Representing Sounds and Images

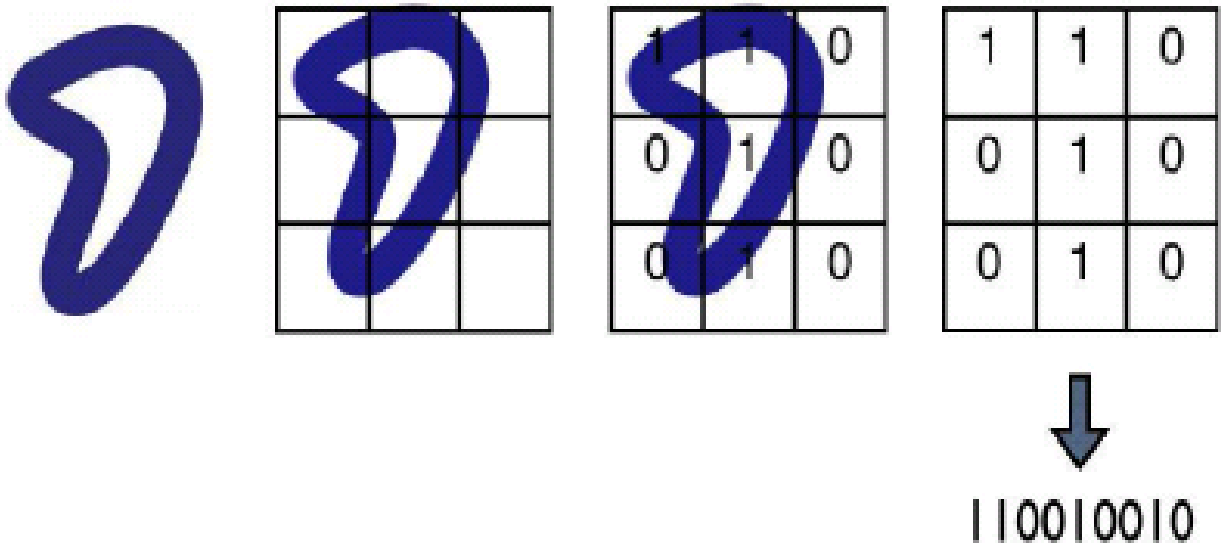
Representing Information Using 0s and 1s

- Numbers
- Text
- Black and White Triangle

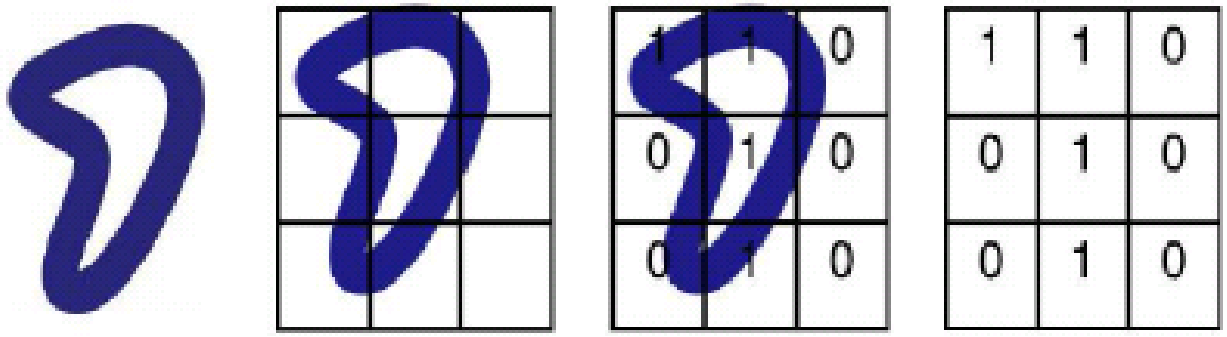
- What are the other kinds of information?

