Sample 7-3

幾何学処理

拡大処理

画像処理特論

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動作確認: MATLAB R2023a

Geometric image processing

Interpolation

Advanced Topics in Image Processing

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Verified: MATLAB R2023a

準備

(Preparation)

```
close all
```

補間率の設定

(Setting of upsampling factor)

- : 補間率 (upsampling factor)

```
% Upsampling factor
uFactor = 2;

% Upsampling phase
uPhase = 0;
```

最近傍補間フィルタのインパルス応答 (Impulse response of nearest-neighbor filter)

一次補間フィルタのインパルス応答 (Impulse response of linear interpolation filter)

オフセットを考慮した場合 (When considering the offset)

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

- : インパルス応答 (Impulse response)

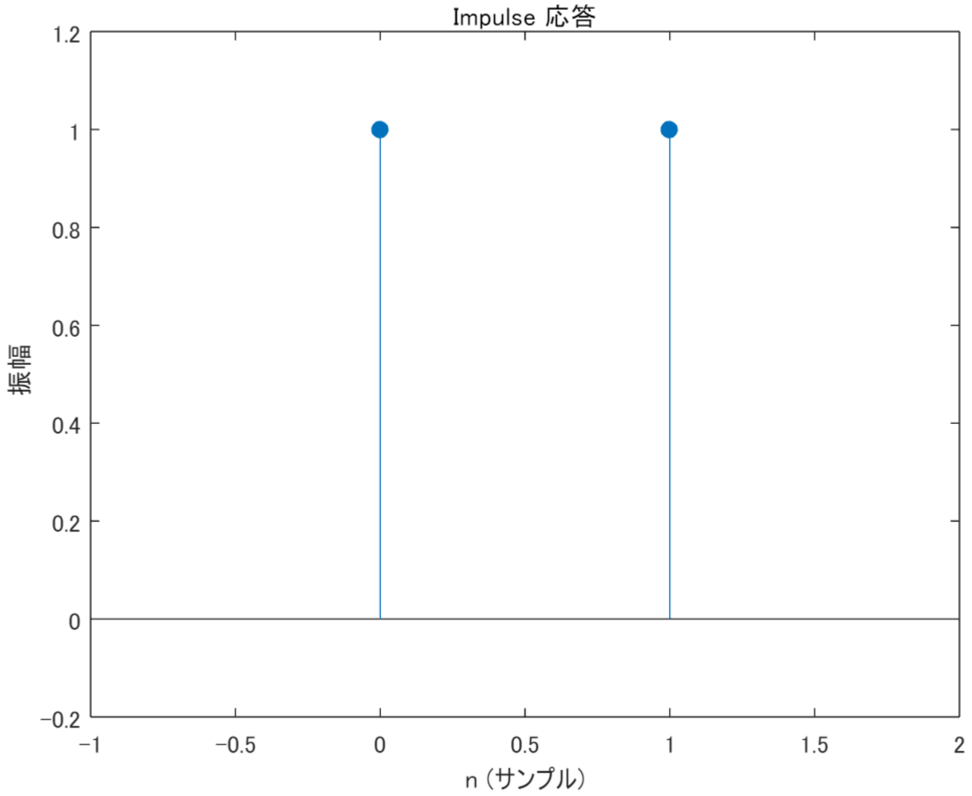
```
% Filter seletion
ftype = "Nearest neighbor";
offset = false; % Set TRUE for even M, FALSE for odd M to make the handmade
bilinear interpolation similar to IMRESIZE

% Impulse response of interpolation filter
if strcmp(ftype,'Nearest neighbor')
    f = ones(1,uFactor);
    offset = false;
elseif strcmp(ftype, 'Bilinear interpolation')
    if ~offset
         f = 1-abs((-uFactor+1):(uFactor-1))/uFactor;
    else
        f = 1-abs(((-uFactor+1):uFactor)-0.5)/uFactor;
    end
else
    error('Invalid ftype')
end
```

