Fundamentals of Multimedia

Lecture 2
Graphics & Image Data Representation

Mahmoud El-Gayyar

elgayyar@ci.suez.edu.eg

Outline

- *Black & white imags*
  - ◆ 1 bit images
  - ◆ 8-bit gray-level images
  - ◆ Image histogram

- *Dithering*

- *Color imags*
  - ◆ 24-bit color images
  - ◆ 8-bit color images

- *Popular File Formats*
  - ◆ GIF (Graphics Interchange Format)
  - ◆ JPEG (Joint Photography Expert Group)
  - ◆ Others

Outline

- ***Black & white imags***

  - 1 bit images

  - 8-bit gray-level images

- *Dithering*

- *Color imags*

  - 24-bit color images

  - 8-bit color images

- *Popular File Formats*

  - GIF (Graphics Interchange Format)

  - JPEG (Joint Photography Expert Group)

  - Others

Images can Represent?!

- *Photographs*

- *Paintings*

- *Drawings*

- *Symbols*

- *Corporate logos*

- *Flags*

- *Maps*

- *Diagrams*

- *Graphs*

- *...*

Image Representation

- *Bit map techniques*

  - Pixel-by-pixel representation of the color : short for "*picture element*"

  - Pixel: the smallest discrete component of an image on the screen

  - Wide range of colors and shades in complex images

- *Vector techniques*

  - comprise mathematical representations

  - Scalable

  - Small file size

Digitization

- *An image is broken into thousands of pixels.*

- *An image stored in this way is called a bitmap.*

- *In color images Pixels are represented by three numbers:*

  - ◆ Red   0-255

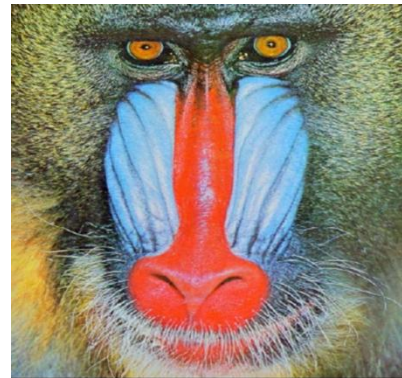 - ◆ Blue   0-255

  - ◆ Green 0-255

Image Presentation

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

- *Image resolution*
  - The number of pixels in a digital image (width x height)

- *Standard Images*
 - Illustrate algorithms and compare the performance

Lena

Baboon

Image Presentation

- *Frame buffer:*

  - Hardware used to store bitmap.

  - A graphics card is used for this purpose.

  - but if not enough video card memory is available then the data has to be shifted around in RAM for display.

- *File size = ?*
  - width x height x #ofBytesPerPixel

1-bit Images

- *Each pixel is stored as a single bit (0 or 1), so also referred to as binary image.*

- *Such an image is also called a 1-bit monochrome image since it contains no color.*

  - ◆ For pictures containing simple graphics / text
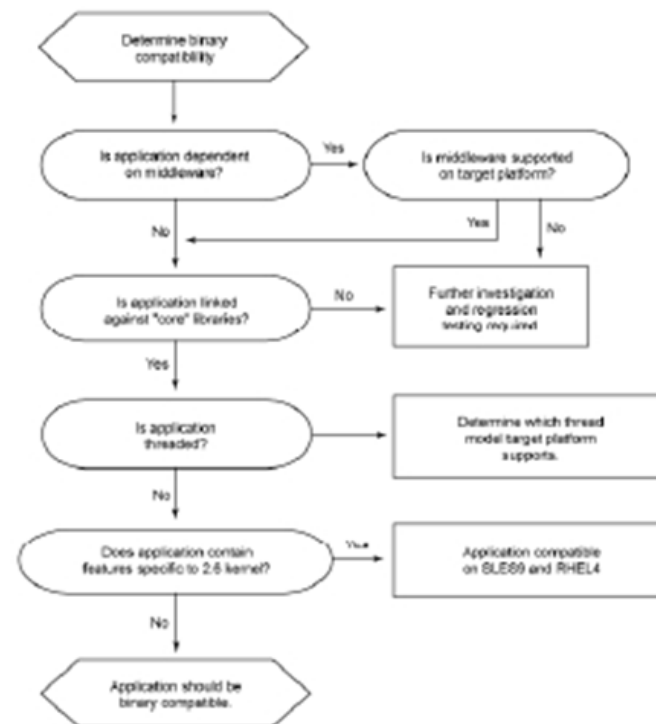
1-bit Images

