ICT Foundation

Analog and Digital

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Analog and Digital

- Analog
  - Information that continuously varies by time
  - Infinite precision is required to represent in numbers
  - Examples: analog clock, weighing scale

- Digital
  - Discrete (discontinuous) information
  - Examples: the amount of money, digital clock

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Analog representation and Digital representation

- Time
  - Analog clock, Sundial
    - The flow of time is represented by continuously changing the angle of needle
  - Digital clock
    - Time is represented by discrete numbers
- Temperature
  - Mercury thermometer
    - The length of the mercury column represents continuously varying temperature.
  - Electronic (Digital) thermometer
    - The body temperature is constantly represented by discrete numeric values.

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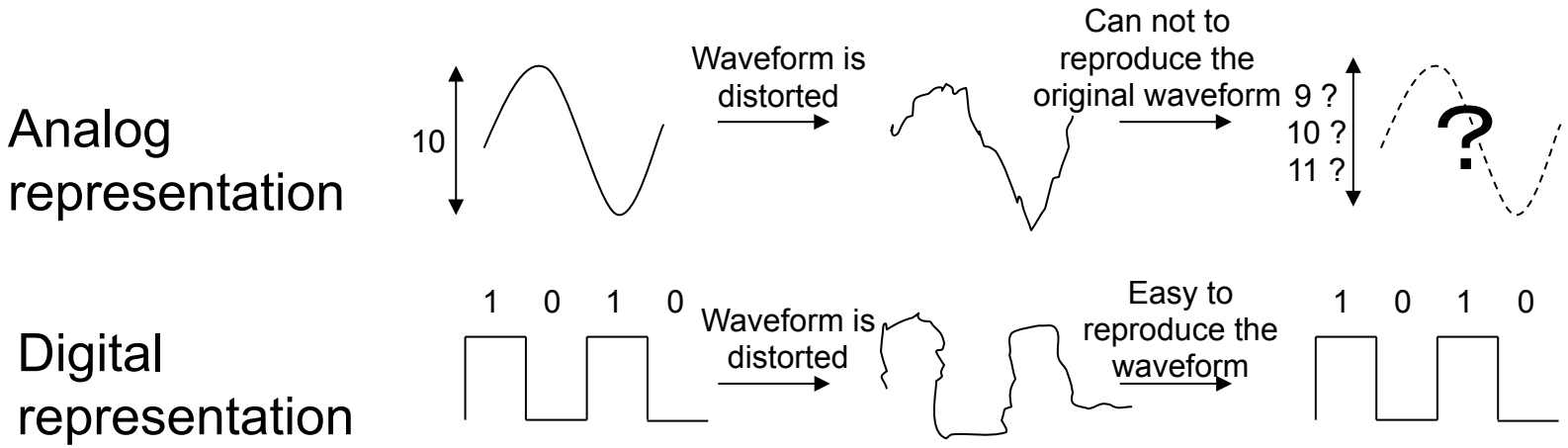
Digital is strong on noise

- Because analog uses voltage values to represent numbers, it's easy to be influenced by the noise on the way and therefore we can not reproduce the original information.
- Digital uses only high/low voltage states to represent numbers, so even though there's noise on the way, it's easy to reproduce the original information.



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Easy to duplicate and process digital information

- Less degradation even be duplicated
  - Because digital is strong on noise, it's less degradation even be duplicated.
  - Analog data is easily influenced by noised so it's degraded once be duplicated.
  - However, it is also easy to make duplication lead to copyright infringement (Detail explanation in lecture 10）
- Easy to process
  - The digital representation can be converted to numeric strings, so it's easy to process on computers.
  - Example：Color correction of digital camera images is easy with one computer.

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Audio digitalization

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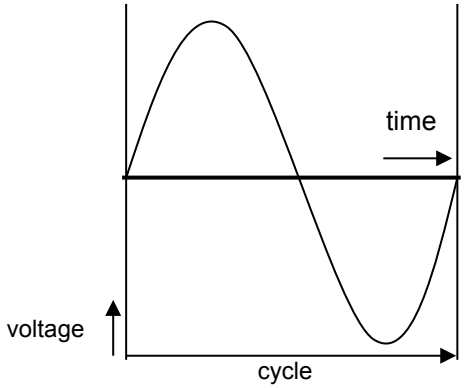
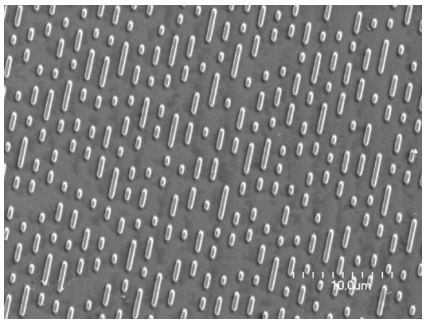
Sound Waves

