3. Sound / Audio

- Sound: produced by the vibration of matter.
- Waveform: the pattern of the oscillation. It repeats the same shape in a period
- Frequency = 1 / period, measured by Hz
- Audible sound is between 20 Hz - \(\boxed{20 \text{ kHz}}\)
- Human voice is in between 40 Hz - 4 kHz
- Amplitude is the loudness of the sound.

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Digital Audio

- Analog to Digital Conversion (ADC)
- Sampling (Nyquist Theorem): Digitization is lossless if the sampling rate is at least twice the highest signal frequency
  - 8000 Hz: Mono sound
  - 22 kHz: Stereo sounds
  - 44 kHz: CD-quality sounds

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Digital Audio (cont.)

- Quantization (bits per sample)
  - 4 bits, 8 bits or 16 bits per sample

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Music and Speech

- Music Instrument Digital Interface (MIDI)
  - Transmit music notes instead of raw samples
  - Reduce the information amount significantly
  - Quality is the main concern

- Speech-related Tasks
  - Speech Generation
  - Speech Analysis
  - Speech Recognition

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4. Images & Graphics

- A digital image is represented by a matrix of numerical values each representing a quantized intensity value.
- The points at which an image is sampled are known as picture elements, or commonly called *pixels*.
Image & Graphics (cont.)

- The image format is determined by two parameters:
  - Spatial resolution: pixels*pixels
  - Color coding: bits per pixel
  - Example: Parallax XVideo card can support 24-bit/pixel and 640*480 pixel resolution

- Many formats available: GIF, BMP, PostScript, JPEG and TIFF

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Visual Perception: Resolution and Brightness

Spatial resolution (of single points) depends on:
- Image size
- Viewing distance

Perception of brightness:
- Higher than perception of color
  - Especially high perception of bright edges
  - Perception decreases with brightness of surroundings
- Different perception of the primary colors
  - Relative brightness:
    green : red : blue = 59% : 30% : 11%

Example:
- 2 lines with distance of 1 mm are recognized as two lines if:
  - Viewing distance < 3m or
  - Viewing angle >10°
Image Formats

Capturing / Recording format:

Spatial resolution [pixel x pixel]

Planes

Color coding [bits/pixel]

Storage format:

2-dimensional matrix representing pixels

Example:

- Bitmap matrix containing binary values

Color image: four important approaches

- 3 numbers representing intensities for red, green, blue (RGB) or ("true color" if numbers fine-grained enough, e.g., 8-bit; very common)
- 3 numbers representing pointers to color table (1 color per entry - R,G,B)
- 1 number as pointer (index) to color table: "color lookup table CLUT"
  (most common, apart from true color)
    - e.g., 8 bit-pointer: 256 colors possible
    - e.g., CLUT-entry 3 Bytes: one for each main color (256-out-of-16
  }
Postscript

History:
- Developed 1984 by Adobe
- First time fonts became important to the general public

Functionality:
- Integration of high-quality text, graphics and images
- Programming language
  - full-fledged
  - with variables, control structures and files

Postscript Level-1:
- Earliest version developed in 1980ies
- Scalable font concept (in contrast to fixed-size fonts available until then)
- Problem: no patterns available to fill edges of letters resulting in lower quality

Postscript Level-2:
- High-quality pattern filling
- Greater number of graphics primitives
Postscript 3 and beyond

1. Finalized in 1997, and remains stable
   - better colors and 4096 gray levels
   - adopted by laser printers and magazines
   - file name: ***.ps

2. Influenced NeXT and SUN with X11

3. A fully-functional programming language
   - Like stack-based Forth and LISP

4. Extended to Encapsulated PostScript (eps)