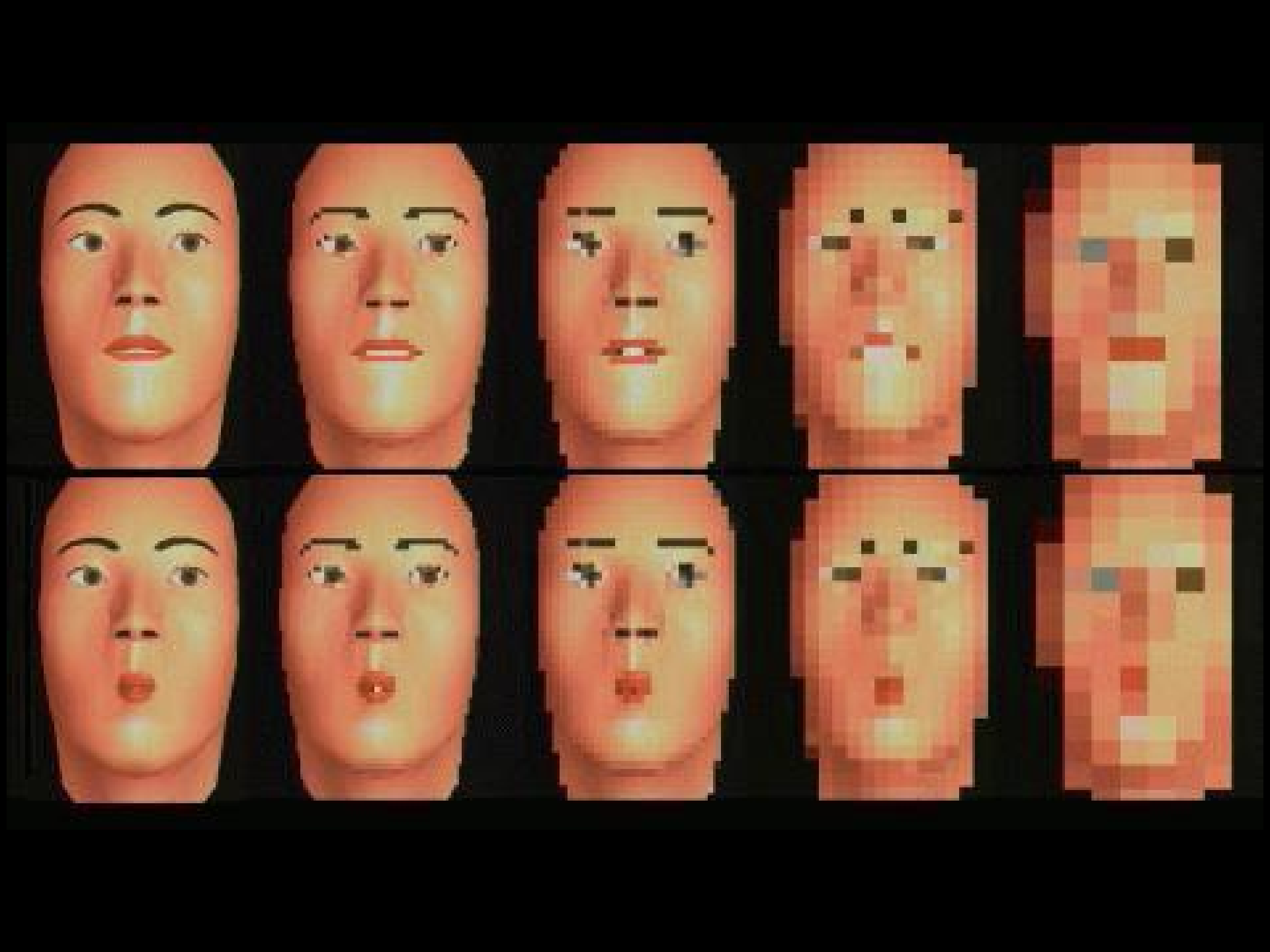
Image Representation

CS 105

Data Representation

- Types of data:
  - Numbers
  - Text
  - Audio
  - **Images & Graphics**
  - Video