- Sound is a continuous wave that travels through the air.
  - Frequency : the number of waves in one second, the unit is Hz
  - Cycle : one time a wave travels, the unit is second





CDの表面の電子顕微鏡写真（明星大学物性研究センター）
http://msrc.amrc.meisei-u.ac.jp/modules/myalbum/photo.php?lid=17

- Music CD has been recorded as a digital representation using roughness in the surface
- To represent sound as digital data, we have to convert it (digitize it).

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Convert analog to digital (1)

- Sampling
  - Divide the waveform by the time dimension, read the height of wave at each point as finite digit real number.
  - Read values are called sampling values
- Quantization
  - Approximate the sampling values by integer values
- Encoding
  - Convert integer values to binary numbers

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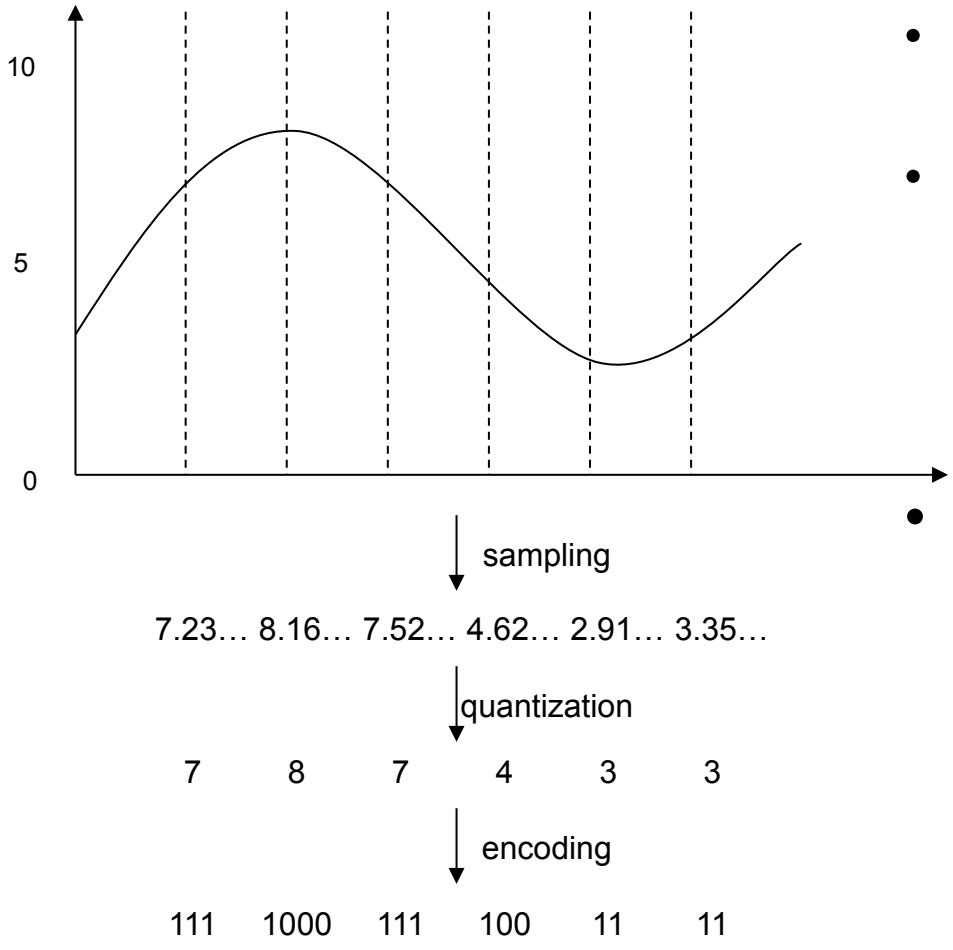
Convert analog to digital (2)



- It's impossible to reproduce the original waveform
- If we sampled in detail, the quantization unit is reduced, so the accuracy of approximation increases but the amount of information is increased.
- It is necessary to consider the balance of converting quality and the increasing amount of information（tradeoff situation)

