

Advanced Information Engineering

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Study Contents

- Digital Image Processing and its applications

Objective of the course

- Learn the basic principles of digital image processing

Questionnaire

- Studying on image processing or its applications
- Have learned about image processing (signal processing)
- Novice, but is interested in image processing
- Others

Lecture Plan #1

- 10/12 (M) Digital Image Processing #1
- 10/19 (M) Digital Image Processing #2+Exercises
- 10/26 (M) Digital Image Processing Demo+Answers
- 11/2 (M) Frequency of Image Signals #1
- 11/9 (M) Frequency of Image Signals #2+Exercises
- 11/16 (M) Fourier Trans. Demo+Answers
- 11/30 (M) Multi-dimensional Filter #1

Lecture Plan #2

- 12/7 (M) Multi-dimensional Filter #2+Exercises
- 12/14 (M) Multi-dimensional Filter Demo + Answers
- 12/21 (M) Enhancement of Images + Exercises
- 01/4 (M) Enhancement of Images + Answers
- 01/18 (M) Geometric Transformation of Images
- 01/25 (M) Applications to Scientific Measurements
- 02/1 (M) Signal Processing in Geometric Modeling

Lecture Styles

- PPT (Q&A anytime, examples)
- PPT print outs, hand out exercises
- Demo with MATLAB

Grading

- Attendance rate
- Performance of exercises

Others

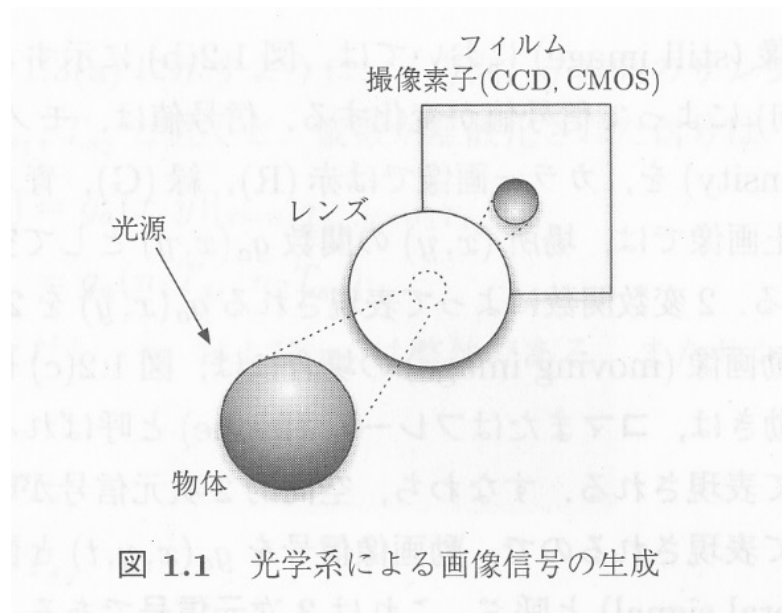
- Questions
- Request

Image Signals

- Image information, in many cases, is transformed to electrical signals or numerical values and is treated as image signals.

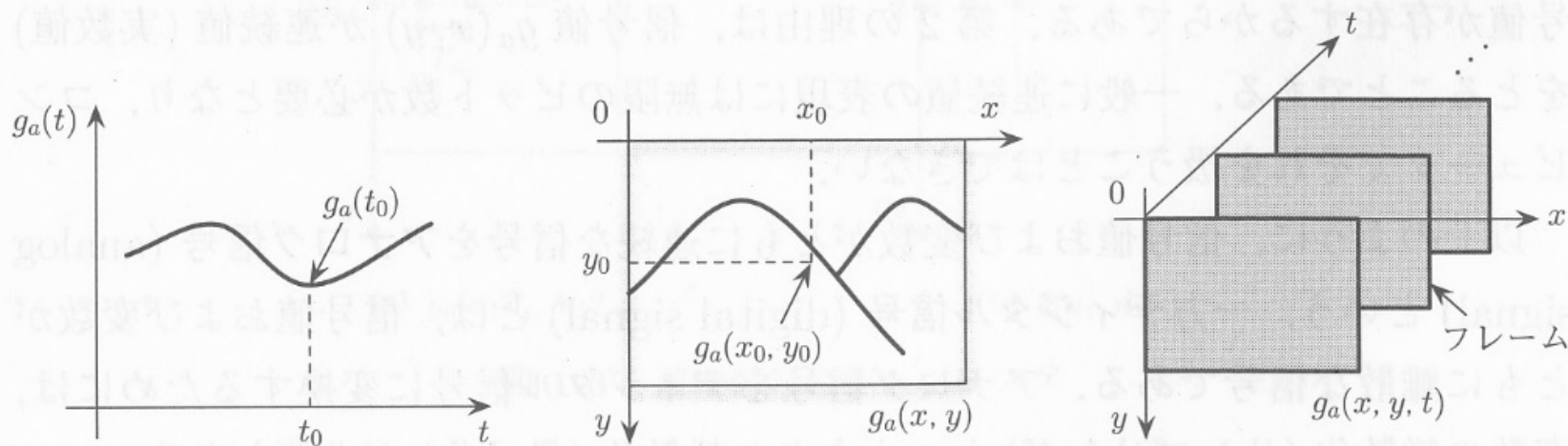
Generation of Image Signals

- Light is reflected on subjects.
- Reflected light is refracted and imaged.
- Image signals are recorded on photoreceptor as film, or transformed to electrical signals by imaging devices.



