Sample 11-1

画像ノイズ除去

加法性白色ガウスノイズ

画像処理特論

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動作確認: MATLAB R2023a

Image denoising

Additive whitel Gaussian noise

Advanced Topics in Image Processing

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Verified: MATLAB R2023a

準備

(Preparation)

```
clear
close all
import msip.download_img
msip.download_img
```

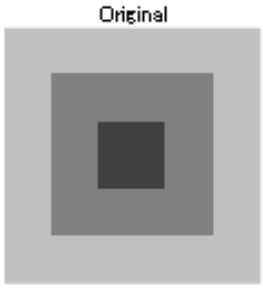
```
kodim01.png already exists in ./data/
kodim02.png already exists in ./data/
kodim03.png already exists in ./data/
kodim04.png already exists in ./data/
kodim05.png already exists in ./data/
kodim06.png already exists in ./data/
kodim07.png already exists in ./data/
kodim08.png already exists in ./data/
kodim09.png already exists in ./data/
kodim10.png already exists in ./data/
kodim11.png already exists in ./data/
kodim12.png already exists in ./data/
kodim13.png already exists in ./data/
kodim14.png already exists in ./data/
kodim15.png already exists in ./data/
kodim16.png already exists in ./data/
kodim17.png already exists in ./data/
kodim18.png already exists in ./data/
kodim19.png already exists in ./data/
kodim20.png already exists in ./data/
kodim21.png already exists in ./data/
kodim22.png already exists in ./data/
kodim23.png already exists in ./data/
kodim24.png already exists in ./data/
See Kodak Lossless True Color Image Suite
```

画像生成

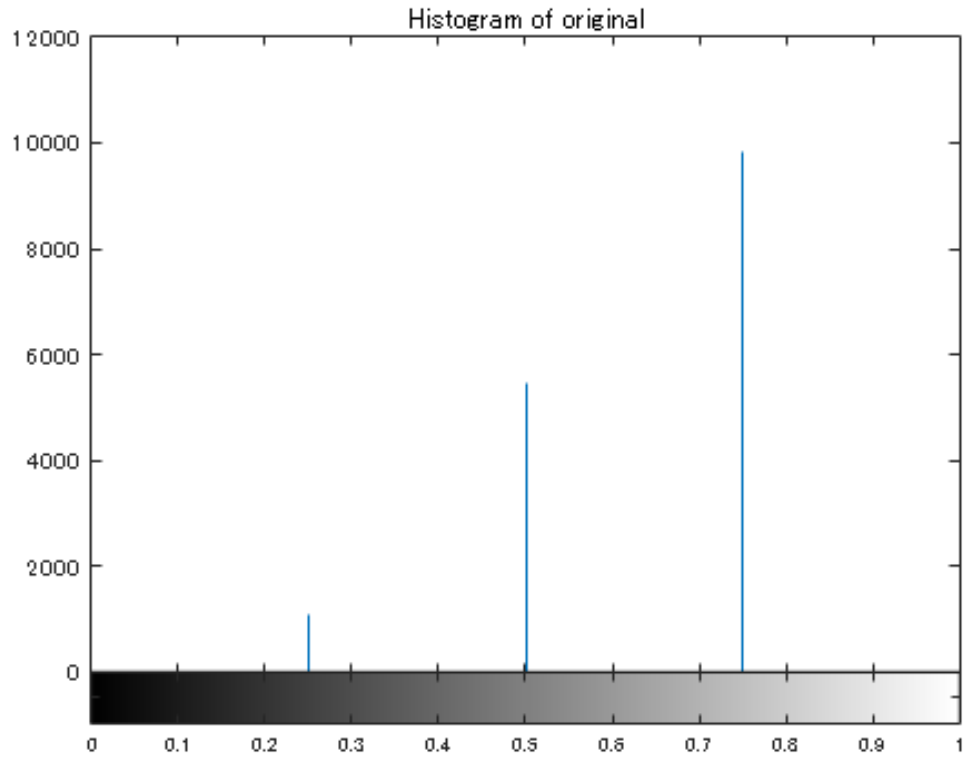
(Image generation)

- $\mathbf{u} \in \mathbb{R}^N$: 原画像 (Original image)

```
% Original image u
u = 0.75*ones(128);
u(24:128-24,24:128-24) = 0.5;
u(48:128-48,48:128-48) = 0.25;

figure
imshow(u)
title('Original')
```




```
figure
imhist(u)
title('Histogram of original')
set(gca,'YLim',[0 12000])
```



白色ガウスノイズ

(White Gaussian noise)

ノイズはガウス分布(正規分布)に従う乱数と仮定．(Noise is assumed to be a random number drawn from a Gaussian distribution (normal distribution).)

