Sample 7-4

幾何学処理

有理数比の解像度変換

画像処理特論

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動作確認: MATLAB R2020a

Geometric image processing

Resizing w/ rational factor

Advanced Topics in Image Processing

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Verified: MATLAB R2020a

準備

(Preparation)

```
close all
```

補間率の設定

(Setting of upsampling factor)

- M: 補間率 (upsampling factor)

```
% Upsampling factor
uFactor = 5;
```

間引き率の設定

(Setting of downsampling factor)

- M: 間引き率 (downsampling factor)

```
% Downsampling factor
dFactor = 3;
```

フィルタの設定

(Setting of filter)

平均フィルタのインパルス応答 (Impulse response of averaging filter)

$$h[n] = \begin{cases} \frac{1}{M_\mathrm{d}} & 0 \le n \le M_\mathrm{d} - 1 \\ 0 & \text{otherwise} \end{cases}$$

- $\{h[n]\}_n$: インパルス応答 (Impulse response)

```
% Impulse response of averaging filter
h = ones(1,dFactor)/dFactor;
```

線形補間フィルタのインパルス応答 (Impulse response of linear interpolation filter)

$$f[n] = \begin{cases} \frac{1}{M_\mathrm{u}}(M_\mathrm{u} - |n|) & -M_\mathrm{u} + 1 \le n \le M_\mathrm{u} - 1 \\ 0 & \text{otherwise} \end{cases}$$

ただし，非因果性に注意．(Note that the incausal property.)

- $\{f[n]\}_n$: インパルス応答 (Impulse response)

```
% Impulse response of interpolation filter
f = 1-abs(-(uFactor-1):(uFactor-1))/uFactor;
```

縦続フィルタのインパルス応答 (Impulse response of the cascade filter)

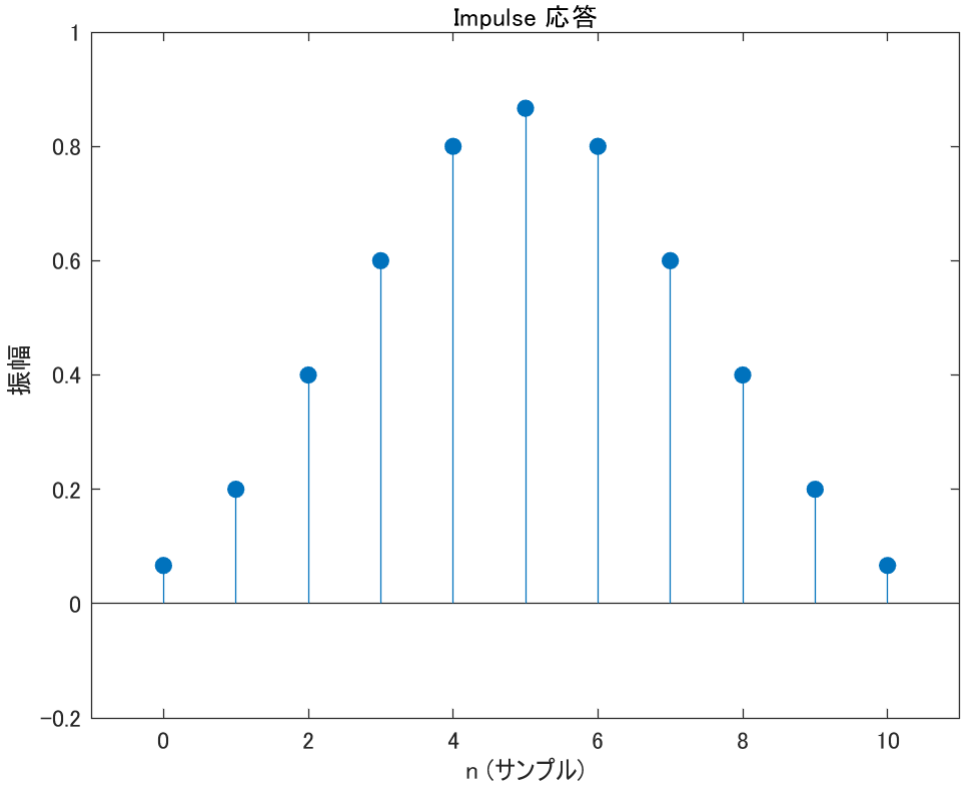
$g[n] = h[n] * f[n]$

```
% Impulse response of the combination
g = conv(h,f);
```