- *File size calculation*

  - Resolution: 640 x 480

  - File size = 640 x 480 x 1/8 = 38.4 kB

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.*

bit_map =

254	210	180	144
112	78	40	0

8-bit Gray-level Images

- *File size calculation*

  - Resolution: 640 x 480
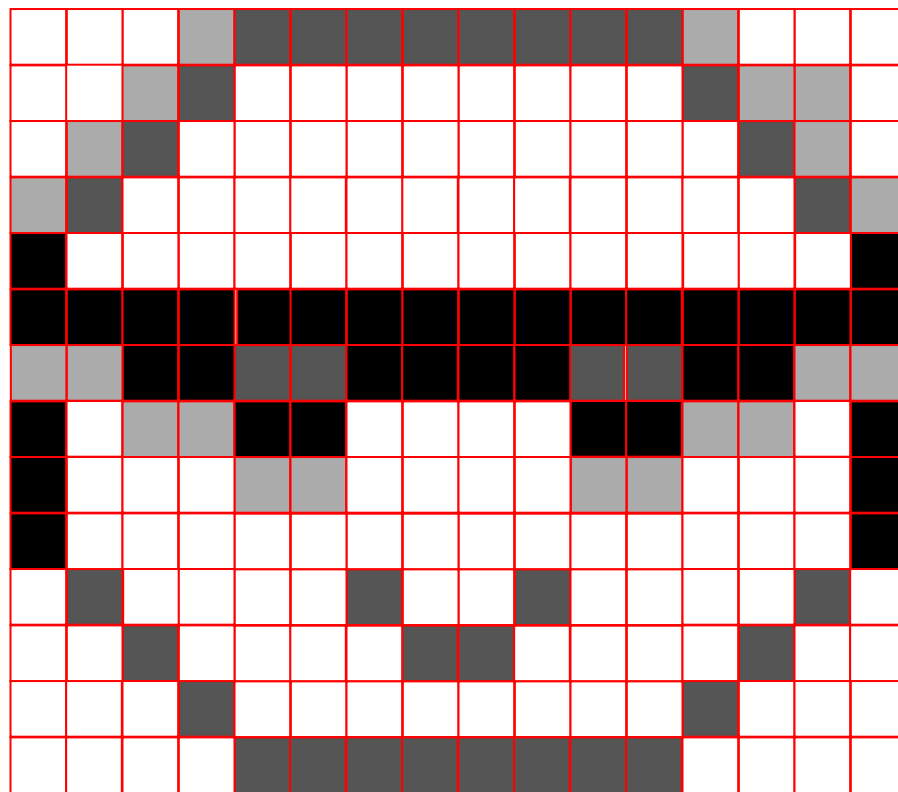
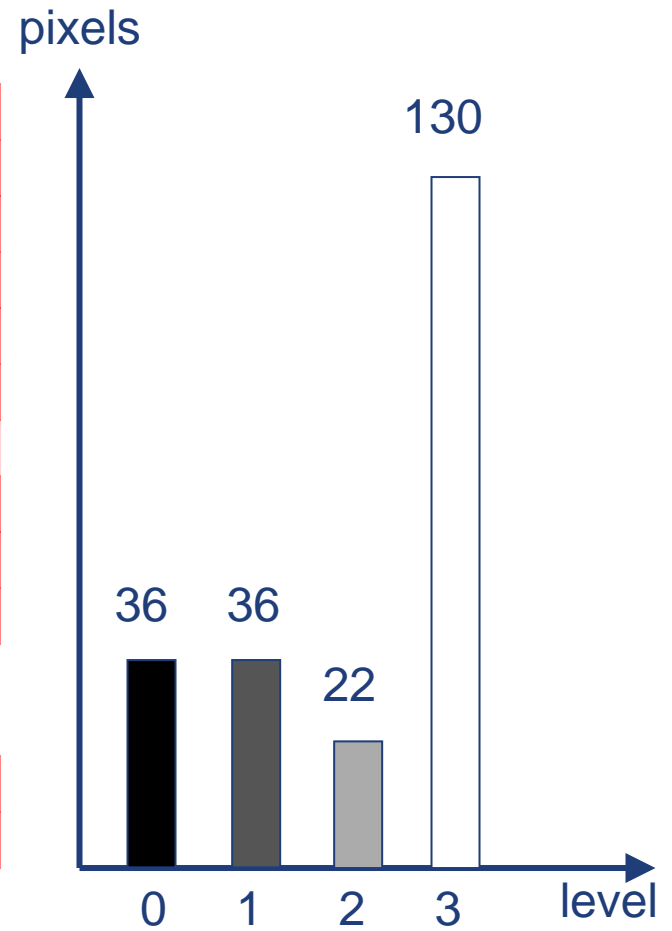 - File size = 640 x 480 x 1 = 300 kB

