

# 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 R2020a

## Image denoising

Additive white Gaussian noise

Advanced Topics in Image Processing

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Verified: MATLAB R2020a

## 準備

(Preparation)

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

lena.png already exists in ./data/  
baboon.png already exists in ./data/  
goldhill.png already exists in ./data/  
barbara.png already exists in ./data/

## 画像生成

(Image generation)

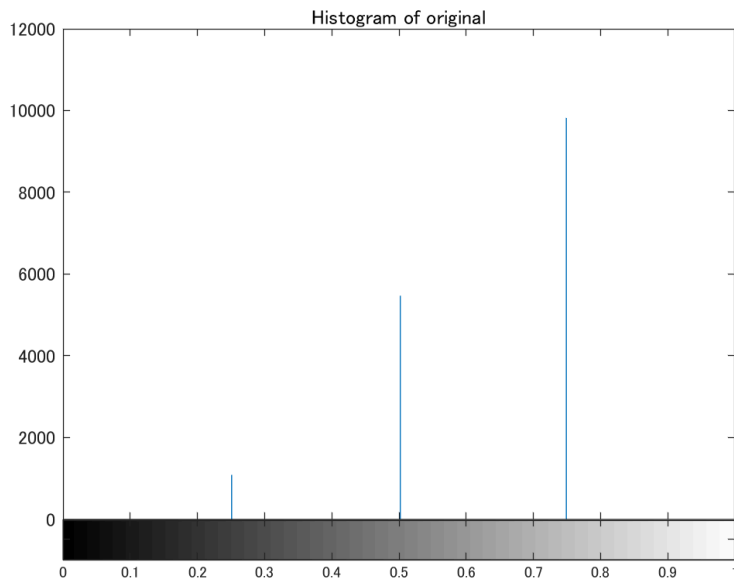
- $\mathbf{u} \in \mathbb{R}^N$ : 原画像 (Original image)

```
% 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(1)
imshow(u)
title('Original')
```



```
figure(2)
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).)

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

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)).

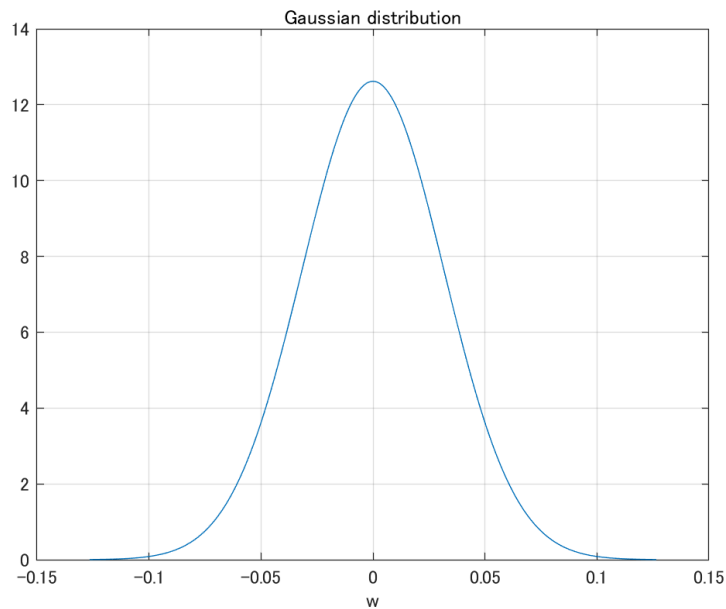
- $\boldsymbol{\mu}_w = \mathbf{0}$
- $\boldsymbol{\Sigma}_w = \sigma_w^2 \mathbf{I}$

```

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

% Gaussian distribution
x = linspace(-4*sgmw,4*sgmw,1001);
wpdf = normpdf(x,muw,sgmw);
figure(3)
h = plot(x,wpdf);
xlabel('w')
title('Gaussian distribution')
grid on

```

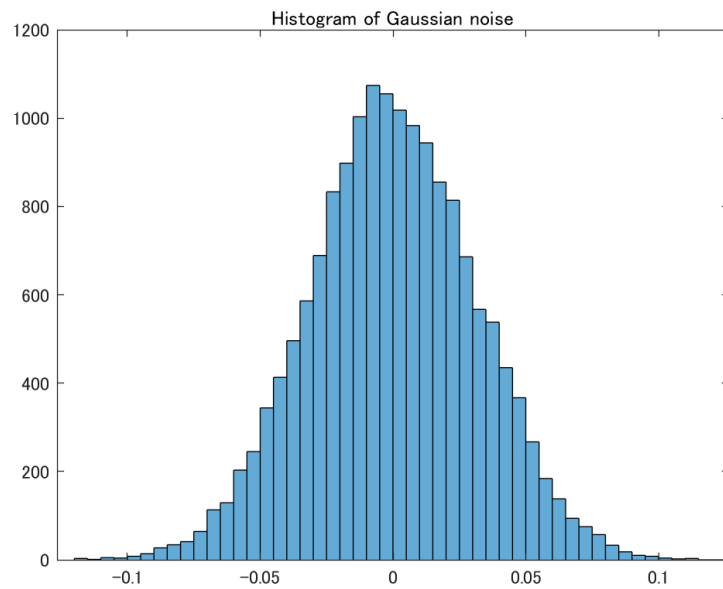


擬似乱数生成 (Pseudo-random number generation)

