

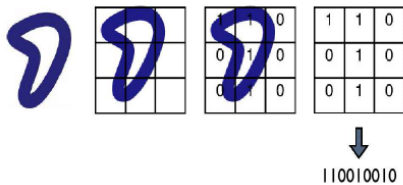
Representing Sounds and Images

Representing Information Using 0s and 1s

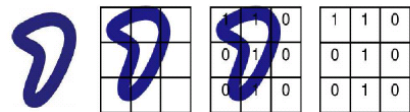
- Numbers
- Text
- Black and White Triangle
- What are the other kinds of information?

Digital Image

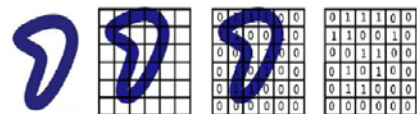
- Computer monitors and printers can only display/print dots of colour (pixels)
- A **bitmap** represents an image as rows of pixels



Digital Image

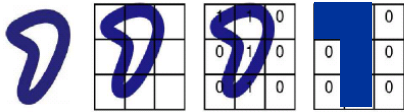


110010010

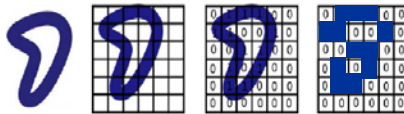


011100110010001100010100011000000000

Digital Image



110010010



011100110010001100010100011000000000

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Image Terminology

- **Colour Depth:**
 - the number of bits used to describe each colored pixel
 - in the previous examples the color depth is _____
- **Resolution:**
 - the total number of pixels, expressed as the dimensions of the bitmap (width x height)
 - the resolution of the bitmaps on the previous slide is _____

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RGB

- Represent colours as a mixture of red, green, and blue, each at different intensities

redgreenblue

Colour Depth 3:	1	0	0	• Red
	0	1	0	• Green
	0	0	1	• Blue
	1	1	0	• Yellow
	0	1	1	• Cyan
	1	0	1	• Magenta
	0	0	0	• Black
	1	1	1	• White

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RGB

- At a color depth of 15, can represent $2^{15} = 32768$ different colours.
- 110010110110101:
 - red value is $11001_2 = 1 + 8 + 16 = 25$
 - green value is $01101_2 = 1 + 4 + 8 = 13$
 - blue value is $10101_2 = 1 + 4 + 16 = 21$



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Image Size

- Digital image with resolution 1600x1200 and color depth 24 (3 bytes per pixel)
 - $1600 \times 1200 \times 3 = 5760000$ bytes \approx **5.5 MB**.
- How can we reduce the file size?
 - reduce the **resolution** (image is less clear)
 - reduce the **colour depth** (image colouring is less precise)
 - compress the image**

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Data Compression

- **Lossless** compression
 - image quality is not reduced
 - like our example HW1, Q7
 - also Lempel-Ziv last class
- **Lossy** compression
 - image quality is reduced

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Image Compression

- **.gif**: (Graphics Interchange Format) is an 8-bit-per-pixel bitmap image format
 - Uses a palette of up to 256 distinct colours
 - Otherwise, lossless
 - Today computers have more colours, but good for animations (different palette per frame) and cartoons



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Lossy Compression

- **Blurring** can be used to reduce the resolution:
 - groups of 4 bits (2x2 sections) in the image are usually similar in color
 - store this entire patch as 1 pixel whose color is the average of the 4 colors.
- E.g. 4 pixels with RGB values (130,100,72), (132,104,68), (131,102,69),(131,100,71) can be summarized to 1 pixel with values (131,101,70).

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Lossy Compression

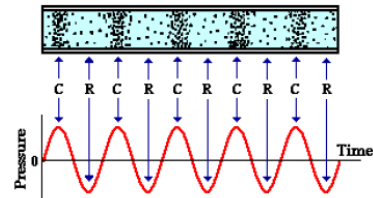
- .jpeg:
 - Brightness information is more significant than colour information
 - Record change in brightness rather than brightness
 - Brightness info encoded using 1 byte per pixel
 - Colour information encoded using 1 byte per 2 x 2 pixel block



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What is Sound?