Digital Image

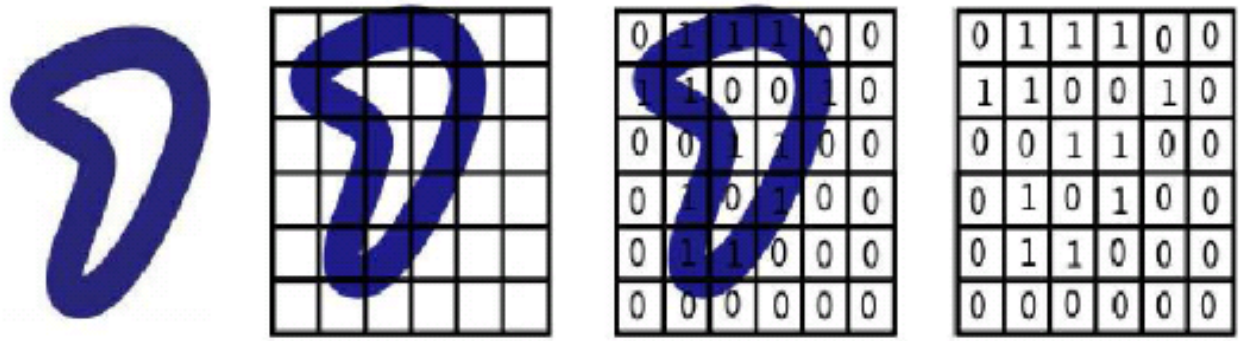
- Computer monitors and printers can only display/print dots of colour (pixels)
- A bitmap represents an image as rows of pixels



Digital Image

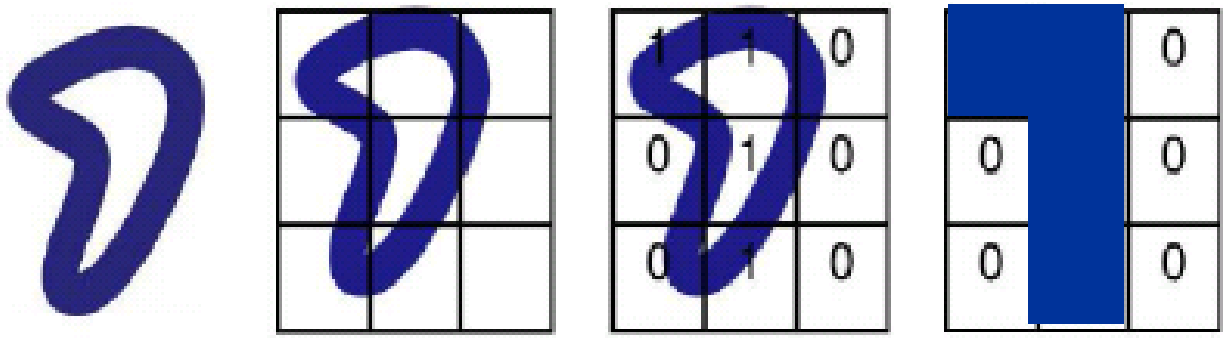


110010010

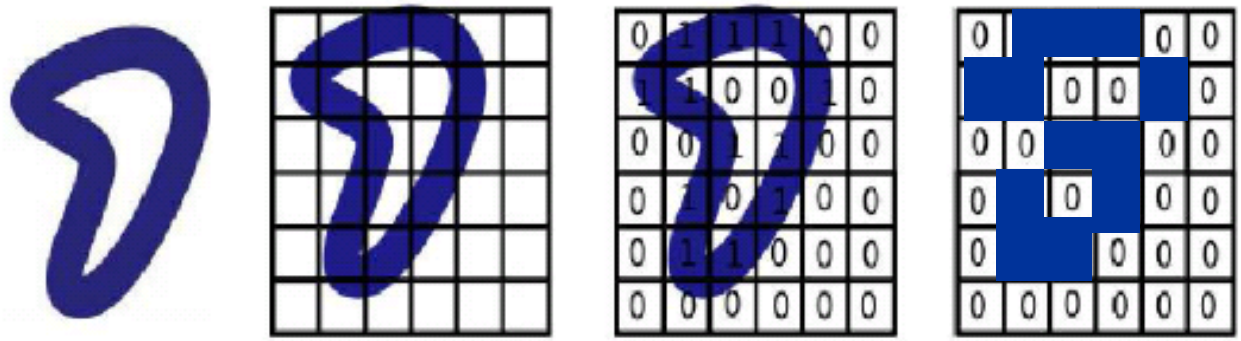


011100110010001100010100011000000000

Digital Image



110010010



011100110010001100010100011000000000

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 _____

RGB

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

	red	green	blue	
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

RGB

- At a color depth of 15, can represent $2^{15} = 32768$ different colours.
- 1100101101101 01:
  - red value is $11001_2 = 1 + 8 + 16 = 25$
  - green value is $01101_2 = 1 + 4 + 8 = 13$
  - blue value is $10101_2 = 1 + 4 + 16 = 21$