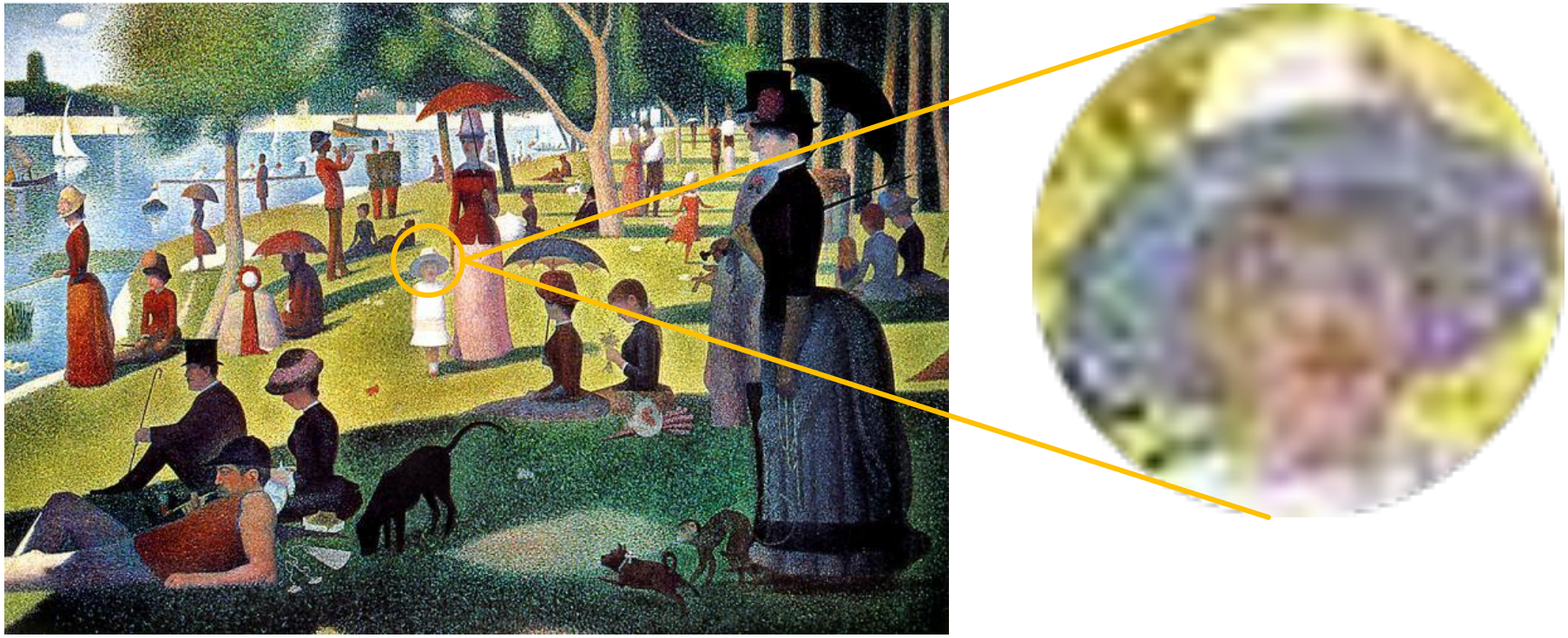
What is an image?

- Rectangular grid of pixels- 5x5 grid
  - If we are using 1 bit per cell, *how many bits are needed to present the picture*?
- What is a pixel?
  - Point/Cell in the image that contains color data
  - Each pixel is made up of *bits*
- Resolution: Details contained in an image
  - Defined by the number of pixels

[0,0]	[0,1]	[0,2]	[0,3]	[0,4]
[1,0]	[1,1]	[1,2]	[1,3]	[1,4]
[2,0]	[2,1]	[2,2]	[2,3]	[2,4]
[3,0]	[3,1]	[3,2]	[3,3]	[3,4]
[4,0]	[4,1]	[4,2]	[4,3]	[4,4]