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Image and Video Digitilization

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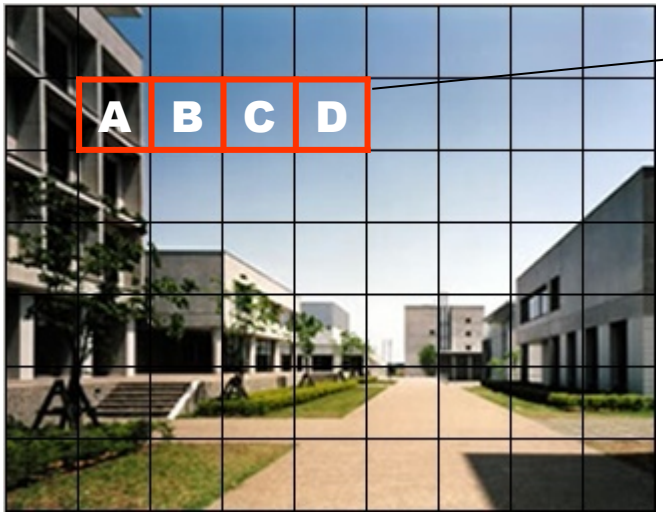
Bitmap (raster) Image (1)

- Reading density and color information as a finite digit real number horizontally from the corner of the screen at regular intervals (sampling)
- Converting those real numbers to integer numbers. (quantization)
- Converting the integers to binary numbers (encoding)



sampling
Divide image into squares, read the density or color information as numbers

Pixel A	Pixel B	Pixel C	Pixel D
6.23…	4.16…	3.52…	3.62…

quantization

Pixel A	Pixel B	Pixel C	Pixel D
6	4	3	3

encoding

Pixel A	Pixel B	Pixel C	Pixel D
110	100	11	11

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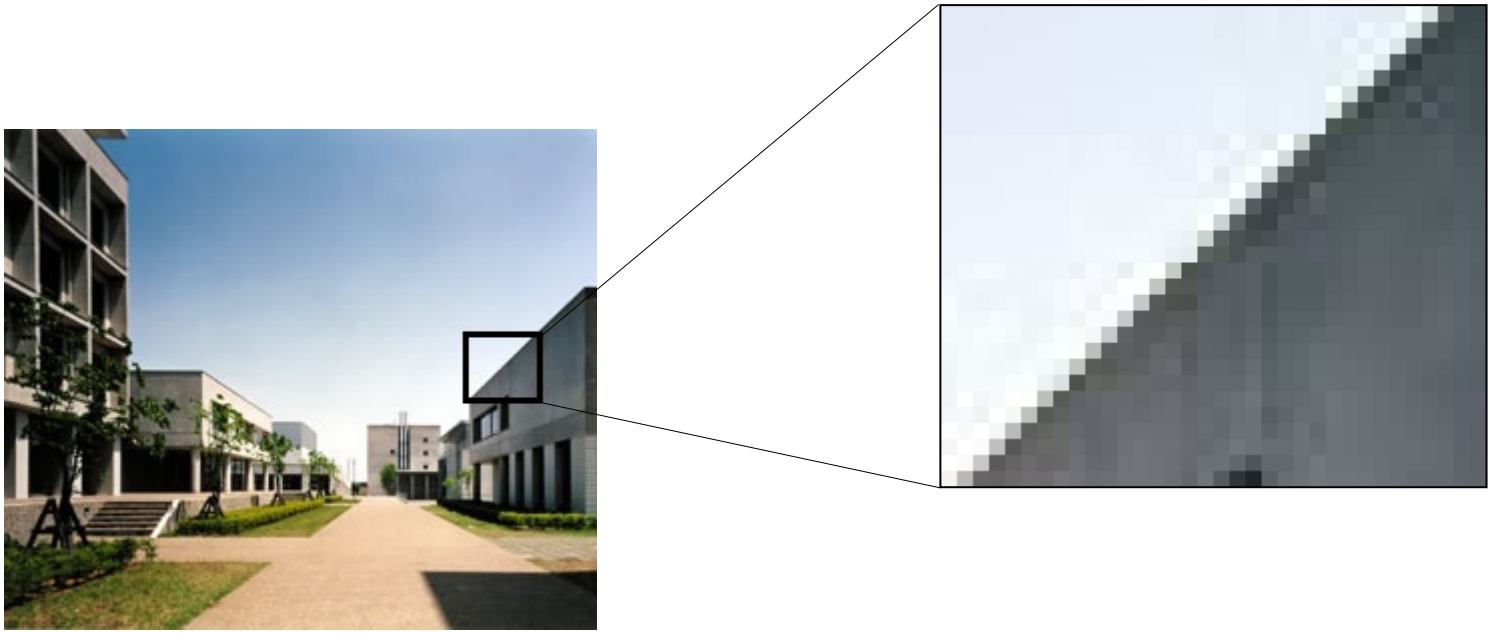
Bitmap (raster) Image (**2**)