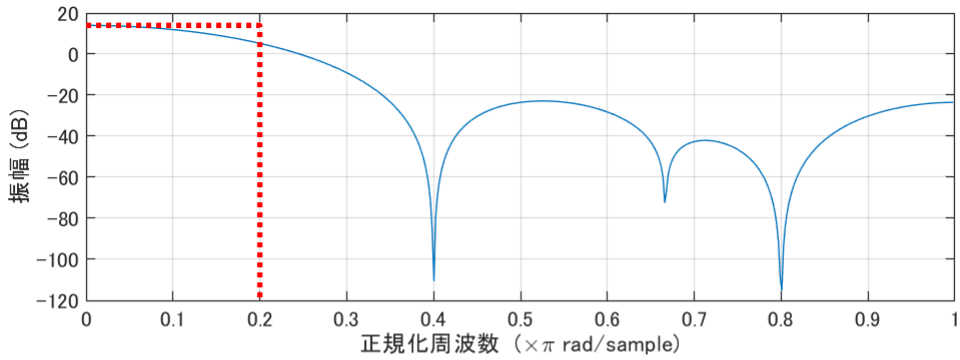
フィルタ特性の表示

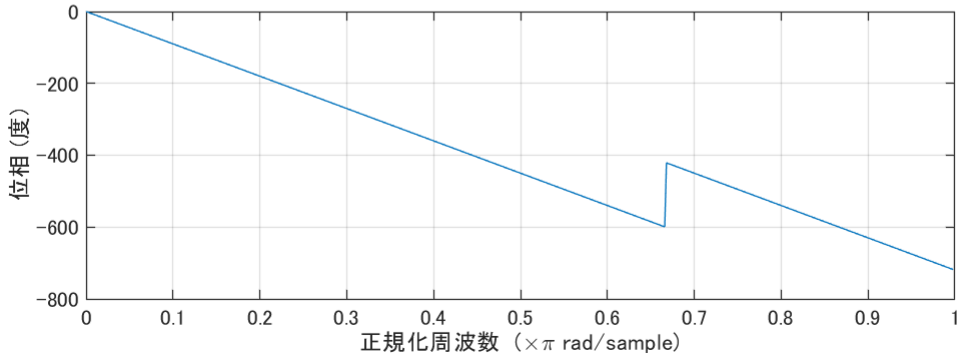
(Display of filter characteristics)

```
% Impulse response
figure(1)
impz(g)
ax = gca;
ax.XLim = [-1 length(g)];
ax.YLim = [-0.2 1];
```




```
% Frequency response
figure(2)
freqz(g)
ax = gca;
hold on
line([0 min(1/uFactor,1/dFactor) min(1/uFactor,1/dFactor)],[20*log10(uFactor) 20*log10(uFactor)
    'LineStyle',':','LineWidth',2,'Color','red');
hold off
```





画像への適用

(Application to images)

$$v[\mathbf{m}] = \sum_{\boldsymbol{\ell} \in \mathbb{Z}^2} u[\mathbf{M}_{\mathrm{u}}\boldsymbol{\ell}]\, g[\mathbf{M}_{\mathrm{d}}\mathbf{m} - \mathbf{M}_{\mathrm{u}}\boldsymbol{\ell}]$$

ただし，(where)

$$g[\mathbf{n}] = h[\mathbf{n}] * f[\mathbf{n}]$$

$$h[\mathbf{n}] = \begin{cases} \dfrac{1}{|\det \mathbf{M}_{\mathrm{d}}|} & \mathbf{n} \in \mathcal{N}(\mathbf{M}_{\mathrm{d}}) \\ 0 & \text{otherwise} \end{cases}$$

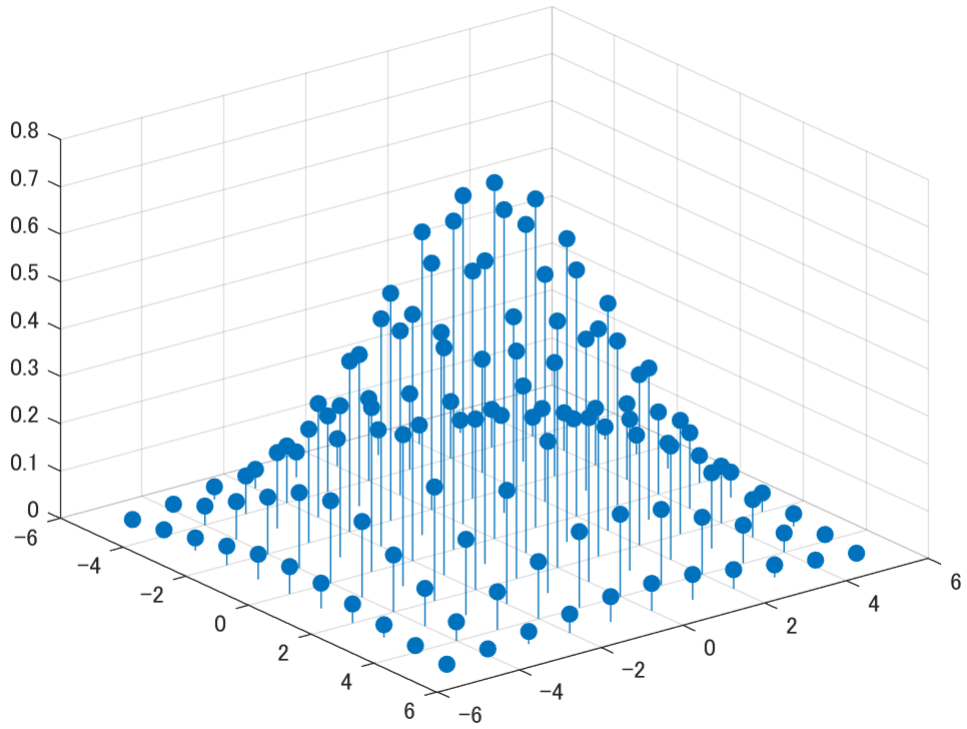
$$f[\mathbf{n}] = \begin{cases} \mathrm{prod}\left(\mathbf{1} - \mathrm{abs}\left(\mathbf{M}_{\mathrm{u}}^{-1}\mathbf{n}\right)\right) & \mathbf{n} \in \{\mathbf{M}_{\mathrm{u}}\mathbf{x} \in \mathbb{Z}^2 \mid \mathbf{x} \in (-1,1)^2\} \\ 0 & \text{otherwise} \end{cases}$$

ただし，非因果性に注意．(Note that the incausal property.)