5 x5 grid

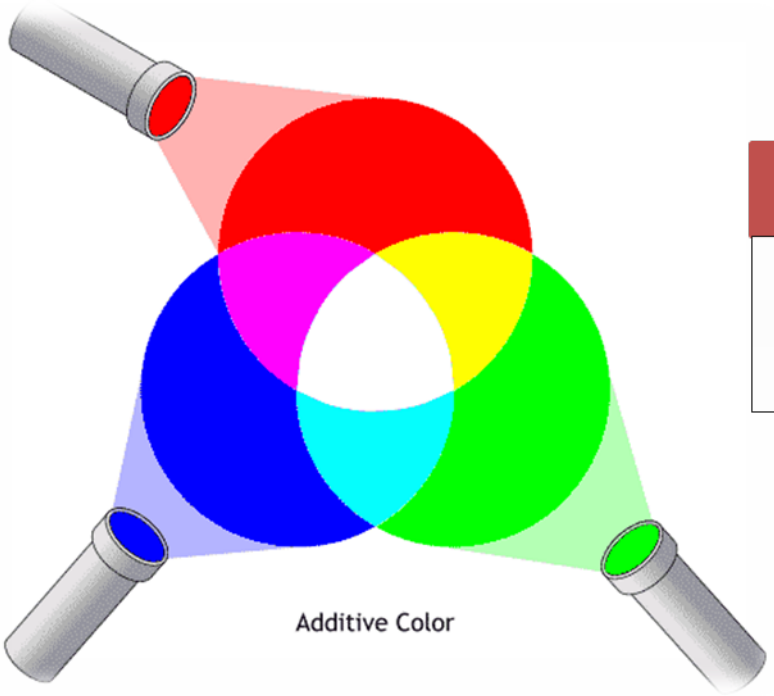
Digital images



George Seurat: *Sunday afternoon on the island of La Grande Jatte (1884-1886)*

Representing Color

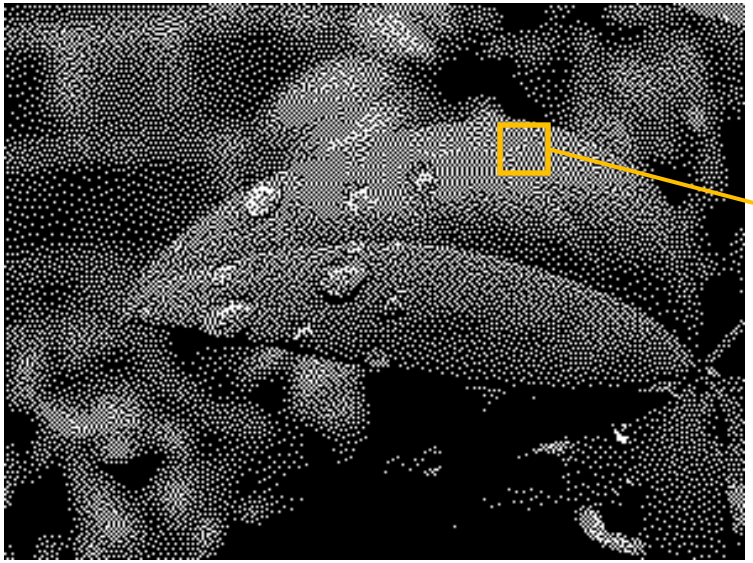
- Computer graphics/Images: RGB
- R: 0 to 255, G: 0 to 255, B: 0 to 255



Red	Green	Blue	Color
• 255 • 255	• 255 • 255	• 255 • 0	• White • Yellow

Binary Images

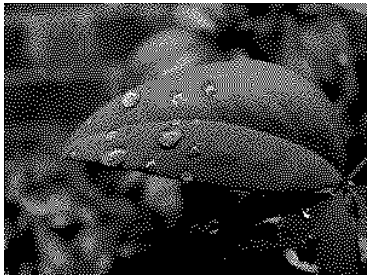
- Remember, everything on a computer is stored as 0s and 1s.
- Thus, we must *interpret* these numbers as different forms of data.
- One bit (binary digit) can be either a 0 or a 1.
  - Therefore, it can only represent two possibilities: hot or cold, black or white, on or off, etc…



1 bit per pixel

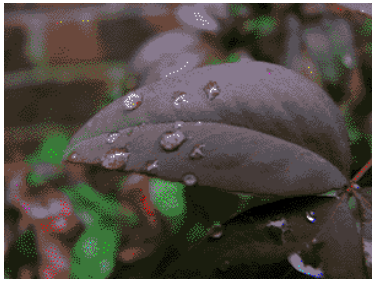
```
00000011001110011100110
00110011101000011100011
00011000111100001110001
11000011100011011100111
01101100010100110001010
00011000101011011101000
11010010101010000111000
10101010000000000001110
```

Bit Color Depth



1 bit

2 bits



4 bits

8 bits

24 bits

1= ON 0 =OFF

00 01 10 11
Different shades of gray

24 bit *TrueColor* can represent more than 16.7 million unique colors. More colors than the human eye can distinguish!