- When scaling up a bitmap image, its edges are blurred and loss of clarity.



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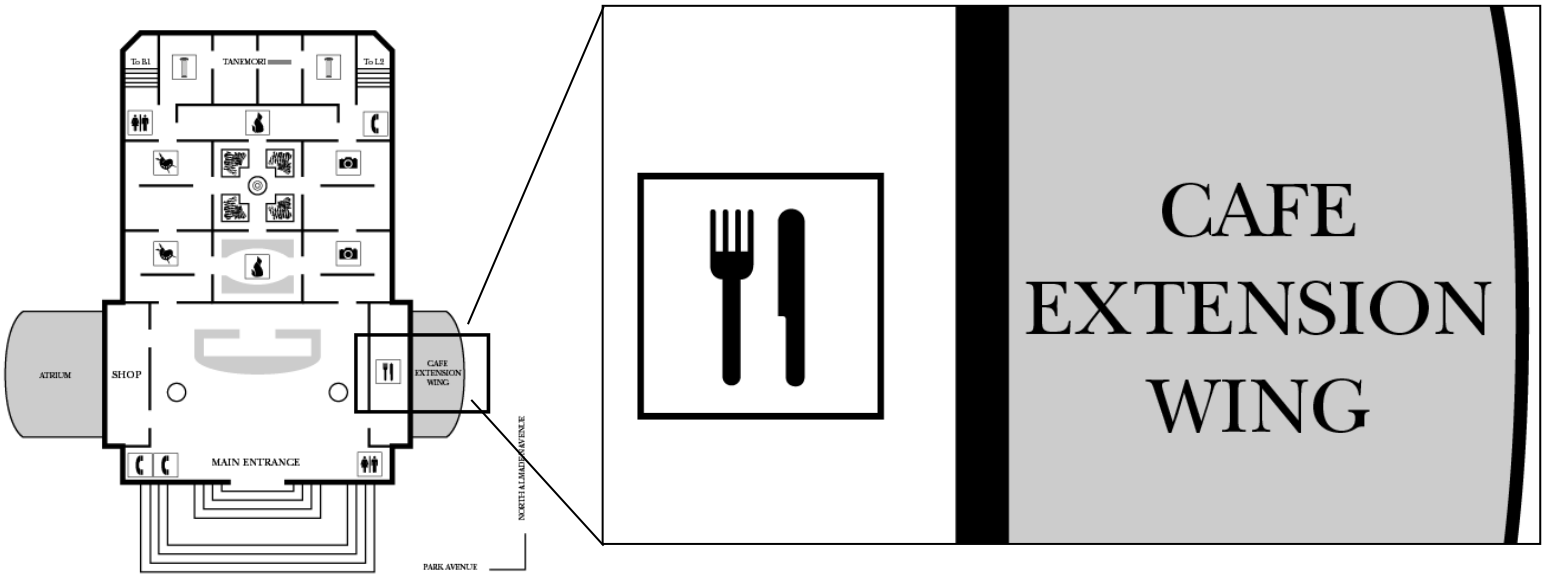
Vector Image

- Vector images are represented using geometrical primitives such as points, lines, curves, and shapes or polygon(s) based on mathematical equations.
- Not lost detail and clarity when scaling up/down.



Adobe Illustrator サンプルより

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Video digitalization

- Video recording and playback are used with the property of human eyes.
  - Recording the motion of still images with 24 frames per second for film and 30 frames per second for television. (the same principle with flip book)
  - Digitalizing each frame
  - Example：Using digital terrestrial broadcasting, the ghost during transmission is gone, thereby the quality is improved.

社団法人 地上デジタル放送推進協会
http://www.d-pa.org/

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