Dimension of Signals

- Signals, whose typical example is sound, is a function of time $g_a(t)$ of one dimensional signal.
- Still image is two dimensional signals and has various values at spacial position (x,y) .



(a) 1次元信号

(b) 2次元信号(静止画像)

(c) 3次元信号(動画像)

図 1.2 信号の次元

Digital Image

- Images taken by a digital camera are digital images and they are recorded as digital signals.
- Image processing processes digital signals by computers.

Analog Image Signals

- Intensities of film photo are analog signals and are given by two dimensional signal $g_a(x,y)$.
- Variables x and y are continuous (real numbers) and pixel which is a discrete space point is not defined.
- Signal values $g_a(x,y)$ are continuous (real values) and are not handled by computers because continuous values need infinite number of bits.

Digital Image Signals

- Image signals whose signals themselves $g(x,y)$ and variables x, y are discrete.
- In order to convert analog signals to digital signals, it is necessary to discretize variables (sampling) and signals (quantization).

Sampling

- Process to discretize variables x and y .
- Let T_{s1}, T_{s2} be sampling intervals in x and y directions, respectively. The signal is given by

$$\begin{aligned}g(n_1, n_2) &= g_a(x, y) \Big|_{x=n_1 T_{s1}, y=n_2 T_{s2}} \\ &= g_a(n_1 T_{s1}, n_2 T_{s2})\end{aligned}$$

- n_1, n_2 are integers and reciprocals of sampling intervals T_{s1}, T_{s2} are horizontal and vertical sampling frequencies.
- A sample point in space is a pixel and its signal value is a pixel value.

Rectangular Sampling

- It is commonly used because of simpleness of output devices and processing.
- The top-left corner is the image origin $(0,0)$ and n_1 and n_2 are variables in the horizontal and vertical directions.

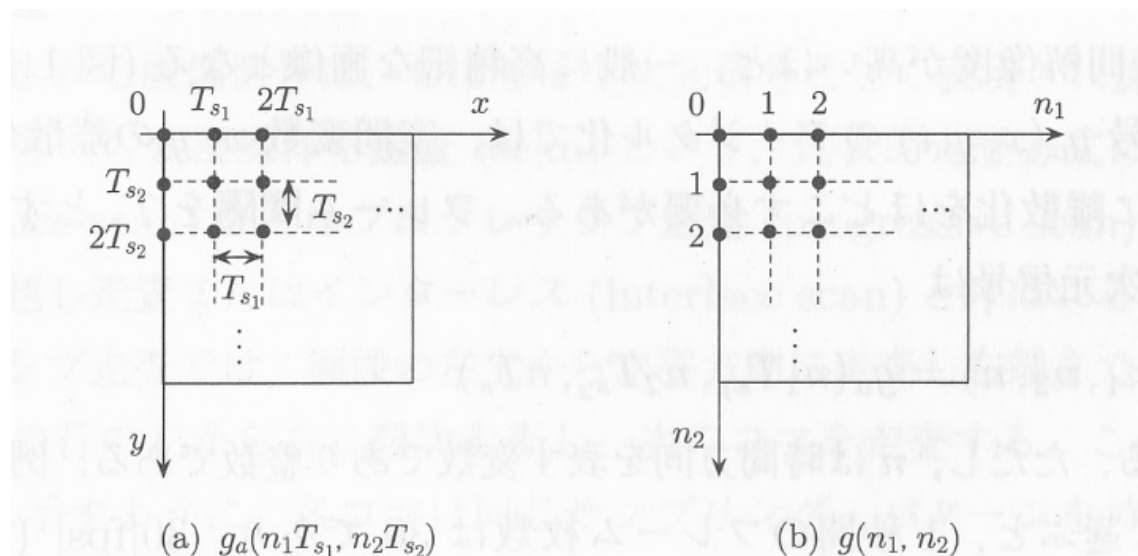


図 1.3 画像信号のサンプリング

Spatial Resolution of Image

- For a digital image, let N_1 , and N_2 be pixel numbers in the horizontal and vertical axes. Its space resolution is given by $N_1 \times N_2$.
- Higher space resolution, higher-definition
- VGA, HD, 4K ?