Raster vs Vector Graphics

- Raster graphics: made up of pixels
  - Resolution dependent
  - Cannot be scaled without losing quality
  - Can represent photo realistic elements better than vector graphics

- Vector graphics: geometric primitives, composed of paths
  - Mathematical equations
  - Resolution independent
  - Can be scaled to any size without losing quality
  - Best for cartoon-like images
  - 3D modeling

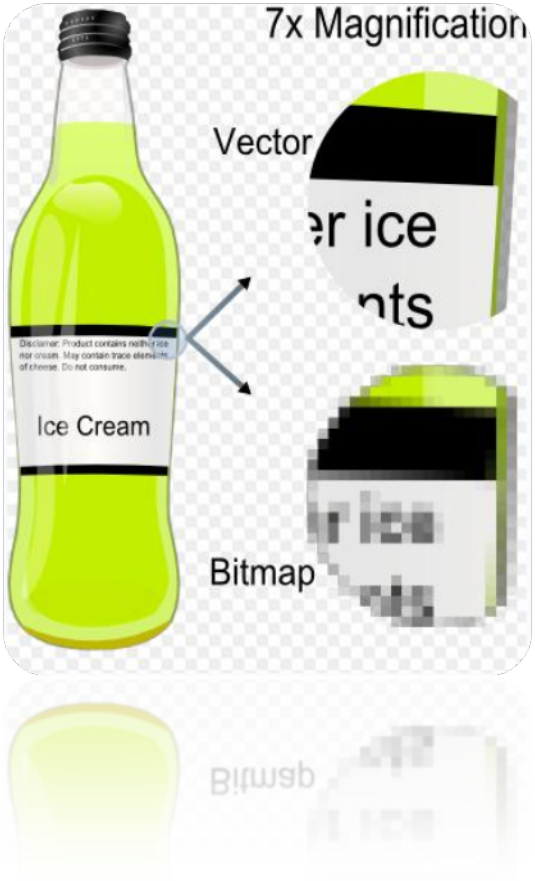


Image File Formats

- Raster graphics - Image formats:
  - BMP (BitMaP)
  - GIF (Graphics Interchange Format)
  - JPEG (Joint Photographic Experts Group)
  - PNG (Portable Network Graphics)
- Vector graphics - Image formats:
  - SVG (Scalable Vector Graphics)
  - CDR (corelDraw)

Raster Graphics

- BMP (bitmaps)
  - Simple structure
  - Pixel color values *left to right, top to bottom*
  - Can be compressed using run-length encoding

- GIF (graphics interchange format)
  - 8-bit palette (any 256 colors)
  - Small size
  - Simple images: line art, shapes, logos
  - Lossless compression: covering areas with single color

- JPEG (joint photographic experts group)
  - Is a *compression method* stored in JFIF (JPEG file interchange format)
  - Lossy compression: Averages color hues over short distances
    - Taking advantage of limitations of our visual system, discarding invisible information
  - Compression ratio is usually 0.1
  - Structure: sequence of segments. Marker followed by a definition of the marker

Image File Formats (Magic Numbers)

Magic numbers are the first bits of a file which uniquely identify the type of file. This makes programming easier because complicated file structures need not be searched in order to identify the file type.