Image Size

- Digital image with resolution 1600x1200 and color depth 24 (3 bytes per pixel)
  - 1600 x 1200 x 3 = 5760000 bytes ≈ 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

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

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

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

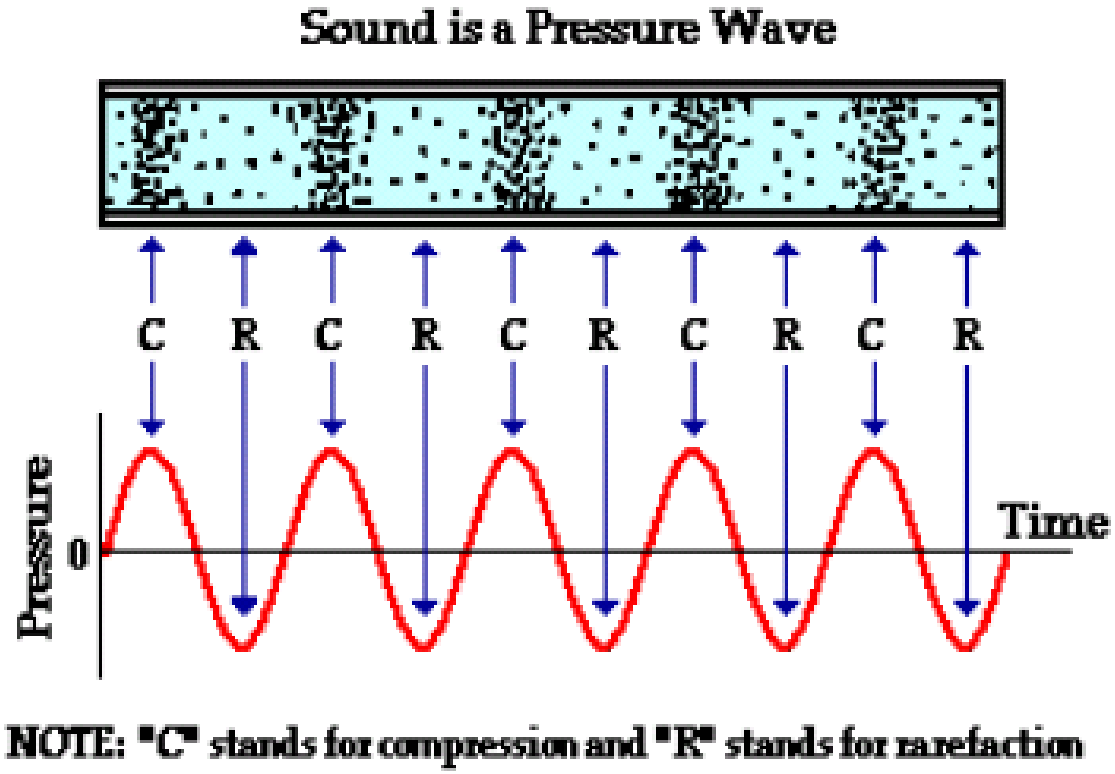
(130,100,72), (132,104,68), (131,102,69),(131,100,71) can be summarized to 1 pixel with values

(131,101,70).

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

What is Sound?