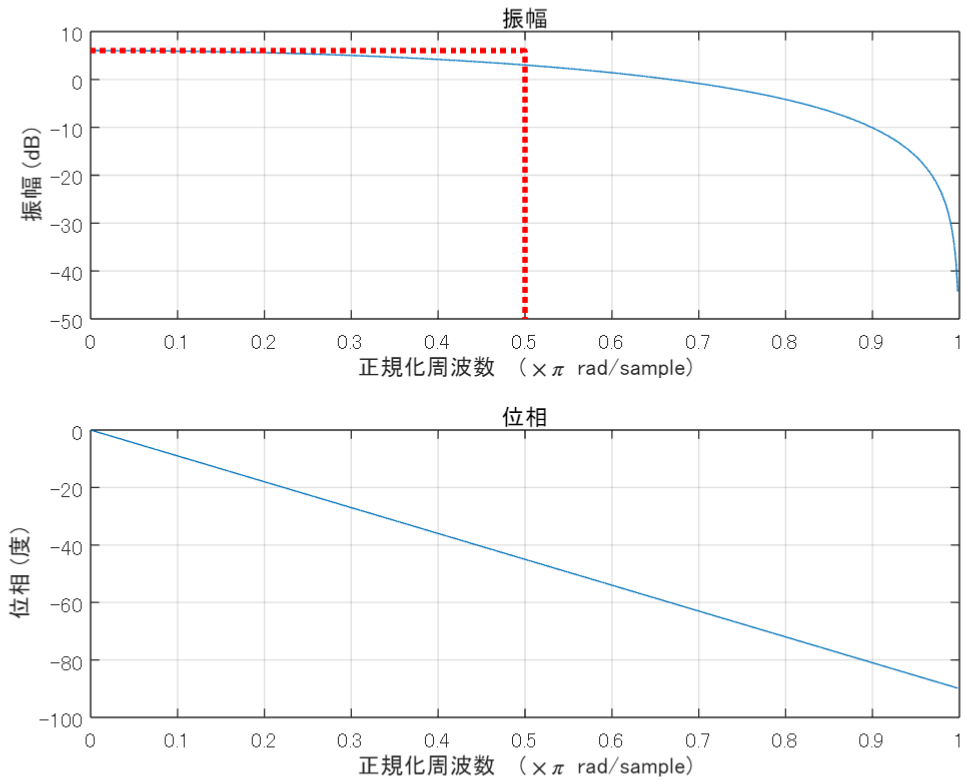
フィルタ特性の表示

(Display of filter characteristics)

```
% Impulse response
figure(1)
impz(f)
ax = gca;
ax.XLim = [-1 length(f)];
ax.YLim = [-0.2 1.2];
```



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



画像への適用

(Application to images)

最近傍補間フィルタのインパルス応答 (Impulse response of nearest-neighbor filter)

双一次補間フィルタのインパルス応答 (Impulse response of bilinear interpolation filter)

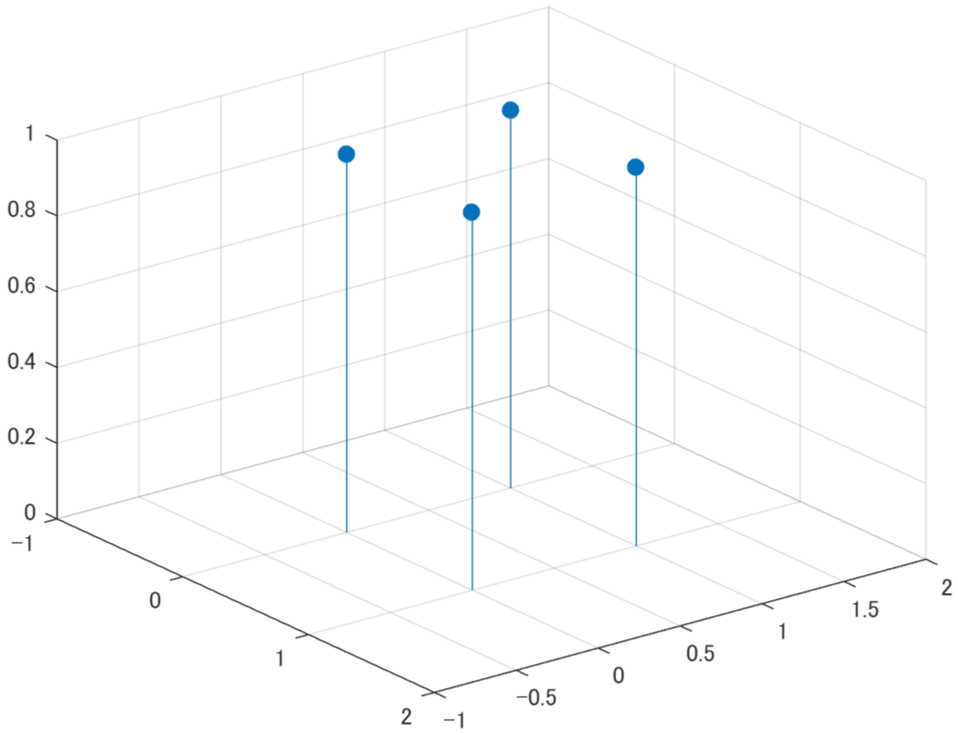
オフセットを考慮した場合

ただし，　は要素の積．非因果性に注意．(where denotes the product of the array elements. Note that the incausal property.)