http://www.astro.keele.ac.uk/oldusers/rno/Computing/File_magic.html

Image File Formats

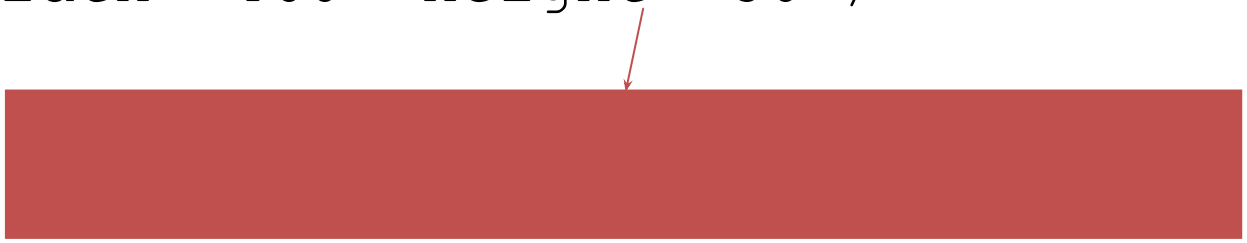
File type	Typical extension	Hex digits xx = variable	Ascii digits . = not an ascii char
Bitmap format	.bmp	42 4d	BM
GIF format	.gif	47 49 46 38	GIF8
Graphics Kernel System	.gks	47 4b 53 4d	GKSM
IRIS rgb format	.rgb	01 da	..
JPEG	.jpg	ff d8 ff e0	....
NIFF (Navy TIFF)	.nif	49 49 4e 31	IIN1
PM format	.pm	56 49 45 57	VIEW
PNG format	.png	89 50 4e 47	.PNG
Postscript format	.[e]ps	25 21	%!
Sun Rasterfile	.ras	59 a6 6a 95	Y.j.
XCF Gimp file structure	.xcf	67 69 6d 70 20 78 63 66 20 76	gimp xcf

http://www.astro.keele.ac.uk/oldusers/rno/Computing/File_magic.html

Vector Graphics

- SVG (Scalable Vector Graphics)
  - Text based scripts

```
 <rect class="redbox" x="10" y="0"
width="460" height="50"/>
```



  - Text compression
  - Compression ratio can be as small as 0.2
  - Great for web-based imaging

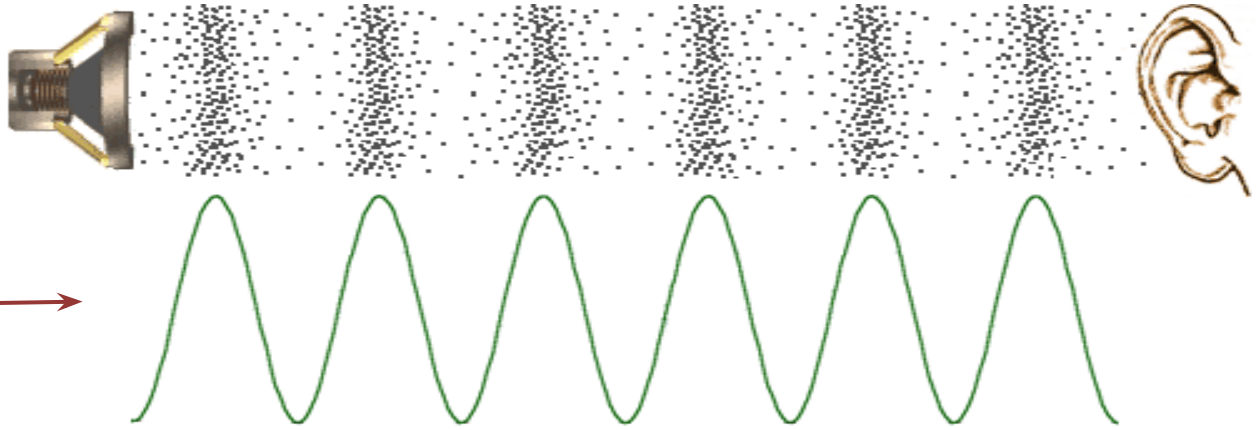
Audio Representation

Data Representation

- Types of data:
  - Numbers
  - Text
  - **Audio**
  - Images & Graphics
  - Video

What is sound?