Image Histogram

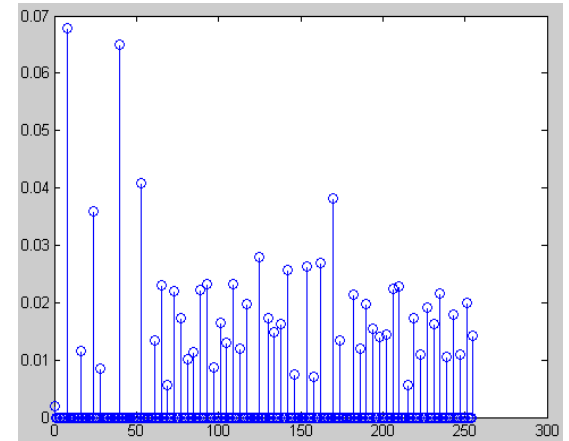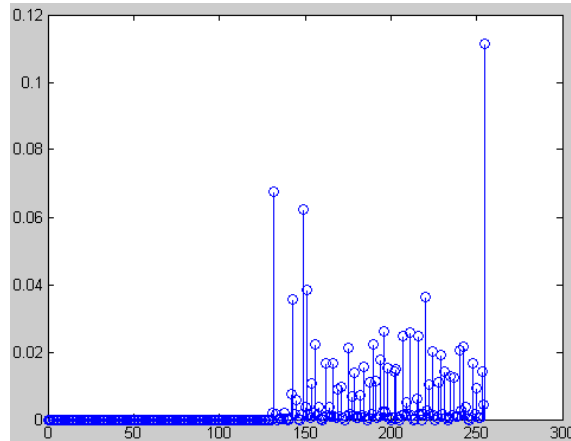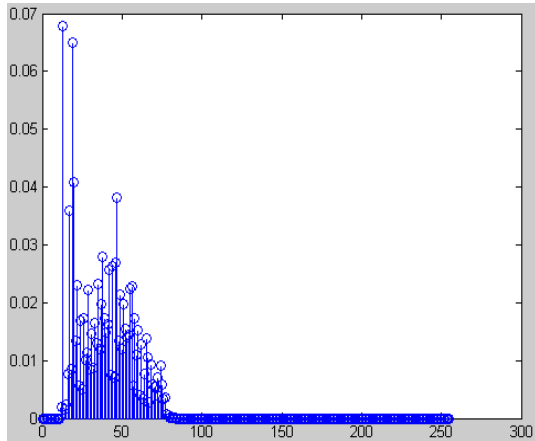Image 16x14 = 224 pixels

