Data Compression

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Topics

1. Data Compression.
2. Run Length Compression.
3. Dictionary Compression.
4. Image Compression
5. Video and Audio Compression

Data Compression

- Lossy versus lossless

1. Run-length encoding (lossless)
2. Dictionary encoding (Includes adaptive dictionary encoding such as LZW encoding.) (lossless)

Run Length Encoding

- The process of replacing sequences of identical data elements with a **code** indicating the element that is repeated and the number of times it occurs in the sequence.

- Example: 11111111111000001111111111111000000000000000000000011111111111111111
  - 70 bits
  - 11 (1) + 5 (0) + 14 (1) + 23 (0) + 17 (1)

Dictionary Encoding

- In particular, an entire word can be encoded as a single reference to this dictionary rather than as a sequence of individual characters encoded using a system such as UTF-8.

- Dictionary encoding can be used by word processors to compress text documents because the dictionaries already contained in these processors for the purpose of spell checking make excellent compression dictionaries.

Dictionary Encoding Example

- A typical dictionary in a word processor contains approximately 25,000 entries, which means an individual entry can be identified by an integer in the range of 0 to 24,999.
- This means that a particular entry in the dictionary can be identified by a pattern of only 15 bits. In contrast, if the word being referenced could be 4 or 8 bytes long

LZW Encoding

- **Adaptive dictionary encoding:** the dictionary is allowed to change during the encoding process.
- We have a dictionary

x	y	space	xxy	yyx
1	2	3	4	5

xxy yyx xxy xxy yyx

112322134343 5

Compressing Images

- Compression is **lossy**!
- GIF: Good for cartoons
  - a dictionary encoding system
- JPEG: Good for photographs
  - most digital cameras use JPEG as their default compression technique.

Graphics Interchange Format GIF

- GIF approaches the compression problem by reducing the number of colors that can be assigned to a pixel to only 256.

- The red-green-blue combination for each of these colors is encoded using three bytes (same technique as lookup for BMP)

- These 256 encodings are stored in a table (a dictionary) called the palette..

Graphics Interchange Format GIF

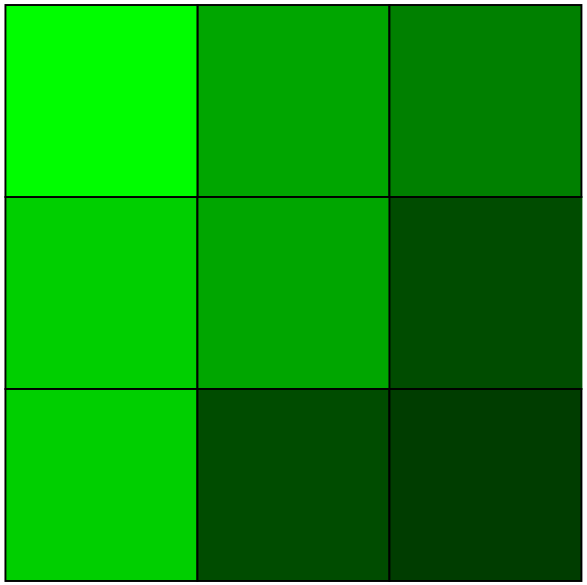
- GIF is a **lossy** compression system when applied to arbitrary images because the colors in the palette may not be identical to the colors in the original image.

- GIF can obtain additional compression by extending this simple dictionary system to an adaptive dictionary system using LZW techniques.

Joint Photographic Experts Group JPEG

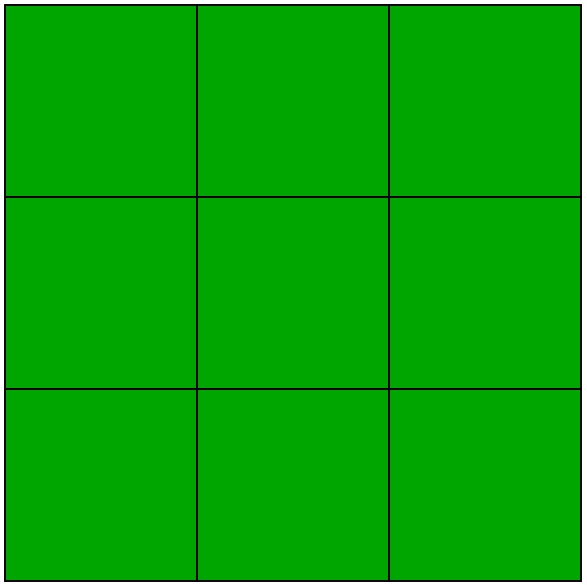
- JPEG's baseline standard (also known as JPEG's lossy sequential mode) has become the standard of choice in many applications.
- It takes advantage of a human eye's limitations.
- Eye is more sensitive to changes in brightness than to changes in color.
- Encoded in terms of **luminance** and **chrominance**.
  - ➢Average the chrominance values over two-by-two pixel squares. This reduces the size of the chrominance information by a factor of four while preserving all the original brightness information.
  - ➢ Then, divide the image into eight-by-eight pixel blocks and Compress each block as a unit.

JPEG



9:1

"averaging"



The result is a significant degree of compression without a noticeable loss of image quality.

Compressing Audio and Video

- MPEG
  - High definition television broadcast
  - Video conferencing
- MP3
  - Temporal masking
  - Frequency masking

Motion Picture Experts Group MPEG

- MPEG encompasses a variety of standards for different applications.
- A video is constructed as a sequence of pictures.
- To compress such sequences, only some of the pictures, called I-frames, are encoded.

MPEG

- The pictures between the I-frames are encoded using relative encoding techniques.
- Rather than encode the entire picture, only its distinctions from the prior image are recorded.
- The I-frames themselves are usually compressed with techniques similar to JPEG

MP3 (*MPEG layer 3*)

- MP3 takes advantage of the properties of the human ear, removing those details that the human ear cannot perceive.
- One such property, called temporal masking, is that for a short period after a loud sound, the human ear cannot detect softer sounds that would otherwise be audible.

MP3 (*MPEG layer 3*)

- Another, called frequency masking, is that a sound at one frequency tends to mask softer sounds at nearby frequencies.
- By taking advantage of such characteristics, MP3 can be used to obtain significant compression of audio while maintaining near CD quality sound.

Video and Audio Compression goals

1. Save storage space.
2. Obtaining encodings that allow information to be transmitted over today's communication systems fast enough to provide timely presentation.

Compression and Data Transmission

- Audio and video compression systems are often judged by the transmission speeds required for timely data communication.
- Example:
  - If each video frame required a MB of storage and the frames had to be transmitted over a communication path that could relay only one KB per second, what about successful video conferencing ?

Communication Speed

- Communication speeds are normally measured in **bits per second (bps).**
  - **Kbps (**equal to one thousand **bps**)
  - **Mbps (**equal to one million **bps)**
  - **Gbps (**equal to one billion **bps**).

MPEG and MP3 Requirements

- For MPEG techniques, video presentations can be successfully relayed over communication paths that provide transfer rates of 40 Mbps.
- MP3 recordings require transfer rates of no more than 64 Kbps.

Exercise

- Suppose a digital camera has a storage capacity of 500MB. How many black-and-white photographs could be stored in the camera if each consisted of 512 pixels per row and 512 pixels per column if each pixel required one bit of storage?

Exercise

- What would be the encoded version of the message:
  xyx yxxxy xyx yxxxy yxxxy
  if LZW compression, starting with the dictionary containing *x*, *y*, and a space were used?

Exercise

- The following message was compressed using LZW compression with a dictionary whose first, second, and third entries are b, c, and space, respectively. What is the decompressed message?

  212311343121353 6