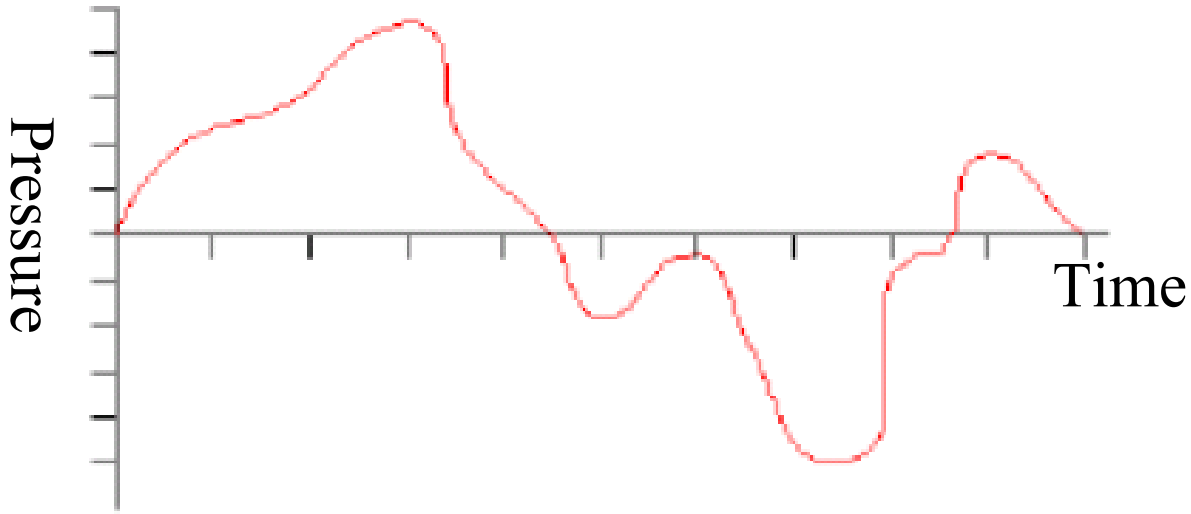
Properties of Sound

- 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)

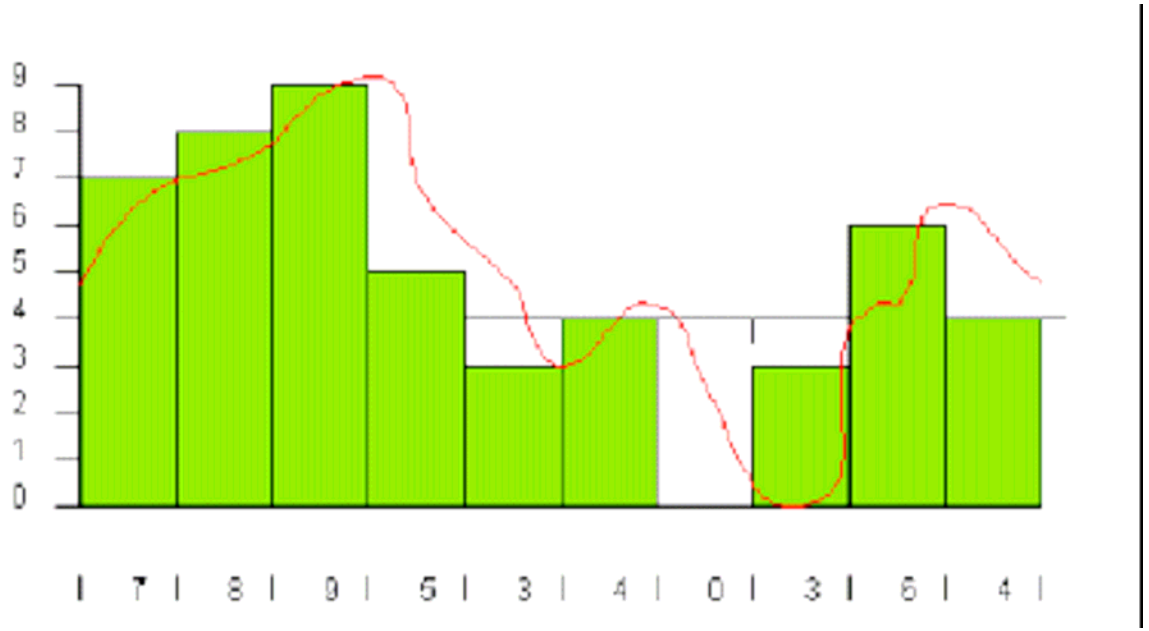
Digital Sound Data

- 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.