Histogram Equalization
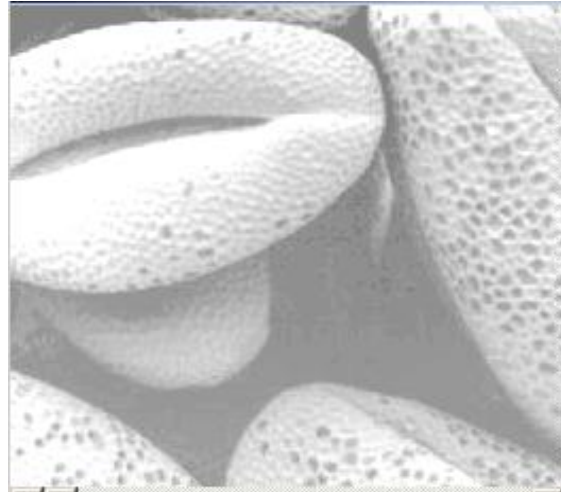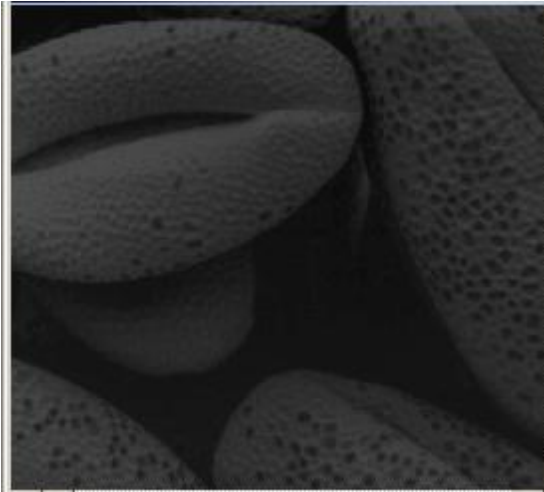
Outline

- *Black & white imags*

  - 1 bit images

  - 8-bit gray-level images

- ***Dithering***

- *Color imags*

  - 24-bit color images

  - 8-bit color images

- *Popular File Formats*

  - GIF (Graphics Interchange Format)

  - JPEG (Joint Photography Expert Group)

  - Others

Dot & Pixel

- *Dot is the smallest discrete component of an image on the paper*

- *Dot is generally much smaller than pixel*
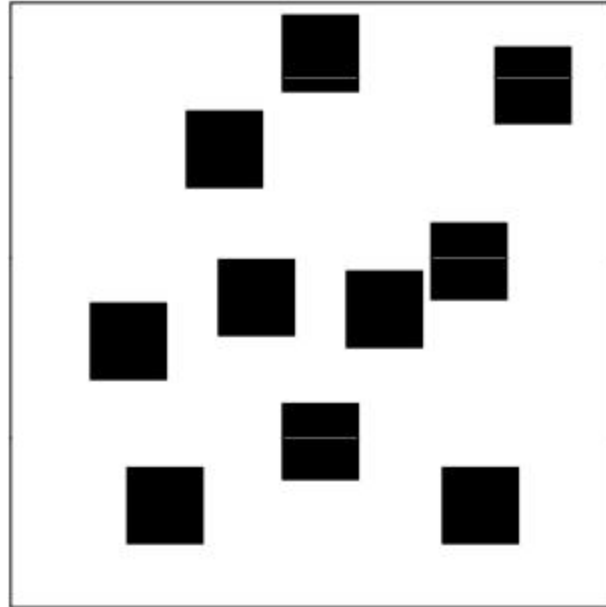
Dithering

- *When an image is printed, the basic strategy of **dithering** is used,*

  - print multi-level images (8) on 2-level (1-bit) printers (laser).

- *Dithering is used to calculate patterns of dots such that values from 0 to 255 correspond to patterns that are more and more filled at darker 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, such that the number of printed dots approximates the varying-sized disks of ink used in analog, in halftone printing (e.g., for newspaper photos).*

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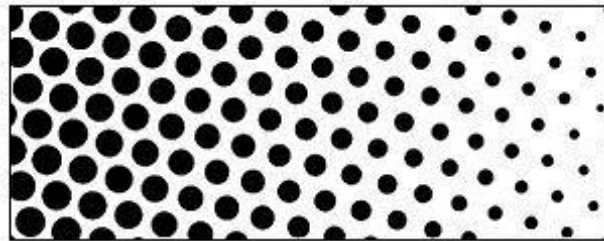
Halftone

