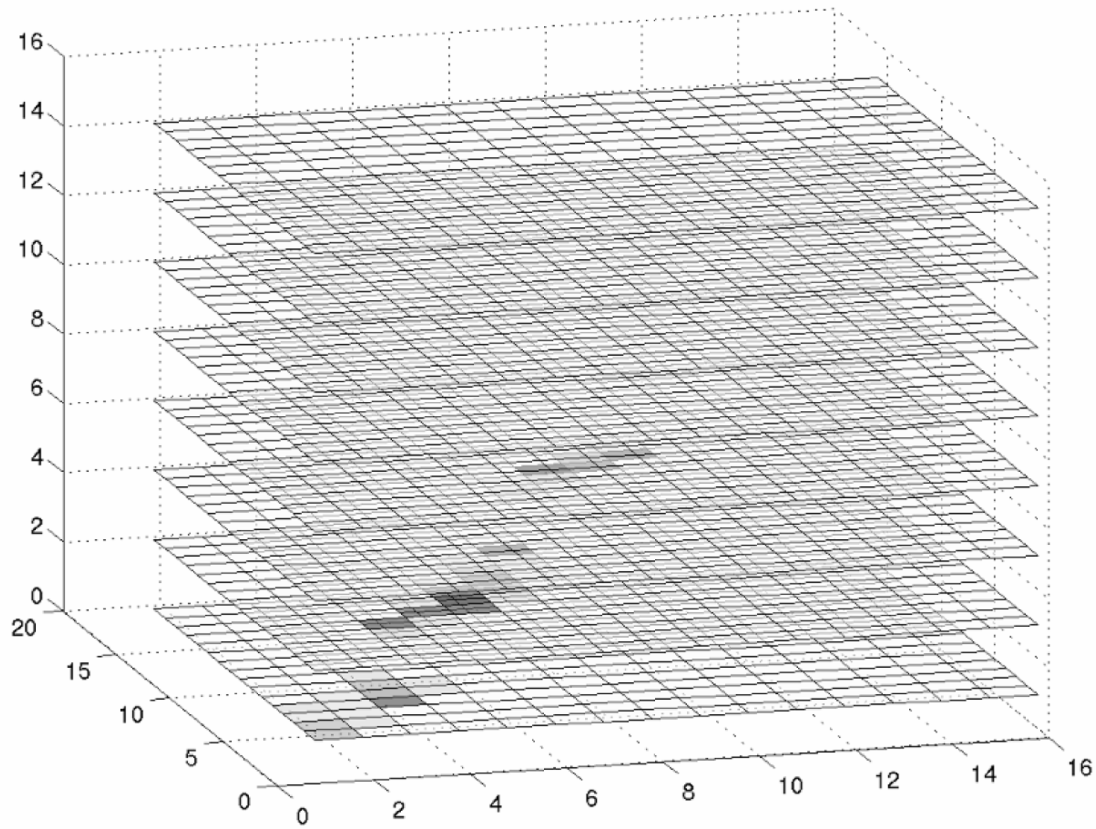

Fig. 3.6: 3-dimensional histogram of RGB colors in “ forestfire.bmp”.

Xi’an Jiaotong-Liverpool University
西交利物浦大學

Color Histogram

- This histogram (Fig.3.6) has 16 x 16 x 16 bins and shows the count in each bin in terms of intensity and pseudocolor.
- We can see a few important **clusters** of color information of the forest fire image.
- Clustering in this way allows us to pick the most important 256 groups of color to use in Look-up Table.

- Image Data Types
  - 1-bit Images (binary image)
  - 8-bit Gray-level Images
- 24-bit Color Images and Color Histogram
- 8-bit Color Images and Color Look-up Tables (LUTs)

8-bit Color images

- Many systems make use of 8 bits of color information (the so-called “256 color”) in producing a screen image.
- Such image files use the concept of **a lookup table** to store color information.

The image stores not color, but instead just a set of bytes, each of which is actually an index into a table with 3-byte values that specify the color for a pixel with that lookup table index.

- Fig. 3.7 shows the resulting 8-bit image, in GIF format.

Fig. 3.7 Example of 8-bit color image.

- Note the great savings in space for 8-bit images, over 24-bit ones: a 640 × 480 8-bit color image only requires 300 kB of storage, compared to 921.6 kB for a color image (again, without any compression applied).

Color Look-up Tables (LUTs)

- The idea used in 8-bit color images is to store only the index, or code value, for each pixel. Then, e.g., if a pixel stores the value 25, the meaning is to go to row 25 in a color look-up table (LUT).

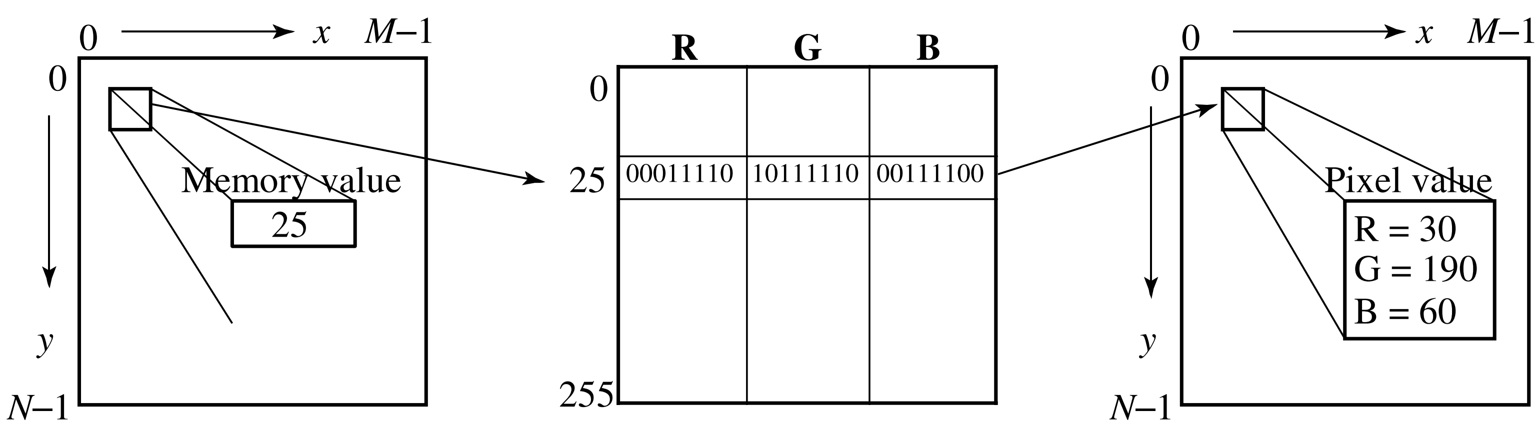

Fig. 3.8: Color LUT for 8-bit color images.

Dithering for color printers

Using 1 bit per color channel and spacing out the color with RGB dots.

If the printer or screen can print only a limited number of colors, say using 8 bits instead of 24, color can be made to seem printable, even if it is not available in the color LUT.

Trick the eye into perceiving colors that are not available, because it carries out a spatial blending that can be put to good use.

•Fig. 3.10(a) shows a 24-bit color image of "Lena", and Fig. 3.10 (b) shows the same image reduced to only 5 bits via dithering. A detail of the left eye is shown in Fig. 3.10(c).

(a) (b) (c)

Fig. 3.10: (a): 24-bit color image "lena.bmp". (b): Version with color dithering. (c): Detail of dithered version.

Xi'an Jiaotong-Liverpool University
西交利物浦大学