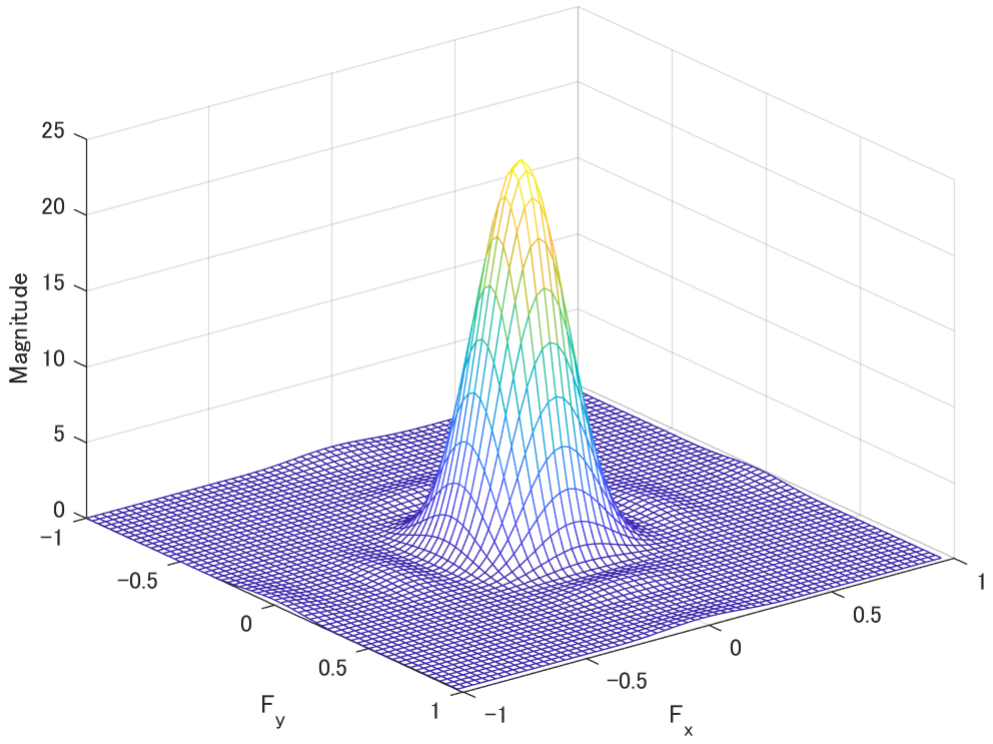
- $\{g[\mathbf{n}]\}_{\mathbf{n}}$: インパルス応答 (Impulse response)

```
% Reading an image
u = imread('cameraman.tif');

% Generating the bilinear interpolation filter
```

```
[n1,n2] = ndgrid(-uFactor+1:uFactor-1);
f = (1-abs(n1)/uFactor).*(1-abs(n2)/uFactor);

% Generating the average filter
h = fspecial('average',dFactor);

% Combination of h and f
g = conv2(f,h);
[n1,n2] = ndgrid(-uFactor-floor(dFactor/2)+1:uFactor+floor(dFactor/2)-1);

% Impluse response
figure(3)
stem3(n2,n1,g,'filled')
axis ij
ax = gca;
ax.XLim = ax.XLim + [-1 1];
ax.YLim = ax.YLim + [-1 1];
```




```
% Frequency response
figure(4)
freqz2(g)
axis ij
```




```
% Bivariate upsampling function
upsample2 = @(x,n) ...
    shiftdim(upsample(...
    shiftdim(upsample(x,...
    n(1)),1),...
    n(2)),1);

% Bivariate downsampling function
downsample2 = @(x,n) ...
    shiftdim(downsample(...
    shiftdim(downsample(x,...
    n(1)),1),...
    n(2)),1);

% Interpolation with upsampling and filtering
x = padarray(u,[1 1],'replicate','both');
w = imfilter(upsample2(x,uFactor*[1 1]),g,'conv');
s = ceil(uFactor/2);
y = w(s+1:s+uFactor*size(u,1),s+1:s+uFactor*size(u,2));
v = downsample2(y,dFactor*[1 1]);
```

画像表示

(Display image)

原画像 (Original)

```
figure(5)
imshow(u)
title('Original')
```

結果画像 (Result)

```
% Display result
figure(6)
imshow(v)
title('Result')
```


```
% Imresize
figure(7)
z = imresize(u,uFactor/dFactor);
imshow(z)
title('Imresize')
```

Imresize