Gradient

Dithering

255

255:5=51

Dither matrix: 2x2 $\begin{pmatrix} 0 & 2 \\ 3 & 1 \end{pmatrix}$

205-255 => 4

0	0
0	0

Ex: 10 => 0

154-204 => 3

103-153 => 2

1	0
0	1

Ex: 125 => 2

52-102 => 1

1	1
0	1

Ex: 180 => 3

0-51 => 0

1	1
1	1
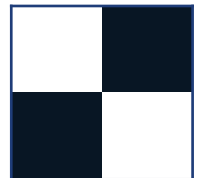
Ex: 240 => 4

0

Dithering

- ***Problem:***

  - Image size is much larger: since replacing each pixel by a 2×2 array of dots, makes an image 4 times as large.

  - In case of a 4×4 dither matrix, the image is 16 times as large.

$$\begin{pmatrix} 0 & 8 & 2 & 10 \\ 12 & 4 & 14 & 6 \\ 3 & 11 & 1 & 9 \\ 15 & 7 & 13 & 5 \end{pmatrix}$$

Ordered Dithering

- ***Solution:***

  - An ***ordered dither*** consists of turning on the printer output bit for a pixel if the intensity level is greater than the particular matrix element just at that pixel position.

  - We simply use the value in the array as a threshold. If the value of the pixel (scaled into the 0-16 range) is less than the number in the corresponding cell of the matrix, plot that pixel black, otherwise, plot it white

$$\begin{pmatrix} 0 & 8 & 2 & 10 \\ 12 & 4 & 14 & 6 \\ 3 & 11 & 1 & 9 \\ 15 & 7 & 13 & 5 \end{pmatrix}$$

Dithering

a grayscale image of "Lena".

The ordered-dither version

a detail of Lena's right eye

Outline

- *Black & white imags*

    - 1 bit images

    - 8-bit gray-level images

- *Dithering*

- ***Color imags***

    - 24-bit color images

    - 8-bit color images

- *Popular File Formats*

    - GIF (Graphics Interchange Format)

    - JPEG (Joint Photography Expert Group)

    - Others

Color Image Data Types

- *The most common data types for graphics and image file formats - **24-bit color and 8-bit color**.*

- *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 256x256x256 possible combined colors, or a total of 16,777,216 possible colors.

  - **Storage penalty**: 24-bit color image would require 921.6 kB of storage without any compression (640x480).

- *An important point: many 24-bit color images are actually stored as 32-bit images, with the extra byte of data for each pixel used to store an alpha value representing special effect information (e.g., transparency).*

