

Fundamentals of Multimedia

Lecture 2 Graphics & Image Data Representation

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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)

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- Black & white imags
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 - 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

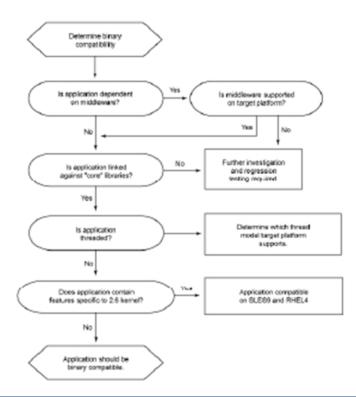
- Frame buffer:
 - Hardware used to store bitmap.
 - A graphics card is used for this purpose.
 - but if not enough video card memory is available then the data has to be shifted around in RAM for display.

- *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



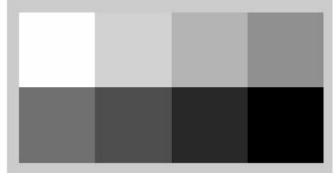


1-bit Images

- File size calculation
 - Resolution: 640 x 480
 - File size = $640 \times 480 \times 1/8 = 38.4 \text{ kB}$

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.

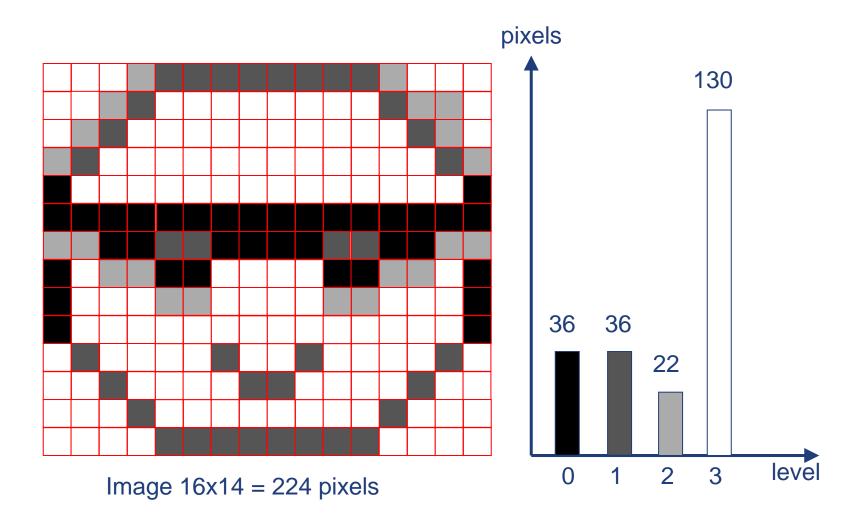




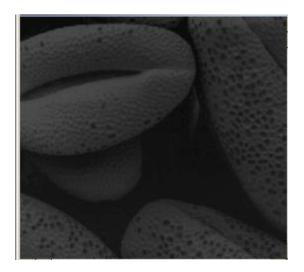
8-bit Gray-level Images

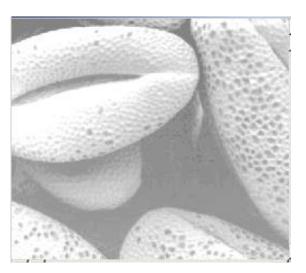
- File size calculation
 - Resolution: 640 x 480
 - File size = 640 x 480 x 1 = 300 kB

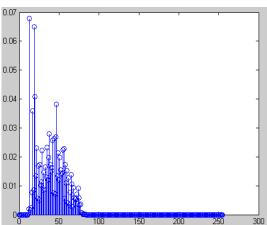
Image Histogram

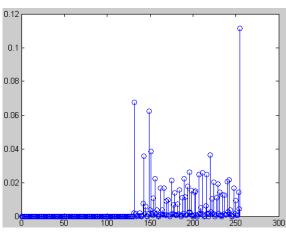


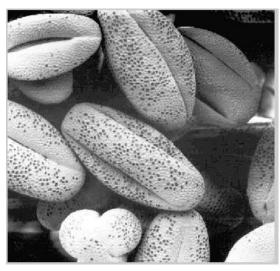
Histogram Equalization

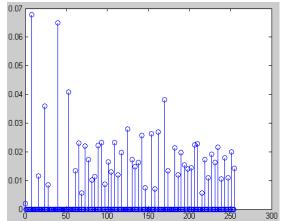










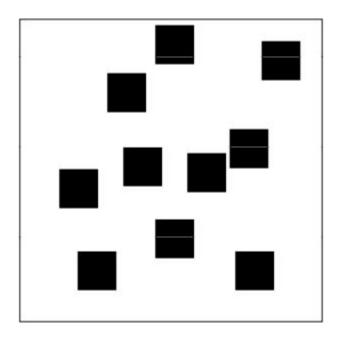


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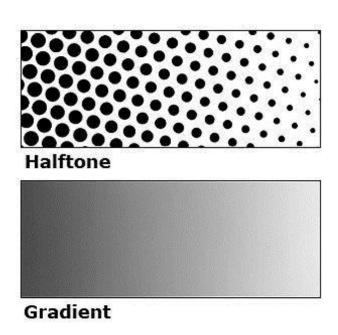
Dot & Pixel

- Dot is the smallest discrete component of an image on the paper
- Dot is generally much smaller than pixel



- 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.