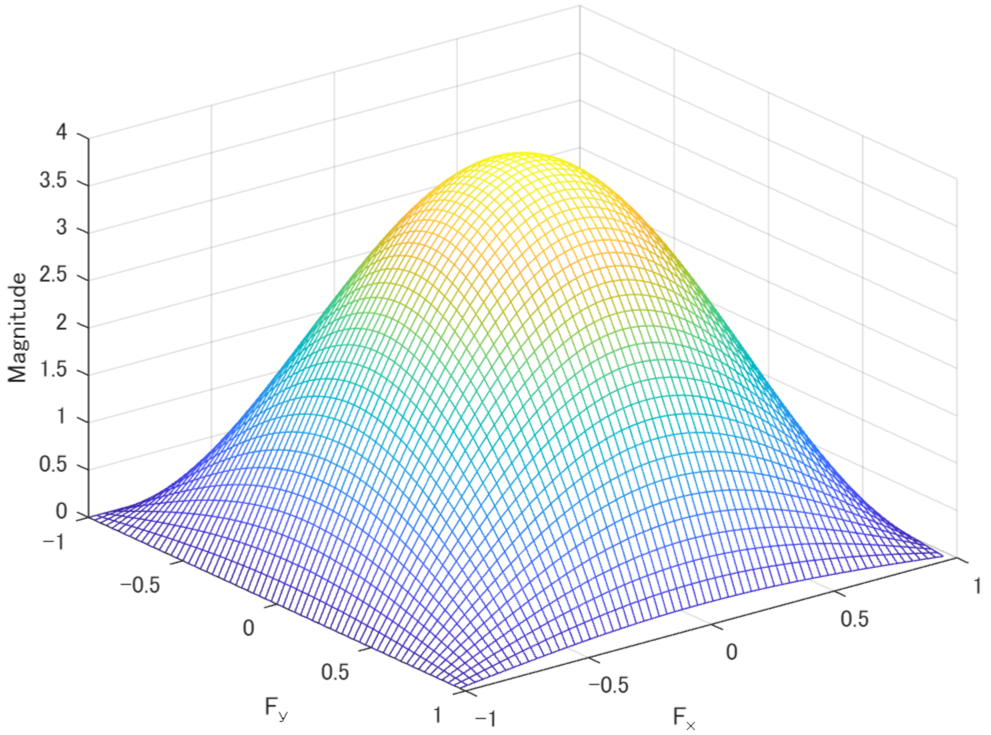
Note that if , and .

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

% Generating an interpolation filter
if strcmp(ftype,'Nearest neighbor')
    [n1,n2] = ndgrid(0:uFactor-1);
    f = ones(uFactor,uFactor);
elseif strcmp(ftype,'Bilinear interpolation')
    if ~offset
        [n1,n2] = ndgrid(-uFactor+1:uFactor-1);
        f = (1-abs(n1)/uFactor).*(1-abs(n2)/uFactor);
    else
        [n1,n2] = ndgrid(-uFactor+1:uFactor);
        f = (1-abs(n1-0.5)/uFactor).*(1-abs(n2-0.5)/uFactor);
    end
else
    error('Invalid ftype')
end
figure(3)
stem3(n2,n1,f,'filled')
axis ij
ax = gca;
ax.XLim = ax.XLim + [-1 1];
ax.YLim = ax.YLim + [-1 1];
```



```
figure(4)
freqz2(f)
axis ij
```



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

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

% Interpolation with IMRESIZE
if strcmp(ftype,'Nearest neighbor')
    y = imresize(u,uFactor,'nearest');
elseif strcmp(ftype, 'Bilinear interpolation')
    y = imresize(u,uFactor,'bilinear');
else
    error('Invalid ftype')
end
```

画像表示

(Display image)

原画像 (Original)

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

Original

拡大画像 (Interpolated image)

```
% Definition of MSE
mymse = @(x,y) sum((x-y).^2,'all')/numel(x);

% Display results
figure(6)
imshow(v)
title('Interpolation w/o IMRESIZE')
```

Interpolation w/o IMRESIZE

```
figure(7)
```

```
imshow(y)
title('Interpolation w/ IMRESIZE')
```

```
figure(8)
imshow(imabsdiff(v,y))
title(['Absolute difference (MSE = ' num2str(mymse(v,y)) ')'])
```