Histogram of Color Images
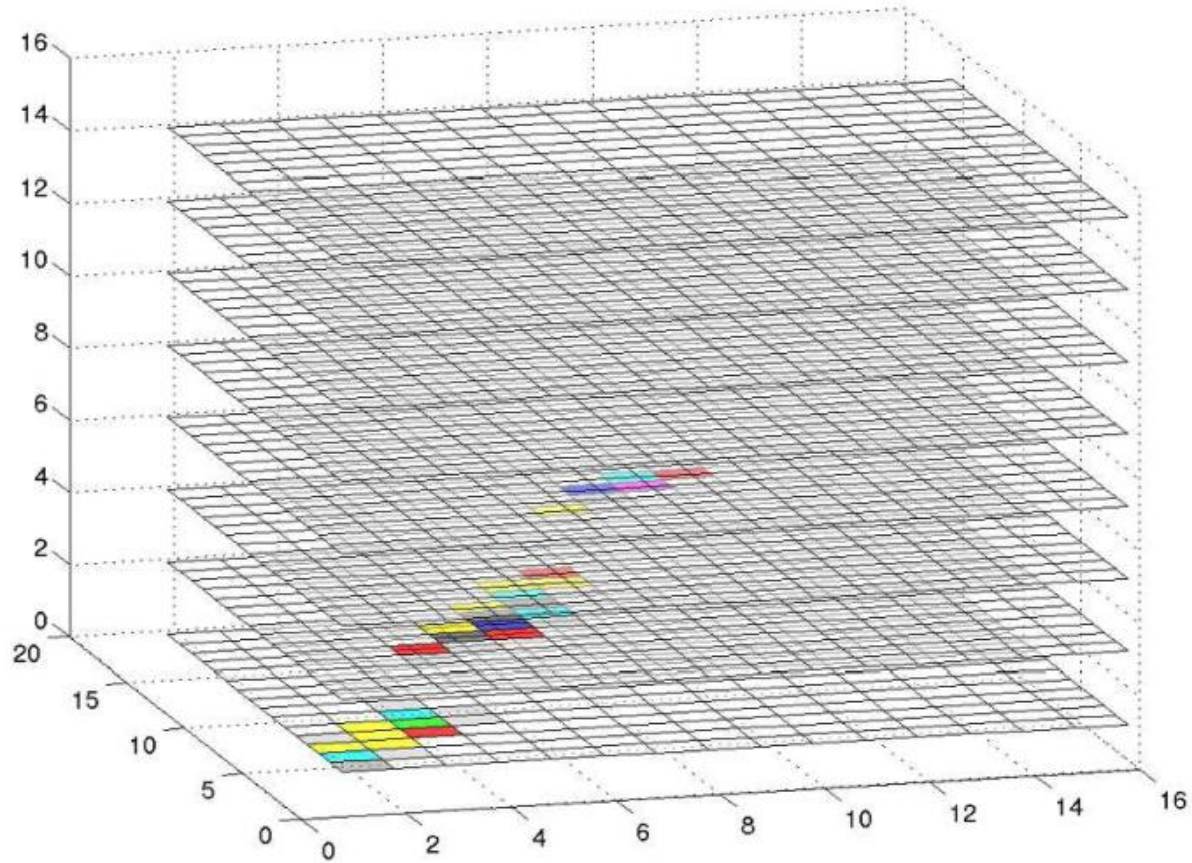
8-bit Color Images

- *Many systems can make use of 8 bits of color information (the so-called "256 colors") in producing a screen image.*

- *Such image files use the concept of a **Color Lookup Table** to store color information.*

COLOR LOOKUP TABLE
(color map, color palette)
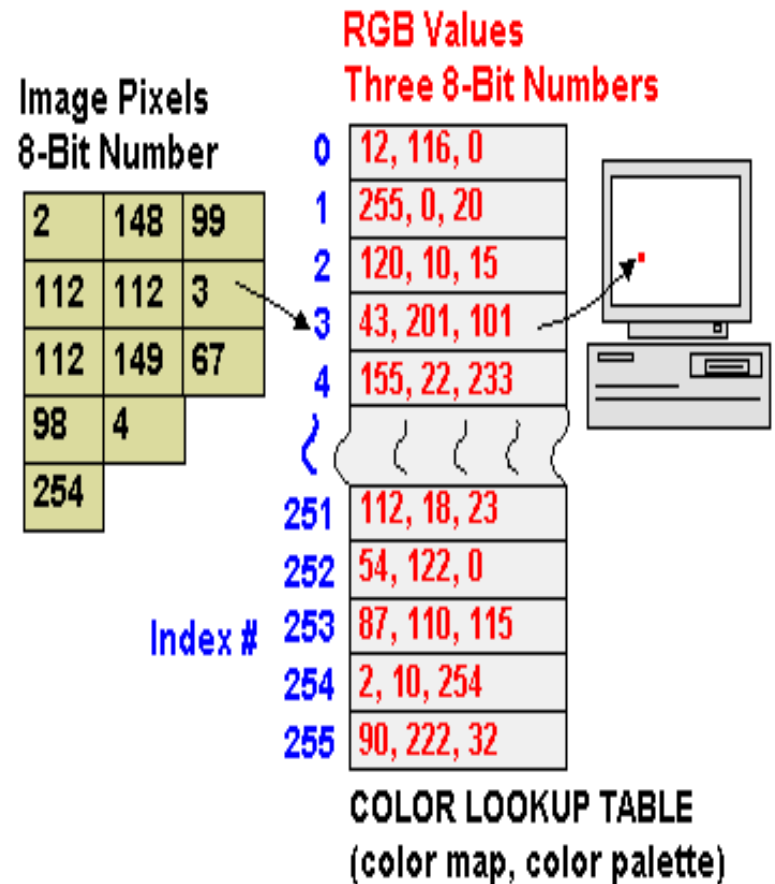
8-bit Color Images

From Computer Desktop Encyclopedia
© 2009 The Computer Language Company Inc.

