Introduction to Multimedia Computing

Digital Image Media Type
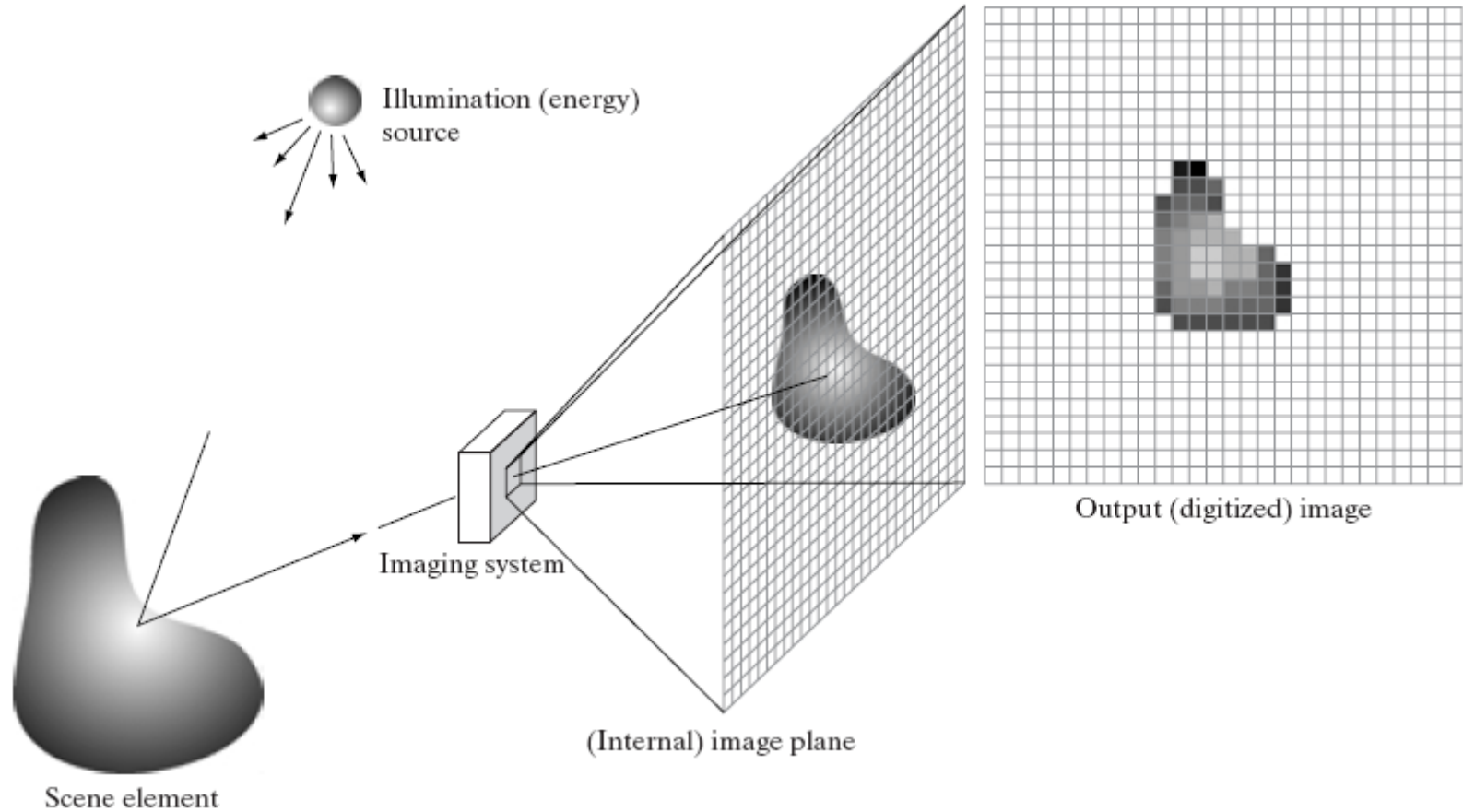
Topics

- Basics of Digital Images (recap)
- Image Representation Standards
- Image formats
- Redundancy Types in Images
- Lossless Image Compression

Image Media (recap)

▶ **Image** is a two-dimensional representation of a scene, as seen by people.

▶ Images are the reflection of the external world as visual data.

Image Formation (recap)

Illumination (energy) source

Imaging system

(Internal) image plane

Scene element

Output (digitized) image

Basics of Digital Images (recap)

- Pixels:
  - ◦ Digital images are composed of *pixels (short for picture elements).*
  - ◦ Each pixel represents the color at a single point in the image

- Pixmaps: A digital image is a rectangular array of pixels sometimes called a *pixmap.*

Resolution (recap)

- The density of pixels in an image is referred to as its *resolution.*
- The higher the resolution, the more information the image contains.

Original (400x262)

Eighth Size (50x32)

Storing Image Data

▸ Digital Images are 2-dimensional numeric values.

▸ An image has extra properties such as:
  ◦ Resolution (number of rows, number of columns)
  ◦ Image type (color, gray, binary)
  ◦ Depth (bits per pixel)
  ◦ Compression (whether or not the image has been compressed, and the compression method)

▸ The image data (pixel values) is stored together with the image properties.