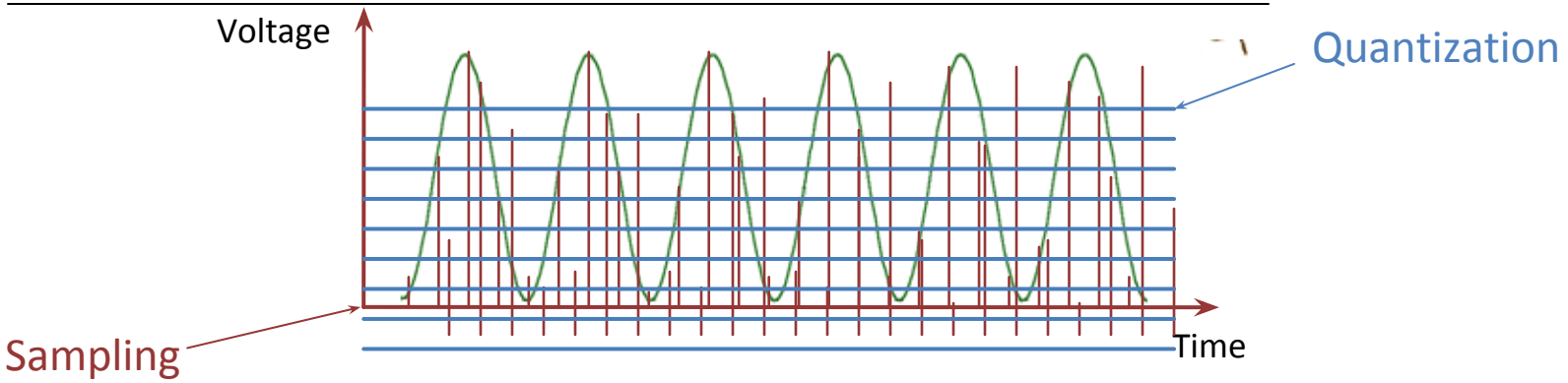
- A continuous wave created by oscillations of pressure through any material (solid, liquid & gas)



Analog signal →

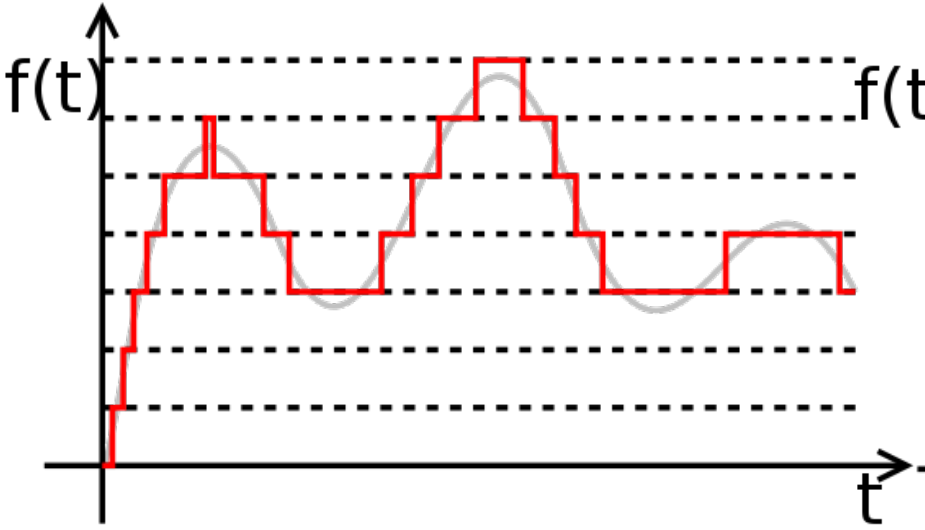
- A computer must perform an Analog to Digital conversion
- A2D conversions require specialized hardware