Sound is a Pressure Wave



NOTE: "C" stands for compression and "R" stands for rarefaction

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Properties of Sound

- Sound consists of *thousands* of oscillations per second
- **Perception:** our ears detect these vibrations and turn them into sound
- Humans can hear sounds that are between 20 - 20,000 Hz (oscillations per second)

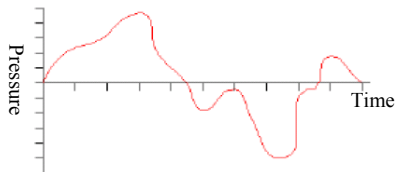
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Digital Sound Data

- **Digital recording:**
 - Converts an **analog** sound file into a **digital** bit sequence that can be stored as a file on a computer.
- **Playback:**
 - DAC (Digital to Analog Converter) in the **sound card**
 - Convert the **digital** sound data to an **analog** wave, amplifies it, and feeds it to the speakers which vibrate to produce sound waves.

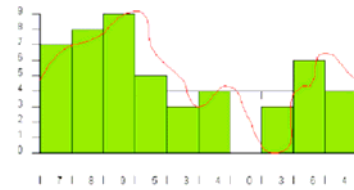
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Analog Sound Data



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Digital Sound Data

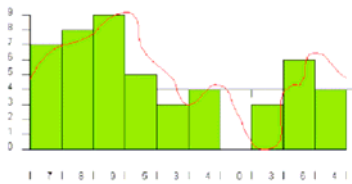


- Data: 7, 8, 9, 5, 3, 4, 0, 3, 6, 4

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Sampling Parameters

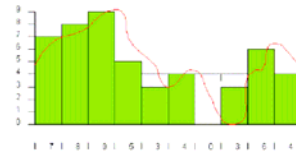
- **Sampling Rate:** number of samples per second
- **Sampling Precision:** number of gradations possible when taking the sample



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File Format

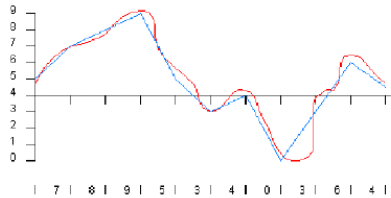
- How many bits does it take to represent one of the rectangles?



- 0111 1000 1001 0101 0011 0100 0000 0011 0110 0100
- Wave (.WAV) file format

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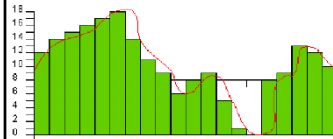
Sampling Error



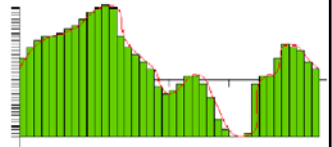
How to reduce this error?

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Reducing Sampling Error



- Sampling rate?
- Sampling precision?



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Audio CDs

- 44,100 samples per second
- precision 65536 (requires 2 bytes)
- $44,100 \times 2 = 88,200$ bytes
- 2 streams being recorded: for each speaker in a stereo system $\rightarrow 88,200 \times 2 = 176,400$ bytes to store per second
- A CD stores 74 mins of music ($74 \times 60 = 4,440$ seconds)
- $176,400 \times 4,440 = 783,216,000$ bytes of music, roughly 746 MB.
- CDs can store 10 MB of data per minute of music
- A 3 minute song therefore requires 30 MB of data (!!)

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MP3s

- mp3s can compress a song by a factor of 10 or 12 and still retain quality sound
- A 30 MB .wav sound file from a CD reduces to a 3 MB .mp3 file

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How mp3s Work

- **Perceptual Noise Shaping** is a compression algorithm used to encode sound into an MP3 format.
- Uses characteristics of the human ear:
 - There are certain sounds that the human ear cannot hear.
 - There are certain sounds that the human ear hears much better than others.
 - If there are two sounds playing simultaneously, we hear the louder one but cannot hear the softer one.

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How mp3s Work

- Fewer samples/second:
 - 176,400 bytes to store per second → 16,000 bytes per second
- Lossy or lossless?
- Example: applause (random)

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