Image file formats

- Many image formats use the simple model shown below (line by line, no breaks between lines).
- The header contains at least the width and height of the image.
- Most headers begin with a **signature** or "magic number" – a short sequence of bytes for identifying the file format.
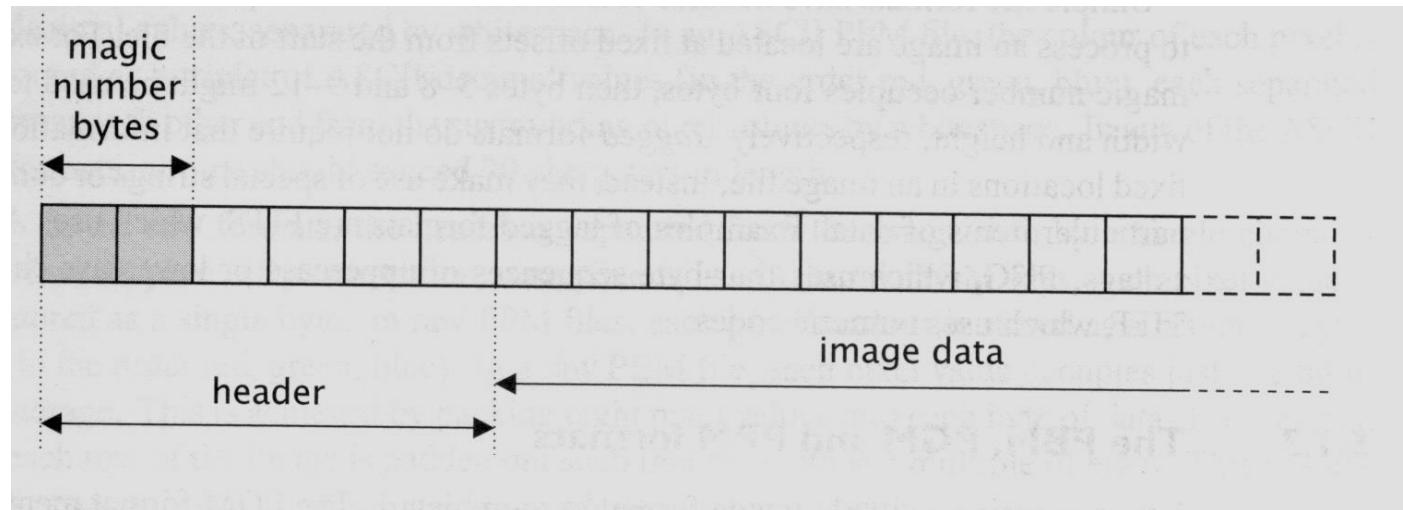
Common image file formats

- GIF (Graphic Interchange Format) –
- PNG (Portable Network Graphics)
- JPEG (Joint Photographic Experts Group)
- TIFF (Tagged Image File Format)
- PGM (Portable Gray Map)
- FITS (Flexible Image Transport System)

Image Compression

- An image is a 2D matrix of pixels
- Each pixel consists of RGB components
- Sample dimension:
  - 1024 rows
  - 2048 columns
  - 3 bytes per pixel
  - Image size = 1024 * 2048 * 3 = 6 Mbytes
  - Compressed size of this image is about 600KBytes (about 10% of its uncompressed size)

How Images are Compressed?

- If there are some similarities between pixels of an image, the image can be compressed

- Similarity between pixels can be:
  ◦ The color of a pixel is close (similar) to the color of its neighbors
  ◦ A color is used more than others in an image
  ◦ An image is similar to another image

Image Compression Types

- Image compression algorithms are classified in two groups:
  - Lossless algorithms:
    - The decompressed image and the original image are exactly the same (no data loss)
  - Lossy algorithms:
    - Decompressed image and the original image are different but generally the difference is not noticeable

Data Redundancy

- Definition: If some parts of data are stored repeatedly, or can be derived from other parts, the data is said to be redundant

- e.g. If the pixels of a region in an image have the same color, we do not need to store the color value for all of them.

Redundancy Types

- Visual Redundancy
- Spatial Redundancy
- Temporal Redundancy
- Stochastic Redundancy

Visual Redundancy

- Our visual system is more sensitive to brightness than color.

- Therefore less color information can be stored for each pixel.

Spatial Redundancy

▸ Pixels that are near to each other have similar colors. This property can be used to reduce the stored data size.

Temporal Redundancy

▸ Two images taken in a short interval have almost similar contents.
▸ This redundancy is used in storing video

Stochastic Redundancy

- If a pixel color is used more than other colors, we can use less bits for it.