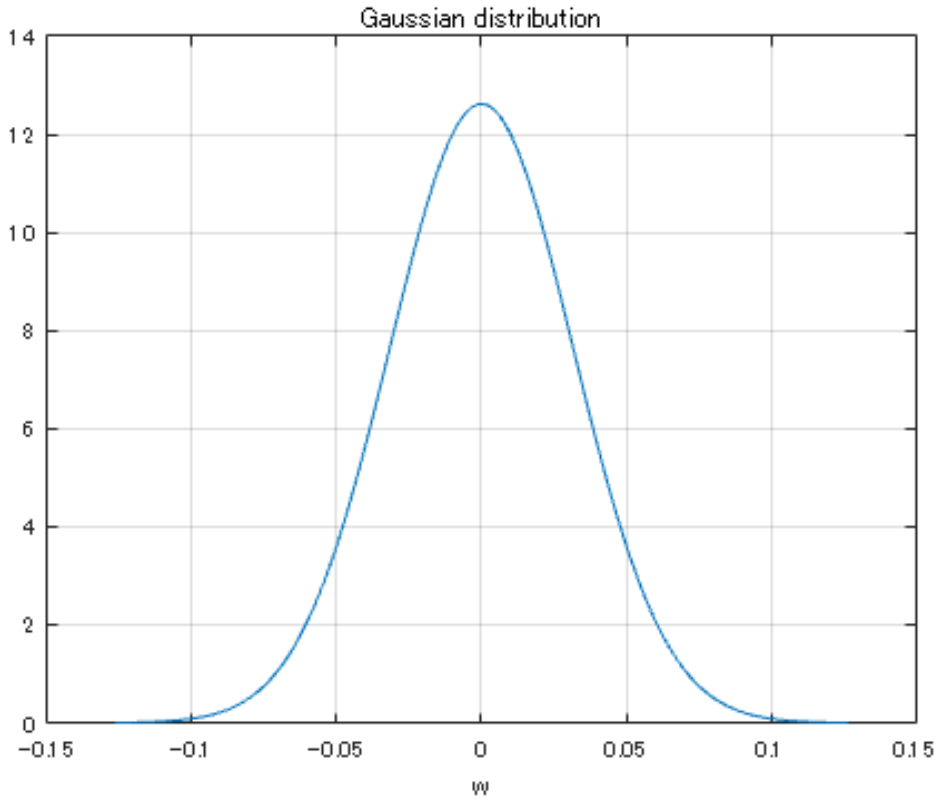
- $\mathbf{w} \sim \mathrm{Norm}(\mathbf{w}|\boldsymbol{\mu}_w, \boldsymbol{\Sigma}_w)$: ノイズ (Noise)
- $\mathrm{Norm}(\mathbf{x}|\boldsymbol{\mu}, \boldsymbol{\Sigma}) = \frac{1}{\sqrt{2\pi|\boldsymbol{\Sigma}|}} \exp\left(-\frac{1}{2}(\mathbf{x}-\boldsymbol{\mu})^T\boldsymbol{\Sigma}^{-1}(\mathbf{x}-\boldsymbol{\mu})\right), \quad \mathbf{x} \in \mathbb{R}^N$

白色とは零平均 (zero mean) かつ 独立同一分布 i.i.d. (independently and identical distribution)を意味する．(White means zero mean and i.i.d. (independent and identical distribution)).