Analog Sound Data



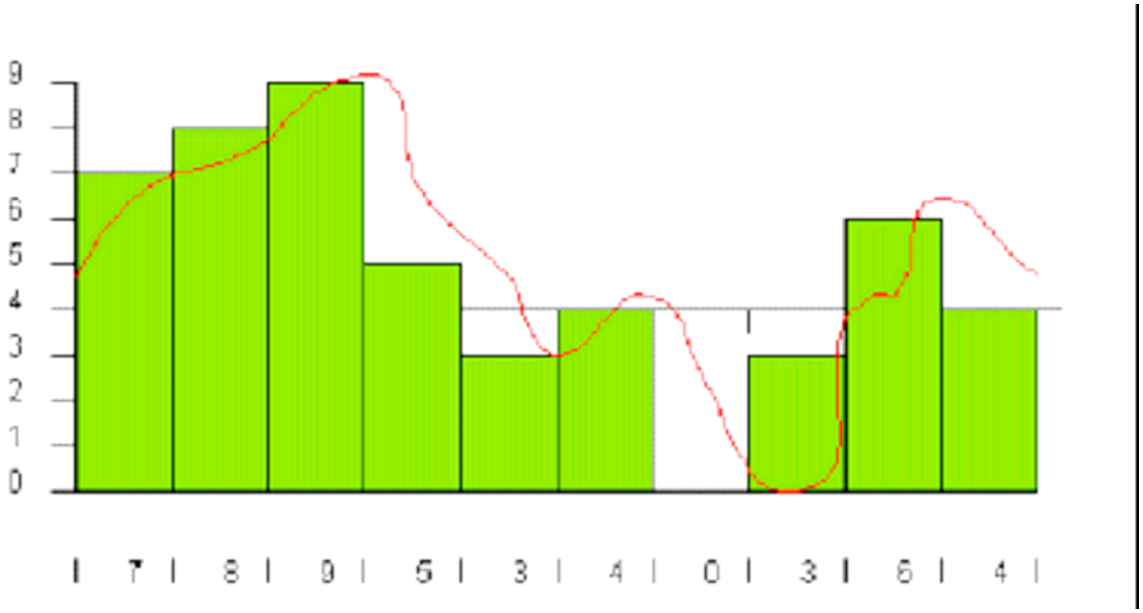
Digital Sound Data



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

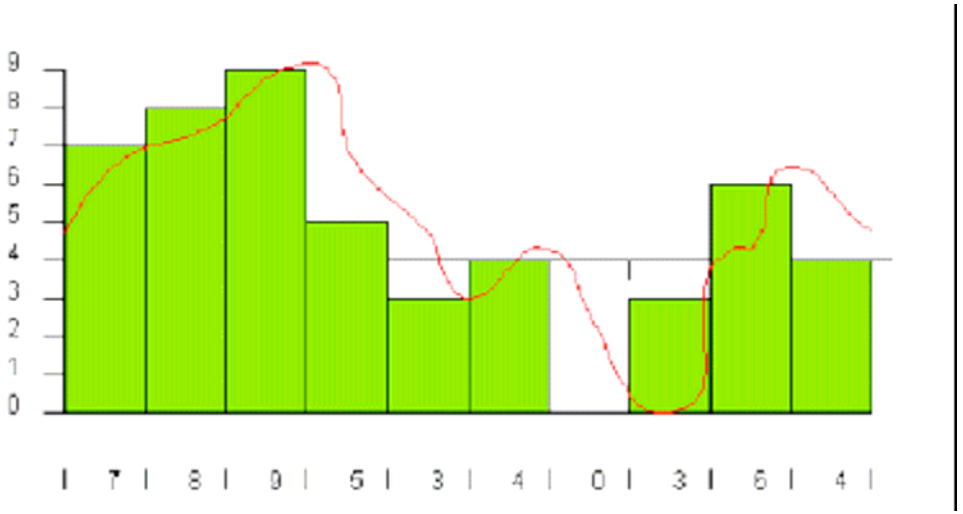
Sampling Parameters

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



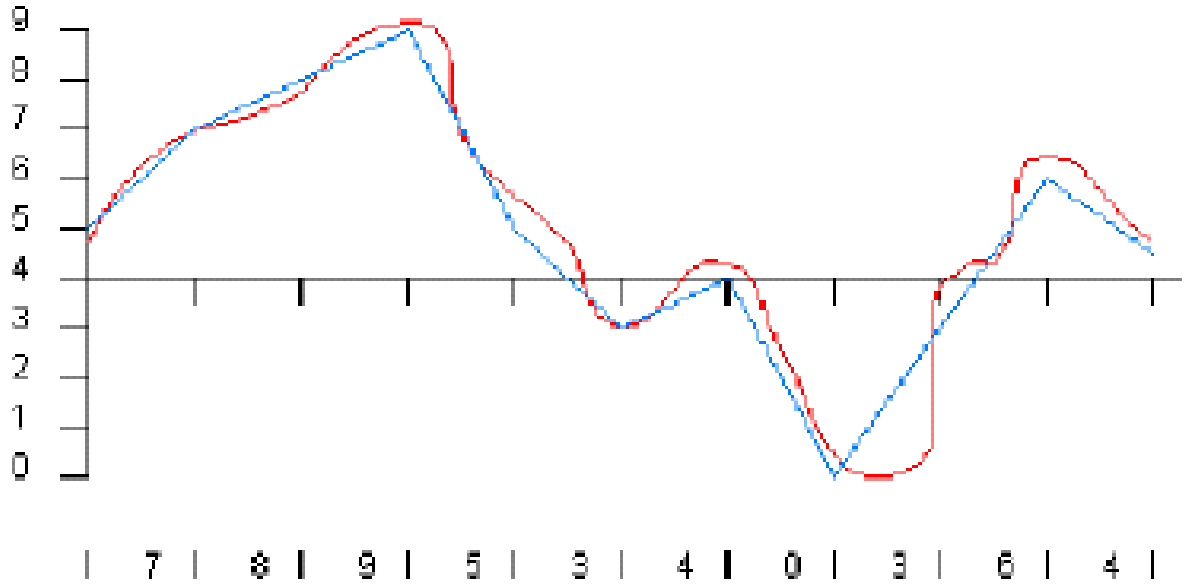
File Format

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



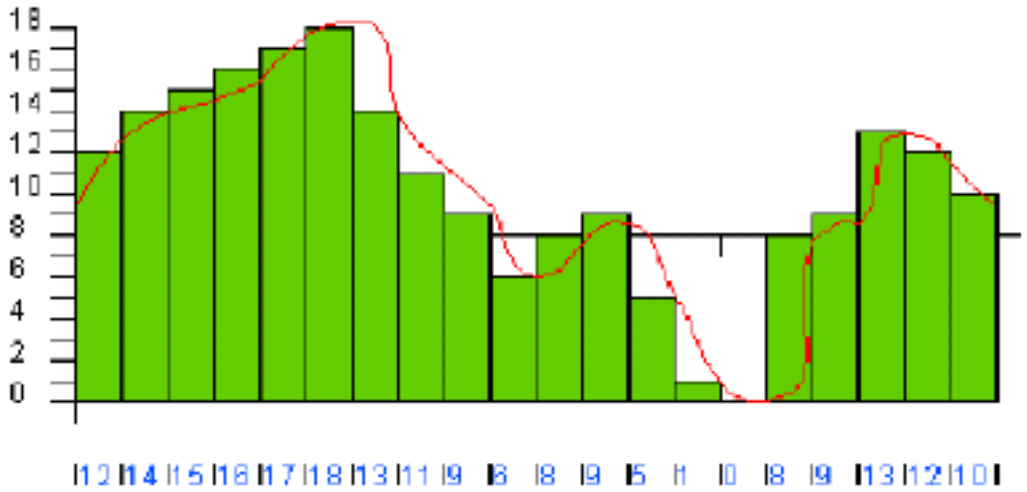
- 0111 1000 1001 0101 0011 0100 0000 0011 0110 0100
- Wave (.WAV) file format

Sampling Error

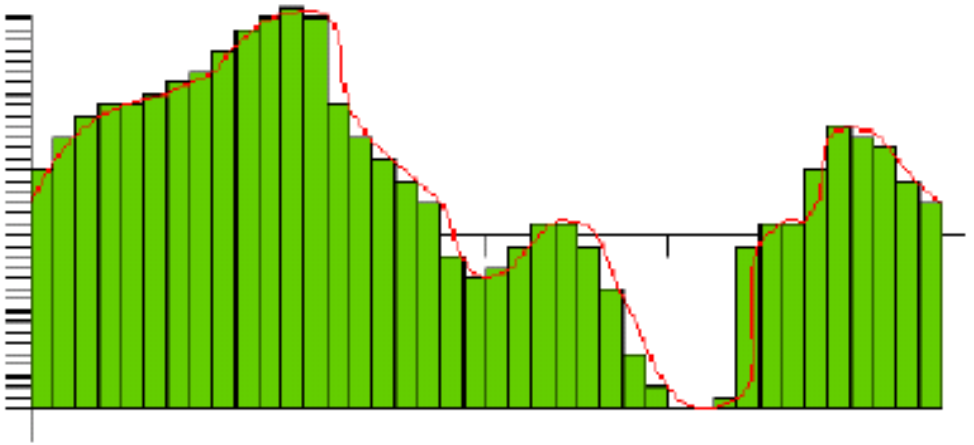


How to reduce this error?

Reducing Sampling Error



- Sampling rate?
- Sampling precision?



Audio CDs

- 44,100 samples per second
- precision 65536 (requires 2 bytes)
- 44,100 x 2 = 88,200 bytes
- 2 streams being recorded: for each speaker in a stereo system → 88,200x2 = 176,400 bytes to store per second

- A CD stores 74 mins of music (74 x 60 = 4,440 seconds)
- 176,400 x 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 (!!)

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

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.

How mp3s Work

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