- Stochastic redundancy is present in all media data types

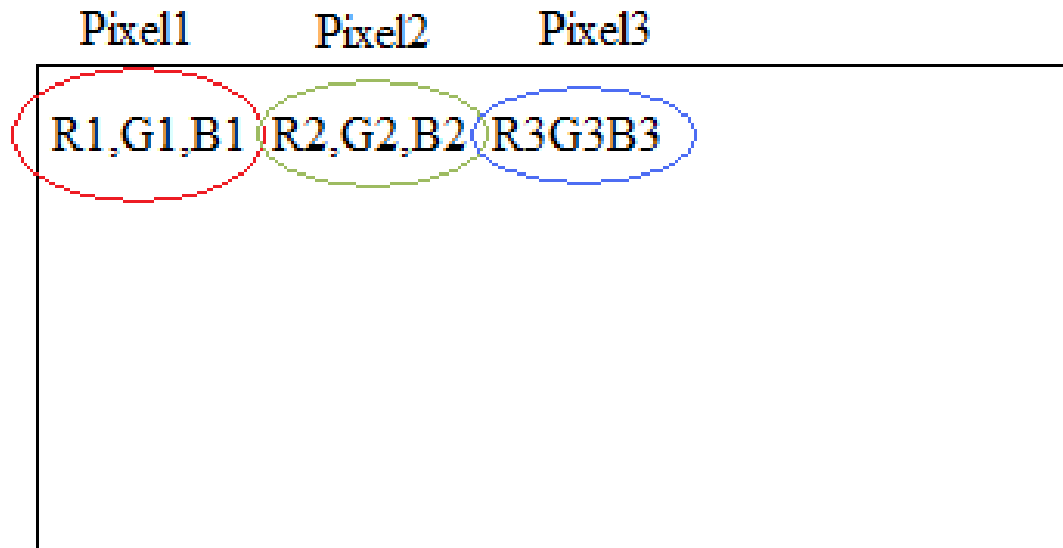# Lossless Image Compression algorithms

Image File Layout

- Each image is stored in a file having a header and a data parts
- Header includes items such as:
  - Number of rows
  - Number of columns
  - Compression type
  - Etc.

Header
Data
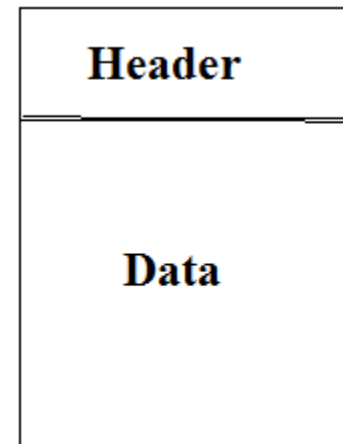
Uncompressed Image Data

- In uncompressed images, data is stored as the values of the pixels

Pixel1   Pixel2   Pixel3

R1,G1,B1 R2,G2,B2 R3G3B3

PCX: A Lossless Compression Standard

▸ Definition:
  ◦ Run: A sequence of pixels (data items) having the same values
  ◦ e.g. 3,3,3,3,4,4,4,4,4,4,4,5,1,6,6,6,6,6,6
  ◦ Runs are:

                    3,3,3,3
                    4,4,4,4,4,4,4
                    5
                    1
                    6,6,6,6,6,6

PCX: A Lossless Compression Standard

- A run can be stored as <run length, value>

- e.g. 3,3,3,3   <4,3>
-
        4,4,4,4,4 <5,4>

- PCX uses run length encoding
- The image is scanned from top to bottom, and left to right. Runs are found and coded.
- Average compression rate is 25%

Indexed Color

- If the number of colors in an image is less than 256, indexed color can be used.
- Each color value (R, G, B) is stored in a table
- Instead of color values, index values are used in image data
- The size of the image data becomes one third of its original size (67% compression)

Indexed Color Example (1)

▸ Color Index

Index	Red	Green	Blue
0	112	13	45
1	65	23	78
2	33	71	99
3	189	45	90

Indexed Color Example (2)

▸ Original Image Data

112,13,45	112,13,46	189,45,90
112,13,45	112,13,46	189,45,90

▸ Indexed Image Data

0	0	3
0	0	3

Indexed Color Example (3)

▸ The color index is stored in the image header

Image Header			
Index	Red	Green	Blue
0	112	13	45
1	65	23	78
2	33	71	99
3	189	45	90
Image Data			
0	0	3	2
0	0	3	1

Lempel–Ziv–Welch (LZW) Method

- If the number of colors in the image is larger than 256, then the color-indexing method will not work.

- A similar method which encodes colors using their indexes is used which is not limited to 256 colors.

- This method known as LZW is used in some image formats such as GIF

LZW Compression

▸ LZW Compression Method is:

  ◦ A lossless compression method

  ◦ based on using a table

  ◦ The table is not stored/sent with the image

LZW Code Table

- Code Table has 4096 entries

- Each code is 12 bits

- First 256 entries are characters with values 0 to 255

- Encoder and decoder use similar methods to construct the code table

Summary

- Images are two dimensional matrices. Each entry in the matrix has a pixel color.

- To compress images we make use of the redundancies in the images.

- Lossless compression methods do not cause data loss

- In lossy methods, the decompressed image and the original image are different but their compression rate is much higher.

Questions?