Digitizing Sound

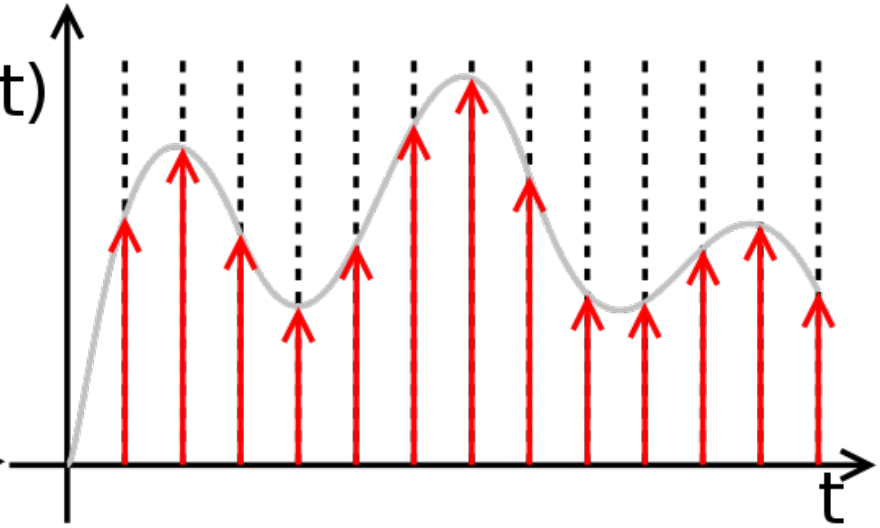


- Discrete time (sampling) & discrete voltage (quantization)
- Reasonable sound production: *40,000 times per sec*
- Quantization: Dividing vertical axis into pieces – process of mapping a continuous range of values by a small finite set of values
- 8 bit quantization = 256 levels, 16 bit = 65536 levels

Digitizing Sound

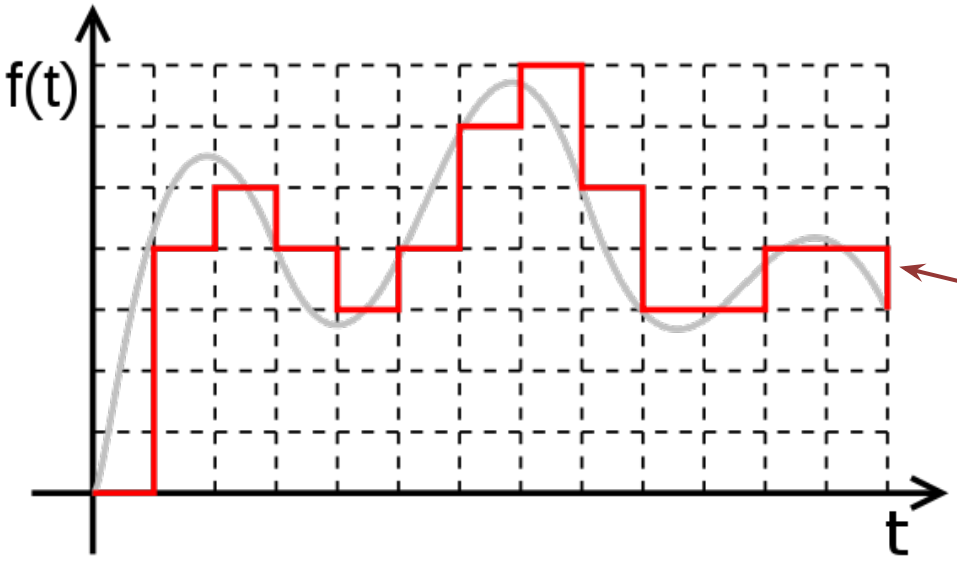


Quantization *into levels*



Sampling *time intervals*

Digitizing Sound



How many bits are needed *to represent per sample*?

- 3 bits
- Power of 2

How many bits are needed *to digitize this signal*?

- 3 x 13 = 39 bits

Bit Depth and Bit Rate

- Bit Depth: Number of bits per sample (in *bits*)
- Bit Rate: Number of bits that are sent per unit of time (in *bits/seconds*)
  - *(number of samples*bit depth)/seconds*

Each tick on the time axis (x-axis) is 1 sec. All levels are represented by 3 bits. What is the bit rate?

Every 4 ticks on the time axis is 1 sec i.e. you sample 4 times a second. What is the bit rate now?

Audio Formats

- WAV, OGG, FLAC, and MP3
- MP3 (MPEG audio layer 3)
  - Psychoacoustic models
  - Form of Huffman encoding
  - Lossy compression
  - Example bitrate: 128 to 320 kbit/s
- WAV
  - 16-bit * 44.1khz * 2 channels = 1411 kbit/s
  - PCM (Pulse-code modulation)