Digitization of Video Image Signal $g_a(x,y,t)$

- Discretize time variable t by frame interval T_s .

$$g(n_1, n_2, n) = g_a(n_1 T_{s_1}, n_2 T_{s_2}, n T_s)$$

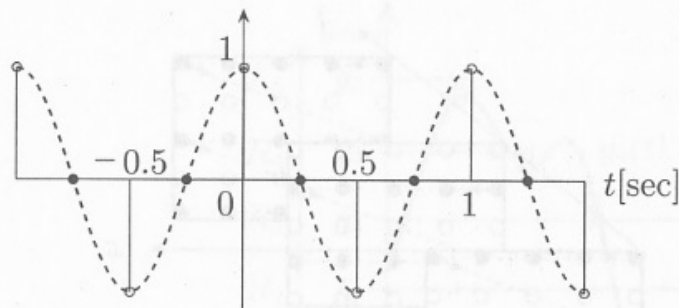
- n is a variable for time elapse and is an integer.
- For example if $T_s = 1/30[\text{sec}]$, the frame rate, which corresponds to time resolution is 30fps.
- F_s , the reciprocal of T_s F_s is called time sampling frequency.

Sample Exercise

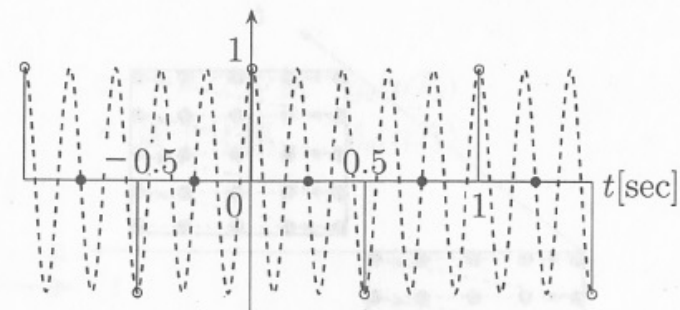
- Let's think about two one-dimensional time signals of frequency $F=1$ [Hz] and $F'=5$ [Hz], $g_a(t)=\cos(2\pi t)$ and $g_b(t)=\cos(10\pi t)$. Please illustrate discrete signals obtained by sampling these signals with sampling interval $T_s=1/F_s=1/4$ [sec] .

Answers

- Their sampled values are the same.
- Sampling time $t=nT_s$, and
$$g(n)=\cos(\pi n/2)=\cos(2\pi + \pi n/2)=g'(n)$$
- Generally when $F'=F+kF_s$ (k is an integer), both of the sampled values become identical.



(a) $F=1$ [Hz]

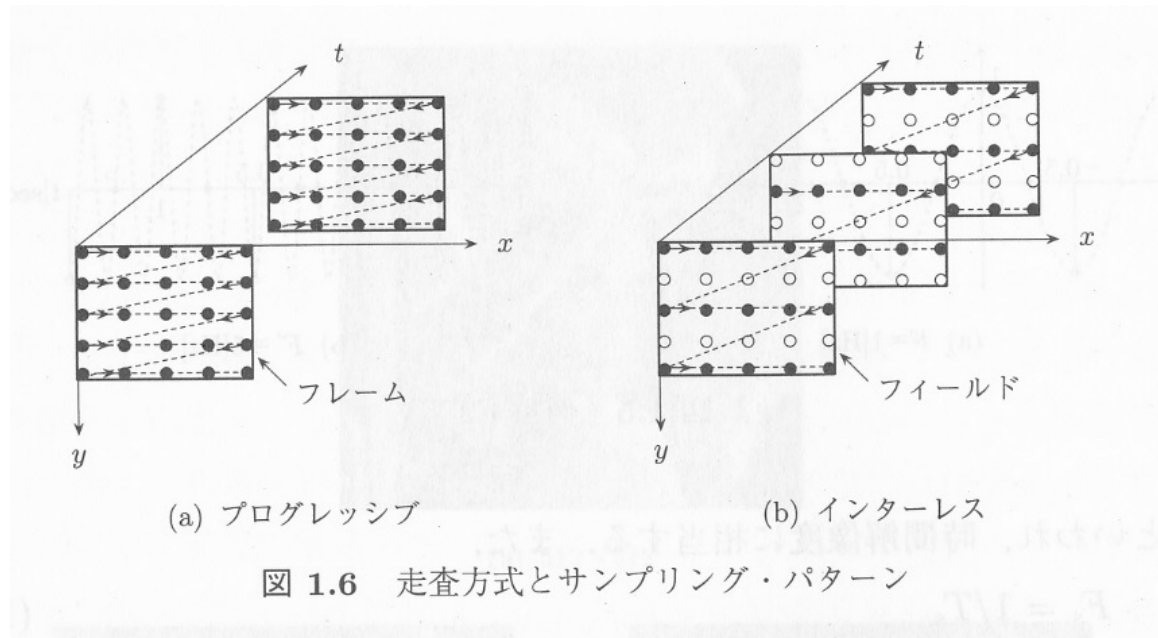


(b) $F'=5$ [Hz]

图 1.5 例题 1.2

Scan(走査)

- Process to transform multi-dimensional signals to one dimensional signals.



- TV broadcasting uses interlace scan and movie files do progressive scan.
- Prioritize time resolution or space resolution?

Summary

- Contents of course
- Image signals
 - Analog image
 - Digital image
- Sampling and quantization