- 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.





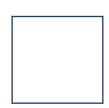
0

255:5=51

Dither matrix: 2x2







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



a grayscale image of "Lena".



The ordereddither version



a detail of Lena's right eye

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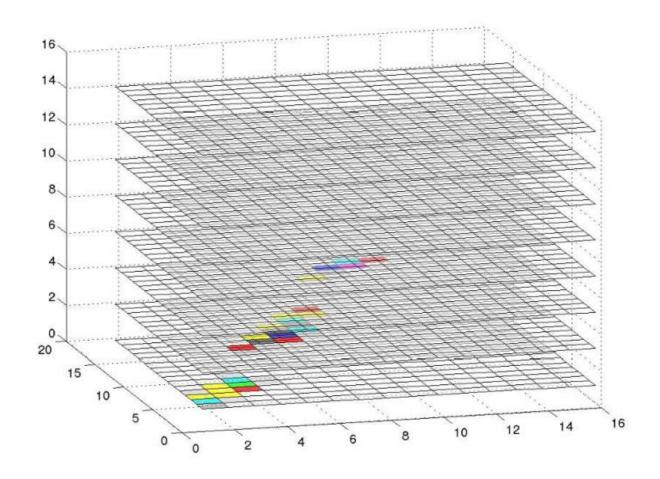
Color Image Data Types

- 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

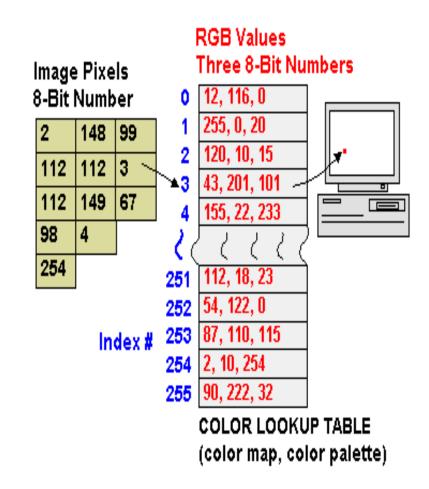
- In a color 24-bit image, each pixel is represented by three bytes, usually representing RGB.
 - This format supports 256x256x256 possible combined colors, or a total of 16,777,216 possible colors.
 - **Storage penalty**: 24-bit color image would require 921.6 kB of storage without any compression (640x480).
- 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.



8-bit Color Images

From Computer Desktop Encyclopedia

© 2009 The Computer Language Company Inc.



16.8 Million Colors



256 Colors

Great savings in space:

640x480 8-bit color image : 300 kB

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.

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Popular File Formats

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- JPEG (Joint Photography Expert Group)
- Others

Popular File Formats

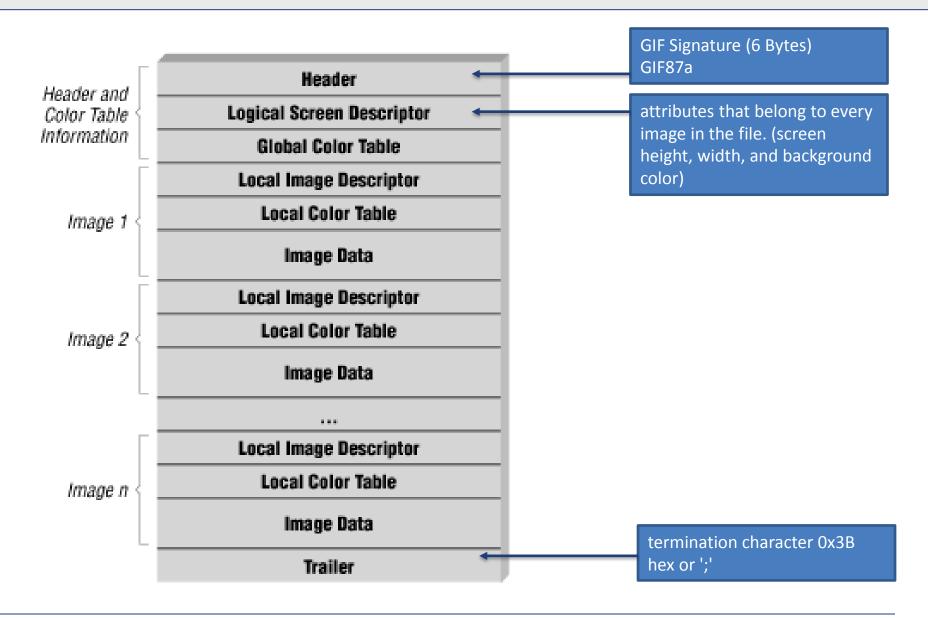
• 8-bit GIF: one of the most important format because of its historical connection to the WWW and HTML markup language as the first image type recognized by net browsers.

• 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



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