- $\boldsymbol{\mu}_w = \mathbf{0}$
- $\boldsymbol{\Sigma}_w = \sigma_w^2\mathbf{I}$

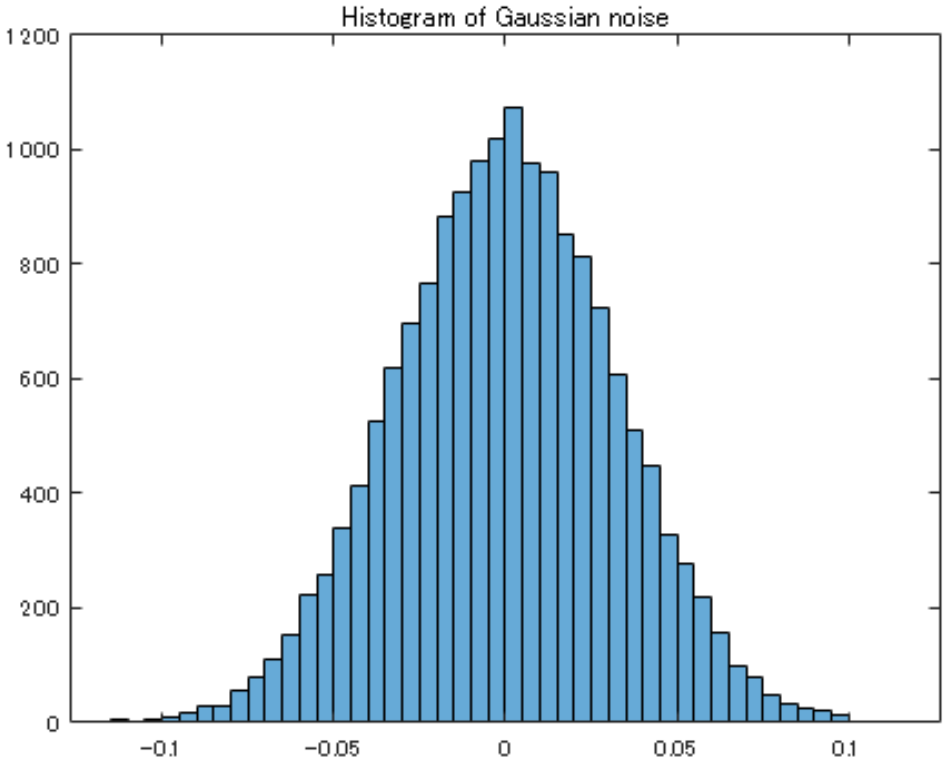
```
% Gaussain parameters
muw = 0;
sgmw2 = 10^-3;
sgmw  = sqrt(sgmw2);

% Gaussian distribution
x = linspace(-4*sgmw,4*sgmw,1001);
```

```
wpdf = normpdf(x,muw,sgmw);
figure
h = plot(x,wpdf);
xlabel('w')
title('Gaussian distribution')
grid on
```



擬似乱数生成 (Pseudo-random number generation)

```
% Additive white Gaussian noise
w = sqrt(sgmw2)*randn(size(u));
figure
histogram(w(:))
title('Histogram of Gaussian noise')
set(gca,'XLim',[-4*sgmw 4*sgmw])
```



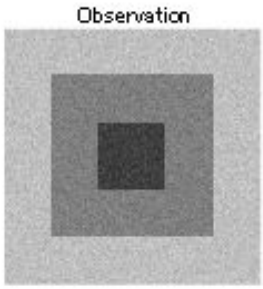
観測画像

(Observed image)

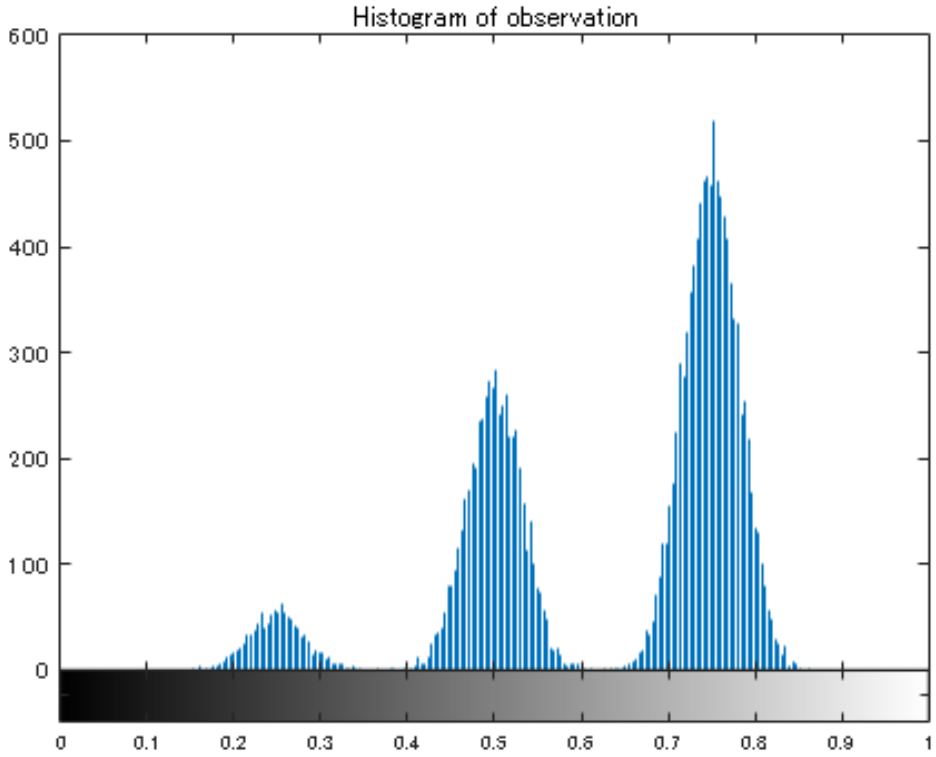
加法性白色ガウスノイズによる劣化のシミュレーション (Simulation of degradation by additive White Gaussian noise)