16.8 Million Colors   256 Colors

Great savings in space:

- o 640x480 8-bit color image : 300 kB

- o Color image: 921.6 kB

How to Devise a Color Look-up Table

- *Straightforward way : divide the RGB cube into equal slices in each dimension.*

- *Humans are more sensitive to R and G than to B,*

  - Shrink the R range and G range 0..255 into the 3-bit range 0..7 and

  - shrink the B range down to the 2-bit range 0..3, thus making up a total of 8 bits.

  - So that 8 * 8 * 4 = 256 colors are uniformly spread over the color space are available.

Outline

- *Black & white imags*

  - 1 bit images

  - 8-bit gray-level images

- *Dithering*

- *Color imags*

  - 24-bit color images

  - 8-bit color images

- ***Popular File Formats***

  - GIF (Graphics Interchange Format)

  - JPEG (Joint Photography Expert Group)

  - Others

Popular File Formats

- ***8-bit GIF:*** *one of the most important format because of its historical connection to the WWW and HTML markup language as the first image type recognized by net browsers.*

- ***JPEG:*** *currently the most important common file format.*

GIF (Graphics Interchange Format)

- *Originally developed for platform-independent image exchange via modem*

- *Limited to 8-bit (256) color images*

  - best suited for images with few distinctive colors (e.g., graphics or drawing)

- *Lossless compression using the Lempel-Ziv-Welch (LZW) algorithm*

- *Well suited for image sequences (can have multiple images in a file)*

GIF

Header
Logical Screen Descriptor
Global Color Table
Local Image Descriptor
Local Color Table
Image Data
Local Image Descriptor
Local Color Table
Image Data
...
Local Image Descriptor
Local Color Table
Image Data
Trailer

Header and Color Table Information

Image 1

Image 2

Image n

GIF Signature (6 Bytes) GIF87a

attributes that belong to every image in the file. (screen height, width, and background color)

termination character 0x3B hex or ';'

JPEG (Joint Photographic Experts Group)

- *JPEG: The most important current standard for image compression.*

- *The human vision system has some specific limitations and JPEG takes advantage of these to achieve high rates of compression.*

- *JPEG allows the user to set a desired level of quality, or compression ratio (input divided by output).*

- *Image, with a quality factor Q=10%,*

    ◆ 1.5% of the original size.

- *Q=75%*

    ◆ 5.6% of the original, whereas a GIF version of this image compresses down to 23.0% of uncompressed image size.

PS &PDF (Portable Document Format)

- *Postscript is an important language for typesetting, and many high-end printers have a Postscript interpreter built into them.*

- *Postscript is a vector-based picture language, rather than pixel-based: page element definitions are essentially in terms of vectors.*

  - Postscript includes text as well as vector/structured graphics.

  - Several popular graphics programs, such as Illustrator and FreeHand, use PostScript.

  - Postscript language itself does not provide compression; (stored as ASCII).

- *Another text + figures language.*

  - Adobe Systems Inc. includes LZW compression in its Portable Document Format (PDF) file format.

BMP

- *The major system standard graphics file format for **Microsoft Windows**, used in Microsoft Paint and other programs.*

  - It makes use of **run-length encoding** compression

  - can fairly efficiently store 24-bit bitmap images

Summary

- *Black & white imags*

  - 1 bit images, 8-bit gray-level images

  - Image histogram

- *Dithering*

  - Printing (ordered dithering)

- *Color imags*

  - 24-bit color images

  - Quantization and compression (8-bit color images)

    - *Color Tables*

- *Popular File Formats*

  - GIF , JPEG , PDF, BMP