```

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

```



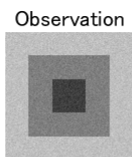
観測画像

(Observed image)

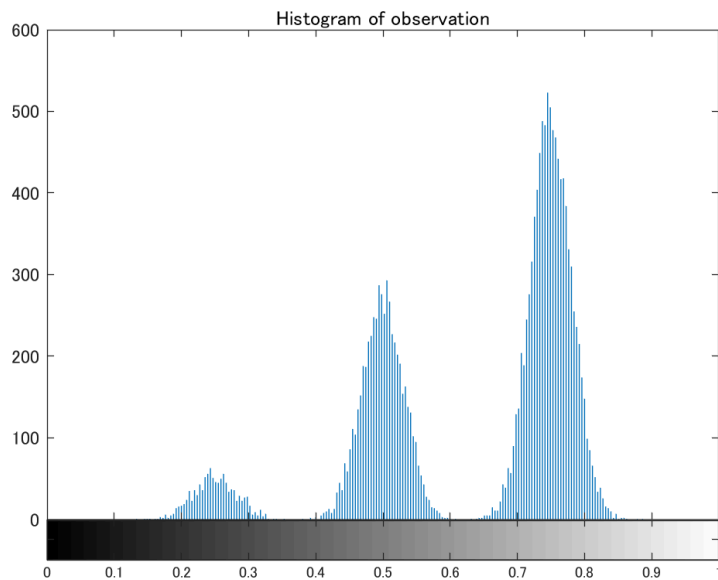
加法性白色ガウスノイズによる劣化のシミュレーション (Simulation of degradation by additive White Gaussian noise)

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

```
% Noisy observation
v = u + w;
figure(5)
imshow(v)
title('Observation')
```



```
figure(6)
imhist(v)
title('Histogram of observation')
set(gca, 'YLim', [0 600])
```



## ノイズ画像生成

(Generation of noisy image)

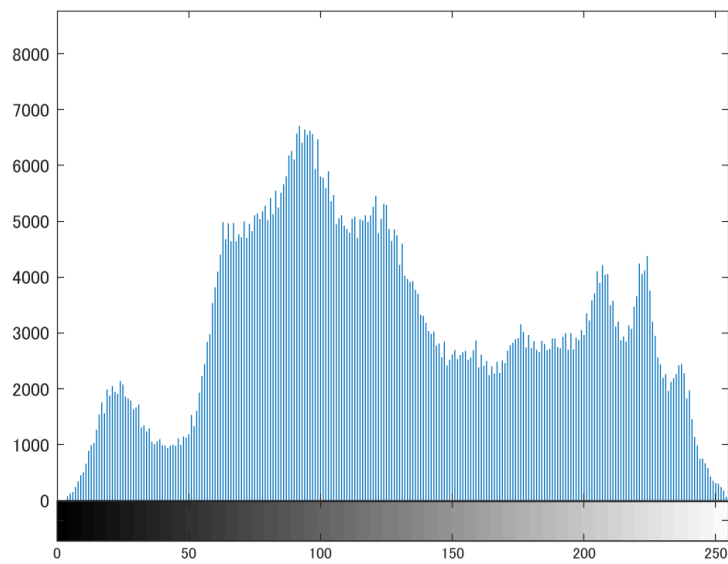
IMNOISE関数を利用できる。(IMNOISE function can be used.)

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 = imread('./data/lena.png');  
J = imnoise(I, 'gaussian', muw, sgmw2);  
figure(7)  
imshow(I)
```



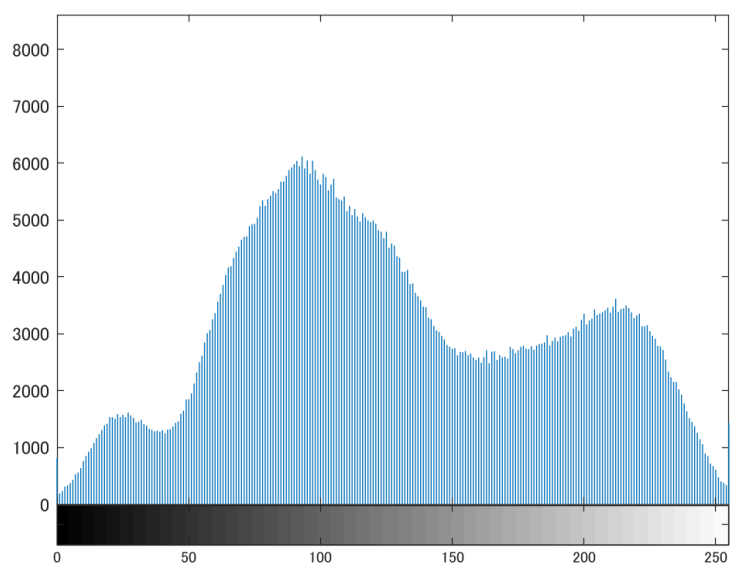
```
figure(8)
imhist(I)
```



```
figure(9)
imshow(J)
```



```
figure(10)
imhist(J)
```



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