- $\mathbf{v} = \mathbf{u} + \mathbf{w} \in \mathbb{R}^N$: 観測画像 (Observed image)

```
% Noisy observation
v = u + w;
figure
imshow(v)
title('Observation')
```




```
figure
imhist(v)
title('Histogram of observation')
set(gca,'YLim',[0 600])
```



ノイズ画像生成

(Generation of noisy image)

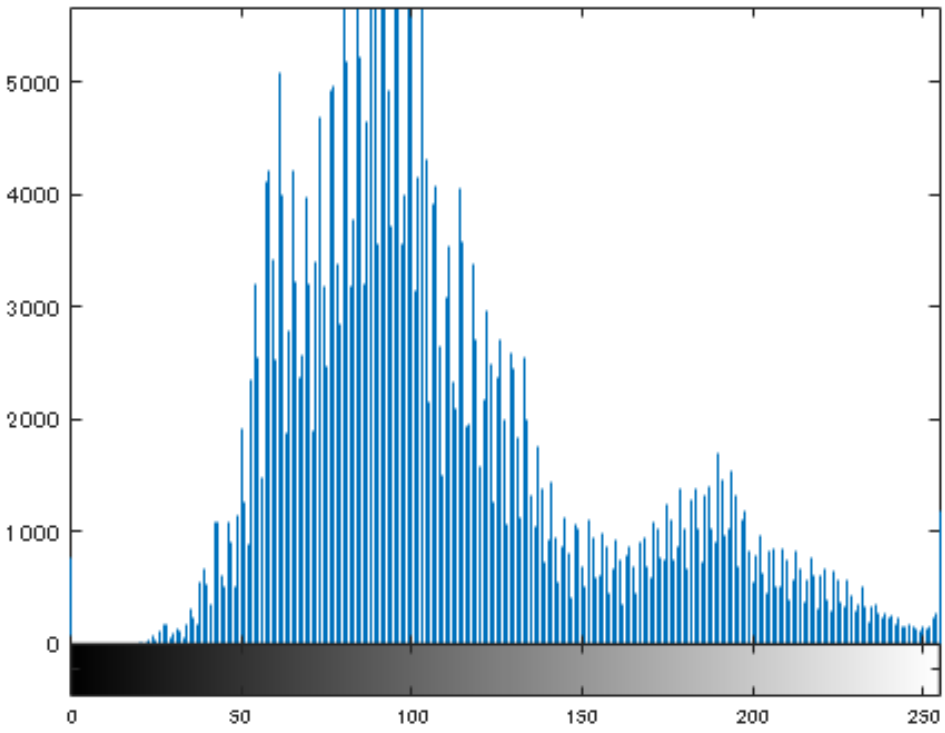
IMNOISE 関数を利用できる．(IMNOISE function can be used.)

加法性白色ガウスノイズ(AWGN)を与える例．(Example of giving additive white Gaussian noise(AWGN).)

```
I = rgb2gray(imread('./data/kodim23.png'));
J = imnoise(I,'gaussian',muw,sgmw2);
```

```
figure
imshow(I)
```

```
figure
imhist(I)
```




```
figure
imshow(J)
```

```
figure
imhist(J)
```